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Resource Technology '98 Nordic Proceedings

June 8 - 12, 1998

Rovaniemi, Finland

International Symposium
on Advanced Technology
in Environmental and
Natural Resources

"World of Information"

Meeting of the Networks

ROVANIEMI RESEARCH STATION



METLA

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Resource Technology '98 Nordic Symposium was held on June 8-12 at Rovaniemi in Finnish Lapland. The event was organised by The Finnish Forest Research Institute, The Arctic Centre, The Geological Survey of Finland, The Forest and Park Service, and The Resource Technology Institute (RTI). The symposium comprised four keynote addresses, 15 sessions, one workshop, and a commercial exhibition. The symposium was attended by 200 participants from 26 countries. The proceedings consist of 68 papers or abstracts, including the oral presentations given at the symposium, and a few papers submitted by scientists who were unable to attend. The articles cover various aspects of information technology and natural resources, with a special emphasis on applications based on the Internet. The scientific committee of RT'98 peer-reviewed the submitted abstracts and accepted the topics to be covered in symposium. Each author is responsible for the final article included in the proceedings.

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The Finnish Forest Research Institute is a state research organization under the Ministry of Agriculture and Forestry. The Institute is a world leader in forest inventories and forest condition monitoring, and has implemented modern information technology as the core of its research activities.



The Arctic Centre, is an institute affiliated to the University of Lapland in Rovaniemi. Steered by an international scientific advisory committee with members from nine countries, the Arctic Centre carries out research, provides data and information services across the circumpolar region, maintains a science centre, and organizes an Arctic Studies Program.

The Geological Survey of Finland a state funded agency, acquires, assesses and provides the geological information needed in promoting the balanced, long-term use of natural resources, especially for exploration and mining companies and the construction industry, as well as for land use, environmental protection and public health authorities.



The Forest and Park Service is a state enterprise responsible for managing state-owned forests and waters. It also manages most of the country's protected areas national parks, strict nature reserves and recreational facilities.



The Resource Technology Institute (RTI) is a non-profit corporation founded in 1987 for scientific and educational purposes that encourages the development and application of advanced technology to support global nature resource management and environmental protection. One major activity of the institute is organizing and conducting international symposia for scientists, educators, environmental and natural resource managers, policy makers and representatives of the industry.

RTI strives to increase manager awareness of emerging technologies, and to make the developers of new technology more aware of the special needs of the environmental and natural resources community.

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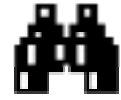
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Foreword

The Resource Technology '98 Symposium was held in Rovaniemi on June 8-12, 1998. The aim of the symposium was to bring together people, from a range of backgrounds, to present and discuss issues that require information technology. The participants indeed came from a wide range of organisations, including universities and higher education, research, governmental and local administration, commercial enterprises, and non-governmental organisations. The special theme of the symposium was "Meeting of the networks". There were several networked workgroups who arranged face-to-face meetings during RT'98, and these participants were also responsible for many philosophical presentations dealing with networks more from a social than from a technical point of view. The emphasis in many of the earlier meetings has been on technological solutions rather than on their role and impact on society. Clearly, we have been given an insight into a new world; global, networked and equal. On the other hand, the importance of the information network infrastructure and international connections is crucial. Environmental phenomena are global, and it is therefore important to provide all parties with the opportunity to get together through the medium of information technology.

The conference chairpersons would like to thank the members of the steering committee and of the scientific committee for their important contribution to the success of RT'98. Our thanks are also due to the sponsors who provided financial contributions.

The role played by many individuals in organising each of the paper workshops and in moderating the sessions is greatly appreciated. We would like to extend very special thanks to the volunteers from the organising institutions for carrying out the many tasks with an admirable attitude and diligence. Recognition is also given to Marja-Leena Porsanger of Rovaniemi-Lapland Congresses, University of Lapland, who managed the conference registrations and logistics in an extremely professional manner.

Finally, we would like to acknowledge the special support provided by the home institutions of the members of the steering committee. Their willingness to support and encourage this service to professional scientific organisations was essential for the success of this symposium, and in achieving the goals of our organisations.

Thank you all!

Erkki Kaila
Symposium Chair

Martti Varmola
Steering Committee Chair

Hannu Salminen
General Secretary

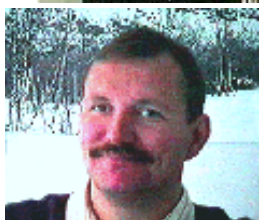
Welcome messages



Hannele Pokka
Governor
[\[Message\]](#)



Matti Pelttari
Mayor of Rovaniemi
[\[Message\]](#)



Erkki Kaila
Symposium Chair
[\[Message\]](#)

Welcome to Lapland

by Hannele Pokka, Governor

On behalf of Lapland, the northernmost province of Finland, I have the great pleasure to welcome you to the International Symposium on Advanced Technology in Environmental and Natural Resources.

Nature has always been a matter of significance to the people of Lapland. The relationship between the residents of Lapland and nature is indeed still strong, even though people are increasingly migrating to the population centres.

The nature of Lapland as a source of both livelihood and recreation is still the greatest treasure of the region's inhabitants, a treasure which has been preserved and nurtured and shall remain so in the future.

Over 90 percent of the country's total area of nature reserves are located in Lapland. Within these areas, the Lapps' traditional right to traverse the natural environment, hunt, fish and engage in reindeer husbandry, are generally ensured.

These protected lands have also proved to be the support pillar of tourism, since most who visit Lapland do so in order to participate in the adventures and experiences provided by nature. The travel industry is a rapidly growing source of income for us Laplanders.

Finland's purest waters, cleanest air and the largest number of areas that are still virtually in a natural state are all found in Lapland. Europe's last great wilderness regions are located in this northern area. Their value continues to grow as the proportion of natural land elsewhere decreases.

Lapland is an especially good place in which to live and have one's home. There is room here to work and space to think. We Laplanders number only about 200 000, with practically the same number of reindeer.

Today co-operation with the neighbouring regions, as well as with more distant regions, is one of Lapland's primary interests. Finnish Lapland is a part of the New North.

I hope you will enjoy your stay in Lapland and wish you a fruitful Symposium.

Welcome to Rovaniemi

by Matti Pelttari, Mayor of Rovaniemi

Rovaniemi, the capital of Lapland and at the same time one third of Finland, is a centre of commerce, education and administration. The changing seasons (and their constancy) represent Lapland at its very best. Summer, the period of "night without night", as well as the "blue weeks" during the winter, invariably provide both local residents and visitors with wonderful experiences.

The University of Lapland, boasting four faculties, is the flagship of education in the region. The international apex of the university is its Arctic Centre, where the life, nature, survival and future of the Arctic world are studied and the relevant details collated and presented. The exhibits of the Science Centre at Arktikum Hall, together with the displays of the Provincial Museum depicting Finnish Lapland, represent sites which are a "must" for every visitor to Rovaniemi. One never reserves enough time to make a proper round of Arktikum!

Rovaniemi, serving as the centre of the Barents region, is one of Finland's most international cities (indeed, it is often referred to as Finland's "Second Capital"). The city is currently home to 36,000 inhabitants.

We would like to bid our conference guests a cordial welcome to Rovaniemi. We also hope that you will have the time to get better acquainted with Rovaniemi, its environs, the Arctic Circle and - last but not certainly least - Santa Claus.

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Welcome to the Symposium

by Erkki Kaila, Symposium Chair

On behalf of the whole organizing team , I have the greatest pleasure in welcoming you to the Resource Technology '98 Nordic Symposium and to Rovaniemi.

All the signs indicate that we are going to have a most intensive and interesting event. With regard to the scientific programme of the symposium, it covers most of the intended topics and after seeing some of the papers, I have to say that a very high standard of quality will be met. The cavalcade of applied information technologies will inspire new conversation during and after the symposium.

"The World of Information" certainly is international, and so is also RT'98; we host delegates from 25 different countries in addition to a large group of "virtual delegates" all over the Internet.

I am convinced that you will enjoy your stay in Rovaniemi and wish you a most successful Symposium.

Comments and questions

Updated by: RT'98 Secretariat/JSaa - June 2, 1998

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David G. Green, Australia:

Coping with complexity - the role of distributed information in environmental and resource management

Eric B. Landis, USA:

Global forest information: a regional approach

Erkki Tomppo, Finland:

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5A	Putilov V., Migulian, Y. and Kuzmin, I.	The information system of the Kola Science Center RAS as an element of the integrated information structure of the Barents region
4B	Saarenmaa, H.	EIONET: Intranet, Extranet and beyond
3B	Saarenmaa, H., Bargmeyer, B., Meekins, W., Murray, R. and Pitts, G.	EDEN (Environmental Data Exchange Network) – an InfoSleuth application
3B	Sandberg, K.W.	Cold climate sustainability: Information Technology to develop a rural community
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2B	Strazdina, S.	Latvian Environment Data Centre as the present and potential environment information resource in the Baltic Sea Region
1A	Sutinen R., Hyvönen E., Hänninen, P., Penttinen, S. and Sutinen M-L.	Classification of forest soils using dielectric and gamma-ray moisture detection
5A	Sytchev, V. I.	Computer-based learning modules on remote sensing application for the Baltic and Sub-Arctic regions
1A	Talkkari, A., Dunham, R., Miller, D. R. and Broadgate, M. L.	A Decision Support Demonstrator for Abiotic Damage to Trees, using a WWW Interface
2C	Tang, H., Bishop, I.D., Yates, P.M.	Systems design options for linking GIS, modeling and visualization: application to forest management
5C	Thorn, A., Daniel, T.C. and Orland, B.	Using data visualization to evaluate economic/aesthetic trade-offs in forest plantation management
Key-note	Tomppo, E.	New Ways for Forest Resource Surveys
5B	Tunney, J.	Anticipating the strategic role of EU law in the development of communications technology in a fragile natural world
5C	Uusitalo, J. and Kivinen, V-P	Implementing SmartForest forest visualization tool on PC environment
4C	Vesa, L.	Use of equation parser in forest information systems
5C	Wherrett, J.R.	Managing scenic resources: modelling natural landscape preferences

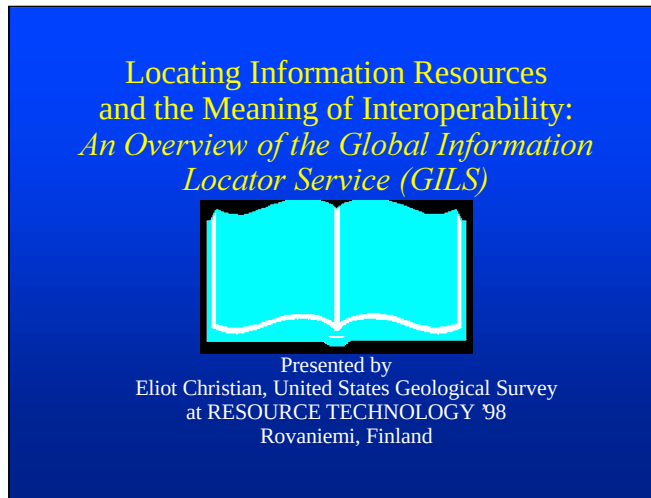
Locating Information Resources and the Meaning of Interoperability: An Overview of the Global Information Locator Service (GILS) – *Presentation*

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Abstract

Interoperability can be understood in many distinct ways. This presentation focuses on the global and long-term problems faced by people trying to discover data and information resources relevant to the environment. Even with widespread access to public peer-computer networks, there remain fundamental problems in common semantics for characterizing information resources (sometimes called “metadata”). A surprising degree of consensus has now been reached in this area by adopting principles articulated in the Global Information Locator Service. These principles operate at levels of policy, standards, and technology, and provide immediate solutions as well as long-term strategies.



The U.S. Geological Survey is one of many participants in the international “Global Change Research Program”. Global Change encompasses very large science, social, and political issues such as climate change and loss of biological diversity. In a sense, the Global Change Research Program is an attempt to understand how Earth systems “really work”.

In 1991, a program plan on data management for Global Change was designed. This plan focused attention on how people find relevant data and information. The aim is to help make Earth science data and information more accessible to researchers and the public.

The Global Change Research program is not only science and technology. The program is also concerned with information policy issues. There is a parallel in public policy issues such as ensuring a free flow of information and public access to government information.

These public policy issues in turn affect the social and political realities that help determine the long-term sustainability of Earth systems.

In dealing with whole Earth systems, understanding and action are intrinsically linked. Access to information is a critical part of that linkage.

In 1995, United States law established a Government Information Locator Service. This GILS adopted the international standards developed in the Global Change work.

Canada and others also adopted GILS. They added document-level search and multiple language support. This second version of GILS was a model for a Global Information Locator Service proposed through the G7 Global Information Society initiative. Aside from political scope, the Government Information Locator Service is identical to the Global Information Locator Service as endorsed in 1997.



The Global Change Data Management Problem

- ◆ Long-term, cross-media, cross-language, cross-discipline
- ◆ Data, publications, information, other abstractions
- ◆ Electronic, paper, artifacts, people, events, rocks

The Global Information Locator Service is shaped by public policy issues that are especially evident in the Global Change Data Management arena.

For instance, How should we define the data and information user community? A user is virtually anyone, anywhere who makes decisions affecting, or affected by, the environment. Users range from children to politicians to specialized researchers. They communicate in any language and in any discipline.

We know that Global Change research will be in a formative stage for decades. It may be 40 years before scientists even know the right questions to ask in some areas. This means most of our users have not even been born. Obviously, we cannot interview them to determine user requirements.

What data and information resources do we need? Relevant resources range from small data tables to massive, global observations. Resources also include directories of organizations and people, chronicles of events, and bibliographic references for publications, books, and maps. Other relevant resources are in natural history museums and archives of all kinds, from seed banks to butterfly collections to genetic libraries to the USGS rock library.

At this point, it may seem that finding data and information is already a huge problem and that this broadly scoped research program only makes it worse. This broad perspective is not only necessary, but also essential because it keeps us focused on fundamentals. In such an important global program, mere technology must not drive public policy.



What's the Solution?

- ◆ Fundamentals
 - Characteristics
 - Pattern-matching
- ◆ Standards
 - Networks
 - Catalogs

In GILS, networks are acting as a vast, interconnected catalog that people use to find information. For example, a person wants to pick a face out of a crowd, find a library book, or search the Internet. Fundamentally, the person is searching for a pattern. The searcher looks for such patterns among the observable characteristics of objects.

There are two kinds of opportunities here to make it easier for people to find information. We can improve the pattern-matching process, and we can make it easier to observe object characteristics.

In the context of electronic networks, we are seeing rapid evolution in pattern-matching and other sorely needed components such as natural language processing. Yet, there is an immediate need for standards to exploit the huge and diverse collections of information already available. Essential to such standards is a common way to perform searches.

Bibliographic searches are very common – publications with a certain title, by a certain author, on a certain subject. GILS adopted the in-

ternational standard protocol for information search. ISO 23950 (ANSI Z39.50). Major players worldwide already support this standard, including most information services and libraries.

The ISO 23950 standard grew out of network search in library catalogs, but it supports much more than bibliographic patterns. It is already used for searching Web addresses, telephone directories, gene sequence libraries, maps by latitude/longitude, imagery by content, and chemicals by structure. Such a growth path is critical for GILS.

Even the best processes for pattern matching need a way to pick out specific object characteristics. Bibliographic objects have well-known characteristics – author, title, subject, date published, and so on. Such characteristics have been developed over many decades and are widely used throughout publishing, libraries, and archives, and other settings. The GILS standard also adopted this widespread set of bibliographic semantics, extended to apply broadly to networked information discovery.



Strategy

- ◆ Sustainability
- ◆ Separate, overlapping domains
- ◆ Decentralized
- ◆ Open standards
- ◆ Evolutionary

The center of the GILS strategy is to adopt relevant parts of existing international standards dealing with information search. These standards allow us to use networks as catalogs for all manner of data and information resources.

What is the strategy for deploying GILS broadly?

To assure that the free flow of ideas is sustainable over the long term, it is not sufficient just to have government mandates. Instead, we must find and promote solutions that respond not only to public sector requirements but to commercial and entertainment interests.

There is now good consensus that information standards intended for global use should presume not central authorities. Instead, everyone is trying to build decentralized and interoperable systems. It now seems that diversity is a defining characteristic of the emerging Global Information Society.

Current bibliographic cataloging practice is a good example of an effective decentralized approach. Cataloging standards provide interoperability across independently maintained libraries, while allowing wide latitude in how collections are developed and organized. Over the last decade, open standards in the library and information services communities have evolved to take advantage of public networks such as the Internet. In particular, the GILS Z39.50 standard is a good example of an open, international standard.

Much progress has been made, but we all recognize the bare fact of the currently primitive facilities for handling complex information, whether at the personal, corporate, community, national, or global scale. The focus of GILS on fundamentals is a conscious strategy to deal with the certainty of continuous technology evolution, and occasional drastic revolution.



Definitions

- ◆ **Locator:** information resource that identifies and describes another information resource
- ◆ **Service (standards):** "middleware" for locating information
- ◆ **Service (policy):** facilities that help people find information
- ◆ **GILS:** decentralized locators and services used directly or through intermediaries to find information

A “locator” is defined as an information resource that identifies other information resources, describes the information available in those resources, and provides assistance in obtaining the information.

A locator can be modeled as a database of locator records, each of which is a set of related data elements. Locator records are also known as metadata, meta-information, directory entries or catalog entries. All of these descriptive mechanisms are “bibliographic” in a broad sense. Again, I would point out that GILS is designed to work with existing bibliographic systems.

In the standards context, GILS defines an application profile as part

of a service definition. This “middleware” service performs specific functions useful for locating information. It is used by higher level applications such as library catalogs, and it uses lower level components such as networks.

Of course, public policy has a less technological understanding of the term “service” and this carries over into GILS at the policy level.

Bringing these together, we can define GILS as: “A decentralized collection of locators and associated information services used by the public either directly or through intermediaries to find information.”



Information Resources

- ◆ Locate ALL kinds of information, in any form, any level of aggregation
- ◆ Communities may constrain and apply more specific rules ("Usage Guidelines")
- ◆ Multiple GILS locators comprise a network for distributed search
- ◆ Not just text: spatial, imagery, chemicals, gene sequences--other pattern-matching

What information resources are typically represented through GILS?

GILS is a very useful way to simplify the locating of networked information resources. For example, Web documents can act as GILS locator records. Such documents can be searched via GILS using embedded metadata.

But, GILS differs from most Internet metadata schemes. GILS locator records are designed to act as pointers not just to Internet pages, but to ALL kinds of information – including people, organizations, events, books, artifacts, paper documents, and so on. Static HTM documents on the Web is just one part of the information addressed by GILS.

GILS itself is open to any level of aggregation. A GILS locator record may describe an information resource ranging from one pamphlet up to an entire multi-national program. North Carolina is using GILS locator records to describe individual fields within tables within databases throughout the state. The U.S. Gov-

ernment Printing Office created GILS locator records at the level of entire agencies. Each community can specify its own preferred level of aggregation in their own GILS guidelines.

Also, a collection of GILS locator records can be described by a record in another GILS locator. Using the Linkage element, the separate GILS locators then form a network for distributed search. This feature addresses the “query routing” problem of Internet searching. GILS is used this way in the public domain “Advanced Search Facility” now under development.

There are also searchable databases giving locator records for hundreds of information sources that are searchable with Z39.50 – many of which have millions of bibliographic or GILS records. Such locators can encompass all library catalogs, Web crawlers, and public directories on the Internet, yet also cover non-electronic resources like the USGS Rock Library.



Client-Server Architecture

- ◆ GILS-compliant servers interoperable for searching, defined in GILS profile
- ◆ GILS profile uses network client-server
- ◆ GILS profile does not constrain clients
- ◆ Server specification during search, independent of content management
- ◆ Anyone can use GILS independently to organize information

Just how does GILS make information searching interoperable?

A key technology for GILS is a network-based architecture called “client-server”. This is the same architecture used for the World Wide Web, and many other network applications as well.

Interoperability among the many different GILS-compliant servers is defined through the GILS Profile. The GILS Profile is part of the ISO 23950 standard and is coordinated through a GILS Special Interest Group within the Open Systems Environment Implementors Workshop. (The GILS discussion list is open to anyone to join – the address is on my last slide.)

The GILS Profile is defined on networks, including the Internet. But, instead of working at the presentation level like Web pages, GILS defines a machine-level network interface.

The GILS Profile only specifies the behaviors of server software at the client/server interface – it does not constrain clients at all. This means user interfaces can be anything you want, including self-operating client software like information gatherers.

The operation of a GILS-compliant server is only defined as an “abstraction layer”. This means GILS doesn’t care how servers actually manage content. You can have relational databases like Oracle, Informix, or Microsoft Access. You can have your own favorite search engine, or an SGML or GIS database, or a Web crawler. You could even operate a search broker and have content only developed as needed to respond to a specific search. Again, the Advanced Search Facility provides a good freeware base for developing new information discovery tools in the context of GILS.



GILS-Compliant Server

- ◆ Server appears to hold "locator records", but GILS does not prescribe a "record format"
- ◆ Search "full-text" or on structured elements
- ◆ GILS defines about 100 "metadata" elements
- ◆ GILS locator records can also include any locally-defined metadata elements
- ◆ Gils-compliant servers map local structured elements to the registered element numbers

GILS-compliant server appears to hold a set of locator records. Each locator record characterizes some information resource. The locator records may be handcrafted catalog records, or they may be created automatically using machine-aided indexing. GILS locator records describing Web sites use a listing of words drawn from the site contents.

A GILS search can be full-text, as is done with Internet-wide search services. Yet a GILS search can also exploit bibliographic elements such as Title, Author, Subject, Publication Date, Language – over 100 elements are registered in GILS with one-to-one mappings to well-known MARC tags.

GILS locator records can also have locally-defined elements –

whatever and as many as you need. GILS-compliant servers must support the required search attributes and all registered elements, and must not degrade locally defined elements.

GILS is based on a common search interface rather than a common record format. This means that you can use GILS to search virtually any metadata structures – HTML, XML, SGML, X.500, SQL databases, Internet mail, IAFA, and so on. GILS-compliant servers simply map local semantics to the registered elements.

Also, multi-lingual searching is supported in GILS because the elements are referenced by number – to display a tag, the user interface simply looks up the number for the particular language in use.



National and International

Australia, Canada, Committee of Earth Observing Satellites, Consortium for International Earth Science Information Network, European Environment Agency, European Legislative Virtual Library, European Wide Service Exchange, Global Change Master Directory, Global Environmental Information Locator Service, Great Lakes Information Network, I*M Europe, Inter-American Biodiversity Information Network, Japan, Nordic Web Index, UN Framework Convention on Climate Change, UN Convention on Biological Diversity

Where are we now in terms of GILS implementations?

There is no central registry of GILS implementations, so the following listings are just a sampler of the GILS implementations.

“National GILS” are showing up in Australia, Canada, the European Union, Germany, Japan, and some other countries. Also Information System Russia is adopting GILS.

GILS is especially well-known for access to environmental information. GILS has been adopted by international organizations such as the Committee on Earth Observing Satellites, the Consortium for International Earth Science Information Network, the Great Lakes Information Network, and the Inter-American Biodiversity Information Network.

In the Global Environmental Information Locator Service, G7 countries and others have agreed to use

GILS for environmental information worldwide. This includes the European Environment Agency “Catalogue of Data Sources”, and United Nations initiatives such as the Framework Convention on Climate Change and the Convention on Biological Diversity.

Cuba has translated GILS materials into Spanish and it is being implemented throughout Latin America for access to health care information. This includes a Spanish gateway to “Medline” using Z39.50.

In addition, there are many other GILS implementations focused primarily on spatial, remote sensing, biological, and other environmental and Earth science information. These include national initiatives for geospatial (map) data in countries such as Australia, Canada, Japan, and Malaysia, as well as a genetic information initiative in Singapore.



U.S. State, Regional, Local

California, Florida, Fort Lauderdale, Greensboro, Madison, Massachusetts, Missouri, New York, North Carolina, Philadelphia, Solinet and Southern Growth Policy Board, South Carolina, Tallahassee, Tennessee Valley Authority, Texas, Washington (State)

There are quite a few GILS implementations already underway in the United States at the state and regional levels. Others at the local level are starting.

The Southern Growth Policy Board is using GILS in the context of economic development. Just as libraries act as a trusted source of diverse information, this regional GILS will provide a trusted source of diverse economic, demographic, and other commercially significant public information – enhancing the region's competitiveness in attracting business investment on a global basis.

Minnesota, North Carolina, Texas, and the state of Washington

have law and executive orders mandating GILS. Several other states and regional organizations also have GILS initiatives, including California, Florida, Massachusetts, Missouri, New York, Ohio, and South Carolina.

We are now seeing the beginning of city-level GILS implementations in cities such as Fort Lauderdale, Greensboro, Madison, Philadelphia, and Tallahassee.

There are many additional states and cities involved in the National Spatial Data Infrastructure and National Biological Information Infrastructure as well, and all of these are also linked by common support of GILS.



As mentioned before, the U.S. Federal GILS is established in law. The rest of these United States initiatives are following GILS without a legal mandate. For example, both the Government Printing Office and the Library of Congress are making their search services GILS-compliant.

GILS is a basic component of the National Spatial Data Infrastructure, the National Biological Information Infrastructure, the National Environmental Data Index, and several other national initiatives.

Although there is not a complete list available, it is clear that there are already many and diverse GILS implementations.

In adopting GILS, these various organizations do not submit to a single view of information, nor do they subordinate themselves to some "mother of all GILS". Although their different Usage Guidelines reflect their disparate goals, they are all interoperable with other GILS as well as libraries, information services, and other major resources worldwide.



Semantic Interoperability

- ◆ Many communities use bibliographic techniques, but different rules for elements
- ◆ Tightly controlled metadata format rules are not sustainable globally and long-term
- ◆ Looser specification for search interface only allows diverse formats, software, and models
- ◆ All information resources need not be characterized the same way

Why do we need mechanisms like abstraction layers and search interfaces?

Simply put – people over the centuries and throughout the world have built an incredibly rich and complex treasure house of information. To preserve that richness and diversity, we must step back and see the commonalities.

Many separate communities worldwide over many decades have used bibliographic techniques to characterize data and information resources. Unfortunately, when each community uses different tags for the bibliographic or metadata elements, this commonality becomes obscured.

The usual result of this independent development is that there is no functional interoperability between the catalog services, unless some organization is able to force the communities to accept imposition of a common format. Such strong-arm tactics may be useful at times, but they are clearly inappropriate on a long-term and global scale.

GILS takes a gentler approach – GILS leverages existing systems instead of trying to supersede them. It provides interoperability at the semantic level but only in this specific interface for a machine-level search service.

With its semantic interoperability approach, GILS allows each community to develop as much additional interoperability as they want. Often, this is merely coming to agreement on a Usage Guideline. Sometimes, a more specific profile is constructed on top of GILS – as in the Geospatial Profile used for maps and spatial data, or the Catalog Interoperability Profile for imagery.

Recently, the GILS community is looking at application of ISO 11179 as a way to enhance the realization of interoperability using semantic registries. The GILS elements have been mapped into the ISO Basic Semantic Registry and the EPA Environmental Data Registry, for example.



Basic Principles

- ◆ Enhance free flow of information globally
- ◆ Assure access to all media and legacy sources
- ◆ Use open, international standards
- ◆ Balance needs of searchers, intermediaries, and content owners
- ◆ Avoid preferred views, central control

Share the vision, Seek help!

The vision of a Global Information Locator Service operates at several levels, including public policy, standards, and technology.

In all these aspects, we expect GILS to evolve over the decades, within some basic principles:

- Enhancing the free flow of information globally.
- Assuring access to all media and legacy sources
- Using open, international standards

- Balancing the needs of searchers, intermediaries, and content owners
- Avoiding preferred views or central control mechanisms

On a global, long-term scale, these are not simple platitudes. Just look back a few decades and consider how fragile is this notion of a free flow of information – and how fragile it is for most people yet today.



Further Information

- ◆ Global Information Locator Service
<http://www.g7.fed.us/gils>
- ◆ GILS Discussion List
e-mail to LISTPROC@CNI.ORG
subscribe GILS <your name>
- ◆ Advanced Search Facility discussion list
e-mail to LISTPROC@CNI.ORG
subscribe GILS <your name>
- ◆ Eliot Christian <echristi@usgs.gov>

Coping with complexity – the role of distributed information in environmental and resource management

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Abstract

If humankind is to succeed in managing the world's resources, and in conserving the biodiversity of nature, then we need really comprehensive and reliable information - a global information warehouse - from which to plan. Building and maintaining such a system is a huge task. Contributing information needs to be a routine part of the activity of every organisation. Nor can a global warehouse be centralised; it needs to be distributed across every contributing agency. Achieving this goal will require work in three areas. First, data collation requires data standards directed towards crucial problems, the systematic use of metadata, and the coordination of data sources via information networks. Secondly, interpretation will require flexible query systems. These can exploit new object technologies that makes possible distributed processing. Finally, and perhaps the greatest challenge of all, is to interpret vast amounts of information effectively. The new field of complexity theory is beginning to provide relevant principles and methods.

I Introduction

One of the great challenges facing mankind at the turn of the millennium is how to conserve and manage the world's living and natural resources.

The problem is immense. The planet's surface area totals

509,000,000 square kilometres. Simply monitoring such vast tracts is a huge task. Taxonomists have described about 1.5 million species (Wilson 1992). The total number of species is not known, but is estimated to be somewhere between 10 million and 100 million. At the current pace it would take at least another 300

years of taxonomic research simply to document them all. Modern technology can help with these task (Klomp et al. 1997) but at the same time generates huge volumes of data that must somehow be stored, collated and interpreted.

The problem is also acute. As human population grows the pressure on resources grows with it. We have now reached a point where no virtually no place on earth is untouched by human activity, and where it can be questioned whether the existing resources can sustain such a large mass of people indefinitely. Slowly we are learning to use resources more carefully.

Given the size and urgency of the problem, piecemeal solutions simply will not do. We have to plan and act systematically. And we need sound, comprehensive information from which to plan. The problem is so huge that nothing less than the coordinated efforts of every environment and resource agency in every country will be adequate.

Our ultimate aim should be nothing less than a global information warehouse documenting the world's resources. Until recently such a goal was unattainable. Collating all available information in one place is simply not possible. However improvements in communications, and especially the rise of the Internet as a global communications medium, now make it feasible to build such a system as a distributed network of information sources.

In this account I outline some of the technical issues involved in developing such a system and describe some relevant recent developments.

2 Mobilising data resources

2.1 Information networks

How do we organise information on a large scale? One first approach is to start at the source and organise publishing sites into an information network. In this context an information network is a set of sites on the Internet that coordinate their activities. In particular they operate under some common framework, especially the indexing of the information that they supply.

There are now many networks that focus on environment and resources. As examples some of the networks that I have been involved with include the International Organisation for Plant Information (Burdet 1992), FireNet (Green et al. 1993), and the Australian Biological Research Network (Green and Klomp 1997).

The advantage of information networks is that they can address directly issues that are crucial in building a reliable information system (Green 1995), including:

- standardisation,
- quality assurance,
- indexing, and
- stability.

Information networks operate best where the subject matter can be well-defined and where the operating model can be tightly defined. However the coupling of sites can vary enormously. Databases typically consist of three main components: an interface, data, and tools for search and retrieval. In a distributed data-

base, information and indexes are shared across computers on each of the participating sites (Fig. 1).

A good example of a centralised approach is the popular software resource called TUCOWS. The TUCOWS system is a network of at least 100 software repositories on the World Wide Web. The network has a central reference site and many mirrors, which duplicate varying levels. The incentive for the mirror sites

is the “honeypot effect” (Green 1995): the software attracts users.

Perhaps the best examples of well-focussed networks are the Virtual Tourist and the World Wide Web Virtual Library. Both of these services appeared early in the life of the World Wide Web to meet obvious needs. Each system has a central indexing site, but the sources of information about each country or topic

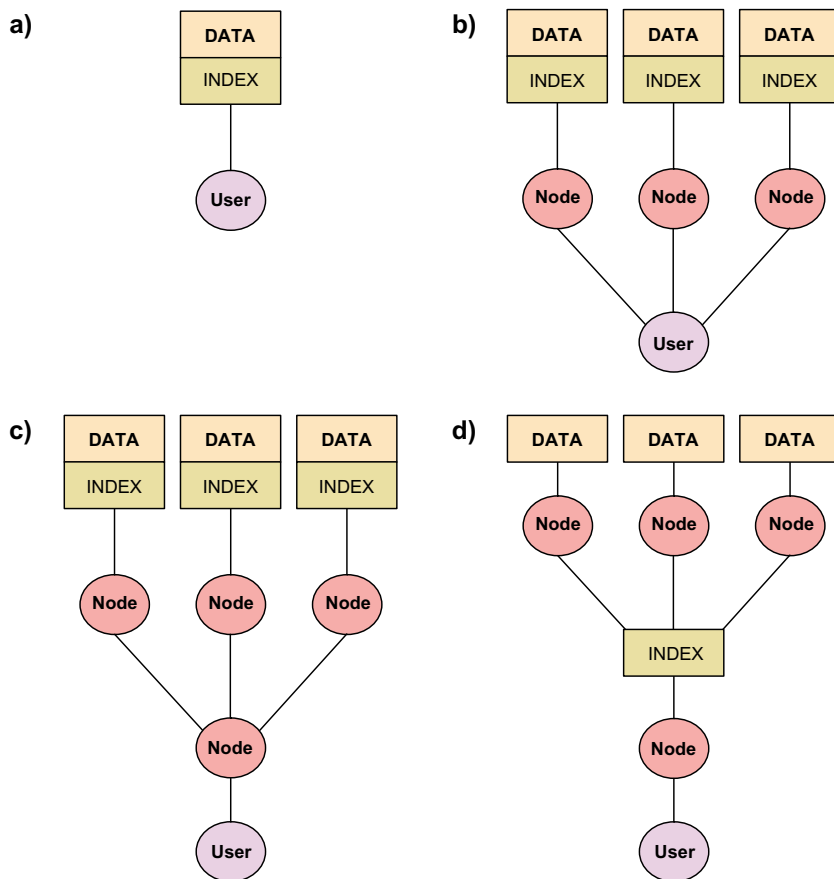


Figure 1. Some alternative designs for distributed data systems. They range from both the index and data being sited on a single machine to various kinds of distributed systems.

are spread across literally thousands of contributing sites.

The current chaotic state of the World Wide Web is a direct result of rapid commercial development. This has put great emphasis on promoting corporate image through Web sites and has discouraged sharing and cooperation between sites. In its efforts to organise on-line material the World Wide Web Consortium (W3C) has concentrated on technical standards that deal essentially with indexing.

2.2 Metadata

Metadata means data about data. Metadata play a crucial role in recording, indexing and coordinating information resources (Cathro 1997).

One approach is to adopt a bottom-up approach by including metadata elements in the head of every on-line document. To this end the Dublin Core defines a set of standard metadata tags to identify the nature, content and provenance of HTML documents. In Table 1, for example are the metadata entries for this document.

The most widespread use of the Dublin Core so far has been in developing metadata indexes for specialised areas. In Australia, for example, the National Library and partners have begun a MetaWeb Project to index government, libraries and some research information. This project also developed software to help automate the addition of metadata to existing documents. There has also been substantial activity towards indexing environmental and resources information. Environment Australia now includes Dublin Core style metadata in all its on-line documents and services. Likewise the National Resource Information Centre now uses DC metadata to index entries for the National Directory of resources information (NDAR), which it has been actively developing for nearly ten years (Shelley 1992).

In order to address the need for metadata for a wider range of material, and to provide greater flexibility, the World Wide Web Consortium has begun developing a more general standard, known as the Resource Description Framework (RDF) (W3C 1998). RDF will use XML (a

<META NAME = "DC.creator"	CONTENT = "David G. Green">
<META NAME = "DC.title"	CONTENT = "Coping with complexity">
<META NAME = "DC.subject"	CONTENT = "GIS complexity biodiversity ">
<META NAME = "DC.subject"	CONTENT = "environmental informatics">
<META NAME = "DC.publisher"	CONTENT = "METLA, Finland">
<META NAME = "DC.language"	CONTENT = "english">
<META NAME = "DC.coverage"	CONTENT = "world">
<META NAME = "format"	SCHEME = "IMT" CONTENT = "text/html">
<META NAME = "DC.identifier"	SCHEME = "URL" CONTENT = "http://">
<META NAME = "DC.date" type="creation"	scheme="ISO" CONTENT="1998-04-26">

Table 1. Metadata entries for this document.

reduced form of SGML) as its transfer syntax. One advantage of XML's content based tags is that they are effectively self-documenting. The aims of RDF (still in its early stages at the time of writing) are:

- to provide a robust and flexible architecture for supporting meta-data on the Internet and WWW; and
- to allow different application communities to define their metadata property sets.

At present the following issues seriously hinder the value of metadata as it is currently used on the World Wide Web.

Misuse

A lot of commercial sites have misused metadata by stuffing metadata headers with spurious terms. For example few people will go looking for a page about widgets, but if you stuff it with hidden fields full of popular terms like games, money, or sex, then the number of hits increases dramatically. Alert to this problem of misuse, many search engines now specifically ignore meta-terms when searching document headers!

Semantics

Although standards such as the Dublin Core define the syntax for metadata elements, they do not define the semantics. That is they do not define the range of each field. For example the subject element really requires a hierarchy of keywords and phrases if we are to group items systematically.

Apathy

Most people simply ignore metadata. It takes time. Few people even know what it is, let alone how to do it. But most of all there is no perceived advantage.

2.3 Databases

Indexing items is just a first step in the business of data gathering. The real issue is what questions do we want to answer with our data? After all the aim of combining data from different sources is to enable us to address questions of substance.

If we wish to mobilise data from individual researchers then there is a need to identify exactly what information we require. As an example take the case of soils data. This can be collected in various ways, ranging from point samples with various physical (e.g. pH, substrate, depth) and site attributes (e.g. Latitude/Longitude, elevation) to areas classified by the dominant types. Some advantages of raw point data are that:

- it can be rescaled;
- it can be recombined with other data more easily;
- it can be used to generate classifications;
- it retains details that are lost in interpreted data (e.g. exact pH value rather than pH class) and may prove important at some time in the future.

However there are also disadvantages. For example, raw data usually has to be processed to derive usable information. Also standards are

rarely applied universally, and idiosyncratic sampling methods abound.

Elsewhere I have argued (e.g. Green, D.G. 1994) for an approach that combines the flexibility with simplicity. That is

- identify raw variables of high priority;
- collect raw data if simple mechanisms exist to retrieve and use it.

For example, field ecologists collect all manner of detailed information about plant and animal communities. Often their data includes fields that are specific to their study alone. Nevertheless archiving data about particular sites would be useful for any future studies of the area concerned. However every study also contains some common data that would be of universal interest. For instance a useful unit of biodiversity data would be a list of species found at a particular site at a particular time, together with appropriate physical data for the site itself.

2.4 The human dimension

All the technical innovations in the world count as nought if people refuse to participate. For instance only a small minority of Web authors and publishers currently include metadata in their publications. There are many reasons why people fail to cooperate. Here are some of them:

- **Ignorance**

People do not know what needs to be done. They do not know that data repositories exist. They do not know where to find

relevant resources. They do not know what metadata is and how to add it. They also do not know why metadata is important.

- **Lack of time or resources**

Activities like submitting index entries or adding metadata take time and can be awkward. The processes need to be fast, simple and automated wherever possible.

- **No benefits**

People are unlikely to make an effort to share data if they see no benefit in doing so.

- **Fear**

This includes fear of losing control of your own information, fear of others stealing your results, and fear of the technology.

There are many carrots and sticks to encourage people to cooperate. Biotechnology has reached a stage where it is now virtually compulsory for researchers to submit their raw sequence data to international databases, such as Genbank (Bilofsky and Burks 1988) and European Molecular Biology Laboratory (EMBL) (Cameron 1988) as a prior condition for publication in any leading journal. This practice has proved so fruitful that many biotechnology companies make the bulk of their data freely available too.

Research funding agencies are now thinking beyond research papers as the only outputs of research projects. Tying data sharing to research funding is an extremely powerful way of enforcing cooperation. Along with various colleagues I have

advocated expanding compulsory submission of research data to all areas of publicly funded scientific research, especially for projects dealing with environment and resources (Green 1994). However such practices require that three conditions are first met:

- establishment of networks of research data repositories;
- identification of key variables in each field of research;
- flexible standards that recognise common practice without inhibiting innovative research.

Along with the above sticks there are many possible carrots. One is to provide a reward in return for cooperation. For example in running various indexing services, such as virtual libraries, I have found no shortage of people wanting to register their online information because doing so gives their work extra exposure. For instance my Mapmaker program (Steinke et al. 1996) allows users to generate maps at the same time as submitting spatial information. This service is currently being expanded into a public domain spatial query system.

Another way of encouraging participation, and conformance to desirable standards is via accreditation. In this context accreditation is a general term for any mechanism for providing recognition or endorsement of information on another web site. In a sense any hypertext link to material on another site is de facto endorsement of that material. However a stronger form of recognition is to provide a badge or label that can be

added to the web page concerned. This approach is particularly effective if the endorsing site belongs to an organisation with substantial credibility, such as a society, major institution or official government agency.

3 Query systems

The value of data lies in what you do with it. If our sources of data are distributed, then so too will be the tools for interpreting those data.

3.1 Distributed information processing

The simplest form of distributed processes are index queries. A number of Internet search engines farm out queries to a set of contributing sites. Several standards, such as the Summary Object Interchange Format (SOIF) exist to support this kind of activity.

For more general processing there is much interest among computer scientists in using the Internet as a large parallel computer. For example, some researchers routinely farm out large problems to a series of workstations. One step beyond this is to systematise the process. The programming language Java is an obvious tool for this kind of activity. It was designed for downloading applications across the Internet and includes features for invoking remote methods. At least one language independent standard - CORBA - has emerged for interface definition in a

distributed environment (Veen 1997).

Object oriented representations raise many possibilities for distributed information processing. Objects form flexible, self-contained units that package data with the methods needed to process them. Negotiation between objects raises the potential for combining them into new, more complex information processing. In recent work colleagues and I experimented with our own prototype system of distributed query objects (Moir, unpublished). Seeking to build on existing infrastructure, this system passed queries as HTTP messages. Each HTTPD server in the object network provides a query interpreter and an object store. Objects consists of metadata identifiers, input slots, processes and outputs. Objects pass queries from one to another, each carrying out specialised tasks. In work to date performance issues have proved to be the most serious limiting factor.

To understand the significance of such a system, consider a simple example, such as real-time monitoring of fisheries or wildlife. Data on the different components (e.g. fishing boats, currents, weather) might be drawn from different sources. The analysis might be carried out on one site, then the results sent off elsewhere to overlay the predicted movements on top of up-to-date satellite images. The advantage is that sites can provide standard processing, for many different purposes, of the specialised data that they provide.

3.2 Distributed publishing systems

Perhaps a good example of a simple processing object is the engine of the Mapmaker service (Steinke et al. 1996) that I provide on my server. The Mapmaker itself allows users to generate maps of any area in the world, using data from the Digital Chart of the World. Moreover they can add their own point data to create (say) customised maps of survey sites. However because the engine for the system behaves as a stand-alone object, we are able to pass queries to it from other applications, such as a spatial query systems for Australian towns and environmental bibliographies, and a geographic virtual library.

The above applications are by-products of a more general project on Web publishing languages (Green 1996, Green et al. 1998). The resulting programming language SLEEP (Newth and Green in prep.) simplifies the installation and operation of many kinds of on-line publications. Interpreting a form is a single function call, for example. We are using prototype versions of the language, which makes extensive use of metadata and SGML/XML, to automate many services on the Johnstone Centre Web site (<http://life.csu.edu.au/>). Besides automating standard Web operations, the language also makes provision for distributed publications. We have also developed specialised modules for several environmental tasks, including map drawing, spatial queries, data plotting and simple spatial statistics.

3.2.1 Example - great circle distances

A simple demonstration of using publishing languages to develop new applications on-line is the form located at

<http://life.csu.edu.au/cgi-bin/itc332/calc?circle>

This example determines the great circle distance between any two points that the user selects on a map of the world. The elements needed to drive the example are:

- a map of the world,
- a form,
- the language interpreter,
- the following script:

```
source circle.sgl
  target STDOUT
  var slat -34.5
  var slong 147
  var tlat -33
  var tlong 149.2
  radius 6306
  circle
  sub
```

Later versions of the interpreter used in this example (Newth & Green in prep.) have been combined with CSU's Mapmaker program (Steinke et al. 1996) to provide a toolkit for implementing a wide range of on-line spatial queries and functions.

3.3 On-line geographic information systems

The Web is fast becoming a standard platform for geographic information systems (GIS). Commercial developers are already producing on-line versions of their GIS software. Also there are many on-line services that include spatial queries or map

drawing. Within Australia alone the range of environmental information available on-line is impressive. The following are simply examples. They include queries, map-making, and spatial metadata:

- Species mapper (Environment Australia) <http://kaos.erin.gov.au/search/mapper.html>
- Data Locator (Australian National Geoscience Information System) <http://www.agso.gov.au/ngis/locator.html>
- CSIRO AGCRC GRASSLINKS <http://www.ned.dem.csiro.au/AGCRC/4dgm/grasslinks/>
- Spatial Query and Retrieve Information (Environment Australia) <http://kaos.erin.gov.au/database/db.html>
- Australian Spatial Data Directory (ASDD) <http://www.nric.gov.au/nric/data/data.html>
- Australia New Zealand Land Information Council http://www.anzlic.org.au/anz_site.htm

Interactive GIS on-line really requires Java based functions to allow query answer sessions to proceed at an acceptable pace (Steinke et al. 1996.). Spatial metadata concerns records that can be identified with features or locations in the landscape. Such information is particularly relevant when considering natural resources (ANZLIC).

4 The problem of complexity

It is important to realise that simply setting up an information system will not automatically resolve every ques-

tion. Assuming that we can overcome all the other difficulties perhaps the greatest challenge still remains. And that is the sheer complexity of the world's environment (Bossomaier & Green 1998, Green 1997). Here we encounter some really sobering truths. In this section I shall briefly explain some of these problems and suggest how they might be addressed.

4.1 The serendipity effect

A standard operation in GIS is the overlay. That is you lay one data layer (e.g. roads) over another data layer (e.g. topography). An important application of this process is to examine the interaction between two distinct systems within a landscape. In effect this procedure asks a simple question: how do the two systems represented by the layers interact with one another.

Now a really comprehensive spatial database might contain dozens of layers. For each layer that we add, we can overlay it on any combination of the existing layers. So the number of possible overlays - in effect the number of questions that we can address with the data - increases exponentially as we add data. Thus the chances of making an interesting discovery by chance – by serendipity – increases exponentially as we add new datasets.

The converse of the above is that the size of any problem that we may need to solve goes up exponentially too. This includes the likelihood of having incompatible data (e.g. different scale, fields etc) and the problem of combinatorial explosions in running classifications and other algorithms.

4.2 Unpredictability

Perhaps the least understood aspects of ecosystems are the ways in which local interactions affect the global composition and dynamics of whole communities. Issues such as spatial heterogeneity, unpredictability and networks of species interactions have a great bearing on the viability of strategies to manage ecosystems, especially in altered landscapes. In trying to address environmental complexity, ecology can benefit from greater dialogue with computing and information science.

New areas of research, including artificial life, evolutionary computation and complexity theory, offer the prospect of answering such questions. These new fields span many existing disciplines and are developing a body of theory and methods for dealing with a wide range of ecological problems. The notion of complexity had its origins in physics but now resides at the interface between biology and computing. This chapter presents a brief overview of the science of complexity, the ways in which it applies to the living world, and some of the new approaches that are emerging to deal with them in practice.

Environmental complexity arises from several sources (Green 1997). First there is the sheer number of organisms and environmental features. But more important are the interactions and combinations between all of these, which are truly vast in number and variety. Finally the interactions are usually non-linear.

Environmental complexity manifests itself in many ways. Some examples include the following.

- Non-linearity leads to two important properties. First there is sensitivity to initial conditions. Small, local variations can lead to major differences in global structure and behaviour.
- Instead of averaging out, as in linear systems, local irregularities or interactions in non-linear systems can expand to affect global properties and behaviour.
- Environments and ecosystems exhibit criticality. Many processes will not occur unless some control parameter reaches a critical value. Examples include the spread of fires, epidemics, and the spread of exotic plants. These processes depend, respectively, on the presence of critical levels of fuel, susceptible animals and vacant growing sites.
- Perhaps the most sobering property is that systems can be inherently unpredictable. That is, no matter how much information we collect, we will never be able to predict the future structure or behaviour of the system.

4.3 Connectivity

An important example of complexity, especially in landscapes, is the critical transition between connected and fragmented distributions. For instance if we remove small patches forest from a landscape then the forest as a whole retains its integrity.

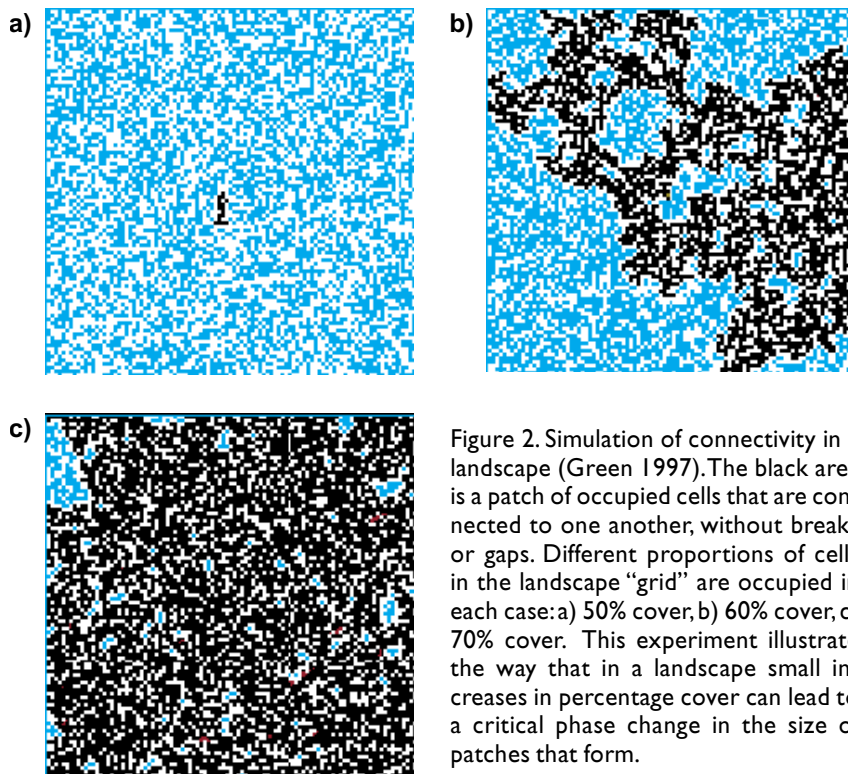


Figure 2. Simulation of connectivity in a landscape (Green 1997). The black area is a patch of occupied cells that are connected to one another, without breaks or gaps. Different proportions of cells in the landscape “grid” are occupied in each case: a) 50% cover, b) 60% cover, c) 70% cover. This experiment illustrates the way that in a landscape small increases in percentage cover can lead to a critical phase change in the size of patches that form.

However if clearing continues (at random), then instead of small patches breaking off the entire system remains connected until a critical point, whereupon it breaks down into many isolated fragments (Fig. 2).

4.4 Modelling and analysis

Although environmental complexity prevents prediction in many circumstances, we can still deal with issues by examining scenarios. For example although we cannot reliably predict the exact nature of global climate change, we can nevertheless examine the potential impact of particular scenarios. Here the advantage of good environmental data becomes

clear. For example Environment Australia's Species Mapper not only allows the user to plot maps of species records, but also to generate BIOCLIM and GARP models of their distributions. These models can be run against relevant climate change scenarios to predict the potential effects on plant and animal distributions. As another example, we can run a model of starfish outbreaks on top of a classified satellite image of a coral reef (Fig. 3).

Several systems are now available for modelling complexity in environmental systems. Perhaps the most notable is SWARM (Langton 1998) which provides tools for generating cellular automata and multi-agent models.

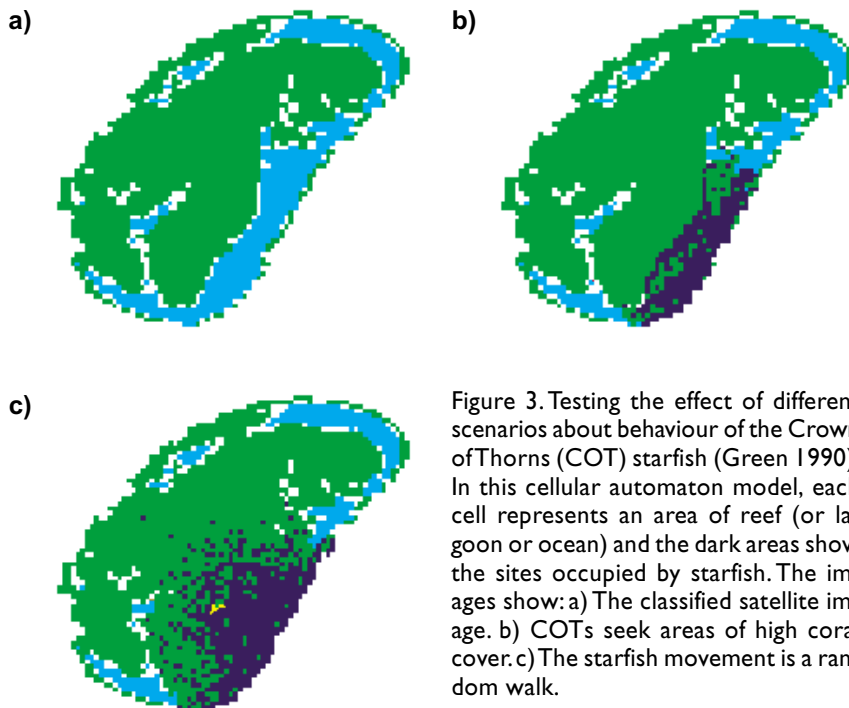


Figure 3. Testing the effect of different scenarios about behaviour of the Crown of Thorns (COT) starfish (Green 1990). In this cellular automaton model, each cell represents an area of reef (or lagoon or ocean) and the dark areas show the sites occupied by starfish. The images show: a) The classified satellite image. b) COTs seek areas of high coral cover. c) The starfish movement is a random walk.

Multi-agent models (Green 1997) teach us that on-line, intelligent agents offer many interesting prospects for handling information (Bossomaier & Green 1998). The most important is the potential for self-organization. Agent-based computing reflects links between computing and biology that are growing ever closer. The organization of an ant colony, for instance, arises out of many simple interactions of ants with each other and with their environment. Likewise software agents on the Web offer the potential to organize information on the Web. For instance an agent acting for an individual user might negotiate with agents at each site that user visits to identify other useful sites and items of information. This raises the potential for “like-minded” agents to form mutual communities, amongst other things.

5 Discussion

As outlined here the paradigm that seems to be emerging is one in which environmental planning, whether local or regional, relies heavily on the interpretation of up-to-date information. Gathering that information will be part of the normal working practice of every agency and every individual researcher. Publishing and indexing that information will be the role of a coordinated network of on-line information servers and Internet publishing sites.

In planning for the future it is important to have a clear image of where you want to get to. What might an environmental information ware-

house look like to a user (say) 50 years from now? My vision of the future of the Internet is what I call the “Knowledge Web”. That is the present emphasis on sites, home pages and proprietary concerns disappears. Instead the user simply looks for information about a topic and is guided to that information by an intelligent system that actually teaches you as you go. This view would also apply to the proposed environmental information warehouse. Suppose for example that a student wanted to know about conservation of plants and animals in the local area. Starting from some general heading (say plants) the system might guide the student through relevant topics (e.g. biodiversity, conservation, geographic information) at each stage providing background information and links to other information. A geographic query might involve selecting an area on a map and choosing what to be shown from a range of choice offered.

Suppose alternatively that a public servant wanted to see a report about (say) natural resources in southwest Tasmania. After selecting the exact area and topic she might use a report generator to select the kinds of items she wanted to include. The choices might cover a standard list of resources, time period, geographic area, type of material (e.g. policy papers, scientific studies, educational material) and types of items (e.g. maps, tables, graphs, text etc). The system would then build a preliminary report with the option of going back and exploring any aspect in more depth.

The above may seem like science fiction, but it is perfectly feasible. How would it work? Many details would rely on future research and not a few developments in intelligent information systems. However some of the background is clear from our earlier discussion. Everyone would contribute information. Field workers would submit raw data; publishing sites would index and massage and archive it. Information networks would merge it into seamless databases that are organised by topic, location and other relevant keys. They would also provide the query functions, models and other facilities that form the user interface. The interface itself might be built around sets of standard queries, with higher level functions (e.g. the report generator) built from flexible scripts that can adapt to a user's profile and interests.

It is clear that some kind of global environmental information system will need to emerge early in the new millennium. The challenge before us is to ensure that such a system is developed in a consistent, orderly fashion. Whatever its final design and organisation may be, this environmental information warehouse represents the working core of a new paradigm for environmental planning and management.

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Global forest information: a regional approach

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Abstract

In 1996, several international organizations met in Portland Oregon USA to address current and emerging problems related to monitoring the world's forests. Improving forest monitoring efforts has become increasingly important as national and international initiatives call for sustainable, diverse and productive forest ecosystems. The meeting (World Forest Monitoring Workshop) was attended by both users and providers of forestry information; and included representatives of national monitoring programs, inter-governmental agencies, non-governmental organizations, international research institutes and the forest products industry. The group's specific objective was to "develop a framework for cooperation between nations and other interested parties with the objective of improving forest monitoring on a worldwide basis."

The outcome of the workshop was an action plan to support both national monitoring and international efforts by establishing a global forest information network. Participants stressed that the network must be simple for users, decentralized, and adaptive to meet future forestry information needs. The network would be comprised of regional nodes, located at existing forestry institutions, that would facilitate the flow of forestry information within their region and, through internodal links, across regions. Information transmission would likely place a strong reliance on the Internet. The regional nodes would not generate or store data, nor would they be responsible for dictating information requirements; they would simply serve as information links. The resulting structure would provide a central location, per region, for accessing current forestry information.

Since the 1996 workshop, discussion on both international and regional levels have taken place. On the international level, discussions among IUFRO, EFI, CIFOR, FAO, WCMC, OFI and others have led to the idea of a consortium operating an information system on the Worldwide Web. Those discussions continue at an IUFRO 4.02 workshop held in conjunction with this conference.

On a North American level, a strategic planning process for the operation of the North American node has been developed. This process places heavy emphasis on conducting a forest information user's needs assessment, and includes an information provider's capacity assessment. The planning process will also identify information system technologies that support information exchange and retrieval. The resulting strategic plan will also assist in the identification of an appropriate forestry organization to house the North American information node.

Keywords: information, network

New ways for Forest Resource Surveys

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Abstract

The history of forest inventories goes back to the end of the Middle Ages when the heavy use of forest resources created a shortage of wood. Traditionally, field measurement based systems have been used. The information needs have increased rapidly during the last decades. On the other hand, new technology has given new sources of forest information and has made it possible to increase the cost efficiency of an inventory. This together with new methods have made it possible to change the forest resource inventories from a field measurement-based listing of articles into a multi-source monitoring of the whole forest ecosystem and so provide information about the structure of forests, their health and their biodiversity status for small and large areas. The results will provide the basis for planning a balanced utilisation of wood resources, the conservation of forests and the maintenance of forest ecosystems.

Keywords: Forest resources, Forest inventory, Satellite imagery, Digital map data

I Definition of forest inventories

The history of forest inventories goes back to the end of the Middle Ages when the heavy use of forest resources created a shortage of wood. This shortage forced people to bring some form of planning to the forests near to towns and mines. The first

information collected for the purposes of this early planning was an assessment of the forests area.

The term ‘inventory’ means the preparation of a detailed list of articles according to their properties. Similarly, forest inventory means tabulated, reliable and satisfactory tree information of forest and tree properties, used on a basis of an areal unit.

For foresters in the Nordic countries, the term inventory rings a special bell. It brings into our minds pictures of endless forests and of men roaming through them loaded with heavy equipment, persistently walking the line - from one side of the country to the other.

2 Development of forest inventories

Assessing the properties of an area of forest is an enormous task, given, for instance, that the total number of trees, with a height of at least 1.3 m, is, e.g., in Finland 65 billion. It is simply not possible to measure each tree, nor is it necessary. Measuring a part of tree population and deriving properties of tree populations from the subpopulation, i.e. sampling, is more rational.

Sampling, though, immediately raises a number of questions. For example:

- 1) What is the smallest part of the population that can be measured and still provide reliable information ?
- 2) How can the mean properties of the population in the sample be assessed ?
- 3) How can it be guaranteed that, on the average, the right parameter value is obtained and that no bias exists ?
- 4) How can the reliability of the parameters be assessed, i.e. what can be said of the real parameter value if the estimate is derived from a sample ?

Inventory methods have been developed in order to be able to answer these and similar questions and to present a clear picture of the state of forests and the amount of forest resources.

Statistically designed forest inventories were introduced simultaneously in the three Nordic countries, Norway, Sweden and Finland at the beginning of the 1920's. In these countries, and especially in Sweden and Finland, the utilisation of forests has been of vital importance to the national economy while for Finland forests and their use form the very hearth of its national identity.

3 Recent information needs for forest inventory

The principal purpose of forest inventories has been to provide accurate information for forest management planning and the planning of forest industry investments. Accordingly, optional cutting possibilities with future forest development scenarios have been computed on the basis of inventory results. These scenarios have formed the basis for forest policy and forest utilisation. This is especially true in industrialised countries.

Timber processing and marketing practices have changed dramatically in these countries during the last decade. Earlier, there was a long time interval between harvesting and the delivery of the timber, panel or paper products to the customer. Harvesting decisions were mainly for-

est production driven, derived from long-term yield regulations and management plans, modified by operational logging schedules. Large timber and end product stocks had to be maintained and prices fluctuated rapidly as the market changed.

Today, mechanised mobile harvesting machinery, high speed processing facilities, and short timber drying or pulping schedules have reduced to less than one week the time between the decision to harvest and delivery of a specific timber end-product. Harvest planning has now the potential to become “market driven”. On the other hand, forestry has increasingly to meet strict environmental demands and to achieve “sustainability” in its widest sense. Forest certification systems are today often seen as a solution to achieve and to show improved practices in forestry and forest industry. To achieve all these requirements, it is necessary to have up-to-dated geo-referenced forestry data systems with precise knowledge about log specifications and the forest ecosystem. If inventories based on field measurement techniques alone are employed, they will require a very high proportion of the trees to be measured, and this is simply too expensive to be a realistic option.

An increasing concern about the loss of biological diversity, caused, for example, by deforestation in some parts of the world, human induced environmental and climate changes as well as the extinction of species, has increased interest in the whole forest ecosystem. There is wide agreement that some compo-

nents and indicators of forest biodiversity can only be measured efficiently in the context of large area inventories. Examples of such components or indicators are the composition and structure of landscape, the existence of ‘ecological corridors’ between different habitat types, fragmentation of forests or land types, the areas and spatial distributions of important habitat types which support rich flora and fauna as well as the amount of rotting wood, in addition to the parameters already measured in forest inventories.

Forests have also been seen as having a role in reducing the effects of global warming by binding the increasing amount of carbon dioxide in the atmosphere. It has been estimated that the current forest area is only one half of the area that was forested 8000 years ago (under hypothetical similar climate conditions). With a proper use of wood resources and an increase of forests area have good a potential to decrease the amount of atmosphere CO₂.

In order to be able to satisfy the increasing and diverse demands for scientifically substantiated information, efficient methods are needed to measure forest resources, their status and the components of the whole forest ecosystem. The areal extent of forests is immense and the natural question is how to measure forests in a cost-effective way and how do that with sufficient frequency.

4 The role of Space Technology for Forest Inventory

The answer of the method I have developed is remote sensing and satellite images, combined with other information sources and applied in a new way. Remote sensing is the science of deriving information about the earth's land and water areas from images acquired from a distance, for example from space. Space technology originated after the Second World War and military applications accelerated its progress.

Remote sensing utilises photosynthesis, the process which maintains life on the earth. The chlorophyll in vegetation absorbs some components of light, mainly blue and red light, but also some green and infra-red, and reflects and emits some other components in a way which is specific to each plant species. Plant species and vegetation composition can in principle be separated by means of this information.

The first commercial satellite, suitable for forestry application, American Landsat 1 was launched in 1972. Landsat 5 with an improved imaging instrument followed in 1984 and the French-Swedish-Belgian Spot in 1986. These satellites are able to recognise objects on the ground with a diameter of 20 - 30 metres. The spatial resolution was high enough for the first Nordic forestry applications. New satellite sensors with a spatial resolution of 5 - 10 metres will be launched within few years.

In addition to remote sensing, the progresses which had earlier happened in mathematical-statistical methods as well as later in image processing and pattern recognition are necessary for my multi-source inventory technique.

5 Identifying the objectives of the method

Remote sensing research in forestry began in the 1970's and was accelerated after the mid of the 1980's. A real need to make inventories more cost-efficient existed. A common approach to utilise satellite images was to identify a few specific classes (for example, by means of dominant tree species or vegetation types) and to classify the forest area into those classes. The demands of forest management and forest industry require much more detailed information.

The number of variables measured in a forest inventory is usually very high, e.g. a few hundred. A classification based on different values of variables leads to an infinite number of classes and to an impossible solution, while the classification of variables separately, e.g. volumes, dominant tree species, site fertility class may lead to unnatural combinations of variables. The classification approach must therefore be rejected and a totally different approach adopted.

The research for introducing satellite images to the Finnish National Forest Inventory started in 1989 at the Finnish Forest Research Institute.

The first goal was to be able to estimate forest inventory information at the municipality level, instead of the earlier 10 to 100 times larger forestry administrative level. A method had to be chosen on the basis that it would be possible to estimate all forest inventory parameters, i.e. the state of forests, for the given units. The existing dependency structure of specific properties should also be preserved for further analysis.

6 Finding the method

The goal was to find a suitable method. It soon became apparent that in addition to satellite image information other digital information could noticeably improve the reliability of estimates. For example, the reflectance of grasses growing on regeneration areas is similar to that of arable land. A classification based solely on digital image analysis may therefore cause some errors in land use classification. The developed multi-source method permits a flexible use of digital base map data. Nonetheless, the method can be applied without the ancillary data, and the lack of such data can be to some extent compensated by using multi-temporal data. The Finnish multi-source system employs digital masks of arable land, built-up land, roads, single houses and swamps.

Land morphology also causes variation in the spectral values of satellite images which is not caused by variations in the structure of growing stock. Northern hill slopes often receive less light than southern aspects and therefore reflect less light.

This means that, with the same growing stock, northern slopes look darker causing errors in digital image analysis if this has not been taken into account. The multi-source inventory method enables the use of digital elevation models to correct for the degrading effect of land morphology in image analyses.

7 Solution: mimic the human eye and brain

The method therefore employs three different main data sources, field data, satellite images and digital map data. How can all this data be put together in such a way that all demands are fulfilled? The method is in principle not complicated. The key is to transfer the entire field data set from some field sample plots, that is to say known picture elements of a satellite image, to unknown picture elements. No classification of the data is required, as was the case in older approaches. The basis for the data transfer is the similarity between picture elements, the similarity measures being based on satellite image properties. The method therefore mimics the process of the human eye and brain when comparing objects.

It was also noticed that if several 'almost similar' picture elements were used instead of only the most similar one, the accuracy of small scale estimates could be improved. The effect of errors caused, for instance, by the light scattering in the atmosphere and the small size of the field sample plots is reduced in this

way. The method is therefore called the k -nearest neighbour (k -nn) method. I developed a computer algorithm which realised this idea and could take into account all data sets. The method also makes it possible to write an estimate of an arbitrary forest parameter in the form of a digital map.

The number of field sample plots in a forest area is usually high, and the consequent demand on computer time when analysing the forest area is huge. Initially, a CPU-time of one week was usual when analysing an area of about one million hectares. Today's computers are more powerful and the same work can be carried out within 24 hours.

The main advantages of the method are:

- compared to the inventory methods employing sampling and field measurements only, much more detailed information about forests can be obtained with very low additional costs
- the method is more statistically oriented than the earlier classification-based approach to use of satellite images
- in principle, all variables can be estimated for each computation unit, which is not possible with ordinary classification methods
- the method preserves the natural dependency structure between forest parameters
- the method can be applied with minor modifications to very different types of forests
- the method can directly be applied using different remote sensing material.

8 How the method can be improved

The prototype of the method was developed rather quickly. The method has been enhanced continuously and new features have been added when applied to foreign circumstances. I can still see some possibilities to further develop the system. Both technical and methodological improvements are possible.

Technical progress in satellite imaging will bring radiometrically and spatially improved sensors and imaging systems which are not sensitive to imaging conditions, such as the amount of light, atmosphere humidity or clouds. Active remote sensing is based on the idea of sending a signal and receiving its scattered reflection. Microwaves penetrate through clouds without changing and imaging is, in principle, possible under any condition. Research has shown, however, that the backscattering depends very much on the canopy and soil moisture conditions. Interferometry may provide a solution for applying the microwave technique.

Air-borne imaging spectrometers are at the moment under active research and have also been tested by my group. The smallest ground element is typically 1 m x 1 m and the number of spectral bands can be almost 300. This makes it possible to detect individual trees and small changes in the reflected light of vegetation and, for example, recognise early signs of stress in trees or ground vegetation. One advantage of the k -nn method is that it can directly be applied to these data as well.

The methodological development is related to improving the reliability of small area estimates. In developing the method, the first goal was to obtain results for the municipality level, i.e. for areas of approximately 10 000 hectares, but we noticed that the results were also applicable at forest holding level, i.e. at the level of 100 ha. Operative forest management planning needs information at the forest stand level, i.e. for areas of about one hectares. To achieve this goal, objects on images should be analysed instead of single picture elements. Methods from pattern recognition and stochastic processes can be applied. The computer must be taught to infer just like a human being does, to utilise the spectral, spatial and contextual information present in digital images.

The increasing demand for new and diverse information necessitates the further development of the method. The monitoring of ground vegetation and its changes may be possible only by means of remote sensing with indirect methods. The analysis of the landscape diversity of forests is a good solution for remote sensing data but presumes methodological development as well.

9 How the world's forests will be monitored in the future

Finally, I would like to leave you with a scenario as to how the world's forest resources will be monitored in the beginning of the coming millennium.

In addition to traditional information concerning timber supply, wood resources and cutting possibilities, information about the forest biomass including both trees and soil, carbon balance, deforestation and afforestation rates, the status of biological diversity, the naturalness of forests, nature conservation and the socio-economic functions of forests will be needed. A relevant time interval for global inventories might be 5 years. Annual information will be required for operative inventories.

Data acquisition for such a task is possible at reasonable cost only if the whole measurement process links digital measurement in the field to remote sensing from air and space. Sampling at different resolutions will be applied. The sampling intensity will vary depending on the the area in question. Large scale inventories will form the basis for small-scale inventories. The sampling designs and ancillary data sources can be decided on the basis of these data. Old inventory data together with mathematical forest development models and new field measurements, as well as air- and space-borne remote sensing data will be applied in computing the results. Results will consist of statistics with reliability assessments and digital maps describing forest resources and the forest ecosystem. Data will be delivered through computer networks to all interested persons, especially to decision makers and researchers, while additional data will be easy to append. The multi-source k-nn method can be seen as a kind of prototype of this type of method.

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Strategic forest simulation model – an application in Internet

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Abstract

Advanced forest planning includes an iterative communication between forest owner, consultant and forest planning software. This working paper presents a preliminary study, which objective is to develop an application of strategic forest simulation model to be used interactively and iteratively in Internet. The simulation model is used to predict the production frontier of a forest area. The auxiliary models are used to produce information about allowable cut in two management periods (in short and long time horizons) for the decision maker to help in adjusting her cutting objectives within a possible range. The simulation model calculates the production frontier of the forest holding for given sets of exogenous variables. The endogenous variables include the volume of standing timber after two management periods and the annual regeneration area during the management periods. The predicted values of the forest level variables produced by the model can be economically interpreted and they can be used as an input data in the strategic analysis. Iterative communication between a decision maker, consultant and a forest planning software is needed to accomplish the planning process. Information networks, for example Internet, provide an effective way to communicate with decision maker and planning software.

Keywords: forest management, internet, iterative planning, production possibilities, strategic planning

I Introduction

In strategic forest planning, the general strategy for the management of forest holding is defined. The goal is to maximize the forest owner's utility by allocating the resources according to the his/her goals. At the strategic planning stage, it is important to shed light on creating a broad conception of the decision base (Wheelen & Hunger 1995). The decision base includes the available alternatives, information about the consequences of the alternatives, and the preferences of the decision maker with respect to these alternatives (Bradshaw & Boose 1990).

In advanced forest planning, the planning process includes an iterative communication between the forest owner, the consultant and the forest planning software. A real iterative communication necessitates the direct feedback from the consultant, the forest owner and the forest planning software (e.g. Kangas 1996). Thus, the forest owner and the consultant has to be physically in the same room. This kind of planning session is one of the most expensive parts of the planning process. However, information networks, for example Internet, provide an alternative way to organize the planning process in that respect.

One characteristic of strategic forest planning is that it covers a long time period and all resources are assumed variable. The information needed in strategic planning, the production possibilities of a forest holding, can be achieved by defining the production functions of the forest.

They can be used to evaluate the relationship between input and output variables and also the rates of product transformation in order to produce different alternatives. The interdependency and development of forest level variables (e.g. cutting incomes, working possibilities, growing stock, biodiversity) are of interest. The means for achieving the forest-level goals, as defined in strategic planning, are worked out during tactical planning, which produces stand-level management prescriptions.

The complexity of the model needed and the variables included in it depend on the solved issue and the data available. Strategic forest planning needs information about the production possibilities of a forest area, and stand level or tree level data are not always available. This kind of situation may arise, for example, when the forest owner is considering an investment decision to purchase an additional piece of forest land. Then, the planning process has to be carried out using more aggregated forest level information, which is more often available.

In this working paper is presented a study, which objective is to develop an application of strategic forest simulation model to be used interactively in the Internet. The model includes the interaction of growing stock, cutting volumes, and regeneration area of a forest area. Following the economic interpretation of the predictions, these predictions can be used as an input data in strategic planning.

2 Strategic forest simulation model

The model used in this study is adopted from the study of Kajanus et al. (1998). It can be used to evaluate the relationship between input and output variables and also the rates of product transformation in order to produce different alternatives.

In the model, the known exogenous variables describe the initial state of the forest area. The exogenous objective variables include the cutting volumes during two management periods, namely the first five years and the next fifteen years. The endogenous variables describe the management outcomes during and after the two management periods (Table 1).

In the model, initial volume (V_0) and initial volume by tree species (V_{pine_0} , V_{spruce_0} , V_{birch_0}), initial log volume (V_{log_0}), shares of age classes ($\text{Age} < 20_0$, $\text{Age} 20\text{--}80_0$, $\text{Age} > 80_0$), increment (i), and area of the forest holding (Area) are exog-

enous variables, which are assumed to be known. Removals during the two management periods (R_{1-5} and R_{6-20}), representing the cutting incomes of the forest holding, were chosen as the exogenous objective variables. Based on this information, the model predicts the values of the endogenous variables: the annual regeneration areas during the two management periods (RA_{1-5}) and (RA_{6-20}), the volumes of standing timber at the end of respective time periods (V_5 , V_{20}), the volume of the birch ($V_{\text{birch}_{20}}$), and share of old forests ($\text{Age} > 80_{20}$) at the end of the planning period. The annual regeneration areas indicate employment possibilities (or necessities) offered by the forest holding, and the volumes of standing timber indicate, for example, the value of assets. The mean volume of birch and share of old forests are endogenous variables that can be used in assessing the development of biodiversity (Kajanus et al. 1998).

The simultaneous equation model computes the production frontier of the forest holding for a given set of

Table 1. The categories of exogenous and endogenous variables.

Exogenous variables	Exogenous objective variables	Endogenous objective variables
Initial Volume $t=0$	Removals $T=1-5$	Volume $t=5$
Log Volume $t=0$	Removals $T=6-20$	Volume $t=20$
Pine Volume $t=0$		Regeneration Area $T=1-5$
Spruce Volume $t=0$		Regeneration Area $T=6-20$
Birch Volume $t=0$		Birch Volume $t=20$
Age under 20-years $t=0$		Age over 80 years $t=20$
Age between 20-80-years $t=0$		
Age over 80 years $t=0$		
Increment		
Area		

exogenous variables. To predict the range of the exogenous objective variables (R_{1-5} and R_{6-20}), two auxiliary models can be used. These models predict the maximal removals during the first five-year period ($\text{Max}R_{1-5}$) and the maximal even flow of removals over the entire twenty year planning period ($\text{MaxEvenFlow}R_{1-20}$; Table 2).

The structure of the simultaneous equations is close to that of a recursive model, although they cannot be solved recursively. The models are solved by applying Cramer's rule (see e.g. Koutsoyiannis 1979). The auxiliary models are used to produce information about the allowable cut during two management periods to help the decision maker adjust her cutting objectives within a possible range. The simultaneous equations calculate the production frontier of the forest holding for given sets of exogenous variables. Moreover, the range of exogenous variables is restricted so that the values of endogenous variables are non-negative.

3 An application in Internet

The model is used by proceeding the following steps:

- Step 1. Open the Internet web site.
- Step 2. Press The Strategic Forest Simulation Model - button in the web page to run the model application.
- Step 3. Input the values of variables describing the initial state of the forest area.
- Step 4. The auxiliary models predict the maximal removals during the first five- year period ($\text{Max}R_{1-5}$) and the maximal even flow of removals over the entire twenty year planning period ($\text{MaxEvenFlow}R_{1-20}$). Using these predictions, the objectives can be adjusted within the suggested range of objective variables.
- Step 5. Input the values of the objective variables, i.e. the cutting volumes during two management periods (the first five years and the next fifteen years).

Table 2. The equations and variables used in the models are as follows (endogenous variables underlined>):

V_5	$= f_1(V_{\text{pine}_0}, V_{\text{spruce}_0}, V_{\text{birch}_0}, V_{\text{log}_0}, i, R_{1-5})$
V_{20}	$= f_2(V_5, V_{\text{birch}_{20}}, \text{Age}<20_0, i, R_{1-5}, R_{6-20}, R_{6-20}/V_0)$
RA_{1-5}	$= f_3(V_5, V_{\text{pine}_0}, V_{\text{spruce}_0}, V_{\text{birch}_0}, \text{Age}<20_0, \text{Age}>80_0, R_{1-5}/V_0)$
RA_{6-20}	$= f_4(V_5, RA_{1-5}, V_{20}, \text{Age}2080_0, \text{Age}>80_0, R_{6-20})$
$V_{\text{birch}_{20}}$	$= f_5(V_{20}, RA_{1-5}, V_{\text{birch}_0}, \text{Age}<20_0, \text{Age}>80_0, i, R_{1-5}, R_{6-20}/V_0)$
$\text{Age}>80_{20}$	$= f_6(V_{20}, RA_{6-20}, V_{\text{log}_0}, \text{Age}>80_0, i, R_{1-5}, R_{1-5}/V_0)$
Auxiliary models:	
$\text{Max}R_{1-5}$	$= f_7(V_0, V_{\text{log}_0}, \text{Age}2080_0, \text{Age}>80_0)$
$\text{MaxEvenFlow}R_{1-20}$	$= f_8(V_{\text{pine}_0}, V_{\text{spruce}_0}, V_{\text{birch}_0}, V_{\text{log}_0}, \text{Age}2080_0, i, \text{Area})$

Step 6. The model calculates the management outcomes during and after the two management periods.

As an example the model was applied to a forest holding of 112,2 ha in size and situated in eastern Finland. The case forest was characterised by its high standing volume (150 m³/ha) and relatively high share of old forests with plenty of cutting possibilities. About 50 % of sites represented medium fertility (*Myrtillus* site). Scots pine accounted for 38 % of standing volume, Norway spruce 55 % and broadleaves 7 %.

Known variables were as follows:

V_0	= 150,4 m ³ /ha
V_{pine_0}	= 56,6 m ³ /ha
V_{spruce_0}	= 82,6 m ³ /ha
V_{birch_0}	= 11,2 m ³ /ha
V_{log_0}	= 71,8 m ³ /ha
$\text{Age}<20_0$	= 28,7 %
$\text{Age}2080_0$	= 26,0 %
$\text{Age}>80_0$	= 45,3 %
increment-%	= 3,9 %
Area	= 112,2 ha

It is possible to present the results in numeric or graphical form to support the strategic planning and decision making process. To illustrate the results of the model, production frontiers were produced for the case holding (Fig. 1).

4 Discussion

In current advanced forest planning, the planning process includes an iterative communication between forest owner, consultant and a forest planning software. This kind of planning session is one of the most expensive parts of the planning process. In this working paper was presented a study, which objective was to develop a new application for strategic forest simulation to be used interactively in the Internet.

A simultaneous equation model (Kajanus et al. 1998), which included the interaction of the growing stock, cutting volumes, regeneration area, and variables indicating change in

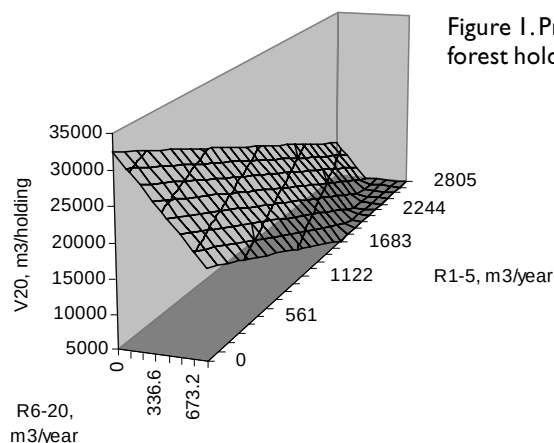


Figure 1. Production frontier of the case forest holding.

the level of biodiversity of the forest area, was used in this study. The model is used for predicting the production frontier of a forest holding. The main purpose of the model is to illustrate the production possibilities of a forest area. The model is suitable for planning situations where aggregate information on cutting levels or incomes, employment possibilities and growing stock are of interest. When the planning situation involves more detailed tactical issues, e.g. stand-level management prescriptions, more detailed models and accurate information should be used (Pesonen 1996, Kilkki & Siitonen 1976).

The main advantages of the model are its small requirements for input data and also its simplicity. The model, using remote sensing data, for instance, could be useful just prior to the preparation of a 10-year tactical forest plan to help in defining the forest-level goals. This could possibly even reduce planning costs by preventing unnecessary measurements in connection with forest inventory and by clarifying the objectives of the forest owner. As a result, the production possibilities of the forest holding and the objectives of the forest owner become clearer, and the first version of the tactical plan is close to the forest owner's objectives.

The model could be applied to a non-industrial private forest holding. The approach is also applicable to other forest planning situations. The model could be used in a situation, where the forest owner is considering the decision to buy an additional forest area and is interested in know-

ing the production possibilities of linking the new piece of forest to her existing forest holding. This kind of a model could also be used in forests owned by forest-industry companies and in regional forest planning. The model enables the linking of the forest production functions to joint production-frontier models, when considering the resource allocation of the whole enterprise. In all cases, the model can be used when strategic issues are of interest, e.g. when defining the overall strategy of managing a forest area (e.g. forest-level goals).

Internet provides an alternative way to organize the planning process

Internet could provide several benefits to forest planning. The planning process could be carried out more effectively by using information networks. For example, traveling costs could be minimized. The planning process could be carried out more quickly. The forest plans could be updated more easily by using information networks. The availability of advanced forest plans could be better, if the service could be get via Internet. Internet could be a good way to advertise forest plans. Internet could also bring more competition to forest planning. Moreover, in the future the electronic markets are expected to be a growing business. However, in using Internet in forest planning, drawback can be the facilities and the willingness among decision makers to use the Internet at the moment. This situation is changing better all the time.

Internet could provide other benefits for forest planning as well. For example, the interaction to electronic timber market systems could be useful. Electronic markets have several advantages compared to more traditional ways of doing business. People become more equal with respect to their place of residence, through the electronic systems it is easy for any user to contact the market place. For the buyer it is easier to search for the most suitable item from a database instead of contacting each seller individually. This will also increase the likelihood of finding a suitable quality of raw material for further processing. The importance of a two-way information flow has also been stressed in the context of electronic markets. This is achieved e.g. through discussion groups and electronic mail. In the timber markets, it is assumed that procurement costs could be reduced by an electronic market place. This reduction could be achieved by describing the stand accurately enough, so that the buyer is able to make an offer without seeing the stand. E.g. Puutori could (Määttä & Pesonen 1998) reduce the need for prospective buyers to visit stands and thus lower the costs. Part of the gain could be transferred to sellers in increased timber prices. An important feature in the timber markets is also that such an electronic system would better meet the requirements of EU competition policies. Electronic information system can induce more competition by increasing the number of offers per stand. The new offers could come

from small companies, who could get easier update information on stands for sale.

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Research and management issues in large-scale fire modeling

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Abstract

In 1996, a team of North American fire scientists and resource managers convened to assess the effects of fire disturbance on ecosystems and to develop scientific recommendations for future fire research and management activities. These recommendations – elicited with the Analytic Hierarchy Process – include numerically ranked scientific and managerial questions and responses. Currently, understanding fire effects and extrapolating fire-effects knowledge to large spatial scales is limited, because most data have been collected at small spatial scales for site-specific applications. Although we need more large-scale fire-effects data, it is more efficient to concentrate efforts on improving and linking existing models that simulate fire effects in a georeferenced format while integrating empirical data as they become available. A major component of this effort should be improved communication between modelers and managers to develop modeling tools that can be used in a planning context. The priority issues and approaches elicited in this workshop setting provide a template for current and future fire science and fire management programs.

I Introduction

Fire is the most important periodic natural disturbance in most forest, shrubland, and grassland ecosystems of western North America. Although large fires are infrequent temporally, they are responsible for rapid changes

in vegetation, soils, biogeochemical cycling, microclimate, and many other ecological properties. There is a substantial scientific literature on the effects of fire in terrestrial ecosystems, but the vast majority of scientific data has been collected at scales of 10–1 to 10 km² (McKenzie

et al. 1996). Our ability to understand and manage for the effects of large fires has been limited by a lack of data at large spatial scales. Applying these data to fire phenomena at much larger scales can result in substantial errors in estimating fire effects, because relevant processes are different at different spatial scales (Simard 1991, Table 1).

Simulation modeling is a convenient and practical alternative to the expensive and time-consuming collection of large amounts of data at large spatial scales. Nevertheless, extrapolating ecological effects of fire across spatial scales using models can result in many sources of error, including: (1) extrapolating fire behavior models directly to larger spatial scales, (2) integrating fire behavior and fire-effects models with successional models at the stand level, then extrapolating upward, and (3) aggregating model inputs to the scale of interest. Regardless of which approach is used, extreme fire events (i.e., large-scale fires) pose a major problem for modelers due to the problem of propagating and com-

pounding errors across spatial scales (Rastetter et al. 1992).

Given the complexity of large-fire phenomena, how do we improve our current scientific assessment and management of natural resources with respect to fire disturbance and to the wide range of fire regimes in complex ecosystems? We cannot afford to wait for decades for the data and techniques that would improve our understanding and managerial approaches. We need to establish priorities now in order to optimize research programs, develop resource management strategies, and encourage cooperation between scientists and managers in the years ahead.

2 Articulating fire issues: a knowledge elicitation approach

In 1996, a group of scientists and resource managers gathered at the Fire-Disturbance Workshop in

Table 1. General classification of scales and examples of relevant fire characteristics, processes, and influences for each scale. Adapted from Simard (1991).

Scale classification	Fire characteristics, processes, and influences
Micro	Energy flux, pyrolysis, personal attitude
Mechanical	Temperature, radiation, ignition, individual behavior
Sensory	Weather observation, fire behavior, suppression, human activity
Meso	Thunderstorm, fire danger, dispatch, supervision
Synoptic	Cold front, fire severity, mobilization, production
Strategic	Drought, fire season, fire planning, organizational budget
Macro	Climate, fire ecology, fire policy, government
Global	Climatic change, fire history, treaty

Seattle, Washington (USA) to articulate the modelling issues presented above. The objectives of the workshop were to: (1) identify the current state-of-knowledge with respect to fire effects at large spatial scales, (2) develop priorities for a scientific approach to modeling large-scale fire disturbance and its effects, and (3) develop priorities for assisting scientifically-based decisionmaking

with respect to fire disturbance in resource management. A structured workshop process was used to conduct workshop discussions, compile information, and to elicit knowledge from participants.

A strawman document was developed to provide a template and generate discussion by suggesting key questions and responses for the four workgroup topics (Table 2). Partici-

Table 2. Summary of proposed key questions in the strawman document.

Linkages among fire effects, fuels and climate

- What are the critical scientific issues regarding the impacts of fire on vegetation and fuels?
- What are the critical management issues regarding the impacts of fire on vegetation and fuels?
- What are the critical political issues regarding the impacts of fire on vegetation and fuels?
- How can the relative impact of fuels and weather on fire regimes be quantified?

Fire as a large-scale disturbance

- What are the most important aspects of long-term changes in fire characteristics on vegetation?
- What is the current state-of-knowledge for the interaction of fire, vegetation, and climate?
- What aspects of fire as a landscape/ecosystem disturbance are relevant to large-scale modeling?

Fire effects modeling structures

- What existing models could be adapted or modified for proposed future research?
- What are the relevant scale issues related to modeling fire impacts on vegetation and fuels?
- What are some potential approaches for GIS-based modeling of fire impacts on vegetation?
- How does one integrate climatic change scenarios in fire-vegetation models?

Managerial concerns, applications and decision support

- How can a rigorous modeling approach be designed to be most useful to resource managers?
 - What are the most useful model structures for resource managers and decisionmakers?
 - How can decision support systems assist resource managers with fire effects issues?
-

pants had the option of using these questions and responses, modifying them, or developing their own. Workgroup objectives dealt with the overall accomplishments proposed for the workshop, namely describing, assessing, prioritizing, and recommending fire-disturbance research and managerial needs. A tactical plan for achieving the strategic objectives was also developed (Schmoldt and Peterson 1997, Schmoldt et al. 1998).

The decision-making and group discussion protocols included: (1) assignment of attendees into workgroups which were the foci for workshop discussions, (2) a conceptual structure for organizing workgroup discussion, and (3) a seven-step process for workgroup conduct that streamlined identifying, assessing, prioritizing, and recommending research and managerial needs.

Each workgroup developed key questions for their assigned topic. They were asked to provide corresponding responses for each key question. Workgroups also prioritized their list of key questions and, separately, their lists of responses within each question. Priorities were assigned for importance and for feasibility. The Analytic Hierarchy Process (Saaty 1980, 1990) was used within each workgroup to calculate priorities (Fig. 1). Following the workshop, statistical analyses (q.v., Schmoldt et al. 1998) were performed to determine which key questions – and which responses within each key question – differed significantly in priority.

3 Workshop output

3.1 Linkages among fire effects, fuels, and climate

The workgroup responsible for this issue developed five key questions which are presented below in order of importance. For each question, the group generated some general statements about the question's subject matter to establish a context for response discussions. The group then produced a set of responses to each question that define current research and management needs. The workgroup limited its discussion to just fuels and climate because it believed they are the most important factors.

Key questions

1. What, where, and when are the factors important to fire disturbance?
2. What do we know about linkages among fire effects, fuels, and climate?
3. At what scales are processes important?
4. How are linkages related in a landscape context?
5. What linkages are important to management?

The workgroup offered several general assessments of linkages. First, besides the importance of the fire-disturbance factors listed, it is their interactions that are truly significant. Second, extreme fire events are driven by climate, and through better understanding and predictability

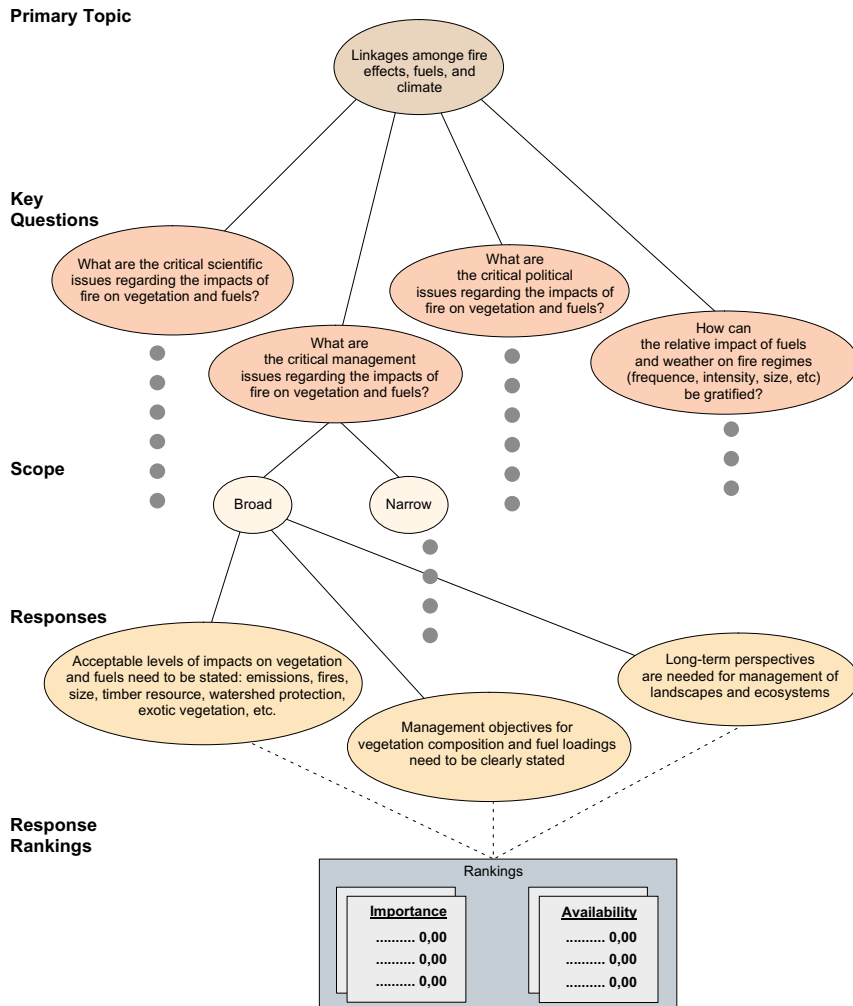


Figure 1. A graphical depiction of the hierarchical structure of the straw document illustrates a portion of one primary topic, including key questions, scope, and example responses for that key question. By ranking responses with respect to importance and feasibility/practicality, we have identified important issues and their feasibility/practicality, which then enabled us to make recommendations for (or prioritize) future research projects. Each of the other key questions were completed in a similar fashion.

of their precipitating conditions, researchers can greatly assist managers. Third, the probability of large-scale disturbances, combined with cost (= risk), needs to be computed more reliably. With respect to future needs, the workgroup noted that as fire suppression activities are reduced, smoke management will become a central fire-management issue.

3.2 Fire as a large-scale disturbance

The vast majority of fires, while important in the maintenance of ecosystem structure and function and the spatial heterogeneity of landscapes, may nevertheless be insignificant from the standpoint of broad-scale fire severity. It may not be necessary to model the behavior and effects of frequent, low-severity fire to the extent done for severe fire in a broad-scale fire severity model. For example, impacts on ecosystems or the atmosphere produced by low-severity fires (i.e., the majority of events) could be represented implicitly by model parameterizations that produce constant (or episodic) but relatively low levels of mortality, nutrient loss, or emissions in broad-scale simulations.

The key questions proposed by this workgroup are summarized below in decreasing order of importance. Due to the broad scope of these four key questions, the workgroup felt that more specific questions would better enable meaningful discussions. Therefore, the workgroup identified 17 focused questions (q.v., Schmoldt et al. 1998) across the four

key questions. Responses were developed for the two or three most important focused questions under each key question.

Key questions

- What are the critical aspects of spatial and temporal dynamics of fire at large scales?
- What ecological role does fire play at larger scales?
- How can fire be managed at large scales?
- What are the critical characteristics of the fire-behavior environment?

3.3 Fire-effects modeling structures

Landscape-level changes resulting from fire are difficult to model due to climate and vegetation heterogeneity, lack of empirical data at large scales, and limited spatiotemporal scope of existing models. Nevertheless, because ecosystem composition and function change where disturbance regimes change, there is a critical need to model large-scale disturbances. Accurate simulation models will be needed to predict the outcomes of complex interactions among disturbances (particularly fire), climatic changes, and large-scale vegetation patterns. A principal difficulty in building large-scale fire-effects models is the extrapolation, or aggregation problem. In the past decade, models have been developed to predict fire ignitions, fire behavior, fire-effects, and vegetation change in response to fire (Schmoldt et al. 1998). Many of these models

partially address the aggregation problem, but each type of model has identifiable sources of error when applied at broad spatial scales.

Scale issues and the aggregation problem framed the discussion and recommendations of this workgroup. Several of the key questions directly addressed scaling and aggregation error, while other more technical questions were motivated by previous difficulties in addressing these issues within models.

Key questions

- How does one validate a model's structure with respect to error propagation?
- What are the relevant spatial and temporal scale issues (including extent and resolution) related to modeling fire effects?
- What are the desired outputs of an "ideal" fire-effects model?
- How does one calibrate a fire-effects model?
- How does scale affect the modeling approach?
- What are the components of an "ideal" fire-effects model?
- What data exist for calibration, validation, and development of fire-effects models?
- What is the appropriate system structure (for example, an integrated system of separate models or a unified model)?
- How does one integrate climate into fire-effects modeling?
- What tools exist to generate data for the development of fire-effects models?

We need to use the modeling process carefully to identify gaps in data, knowledge, and theory. By quanti-

fying the calibration necessary to match observed data, we can estimate the importance of missing spatial information or the magnitude of error associated with aggregation. Spatiotemporal variability, resolution, and extent were listed both as the most important scale issues and as the most feasible to solve. We need to be conscious of intrinsic limits of the accuracy and precision of our knowledge, and therefore, the predictive ability of our models. Judicious use of state-of-the-art aggregation techniques will be a key factor in optimizing models.

3.4 Managerial concerns, applications, and decision support

Good management rests on a foundation of solid science. There are two challenges that must be met to properly integrate management and science. First, research and management must collaborate through research-management partnerships. The key to this relationship-building challenge is communication. Second, biological, physical, and social science knowledge must be integrated as fire-disturbance models are developed. Fire-disturbance models are the nexus of fire management and research, and need to integrate all the sciences to provide an adequate foundation for successful management of fire on the landscape.

After some initial discussion covering a broad range of topics, the workgroup settled on a short list of key questions. These five management and application questions are

Table 3. Management concerns, applications, and decision-support key questions and their responses are rated according to importance and practicality as calculated with the AHP.

Importance	Key Questions and Responses	Practicality
0.43	1. What are the most useful model structures and outputs, to support issues in planning, operations, monitoring and learning by resource managers decisionmakers, policy makers and researchers?	0.15
0.53	Model to allow users to select fire regimes and show their probabilistic effects on the landscape	0.14
0.19	Data structures must be compatible with user capabilities	0.32
0.18	Develop hierarchical and selective modeling framework for fire regimes and fire effects	0.23
0.10	Communicate model limitations to users, and user needs to model builders	0.31
0.28	2. How do we improve communication between users and model builders relative to the development life cycle?	0.44
0.67	Pro-actively seek opportunities to communicate	0.85
0.33	Build long-term relationships	0.15
0.15	3. How can we transfer research information rapidly and effectively?	0.17
0.39	Improve documentation (user manuals, tutorials, on-line help, etc.) and model support (technical support, programming, scientific documentation, software distribution and support via Internet, etc.), apply product life cycles	0.13
0.27	Standardize and provide desired user interfaces	0.31
0.13	Explore alternate means for accomplishing data management (contracting, etc.) and technology transfer	0.33
0.13	Establish and support a development group	0.14
0.09	Apply free market principles (product development, support and distribution)	0.10
0.07	4. How can we incorporate social and political issues into models/ decision support systems?	0.06
0.66	Incorporate sociological research when developing decision support systems	0.53
0.34	Modelers and managers must be aware of emerging issues and anticipate future concerns	0.47
0.06	5. How can relevant interdisciplinary resource management issues be incorporated into models?	0.18
0.61	Improve communication between modelers and users	0.40
0.29	Involve a cross section of managers and policy makers in model development	0.38
0.10	Assign responsibility, develop measurement criteria, monitor accomplishment and provide accountability for both research and management	0.22

listed in Table 3, in order of importance. For each of the key questions, lists of responses are also enumerated in order of importance. This type of table was calculated for each of the workgroups, but only this workgroup's table is shown here because of limited space.

In general, the needs addressed by this workgroup include building "better" models (more accurate, more inclusive, more useful), integrating models into decision-support tools, improving communication, and strengthening relationships between management and research. Models

need to have increased flexibility to cover a broad range of vegetation, fuels, climate, and topography. They also need to include more aspects of fire behavior, such as lightning strikes, crown-fire ignition, and crown-fire spread. In order to assist with decision support, modelers and users must communicate effectively in order to develop joint models that address current management issues, such as social and political needs and biodiversity concerns.

4 Conclusions and applications

The structured workshop process proved to be an effective way to develop issues, information, and approaches for addressing fire-disturbance effects on ecosystems. Application of this process and use of the strawman document (Table 2) varied among workgroups, but the availability of a prescribed process and conceptual template greatly facilitated timely discussion of topics and quantification of priorities. We observed that resource managers in the workshop appeared to adapt to the structured approach more readily than the scientists, a phenomenon we have observed in other workshops and settings as well (e.g., Peterson et al. 1994).

All of the recent "paradigms" that are currently part of the managerial lexicon of public agencies—ecosystem management, watershed analysis, landscape design, etc.—must be addressed within large spatial and temporal scales. The effects of fire

disturbance on ecosystems are increasingly integrated into resource management plans as a "natural" process, or at least a strong consideration in fire management. The information compiled at the Fire-Disturbance Workshop offers a template for prioritizing future fire-effects research and for facilitating communication between scientists and research managers in the coming decade.

Acknowledgments

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Classification of forest soils using dielectric and gamma-ray moisture detection

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Abstract

The present paper demonstrates that till soils in Lapland vary in hydraulic properties. Hydraulic site requirements are different between Scots pine (*Pinus silvestris* L.) and Norway spruce (*Picea abies* Karst) and tree species distribution follows the mosaic pattern tills. It was found that Scots pine tend to be adapted on dry tills, while Norway spruce has a larger tolerance for soil water content. The *in situ* dielectric determination of soil moisture, coupled with terrestrial gamma radiation measurements, are reliable ground truth reference for the classification and interpretation of airborne radiometric data. The airborne gamma-ray data will provide necessary information to soil moisture and thus help in tree species selection when artificial regeneration is applied.

I Introduction

Forestry is practised over extensive, isolated areas under harsh climatic conditions in Finnish Lapland. Forest management intensified since the early 1950's when fellings increased greatly. Owing to the higher produc-

tivity and timber value of Scots pine compared with other species, the clear cutting, site preparation and artificial regeneration of pine have been the predominant forest regen-

eration activities during the last 40 years.

Serious cases of seedling dieback have occurred occasionally, the worst failures occurring in pine regeneration areas on fine-textured soils with a thick humus layer that have formerly been covered with spruce-dominated stands (Lähde 1974, Pohtila and Pohjola 1985). Even though some damage, such as frost heaving and fungus diseases, specially snow blight (*Phacidium infestans* Karst.) and Scleroderris canker (*Ascochyta abietina* Lagerb.), could be observed in the field, the primary physiological reasons for the pine seedling dieback are still unclear.

The main problem has been the lack of techniques for classifying and mapping soils on the basis of their physical properties and for identifying the sites suitable for different tree species. Particle size distribution is the major factor determining the field capacity of soils (Hillel 1971, Viro 1962, Sepponen 1981), and the quantity and quality of the soil matrix govern the moisture content and hydraulic properties of soil materials. However, the conventional sedimentation techniques (hydrometer and pipette) used in standard particle size analysis have poor reproducibility and are too slow for practical soil classification and mapping. Furthermore, the conventional gravimetric techniques for measuring forest soil moisture cannot be used for areal mapping procedures. Therefore, rapid *in situ* techniques and remote sensing of the soil moisture content would be an enormous asset in forest regeneration work.

2 Materials and methods

Tills cover 75 % of the land area in Central Finnish Lapland. Due to the weak glacial erosion and deposition and presence of incorporated preglacial weathering products, tills are highly variable in hydraulic properties. A relatively thin layer of till (1–4 m) covers the bedrock in the study area. Limited proportion of stratified sandy and gravelly materials are found in the river valleys only. We studied hydraulic properties and tree species composition at 12 sites about 150–280 km north of the Arctic Circle. These sites, one hectare each, were surveyed in 1995 with terrestrial dielectric and gamma radiation measurement with 10-meter line separation and five-meter station separation. Since water content varies temporally, dielectric values of till soils monitored once a week from 1995 through 1997. In six sites gamma radiation was also monitored in order to acquire ground-truth reference for the airborne gamma radiation data such that half of the stations located on fine-grained tills and the other half on coarse-textured sandy tills. Registration period was from the end of April to the begin of September at least once a week. Scots pine was a predominant tree species at five sites, rest of the sites were occupied by stands formed of Norway spruce or mixed Norway spruce and pubescent birch.

2.1 Dielectric properties

Dielectric properties (ϵ_r) of soils are predominantly dependent on the soil volumetric water content (Topp et al., 1980; Sutinen, 1992, Fig.1.). The dielectric properties of forest till soils *in situ* at each study site determined in grids using time domain reflectometry (TDR, Trase System 1, Soilmoisture Corp., Santa Barbara CA, USA). TDR provides information of the electromagnetic wave velocity and dielectric properties about the material along a parallel transmission line. For the grid measurements two parallel 15-cm-long steel probes with 5-cm-spacing inserted vertically into the soil. For the monitoring purposes probes installed horizontally into the soil layers and ϵ_r determined with TDR (1502B metallic cable tester, Tektronix, Beaverton OR, USA) on a weekly basis.

2.2 Gamma ray

spectrometry

All minerals and consequently till soils are radioactive to some extent. The attenuation of gamma radiation is dependent on the quantity and quality of the absorbant medium and the energy content of the gamma radiation. Natural gamma radiation is effectively attenuated by water, and variations in soil moisture can be detected by terrestrial gamma-ray spectrometry (Zotimov 1971). For example, 50 % attenuation of the radiation in the potassium energy window occurs in about 100 m of air, 10 cm of water and 5 cm of rock.

The low-altitude airborne geophysical surveys carried out by the Geological Survey of Finland consist of the recording of the total magnetic field, in-phase and out-of-phase components of the electromagnetic field, as well as gamma radiation.

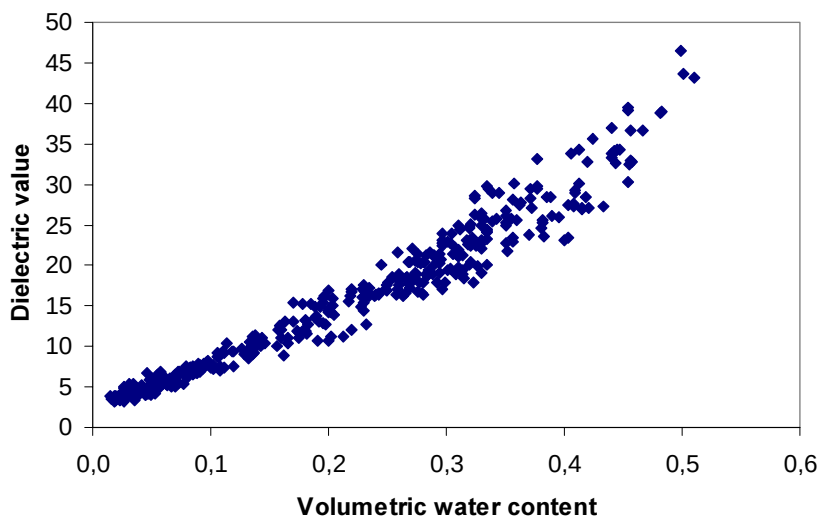


Figure. 1. A plot showing correlation ($r_s = 0.98$, $P < 0.01$, $n = 425$) between the soil dielectric values and volumetric water contents according to Sutinen (1992). An empirical relationship $\epsilon_r = 3.2 + 35.4 * \theta_v + 101.7 * \theta_v^2 - 63 * \theta_v^3$ is obtained.

These airborne surveys have been conducted since 1972. The flight altitude varies from 30 to 50 m with a flight line separation of approximately 200 m. The data recording speed, 1–4 times per second, and a flight speed of 50 m/s permits a data-recording spacing of 10–50 m. The airborne gamma ray data are recorded by a gamma spectrometer equipped with six NaJ(Tl) sensors with a volume of 25 l. The gamma spectrum of 0.3–3.0 MeV consists of 120 channels with 24 keV. The measuring range is divided into four windows: total, potassium, uranium, thorium (Table 1). This is the most common distribution because the 42 % of gamma radiation of the rocks is derived from K^{40} isotope, 32 % from Th^{232} and 25 % from U^{238} isotopes (Grasty 1977).

The terrestrial gamma radiation data were obtained using a 256-channel gamma spectrometer (GS-256, Geofyzika Brno). The volume of the NaJ(Tl) sensor of the instrument is 0.35 l and a four window division, analogous to the airborne data was used (Table 1). The detector diameter is 3.5 cm, thus allowing point-wise radiation detection.

Table 1. Energy contents of the airborne and terrestrial gamma-ray spectrometers.

Window	Airborne (MeV)	Terrestrial (MeV)
Total count	0.30–3.0	0.83–3.0
Potassium	1.36–1.56	1.36–1.53
Uranium	1.66–1.86	1.65–1.86
Thorium	2.41–2.81	2.48–2.74

2.3 Hydraulic conductivity

The vadose zone hydraulic conductivity (K) was determined using a constant head infiltration along with automatic dielectric measurements with TDR (CS-615 probes with CR10 dataloggers by Campbell Scientific Inc., Logan, UT, USA). K -values calculated by Darcy's law by deriving the pressure potential gradient from the water pressure and the soil suction. Darcy's law originally conceived for saturated flow only was extended by Richards (1931) to unsaturated flow. The unsaturated conductivity is a function of the matric suction head, $K=K(\psi)$, and Darcy's flux, $q=Q/A=-K(\psi)\Delta H$, where ΔH is the hydraulic head gradient, which may include both the suction and the gravitational components.

3 Results

3.1 Spatial variability

Dielectric and gamma data from the twelve sites show the water status to be significantly different between the sites (Fig. 2). Low mean dielectric values $\epsilon < 13$ and high mean gamma values $\gamma > 1$ (potassium window) were observed at the sites naturally occupied by Scots pine stands. In contrast, high mean dielectric values $13 < \epsilon < 30$ and low mean gamma values $\gamma < 1$ were typical to sites occupied naturally by Norway spruce stands. The spatial variability of the sites, according to semivariogram models, ranges from 20 to 150 m (Hänninen 1997).

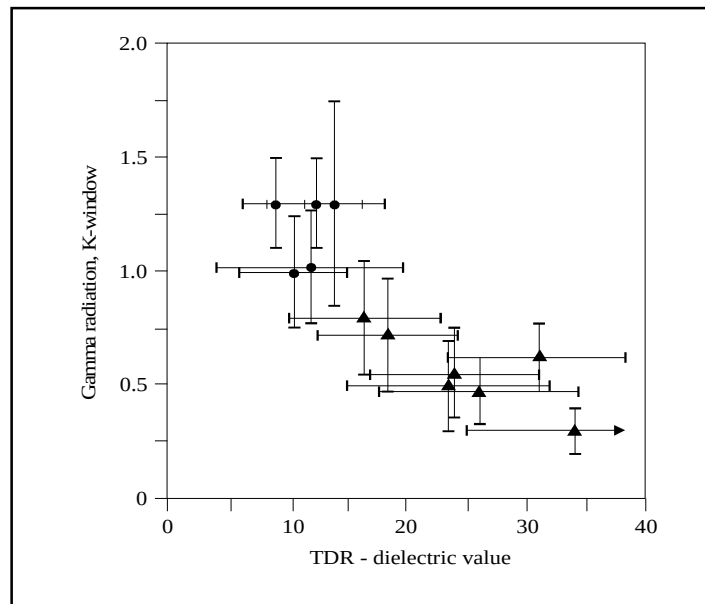


Figure 2. A plot of the terrestrial gamma radiation vs. TDR dielectric data of forest till soils in Central Lapland. For each site 220 TDR measurements and 110 gamma spectrometer measurements were made. Dots indicate sites occupied by Scots pine stands, triangles sites occupied by Norway spruce stands.

The dielectric data indicate hydraulic conditions at the soil surface such that dielectric information is from the top 15 cm. Also, most of the gamma radiation is resulted from till soil and radiation intensity is depending on the concentration of radioactive emitters in the soil, texture and soil water content. Natural gamma radiation is effectively attenuated by water. Previous experiments (Zotimov 1971) have indicated that the water content in soil to a depth of 50 cm can be determined by measuring the gamma field of the earth. It is suggested that increase in a 10 % soil moisture causes a reduction of 3–5 % in ^{40}K counts. The radon effect is most insignificant in ^{40}K channel.

The terrestrial gamma radiation data are related to the dielectric properties of the soils on the studied sites. The plot (Fig. 2) clearly indicates that soils with a high dielectric values and consequently a high water content have low gamma values due to strong attenuation. Consistently, soils with a low dielectric values and low water content have larger gamma radiation values. The till soils with high water content in Central Lapland are typically derived from fine-grained schistous rocks of the Central Laplands Greenstone Belt. The matrix of these tills contain silt and clay size particles enough to effectly resists water percolation through the soil sequences. Precipitation water presumably pass directly into the

streams and rivers via surface run-off. The tills on the sites occupied by stands formed by Scots pine are coarse-textured and sandy in matrix. These tills are dominantly derived from coarse-textured granitoids.

3.2 Temporal variation

Our monitoring results showed that 40K counts were more than 1 %K on sites dominantly occupied by Scots pine (Fig. 3) where as the counts were less than 1 %K on sites occupied by Norway spruce (Fig. 4). In similar way, dielectric values were low on the pine sites, such that mean dielectric was $\epsilon < 13$ through the growing seasons (from June through September) 1995 and 1996. In contrast, the sites occupied by Norway spruce were high in soil water con-

tent during the growing seasons. The most pronounced feature was several weeks long saturation following snowmelt. The greatest variations in gamma radiation intensity were observed in fine-grained tills in the early summer due to frost and snow melting. Gradual soil warming and drying results in increasing levels of the gamma radiation. The maximum values simultaneously with maximum soil temperature reached in mid-August. The difference between the minimum and maximum values of ^{40}K counts was at least double of the minimum value at every station. Heavy rainfalls caused reduction of 10–20 % in ^{40}K counts. The second critical period in the gamma radiation is in autumn when soil cools, evaporation reduces and probability of rainfall increases.

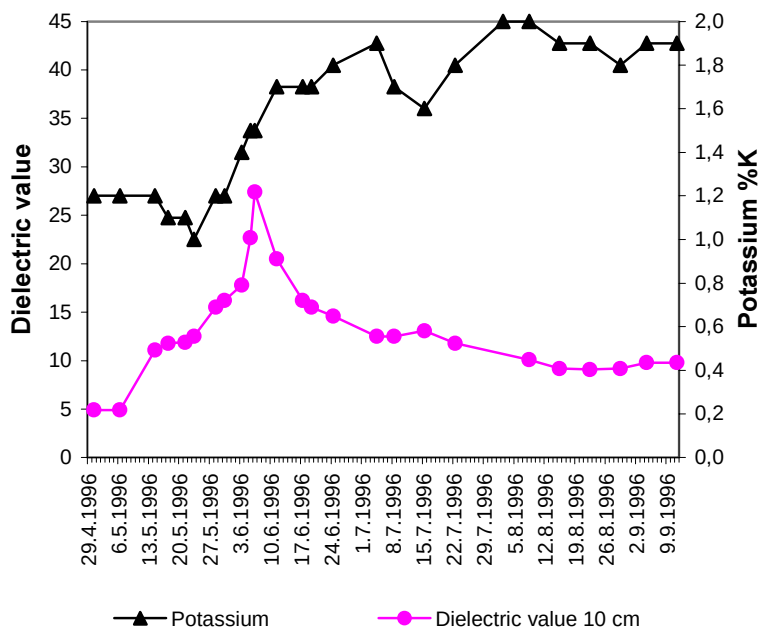


Figure 3. An example of temporal variation of gamma radiation (potassium window) and dielectric values at the till site established naturally by Scots pine stands.

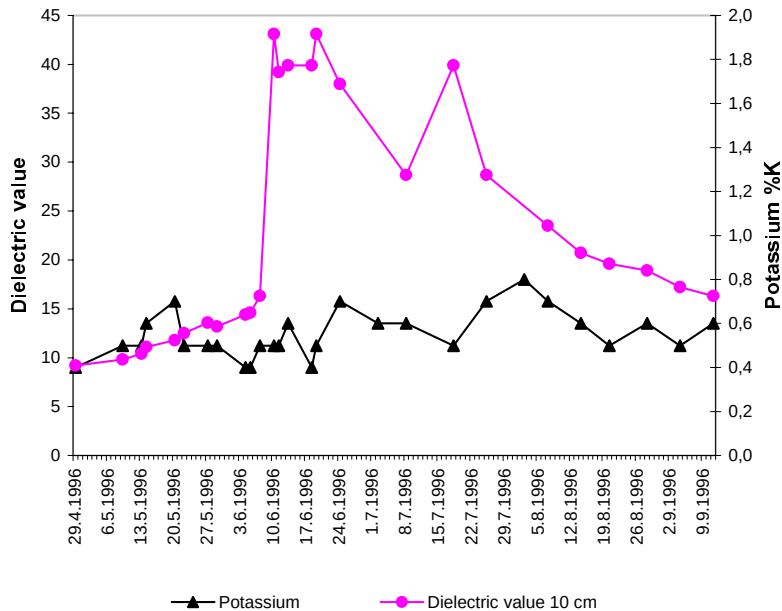


Figure 4. An example of temporal variation of gamma radiation (potassium window) and dielectric values at the till site occupied naturally by Norway spruce.

These data showed that for the interpretation of airborne gamma radiation data it is necessary to know the basic level of the gamma radiation in the research area. Dielectric detection was found to be reliable ground-truth reference and the quantity of ground measurements varies from one lithology to the other. An other important factor is the flight date. The airborne surveys in Finland date back to 1970's and the basic level of radiation has been varied annually. Therefore most reliable results will be obtained when flight data from each year will be processed and classified separately. From this standpoint the areal mapping of moisture content of forest soils is possible on the basis of airborne gamma radiation data.

3.3 Hydraulic classification

Water content, matric potential, gamma radiation and dielectric values are temporally changing features, but are controlled by the texture and structure of tills. The measured matric potentials, however, were significantly different between the till sites occupied by Scots pine ($5 < \psi_p < 17$) and Norway spruce ($0.5 < \psi_p < 8$) (Siira 1988).

Hydraulic conductivity is a property determining how rapid the changes in water contents are after rainfalls and snowmelt. Under the field conditions the maximum value of hydraulic conductivity may only be about half of the saturated hydraulic conductivity (Stephens 1996). Good correlations were found be-

tween the unsaturated hydraulic conductivity and soil dielectrics ($r_s = 0.80$, $P < 0.01$, $n = 16$, Fig. 5) and between hydraulic conductivity and gamma radiation ($r_s = 0.79$, $P < 0.01$, $n = 12$; Fig. 6). Regression line goodness in both cases are good $R^2 = 0.79$ and $R^2 = 0.82$, respectively. The highest hydraulic conductivity values (10

$^{-5} < K < 10^{-7}$ m/s) were observed to be typical of coarse-grained sandy tills where Scots pine stands are dominating. Lowest K -values ($10^{-7} < K < 10^{-10}$ m/s) recorded from fine-grained tills. Scots pine is lacking on these till soils, but are covered by Norway spruce and/or mixed spruce-pubescent birch.

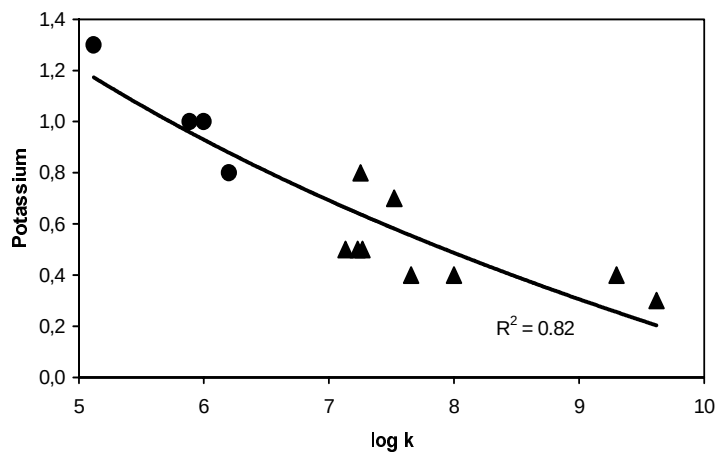


Figure 5. Relationship between in situ dielectric values and vadose zone conductivity (log scale). Symbols are same as in figure 2.

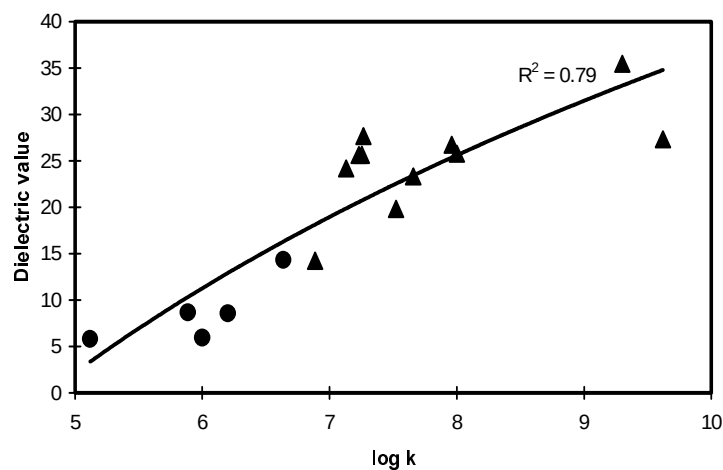


Figure 6. Relationship between in situ gamma radiation (potassium window) and vadose zone hydraulic conductivity. Symbols are same as in figure 2.

4 Discussion

Terrestrial dielectric moisture detection is a rapid and reliable technique for the detailed surveys of forest soils. Even if laboratory tests with frequencies higher than 1 GHz indicate slightly different texture dependent relationships between the dielectric properties and the volumetric water content (Ulaby et al. 1986), our *in situ* results obtained from Central Lapland and also elsewhere (Sutinen 1992) suggest that dielectric variations and respective variations in soil water content between different types of till soils are large enough for the classification of forest soils.

The main part of the gamma radiation is derived from the top half meter of soil (Grasty 1977) and the radiation is dependent on density of the rock and unconsolidated earth materials. The density of till in Central Lapland varies between 1.4–2.1 g/cm³ (Nieminen, 1985) so 90 % of the radiation is derived from the top 35–45 cm. Therefore, better correlation would be achieved between the dielectric and gamma data if the dielectric logging averages of the top 40 cm are used. However, the airborne surveys averages gamma values from an oval area 110 m in longitudinal diameter, while the terrestrial measurements are only points. The interpolated airborne imagery is only feasible for general-scale overviewing of the variations in forest soil moisture (Sutinen et al. 1994). Gamma radiation and dielectrics are both temporal variables and therefore best results will be obtained if flight data for each year will be processed and classified separately.

The present paper shows that till soils derived from fine-textured schistous rocks in Central Lapland have a high water content, that is indicated by high dielectric values ($\epsilon_r > 15$), low gamma radiation values (^{40}K counts less than 1 %K) and low hydraulic conductivity ($K < 10^{-7}$) values. These tills are generally occupied naturally by Norway spruce and/or mixed spruce pubescent birch stands. In contrast, Scots pine is naturally growing on till sites with low dielectric values ($\epsilon_r < 13$, Sutinen et al. 1997), high gamma radiation values (^{40}K counts more than 1 %K) and low hydraulic conductivity ($K > 10^{-7}$).

The site requirements of Scots pine and Norway spruce are different. Therefore some of the failures in artificial regeneration by pine might be attributed to high soil water content. The rate of seedling mortality in the early stages seem to increase along with an increasing soil water content (Sutinen et al. 1994). From a physiological point of view, the roots of pine seedlings may suffer from a lack of oxygen in silty till and hypoxia is suspected to be one reason for the damage. Hydraulic conductivity of silty till in Central Finnish Lapland seems to be very low, and much of the excess of rain water is lost through surface run-off. This might partly increase the hypoxia effect during the early stages. Presumably the moisture content in ploughed tills increases as a result of compaction and the realignment of the capillary pathways in the tills. This may explain the cases of pine seedling dieback after 10–20 years after ploughing.

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A Decision Support Demonstrator for Abiotic Damage to Trees, using a WWW Interface

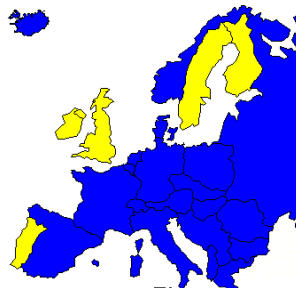
<http://bamboo.mluri.sari.ac.uk/aaair/demo/>

Ari Talkkari
Roger Dunham
David Miller
Marianne Broadgate



Part of the STORMS project

- Silvicultural
- Techniques
- Offering
- Risk
- Minimizing
- Strategies



Storm Damage in Europe

- Major constraint on forestry
 - 100 million m³ destroyed by wind in one night
 - 4 million m³ damaged by snow each year
 - 500,000 ha destroyed by fire annually
- Results of damage
 - Increased costs
 - Decreased revenues
 - More dangerous working



Initial knowledge

- Already much advice available
 - Thinning should be avoided on some sites
 - Alter rotation lengths from financial optimum
 - Use different establishment techniques
- Crude method of assessing wind risk available
 - No account of species, stocking density, stem shape
- Aims of the STORMS project
 - Improve general knowledge of principles involved in forest damage
 - Develop a method for identifying where and what areas are at greatest risk - minimise areas where expensive management practices must be used
 - Develop a method for assessing risks due to alternative management practices



Aims of Demonstrator

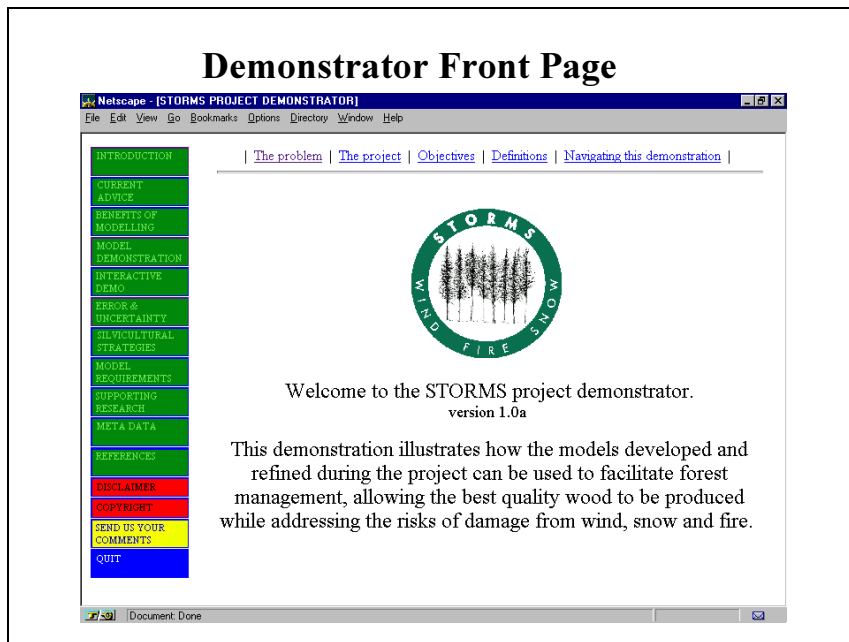
- Provide a single point of access to the spatial and aspatial models
- Indicate levels of error and uncertainty that can be expected
- Illustrate the use of the models for assessing alternative management options
- Facilitate dissemination of project results



Why use the World Wide Web?

- Allows integration of diverse models into a single interface
- “Instant” accessibility to the outside world
- Ease of updating individual parts of the framework (as models develop) without recompilation
- Easy and effective dissemination of results
- Uses standard low cost equipment and widely available software
- Enables monitoring of user access





Interactive demonstrations

- Provides access to 'restricted' versions of the models developed within the project
- Uses 'javascript'.
- Results are derived from lookup tables, rather than the 'real model', to protect the commercially valuable models from being copied

Instructions available Information about the model

The Hwind model demonstration

Instructions | Notes | Contact model developer

Species BIRCH	Soil type PODZOL	Email link to model developer
Cultivation ALL TYPES	Location STAND EDGE	
H/dbh ratio 80	Height 16 metres	
Thinning type Current density	Snow load None	
Accurate data	Height data wrong	
At canopy top	Overturning speed 20.5 m/s	Possible to investigate the effect of errors in input data
Stem breaking speed	26.8 m/s	Outputs can be coupled with wind climate data to provide risk estimates

ROVANIEMI POLYTECHNIC

HACQUILL LAND USE RESEARCH INSTITUTE

Instructions | Notes | Contact model developer

Valinger model demonstration

Species SCOTS PINE	Soil type ALL SOILS
Mean diameter 25 cm	Stand age 75 years
Proportion of spruce 0 %	Site index 45
Altitude 100 m	
Latitude 68	
Longitude 21	
Accurate data	Height data wrong
Risk of damage	1322 %

Risk of damage (at least one tree damaged in 10m radius plot over a five year period)

ROVANIEMI POLYTECHNIC

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Using the models for assessing risk on a forest scale

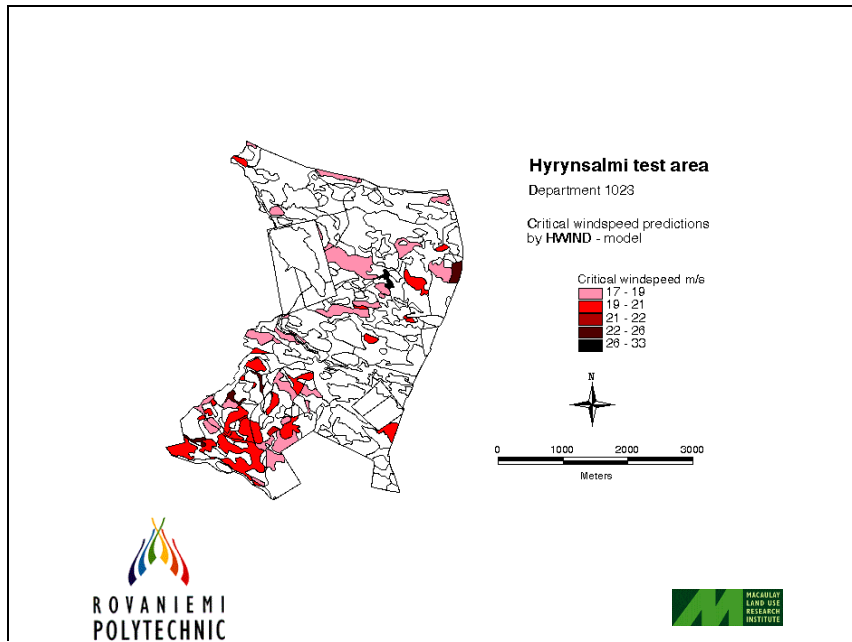
- Demonstration contains examples for the UK, Finland and Portugal



Use of model in Finland

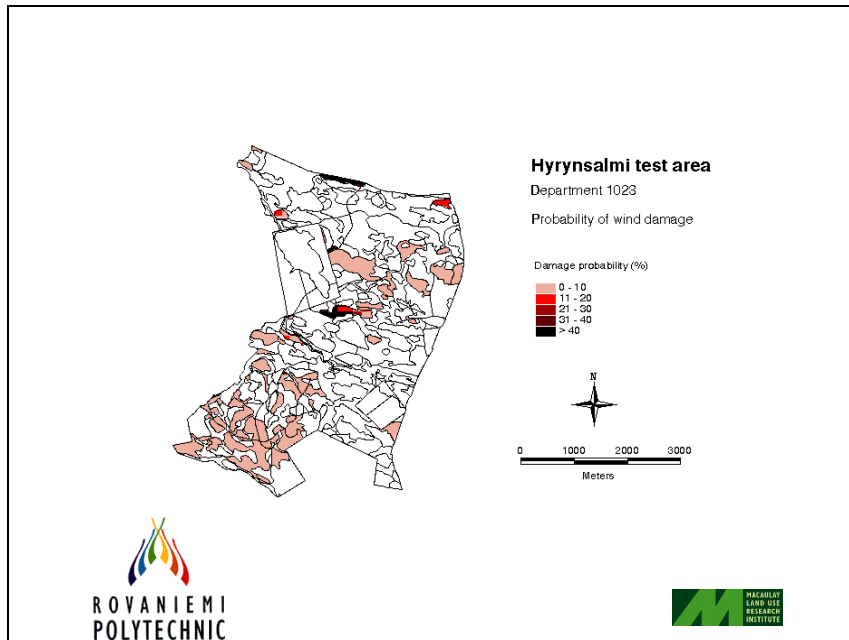
- Mechanistic model applied to all the stands of Scots pine in a forest compartment in Finland to calculate wind speed to cause damage





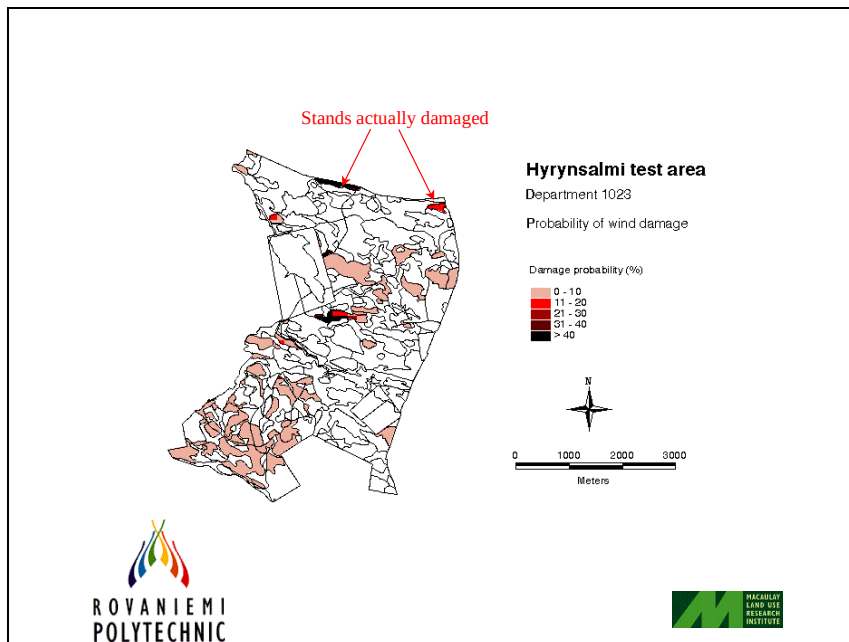
Use of model in Finland

- Mechanistic model applied to all the stands of Scots pine in a forest compartment in Finland to calculate wind speed to cause damage
- Risk of damaging wind speed occurring calculated



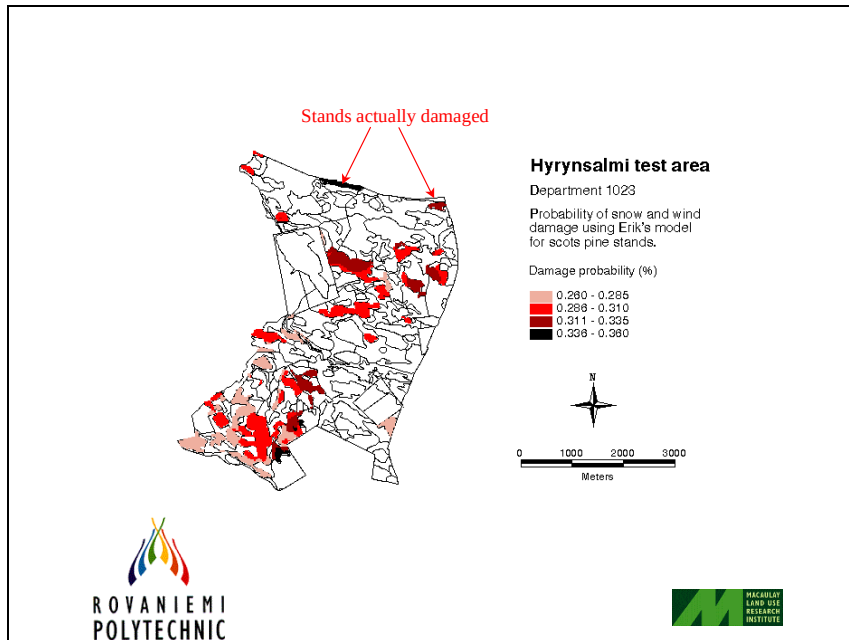
Use of model in Finland

- Mechanistic model applied to all the stands of Scots pine in a forest compartment in Finland to calculate wind speed to cause damage
- Risk of damaging wind speed occurring calculated
- Stands of trees which actually suffered damage had been identified as being at high risk - model validation!



Use of model in Finland

- Mechanistic model applied to all the stands of Scots pine in a forest compartment in Finland to calculate wind speed to cause damage
- Risk of damaging wind speed occurring calculated
- Stands of trees which actually suffered damage had been identified as being at high risk.
- Use of logistic model developed in Sweden also identified the stands which were damaged



Use of model in Finland

- Mechanistic model applied to all the stands of Scots pine in a forest compartment in Finland to calculate wind speed to cause damage
- Risk of damaging wind speed occurring calculated
- Stands of trees which actually suffered damage had been identified as being at high risk.
- Use of logistic model developed in Sweden also identified the stands which were damaged
- Models appear to exaggerate the risk of damage - but damage occurs every year, and 'actual damage' data relate to just a single year.

So, the models appear to work

BUT a *good* Decision Support tool also

- indicates how certain the results are (error and uncertainty)
- provides background information to the decision

These are also included within the demonstration



Error and uncertainty

Possible causes

- Absolute error (e.g. measurement)
- Attribute error
- Algorithm derived inputs
- Resolution
- Scale



One example: scale and soil classification

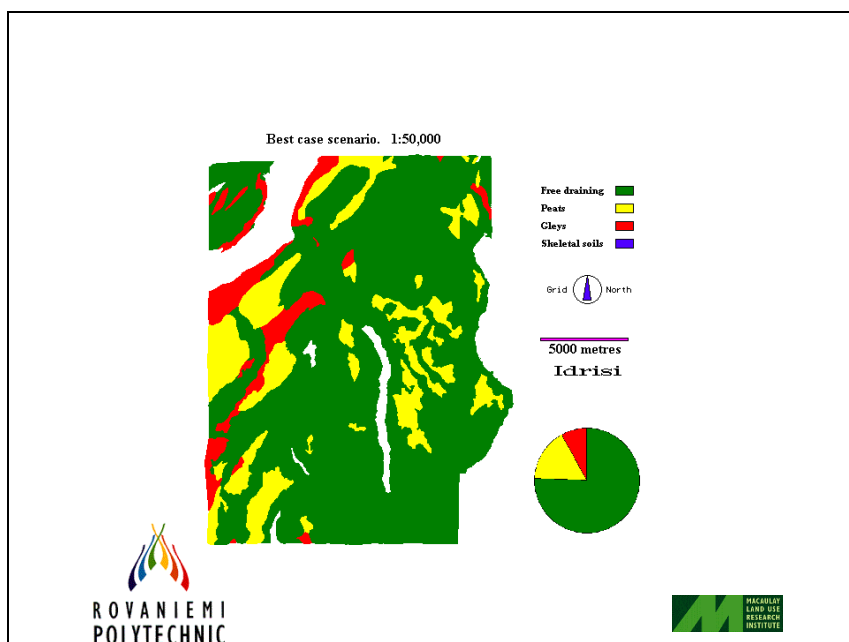
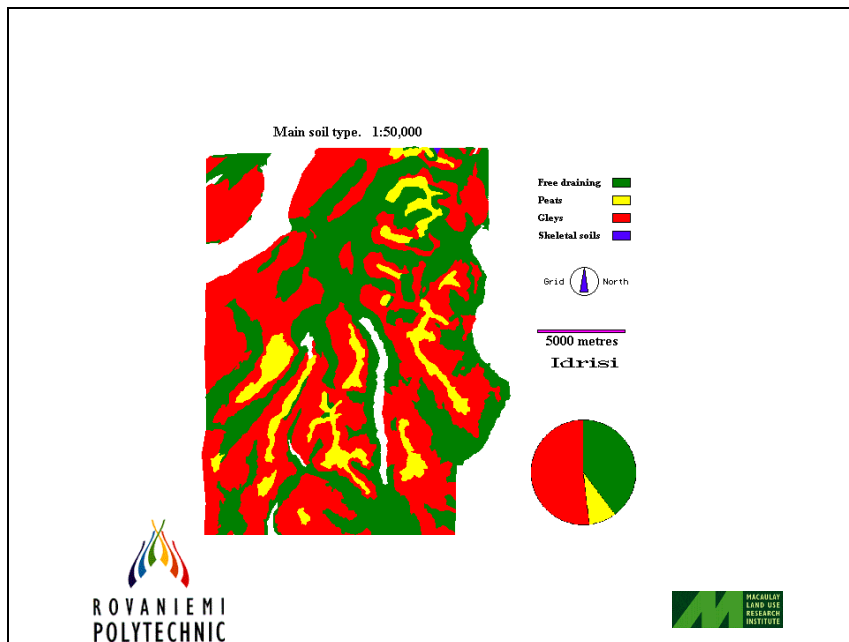
- Soil has a major influence on tree stability
- It is, however, impractical to map small areas in polygonal datasets resulting in minimum mapable unit and inclusions. (This occurs irrespective of scale used)
- sub-class information is therefore usually included in the key
- This means that various options are available for modelling: dominant, subdominant or “statistical” soil types, and this can give different model outputs

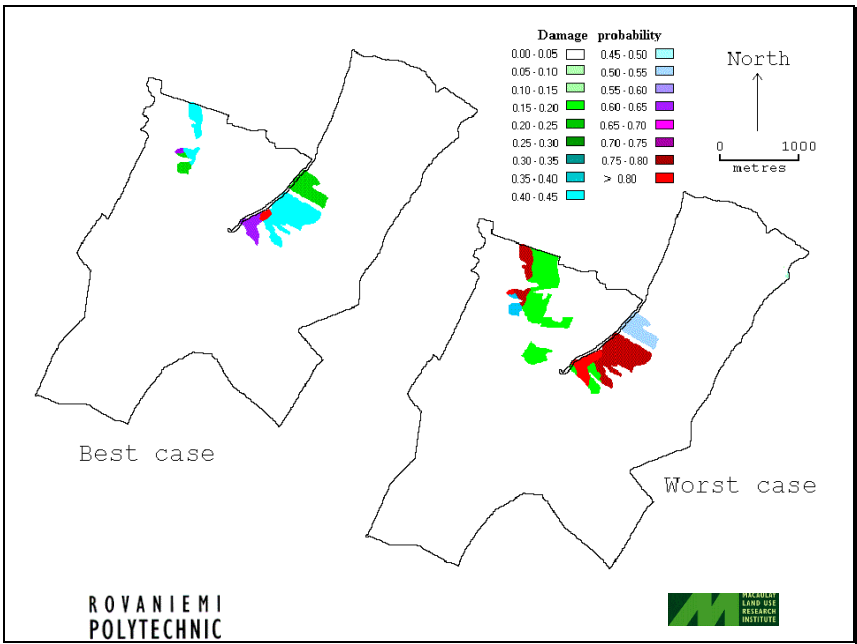
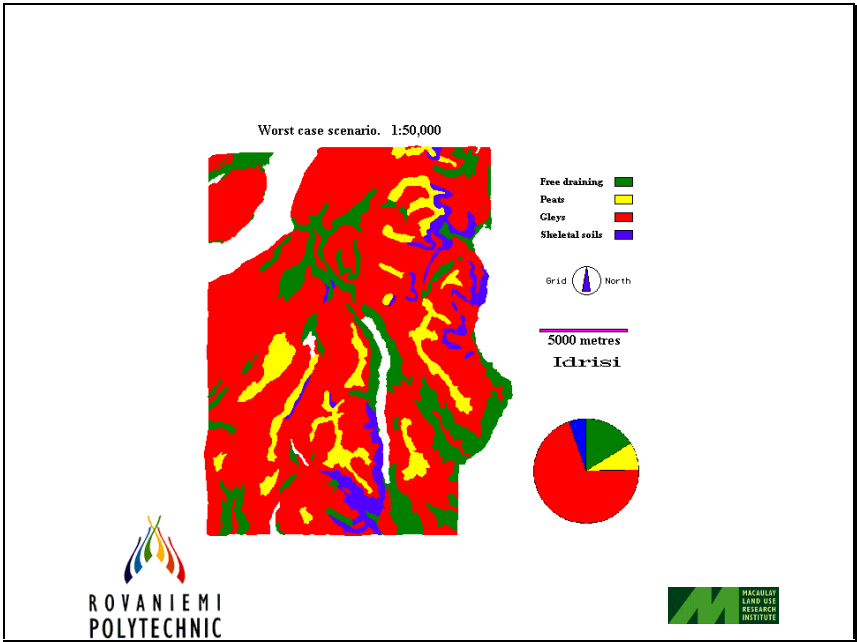


Forest in west of Scotland Six scenarios

- 1:10000 - Forestry Commission soil map
- 1:50000 - major soil type
- 1:50000 - inclusion soil type
- 1:50000 - “best” soil type *(major soil type or inclusion soil type which offers the greatest rooting ability)*
- 1:50000 - “worst” soil type *(as above, but which offers the least rooting ability)*
- 1:1000000 - European soils map







The Demonstrator also illustrates scenario testing

For a forest in mid-Wales, we can consider two options:

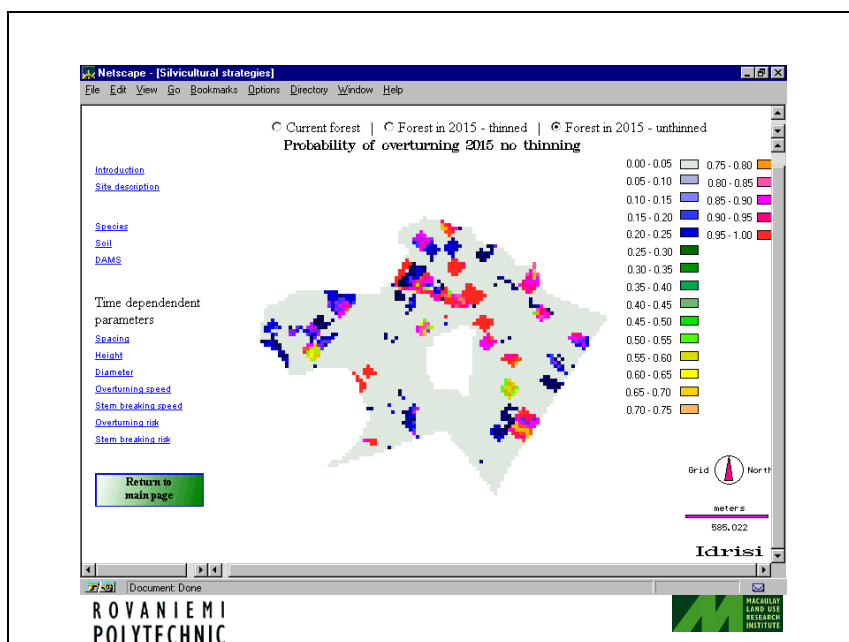
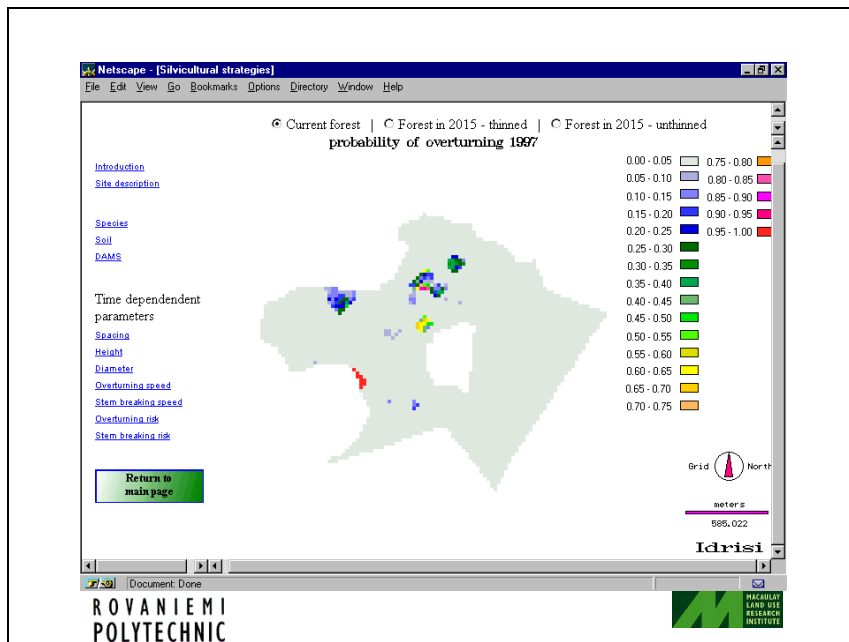
- thin the trees (produces a higher quality final crop of timber)
- don't thin the trees (may reduce the risk of damage, and avoids expensive early thinning)

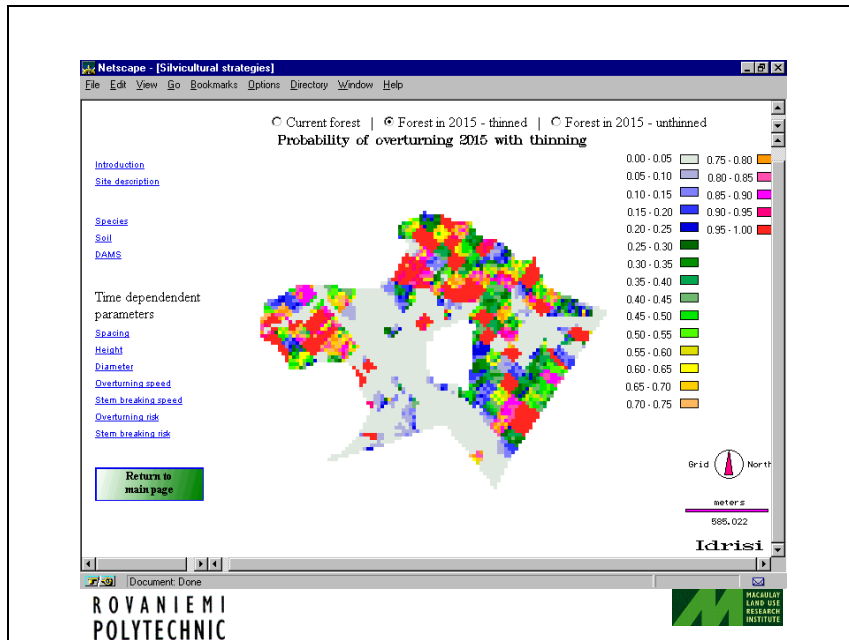


Scenario testing -method

- Current stand data can be used to predict what the stand will be like in twenty years time if managed using one or other of the silvicultural options. The data can then be used to assess where wind damage may occur.







Scenario testing - results

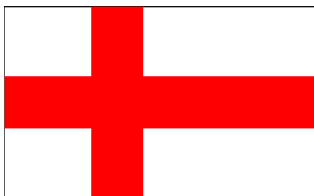
- Thinning the stand will cause more damage than non-thinning.
- **BUT** before making a final decision on which option is best, a detailed economic evaluation would be required. Although the trees from the unthinned stand may not have been damaged, they may not satisfy market requirements.

Conclusions from running the Demonstrator on the WWW

- WWW interface offers an excellent medium for integrating models into a single Decision Support framework
- Can be used to run models “live” or “pre-prepared”
- Problem of “security” and copyright. If it’s on the WWW it must be free.....!
- It also offers an easy (and updatable) method of dissemination, which uses standard and widely available equipment and software



An example of Finnish/Scottish Collaboration!



Multipurpose resource inventory in Far East of Russia (*economical aspect*)

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Abstract

The analysis of the approaches used by conservation, management and sustainable development of all types off forests shows that a small progress has been made in preparing of comprehensive inventorying and monitoring. At the same time on the level of the concrete application of necessary programs is facing a series of obstacles, which need to be overcome. A multipurpose resource inventory (MRI) is designed to collect and analyze data from some existing federal datasets. A pilot project aims to provide a more comprehensive estimate of extent of land under conservation management; to identify gaps in existing conservation area networks and highlight the need for increased allocation of temperate forests for protection and conservation. Most of such information are used a number of resource agencies (Forest and Hunting Services, Service of Zapovedniks and Nature Parks, Environmental Committees, etc.). To improve the state of existing forest inventory the special program was initiated. Program designing focusing on issues and options related to the process of defining economical goals, regional policies and inventory. The preparatory work based on the provisions of program principles as demand-driven processes, which recognize that local priorities and constraints change. Within project activity all forest inventory and monitoring estimates were accompanied wildlife surveys and landscape quantification. The development and conduct of inventory and monitoring systems coordinated to ensure data compatibility. The results of inventories were by analyzed, maintained and presented using GIS technologies (PC ARC/Info software).

I Setting up a problem

The challenges of the existing global ecological problems make for the search of the urgent and efficient ways of their solution. Undoubtedly, the preservation of global diversity, the slowing-down of the pace of forest degradation, the minimisation of the anthropogenic influence on the preserved nature territories require the involvement of the essentially new information technologies in the process of decision-making on the nature conservation issues. At the same time a pressing necessity exists to use complex methods for the assessment of the nature resources potential, especially for the vast forest territories that still occupy most of Earth's dry land (Mitchell and Hagenstein 1992, Zlotin and Yasny 1992, Kondratyev 1992, Voronkov and Turkevich 1993).

The global problems are to be solved on the territory of the specific regions, and it is very important that the decision-makers could receive complex information for the purposes of regional planning. Nevertheless, even when there is a relatively sufficient knowledge of the different components of the nature or resource potential on a given territory, in actual practice, the decisions are often governed by the priorities that have little in common with the real value of the forest resources. The reason for this lies in the extreme complicity of the assessment procedures for the investigated nature objects (systems) and the insufficient reliability of the results

obtained by traditional methods. The "one-sided" character of the information that is officially collected by the main resource agencies and organisations also does not contribute to the progress in this area (Teplyakov 1997).

Other practical difficulty resides in the fact that each resource and nature conservation agency has its own mechanism of the assessment of resources, which, correspondingly, implies obtaining of a specific set of parameters and criteria. However, their activities do not guarantee that complete information is collected that would be sufficient for a comprehensive analysis and for making an optimal decision. Very often the same information is collected by different agencies, regional and federal structures, public and state organisations.

In the recent decade the emphasis has shifted greatly towards the inexhaustible use of nature resources. As a result, the resource conception in forestry is replaced by the sustainable forest exploitation that is able to take the best account of the social, cultural, environment-forming, and environment-protecting functions of the forest (Moiseev and Pisarenko 1996, Kozhukhov 1997, Strakhov 1997a, b, Shubin 1997). However, despite the crucial importance of this approach for the long-term sustenance of nature systems, more often the economical interest still remains the most important factor in choosing the variant of the territorial development.

In the 1990-ies, the Multipurpose Resource Inventory (MRI) attracted a great attention as a promising ap-

proach in the scientific investigations, practical undertakings, and international projects (Lund 1997). Using the Multipurpose Resource Inventory for the assessment of several kinds of resources, which is most suitable for the forest territories, it is possible to make a more objective assessment of the significance of different components. However, as the experience of many countries shows, it is very difficult to put into practice the main idea of this method, which lies in the inventory conducted simultaneously for the needs of many users (it is of no importance whether they will be governmental agencies or private forest companies) (Grumbine 1992, Noss and Cooperrinder 1994, Bocharnikov et al. 1996).

2 Evaluation of modern situation, urgency and need of economical assessments

Taking into consideration the international obligations of Russia on the preservation of biological diversity, the need to obtain the reliable assessments of the nature resources potential of the forest territories and in accordance with the Concept of the sustainable development of the country, the independent non-state organisation Scientific-Research Centre for Forest-Dependent and Aboriginal People (SRC FDAP) has developed a special project financed by WWF-Russia. Its main goal is to develop

an original algorithm for obtaining an integrated economical assessment of the forest territories of the Russian Far East.

Far East of Russia belongs to the territories where the most diverse forest formations have preserved which have their typical structure, vegetation composition and biodiversity level. A specific feature of this territory is that in the south-western part of this region, in Primorye (Fig. 1), many forest ecosystems possess floristic and faunistic elements that are characteristic of different geographical zones: Arctic and taiga zones, forests of temperate and subtropical zones (Kolesnikov 1966, Bocharnikov 1996).

On the territory of the Russian Far East a large number of endemics have been registered: over 21 % local mammals (or more than 5 % of all terrestrial fauna of Russia), over 14 % nesting birds (almost 5 % of all ornithofauna of Russia); 66 %

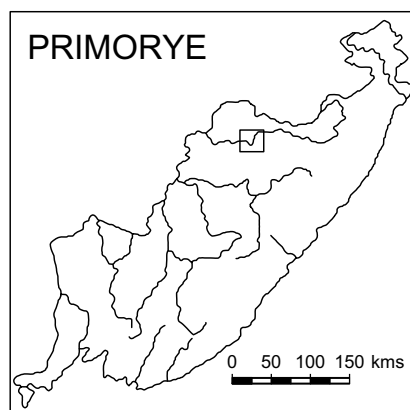


Figure 1. The south-western part of the territory of Far East of Russia.

reptiles (more than 10 % of all reptiles of Russia); over 55 % amphibians (or more than 15 % of all amphibians of Russia). One third of 18,000 species of higher plants are relicts, out of them the representatives of 16 families, 200 genera and 800 species of vascular plants occur only in the southern part of Far East. Therefore, the total biodiversity level is the highest on the territory of North Asia (Voronov et al. 1997).

In modern conditions the economical and social problems on the territory of Siberia and Far East have become of profound concern. For this reason very often the situations occur when it is necessary to determine which most economically suitable variant can be used on a specific territory. In fact, the most frequently used alternatives are the use of a forest site for commercial timber-cutting; complex nature management (collecting non-timber resources, commercial hunting, recreation, etc.) or organisation of a specially protected nature territory (SPNT).

When the strategy for preservation of the biodiversity in Sikhote Alin was developed, the optimum location of the existing and planned SPNT was evaluated (Bocharnikov, Krasnopeev, 1997). The creation of new SPNT and the correction of the borders of the existing SPNTs is possible only when there is a strong and objective justification of the economical appropriateness of them. It is necessary to develop a simple and practical algorithm of the economical assessment of forests to obtain a full picture of different variants of nature use.

Taking into consideration the recommendations prepared on IUFRO 4.02 meetings (the Monte Verita Conference on Forest Survey Designs and Assessment of Non-Timber Resources, Ascona, Switzerland 2–7 May 1994; the International Conference on Multiple Resource Inventory & Monitoring of Tropical Forests, Seremban, Malaysia, 21–24 November 1994) where the advantages of using **GIS** for practical analysis of spatially distributed data were clearly demonstrated and it was decided to implement an automated computer algorithm of economical assessment.

It is known that in order to make the needed changes in Russia regarding the ownership on the nature resources, it is first of all necessary to conduct their objective inventory and additional economical assessment. On the basis of data obtained it is necessary to develop sophisticated regional information systems for the control of the condition and dynamics of the nature resources potential within the frame of individual nature resource systems, regions, territories and republics (Baklanov 1992, Giryayev 1995).

The main structure of forest management in Russia has been in existence without any significant changes for more than 60 years, and its main element has been supporting the main industrial enterprises on cutting, export and processing of timber (Kozhukhov 1997). However, starting with the middle of this century, many times in Russia practical efforts were made to organise complex commercial enterprises, having state or public ownership on means

of production for the exploitation of the forest resources. During the years of their existence the experience of obtaining integrated assessments and prognosis for complex forestry and hunting management was accumulated (Kucherenko 1979, Kukuev 1997).

In the 1990-ies a cardinal change in the system of nature resources exploitation and management resulted in a practical uselessness of the existing departmental methods of the resources assessment and procedures of monitoring of the environment state. The need for developing a new plausible procedure, which could adequately provide, on the basis of a complex approach, obtaining comparative assessments for choosing a scenario for the territorial development of any forest site, became evident.

Besides, to get the reliable assessment on the existing resources, the volume of timber production, its prime costs and market potential of the forest goods, it is necessary to actively involve the local population in the inventory making. Obtaining such data is even more urgent now, when the Soviet system of planned economy has stopped its existence, and the new market mechanisms have not been fully formed yet. For this reason a large-scale sale of cheap nature resources of the country is observed.

Practically, it was assumed that a mechanism would be obtained that would allow to avoid the duplication of the efforts of different departments. At the same time it would allow to obtain regularly reliable data, to cover the "gaps" in data collec-

tion and processing; to reduce significantly the cost of the monitoring and inventory operations.

3 General algorithm of economical assessment of forest resources

There are three most common concepts of the assessment of nature resources: expenditure, rental and combined ones. In the first case, the notion of economical assessment is connected with the expenditures invested in the development of resources; the second approach is based on differential rent that was calculated in the Soviet period as a difference between the value of the production obtained from the exploitation of the nature resources and the normative level of individually given expenditures for its production. In the combined approach the economical assessment of nature resources means the value of the annual profit from their exploitation, i.e. both the expenditures and the effect from the exploitation of the resources.

The choice of the methods of assessment depends on the goals, object and time period of the assessment. If it is necessary to calculate an optimal territorial scenario three almost polar assessments are chosen: the extensive exploitation of timber resources on the industrial scale, the inexhaustible use of the maximal number of forest components and the lack of exploitation in case of SPNT.

When comparing such variants, the most acceptable is the modified rental approach with a use of integrated cost estimations, including both the profits and the expenditures from all the components of the utilised nature resources. The value of such assessment by the economical content represents the net present value that depends on the resources taken into account, on the chosen scenario of forest land use and on the time period of the exploitation assessment.

As a cost-determining basis for evaluation of the production it is suggested to use both home market and export prices on the real forest production. It is planned to make calculations in the interval price estimations on the basis of practically accessible volumes of production with further organization of data into a "transparent" information system in order that it would be possible in future to correct the main indexes of the economical assessment.

It is fundamental that the division should be done into three main categories of timber and non-timber resources: economically available, exploitational, and potentially suitable for exploitation. Such division is made based on the accepted methods: state of the market, modern economical situation, availability of roads and infrastructure, processing capacities, peculiarities of nature management and other factors (Procedure.. 1991).

The potential resources include all the biological harvest that is formed under the influence of the forest productivity, climatic factors, crop capacity and other natural fac-

tors. The exploitational resources include the volume of resources that may become a real object of man's efforts. The economically available resources encompass a part of the exploitational resources that can be obtained, processed and sold at a profit level sufficient in the modern conditions.

At this stage the economically available resources must become an object of study. The suggested formula for the assessment is:

$$R = \sum_{t,i=1}^{T,I} \frac{(pt_i * V_{ti} - C_{ti} - Z_t)}{(1 + E)^t} + \sum_{t,j=1}^{T,J} \frac{(pt_j * V_{tj} - C_{tj})}{(1 + E)^t}$$

where

- R integrated assessment of resources with a chosen scenario of use;
- T period of assessment;
- E coefficient of discounting;
- i index of production obtained from timber resources;
- j index of production obtained from non-timber resources;
- t year of resource use;
- pti cost estimation of a unit of i-production obtained from timber resources in t-year;
- ptj cost estimation of a unit of j-production obtained from timber resources in t-year;
- Vti volume of i-production obtained from timber resources in t-year;
- Vtj volume of j-production obtained from timber resources in t-year;
- Cti total expenditures on obtaining, processing and transportation of Vti of i-production obtained from timber resources in t-year;
- Z expenditures on forest restoration works in t-year;
- Ctj total expenditures on obtaining, processing and transportation of Vtj of j-production obtained from non-timber resources in t-year.

The volume of i-production obtained from timber resources in t-year was calculated using the next equation:

$$V_{ti} = \alpha_{im} * k_{im} * F_{mt}$$

where

F_{mt} economically available stocks of timber resources of m -kind planned for exploitation in t-year;
 α_{im} proportion of economically available stocks of timber resources of m -kind felling within i-production;
 k_{im} coefficient of conversion of economically available stocks of timber resources of m -kind into i-production.

Economically available stocks of timber resources of m -kind planned for exploitation during all period of assessment are:

$$\sum_{t=1}^T F_{mt} = \gamma_m * Q_m,$$

where

Q_m total stocks of timber resources of m -kind;
 γ_m coefficient of conversion of total stocks of timber resources of m -kind into economically available ones.

The volume of j-production obtained from non-timber resources in t-year:

$$V_{tj} = \beta_{jn} * l_{jn} * H_{nt}$$

where

H_{nt} economically available stocks of non-timber resources of n -kind planned for exploitation in t-year;
 β_{jn} proportion of economically available stocks of non-timber resources of n -kind felling within j-production;
 l_{jn} coefficient of conversion of economically available stocks of non-

timber resources of m -kind into j-production.

Economically available stocks of non-timber resources of n -kind planned for exploitation in t-year:

$$H_{nt} = S_{nt} * h_{nt} * \lambda_{nt}$$

where

S_{nt} total area occupied by non-timber resources of n -kind in t-year;
 h_{nt} biological productivity of an area unit of n-resource in t-year;
 λ_{nt} coefficient of conversion of total stocks of non-timber resources of n -kind into economically available ones.

4 Methodical basis for inventory of forest resources

Rational management of forest resources and forest landscapes requires distinguishing the elements that would practically reflect the important properties of the forest, implementation of quantitative measures of diversity that would provide a full picture of its functional properties, which is necessary for practical work. The forest taxation and forestry accepted in our country are a form of systematised reflection of different aspects of forest communities and forest landscapes. Such notions as forest type, habitat type, types of trees, condition of trees, diameter class, age, bionitet class etc. are directly reflect the peculiarities of forest resources, and lately, diversity indexes (Isaev et al. 1997, Golovikhin and Kukuev 1998).

In fact, the components used for the assessment of the timber resources are universal, because the main calculations on a possible “calculated timber-cutting area” are based on standard forestry data the same for all the territory of Russia, and the procedure of choosing timber for exploitation is officially stated in the corresponding documents, first of all in Instruction on organisation of forest management in the unified state forest fund of the USSR (1986) and its revised versions, up to Forest Code of the Russian Federation (Moiseev 1974, Polyakov and Nabatov 1992, Kukuev 1997, Romanov 1997).

In the project proposed, the materials on forest management for Primorskii Krai for 1986–1997 have been chosen as a documentary basis for the practical algorithm of forest assessment. During the last three decades, forest management works were conducted on a regular basis (usually once in every decade) in each state forestry enterprise on Primorskii Krai territory using a standard forestry procedure (Instruction on... 1986, 1995).

With a support of a joint Russian-American project (**ERT**) earlier, in 1995–1997, on the basis of the primary forestry materials (plans of forest-plantations, description of wood vegetation) a database (DB) “Forests of Primorye” was created (Krasnopeev, Bocharnikov, 1997). The total information array of DB includes the description of about 500 thousand forest **sites** on an area of over 11.5 mln hectares of Primorskii Krai territory.

In the forestry practice of Russia the projects of federal forestry management by state organs are developed on the basis of forestry data, in which the original characteristics of forest plantations are used for the calculation of planned exploitation indexes, their restoration and protection on the territory of forest enterprises. A high level of data and procedure standardization allowed to create rather easily a corresponding information system. A further perfection of the user’s interface and BD structure in the project implemented is aimed at that the program block could be widely used by different users, especially in the calculation by use of the main automated algorithm of economical assessment.

Usually the integrated resource assessment is proceeded by the calculation of different components, and the general assessment is obtained by use of summarizing of individual assessments taking into account their weight, if the parameters investigated are not connected with each other by complex functional dependence. The dynamics of the accumulated timber stocks is calculated by the bionitics of forestry enterprises; all other “**usefulnesses**” of the forest are calculated more often in free form by different departments and organizations (Procedure of detection... 1987, Methodical instructions... 1988, Petrov 1996, Vorobyev and Vekx 1997). There is also a practical instruction on the assessment of non-timber forest resources in the southern part of Far East (Solovei et al. 1996).

The main idea of modern practical assessment of a forest site lies in establishing a strict connection between the existing in the estimated time marketing possibilities for the kinds of production and raw materials on an estimated site and the necessary inventory procedures. Thus, based on the practical side of **realisation** of the production that is in greatest demand, the number of the assessed kinds of resources is reduced to the minimum. Usually for the southern part of Far East these are 2–3 kinds of coniferous and deciduous trees, not more than 5–6 kinds of herbal and food materials; 1–2 kinds of furs. More detailed calculations are made when preparing a business plan for a specific enterprise or for an expert assessment of the damage.

The calculations on commercial game animals that are important for the sustenance of the life level of local people were made within the group “non-timber forest resources”. Data obtained as a result of field studies, mapping of hunting lands and questioning of the local hunters are organized into a special DB. Standard relation tables allow to keep data obtained from different sources indicating their reliability and the time when they were obtained. The created user friendly interface of the program makes it possible even for a non-prepared user to work easily with data. The built-in editor allows to make corrections, additions and to remove some non-correct or out of date data. The system of **cross queries** helps to get necessary data and calculations promptly, presenting them in a **chart form**.

5 Conclusion

During the last 5 years in the USA a special system of forest inventory and monitoring based on special programs (Talent-Halsell., 1994). The net of permanent sampling sites embraces all the country. Each sampling area represents a complicated hierarchical structure of smaller sampling areas the end use of which varies: inventory of tree, bush and grass levels, soil, soil invertebrates, etc. Probably, based on these approaches monitoring systems in the developed countries can be developed (Pavinen et al. 1994).

Other possible future development of monitoring is **high resolution** organization and processing of field observations data. Even now everywhere in forest management, biological studies and monitoring GPS are widely used for **choosing the sites** for field observations. This method is most promising for the assessment of different biodiversity components. But we can surely say that in Russia different assessments of the forest territories will be mainly done on the basis of mass data on forest management.

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Estimation of leaf area of Loblolly pine needles by new rapid method

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Abstract

The methods developed to determine total needle surface area of pine trees are time-consuming, require expensive laboratory instrumentation, and cumbersome under field conditions. Needle surface area and leaf area index of Loblolly pines (*Pinus taeda* L.) were investigated using three approaches namely the Photo-Electronic method, Johnson's method and the Shivaji's method. The Photo-Electronic method was generally not effective for determining needle surface area. Johnson's method and the Shivaji's rapid method produced needle surface area values closer to the actual values than the Photo-Electronic method. There was a highly significant correlation ($r^2 = 0.99$) between the Johnson and Shivaji methods. Although the Shivaji's method produced slightly lower leaf area values than Johnson's method, there were no significant differences observed between the two methods. The simplicity of the proposed (Shivaji's rapid) method suggests that it has great promise for predicting needle surface area, and consequently the leaf area index of pine trees.

I Introduction

Research on the efficiency of intercepted solar radiation and utilization by vegetative canopies, requires frequent measurements of leaf area and leaf area index are important biophysical descriptor of crop canopies, and are important parameters used routinely in forest ecology and tree

physiology (Johnson 1984). Because accurate measurements of leaf area are laborious and time consuming, numerous direct and indirect methods of measuring leaf area for various crops have been developed (Hatfield et al. 1978, Marshall 1968, Johnson 1984). Kvet and Marshall (1971) characterized the methods into two broad categories: estimation

methods that employ a mathematical relationship between leaf characteristics, and leaf area planimetric methods including photo-electric techniques. The glass bead technique described by Thompson and Leyton (1971) is another approach of surface area estimation. These methods vary greatly in their accuracy, precision, bias and ease of measurements.

The method proposed by Johnson (1984) hereinafter referred to as Johnson's method, requires a very high degree of precision in measurements. Hence, it is potentially vulnerable to serious errors basically due to two major problems: (i) the volume measurements of displaced water at 20 °C has to be very precise, to the hundredth of a cm³, and (ii) the measurement of cumulative lengths of all needles has to be very precise, to the hundredth of a mm. Therefore, this method requires some special skills in measuring the volumes and the cumulative lengths to avoid serious errors. Also, additional problems may arise when the needles are not tied loosely before measurement. In such cases, the sample needle-bundles may trap a considerable amount of air bubbles which will increase the volume measurement readings considerably compared to the true measurements. These result in serious efforts, and Johnson (1984) cautioned against these flaws. The temperature of water for measuring the volume displacement is critical; it has to be maintained at 20 °C. In conditions where maintenance of this constant temperature is not possible, it adds significant efforts in volume readings.

The method proposed in this study for pine needle surface area determination is based on the concept that there is a definite and constant relationship between density and the volume for all pine needles. Johnson's method was based on the assumption that a pine needle can be represented by a segment of a cylinder. His assumption was primarily derived from the findings reported by Madgwick (1964) for red pine fascicle shape where most of them taper in the terminal few millimeters of the needle, for radiata pine (Wood 1971), and Scottish pine (Rutter 1957). However, while making approximations (i.e. assuming a cylindrical shape of the pine fascicle), Madgwick (1964) noted that most of the taper occurred in the terminal few millimeters of the needle circumference, 2 mm from the tip and averaged 77 % of the mid-length. From this, it is obvious that at least for 23 % of the cases, the results were false. The needle geometry is also a function of climatic effects and the genetic make-up of pine species, and hence the species variations also cannot be left unaccounted for. Johnson's and other methods which produce results based on these assumptions can be erroneous, and will produce under or over estimation. They may also fail to reveal the accurate needle surface areas. Previously proposed methods (Johnson 1984, Beets 1977) also rely heavily upon the use of the volume of water (at 20 °C) displacement by pine needles. This usually is a prime source of potential error because of the fresh needle volume which changes its character depending upon its water

content, species variations, and other seasonal as well as regional variations.

The methods developed so far to determine total needle surface area of pine trees are time-consuming and require expensive laboratory instrumentation, and are cumbersome under field conditions. The objectives of this research were: (i) to estimate the total needle surface area of Loblolly Pine (*Pinus taeda* L.) by two approaches and a new procedure using growth parameters and (ii) to examine relationships between the proposed and the existing procedures for estimating total needle surface area.

2 Materials and methods

The study was conducted in young pine plantations (3 to 5 year old) located at 32.5°N and 85.5°W, during mid-June, 1987 and 1988, at the USDA-Southern Forest Research Station, Auburn University, Auburn, Alabama. The pine trees from each observation site were cut and the needles were separated. Ten percent of the needles of each tree were used to determine the leaf area using an area meter, and a video screen monitor for measurement displays.

The calculation of total needle surface area according to Johnson's method required the determination of the cumulative needle length of all needles in the sample, volume of water displaced by the needles, and the number of needles per fascicle. Needle length was measured from top of the basal sheath to the tip. The

needles were cut at the basal sheath prior to determining the volume. Individual needle lengths were summed to give the cumulative length of needles in each sample. These three observations were used to compute the total needle surface area using the following formula given by Johnson (1984):

$$A = 2L (1 + p/n) (Vn / p L)^{0.5}$$

The above equation provides the total surface area. In this equation, **A** is the total surface area (cm²), **L** is the total cumulative length (cm), **n** is the number of needles per fascicle, and **V** is the volume of water (cm³, at 20 °C) displaced by needles. This is similar to the model developed by Beets (1977) to estimate total leaf area of whole fascicle of Radiata Pine needles. However, it required sub-sampling (20–30 fascicles per tree) for fascicle volume, dry weight and length, mean shape coefficient for needles, and number of fascicles on tree of interest. In the photo-electronic method, the fascicles were separated from the individual pine trees and 10 % of the total fascicles were used each time for leaf area measurement. The separated fascicles (needles) were placed on a transparent plastic conveyor belt and the cumulative area (cm²) of all the needles were measured electronically by LI-COR LI 3000 surface area meter.

The "Shivaji's proposed" method requires the determination of the cumulative length of all the fascicles in the sample, the oven dried weight of the fascicle sample, and the number of needles per fascicle. This

procedure is similar to Johnson's method except that it requires the dry weight of needles instead of volume of water displaced. The pine constant (**Pc**) is a constant derived from ratioing volume to the oven dried weight of needles of the sample for which the total surface area determination is desired.

Due to the geometric similarities in the pine needle geometry, this constant should be similar for different pine varieties. Hence, the constant (1.537) may be used for all pine varieties as far as the needle geometry is concerned. This constant for pine geometric configuration is not influenced by age, size of needle, plant varieties or any other non-geometrical parameters of the pine needles. The "Shivaji's proposed model" is derived by replacing '**V**' in equation (1) by '**NDW**', and by including **Pc**. The proposed model for needle surface area is expressed as:

$$A = 2L Pc(l + p/n) (NDWn/pL)^{0.5}$$

where **A** is the total surface area (cm²), **L** is the total cumulative length (cm), **n** is the number of needles per fascicle, **NDW** oven dried weight of needles (g), and **Pc** is the pine constant which is a ratio of volume of needles (cm³) to its oven dried weight (g). The data were analyzed using REG procedure in the Statistical Analysis System (SAS) software (SAS Institute, 1985) to determine relationships between predicted and measured surface areas of Loblolly Pine needles.

3 Results and discussion

The surface areas of needles obtained from the photo-electronic planimetric procedure were frequently higher compared to Johnson's or the proposed method, and the results are presented in Table 1. This method consistently gave more needle surface area than the Johnson or proposed methods. Overall, needle surface area was higher by 32.2 % and 32.1 % compared to the Johnson's and "Shivaji's proposed" methods, respectively.

The calculated total surface area of the sample needles as calculated using Johnson's model are presented in Table 1. This method gave 32.2 % lower needle surface area than did the photo-electronic planimetric method. The reasons for this discrepancy may be due to the overlap of pine needles while passing through the screen on the plastic conveyor belt. In addition, the shadowing and the reflections due to needle geometry might contribute to over estimation of needle surface area as compared to the actual area values measured by the photo-electronic procedure. Therefore, Johnson's procedure should result in calculated surface area values closer to the actual surface area compared to the photo-electronic planimetric method. However, the accuracy of Johnson's method largely depends on the degree of needle taper and the ability to determine and measure the representative needle parameters.

Table I. Pine needle surface area determination by different methods for the different study sites.

Tree Number	Cumul. Length (cm)	Pine Needle		Pine Constant	Methods of Leaf Area Determination		
		Volume of Displaced Water (cm ³)	Dry Weight (g)		Photo-Electronic (m ²)	Johnson's (m ²)	Shivaji's Proposed (m ²)
Site – I NA 1							
1	222.09	1200	502.0	1.540	3.04	2.06	2.05
2	223.32	1080	451.0	1.550	2.82	1.96	1.95
3	87.46	410	169.0	1.560	1.048	0.76	0.75
4	209.32	1400	643.0	1.480	3.76	2.16	2.25
5	128.76	500	211.0	1.530	1.38	1.01	1.01
6	192.58	2680	1295.0	1.430	6.6	2.87	3.07
7	116.32	630	219.0	1.690	1.17	1.08	0.98
8	366.62	1850	958.0	1.390	4.29	3.29	3.64
9	144.84	630	283.0	1.490	1.26	1.21	1.24
Site – II NA 2							
1	70.89	340	132.0	1.600	0.86	0.62	0.59
2	106.37	540	224.0	1.550	1.33	0.95	0.94
3	24.97	110	42.2	1.590	0.26	0.21	0.20
4	72.15	280	139.0	1.420	1.04	0.56	0.61
5	1.76	50	28.7	1.310	0.21	0.03	0.04
6	10.03	40	20.6	1.380	0.08	0.08	0.08
7	14.89	80	25.5	1.750	0.17	0.13	0.12
8	8.1	30	10.7	1.650	0.06	0.06	0.05
9	59.24	150	148.0	1.010	0.85	0.37	0.57
Site – III / Highway 54							
1	31.94	200	60.0	1.820	0.49	0.32	0.27
2	89.72	445	184.0	1.510	1.15	0.79	0.79
3	102.27	510	215.0	1.540	1.31	0.91	0.91
4	43.49	160	68.7	1.520	0.45	0.33	0.33
5	133.84	540	248.0	1.47.0	1.56	1.07	1.12
6	21.91	120	30.0	2.000	0.22	0.20	0.15
7	62.12	310	118.0	1.620	0.82	0.55	0.52
8	170.59	910	414.0	1.480	2.28	1.57	1.63
9	151.61	810	320.1	1.590	2.12	1.40	1.35
Site – IV / Pill Baptist							
1	54.34	230	98.0	1.530	0.66	0.44	0.45
2	18.03	60	42.6	1.180	0.16	0.13	0.17
3	6.35	20	11.2	1.350	0.04	0.04	0.05
4	9.91	40	16.7	1.530	0.09	0.08	0.08
5	9.35	40	15.5	1.580	0.08	0.07	0.07
6	32.78	170	62.4	1.650	0.44	0.29	0.27
7	42.6	180	73.2	1.570	0.43	0.35	0.34
8	38.6	170	64.0	1.630	0.21	0.32	0.30
9	11.2	80	23.7	1.820	0.18	0.12	0.10

The relationship of needle dry weights vs. the corresponding volume of water displaced, and needle dry weights vs. needle cumulative lengths are presented in Figures 1 and 2.

These results show a linear relationship and high correlations with r^2 of 0.98 and 0.95, respectively as follow.

Needle Dry Weight (Y) vs. Volume of Displaced Water (X):

$$Y = 0.4644 X, r^2 = 0.985$$

Needle Dry Weight (Y) vs. Needle Cumulative Length (X):

$$Y = 2.314 X, r^2 = 0.952$$

There was also a linear relationship between the volume of water dis-

placed by the sample needles and the needle cumulative lengths (Fig. 3) which was highly correlated ($r^2 = 0.965$).

Volume of Displaced Water (Y) vs. Needle Cumulative Length (X):

$$Y = 5.0899 X, r^2 = 0.965$$

There was a high correlation between the volume of water displaced (VDW) and the needle dried weight (NDW) of each sample. Due to the high correlation between VDW and NDW, VDW/NDW values for each observation were calculated and their square roots for all four study sites were averaged (Table 1) as the pine constant (**Pc**). The average of the resulting pine constant based on observations (1.537) was used as input to the proposed model.

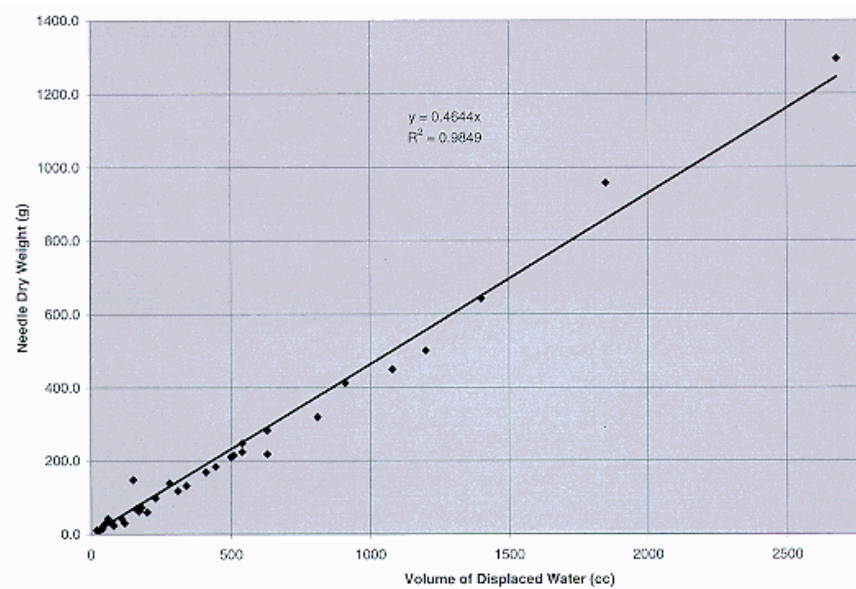


Figure 1. Relationship between needle dry weight and the volume of displaced water.

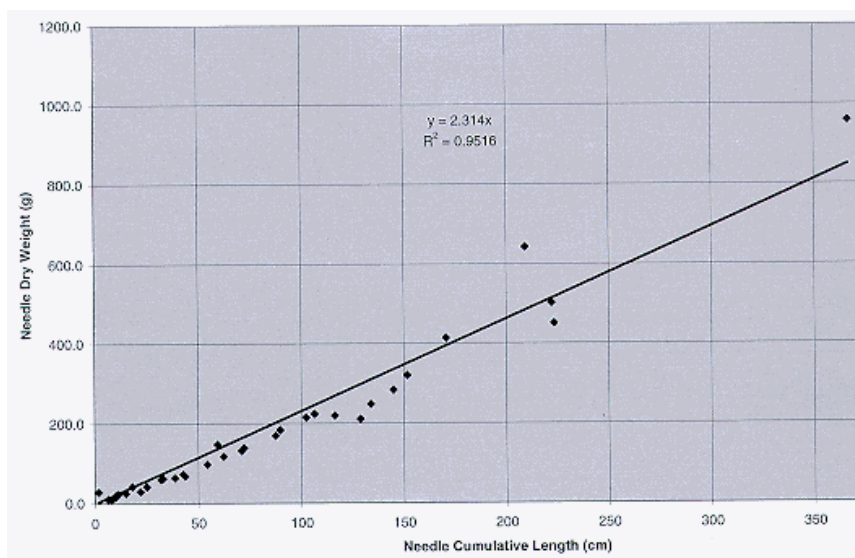


Figure 2. Relationship between needle cumulative length and needle dry weight.

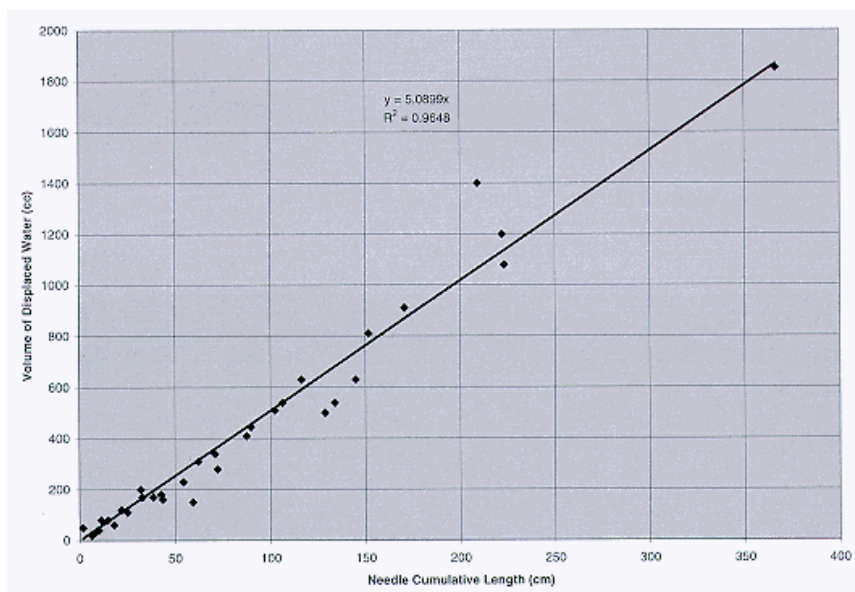


Figure 3. Relationship between needle cumulative length and volume of displaced water.

A comparison of the total surface area of the sample needles resulting from the was performed. The resulting relationship “Shivaji’s proposed” and Johnson models is shown graphically in Figure 4.

There was a very high correlation between the two methods with correlation coefficients (r^2) of 0.995, 0.955, 0.999, and 0.985, for sites NA-1, NA-2, High Way-54, and Pill-Baptist, respectively. Figure 4 shows the relationship of data for all the four sites combined. The regression equation is as follow:

Shivaji’s Method (Y) vs. Johnson’s Method (X):

$$Y = 1.0587 X - 0.0283, r^2 = 0.994$$

The highly significant correlation ($r^2 = 0.994$) between these two mod-

els clearly indicated that the results obtained are not significantly different from each other at 0.01 level of probability.

The advantage of the “Shivaji’s proposed” method over Johnson’s and other methods is that the individual needles or the sample needle volumes are not required for the calculation of the needle surface area. Instead, the oven dry matter, which is the most commonly recorded and easily measured variable, can be reliably used. The only measurement required is the cumulative length of the needle which could be measured while the needle fascicles are intact. The oven dry weight required by the proposed method which is inherently more accurate, easily determined and involve only the use of a simple weighing balance without any spe-

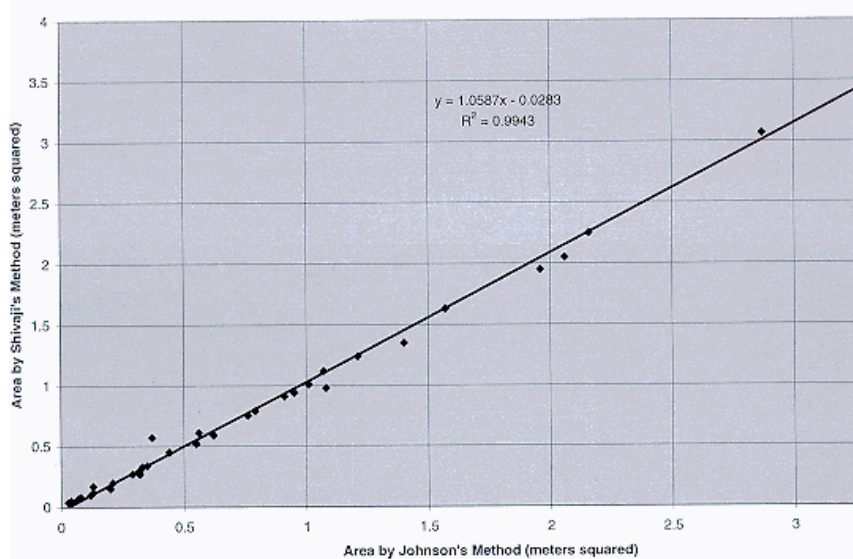


Figure 4. Relationship between needle area calculated by Johnson’s method and by Shivaji’s proposed method.

cial skills, training, techniques or additional equipment. This eliminates the chances of inherent errors in measurements associated with Johnson or photo-electronic methods. The “Shivaji’s proposed” method is much simpler to use than Johnson’s procedure for pine needle surface area determinations. Johnson (1984) clearly pointed out that the accuracy of his method would largely depend on the degree of needle taper and the ability of the investigator to determine and measure representative needle parameters. Because of this, the “Shivaji’s proposed” method is inherently more accurate and would tend to be more reliable. Further, the environmental conditions, and hence the needle geometry do not influence **Pc**, hence, **Pc** may be useful for different species of pine growing in different environments and locations. The pine constant used in the “Shivaji’s proposed” model, theoretically, should be applicable to all pine species (short-needle and other common species), and thus very useful for needle surface area determinations.

The “Shivaji’s proposed” method is based on the easily measured and more stable parameter such as the oven dry weight of needles. Unlike Johnson’s and many other methods, it does not depend upon needle volume which is quite variable as the prime parameter. In the “proposed” method, these variations and potential sources of error have been further reduced through the use of a factor called pine constant, which makes the “proposed” model much more versatile and reliable.

4 Summary

The determination of Loblolly Pine needle surface area was carried out using two established methods and a modified method. The photo-electronic method was generally not very effective in determining pine needle surface area. Johnson’s method and the “Shivaji’s proposed” method generated needle surface area values which were much closer to each other than the other method. There was a highly significant correlation ($r^2 = 0.99$) between the Johnson method and the “proposed” method. Although the “Shivaji’s proposed” method produced slightly lower values than Johnson’s method, there were no significant differences observed between the two methods at a 0.01 level of probability. The relative simplicity of the “Shivaji’s proposed” model to the other methods suggests that it may be better for predicting needle surface area, and consequently the leaf area index of pine trees.

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Northern Lapland nature survey 1996–1999

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Abstract

The survey area includes all the protected and wilderness areas of Northern Lapland and other lands not used for commercial forestry. Altogether the survey area covers about 2.5 million hectares, which accounts for almost 30 % of the land area administered by the Metsähallitus – Forest and Park Service.

Interest towards northern nature is increasing. Decision makers need information about nature, its current state, and changes occurring. Information is needed for planning the use and management of northern natural resources on a sustainable basis. The Forest and Park Service needs information for land use planning and management, for instance in protected and wilderness areas. The Nature Survey gives a firm basis for monitoring environmental changes.

In the Nature Survey every hectare of the study area is classified according to the nature types. The biotopes are identified and their boundaries are marked on aerial infra-red photographs. In addition to aerial photographs, information from other sources, such as old surveys, topographic maps, previous studies and local inhabitants, is utilized.

The various nature types are identified according to topography, vegetation, trees and natureless of the site. Nature types include rock, mineral soil, peatland, water and built environment. From the tree layer tree coverage, volume and species are listed among other things. Naturalness of a compartment is estimated using signs and knowledge of earlier timber harvests, deterioration of vegetation and amount of buildings or their remnants.

The most important outcome will be a modern and continuously updated geographical information system covering almost the entire northern Lapland. In addition, the data base will make it possible to produce maps and reports for various purposes.

This project has been started in the beginning of 1996 and it has to be completed by the end of year 1999. The budget for this is about 10 million FIM. European Community has granted about 2 million FIM for survey of Urho Kekkonen National Park.

1 Survey area

Mapping of the ecosystems of the protected areas, wilderness areas and other timberline areas in the Northern Lapland District for Wilderness Management and within Urho Kekkonen National Park commenced in the summer of 1996. The surface area of the region to be inventoried totals some 2.5 million hectares, which amounts to almost 30 % of the land area under Forest and Park Service (FPS) management (Fig. 1). The purpose of this work is to map the habitats, or biotopes, occurring in Northern Lapland. Data is being stored for computer processing on a real time basis. This is not a one-off documentation project but the creation of a permanent geographical information system (GIS).

2 Why is mapping data required?

The northern fell region and timberline forests were last mapped in the 1940s. Under the leadership of forester A. Hiilivirta, the mapping was based on field inspections, making use of the maps available at the time. The data recorded is imprecise and outdated. Lemmenjoki and Urho Kekkonen national parks were mapped during the late 1970s to early 1980s period, making use of monochrome aerial photographs taken mainly by aircraft. Using a method developed for forestry needs, it is not possible, however, to bring out all the essential features from the standpoint of protected area management and use. In the Nature Protection Unit it



Fig. 1. Nature survey area.

was considered expedient to prepare a common biotope inventorying guideline for the entire country. The Northern Lapland District for Wilderness Management and Urho Kekkonen National Park constitute the first area to which the inventorying method has been applied.

Finland has long traditions in matters associated with forest management. Our forests have been mapped for forestry purposes for more than a century. One requirement of the sustainable use of forests is the availability of up-to-date information. A forest management plan is required.

Data on ecosystems, their state, and changes in them is also needed as a basis for decision making connected with the management and use of protected areas and wilderness. The FPS requires documentable data for land use planning and control. Information is needed to make it possible to manage and use natural resources – both material and non-material – sustainably.

Mapping will provide better knowledge on the representativeness of protected areas, making their comparison possible. Afterwards we will know more about the natural values of the protected areas. Mapping data also provides basic information for studies on protected areas and for more precise mapping of the vegetation. Mapping provides a foundation for monitoring the state of the environment and changes taking place therein. Is the Scots pine limit shifting? Are the birch woods damaged by the autumnal moth recovering? Up-to-date data on these and other

subjects becomes available after mapping.

The results of ecosystem mapping published in various forms can be benefitted from by e.g. decision-makers, researches, reindeer herds-men, hunters, berry pickers, and those who generally ramble in the wilds for pleasure.

3 How is mapping carried out?

During mapping, the biotopes are recognised and their boundaries established, i.e. they are depicted using colour aerial infrared photographs (Fig. 2). The different biotopes are clearly distinguishable from each other in these so-called false-colour aerial photos, because the image on the aerial photos is based on the reflection of the near infrared radiation by the vegetation. Distinguishing different tree species and different degrees of moisture from false-colour aerial photos is thus easier than doing so e.g. from an aeroplane. In addition to aerial photos, information is also obtained from other sources, including old maps, topographic maps, studies, and local inhabitants.

Old maps and documents provide information on single tree selection cutting and forest management practices, as well as on pest epidemics. For instance, data is being entered in the database on the rather extensive Scots pine planting undertaken in Utsjoki and the northern part of Inari in the 1920–50 period north of the present Scots pine limit. FPS forest fire reports furnish us with information about fires that have raged in the

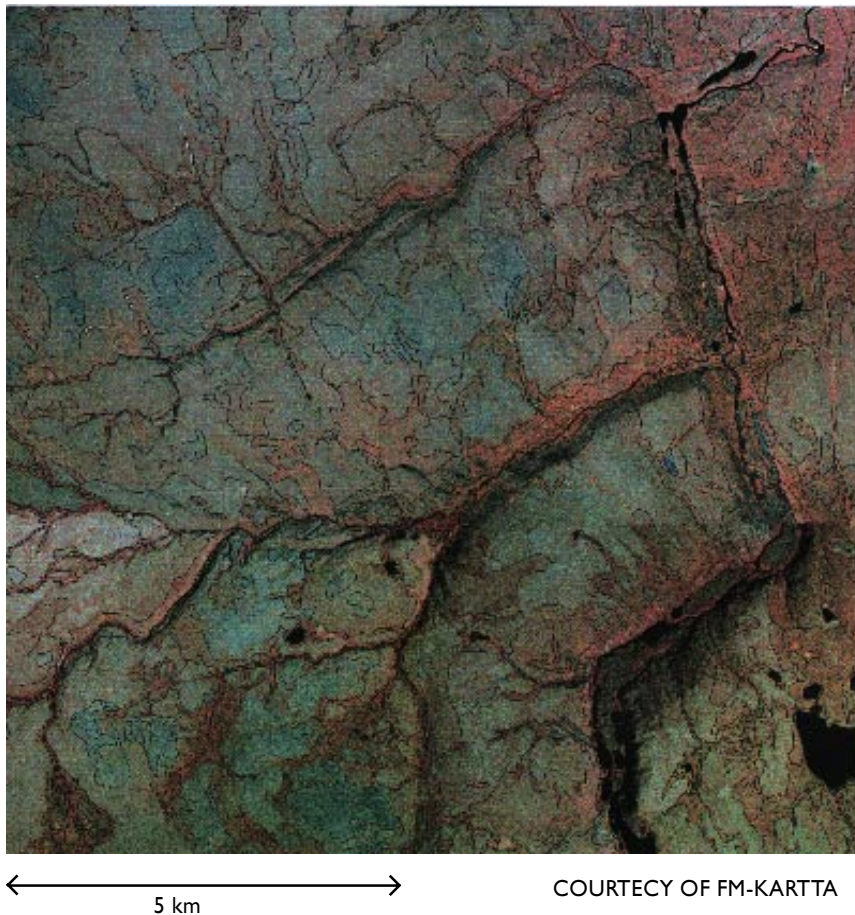


Fig. 2. The biotopes are identified and their boundaries are marked on areal infrared

region as far back as the late 1800s. Further information has been obtained on the damage caused by the autumnal moth in the Utsjoki fell districts during the 1960s, and on the extent of this destruction, from studies carried out on the outbreak.

Biotopes are determined on the basis of the terrain, vegetation, tree stand, and closeness to the natural state. A biotope may consist of exposed bedrock, mineral soil, peat-

land, water, or a heritage or cultural environment. The canopy coverage (%), amount of timber (cu.m), and tree species composition, among other things, are determined for tree stands. “Natural state” is assessed according to e.g. cuttings, physical damage to the vegetation, and construction. The inventorying method is based on evaluation of the data regarding the characteristics of the biotope. In the evaluation the classi-

fication system is incorporated in the GIS. This forms the biotope with the desired definition in each case.

The documentation work is divided into two stages. In summer, the surveyors visit the terrain and determine how the various biotopes are distinguished on the aerial photograph. Owing to the size of the area being mapped, it is not possible to visit every point in the terrain, so the surveyor carefully selects the aerial photographs beforehand by studying those areas in which he or she will perform field inspections. The aim is to obtain as comprehensive a set of data as possible on the different biotopes of the area. Field inspections are carried out over about 10 % of the total surface area. Making use of these keys to interpretation, the actual interpretation is then carried out in the winter as an indoor job. The boundaries of the biotopes are brought out by viewing the aerial photos with a three-dimensional stereoscope, and the data for each of them is entered in the GIS.

4 What is the result of mapping?

The primary result of the mapping is a GIS covering almost the whole of Northern Lapland which is kept constantly up to date. As a final result of the work a book is to be published

showing Northern Lapland's ecosystems and biotopes. Once the GIS data base is ready, it is possible to produce thematic maps (Fig. 3) and reports for various purposes from the material gathered.

5 EU financing

The overall costs of the ecosystem mapping are around FIM 10 million. Funds to the total amount of FIM 1 million have been received from the EU's construction fund target 6 programme for the Urho Kekkonen National Park part of the project. In addition, FIM 50,000 has been obtained from the European social reserve (ESR), and a further FIM 20,000 of provincial development funds to help meet the costs of the project's training phase.

Field work in conjunction with the ecosystem mapping was carried out in the summers of 1996 and 1997. The intention is to complete the documentation by the end of 1999. At the moment, about half of the mapping work has been completed and the numbering of sites is taking place.

The work is being carried out by the FPS's Rovaniemi Property Unit staff of 20. Additionally, use is being made of the expertise of the FPS's Data Services and Nature Protection staff.

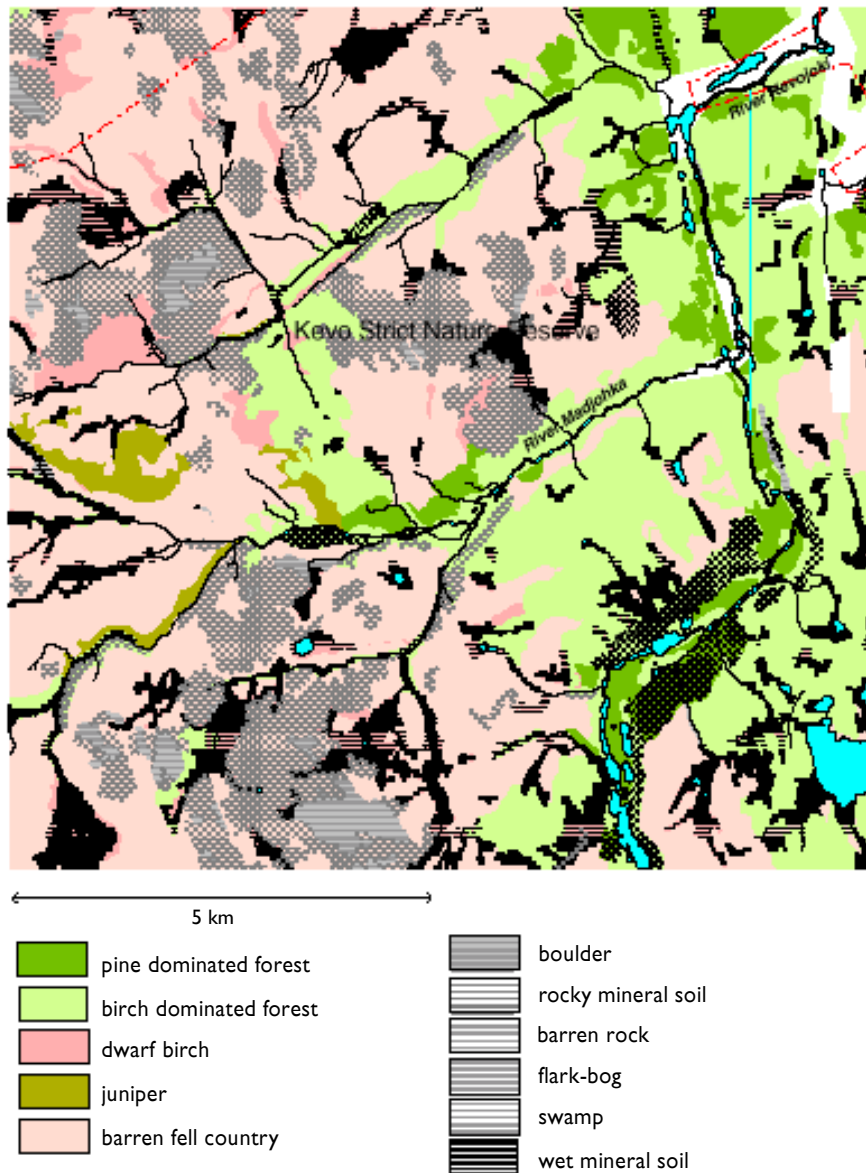


Fig. 3. Thematic map of northern part of Kevo Strict Nature Reserve: Birch and pine dominated forest and barren fell country.

Practical ways to minimize underutilization of forest resources: a case study

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Abstract

In northern areas one of the basic resources is wood in different utilizable forms. The forest environment also represents values of nature and recreation; however, the present paper is concentrated on material values of wood resources, such as traditional pulp and saw wood and new possibilities to utilize wood as energy. Also some newer possibilities to utilize wood resources are shortly discussed.

As a background for the paper is a recent study from Ii District, close to Oulu, northern Finland. In this study the sustainable utilization of forest resources in five communities is first estimated. The degree of apparent underutilization is estimated.

The practical ways of improving the degree of utilization of forest resources is considered: the pulp and saw wood, energy wood for different kinds of boilers and mechanical processing of wood.

At every stage of minimizing underutilization of forest resources, the information concerning local forest resources has been utilized. The role of available information sources will be discussed separately.

The question of quantitatively and qualitatively well-developed forest utilization is a general question, concerning all forest utilizing areas. In northern areas, however, the relative role of forest resources for the local well-being is the more evident. The present paper discusses this general question utilizing a regional case study.

I A short research description: a regional case study

Wood resources represent a natural resource which has a widespread utilization both in industrialized and

developing countries. For some areas there is a risk for overutilization, for tropical forests for example. On the other hand there are areas where forest resources are underutilized for one reason or another; the actual reason may be the long term development of the capacity of wood utiliz-

ing industry or the the general development of population localization, to mention some basic factors.

Set against this background we have carried out a case study concerning the underutilization question of wood resources in Ii District, northern Finland. This area consists of five communities in close proximity to the city of Oulu and the Gulf of Bothnia. The population of the five communities is altogether about 18.000 people and the area is 4 987 km². The number of employed people in the area is about 5 200. About one fourth of the population will get its incomes from the agriculture and forestry and three fourths from industry and different services related sectors.

The forests on the area are 69 % privately owned and the rest is owned by State and different companies. Typical for the forests in the example area is the high percentage of bog areas, about 55–60 % of the forest land area. Ditching has been carried out intensively on these areas and therefore there is relatively

high share of young pine and birch forests in the area.

In the case of the Ii District the hypothesis of the research was that it is possible to estimate the economic value of the wood material underutilization and also to point out those practical actions which may substantially decrease the amount of wood material underutilization. In other words there is a certain set of subtasks which has to be analyzed, in order to seek ways to decrease the underutilization of wood resources.

2 Degree of under-utilization of wood resources

When discussing the term ‘underutilization’ we must first define the sustainable level of wood resource utilization. A practical measure for sustainable forest resource utilization is the regional cutting plans which are based on actual cutting needs. The degree of underutilization is the ratio of actual cuttings to planned cutting needs.

Another measure for underutilization could be the qualitative term expressing for example the average refining degree of regional wood based products. Because the majority of the wood material from the case area goes to pulp wood and saw wood, this measure does not offer very clear possibilities of utilization. Thus we restrict ourselves here to refer to previously defined underutilization measures.

Technically the degree of underutilization can be estimated from the

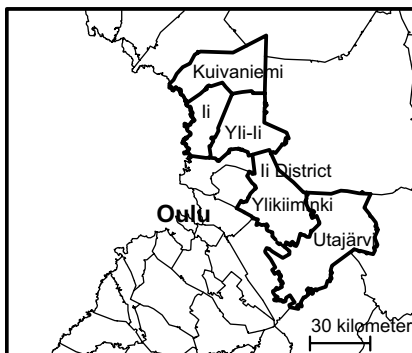


Figure 1. The map of the case area.

data obtained from local forest center. Basically this data is based on forest inventory which has been carried out over the whole country.

In the case of Ii District the above defined underutilization degree is about 40 % as can be seen from Fig.2.

The actual reason for underutilization is the realized cutting level which in turn is determined by the raw material requirements of the industry, both for pulp and sawing industry. The cuttings of course have been selective in the sense that final cutting areas are more economic for the cutting entrepreneurs than for example first thinning forest stands. Therefore the underutilization of wood resources is weighted mostly to the younger forests. Consequently, there is a trend in the case area that first thinnings are delayed.

3 Decreases in the wood underutilization through pulp and saw wood, energy wood and mechanical wood refining industry

In the case area the main ways to decrease the underutilization were investigated. The practical firms and operators of wood utilization were communicated to clear out ways to decrease the estimated underutilization in:

- pulp and paper wood and saw wood material
- energy wood material
- material for further mechanical wood processing

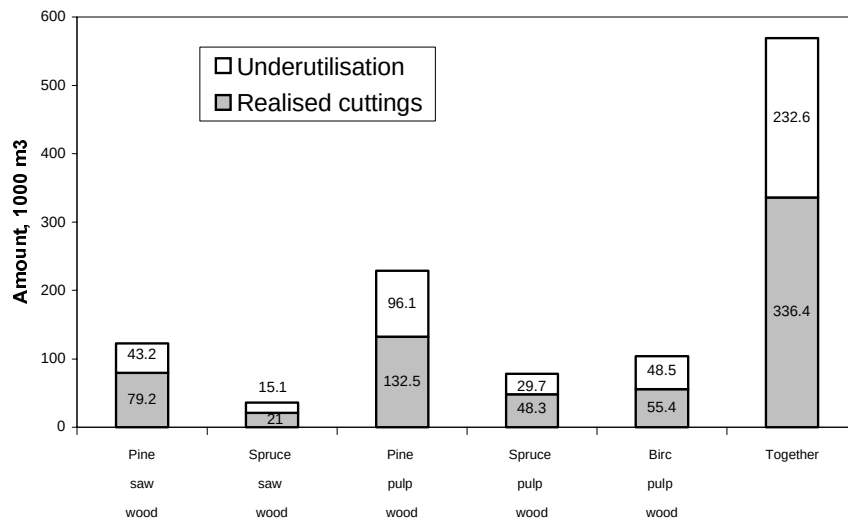


Figure 2. The underutilization of forest resources in the Ii District municipalities.

For the chemical wood processing industry there were three main wood utilizing firms active in the case area. All wood purchasers pointed out that their material purchases were clearly market controlled. Some addition might be found by intensifying the local forestry planning. In practice this means that the number of forestry plans for farms should be increased to activate wood selling of private forest owners.

The activation of energy wood production can be divided into several subtasks each one of which has its own economic terms or threshold factors:

1. development of large boilers fuel supply systems
2. district heating fuelling systems
3. large households fuelling systems
4. farm and family house fuelling systems

Each one of the above systems have their own possibilities to use energy wood as fuel. Essential for the energy wood utilization for each one of the above applications is the reference fuel price or reference energy price. For example, in Toppila heat and power plant there is chance to mix energy wood chips with milled peat so that about 700.000 cubic metres of wood chips could be utilized as fuel. The price of energy in wood chips should be approximately at the same level as the price of energy in peat, about 45 FIM/MWh (Mikkonen 1997).

Presently there is going on investigation how much energy wood actually can be produced at that price level within the fuel peat production radius of the power plant. The peat

production network is planned to be utilized simultaneously for energy wood transport from final cuttings and partly also from thinning areas close to peat terminals and transport routes, as seen in Fig.3.

This application is considered to be a quite potential chance to decrease the obvious underutilization of energy wood in large scale. The price-availability ratio will be decisive for this application.

In smaller boilers the use of energy wood is also possible, again depending on the reference fuel price. In medium size boilers, size 1–10 MW, the reference fuels are mostly heavy fuel oil, 104 FIM/MWh, and sod peat, 45.8 FIM/MWh. In a fluidized bed or grate type sod peat boiler wood chips can be easily used as an additional or alternative fuel.

In small households energy wood can be used as wood chips or piece like fuel. In the sample area, Utajärvi municipality there is a district heating plant and numerous larger and family households where energy wood is a real fuel alternative; the fuel selection is practically always done on economic basis, comparing with the economically closest fuel or energy alternative.

A systematic search for finding the most advantageous energy wood boilers in the case area will be carried out.

The estimate of energy wood resources in the case area is calculated based on certain average energy wood amounts per final cuttings and thinnings. The results show that there would be available energy wood for household use, district heating and

some excess also for uses in the larger power plant in Toppila. The actual future use will finally depend on the price development of the energy wood and the alternative fuels. In any case it is expected that utilization of energy wood will gradually increase by the efficiency improvements in the harvesting methods. Cutting residue is the most potential method to produce larger amounts of energy wood for larger boilers. The harvesting can be quite effective in this case, resulting in fuel price of about 50 FIM/MWh (Mikkonen 1997).

For smaller boilers the price for energy wood is 'allowed' to be slightly higher because of the higher reference fuel prices.

The important mechanical wood processing type in the area is wood plate industry for domestic purposes and exports. For mechanical wood processing of the example area wood is transported partly from outside of the area. Simultaneously there is an excess of young pine growing forests which is not fully utilized. Therefore sawing of small diameter wood would be very appealing development target in order to decrease the

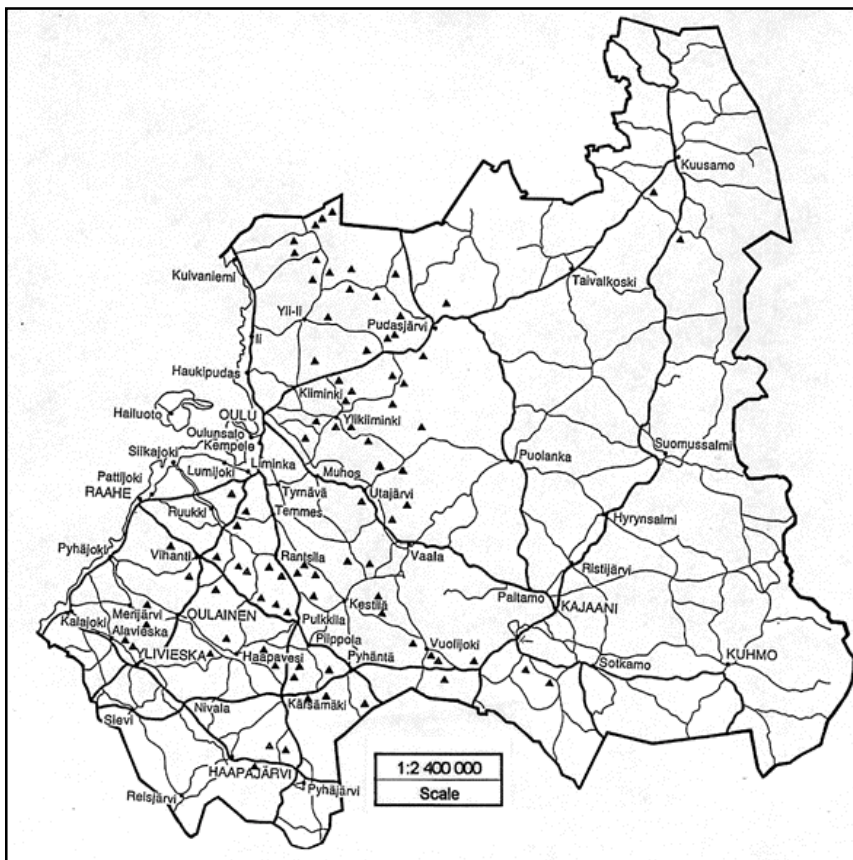


Figure 3. Peat and energy wood supply network.

local underutilization of wood in this way. The production of wooden plate elements for further refining industry is already an operating branch of industry in the case area.

As can be seen the represented methods for decrease of underutilization of wood resources are all dependent on many factors:

- market of pulp and paper
- fuel prices of alternative fuels
- development of the efficiency of energy wood harvesting
- development of small wood utilization technology
- the availability of exact wood resource information on local level

The actual expectations of the decrease in underutilization wood are in practice quite low and develop also slowly because of quite stiff development factors involved. However, the economic effects of the increased wood resource utilization are very valuable for the society. In the case area the theoretical total elimination of wood resource underutilization would result in about 300 man years addition in annual employment and in corresponding incomes in the area. Therefore even a slow positive development will be worth of efforts.

4 Role of information and technology in the utilization of wood resources

As can be seen from the above discussion the phenomenon underutilization of wood resources is ap-

parent in the case area. The same situation is valid, more or less, also elsewhere in northern Finland. In order to decrease the underutilization information about true resources should be available, as exact as possible. This concerns pulp and paper wood, wood for mechanical wood processing and different forms of energy wood.

Important from the information point of view is that, for each geographical area, we can obtain the information about the actual cutting possibilities for industry wood and energy wood. In practice this information is available in Finland in the regional forestry organizations and the Finnish Forest Research Institute. This information is based on periodical inventories of forests which is in turn based on test area methods.

The role of harvesting technology is essential both for industrial wood and energy wood production. Therefore it has a clear link into the underutilization problem: the more efficiently wood can be harvested the more competitive wood material can be offered to the market. This concerns both wood for refining industry and energy.

5 General conclusions

Based on the case study in Ii District, northern Finland, it has been shown that the underutilization of wood resources is annually about 40 % of the sustainable cutting level. Even partial reduction of this number would result in important effects in local

employment and income flows. This raises the question of ways to decrease the underutilization.

Underutilization of forest resources, qualitatively or quantitatively, is obviously a more general question. Therefore the discussion of underutilization can be understood as methodical one, applicable also on other forests utilizing regions.

The clearest ways to decrease the underutilization of wood in the example area are to further effectivize the forestry planning and wood marketing, to develop energy wood utilization chains as fuel in different sizes of boilers, and to develop the utilization of even small diameter wood use in mechanical wood industry.

The technology and information required in actual decrease of wood underutilization are partly those already utilized in conventional forestry but especially in energy wood utilization some new production concepts should be developed. The same concerns small diameter wood utilization technologies.

In northern sparsely populated areas, like Ii District is, the full utili-

zation of forest resources is very valuable for the local population, adding labour opportunities in rural areas where there is generally difficult to create new working places. It is expected that in the case area some tens of annual working places can be created by time when the underutilization of wood is decreased. To achieve this goal a systematic re-evaluation of wood utilizing systems will be necessary.

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Critical evaluation of frequent thinnings from the aspect of energy consumption and damages in the stands

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Abstract

The co-natural forest management has been demanded in Forest Act in Slovenia for many years. A part of co-natural approach is based on tending the stands, which is done repeatedly with the thinnings. So far, there has been a clear tendency to act in the forest intensively in time if the stands are able to react positively to our measures. The effect of tending is highest in young development phases but in these phases the principle is faced with strongest economical limitations. The consequences of the cuttings in younger phases are also damages of the standing trees which remain in the stands for a long time - until the end of the rotation period. Accumulated damages of the standing trees seriously endanger the positive effects of the tending. Evaluating the above statements, we used a mathematical model and simulations. The results from the model were also compared to the field observations in the stands of different ages. The comparison showed a close connection between the model results and the real situation in the forest. The paper discusses possible improvements. With later and less frequent thinnings we could probably get higher value of wood with less energy consumption and with better economical result. Present technologies of felling trees and long wood extraction are not adapted to intensive forest management on the principle of co-natural, sustainable and multifunctional forest management. One of the reasons is a very large share of damaged remaining trees during every forest operation (around 20 %). Where possible, the technologies should be changed to shortwood systems. Forest operations should be planned and done much more carefully.

Keywords: damages, forest operations, thinnings, co-natural, forest management, Slovenia

I Introduction

Despite proclaimed principles of sustainability, co-natural and multifunctional management is in practice many times contrary to possibilities of man's capabilities. They remain distant wishes. The difference between the desired and the possible remains a source of discussions among foresters. The arguments give legacy to those who say modern techniques are not adapted enough to forest environment, and also to those who argue that the ways of practical forest management do not include sustainable economics and real possibilities of forestry operations. Even-aged and mainly spruce alpine stands in Slovenia are very suitable for the study of coordination between silvicultural concepts and technical abilities to do proper work. The reason they were chosen for this study lays in good comparability with some parts of Europe as the Alps and some parts of Scandinavia where similar stands and terrain conditions could be found as well. With this we do not ignore the specifics of the Slovenian sites. We are only trying to simplify the comparison. In this paper we were interested in, what kind of long term consequences we can expect from widely used concept of early, low intensity and frequent thinnings on rationality of the management of these stands. For estimating the rationality we took in account the performed energy, harvesting costs, damages of remaining standing trees and the value of annual volume cut. The goal of research was to build a model of spruce stand development and to find relations between age and

tree diameter distribution on one side and harvesting time, energy consumption (machine and manual work), harvesting costs and the value of timber from undamaged and damaged trees when they are cut.

2 Methods

2.1 Model of spruce stand development

Input data for the model are the number of trees per hectare, average stand diameter, growing stock and the data of thinnings in certain age (Halaj et al. 1987, Kotar 1995). For achieving distribution of stand diameters in certain age we used the Gauss normal function. The parameters for each age (a five-year interval) distribution were arithmetical mean of stand diameter or mean diameter of the thinning and standard deviation which were $1/3$ of the mean. The result was the distribution of stand diameters as well as volumes according to age for original stand and for each thinning during the rotation age of 160 years. These data were used for computing cutting time (motor-manual) and wood extraction (adapted tractor). Model covers the period from the end of previous regeneration period to the beginning of establishing next generation. Rotation period of 160 years which is too long for normal spruce stands is chosen according to silvicultural practice in mountain forests where the possibility of producing high quality and large timber is the most important goal.

2.2 Working time and energy spent for cutting and wood extraction

Working times for cutting with a motor saw were calculated with regression analysis of data of the actual workers' performance during two last years in alpine spruce stands. Equation (1) is valid for cutting spruce on high mountain plateaus and for bucking up to 12m long assortments without barking.

$$Nt_{sec} = 29.2 + 12.6/v - 0.017/v^3 + 1.24 \cdot v \quad (1)$$

Where:

Nt_{sec} working time in min/ m³;
 v volume of timber in tree in m³.

Standard times for wood extraction with adapted wheeled tractors were calculated according to the acquisition:

$$Nt_{spr} = 1.13/v + 12.90 \quad (2)$$

Where:

Nt_{spr} working time in min/ m³;
 v volume of timber in tree in m³.

Fuel consumption for cutting with motor saw (l/m³) was calculated:

$$Ec_{sec} = 0.0092 \cdot Nt_{sec} \quad (3)$$

Fuel consumption for wood extraction (l/ m³) was calculated:

$$Ec_{spr} = 0.05 \cdot Nt_{spr} \quad (4)$$

Energy consumption of the machine and manual work during cutting and skidding was calculated with assumption that a motor saw needs 0.67l/kW of gasoline, a tractor 0.31l/kW of diesel oil, a cutter needs 29.3 and a tractor operator 14.7 kJ/min of work.

2.3 Value of timber and operational costs

The value of timber was calculated from the structure of assortments in dependence on breast height diameter of the tree (Fig.1). This value was calculated for every thinning in different ages and for every tree diameter in the stand. We took the following selling prices of the timber: veneer 16,500SIT, sawlogs I – 12,000SIT, sawlogs II – 9,500SIT, sawlogs III – 6,500SIT and pulpwood and other assortments – 4,000SIT/ m³ (data for January 1998, 1DEM = 92SIT).

The value of timber that is bucked from damaged trees was calculated with correction of the value dependant on the age of the wounds in the stand. Damaged trees in first thinnings remain in the stand for a very long time and their final value was only 20 % of undamaged trees.

The costs of cutting were taken as 2,406 SIT/h, costs of tractor skidding 4,332 SIT/ m³ (January 1998). The fuel prices were: 1l of motor saw gasoline – 108.56 SIT/l and diesel oil – 86.20 SIT/ m³. The costs of 1 kWh in cutting was therefore 72.74 SIT in tractor skidding 26.72 SIT. The costs of manual work during cutting were 1,175.00 SIT and in wood extraction 588.00 SIT/kWh.

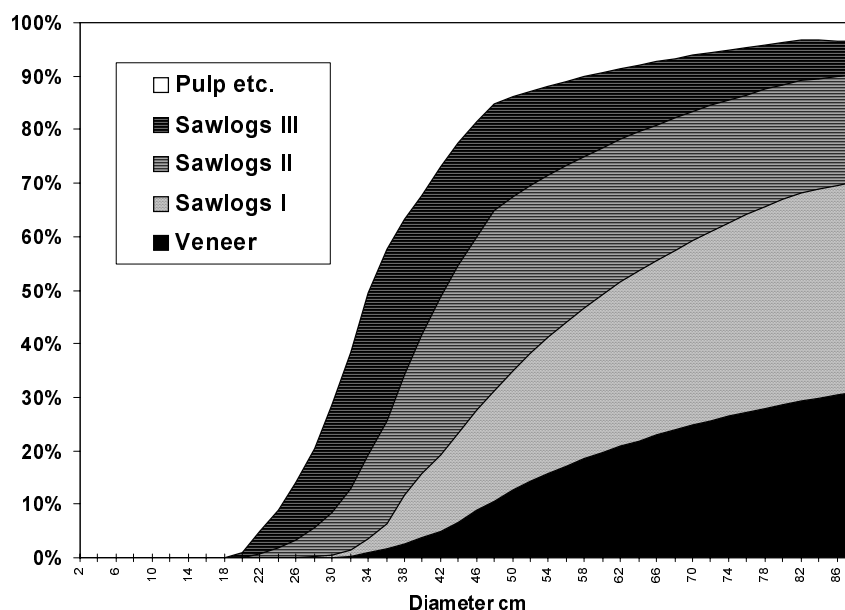


Figure 1. Structure of assortments in dependence on breast height diameter of the tree.

2.4 Damages of the standing trees

Parameters which influence the share of damaged standing trees (new and old damages) after each thinning are the intensity of thinning and the share of damaged trees in actual thinning. After many thinnings the damages are accumulated in the stand and the final result is calculated from the following formula (Košir, Cedilnik 1996, Košir 1996, 1998):

$$D_n = 1 - (1 - D_0) \cdot \prod_{i=1}^n (1 - d_i) \quad (5)$$

Where:

- n number of years;
- D_0 share of the damaged trees before the thinnings began (original stand),
- d_i share of the damaged trees in i thinning.

When we repeat thinnings the new damages join the previous ones, and the share of damaged trees is increasing and slowly approaching 100%. The final share depends on the number of thinnings and on the share of the damaged trees before the thinnings begin.

3 Results

3.1 Model of stand development

Model of stand development gave us diameter structure of the stand for each five-year period according to so frequent thinnings. The growing stock of the stand before and after thinning was therefore defined, as

well as the diameter structure and timber volume of each thinning. Distribution of tree diameters was normal, therefore the distribution of the tree volume was slightly asymmetrical. That was true for the stand as well as for the thinnings. Total value of number of the trees and their volume through the rotation period is shown in Fig. 2, where the dependence of the tree number and their

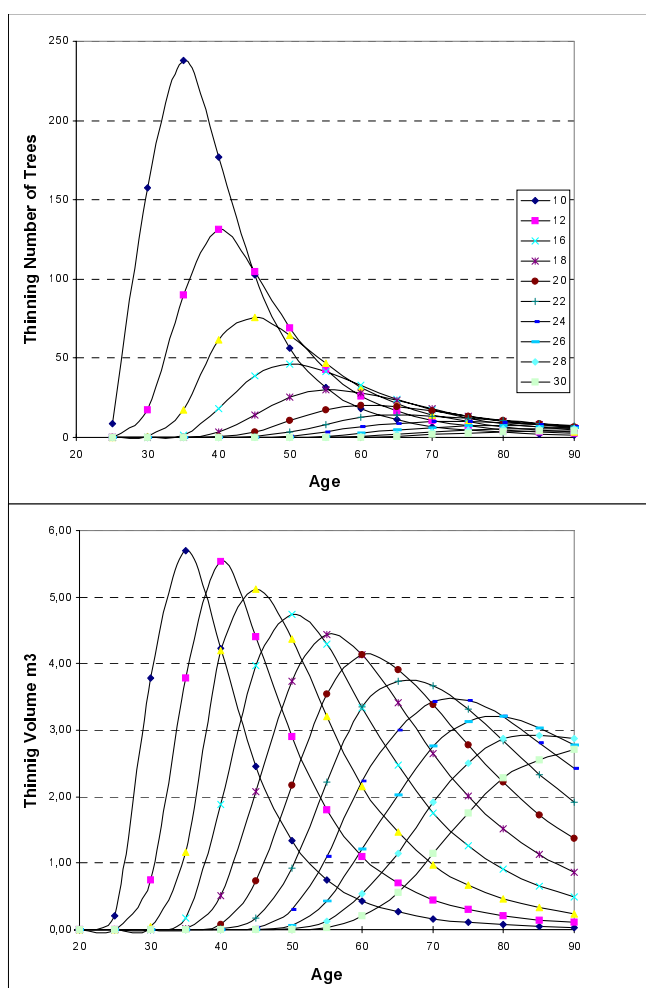


Figure 2. Distributions of trees according to age and diameter (range 10 to 30 cm as an example).

volume on the age of thinning is also displayed. Small wood prevails during the whole rotation period because larger tree diameters emerge in late ages.

This type of distribution significantly influenced the results. According to the input data we had to handle with great number of thinnings – as it is built in the concept of intensive forestry - where intensities of removed trees in thinnings are very small. The number of removed trees decreased very fast with the age whereas the volume of the thinning stood on almost the same level. The distribution of tree diameters in the whole rotation period has therefore a typical asymmetrical distribution with modus around 26 cm.

Comparison with the similar study that was done for similar reasons in different places in Slovenia in spruce stands of prealpine region shows the essential difference in shorter rotation age and more intensive thinnings as we assumed in our case (Krajcic 1996). That resulted in smaller average tree diameter and volume, which can be explained with different silvicultural concept.

3.2 Working time spent, consumption of energy and operational costs

Tree diameter structure is directly involved in harvesting working time and needed energy. Working time is defined with standard times functions and degresively decreases with the tree diameter. The working time spent in harvesting in the juvenile stage of the new stand equals zero.

At this time we do in the young stand first silvicultural works which are not included in the model. After the age of 25 years we start with the first thinnings where the majority of work is devoted to cutting the trees with a motor saw. The share of working time used for wood extraction in later development phases increases (Fig.3).

Working time is closely connected to energy consumption. The energy consumption in harvesting in dependance on the age of thinning shows very similar feature, slightly in favour of cutting because in wood extraction the energy consumption is higher. Most of the fuel we need in the whole rotation period is spent in thinnings up to 80–90 years (Fig.4). In later thinnings the demand for energy slowly decreases. Connection between this reasoning and emissions to the environment that have origin in burning fossil fuel and using lubricants shows us that in the time of early thinnings – where we can influence important selection of individual trees - the impact on environment is the greatest.

In total costs of working with machine the costs of energy represent a significant share (Fig.5), because they consist the sum of direct costs of fuel as well as the costs of manual work. In cost calculation of working hour we also find other costs which make the dependancy between the energy consumption and total costs of working hour unclear, but are important for comparison with the selling price of timber. Machine and manual work, differing in ammount of input energy per unit of production, show the state of tech-

nology in certain time. If we do not include the diversity of working conditions in wood extraction, the tree size has the major impact on the input energy. It is obvious that in whole

rotation period the number and intensity of thinnings are also extremely important when we talk of energy consumption.

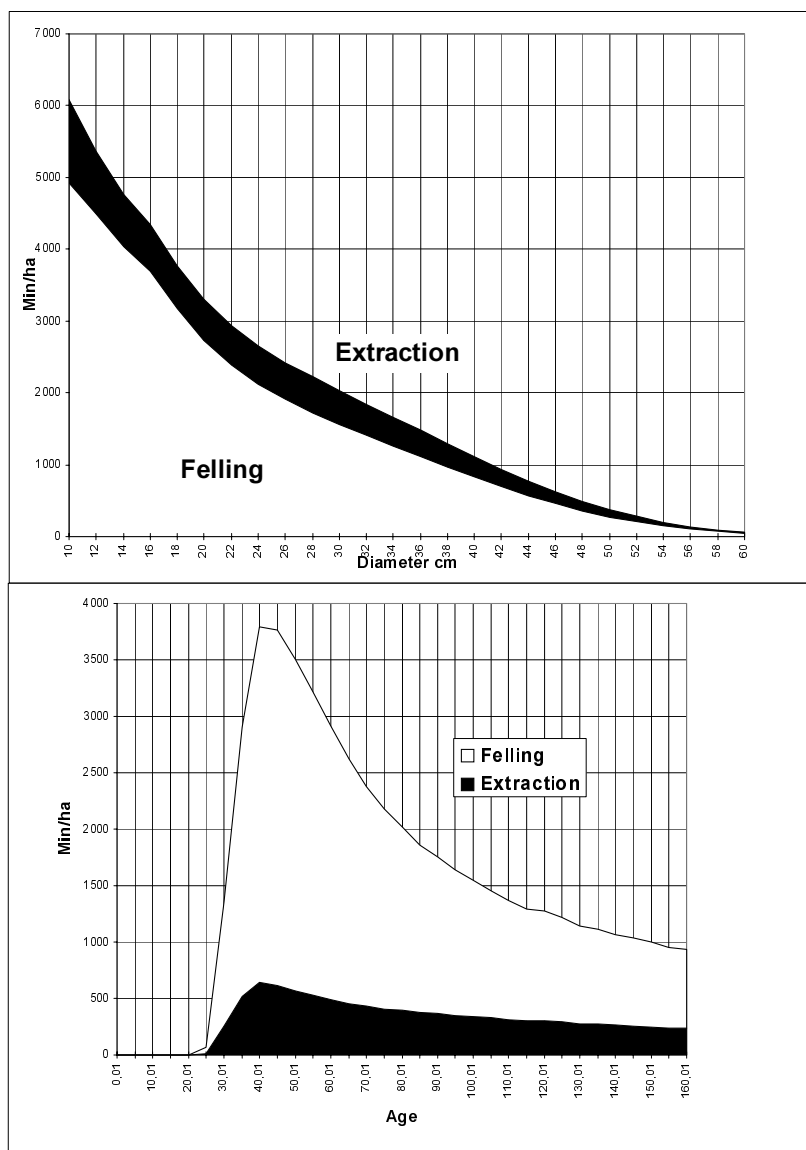


Figure 3. Working time of felling and wood extraction (min/ha).

Energy consumption of the manual work is within existing technology at every tree diameter smaller than machine work, and reaches the level of 10–12 manday/100m³ at the trees larger than 30cm. Machine work energy input is at those tree

dimensions around 33–35 kWdays/100 m³. This estimation is true mostly for larger trees, while for modulus of tree diameters (26cm, 0.46 m³/tree) the input of manual work would be 15 manday/100 m³ and machine work 41 kWdays/100 m³.

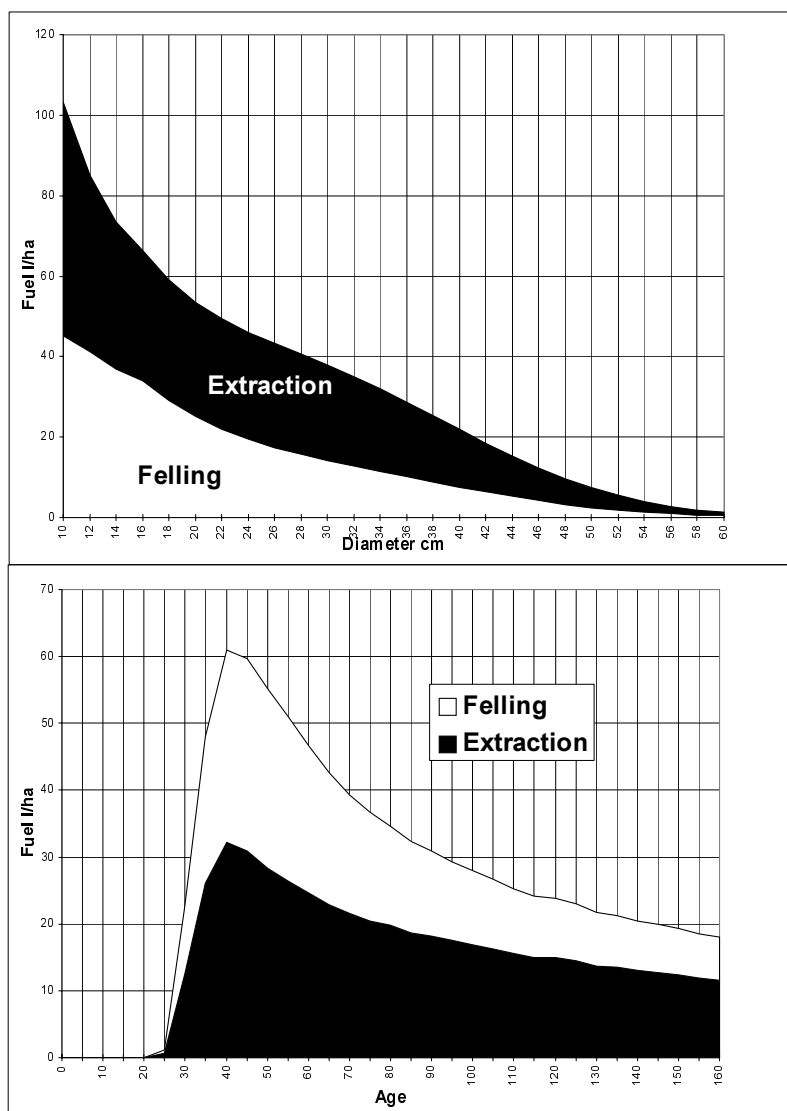


Figure 4. Fuel consumption of felling and wood extraction (l/ha).

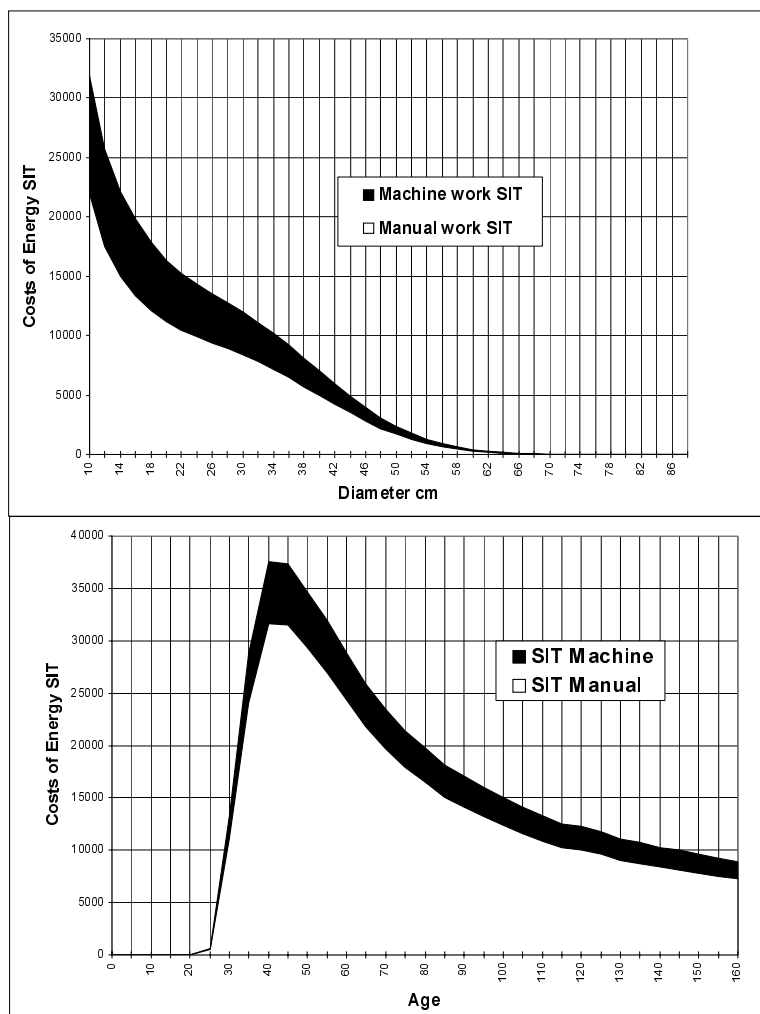


Figure 5. Energy costs of manual and machine work in relation to tree diameter and age of the stand.

3.3 Damages of standing trees

When cutting and skidding timber, the damages of standing trees are unavoidable consequences of this action. They accumulate in the stand in time, despite the removal of some of the most damaged trees in re-

peated thinnings. Field observations showed that a large share of damages occurs in regeneration period when heavy timber is transported through the regenerated area. In our calculations the damages in young stand were not included, therefore we supposed that the stand at 25 years, when we start with the first thinning, is

entirely undamaged. The share of damaged standing trees increases very quickly and after several first thinnings reaches 50 % of remaining standing trees (Fig.6). At the time

of greatest energy input we cause the most severe damages in the stand and in the environment through emissions. This practice is very dubious and critical if we have in

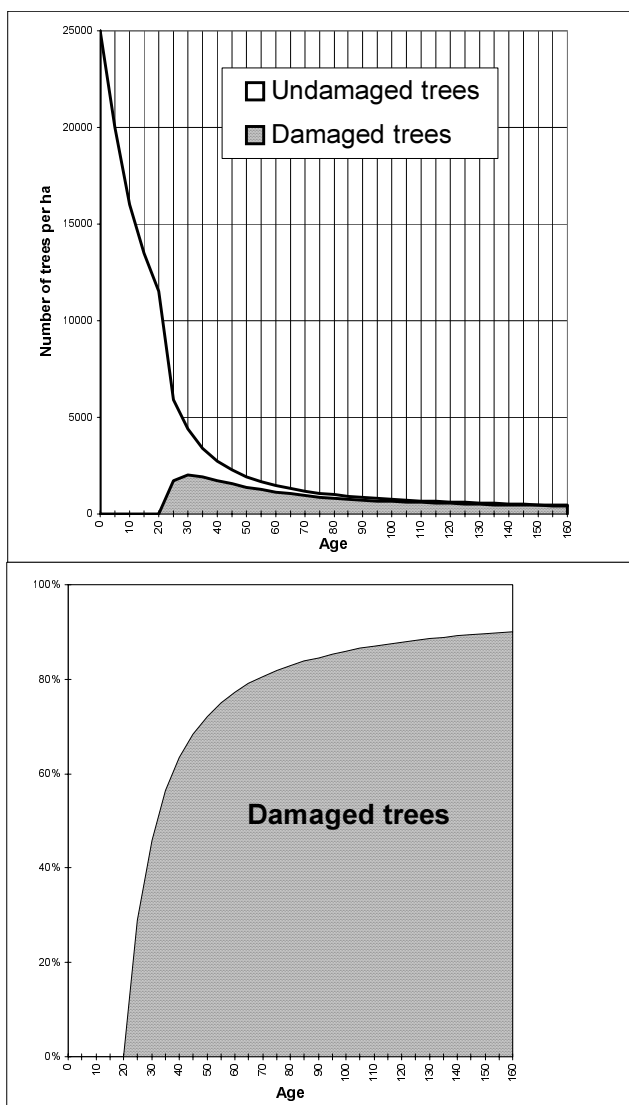


Figure 6. Damaged and undamaged trees in model stand.

mind sustainable forest management which includes the economics too, despite those thinnings should have good influence to the future stand from silvicultural point of view. Once again we have to stress that field observation confirmed a very high share of damaged trees in alpine spruce stands (Košir 1998).

Damages in the stand emerge at every thinning and some of them stay in the stand from the time they occur to the end of rotation period. The influence of such damages on the value of the timber is the greatest. Among the damaged trees the share of new damaged trees is at the end of rotation period very small, while the share of old damages strongly prevails.

3.4 Timber value and operational costs

The theoretical values of timber based on the estimation of assortment structure regarding the tree diameter were calculated for healthy and damaged trees. In calculation of timber value of damaged trees we supposed that beside tree diameter the main influence had the age of the damages. Smaller value of damaged trees had the reason in worse assortment structure and because of higher amount of cutting residues. We represented all those facts in a factor which was used to calculate decreased value of the removed trees in each thinning in dependance to the age (Fig.7).

The operational costs in damaged and in undamaged stand are more or less equal and could be directly compared to the value of the timber re-

moved in thinning. This way, we get the answer to the rationality in different ages (Fig. 8 and 9). The influence of damages to the value of the stand and to the value of removed wood is very high. In the undamaged stand the operational costs would be higher than the timber value up to the age of 75 years, when the positive difference would degresively increase until the end of rotation period or the beginning of new regeneration period. In the damaged stand the value of timber removed in later thinnings is getting smaller. The difference between operational costs and this value is slightly positive only for a short period. Only after the age of 95 the operational costs are smaller than the timber value, and the difference is very small. After 140 years the operational costs again overtake the value of removed trees.

The same relations could be observed in dependance to the tree diameter during the whole rotation period. Difference between operational costs and timber value in the undamaged stand is positive at trees larger than 22 cm, while in damaged stand break-even tree diameter is 30 cm. The difference in the damaged stand is also significantly smaller than in hypothetical undamaged stand. The loss in timber value due to damages in thinnings is very high and puts out the question of rationality of any thinning in the rotation period.

Sustainability has many parameters and only few of them are recognised in Forest Act and acknowledged in practice. Majority of silvicultural concepts, as well as forest operation practice, has not been adapted to the trends toward complex

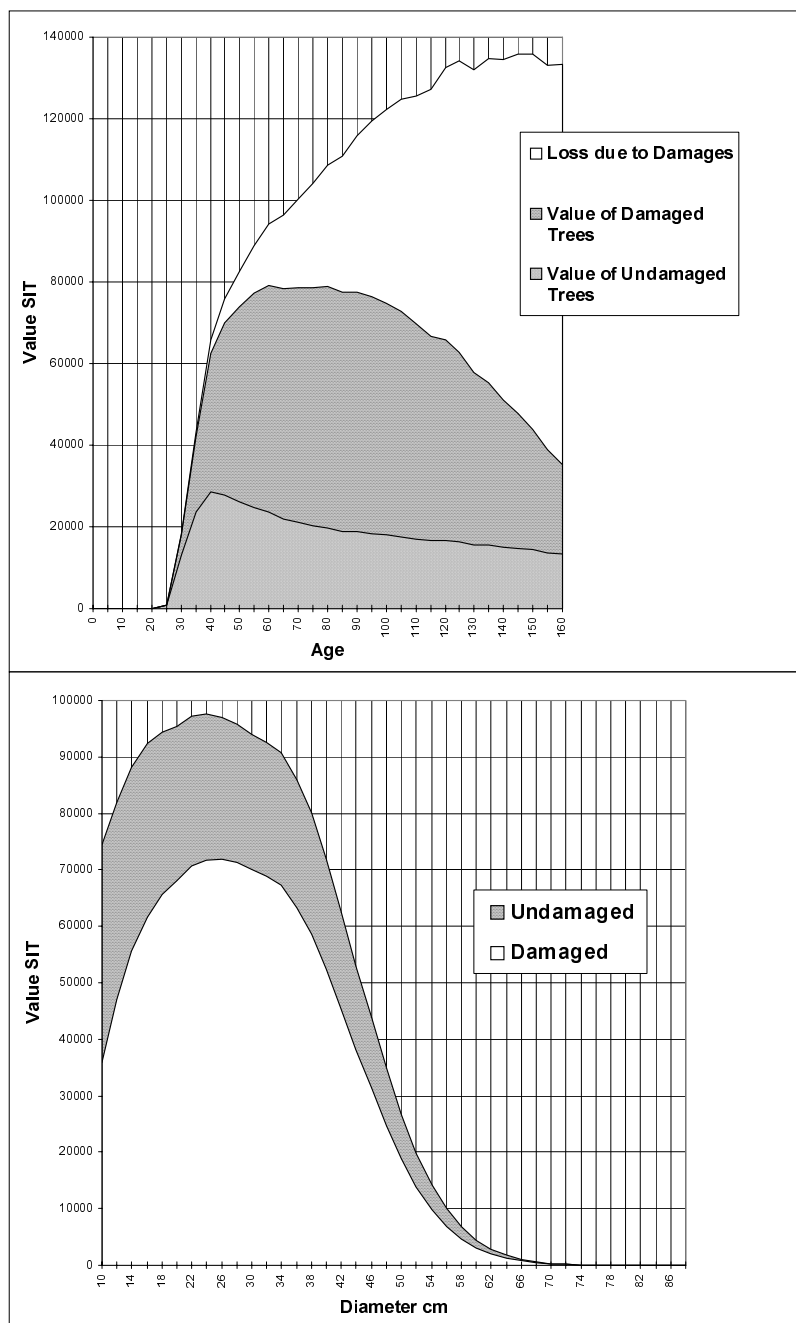


Figure 7. Value of damaged and undamaged part of the stand.

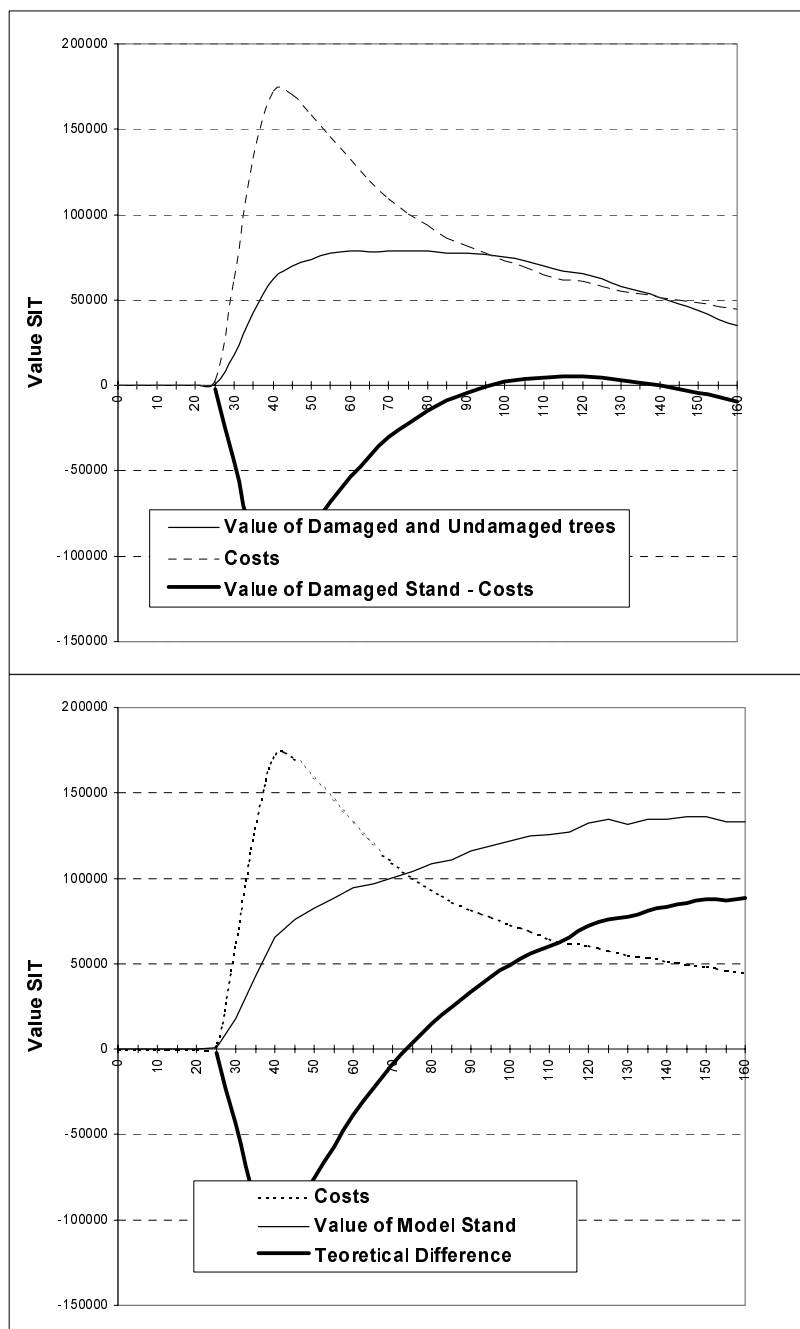


Figure 8. Value of damaged and model stand in comparison with costs during the rotation period.

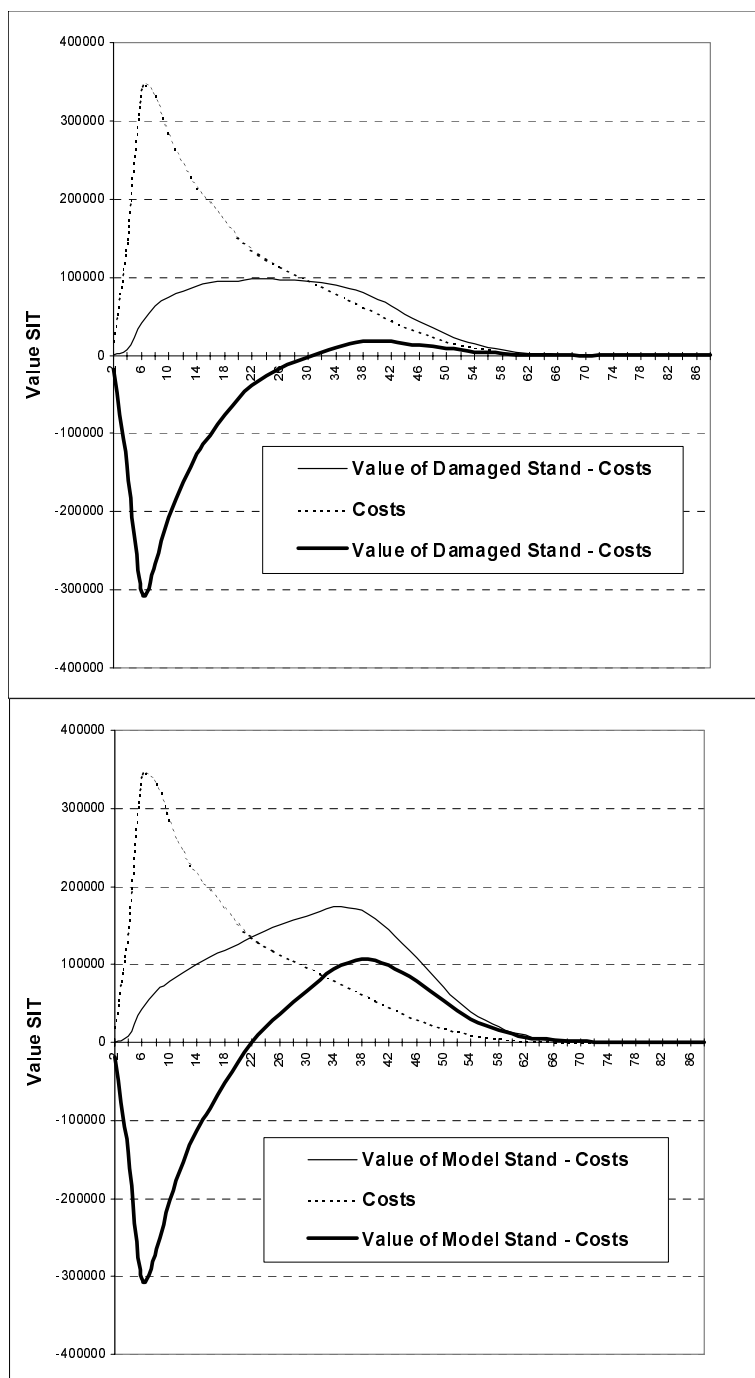


Figure 9. Value of damaged and model stand in comparison with costs in dependence upon tree diameter.

environmentally friendly behaviour that has developed recently. The answer is not in abandoning forest management on vast areas and in more or less rigid restrictions but in changing concepts of forest management on the basis of complex conclusions and applied research results. Forestry has to contribute its share in searching more sustainable way of living with nature and urban environment.

4 Discussion

The model should do the work which is trusted to models: to simplify reality so much to loose nonessential details which are hiding the rules of our interest. In our model some of very important input data which would be the results of research are missing, therefore we had to accept some assumptions and simplifications. Data which could improve the model's results are a better structure of assortments in dependence on the tree diameter and more reliable data of value loss when the tree is damaged at different age. The growth in the model could be improved with knowledge of growth functions for main domestic species where the necessary thinnings would also be included.

The model would show different results if it was applied to beech stand. In any case, the results show that in the conditions of present technology the early thinnings – where too many damage is caused – are not rational. Much more cost effective, as well as energetically more reasonable results we may expect in thinnings up to 26 cm of tree diam-

eter, if we use mechanized felling and forwarding. The results of the model must be however proven with field observations, despite some field research having already confirmed a very high rate of damaged trees at the end of rotation period. It is obvious that such practice should be changed if we wish to switch to sustainable forest management.

The model includes only a few factors which are important for forest management and have origin in forest itself (tree species, timber volume and its structure), technology (standard times, energy) and economics (costs and timber value). Factors connected with man and society have not been included in the model, but at this time that was not the intention of the research. Multifunctional role of the forest, restrictions in relation with it and its impact on forest management, stays a matter of further discussion.

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WWW environmental information resources “ecological bridges”

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Abstract

”Ecological Bridges” is one of national and the first for North-Western Russia regional Internet-server. The objective of the site is to create transparency for information on ecological problems, providing free access to the site not limited by submission and facilitating free opinions exchange.

Main sites of ”Ecological Bridges” are:

- The Red Book of St.Petersburg region, that is not the classical Red Book of region and the page does not pretend to be a legislative act. The items of information, submitted on page, on rare species and flore are also ordered by species - indicators selected during work on the project ”Corine-Biotops-North Europe”.
- Homepages of Environmental Organisations of Saint-Petersburg and Leningrad region.
- Bulletin of ecological safety.
- HELCOM Review in Russian.
- EMEP review in Russian.
- Internet- University and Ecological Education.
- Green World.
- Forests of region. Problems and it’s state.
- List of publications in General Ecology, the journals of the natural ecology in the WEB Site.

There are also examples of information on the most known ecological initiatives and events in the World:

- The UNESCO - Cousteau Ecotechnic Programme that supports institutional development, education, research, policy formulation, field projects and networking in interdisciplinary areas, such as Ecological Economics, Human Ecology and Ecotechnology.

- International Year of the Ocean' Web-site. The objective of this site is to provide up-to-date information on 1998 IYO activities around Russian and Baltic coasts.

"Ecological Bridges" are addressed to the young generation to show what a wonderful world of nature surrounds their virtual Internet world, and to let them know this world of nature needs their support. It supports education, research, field projects and networking in ecology and interdisciplinary areas.

On the fuzzy integrated assessment – influences of mechanised harvesting operation on forest environment

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Abstract

Promoting mechanisation of forest operation results in a more and less unacceptable environmental impact. Due to the increasing environmental concerns during past more than ten years, forest managers are urged to assess the environmental impact of current mechanisation and to solve those problems. From the point view of harvesting timber, it is very important that the optimization of harvesting system should be based on the environmental oriented procedure. In doing so, critical point is how to quantitatively assess the impact of harvesting operation on forest environment during optimising procedure of harvesting system. In this paper, harvesting machine performance indexes are defined as analytical tools of output of harvesting machine or mechanical systems in the way of standardised and aggregated factors. Based on analyzing the environmental consequences of harvesting operations, soil compaction, forest site disturbances and damage to stands are arisen as critical environmental parameters for the purpose of integrated assessment. Further more, in the scope of the theory of fuzzy mathematics, a fuzzy integrated assessment model has been established for assessing environmental consequences in relation with the reasonability and operability of harvesting machine.

Keywords: harvesting operation, harvesting machine performance index, environmental parameters, fuzzy sets, fuzzy integrated assessment model

1 Introduction

In Europe and other developed countries, mechanisation of operation is a rapidly increasing trend in order to increase labour productivity and harvest timber in cost-effective way. At

same time, promoting mechanisation of forest operation results in a more and less unacceptable environmental impact, caused either by misuse or by the objective inadequacy of a specific piece of equipment (Spinelli 1994). From the point view of har-

vesting timber, when setting up the planning of wood procurement for forest managers or decision-makers concentrate mainly on the most appropriate mechanical system interaction with harvesting target area in specific given topographical conditions, i.e. methods for the selection of appropriate equipment and techniques, which is an effective procedure of optimising harvesting system in theory and practice. In conventional rules, operability of mechanical systems are always paid close attention under the given conditions. Due to the increasing environmental concerns during past more than ten years, foresters are urged to assess the environmental impact of current mechanisation and to solve those problems.

According to a large amount of literature, environmental consequences of harvesting operation had been worked out elaborately in the relation with the various types of forest machines. Consequently, operability and functionality of machines are greatly improved with the aspects of environment-friendly and ergonomically requirements. However, it is easily ignored and difficultly figured out that the point is, let's say, environment first, and then use of machines and system assessment. From this point of view, a critical point is how to correctly use machines in any given condition so that the minimum damage must be inflicted on the forest environment. In other word, this is other facet to solve problems concerned in opposite way under the environmental orientation. This paper deals with the biological and mechanical system interaction

and assessment method on harvesting operation, which tries to figure out the critical parameters on appropriate mechanical system of harvesting timber operation and establish a fuzzy model of mechanical system assessment.

2 Common points to be interrelated between harvesting operations and mechanical systems

Timber harvesting operations, as a systematic behaviour, exist strictly as multiple targets, including not only timber production itself but also socially acceptable state, economical feasibility and environmentally friendly aspects, under which might establish an integrated optimization model of harvesting system based on the environmental assessment on influence of harvesting operations during the commercial timber production rotation. Assessment of environmental consequences on harvesting operation focuses naturally on the man-machine system (mainly involving the skills, scrupulousness, and motivation of the operator) and interaction between machine and forest land.

2.1 Logging patterns and machine size

For the activities of timber harvesting, from first thinning and commercial thinning to the final cutting, different machines and tools are always

travelling through the stand. Mechanised operation are always carried out with small, medium or large size machines. As a system, harvesting operation incorporate different machines fitted to each necessary process. Under the conditions of different logging patterns, harvesting method and operation with different size machines must meet following requirements: ecologically based, management objectives, operationally feasible and socially acceptable. Machine size and its characteristics, to a large extent, plays a determinative role of reducing damage to soil condition and forest stand. The basic parameters to directly bring about the environmental consequences include overall height, length and width defining vehicle gauge which is related with spacing, free height and manoeuvrability between the trees especially in carrying out thinning operation. Theoretically, machine size reflects the working ca-

capacity in dimensions, volume and weight which define ground pressure impacts on the soil. In addition, structural properties of the machine determine the extent of environmental consequence dominating concerns of damage to soil and remaining stands.

Defining parameters of machine size incurring environmental risk in a given logging pattern is principally in relation with the vehicle gauge and weight for the management and the execution of the operations, category of engine power and pressure on the soil concerned as well in accordance with biological requirements. According to the presentation of Abeels (1994), for the purposes of classification relating to machine size with small, medium and large type to be fitted with different logging patterns, data about forest equipment might be demonstrated as the relationship between engine power, vehicle gauge and estimated pressure on the ground soil as Table 1.

Table 1. Machine size and correspondence to data about forest equipment.

Machine size	Engine power (Kw)	Width (m)	Total height (m)	Distance between axles (m)	Pressure on the soil (kPa)
<i>1. Ordinary forest tractors</i>					
small	<55	1.1–2.5	<2.8	1.1–2.9	15–100
medium	55–80	2.0–2.6	2.3–2.9	2.3–3.0	20–120
large	>80	2.3–2.9	2.4–3.6	2.6–3.6	20–130
<i>2. Specialised tractors (skidders, haulers, etc.)</i>					
small	<50	2.2–2.5	3.1–3.4	2.9–4.0	50–140
medium	56–80	2.3–2.8	3.2–3.6	3.8–5.2	50–140
large	>80	2.3–2.7	3.3–3.8	4.2–5.3	50–140
<i>3. Combined tractors and trailers (forwarders, processors, etc.)</i>					
small	<50	2.0–2.5	2.7–3.3	4.0–4.5	30–120
medium	56–80	2.1–2.5	2.8–3.5	4.5–6.0	30–180
large	>80	–	–	–	30–180

In practice, the pressures on the soil are dependent on the theoretical contact areas given by the manufacturers, which are strongly in relation with the width and numbers of tires or types of tracks of machine.

2.2 Harvesting methods and machine types

Three quarters of the industrial timber crops of the world are harvested with the tree-length and whole-tree skidding systems (Hakkila 1995). In Nordic countries harvesting is completely based on the cut-to-length system. The harvesting methods adopted in given situation determine the types of machinery systems in timber harvesting and the operation mode of the machines by which the environmental factors to be taken into consideration could be specified. Those operation modes of the machines, including processing (i.e. harvesting with harvester, forwarding and feller-bunching), cable yarding, grapple skidding, winching or direct dragging, and loading which means normally that crane loading is a necessary step in the handling of the forest products that implies typical devices mounted on the frame and the machine, can be arranged under categories of different harvesting methods.

In Table 2, environmental consequences of harvesting operation depend on the harvesting method and its operational mode, which can be indicated by the Index of machine performance. And these vary with the logging pattern from thinning to final cutting.

3 Environmental consequences of harvesting operations

Environmental influences of all harvesting operations in the forest stand occur on the ground where it is ineluctable. Especially in the case of first thinning and commercial thinning operations machines have to travel inside the growing stand. It is evident that individual machine or machinery systems in relation with the logging patterns and methods under different working conditions, to a large extent, will exert detrimental impacts on the soil and damage to stands. Different types of machine which operate under the same condition might bring about impacts on the soil and stands depending on the structure and function of machines, for instance, vehicle gauge, stability and trafficability of the equipment and working capacity etc. According to a compilation of the literature (Strokes etc. 1994) and other research concerned, main impacts of harvesting operations on the environment are discussed as following.

3.1 Impacts on the soil

Impacts on the soil involve mainly several detrimental consequences including the logging site disturbance, soil compaction and other consequences of soil. The displacement of forest floor incurs a decrease in water infiltration and drainage, a interruption of pore space continuity with loss of capillarity and allelopathy due to rutting caused by machine passes. On the other hand, compaction of the soil relating to soil

Table 2. Harvesting methods and main environmental consequences and measurement for assessment

Machine	Operation modes	Environ. conseq. (mainly)	Index of performance	Weight of factors
<i>1. Cut-to-length system</i>				
Harvester	Harvesting	– Soil Comp. – Disturbance – Damage to tree	$\mu(u)^*$ applied	$\sum_{i=1}^n a_i^*$ applied
Forwarder	Forwarding	– Soil Comp. – Disturbance		
<i>2. Tree-length system</i>				
FellerBuncher	Fellbunching	– Soil Comp. – Disturbance – Damage to tree	applied	applied
Processor	Processing	– Soil Comp. – Disturbance		
Skidder	Skidding	– Soil Comp. – Disturbance – Damage to tree		
<i>3. Whole-tree system</i>				
FellerBuncher	Fellbunching	– Soil Comp. – Disturbance – Damage to tree	applied	applied
Skidder	Skidding	– Soil Comp. – Disturbance – Damage to tree		

* Definition of Index of machine performances and Weight of factors could be seen in section 4 and 5.

bulk density is the effects of machine traffic, which causes a increase in bulk density and soil strength, a decrease of pore space and water infiltration rate and changes in osmotic pressure.

The extent of site disturbance reflects the results derived from the interacting formation of machine-terrain. The rut formation goes further to reflect the extent of site disturbance in relation with the types of

tracks and tyres. According to Koger et al. (1984), the dual-tired machines cause much less rutting than the single-tired ones and the trafficability of machine could be greatly improved simultaneously. The research indicated that increasing tyre size would increase bulk density under conditions of the same dynamic load, inflation pressure, and percent travel reduction. And the greatest effect on bulk density is percent travel reduc-

tion and the number of machine passes is also the most significant factor influencing rut formation. In addition, where wide and narrow tyres were operating under identical conditions, results showed that wider tyres do decrease the degree of soil compaction and that rut depths increased with the number passes were more for the narrow tyres than for wider tyres. But wider tyres, in fact, caused significantly loss in manoeuvrability. A good planning and precise evaluation is needed when keeping logging costs at acceptable level.

From the point view of machinery systems, in two popular systems of harvesting mechanisation: a feller-buncher, grapple skidder, loader/slasher system and a harvester, forwarder system in thinning operations, the skidder system had significantly more ground disturbance than the forwarder system. In a review (Strokes et al. 1994), the skidder system significantly compacted the soil with surface disturbance, the forwarder system only compacted the soil at the 5-cm depth where the surface was highly disturbed. Further more compared soil disturbance and compaction in different cases of cable logging and ground logging, skidder trails disturbed a large area of the stand, and the greatest compaction occurred in the skyline corridors.

3.2 Biological damage

The damage to stand in harvesting mechanisation comes to the main problem to be paid more attention, which especially occurs in thinning operation. There are mainly three

types of damages having directly influences on the stand growth, timber quality or diversity compromising (Abeels 1994): 1) Bark peel off with visible sapwood but no marks in the wood, occasionally incurring harmful infection risk of entrance for insects, fungi or cankers; 2) Stem damage of any kind where wood and so cambium is affected; and 3) Breakage of a stem or even of living root over 20 mm in diameter, which there is a growth loss and it affects the branching type and growth rate. In addition, where soil disturbance is severer, early survival and height and diameter growth are reduced, malformation frequency is increased (Terlesk 1986).

The machine types with the specific modes of operation and the machinery systems to be fitted to harvesting methods have different extent of damages to stands and other vegetation. In two thinning systems mentioned above, the skidder system had much more and severer damage to residual trees than the forwarder system based on different modes of operation, which was assessed by scar size and number of scarred trees per hectare. Operation modes of direct dragging and winching are often more dangerous for the standing trees. Grapple skidding mode will disturb more places, incurring more damage risk to stands. The operating and loading with the crane operation when harvesting and forwarding respectively cause the same problems because visibility is not always free over the zone of action. With no doubt, besides the skills and motivation of operator, amount of injured trees to some extent is caused

by uses of unsuitable machinery system and appropriate logging methods as well.

4 Method of integrating assessment of mechanical systems interacting on environmental aspects

In modern mechanised harvesting, influences on the environment aspects are apparent and ineluctable. The assessment of environmental aspects on mechanical systems implicate the integration of processing and analysing multi-parameters of mechanical and biological interaction based definitely on the operability of mechanical systems under the given conditions. The selection of mechanical and environmental parameters and monitoring are of importance to the resonability of integrating assessment.

4.1 Description of parameters evaluating machines and mechanical systems

From the point of view of optimizing the harvesting system, there might be four groups of parameters to be considered as critical parameters of evaluating the operability and reasonability of harvesting systems. These should include: 1) productivity; 2) cost effective issues; 3) environmental indicators; and 4) ergonomical aspects. In this paper, we concentrate mainly on specifying the

influences of harvesting operations on the logging site in the forest. Environmental consequences involve in several aspects of special emphasis on visual forest ground and tree damage assessment in practical way as following descriptions.

Soil compaction

The ground pressure of machine is a key factor in soil compact, which is a function of the weight of a machine on an average area of supporting surface. It can be mainly indicated by the bulk density in relation with ground pressure which is involved in track or tyre types of harvesting machinery. From the environmental requirements point of view, although soil compaction is ineluctable in practice the point is how to minimize the extent of ground pressure impacts on the soil conditions. From the more practical soil inspection point of view after harvesting operation, what kinds of situation that will exist depends strongly on the ground pressure of the machine and machinery system. It could be categorised as a range of ground pressures, for instance:

- most suitable range
- acceptable completely
- satisfactory
- unacceptable

The ground pressure of a specific machine correspond to the acceptability of harvesting operation in given conditions. It should be noted that there are different range of ground pressures due to machine types with various tires or tracks corresponding to different harvesting methods.

Site disturbances

It can mainly be indicated with the total across-sectional area of disturbances and some extent of the rut formation. The trafficated area of harvesting operation varied as different harvesting systems and logging methods. On the other hand, minimizing the trafficated area is very much dependent on the good operational planning, for instance, reasonable skidding road spacing and operator's skills. In many cases, under the given same conditions there are no big difference of across-sectional area. So, as a critical indicator of soil disturbance, the rut depth could be taken into considerations of site disturbances, which relies mainly on the types, size and inflation pressure of tyres besides the ground pressure of machine. The rut problem on harvesting operation would be categorised as a range of rutted extent as following:

- slight rutted
- accepted rutted
- heavy rutted
- unaccepted rutted

As mentioned, the rut depth results from the impact of various factors. So there are difficulties to some extent to specify reasons for the rut formation. On the basis of specification of each factor, a range of rutted extent could be indicated by an integrated index as a indicator of rut formation.

Damage to stands

This problem is in principle concentrated on the commercial thinning operations. Besides the suitable skidding road spacing needed and operators' skills during operations, types

and gauges of harvesting machine are determinatives in relation with damage to stands. Generally, the more bigger the machines are, the more risk of soil and stands damage they cause. Machines for the cut-to-length system result in less damage to ground floor and stands than machines for tree-length system do (McNeel & Ballard 1992). Machine with a boom-mounted processor is operated at wider spacing; and other type of machine, for instance, feller-buncher and skidder system has to travel to each tree, which could increase the disturbed area and more damage to remaining trees. The assessment of these consequences might emphasise on the structure and dimensions of machinery as following:

- machine size: large, medium and small size
- system type: cut-to-length, tree-length or whole-tree
- operation mode: skidding, winching, processing or loading with crane or boom and forwarding etc.

4.2 Fuzzy method of integrating assessment and analyses

The effect of machines and mechanical system on forest environment is one of aspects that are taken into considerations of evaluating the adaptability and optimisation on the mechanical system in given conditions. As mentioned at previous section, environmental consequences resulting from the machines interacting with forest land are determined

through some critical mechanical parameters. It is facts further more that those parameters are also specified with some of more detail factors. Due to the situations existing at timber harvesting systems, fuzzy models could be established as assessing tools.

Model I

Given, a set of factors, U

$$U = \{ u_1, u_2, \dots, u_n \} \quad (1)$$

and a set of evaluations (fuzzy set), V

$$V = \{ v_1, v_2, \dots, v_m \} \quad (2)$$

when evaluating a set of factors respectively, significance of each factor affecting the integrating evaluation can be indicated as a weight in a set of factors' range. It is expressed as a fuzzy vector, given A, relating to the U set; that is

$$A = (a_1, a_2, \dots, a_n) \quad (3)$$

where a_i is a weight of i^{th} factor ($i = 1, 2, \dots, n$), and it is satisfied with

$$\sum_{i=1}^n a_i = 1 \quad (4)$$

Evaluating n factors of U set respectively, a fuzzy evaluating matrix can be formed as following, let it be R

$$R = \begin{bmatrix} r_{11} & r_{12} & \dots & r_{1m} \\ r_{21} & r_{22} & \dots & r_{2m} \\ \dots & \dots & \dots & \dots \\ r_{n1} & r_{n2} & \dots & r_{nm} \end{bmatrix} \quad (5)$$

Suppose that the vector A be defined as an input of the evaluating system; and let's say that matrix R is a transformation of fuzzy relationship. Then, as a output, final results could be expressed as, given, B

$$B = A \circ R$$

$$= (a_1, a_2, \dots, a_n) \circ \begin{bmatrix} r_{11} & r_{12} & \dots & r_{1m} \\ r_{21} & r_{22} & \dots & r_{2m} \\ \dots & \dots & \dots & \dots \\ r_{n1} & r_{n2} & \dots & r_{nm} \end{bmatrix} \quad (6)$$

where $\circ$ expresses a multiplication of fuzzy matrix based on the max-min operand rules.

Model II

In the cases of too many parameters and complicated situations, evaluating procedure can be gradually accomplished according to different level of parameters. As Model I, given fuzzy sets of U and V, set U is divided into some subgroups; that is

$$\bigcup_{i=1}^p U_i = U, \\ U_i \cap U_j = \Phi, \quad i \neq j; \quad (7)$$

Thus, U has been divided into p subsets; these are

$$U = (U_1, U_2, \dots, U_p); \quad (8)$$

For each U_p , according to Model I, results of first evaluation could be as follow, B_i

$$B_i = A \circ R_i = (b_{i1}, b_{i2}, \dots, b_{ip}) \quad (9)$$

where, A_i is a set of weight corresponding to the U_i subset; and the R_i is a matrix of fuzzy transformation

$$\text{Let } R = \begin{bmatrix} B_1 \\ B_2 \\ \dots \\ B_p \end{bmatrix} = \begin{bmatrix} b_{11} & b_{12} & \dots & b_{1m} \\ b_{21} & b_{22} & \dots & b_{2m} \\ \dots & \dots & \dots & \dots \\ b_{p1} & b_{p2} & \dots & b_{pm} \end{bmatrix} \quad (10)$$

As a whole, suppose that fuzzy vector A be a weight range corresponding to the p subsets of U set, i.e.

$$A = (a_1, a_2, \dots, a_p) \quad (11)$$

then, final results could be expressed as

$$B = A \circ R \quad (12)$$

In fact, Model II is a second hierarchical evaluation model. Theoretically, there could be more detail model in multi-hierarchy depending on the complexity of system evaluation. For the purpose of solving problem concerned, there are several critical points to be discussed below.

- It is first point to carefully determine the weight range of the evaluating factors. Environmental constraint is one of the aspects affecting on the optimisation of harvesting system. It exists in different significance for the each factor to be taken into considerations. It might be different for the same factor to give rise to system evaluation under different situation, for instance, at different logging methods etc.

- In practice, due to complexity of system evaluation with multi-parameters, the max-min operand rule is not fitted with resolving of system evaluation problems in many cases. For this reason, based on the matrix of fuzzy relation, fuzzy linear weighted transformation is introduced as the treatment of solution as following, given matrix of fuzzy transformation

$$R = \begin{bmatrix} r_{11} & r_{12} & \dots & r_{1m} \\ r_{21} & r_{22} & \dots & r_{2m} \\ \dots & \dots & \dots & \dots \\ r_{n1} & r_{n2} & \dots & r_{nm} \end{bmatrix} \quad (13)$$

and a weight in a set of factors' range

$$A = (a_1, a_2, \dots, a_n), \text{ here } \sum_{i=1}^n a_i = 1 \quad (14)$$

then, results of system evaluation B :

$$\begin{aligned} B &= A \circ R \\ &= (a_1, a_2, \dots, a_n) \begin{bmatrix} r_{11} & r_{12} & \dots & r_{1m} \\ r_{21} & r_{22} & \dots & r_{2m} \\ \dots & \dots & \dots & \dots \\ r_{n1} & r_{n2} & \dots & r_{nm} \end{bmatrix} \\ &= (b_1, b_2, \dots, b_m) \end{aligned} \quad (15)$$

where

$$b_j = \sum_{k=1}^n a_k \cdot r_{kj} \quad (j = 1, 2, \dots, m)$$

5 Defining Index's method of forest machine performance

5.1 Standpoints of fuzzy assessment in identifying the influences on forest environment

In order to adequately reflect the impact the machines and mechanical system would have on the forest environment, we have to identify indicators that indicate the environmental consequences of harvesting activities and define the measurements of those impact caused by various kinds of parameters. In many cases, those impact would obviously result from the aggregation with respect to the multi-factors. A meaningful indicator reflecting the overall impact on the forest environment should be simple, but in some sense it might be expressed mathematically. The key problem of environment performance measurement is converting large amounts of data into managerially useful information via appropriate matrices (Tyteca, 1996). According to analyses referring to activities of harvesting operations above, many of the quantities to be measured are naturally expressed in physical and biological units. Normalizing those quantities can introduce a uniformity of measurement, which will also result in unitless or dimensionless measures. It is harmonized with the fuzzy method of an integrated assessment to be standardised in order to allow for proper and

easy comparisons. Thus, we could define an indicator such that

$$\theta \in (0, 1) \text{ or } \theta \in [0, 1] \quad (16)$$

with 0 and 1 being the worst and best possible values, respectively. First expression means that no absolute the worst and best value can be achieved in the open interval. On the other, the closed interval refers to worst and best observed value at more practical situation, instead. With the range of upper bound and lower bound, it is indicated as the some extent of environmental consequence in a particular parameter. An indicator can be relative or absolute, depending upon what the situation exists in the practice of integrated assessment. For instance, in the pre-operational analysis we frequently define a relative quantity as being the result of the comparison with different machines or mechanical systems. From the technical point of view, defining an absolute quantity can be utilized as an index of improving the technology, functionality, characteristics of the machines or even regulatory standards.

5.2 Index's method – machine performance indicator

Defining forest machine performance indicators as tools to assess environmental consequences on timber harvesting operations, it involves the critical parameters to be specified in relation with the interaction of machine and forest land. The indexes can range from very simple indica-

tors to more aggregated ones. From the point of view on wood procurement, it is dependent on the harvesting operations, for instance, being the differences among the clear-cutting and thinning operations. In many cases, for those parameters which directly indicate the system capacities, functionality and so forth, we can define the machine performance index as follow:

$$\begin{aligned} &\text{machine performance index} \\ &= AL / SL \end{aligned} \quad (17)$$

in which AL equals to actual machine performance level in a specified parameter for the given harvesting machine, and SL equals to the standard machine performance level corresponding to the types of harvesting operations. The standard level can result from the work study and efficiency research and so on. In the case that an index should be determined by the multi-parameter, for example, indicator soil compaction caused by the several mechanical parameters, travel times in that area and operator skills etc., we can simply define the machine performance index by the weighted average methods,

$$\begin{aligned} &\text{machine performance index} \\ &= \frac{1}{n} \sum_{i=1}^n (AL_i / SL_i) \bullet \text{weight}_i \end{aligned} \quad (18)$$

in which AL_i / SL_i can be calculated according to the equation (17) methods; and weight_i is satisfied with the condition $\sum \text{weight}_i = 1$, which means the extent of the significance in relation with the different parameters respectively.

Let's back to the description of fuzzy model. in fuzzy model I and II, elements of fuzzy relation matrix R involve the fuzzy measure with respect to a fuzzy set of assessment in a set of factors U. Each element, as a characteristic function, letting it be $\mu_A(u)$ indicates the grade of membership of u in A . Here, as the valuation set is allowed to be the real interval $[0,1]$, A is called a fuzzy set (Zadeh, 1956). The more closer the value is to 1, the more u belongs to A . A is a subset of U that has no sharp boundary. So far we are ready to define another method which calculates a value of the machine performance index according to the characteristic function in relation with a fuzzy set. For the purposes of assessment on forest machine performance, each elements of matrix R in the fuzzy model can be resolved by means of a specified fuzzy characteristic function $\mu_A(u)$ corresponding to the specific parameter in the given situations. Actually, there are different methods to determine the value of $\mu_A(u)$. In some cases, $\mu_A(u)$ might be determined by the fuzzy statistic method. According to the conclusions of He Z.(1984), most common methods to be used in practice are as follow,

Hamming distances or weighted Hamming distances

Let A and B be subsets of the factors set U respectively, i.e.

$$\begin{aligned} \delta(A, B) &= \frac{1}{n} d(A, B) \\ &= \frac{1}{n} \sum_{i=1}^n \mu_A(u_i) - \mu_B(u_i) \end{aligned} \quad \text{or}$$

$$\begin{aligned} \delta_w(A, B) \\ = \frac{1}{n} \sum_{i=1}^n \omega(u_i) |\mu_A(u_i) - \mu_B(u_i)| \end{aligned} \quad (19)$$

in which $\omega(u_i)$ is a weight relating to the u_i in U .

Several **fuzzy characteristic functions** can be selected, depending on what kinds of situation exists. As a value of u is smaller, descending half normal distribution or linear function are used as follow,

$$\begin{aligned} 1) \quad \mu(u) &= e^{-ku^2} \quad \text{or} \\ \mu(u) &= \frac{1}{1+ku^2} \quad (k > 0) \quad \text{or} \\ 2) \quad \mu(u) &= \begin{cases} 1 & (0 \leq u \leq a_1) \\ (a_2 - u)/(a_2 - a_1) & (a_1 \leq u \leq a_2) \\ 0 & (a_2 < u) \end{cases} \end{aligned} \quad (20)$$

when a value of u is larger, ascending ones are used as follow,

$$\begin{aligned} 1) \quad \mu(u) &= \begin{cases} 0 & (0 \leq u \leq a) \\ 1 - e^{-k(u-a)^2} & (a < u) \end{cases}, \\ \mu(u) &= \\ 2) \quad \mu(u) &= \begin{cases} 1 & (0 \leq u \leq a_1) \\ (u - a_1)/(a_2 - a_1) & (a_1 < u < a_2) \\ 0 & (a_2 \leq u) \end{cases} \end{aligned} \quad (21)$$

It is facts that there are also other types of fuzzy distribution to be chosen in real world. Due to relativity

of assessment of forest machine performances, linear characteristic function $\mu(u)$ is simply used in many cases. On the other hand, it is fact that a value of $\mu(u)$ in real interval $[0, 1]$ can be defined as an index of forest machine performance relating to a specific parameter in the way of fuzzy sets.

6 Discussion and Conclusion

In this paper three critical factors as the basis of assessing harvesting operations are discussed. In fact any one of environmental consequences should result from the aggregated factors, i.e. some difficulties take naturally place in the recognition of parameters and proper and objective quantification or measurement relating to harvesting machine performance. At this point defining an index method allow us to conduct some kind of comparison in the given standpoint; and go further to identify the various environmental impacts of harvesting operations for the purpose of fuzzy integrated assessment.

1) Fuzzy assessing model and index method

In fuzzy model, there is a crucial stage of processing the input and transformation of information, which account for the matrix of fuzzy relation transformation by means of harvesting machine performance index. In doing so, the measurement and evaluation basis should be harmonized in accordance with the definition of performance indexes. On the

other hand, in the case that use fuzzy characteristic function $\mu(u)$ to form fuzzy matrix, it must be very careful to identify the distribution of fuzzy characteristic function, provided that it plays a determinative role in the integrated assessment of harvesting operations.

2) Interpretation of fuzzy integrated assessment

An effective result of fuzzy assessment is situated in the interval $[0, 1]$ in which the closer the value of result is to 1, the more relative the interaction between machine or mechanical system and forest environment is under the given conditions. Assessing environmental consequences of harvesting operations could focus influences of environmental parameters on individual forest machine. In the case of involving comparison with different machines or mechanical systems, result of assessment is a relative in the same conditions.

3) Pre-operational and post-operational assessment

Generally, for the purpose of optimising harvesting system, assessing the interaction of machine and forest ground should be done during harvesting planning in order to identify the extent of influences of harvesting operation on forest environment. But in practice specifying environmental consequences of machine behaviour are based on the monitoring, observation, analysis and evaluation during harvesting operations. There in fact exists affirmation of some parameters in fuzzy assessing model that involve the interrelation between machine param-

eters and environmental parameters. It is of great significance that the interrelation of machine acting on forest environment could be determined so as to facilitating the pre-operational assessment relating to harvesting operations.

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The Internet Puutori – an electronic information exchange for timber trade in Finland

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Abstract

The main aim of this paper is to describe the ongoing process of establishing an electronic market place in the Internet for timber trading. There are several advantages of electronic markets. For the buyer, it is easier to search for the most suitable item from the database and the likelihood of finding suitable quality of timber for further processing will increase. Electronic market system, like Puutori, can also reduce timber procurement costs. It is likely that Puutori will induce more competition in the Finnish timber markets. The participants become more equal with respect to their place of residence which is an important feature for timber sellers. The Internet technique has several advantages compared to the client-server solutions.

Keywords: electronic markets, timber trading, Puutori-system, Internet

I Introduction

I.1 Timber trading and electronic markets

The Finnish timber trading business has been quite traditional in its ways of operating. The representative organisations of both timber buyers and sellers used to agree over the timber

price for the following season. However, EU officials promoting free competition focused their attention on the agreement system. Starting from the beginning of 1997, price agreements in the old form were no longer allowed. The negotiations have to be executed directly between the company and the forest owners or their representative.

The electronic markets have grown fast in recent years. The Internet has made it possible for people to communicate, transfer data and do business in a whole new way. Previously, the applied technique has widely been the client-server solutions. Here the expression electronic markets refers to both techniques, while the consequences to markets are similar.

Electronic systems may be used in trading goods and services in several ways and levels. In an information exchange, the participants get only information about traded goods, usually from a sales announcement on the computer screen. Often this form of information sharing is also referred to as an electronic market place. In the electronic markets, in addition to information transmission, the actual trade can often be executed on the screen. The speed of establishing electronic markets for various products has been very fast over the past few years, although so far it is still mainly some small size consumer goods that can be ordered via the Internet.

Compared to more traditional ways of doing business, electronic markets have several economical advantages. Electronic market place is a new way of trading goods. People become more equal with respect to their place of residence. Through the electronic systems it is equally easy for any user to contact the market place. For the buyer, it is easier to search for the most suitable item from a database instead of contacting each seller individually. This will also increase the likelihood of finding a suitable quality of raw material

for further processing. The importance of a two-way information flow has also been stressed in the context of electronic markets. This is achieved e.g. through discussion groups and electronic mail.

In timber trading, it is assumed that procurement costs could be reduced by an electronic market place. This reduction could be achieved by describing the stand accurately enough, so that the buyer is able to make an offer without seeing the stand. The need for prospective buyers to visit stands can be reduced which lowers the timber procurement costs. Part of the gain could be transferred to sellers as increased timber prices.

Electronic information system can induce more competition by increasing the number of offers per stand. The new offers could come from small companies who could easier get update information on stands for sale. An important consequence of establishing electronic timber markets is that such a system better meets the requirements of EU free competition policies.

1.2 Related research and aim of the study

In Finland, there has been discussion about the need for a timber (round wood) exchange since mid 1980's. Both the Helsinki School of Economics and Finnish Forest Research Institute have conducted research on this topic. Timber exchange was investigated and simulated by Kallio and Salo (1992), Kuula et al. (1992) and Vepsäläinen and Kuula (1992).

Their idea was to let the computer optimize the trades among the buyers and sellers. The feasibility of derivative instruments, futures and options, on the Finnish timber and lumber markets was investigated by Määttä and Palo (1991). They found that there is some interest for experimenting a commodity exchange in the Finnish timber and sawn timber markets. So far timber is not traded in any futures exchange in the world.

Toivonen and Palo (1995) stated that there is demand for an information exchange type of system for timber trading in Finland. Normal exchange and timber futures exchange were at that time not considered by the interviewed experts to be suitable for timber trading.

The main aim of this paper is to describe the process of establishing in the Internet a market place for timber trading. A preliminary study has been conducted to find out the attitudes and technical preconditions towards an electronic information exchange for the timber trade in the Northern Savo area of Finland (Määttä & Pesonen 1998). The project was named Puutori (a Finnish word Puutori means literally a market-place for wood). The results of the study have formed a basis in developing a prototype of the Puutori software and its Internet version. Even the most sophisticated and user friendly system may fail in becoming accepted by the potential users. Bearing this in mind, special emphasis in the project has to be put also on supervising the users and informing the timber trading parties about Puutori.

2 The Puutori market place

2.1 The Puutori system

There are two versions of Puutori: a client-server version and the Internet version. In the client-server version, the program installed into the client computer handles the transfer of sales announcements to the server computer. The server takes care of the storage of the sales offers. The client contacts the server through modem and the public telephone net. In the Internet version, the connection is made as to any web site using a web browser. The information content is the same in both versions. Users are identified by a personal username and password in order to control system users and gather statistics. Some forest owners prefer to place sales offers anonymously into the system. This is most easily arranged by putting the contact information of the local forestry association in the offer.

Advantages of the Internet version are often obvious. It is easier to start using the web version than a program requiring installation to a computer. The maintainer on the other hand avoids copying and sending disks, which is very convenient also in case of version revisions. In large timber buying companies, the security of the network is utmost important. The Internet services are easier to build safer against unpleasant attacks through data cables. The client-server version has often problems getting through the fire wall systems.

Using Puutori is easy for anybody familiar with Windows programs and the Internet. The seller fills in the facts describing the stand and sends the offer to Puutori. The timber buyer can set search criteria in the program, and the sales announcements in the server meeting these criteria are transferred to his screen. In the search criteria window, the timber assortment can be selected from a list and criteria for the amount per assortment can also be given (Fig. 1). In the client-server version the connection for data transfer is established by the Puutori program. After the transfer operation the program automatically disconnects the line. The server checks for the password and username. The server computer was situated in the Finnish Forest Research Institute.

The information in Puutori system has to be up-to-date in order to maintain the interest for using the program continuously in the timber trading process. To avoid old sales offers hanging on in the system, the deleting has to be properly arranged. An offer becomes expunged e.g. when the stand is sold or the data in the announcement has changed. Only the person who has put in the offer is also able delete it at any time. The users may neglect removing the offers, so there has to be also an automatic system for this process. A common method is to set a maximum time limit for the information to stay in the database.

There are of course many features to be included into the Puutori, the software development is never finished. The Puutori software should

Figure 1. Sample screen of Puutori - query from sales offers.

be integrated with the other software used by forestry associations. It should be possible to easily transfer the data contained in forestry plans and stamping captions into Puutori to avoid writing the same data twice. The benefits of Puutori would be further increased, if the stands could be seen on the map. Also the possibility to send bids by e-mail has been wished by the test users.

2.2 The suitability of electronic market systems for timber trading

In this section, we refer to the study made by Määttä and Pesonen (1998). The data in their study was collected by a mail inquiry in Autumn 1995. The questionnaire was sent to the private forest owners, forestry associations and forest companies in Northern Savo district. There was also a brochure enclosed to ensure adequate information for answering the questions. Here we present some of the results, which can be applied to both the client-server version and the Internet version of Puutori.

The expectations towards Puutori were asked from the forest owners and forestry associations. It is assumed that timber sellers prefer several buying offers over few offers. Forest owners estimated that the amount of offers on their stands would increase or remain stable after Puutori had commenced (Fig. 2). Similarly, forestry associations expected the number of offers either to increase (38 %) or to remain stable (38 %). In forest owners' opinion, electronic market place is expected

to have a positive effect on the timber markets.

The stands sold directly by forest owners are visited by two buyer candidates while the number is three when sold via associations. Every fifth of the stands marketed through associations is visited by more than three buyers. Asking a related question from the forest companies, 77 % answered to visit every or almost every stand which is on sale. The most common reason for visiting a the stand is to check the timber quality. Cutting conditions are checked by half of the buyers. There is a chance for huge savings in timber procurement, if there were only one preliminary visit to the stand before the trade.

Forestry associations were prepared to use computer programs in timber trading (Fig. 3). Half of the forest companies and 20 % of forest owners were also prepared to use

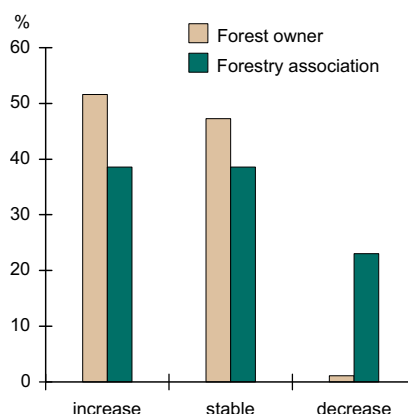


Figure 2. The effect of Puutori on the amount of bids per stand.

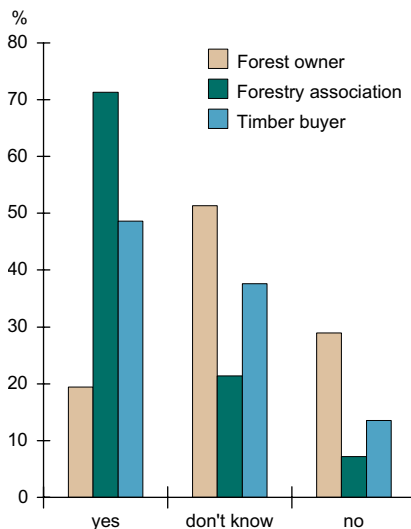


Figure 3. Readiness for computer based timber trading.

computer program. The share of people who had no opinion was quite high especially among forest owners. The timber trading professionals benefit more from electronic market system which might explain the differences between the groups. Forest owners sell timber irregularly and are often elderly people. The result is encouraging and probably changing even better along time.

3 Discussion

The decline in the number of timber buyers and agreements on timber price have caused the lack of real competition in the Finnish timber markets. The aim to increase competition was one of the reasons to start investigating the possibility to establish an electronic market place for the Finnish timber trading. Elec-

tronic information system can induce more competition by increasing the number of offers per stand and thus better meet the requirements of EU competition policies. The project to develop an electronic market place for Finnish timber trading was named Puutori.

Currently the technique to put up an electronic market place is the Internet. Puutori has got both the Internet version and the older client-server version. Advantages of the Internet version are often obvious. It is easier to start using the web version than a program requiring installation to a computer. The maintainer on the other hand avoids copying and sending disks, which is very convenient also in case of version revisions. The Internet connection is safer for companies with own network which is protected with fire wall technique. The client-server version has often problems getting through the fire wall systems. The impact on market structure is in both cases about the same.

There are several possible benefits known to be achieved by establishing electronic markets to a certain commodity or service. It is possible to reduce the costs in the whole trading and production chain. Information is electronically transferred to larger amount of people at lower unit costs as compared to more traditional methods. Cost savings can be achieved also in order handling etc. Electronic systems are thus often more effective than old trading systems.

Usually the timber buyers get the information of stands for sale from the forestry associations or directly

from sellers. If the same information were given to Puutori, the buyers would not have to go to forestry association office to check the stamping captions. The information is easier to keep up-to-date in an electronic system. At the same time a sales offer is transferred to database by the seller, it can be seen by all the buyer candidates.

It is common that the buyers go also to the forest to check the timber quality and harvesting conditions in the stand. Most of these visits to stands do not lead to a deal. In Puutori the timber quality should be described accurately enough in order to avoid the unnecessary visits to the stands. This would lead into reductions in the timber procurement costs.

Especially small timber buyers using in production special timber qualities, can benefit from Puutori. Small companies usually do not have own timber procurement personnel and they use more often special timber species and qualities in the production. Special quality may be for instance certain length or diameter of timber suitable or optimal for manufacturing a particular product.

The establishment of Puutori does not necessarily mean giving up the traditional ways of dealing with business partners. Puutori is a supplement system to the current timber trading method. When the system becomes better known in the markets, an increasing number of trades could be done based on the information obtained from Puutori. The fear of losing market power has raised some doubt against an electronic system among timber buyer and seller or-

ganizations. It is likely not the system causing the changes in market strength, more probable cause is the new regulations enforced by authorities.

During the experiment using Puutori is free of charge. In the future the system should be able to cover its expenses. There are several ways of taking a commission of using Puutori. Usual methods in similar systems are e.g. a fixed annual charge, per cent of trade sum and paying based on the time connected to Puutori. According to the study by Määttä and Pesonen (1998) the timber traders prefer to pay a fixed per centage of the trading sum.

The duration of sales offer before expiry is important for the system reliability. In similar market places has also arisen the problem of old announcements remaining in the database. Unnecessary contacts based on the old information undermine the system reliability and usability.

The organization to run Puutori should be clearly specified and impartial. This ensures the trust of the trading parties towards the system. The maintainer will be decided later based on the information obtained in the experiment period. The physical location of the Puutori server, however, does not play an important role for the system users.

The technical preconditions for the experiment are good: forestry associations and most buyers have the equipment to run Puutori software. There are many essential questions to be answered after the test use period. The fee for using the Puutori system and the information content of the software are some of the most

important questions to be decided. According to the results, the timber trading parties in Northern Savo in Finland are willing to participate in the Puutori experiment (Määttä and Pesonen 1998). It will in timber market participants' decision whether they start using the new possibility of contacting trading partners. It seems to be evident, though, that there will be changes forthcoming also in the traditional timber trading business.

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Distance learning courses: adjusting to conditions in Russia and NIS countries

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Abstract

In developing new software its use as an educational tool remains paramount in the programmers' minds. This development allows the lesson material itself to be supplied in different forms. The first interactive lessons in different languages for the students in coastal management, meteorology, environmental and other sciences are now available via Internet. These on-line lessons have the advantage of hypertext links and Java scripts to make the lessons more interactive, responding to the needs of the individual user. Besides, Java opened the door to really interactive training through platform-independence. Nevertheless, while striving for the higher degree of interactivity and filling the educational Web pages with Java applets in efforts to provide new educational facility to the world, attention should be paid to the fact that the number of Internet users substantially exceeds the number of users who have reliable Internet access. In our case, low speeds of data transfer bring to the first plane the idea of combining pre-installed platform-dependent software on one hand and Internet accessible instructions to training modules and their updates on the other.

The examples of the platform independent approach could be found on EuroMET home page, the European project on distance learning in meteorology, <http://euromet.meteo.fr/>.

The combined approach was realized in UNESCO project on CAL modules in remote sensing. The first on-line CSI-UNESCO lesson in English ("Deriving sea surface temperature maps from the ERS-1 Along Track Scanning Radiometer") is available from the University of Colorado, USA: http://frodo.colorado.edu/~cjd/atsr_sst/at_l2f.html.

Two pilot lessons for the Baltic sea and Gulf of Finland can be accessed interactively over the Internet from St. Petersburg, Russia: <http://www.dux.ru/csi/winbilko/index.htm>. These lessons comprise:

- an Intro to help the user to adjust software
- Lesson 1 (in English and Russian) Determination of surface types, snow and ice characteristics using visual study of AVHRR images and simple methods of its numerical processing
- Lesson 2 (in English and Russian) Comparison different methods of retrieval sea surface temperature in the Gulf of Finland.

Internet access to research results: an evolving effort

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Abstract

Since October 1995, our Research Work Unit of the US Forest Service has operated a Web site to disseminate research results. Initially, this took the form of basic information about the Unit's goals, organization, research problems, cooperators, etc. Over time the site has expanded to provide lists of available publications, abstracts of those publications, abstract searching, publication request forms, and electronic versions of publications. As part of the Forest Service's commitment to customer service, each reprint request or publication download also offers site visitors the opportunity to provide feedback to our Unit and to Forest Service headquarters using a customer survey questionnaire. The Web server's visitor log file has enabled us to analyze visitor usage and to make some valuable inferences about visitor preferences for particular subjects and for the technical content of research reports. The evolution of our Web site is described and some site-access statistics indicate how site visitors make use of the information provided there and how they respond to this mode of technology transfer. Since publications have been made available on our site more than 15,000 reprints have been distributed either in paper form or electronically, averaging approximately 700 per month currently. Many of these requests have originated internationally, mirroring the extensive reach of the Internet, and thereby including clientele that are otherwise excluded via traditional channels. Visitor response has continually encouraged the use of electronic documents (PDF files) due to their speed, quality, and ease of access.

Keywords: World Wide Web, electronic publishing, technology transfer

I Introduction

For the past 2-1/2 years our Research Work Unit (RWU) has been operating a Web site. The site became op-

erational in October of 1995. In the beginning, it was primarily designed to stake out a piece of the Internet with our name and our RWU's organizational mission. Quickly, it be-

came apparent to us, however, that our user community could benefit greatly if we increased the content of our site. Since that time, the Web site has continually evolved as we have seen opportunities to increase and modify services to our clientele.

Because we are a research organization, our primary product is research results. At first, we made these products available as on-line lists of publications (categorized by subject area) and as corresponding on-line abstracts. Site visitors could order publications by filling out an electronic form. Upon receiving form requests, the requested publications were copied and surface mailed to the customer. This process was very time-consuming and tedious, and reprint quality was often marginal.

Beginning in December 1996, we began to make our publications available as Portable Document Format¹ (PDF) files. Some overhead, in terms of time and expense, is incurred to produce PDF files, but the long-term savings are very attractive. PDF file availability permits visitors to download many different publications quickly without our intervention. Most notably, publication quality is equal to, or better than, reprints and photocopies.

Over time we have continued to retain and periodically analyze Web server log files. These records provide us with cursory information about users and allow us to infer certain other information. Six months into Web site operation, we performed an extensive analysis of site visitors and their use of our site's offerings (Schmoldt et al. 1997). We identified certain subject areas with

high interest, and found that certain subject areas could benefit by an increased number of popular (as opposed to technical) publications. We also found use by international visitors to be quite high. This is a clientele group that we would otherwise not have been able to reach through traditional technology transfer mechanisms.

In the remainder of this report, we provide additional details about our site and give some statistics regarding its use.

2 Web server details

2.1 Server hardware

At the time that we set up our Web site there was only one computer in our unit that had a hardwire Internet connection (campus Ethernet). Our remaining computers had 19.2K bits/sec connections. While the latter type of connection may be acceptable for accessing a Web site, it does not provide the bandwidth and reliability necessary to serve text and graphics to multiple, simultaneous users. Therefore we selected the desktop computer with an Ethernet connection as our server platform. This machine also served as one scientist's personal computer and, hence, our server did not use dedicated hardware. Because Web server access by users is intermittent, we did not expect that this dual use would significantly hamper the scientific use of the machine. After several months, however, we were able to move the server to another machine that was used only part-time by an adminis-

trative staff member. Finally, late in 1997 we moved the server to a dedicated machine that serves no other purpose than as a WWW and Mail server.

Our server platform is an Apple² Macintosh 7100/80 with a 10 Mbit Ethernet connection. We find that this provides adequate bandwidth and throughput for the load our site experiences.

2.2 Server software

We began our Web site using a shareware version of WebStar's WWW server software called MacHTTP³. About 1 year ago we switched to a freeware version of Quid Pro Quo⁴. We find that it is much faster than MacHTTP, is well supported, and has a compatible, high-performance commercial version available. We also operate a Mail server on the same machine. This allows us to set up mailing lists without relying on Mail servers outside of our control. In particular, we have considered creating a mailing list for our site visitors, but have not yet felt that it is warranted. We also operate an FTP server on the Web server machine, which allows us to edit and transfer files remotely. In addition to periodic backup copies of our server files, we also maintain a mirror directory structure on another machine.

Several server functions are carried out by Common Gateway Interface (CGI) plug-ins and scripts. One of these CGI's is freeware, provided by Apple Computer that allows visitors to search our site. This search plug-in is not very flexible, but pro-

vides basic functionality. The primary searchable content consists of our abstract pages. A second CGI allows us to easily mail and store information provided by user forms; this is a shareware plug-in. The third CGI is a script written by us in Perl to respond to user requests for PDF files. When a visitor selects a PDF file to download, they are automatically given a customer survey form to fill out and can then download the selected file.

2.3 Creating PDF files

Documents can be converted to PDF files in one of two ways. The first, and easiest, is to print a word processing document to a PDF file using the Adobe Acrobat PDFWriter printer driver. This method takes the least amount of time and requires the least amount of editing. Unfortunately, we don't have electronic versions of many of our older publications. Also, for those publications which we do have electronic copies of, final page layout was usually customized by the publisher. This prevents us from creating a PDF file identical to the published version. For this reason, most of our PDF files are created by scanning hard copies of the published documents and converting the scanned image to PDF format.

This method of converting documents involves three basic steps: scanning, processing and editing. The amount of time it takes to convert a paper document into a PDF file varies, but on average, it takes about 15 minutes per page. This includes all 3 steps mentioned above. Conver-

sion time depends on such factors as the quality of the original document and the page layout. Poor paper copies result in poor scanned images and thus increase editing time due to inaccuracy during processing. Tables, figures and variations in text styles also increase editing time.

The first step in creating a PDF file is to scan the paper document. Documents are scanned in black and white at 360 dpi using an Epson⁵ ES-1200C flatbed scanner and the Adobe Acrobat Capture software. Each image is saved as a separate TIF file and given a unique file name. File names are given sequentially so that the processing software knows the documents page order (e.g. page1.tif, page2.tif, etc.).

After all the pages have been scanned, the image files are processed using Acrobat Capture software. The processor converts the text image into text using OCR (Optical Character Recognition) and determines its font attributes. All other parts of the image, not determined to be text, are left as bitmap images. The results of the processing are saved as an ACD file (Acrobat Capture Reviewer document).

The final step in the conversion is to edit the ACD file using the Adobe Acrobat Capture Reviewer software. All suspect words found during the OCR are shown highlighted in the ACD file. Suspect words include those with a confidence level below 95%, those not in the dictionary, those with uncertain fonts, and those mixed alpha/numerically. The file is edited by tabbing through the suspect words, comparing the processed results to the origi-

nal document, and making changes as necessary. Once the file has been edited, it is saved in PDF format.

3 Results

Pages accessed on our Web site have increased steadily, but have leveled off at about 7,000–8,000 per month (Fig. 1). Our count of pages does not include graphic files (*.gif, *.jpg), but only HTML files and PDF files, so it is not equivalent to “hits”. The recent low value for April 1998 is most likely due to the fact that we changed our directory structure slightly. Consequently, regular visitors that had bookmarked certain pages on our site were not able to reach them in the usual way. Once we realized this problem, we added an alias to the old directory structure, so that the new structure could be accessed using the old bookmarks.

The number of publications requested has also increased steadily (Fig. 2). However, since PDF files became available in December 1996, the number of distributed publications escalated dramatically. The number of reprints requested has continued to decrease in number as more publications have become available as PDF files. The total number of publications distributed averages between 800–1,000 per month, with the total number greater than 16,000 over the past 2–1/2 years. The recent dip in publications in April is probably due to the bookmarking problem mentioned above.

Customer satisfaction is important to our government agency. Standard customer survey question-

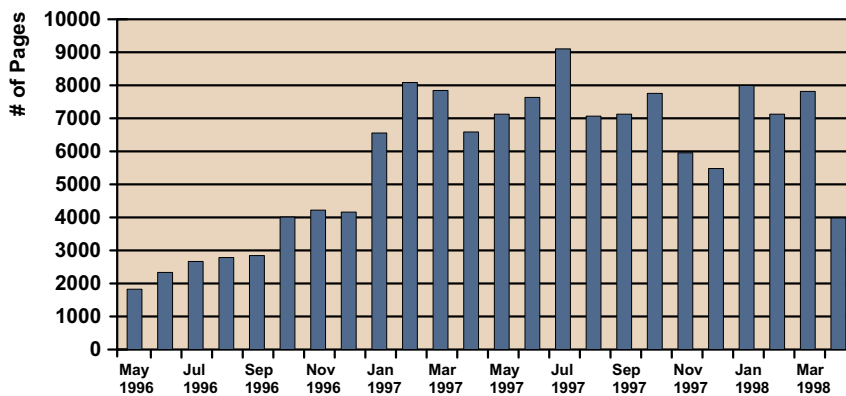


Figure 1. Pages accessed by site visitors are tracked over 24 months. Pages accessed are not synonymous with "hits"—graphic files are not included in these numbers.

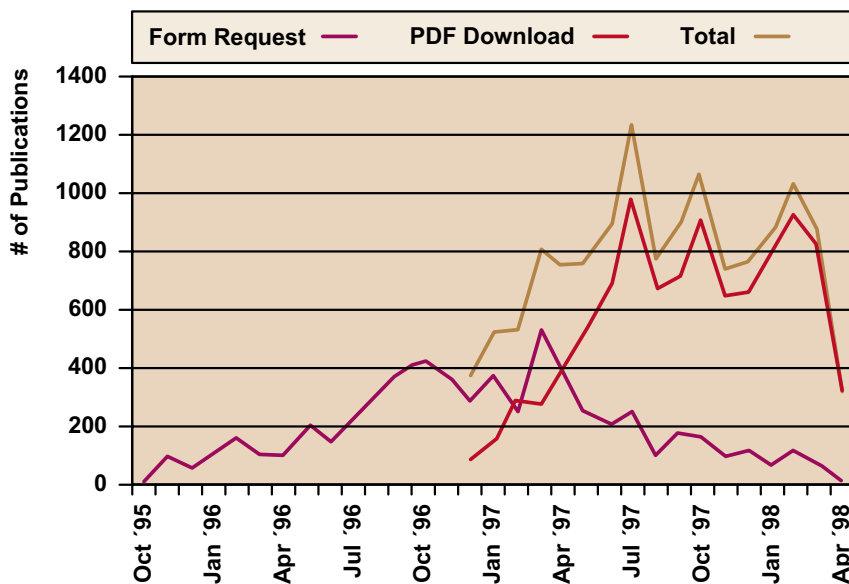


Figure 2. Publications distributed monthly are tracked for the 2-1/2 years the Web site has been operating. PDF files became available in December 1996.

naires are available and are given to customers after they have requested services from some facility or person in the organization. Form completion is entirely voluntary. We have

modified the standard agency questionnaire to accommodate our electronic services. Results from the 300+ surveys that we've received to date appear in Fig. 3.

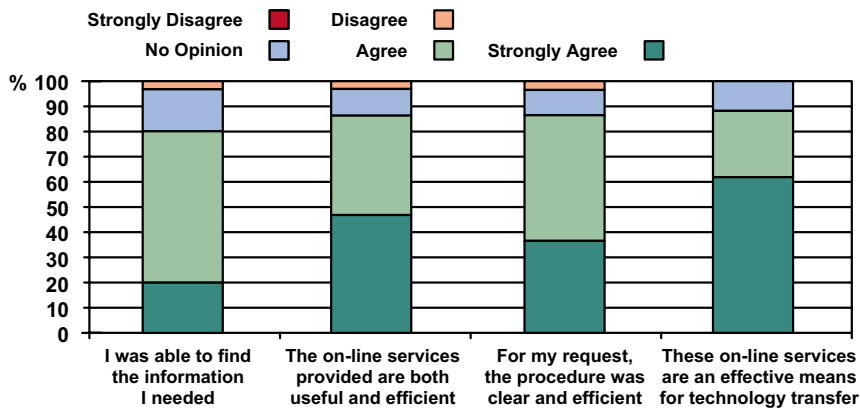


Figure 3. Our Web site is viewed quite favorably by visitors, as is evidenced by summary responses to the four questions included in our customer survey questionnaire.

4 Conclusions and discussion

Web site usage increased steadily for the first year or so of operation. Since then, site activity both in pages accessed and publications distributed has leveled off. This equilibrium behavior is entirely expected and seems to indicate we have reached a saturation point with our clientele. Based on visitor feedback in terms of survey responses, this electronic means of technology transfer is well received. In fact, earlier survey responses continually encouraged us to make more publications available as PDF files. The only publications not yet converted to PDF files are very dated ones and infrequently requested ones.

As noted earlier, we have greatly expanded the customer base that we

have been able to reach. Historically, research publications have been stored and distributed in paper format by our Station headquarters. Publication lists made available by them, however, were not targeted specifically to any particular customer group, e.g. forest products, in our case and were generally not available outside of the U.S. The worldwide reach of the Internet has allowed us, instead, to distribute beyond our own shores and to target those organizations and individuals most likely to benefit from our research results.

References

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Tradenames are used for informational purposes only. No endorsement by the U.S. Dept. of Agriculture is implied.

¹ Adobe Systems Incorporated.

² Apple Computer Incorporated.

³ Biap Systems Incorporated.

⁴ Social Engineering Incorporated.

⁵ Seiko Epson, Inc.

Activities in Latvia to establish the electronic information network for environmental management

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Abstract

There is the work group under the Cabinet of Ministers to develop the national programme "Information" in Latvia since the Autumn of 1997. This group will develop the strategy for Latvian governmental, academic, education and business organisations to be able to use up-to-dated information technologies in their respective fields – the environment management field included.

The national investment project "Establishing common environment information system (EIS) in Latvia" was accepted by Government in 1996. Latvian Environment Data Centre (LEDC) is responsible for implementation of the project. The project was intended as the extension of the activities carried out in Latvia to establish Local Area Networks (LAN) in the LEDC and in the Ministry of Environment Protection and Regional Development (MEPRD) of Latvia with the technical and financial support of US Environment Protection Agency (EPA) in 1994–1995.

Now the main achievement is the backbone of Wide Area Network (WAN) to link LANs in the following institutions

- Ministry of Environment Protection and Regional Development,
- Latvian Environment Data Centre,
- Environment Consulting and Monitoring Centre,
- Latvian Hydrometeorological Agency,
- State Environment Inspectorate,
- State Environment Impact Assessment Board,
- State Geology Survey,
- 8 Regional Environmental Boards.

The leased line connections are used in Riga (capital of Latvia) and the dial-up connections for Regional Environment Boards. The service of Government Data Communication Network (GDCN) is used to establish the WAN. The GDCN was announced by Government as the backbone for establish-

ing wide spread network for governmental organizations in Latvia. All developments will be based on this network in the future.

LEDC was nominated as European Environment Agency (EEA) National Focal Point of Latvia in 1996 and in the framework of Environment Information Observation Network (EIONET) the EIONET node point will be established and will operate in LEDC in 1998 to build-up capacity in the context of Europe.

The next step in the WAN development will be establishing the topic centers and providing on-line acces to the topics centers by using WWW, Oracle DBMS and GIS technologies according to the "Information Strategy of MEPRD for 1997–2002".

Integration of Telematic Projects: from UN projects to local authorithies' projects

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Abstract

A number of telematics projects is going, is planned or has been implemented in Ministry of Environmental Protection, Lithuania. Joint Research Centre is responsible for all these activities. As a number of projects is continuously increasing the integration of a set of projects to entire system is one of the main problems to be solved all the time..

The integration should include all components of telematics projects in full life cycle of project from idea to developing to implementation and to maintaining of knowledge base for experience collecting and dissemination and for providing a feedback. The components of projects are business processes, information content, informatics and telecommunication systems. All types of resources (human, financial, equipment, facilities, information) should be used in the most reasonable mode and assessed to meet requirements of a system approach..

The Ministry is dealing with projects in different levels: UN (INFOTERRA, maESTro), European Union (EIONET), European Regions (BALLERINA, Lielupe River Basin Water Monitoring and Management in Latvia and Lithuania), national wide projects (VADIS (Government Administrative Information System), State Treasury System), Ministry (information networks , including level of regional departments and agencies (municipalities).

As projects are in different stage and different technological infrastructure is used there is a number of integration problems both in technological aspects and in institutional ones including management (from international to local level) of project system, institutional strengthening (business process reengineering if possible), harmonizing legal and environmental content aspects and so on.

The Ministry has collected some experience in integration of projects and has prepared proposals for better management of the system of projects and solving of the integration problems.

There are a number of environmental information technology (IT) projects in different management and using level that our Ministry is carrying out, implementing, maintaining or discussing to start.

Level	Projects	Responsible
World and international organizations	UNEP UN network for environmental information dissemination UN maERSTro UN Environmentally Sound Technologies DB in WWW	JRC Science and Research coordination division Standard and Technology Division
European Union	EIONET European Environment Information and Observation Network	JRC Centre of Information Technology (CIT)
European regions	BALLERINA (all Baltic Sea Countries) Baltic Sea Region On_line Environmental Resources for Internet Access LIELUPE project (Latvia_Lithuania_Sweden) Water Quality monitoring and management for Lielupe River Basin	JRC CIT JRC CIT
LITHUNIA	Coordination Workgroup for Information Society Special Committee of Communications, Information and Informatics, National UNESCO Committee	ZB ZB
Government and interagency systems	State TREASURY system VADIS Government Administrative Information System	Accountant office of MEP CIT CIT Document Office of MEP
Ministry of Environmental Protection	Denmark ISIT project Institutional Strengthening through Information Technology (development of Klaipeda Regional Department LAN and connecting of Ministry and Klaipeda RD LANs) Homepage of Ministry of Environmental protection (legal, administrative and environmental information) PHARE DB of protected areas	CIT CIT MEP, JRC, CIT MEP, CIT
Regions (counties)	PHARE DB of protected areas (parks, reserves) Denmark ISIT project (Klaipeda) LIELUPE project (Siauliai, Panevėžys)	CIT
Agencies (municipalities)	Finland - Druskininkai environmental inspector GIS application	CIT, Druskininkai agency

I Integration aspects of environmental IT projects

For success of such a large number of projects to reach the best cost-performance, the best effectiveness, to minimize obstacles of implementation we

should integrate different aspects of projects during full life cycle:

- integration of goals
- integration in institutional aspect
- integration of information technologies for all components -networks, hardware, software
- integration of information content mainly in structured and paying special attention to understanding in different user groups

2 Problems for integration

Integration of goals needs to arrange linking of projects that are initiated, supported, maintained and used in very different institutions and organizations, e.g. UNEP, EEA, Government of Lithuania, Environmental institutions and funds of different countries and organizations, Environmental Protection Ministry of Lithuania, universities and research institutes, NGO and public.

As levels of management are very different there is a lot of different approaches how to prepare proposals for developing of goals and their integration.

Therefore institutional aspect of integration depends on persons responsible for initiating of the projects developing and implementing them. Institutional structures both of Environmental protection ministry and Ministry of Communications and Informatics is very important. Now in Lithuania one more public administration reform is expected after inauguration a new President in February 26, 1998.

Integration of IT consists of integration of hardware, software and telecommunications (network). The software is operational systems, data base management systems, office systems and so on. It is important if there are programs for conversion (transformation) formats from one software to other without losing the most important features of information structure and content.

Software is changing in increasing speed and not always the new

versions can use the information of previous version. Therefore it is a lot of problems in integration both different software and different versions of the same software.

Integration of content consists of different components. One of them is a classificatory or coding tool. The best solution is to use international codes but there are problems both in region (e.g. Europe) and in the country and sometimes in one large institution, e.g. Ministry. Other problem is terms; the third problem is related with grouping and storing of information and afterwards with searching. In Lithuania we plan to use Eurovoc for searching of documents in governmental institutions. Using of EnVoc is in the stage of discussion.

3 Other problems and obstacles

- management and integration of all types of resources (people, finance, equipment, information)
- long project life cycle, sometimes especially in preparation stage. IT are developing very fast and therefore if the prepared proposal or application is discussed for a long time the situation can be changed and you need to prepare new version.
- usually too small attention to information content as a lot of environmental IT projects are managed by IT specialists

4 Project success factors

- understanding of the importance of IT projects by top managers
- climate in institution or computer literacy
- high skilled IT staff
- professional system analysis especially in the preparation of proposals
- sufficient motivation for initiating of the new projects and for implementing and understanding of benefits of using IT
- understanding of extra time and labor expenses in the stage of implementation
- sufficient attention or integration of IT with existing (traditional) technologies (e.g. paper documents)
- integration of project management with information content quality assurance
- increasing of public awareness
 - developing of proposals for content structure to be understood in different user groups or easily transformed
 - target dissemination of information by implementing the new IT (webcasting, videoconferencing and so on)
- increasing of feedback between publishing sources and users
- training
 - general system theory as a background for integration of IT projects and information content
 - information management
 - teamwork for developing new information

5 Proposals

- Ad hoc workshop for integration of environmental IT projects
- Study for developing of strategy for integration of IT projects
- Discussion on the main directions
 - integration of business process reengineering and IT projects
 - integration of information management and IT

6 Conclusion

As the world is going to global information society and a lot of independent projects are carried out, going on or planned both in developed countries and countries in transition it is just a time to discuss the problems of integration of IT projects both in one sector and entire IT strategy for implementing in different sectors.

Environmental information from green world via email and www

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Abstract

Green World (GW) is the only one environmental NGO in Sosnovy Bor city, where the Leningrad Nuclear Power Plant is located. Sosnovy Bor also has other environmentally dangerous objects. Nevertheless, there are plans to build new nuclear reactors in this small picturesque city. Also, an oil terminal is to be constructed within the territory of Lebyazhiy natural reserve (protected by the Ramsar Convention) at the distance of 10 km from Sosnovy Bor. All this makes independent environmental information from the South coast of the Gulf of Finland highly important.

Striving to close the gap in such information, GW publishes two periodicals: the GW News: "Nuclear News of the North West Russia", and the GW Bulletin: "Baltic Region – Our Common Habitat". The goals of the GW News are to get and publish independent information about current and "hot" environmental issues in the Russian part of the Baltic region, and of the GW Bulletin – to get and analyze information about environmental problems, and to give information to residents and decision makers.

Until now, GW News and GW Bulletin, Russian and English versions, are distributed via e-mail to over 300 addresses to GW partners, and to subscribers of the Environmental North-West Line email network. The hard copy of GW Bulletin is also available, in Russian and in English, and is sent to over 200 addresses.

In March, GW will open its Web homepage. Some of its goals are to give access to Internet users to the issues of GW News, GW Bulletin and information about environmentally dangerous objects (existing, under construction, and planned) at the South coast of the Gulf of Finland. The participants of the Second BALLERINA Annual Meeting will get the address for this homepage.

BALLERINA - Quo Vadis?

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BALLERINA network co-ordinator
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BALLERINA Editor

Purpose & structure

- What is BALLERINA?
- History and background
- The way forward

What is BALLERINA?

BALLERINA

www.baltic-region.net

- An acronym
- A transboundary information initiative
- A Special Interest Network
- A 'top-level' Internet web site offering information resources and services

What is BALLERINA?

BALLERINA

www.baltic-region.net

- An acronym
 - BALtic Sea Region on-
Line
Environmental
Information
Resources for
Internet
Access



What is BALLERINA?

BALLERINA 

www.baltic-region.net

- A transboundary information initiative
- Overall aim
 - to contribute to the sustainable development of the Baltic Sea Region environment, by improving the availability and accessibility of relevant information on the Internet for decision-making at all levels.

What is BALLERINA?

BALLERINA 

www.baltic-region.net

- Objectives
 - To bring more substantive and relevant information on environment and sustainable development from and about the Baltic Sea Region to the Internet
 - To make it easier to find information by offering a user-friendly and comprehensive 'top-level' Baltic Sea Region web site -- the BALLERINA web site.
 - To develop a voluntary personal and institutional network of partners working towards the overall aim of BALLERINA.

What is BALLERINA?

BALLERINA 

www.baltic-region.net

■ As a phenomenon: A Special Interest Network

A Special Interest Network (SIN) is a group of people and/or institutions who collaborate to provide comprehensive information about a particular subject by means of various information activities on the Internet

(Green 1994, 1995; Langaas 1998)

What is BALLERINA?

BALLERINA 

www.baltic-region.net

■ BALLERINA network organisation

- Lead parties (UNEP/GRID-Arendal & Stockholm Marine Research Centre)
- Advisory Board
- Partners
- Funding sources (1996 - 1998); UNEP, EEA, World Bank, MoE Norway, MoE Sweden, Swedish EPA

What is BALLERINA?

www.baltic-region.net

■ Capacity Building activities

www.baltic-region.net



BALLERINA

BALTIC SEA REGION ON-LINE ENVIRONMENTAL INFORMATION RESOURCES FOR INTERNET ACCESS

BALLERINA is the place to go when you seek information on the Baltic Sea Region, have information to provide, or wish to communicate with others in the region. **BALLERINA** is a virtual meeting place, providing an opportunity for persons and institutions to find like-minded in the region.



BALLERINA is the result of a co-operative effort to provide comprehensive information about issues on environment, natural resources and sustainable development relating to this transboundary region.

Welcome to your environmental gateway to the Baltic Sea Region.

Baltic Facts

- Facts about the 14 **countries** in the Baltic Sea Region. - Facts about the **Baltic Sea and its basins**.

Environment

- National and international **State-of-the-Environment Reports**.
- **Environmental issues** in the region: Acidification. Air pollution. Agriculture. Climate change. Energy. Biodiversity. Eutrophication. Forests. Fish. Fresh water. Spatial planning. Toxic substances. Transport. Waste.

Meeting Points

- A regional **calendar** for 1997 and 1998.
- Coming up: **Mailing list** for announcements and interactive communication.

Actors

Who is doing what - why and how - in the Baltic Sea Region. **Organizations, agencies, networks, agreements, conventions, action plans**.

Baltic 21

A special web site about the ongoing work to develop a **regional Agenda 21** for the Baltic Sea Region.

Science

International **science** and R&D programmes. Activities in **education**. News from business and industry on **clean technology and new solutions**.

Search

- The **BALLERINA search engine** to search the site.
- Information about major **changes** and updates on the site.

Feedback

- Is BALLERINA user-friendly? Relevant? Terrible? **Tell us!**
- Also: **Propose more links** and information resources to be included.

About

Information for the BALLERINA network partners, and for anyone who wants to know **more about the BALLERINA initiative and network**.

What is BALLERINA?

BALLERINA

www.baltic-region.net

- Mailing list & announcement forum

The screenshot shows the BALLERINA website interface. At the top, there's a blue header with the word 'BALLERINA' and a small logo. Below it, a navigation bar contains links: Home, Baltic Facts, Environment, Actors, Meeting Points, Baltic 21, Science, Search, Feedback, and About. The main content area has a large blue banner with the word 'BALLERINA' and a ballerina logo. Below the banner, it says 'Announcements, Questions and Answers on BALLERINA-L'. There are links for 'Subscribe', 'Browse the Archive', 'Post a message', 'Unsubscribe', and 'More info'. A section titled 'Welcome to BALLERINA-L!' is followed by a 'What is BALLERINA-L?' section with three bullet points:

- A bill-board for announcements of relevance for all those concerned with issues related to environment, natural resources, and sustainable development in the Baltic Sea Region.
- A place to share Baltic environmental news -- in a very wide sense -- with others interested in the region.
- A forum where you can ask questions, or answer questions from others, concerning environment, natural resources, and sustainable development in the Baltic Sea Region.

What is BALLERINA?

BALLERINA

www.baltic-region.net

- Multiple site search facility

The screenshot shows the BALLERINA website interface. At the top, there's a blue header with the word 'BALLERINA' and a small logo. Below it, a navigation bar contains links: Home, Baltic Facts, Environment, Actors, Meeting Points, Baltic 21, Science, Search, Feedback, and About. The main content area has a large blue banner with the word 'BALLERINA' and a ballerina logo. Below the banner, it says 'Search the BALLERINA partners!'. A text box explains: 'This BALLERINA partner search facility is provided by the Regional Environmental Center (REC), Hungary.' Below this, there's a search form with a text input field labeled 'Enter some key words to search by:', a dropdown menu for 'Find pages with' (set to 'all'), and a text input field for 'of these words and return' (set to '10') followed by 'results.'. At the bottom, there's a section 'Select session for search (select none for all sessions):' with a list of sessions, including 'BALLERINA (4/30/98 - 35616)'.

History and background

BALLERINA 

www.baltic-region.net

- The BALLERINA initiative was proposed as a regional response to chapter 40 of Agenda 21, Information for Decision-making
- Concept idea first proposed 1995 with the Great Lakes Information Network (GLIN, www.great-lakes.net) as model
- Proposal discussed June 96 at Workshop in Stockholm

History and background

BALLERINA 

www.baltic-region.net

- BALLERINA web site launched ultimo April 1997
- The First Annual BALLERINA Meeting, Riga, Latvia, May 1997
- The Second Annual BALLERINA Meeting, Rovaniemi, Finland, June 1998

History and background

BALLERINA 

www.baltic-region.net

■ Justification

- Limited Baltic region environmental information on Internet
- Difficult to find this on-line information
- The Internet - an eco-regional environmental information sharing, networking and decision support tool with great potential

The way forward

BALLERINA 

www.baltic-region.net

■ Main challenges

- Fund raising
- Mobilising the forces in the personal & institutional network
- Improving the usability and services on the BALLERINA server

BALTICSEAWEB – an information system about the Baltic marine environment

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Abstract

Baltic Marine Environment Bibliography and Database contains currently more than 11 000 references to published scientific information on environmental aspects and condition of the Baltic Sea. The database is available on traditional online services and via user-friendly www-based search interface on the Internet. A specific project, BALTICSEAWEB within the EU Telematics Applications Programme was started in the beginning of 1997 and it will continue until mid 1998. The aim of the project is to develop a map-based search interface to the Database and to input original documents allowing also retrieval of original documents in electronic form. Users are encouraged to comment the system under development. The home page of the project can be found at URL <http://www.baltic.vtt.fi>.

I Introduction

The research work carried out on the condition of the Baltic Sea marine environment is documented as research reports, the results are presented in conferences and published as conference papers, articles in scientific journals, books, dissertations etc. An information system related to these publications was created in late 1970'ies under auspices of the Baltic Marine Environment Commission, the Helsinki Commission to offer a concise source of information about the findings related to the Baltic Sea.

National focal points in the countries around the Baltic Sea, i.e. in Estonia, Latvia, Lithuania, Poland, Germany, Denmark, Sweden, Finland and Russia make the selection of information to be inputted to the database. The publications are catalogued, indexed and abstracted according to international standards. The classification of ASFIS, the Aquatic Science and Fisheries Information System is used for subject headings.

The database has been available on traditional online systems, where searches can be made using a com-

mand-based search interface. Printed bibliographies and previously COM (computer output on microfiche) listings have also been compiled of the database.

A user-friendly form-based interface has also been developed and the database has been made available on the Internet. This has greatly increased the usage of the database. A new project was initiated in 1997 for further development of the system. The project, called BALTICSEAWEB, is supported by the European Commission within the Libraries sector of the Telematics Applications Programme. The project is being carried out by VTT Information Service together with libraries of the Swedish Environment Protection Agency, the Federal Fisheries Research Institute and the Federal Maritime and Hydrographic Agency in Germany. The project started in the beginning of 1997 and its duration is 18 months.

BALTICSEAWEB has two basic aims:

1. To develop a geographic user interface allowing database searching by using maps.
2. To convert original documents into electronic form and link them to the system so that they can be retrieved by clicking the results of a bibliographic search.

2 Database

The Baltic Marine Environment Database currently contains more than 11 000 references. It covers information on the Baltic Sea, i.e. all marine areas from the Gulfs of Finland and Bothnia in the east and north to the Belt Sea and the Kattegat in the west.

It contains references to reports, including 'grey literature', journal articles, books, conference proceedings, dissertations, etc. The subject coverage includes all aspects on the marine environment of the Baltic Sea, for example ecology, fauna and flora, fisheries, hydrography, pollution, environmental impact, research, planning and administrative measures. Information on the database and bibliography can be found in: <http://trip.hut.fi/vtt/baltic/intro.html>.

3 User interfaces

The database has currently three different user interfaces available: WWW-search form and two versions of the geographical interface. Geographical user interfaces that have been developed within the project are a dynamic Java-applet with scalable map and a solution with a more static clickable map.

3.1 WWW-search form

WWW search form is implemented with standard CGI-scripts, which handle the queries between WWW server and the database. The user can either make a global search by searching from every field in the database at the same time or focus the search on specific field (e.g. title, author, keywords, language, publication year, contributing country, source information). To receive more accurate results user can combine different fields in the search. The use of Boolean operators is supported.

Different output layouts for displaying the search results are available. The user can receive the bib-

liographic information of an interesting document either by clicking its title on the list or selecting a continuous output, which displays all references in the hit list in one output file.

The search form is in: <http://trip.hut.fi/vtt/baltic/search.html>

3.2 Geographical user interface with Java-applet

The geographical user interface which allows free area selection is implemented with a Java-applet (Figure 1). The user can select multiple regions, cities or monitoring stations from the map.

By drawing an area with the mouse the user can select specific regions, smaller cities or other geographical locations (e.g. rivers, bays) and combine them for a search. The

user can also select to display data monitoring stations on the map. After combining different search criteria the user then either submits the query or goes to an advanced search form, where the selected criteria have been automatically transferred.

Links to monitoring data are also enabled. Icons showing monitoring stations on the map are linked to corresponding inventories of monitoring data. The demonstrator is also furnished with a button which offers basic environmental information pages for all major Baltic Sea sub-regions and cities.

3.3 Search interface with a clickable map

The other currently supported version of the demonstrator is a clicka-

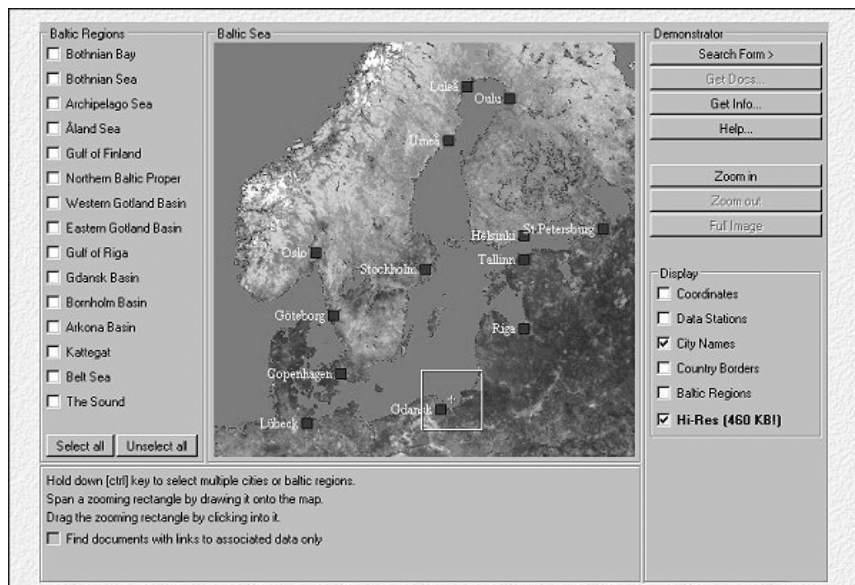


Figure 1. GIS with a Java-applet. Scalable map allows free area selection, which can be combined also to a selection from predefined Baltic Sea regions. Multiple selections are supported.

ble Baltic Sea area map (Figure 2). It is implemented with standard (static) Html-pages, without any Java programming.

The Baltic Sea area is divided into 15 sub-regions according to scheme used by the Baltic Marine Environment Commission. (e.g. The Baltic Sea Joint Comprehensive Environmental Action Programme. Helsinki, 1993, Baltic Sea Environment Proceedings. No. 48) By clicking the map the user can limit the search to concern a selected region only.

The resulting screen is divided into three windows for documents, references and introductory text (a general description of the local environmental conditions) for the particular area (Figure 3).

User searching for references can choose a subject descriptor from the menu of ASFA descriptors used for

indexing the references or enter any free search term(s). The user can also opt for a query directed to only those regional references, which have corresponding full text documents available.

As a result of the search a list of titles of available documents is displayed.

4 Original documents in electronic format

A number of original documents have been converted into electronic form by scanning. Scanned electronic documents are available in the Adobe Acrobat pdf format, which for chosen because of its' many advantages: pdf retains the layout of the original document, it has great popularity in the publishing world and the

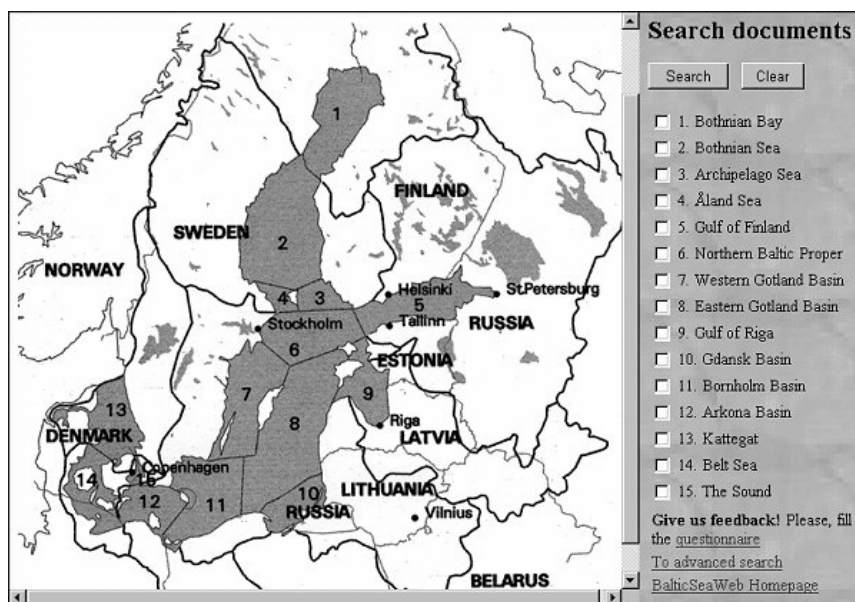


Figure 2. Clickable map allows users to select a predefined region of the Baltic Sea.

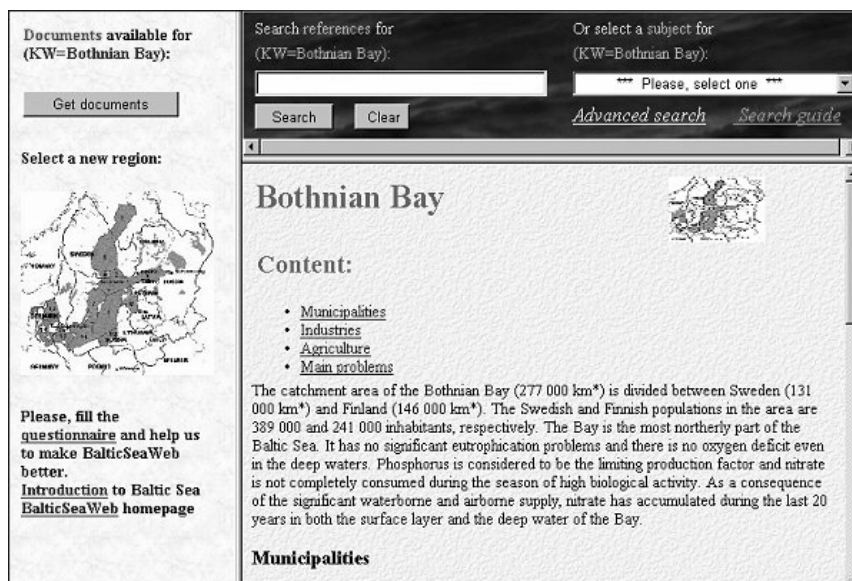


Figure 3. A sub region selected from the main map.

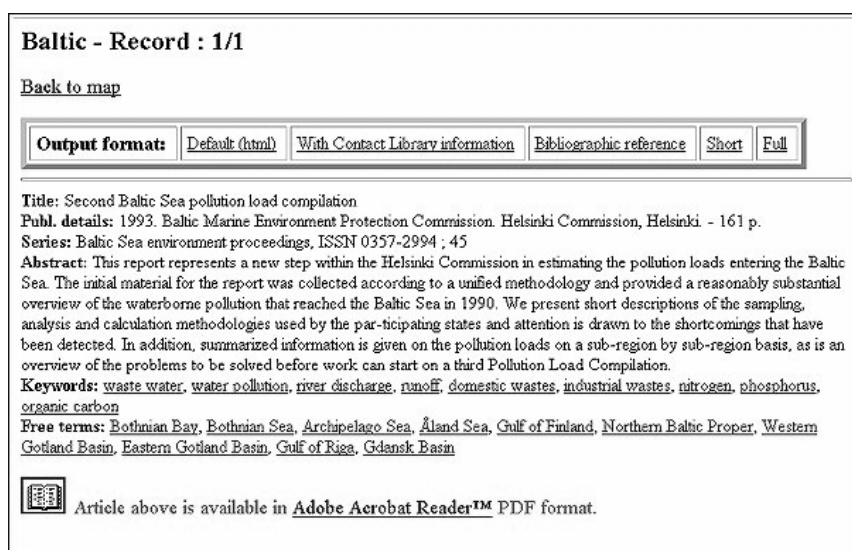


Figure 4 . Reference from the Baltic Marine Environment Database with a link to corresponding electronic document.

file sizes are smaller than in e.g. PostScript or TIFF format. In addition, the most common WWW browsers (Microsoft Internet Explorer and Netscape Navigator) sup-

port pdf. The availability of the original document in pdf format is indicated in the bibliographic record (Figure 4).

The software needed for viewing the documents is freely available from the Internet and the link to the downloading site is given. Adobe Acrobat Reader allows browsing the document e.g. with help of the thumbnail images of the pages (Figure 5). References in the database include also links to other relevant electronic full text documents on the Internet.

5 Discussion

By offering environmental information on Baltic Sea through a user-friendly and well structured geographical interface, end-users will have more direct access to the Baltic Marine Environment Database. For example, officials in state and local governments need frequently infor-

mation on regional environmental problems for decision making. The geographical user interface of the BALTICSEAWEB will provide a tool for accessing this kind of information.

In addition to bibliographic references most end-users are interested in retrieving also the original full-text documents. The documents referenced in the Baltic database have been selected by the national focal points. Information about research on the Baltic Sea appears also in other databases depending on the subject matter. Comparisons made have, however, proven that 75% of the material in the Baltic database is unique. The Baltic database obtains much of the material directly from authors, institutes and libraries and to a lesser extend from monitoring journals and serials, which is the

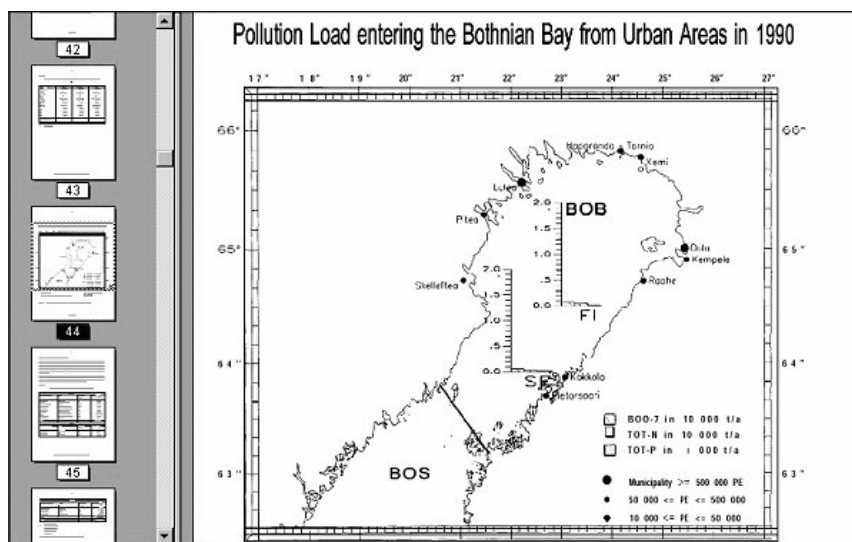


Figure 5 . Original document as retrieved from the Baltic Marine Environment Information System.

main method in the case of large international databases.

Because of the large number of references (currently more than 11 000) and because of copyright problems all documents cannot be inputted into the system. Scientific journals published by commercial publishers normally do not grant copyright for scanning articles and offering electronic access to them. Reaching thousands of authors for copyright requests is another problem. It seems, however, that a considerable amount of documents can be obtained and converted into electronic form both within the project and afterwards. In addition the printed original documents are available in the contact libraries in the countries around the Baltic sea and there is an option in the output forms to obtain the address of the contact library responsible for the particular reference.

Several file formats are possible for storing original documents electronically. Commonly used formats are postscript, pdf, tif and word-processing formats e.g. MS Word or WordPerfect. Printed documents can be transferred into electronic form by scanning. However, scanned documents cause technical problems. The files are often large, they are difficult to handle and their retrieval via the Internet can be time consuming. It would be preferred to receive documents in electronic form from

the authors. In the future it would be desirable, if the authors, when submitting their manuscripts for publishing in printed journals, would retain a copyright of the electronic manuscript, "compuscript" with themselves, so that it could be offered electronically in information retrieval systems.

BALTICSEAWEB complements a number of other relevant projects, such as MARIS, BALLERINA and EDMED. It can be concluded that the database of the Baltic Marine Environment Protection Commission offers a concise and important source of information related to the Baltic Sea area in a user-friendly way.

Acknowledgements

The following organisations have sponsored the development of the Baltic database: The Baltic Marine Environment Commission and the Nordic Council of Ministers. The present BALTICSEAWEB project is being jointly financed by the European Commission within the Libraries sector of the Telematics Applications Programme and by Technical Research Centre of Finland, the Swedish Environment Protection Agency, the Federal Fisheries Research Institute and the Federal Maritime and Hydrographic Agency in Germany.

Latvian Environment Data Centre as the present and potential environment information resource in the Baltic Sea Region

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Abstract

Latvian Environment Data Centre (LEDC) is subordinated to the Ministry of Environment Protection and Regional Development of Latvia and deals with:

- Implementing information technologies to support experts and decision makers in the ministry with environmental information;
- Emission statistical data bases;
- GIS and thematic map production;
- Coordination of EEA activities in Latvia as National Focal Point

LEDC experts participated in the BALLERINA initiative since June, 1996 and had taken active compain in the ministry to get support to extend activities in the future. The results are quite good.

The short english report "State of Environment in Latvia in 1996" in cooperation with Environment Consulting and Monitoring Centre has been prepared to publish on WWW server.

LEDC uses different information technolgies for information dissemination-mostly WWW server, GIS data bases. Now LEDC is testing on-line access application for the ministry experts to get the statistical data about emission into water via Internet. The first experiments will be extended for other data bases. The access to the most importand data will supported in English, as well.

Establishing EIONET node point of Latvia in the LEDC will be a new phase of capacity building for environmental imformation dissemination in Internet.

I Basic facts about Latvian Environ- ment Data Centre

Latvian Environment Data Centre (LEDC) is subordinated to the Ministry of Environment Protection and Regional Development of the Republic of Latvia (the Ministry) and it has obtained its present status due to re-organization of Environment Protection Committee into the Ministry in 1993. LEDC consists of two main departments: Data Processing Department (DPD) and Laboratory Department (LD), and both the goal and main objectives of each department completely differs.

I.1 Data Processing Department goal and objectives

The goal of DPD is establishment of Environmental Data Information System. There are some of the main objectives DPD is responsible for:

- implementation of information technologies to support the Ministry's experts and decision makers with environmental information;
- statistical data bases and annual reports;
 - * Geographic Information Systems (GIS) and thematic maps;
 - * co-ordination of European Environment Agency (EEA) activities in Latvia;
- implementation of international projects and programmes (CORINE Land Cover, HELCOM

Pollution Load Compilation, Integrated Coastal Zone Management, etc.);

I.2 Laboratory Department goal and objectives

The goal of LD is establishment of Latvian Environment Quality Testing Laboratory System and the main objectives of LD are:

- laboratory methodology adoption and introduction of internationally comparable standard methods;
- co-ordination of environmental quality testing and organisation of national inter-laboratory comparison studies of environmental quality testing in Latvia;
- complicate environment quality tests.

2 LEDC significance in information technology development

As the overall aim of the BALLE-RINA initiative is: to contribute to the sustainable development of the Baltic Sea Region environment, by improving the availability and accessibility of relevant information on the Internet, further this presentation will be devoted to observe LEDC as one of environmental information technology development founders/pioneers in Latvia.

2.1 Environmental data at present...

LEDC as one of the environmental information providers in Latvia offers the following environmental information resources about Latvia:

- annual statistical reports:
 - * emission into air;
 - * emission into water;
 - * emission of hazardous waste;
 - * production of chemical substances;
- gamma radiation monitoring data base;
- data base of protected nature areas;
- data base of water resources;
- digital maps:
 - * soil genetic types, 1953 ;
 - * inland water quality monitoring posts, 1995 and 1997;
 - * biological water quality of small rivers, 1993 - 1997.

2.2 ...and in future

LEDC plans to add the following information resources this year:

- water economical balance, 1997;
- digital maps:
 - * land cover map (according to CORINE Land Cover nomenclature);
 - * waste water outlets;
 - * water abstraction sites (partly);
 - * river drainage basins (large and medium basins).

2.3 Development campaign in Ministry

LEDC experts participates in the BALLERINA initiative since June, 1996 and have been taken active campaign in the Ministry.

There are some achievements in the field of environmental information dissemination via Internet:

- the Ministry has accepted the Regulation "WWW Home Page development and publications via Internet" in August, 1997. LEDC co-ordinates web site development within the Regulation framework and offers LEDC web server space for WWW Home Page maintenance. 5 of 8 Regional Environment Boards (REB) have taken that opportunity and published their information in Latvian and partly in English for world wide access: <http://www.varam.vdc.lv/regioni.htm>. The process is still going on and it is planned that the rest of REB will provide the relevant information during 1998;
- Information Technology Board (ITB) was set up in October, 1997. ITB comprises one expert of each Department of the Ministry and its subordinated institutions except REBs. ITB main task is to co-ordinate all Information Technologies (IT) related projects within the Ministry and its subordinated institutions. ITB members:

- * accept/reject IT related working plan of institutions;
- * give references for IT projects;
- * acceptance of financial support to IT related activities.

2.4 Approach to information dissemination ...

LEDC uses different IT for information dissemination – mostly WWW server and GIS data bases.

2.4.1 ... via Internet...

LEDC in co-operation with Environment Consulting and Monitoring Centre has been prepared shortened version of the report “State of Environment in Latvia, 1996” in English. Now the report are available on LEDC web server: <http://www.vkmc.vdc.lv/soe96/>

“The Strategy of Information Development, 1997 – 2002”, accepted by the Ministry in January, 1998, is one of the latest documents relevant to all institutions of the Ministry and now available on LEDC Web site in Latvian: http://www.vdc.lv/dokument/varam_inf/saturs.htm

2.4.2 ... and on-line ...

The first attempt of on-line information access via Internet is LEDC test application in Latvian of the annual statistical data about emission into for the Ministry experts and other people with interests of environmental information. Water related data such as water receipts, drainage into

surface water bodies, pollution load for 1991 – 1996 also are presented as summaries on the LEDC Home Page: <http://www.vdc.lv/update/update.htm>.

The success of the first experiments will promote other data base on-line access and it is envisaged also to accomplish on-line access of most important environmental data bases in English later this year.

2.4.3 ... or via Intranet

LEDC as mentioned above co-ordinates EEA activities in Latvia. To be more precise: LEDC acts as National Focal Point of EEA and node point of the European Information and Observation Network (EIONET). LEDC provides the necessary information for “Dobriš+3” report since 1997 and will do it further. The most important and most recent event of this year is: the set up of EIONET server in Latvia under the guidance of EEA experts at the beginning of May. This is a new phase of capacity building for environmental information dissemination via Internet. The new EIONET node point server is located in LEDC and it supports the most updated Internet technologies and we can say that it “switches on the green light to environmental information exchange for all environmental experts in Latvia”. Now it became possible to connect to EIONET Intranet and both to receive and to supply objective, reliable and comprehensive environmental information used for EEA purposes. The next step will be establishing of public server until the end of this year.

The applicability of GIS in wilderness planning with an example of the Käsivarsi Wilderness Area

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Abstract

This paper examines the applicability of computer-based geographic information systems (GIS) in wilderness planning in general and in recreation planning in particular. The case of GIS application in the Käsivarsi Wilderness recreation plan is presented.

The Finnish Forest and Park Service (FPS) is preparing a plan for the Käsivarsi Wilderness Area. FPS uses public participation widely in land use planning and recreationists are one important interest group in the Käsivarsi Wilderness Area. Therefore, recreation use volume, used routes, huts, as well as users' characters and opinions were surveyed for one year (June 1996 - May 1997). This yielded a data base of 1369 recreationists. The travelled routes and backcountry overnight locations were entered into a GIS database using Arc/Info-software.

Spatial information is an essential part of land use planning. The example from the Käsivarsi Wilderness Area demonstrates that GIS provide new technological possibilities for the planning process, supporting participatory recreation planning of the area.

Keywords: GIS, wilderness planning, outdoor recreation

1 Introduction

Land use planning is dependent on accurate spatial information. Typically, maps of different themes have been used. More recently computer-based geographic information sys-

tems (GIS) have been developed to provide up-to-date data storage and to aid in planning. Geographic information systems were developed by combining computer assisted cartography and database technology. The first system to be generally acknowl-

edged as a GIS was developed in Canada to analyse land inventory data (Star and Estes 1990). Since the earliest prototypes from the early 1970s the number of applications has been numerous. GIS has been widely applied in network management (pipelines, sewer and cable networks), land use planning, natural resource planning and forestry (Bernhardsen 1992).

The application of GIS in outdoor recreation and wilderness planning is much more recent. Although spatially related information plays an important role in recreation and wilderness planning, GIS is not yet widely applied. Spatially referenced data is used in databases storing information on the area's physical attributes such as land use, camp sites, watercourses or tourist resorts. Examining the attributes of recreationists with GIS is fairly rare and studies about the subject are few. However, the number of GIS applications is expected to increase considerably in the next few years as soon as planners become fully aware of the potential of the systems.

This paper examines the applicability of GIS in wilderness planning in general and in outdoor recreation planning in particular. The case of GIS application in the Käsivarsi Wilderness recreation plan is presented.

2 Use of GIS in land-use planning

Geographic information systems have been used in numerous applications and in some cases the neces-

sity of GIS has also been criticised. The system was originally developed for analysing data where spatial referencing was relatively easy (e.g. physical environment). However, in several applications the spatial representation is inherently more difficult. For example in socio-economic applications, when studying phenomena relating to people (e.g. unemployment, deprivation), the accurate defining of location is usually not possible (Martin 1996). An area in which GIS technology and associated methodologies have the potential to make an important impact is land use planning (Haines-Young et al. 1993). The need to manage urban areas was one of the main reasons for the development of GIS. Planning new infrastructure, waste and factory site selection are sectors where GIS has been widely applied and the results have been good. Usage of GIS to solve rural and agricultural problems has been extensive covering applications from dam site selection and runoff analyses to predicting crop yields on farmlands (Haines-Young et al. 1993).

Recreation and wilderness planning are fields where the combination of maps and thematic information forms an important part of the planning process and therefore the application of GIS offers great prospects. One would think GIS would be the most important tool for planners, but this does not seem to be the case. GIS has until recent years been a relatively unfamiliar tool in wilderness and recreation planning. It seems though that the predicted boom in the number of GIS applications has been starting to enter the

field only in the last couple of years. GIS has been applied in several wildlife management studies when determining habitats of wildlife species and wildlife movement corridors (Knick and Dyer 1997, Waller and Mace 1997). Several GIS applications have spawned especially in the United States to restore, protect and manage natural resources. In areas heavily used in recreation, GIS is used in identifying unique habitats, in resource management, designing of park infrastructure and in impact assessments. GIS provides also an efficient tool to graphic displays thereby facilitating e.g. in public participation processes.

3 The case of the Käsivarsi Wilderness Area

3.1 Study area

The Käsivarsi Wilderness Area covers about 221 000 hectares of land and water in north-western Lapland, in the municipality of Enontekiö. It is the most arctic wilderness in Finland with about 20 fell tops reaching over 1000 meters above sea level. Also Finland's highest fell, Halti (1328 m) is in the area. The entire area is north of pine tree line consisting mostly of barren fell-lands (72 % of the surface area) but also of subarctic birch forests (14 %), peatlands (10 %), and waters (4 %). The area is covered with snow and ice for 8 months of the year. The northernmost part of the wilderness is the only region in Finland being part of the Scandinavian Köli moun-

tain chain. Therefore the area is unique in Finland in its geology, vegetation and landscape.

Recreation is the most recent form of land use in the Käsivarsi Wilderness Area. However, recreationists found the Käsivarsi region relatively early compared to other Finnish wilderness areas. The first known recreationists to the area were Finnish women gymnastics in the beginning of 1930s (Kari 1978). The Käsivarsi Wilderness Area continues to be the most popular Finnish wilderness area among recreationists. The area has 18 open huts and 5 reservation huts, a marked backcountry hiking route (Kalottireitti), and a marked snowmobile route.

3.2 Study design

The Finnish Forest and Park Service (FPS) is preparing a plan for the Käsivarsi Wilderness Area. FPS uses public participation widely in land use planning and recreationists are one important interest group in the Käsivarsi Wilderness Area. Therefore, a recreation survey covering an entire year (from June 1996 to May 1997) was implemented in the area.

The sample for the survey was obtained by placing a book with a cover letter in every wilderness hut asking for name, address and some basic information about the visit. At the end of the snowfree season (summer – autumn 1996) the books were replaced with new ones. Information was entered into a data base from which a sample of 1000 visitors over 16 years of age was randomly chosen (Table 1). They received a more detailed questionnaire via mail ask-

Table 1. The sample size and response rate.

	Number of names	Sample size	Number of respondents	Response rate, %	Representativeness	Number of visitors
Summer-autumn (snow-free season)	2 213	1 000	845	84.5	63.4	2 800
Winter-spring (snow-covered season)	1 425	644	524	81.4	61.1	1 800
Overall	3 638	1 644	1 369	83.3	62.5	4 600

ing which route they had travelled, their opinions about various wilderness related issues as well as background information. Same arrangement was implemented after the snow-covered season (winter1996/97 – spring 1997) had ended. This arrangement ensured that every recreationist over 16 years of age who had written his/her name into the book had the same likelihood to be involved in the sample. Overall this arrangement yielded a data base of 1369 respondents.

Both in summer and in winter there were field interviews to find out how representative the name list in the book was. Approximately 75 % of visitors wrote their name and address information into the books. It could thus be calculated that the overall representativeness of the mail survey was 62.5 %. However, snow-mobilers doing only a day-trip into the wilderness tended not to stop in any hut, and are thus clearly under-represented in the sample.

3.2.1 Programmes used

The mail survey results were entered into an Excel data base. This did not include the travelled routes and

backcountry overnight locations, which were entered into a GIS database using Arc/Info-software. Arc/Info is a widely used geographic information system package, which was originally designed for analysing vector data. More recently, the usage of raster data has also become possible. The system consists of modules, from which every user can create the combination best suitable for his/her purposes (Tokola et al. 1994). Each module manages its own activity: Grid is a tool for raster analysis, land use planning and hydrological modelling; Tin is for elevation models and groundwater modelling; Network is used in network analyses, route optimisations and planning. Small scale programmes can be written with Arc/Info Macro Language (AML) which can be used to customise the programme-package better suitable for specific needs.

The routes and overnight locations were transformed into digital form in order to import them into Arc/Info. The routes on paper maps were digitised using a relatively common Finnish cartographic programme Topos. It is a vector-based cartographic system, where map el-

ements are described by lines, points and polygons. Information about the elements is stored in a file as co-ordinates, attached to a type-code corresponding to the map element. Conversion of co-ordinate-files to Arc/Info format is done with a conversion programme called TOAI.

3.2.2 Methods

The distribution of the wilderness use was examined with raster analysis whereby the uneven distribution and use concentration on different parts of the area could be examined with an overlay analysis. The routes were stored into Arc/Info by digitising each route with overnight locations in its own file using the cartographic programme Topos. The analysis was performed by changing the pixel values in each data file into zeros and ones so that the pixels forming the route were defined as ones and other cells as zeros. By summing together the rasterised data layers it was easy to find out the number of visitors going through each pixel. Reclassifying these values into suitable categories the final maps were produced.

The overnight location maps were produced in the same way as the route maps. The overnight locations were digitised as points and the rasterised layers were summed together in order to define the most frequently used camping sites. This way the number of overnight stays in each pixel was obtained. From this map the most popular campsites were selected and buffers were produced around them in order to find out the overnight stays in each campsite and

in its neighbourhood. With “zonal sum” -function the campsite use within each buffer was calculated.

Arc/Info Macro Language was used to facilitate the data management. With the help of AML the functions were automated so that the programme performed repetitive operations needed for each file with one command.

3.3 Characteristics of the sample

The average age of all adult (16 years or older) visitors was 41 years. 70 % of all the visitors were men. Similar gender imbalance is a common finding among backcountry visitors; it was found e.g. in the UK National Park located in northeastern Lapland (Saarinen 1995). The difficulties of travelling during the snow-free season were reflected in overnight patterns: during the snow-free season 96 % of the visitors stayed overnight in the wilderness area, while for the entire year the figure is 85 %.

Respondents were asked both how they had travelled on this trip (Table 2). One should keep in mind the under-representativeness of snowmobilers, which is evident also from table 2.

Table 2. Mode of travel on this trip.

	On this trip, %
Hiking	53
Skiing	31
At least partly flying	8
At least partly snowmobiling	6
Boating	2
Total	n=1353

3.4 Results

3.4.1 Travelled routes

The number of hikers is heavily concentrated on certain routes, Kalottireitti-route being the most dominating one (Figure 1). The number of hikers per hectare along the marked route varies from 301 up to 900. Other very popular routes are the route to Luossujärvi and the route following a marked snowmobile route to Terbmisjärvi-lake with 301–600 hikers per hectare. Also the route to Ropi Fell and the corridor of river Toriseno are fairly popular hiking routes. The most common route

choice among those recreationists who had been using also some other mode of travel than walking during the snow-free season is the river Lätäseno used mostly by canoeists and rafters (Figure 2). Other route choices in this group seem relatively random.

Also during the snow-covered season (winter and spring) the Kalottireitti-route is clearly the most popular (Figures 3 and 4). The number of visitors in the area is generally lower in winter and the concentration on the marked winter route to Halti Fell is 101–300 per hectare (Figure 3). The wilderness visitors

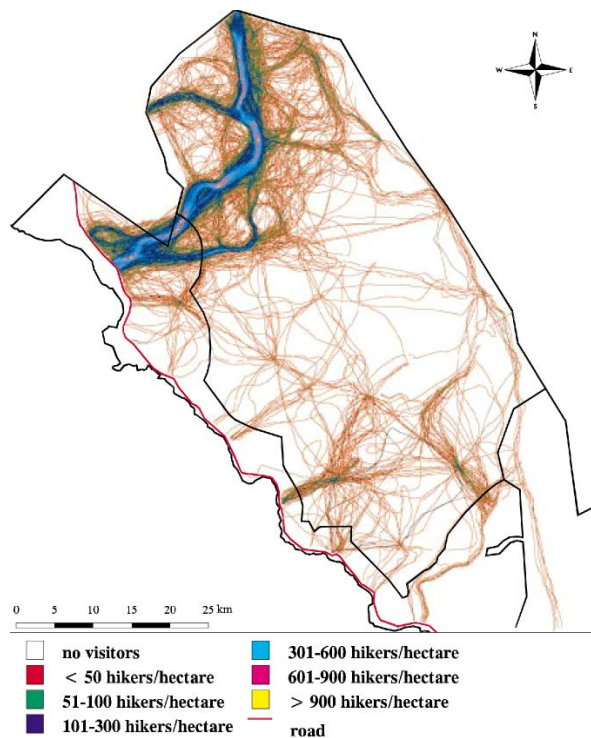


Figure 1. Number and distribution of hikers in the Käsivarsi Wilderness Area during the snowfree season of 1996.

Figure 2. Number and distribution of recreationists travelling also in some other way than walking in the Käsivarsi Wilderness Area during the snow-free season 1996.

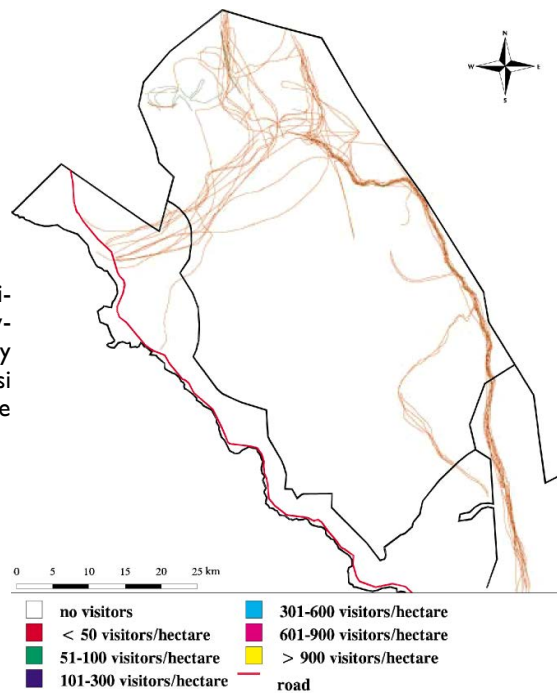
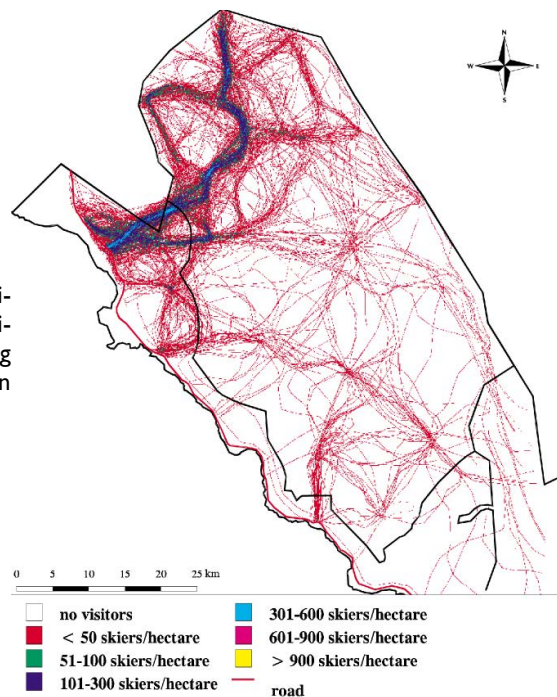


Figure 3. Number and distribution of skiers in the Käsivarsi Wilderness Area during the snow-covered season 1996–97.



who do not ski in winter are mainly snowmobilers (Figure 4). Residents of the municipality of Enontekiö are allowed to snowmobile freely in the wilderness area, while others are requested to stay on marked routes. The route to Halti, requiring a guide, is the most frequently used one also among snowmobilers.

The number of overnight stays is somewhat greater during the snow-free season than in winter due to the smaller number of winter season visitors to the area (Figures 5 and 6). In

summer the most popular overnight location was the hut of Meekojärvi with over 700 overnight stays. The next most popular places were Pitsusjärvi, Saarijärvi and Terbmisjärvi with 301–700 stays. Three of these most popular huts are situated along the Kalottireitti-route, and also Terbmisjärvi is fairly close to the main route. During the winter season the two most popular overnight locations are Pitsusjärvi and Saarijärvi, each with over 300 overnight stays.

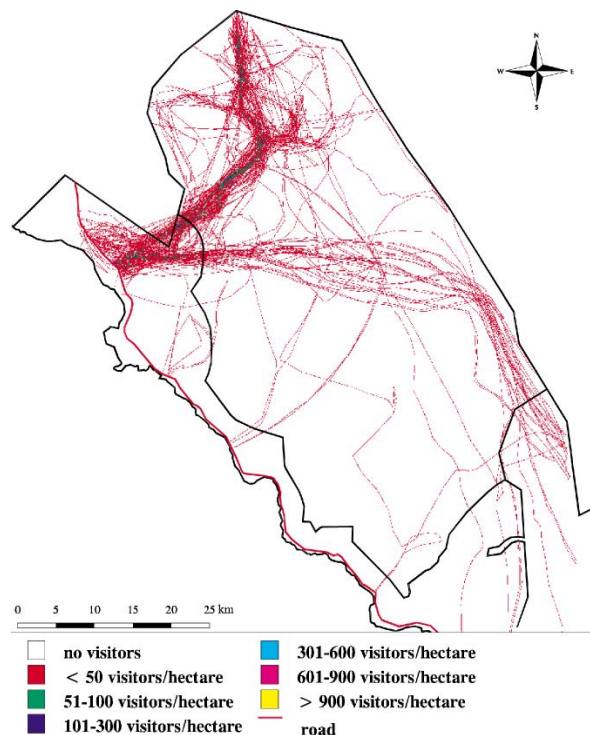


Figure 4. Number and distribution of recreationists travelling in some other way than skiing in the Käsivarsi Wilderness Area during the snow-covered season 1996–97.

Figure 5. Distribution of overnight stays during the snow-free season 1996.

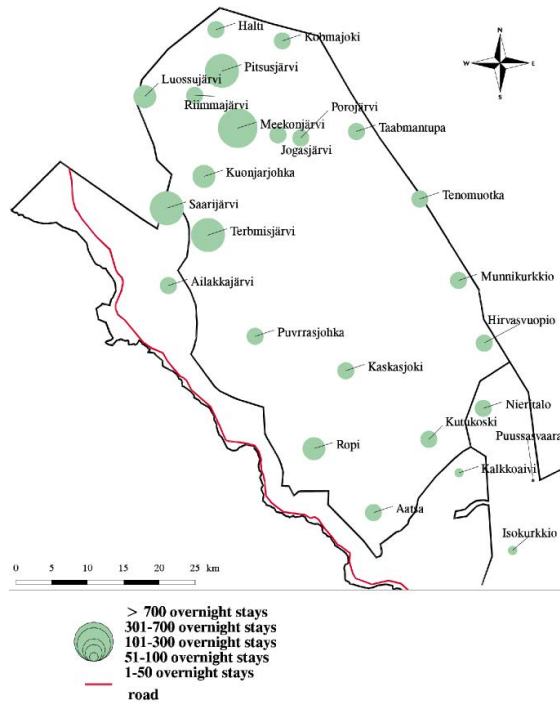
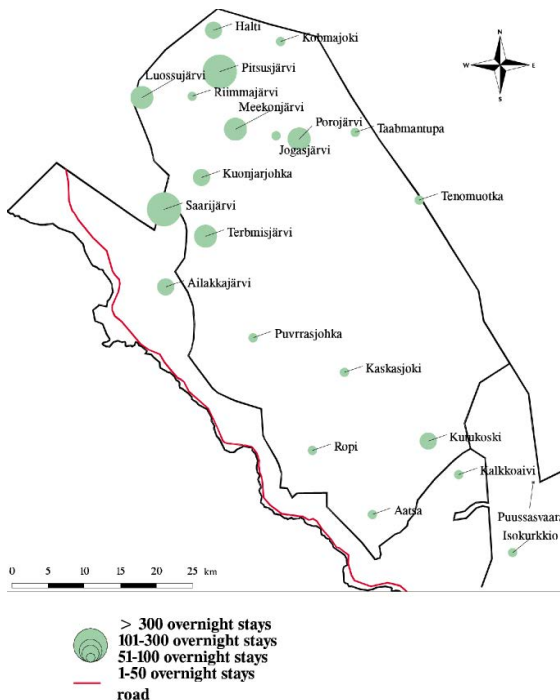


Figure 6. Distribution of overnight stays in the Käsivarsi Wilderness Area during the snow-covered season 1996–97.



3.4.2 Selected management issues

About half of the visitors in the Käsivarsi Wilderness Area had been at least sometimes bothered by crowding, behaviour of other visitors, terrain being trampled or by some other factor (Table 3). The most common explanation for summer time visitors having been bothered

by some other factor was helicopter and aeroplane transportation. Motorised modes of travel, i.e. snowmobiling, motorboating, helicopter and aeroplane were the least acceptable modes of travel according to most visitors (Table 4). However, most of these motorised activities are acceptable at least in parts of the wilderness area.

Table 3. Has any of the following factors disturbed you while visiting the Käsivarsi Wilderness Area? (n=1149...1352).

	Not at all	Somewhat	A lot
		%	
Number of visitors	51	42	7
Behavior of other visitors	59	34	7
Some other factor	59	29	12
Terrain being trampled	65	32	3

Table 4. How suitable do you find the following functions in the Käsivarsi Wilderness Area? (n=1307...1348).

	Fully suitable	Suitable in parts of the area	Not suitable at all
		%	
Snowmobiling outside the route	3	12	85
Motorboating	3	26	71
Guided snowmobile tours	13	43	44
Snowmobiling on the route	13	45	41
Aeroplane transportation	12	47	42
Helicopter transportation	14	48	39
Dog-sledges near huts	28	46	26
Hikers with dogs	57	31	13
Reindeer drives	54	38	8
Guided hiking tours	49	45	6
Dog-sledging	45	49	5
Guided ski-tours	52	44	4

3.4.3 GIS knowledge in management of the Käsivarsi Wilderness Area

The purpose of the Finnish wilderness areas is to preserve their pristine character, to protect the Sami culture and traditional subsistence uses, and to facilitate greater multiple-use of the natural environment (Wilderness Act 1991). Preserving the pristine character of the area is essential also from a recreation experience point of view. According to the survey the three most important reasons for visiting the Käsivarsi Wilderness Area were scenery, area's wilderness and pristine character.

The geographic analysis on the distribution of wilderness recreation use in Käsivarsi shows a trend, also known in wilderness recreation literature, that the distribution of visitors is never even but tends to follow certain routes (Lucas 1990). The most popular route in the Käsivarsi Wilderness Area is the marked back-country hiking route Kalottireitti. Regardless of the season the Kalottireitti-route is the most popular. Similarly, the overnight locations are unevenly distributed. The most popular overnight locations are found along the Kalottireitti-route, where the density of visitors is the greatest. The concentrated use patterns were reflected also in the responses to the survey question about crowding.

Wilderness planning aims at integrating the goals of different users into an acceptable management plan that meets the requirements of the Wilderness Act. According to the survey, the most significant recreation conflict exists between those visitors travelling by traditional

modes of travel and those travelling by motorised methods (flying, snowmobiling).

The result that most visitors accept all modes of travel at least in some parts of the Käsivarsi Wilderness Area gives possibilities for zoning. Wilderness character is a relative and subjective concept, and therefore zoning can create regions with different wilderness character.

Once the zones from a recreation point of view have been created, they will be compared to focus areas of other important wilderness uses. These include local subsistence use (reindeer herding, hunting, fishing and picking cloudberries) and commercial nature tourism. Thus, GIS continues to be an important tool throughout the planning process. Knowledge of the current recreation use patterns in the Käsivarsi Wilderness Area in an easily interpretable map format will facilitate in making well informed decisions. This kind of spatially related information is useful for everybody involved in the planning process from local people to managers.

4 Conclusions

Geographic information systems can dramatically expand information storage and manipulation capabilities. They help to supply current information on the state of the planning area and provide tools for efficient analysing.

The advantage of digitising information compared to other geographically oriented methods is the simplicity of storing. The routes can be

stored with the same accuracy as they are expressed on paper maps. Storing is easy because no consideration is necessary on the category of the route or the equivalency of routes close to one another. Also exceptional choices of hiking routes can be stored without difficulties or making the storing system more complex. The main source of error in the Käsivarsi GIS analysis comes from the scale of the map (1:400 000). It is not easy to digitise information fully accurately from this scale, and on the other hand, not all the respondents had drawn the routes that accurately.

The type of geographic data gathered about recreational use in the Käsivarsi Wilderness Area provides also possibilities for more detailed analyses. For example, the relationship between the route chosen and personal attributes (age, gender, etc.) could be studied. Similarly, the relationship between the route chosen and the physical attributes of the area, or between the route chosen and recreational activities participated could be studied. Moreover, with buffers around main watercourses the correlation between the vicinity of water and choice of overnight location could be studied.

In conclusion, the example from the Käsivarsi Wilderness Area demonstrates that computer-based geographic information systems (GIS) provide new technological possibilities for the planning process, supporting participatory recreation planning of the area.

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Protected Areas Strategy for New Brunswick – a science-based approach

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Abstract

The protected areas management strategy developed for the province of New Brunswick is a multiple-analysis GIS model designed to integrate enduring ecosystem structural and functional characteristics across a spatial landscape. The process involves understanding regional landscapes as ecological functional systems and using this knowledge to quantify and qualify the percentage of biological representation across the landscape.

One of the primary aims of the new protected watershed areas will be to provide habitat blocks in which ecological functions are representative of the eco-regions of the Acadian Forest. In order to compensate for the known and predicated effects of edge and isolation effects, the designated protected areas will vary in size from 20,000 to 25, 000 hectares and be representative of the major eco-region within the eco-district.

The management goal of the Protected Areas Strategy for the Province of New Brunswick is not to maximize populations of any individual species. It is to create protected areas that will ensure that the dynamic ecological processes to which mature forest species are adapted, can continue to evolve in collaboration with the forest management regimes within the Acadian Forest. The goals of the protected areas strategy will reflect the evolving natural conditions that have evolved across the landscape as a result of human and natural evolution rather than be representative samples of exact, static recreation of pre-settlement conditions.

I Protected areas

I.1 Introduction

Protected areas have been part of societies' choices about land use

since early human civilization. Natural areas were set aside in Sri Lanka for religious reasons as early as 200 BC. The first national park was declared in Yellowstone in 1872, followed in Canada by Banff National

Park in 1885. Today, virtually every country and jurisdiction in the world has protected areas. Protected areas are best known as national and provincial parks, but they also include a number of other categories such as scientific reserves and managed landscapes. Because the idea of protected areas has such a universal appeal and application, they have been called the most common human response to environmental concerns.

1.2 Defining protected areas

Protected areas are lands set aside to protect the province's diverse natural and cultural heritage. They are dedicated to present and future generations for a spectrum of compatible uses: as scientific benchmarks, as nature preserves, as places for education, appreciation and inspiration, and as places to enjoy certain recreational activities.

The Protected Areas Strategy will respect the treaty rights and Aboriginal rights and interests that exist in New Brunswick for land and resource use. Sustenance use by Aboriginal peoples will be permitted in protected areas, subject to conservation objectives.

1.3 Protected areas: a multiplicity of values

Protected areas are established for many reasons. They serve to conserve biodiversity, which simply refers to genes, species, populations and ecological processes. The world

is currently losing biodiversity from human activity at unprecedented rates. Protected areas are part of a larger strategy to stop these losses. Protected areas are part of a strategy that uses a pre-cautionary principle of biodiversity conservation. They are a safeguard given our lack of understanding of the effects of resource extraction on the environment.

In addition to acting as ecological reserves for biodiversity, protected areas have many other important values. They provide ecological services such as clean fresh water to drink and a supply of oxygen to breathe. They provide refuge for flora and fauna and for species to be perpetuated. They serve as ecological benchmarks from which to monitor change and to evaluate the long-term environmental implications of resource management initiatives.

Protected areas can have an important socio-economic role by serving as places for people to get away from the hectic pace of modern life, a place to be surrounded by wilderness and experience and appreciate human connections with nature. Protected areas can serve as places to hike and watch wildlife.

From a very practical viewpoint, protected areas can have an extremely positive economic value. They are focal points for tourism, often bringing in more revenue per unit of land than other extractive activities. A 1995 study in British Columbia showed that for every dollar spent on parks, there were 9 dollars in visitor expenditures. Provincial parks contribute 400 million dollars to the provincial economy each year

and provide 9300 direct and indirect jobs.

Worldwide, protected areas typically comprise less than 6.9% of the land-base of a country. This means that protected areas do not cover the majority of area and can not be expected to fulfil a mandate of protection by themselves. They must be part of a more comprehensive land use strategy. In the last two decades there has been a considerable amount of research on the role and value of all protected areas. There have been studies done on park size, what their shape should be, and how close they should be to each other. While some of these questions are still under debate and study, many issues have become clear.

Research has demonstrated that protected areas will be successful only when they are:

1. of minimum sufficient size and;
2. are integrated into the surrounding landscape and;
3. connected at a regional level to allow some movement of individuals (and thus genes) between the protected areas.

It is certain that protected areas must be of a minimum critical size to be effective. To be successful, a protected area must be able to protect whole populations (called a minimum viable population) as well accommodate ecological processes (such as fire or flooding). It is also certain that each protected area must not be managed like an island of wilderness in a sea of intensive land-use. Regardless of the size of a protected area, there are always border zone issues. Large-home-range animals

like bears cross-park boundaries, as do rivers and air-borne pollutants.

From a regional perspective, it is important that there is gene flow between populations so that inbreeding does not occur. This requires land use planning at an interregional level that allows movement of species across the landscape.

1.4 The vision for a system of protected areas within New Brunswick

Protected areas are a major component of New Brunswick's commitment to protecting and restoring the quality and integrity of the environment, and to securing a sound and prosperous economy for present and future generations. New Brunswick will designate and manage a system of protected areas to protect a diversity of biological, natural and cultural heritage resources.

By the year 2005, New Brunswick will have a comprehensive network of protected areas dedicated to present and future generations. As places where natural processes are allowed to occur with minimal human interference, these protected areas will form the cornerstone of a sustainable environment for New Brunswick. The existing inventory of protected areas will be expanded through a cooperative effort from all levels of government, non-government organizations, the private sector and individual citizens of the province.

The protected areas system will include selected areas that represent

the ecological diversity of the province's seven ecoregions, as well as highlight the natural, cultural and recreational features that are rare, special or outstanding. It will provide a diverse range of, research and heritage appreciation opportunities, all of which are compatible with natural and cultural values. As well, the system will include places where Aboriginal peoples can continue their traditional relationship with the land.

Use and management decisions will be guided by the principle that the protection of ecological viability and integrity is primary importance within a land management strategy.

1.5 Benefits of protected areas

Parks and protected areas offer a wide variety of benefits, ranging from the environmental and educational to the social and economic. Here are just a few:

- Protected areas maintain essential ecological processes and preserve the genetic diversity of species.
- They provide “environmental services” such as producing oxygen, creating and protecting soils, absorbing and breaking down pollutants, and improving local and global climates.
- They act as natural laboratories in which to gather and assess information about how ecosystems work and how they respond to change.
- They serve as benchmarks against which to measure changes caused by humans and nature.

- They build public support for habitat protection.
- They can help to diversify local and regional economies through nature tourism and sustainable use of parks and wilderness areas.
- They preserve biodiversity for potential future development of economic products such as plants for medicinal uses.
- They provide places of spiritual renewal and inspiration.

1.6 Defining how much to protect

The provincial government is committed to developing a protected areas network that will protect a representative sample of our biodiversity. However, in order to gain a proper understanding of the New Brunswick's protected area strategy it must be evaluated within the context of the Acadian Bioregion

Some ecoregions within the province may end up with differing level of representivity of their biodiversity, due to over-riding provincial objectives or existing land use commitments. In some areas, for example, the opportunity still exists to protect large areas with low fragmentation. In other areas, achieving satisfactory representation within areas of low fragmentation may not be possible. Flexibility and integration with surrounding political jurisdictions is therefore necessary in the development and application of a protected areas strategy.

2 The Current Status of Resource Conservation Initiatives in NB

2.1 Overview of the land resources in NB

New Brunswick is 7,108,309 hectares in size. 3,191,827 ha of this amount is Crown Land while 3,916,482 ha is privately owned.

This land base supports a variety of uses, the principal ones being agriculture, forestry, mining, residential, industrial, institutional, etc. A

growing proportion of New Brunswick is also subject to numerous conservation related management programs and initiatives. The total protected area of NB is 755,894 ha (Table 1). Some of the major protection initiatives which are presently integrated within New Brunswick's conservation initiatives are presented in the chapters 2.2-2.16.

2.2 Wetlands

Wetlands are critical habitat for a variety of aquatic plants and animals and especially for migratory birds. By definition, wetlands include fea-

Table 1. Existing New Brunswick Protected Areas by IUCN Classification¹ (number and area in hectares for each class).

IUCN CLASS	PUBLIC (HA)	PRIVATE	TOTAL NB
1A	1 210 (0.04)	0 (0)	1 210 (0.02)
1B	7 907 (0.2)	0	7 909 (0.1)
2	68 263 (2.1)	272 (.007)	68 535 (1.0)
3	18 379 (0.6)	44 (.001)	18 423 (0.3)
4	633 356 (19.8)	16 254 (0.4)	649 610 (9.1)
5	1 052 (0.03)	142 (0.004)	1 194 (0.02)
6	9 105 (0.3)	0	9 105 (0.1)
Total	739 272 ha	16 712 ha	755 984 ha
CLASS 1–3	95 761 (3.0)	316 (0.008)	96 077 (1.4)

¹ see http://www.unep.wcmc.org/protected_areas/categories

The average size of provincial parks and ecological reserves is less than 100 ha (1 km²).

Only classes 1–3 are primarily concerned with conservation. Class 4–7 IUCN sites address conservation as a secondary objective.

tures such as ponds, lakes, swamps, bogs, coastal marshes, inland marshes, floodplains and other related aquatic environments.

While a great many wetlands of varying descriptions exist throughout NB, numerous initiatives have been undertaken over the years to conserve, enhance and restore important wetlands as part of multi-jurisdictional long range waterfowl and shorebird management plans. As of 1997, 20,622 ha of wetland were being managed as habitats for a variety of species. Approximately 7,747 ha of this amount involves Crown Land while 12,875 ha are located on freehold.

The Canadian Wildlife Service, Ducks Unlimited Canada, DNRE, and Eastern Habitat Joint Venture are a few agencies involved with the conservation of wetlands. These and other wetland enhancement initiatives are expected to continue, as opportunities become available.

2.3 Ecological Reserves

Ecological reserves are created to protect rare and or endangered species and ecosystems; critical floral and faunal habitats of limited extent; outstanding assemblages of flora and fauna; representative examples of natural ecosystems; distinctive natural features of scientific or educational value; and, modified sites which would meet the aforementioned criteria through restoration. Public access to ecological reserves is generally not encouraged and all sites are subject to a range of specific land use restrictions so as to

preserve their natural integrity in perpetuity.

Fifteen ecological reserves encompassing 1212 ha existed in NB as of 1997. These average in size from 50 to 200 ha (although a few are larger) and include such features as a red oak stand, a peat bog, a coastal dune system, a steep coastal forested ravine, waterfalls, a remnant hardwood stand, a series of shallow lakes, a great blue heron nesting area and an osprey nesting area. Other candidate sites are being investigated on an ongoing basis.

2.4 Conservation Areas

Conservation Areas are similar to ecological reserves and are limited to Crown Land. These areas are subject to the same land use restrictions which apply to ecological reserves but allow for some traditional recreation activities, subject to site specific management plans (e.g. hunting and fishing, etc.), which are not permitted in ecological reserves. Five conservation areas totaling 7909 ha were proclaimed in 1996. It is anticipated that other sites will be established in the coming years.

2.5 Deer Wintering Areas

Deer Wintering Areas are forested landscapes used by deer during periods of deep snow. Deer generally use the same locations annually when snow depths necessitate yarding. With that, Crown Land and some industrial freehold wildlife management practices designate yarding

sites as deer wintering areas. This designation ensures that disturbances within these locations (e.g. forest harvesting, mining, etc.) are minimized. As of 1997, 268, 500 ha of Crown Land in over 900 sites were being managed as deer wintering areas. Although an acreage figure is not available at this time, some deer wintering areas located on industrial freehold are subject to limited harvesting.

2.6 Mature Coniferous Forest Habitat

Crown Land wildlife management practices call for mature coniferous-forested blocks to be set aside on a long-term rotational basis as habitat for a variety of birds and mammals. This initiative is being undertaken in recognition that certain wildlife requires this type of vegetative cover and to ensure that NB continues to have healthy populations of native wildlife. As of 1997, approximately 274,000 ha on Crown Land were being managed for this purpose.

New mature coniferous stands are continuously being evaluated and “set aside” as forest stands age.

2.7 Watercourse Buffer Zones

Watercourse buffers are vegetative strips (trees, bushes, etc.) maintained along watercourses to protect their environmental integrity. This applies to brooks, streams, rivers, lakes, ponds, etc. and is a requirement of the Province’s Clean Water Act.

Watercourse buffers are necessary in that many land use activities (e.g. farming, forestry, construction, etc.), have the potential to adversely affect many aquatic ecosystems. As of 1997, approximately 247,800 ha of Crown Land were being managed for this purpose. Freehold land subject to watercourse buffers is estimated at 36,700 ha.

Much wider watercourse buffers are usually maintained on Crown Land than is required by legislation since these areas also serve as important riparian zones.

2.8 Wildlife Reserves

Wildlife reserves are essentially game refuges. Hunting and other disturbances to wildlife are prohibited on these sites (approximately 12,636 ha). The majority of New Brunswick’s eight reserves are managed such that disturbances to ecological processes are minimized.

Given the array of other initiatives being undertaken to protect wildlife in New Brunswick, no plans exist at this point to establish additional wildlife reserves.

2.9 Migratory Bird Sanctuaries

New Brunswick is located along the eastern North American flyway and is an important staging/resting area for a variety of waterfowl and shorebirds during their annual migrations. Among the many initiatives undertaken to provide and protect habitat for migratory birds passing

through NB has been the establishment of three sanctuaries. Totalling 275 ha, these are managed by the Canadian Wildlife Service. Hunting is prohibited within these areas and access is limited. Migratory bird sanctuaries are established under the Migratory Birds Convention Act.

2.10 Ramsar Sites

Ramsar sites are designations given to wetlands of international importance in accordance with the provisions of the Ramsar Convention. This designation is designed to promote the conservation of such areas.

Wherein Ramsar sites contain exceptional habitat for migratory shorebird populations, management guidelines call for the ecological character of these areas to be preserved and maintained.

Three such sites, which total over 17,484 ha, have been designated in New Brunswick.

2.11 Nature Preserves

Eight nature preserves totaling 317 ha are located throughout the Province and are managed by the Nature Trust of New Brunswick. These sites are of unique ecological/bio-physical value and are protected in perpetuity. Natural features found at these sites include a fen and bog which support a variety of rare orchids; a Furbish lousewort colony; several Bay of Fundy islands; a sea bird sanctuary; a marsh - lowland forest complex; a Gray Tree Frog colony;

a coastal salt marsh and a Saint John River floodplain island.

It is anticipated that additional nature preserves will be established in the future.

2.12 Provincial Parks

Provincial Parks are unique landscapes which are managed for a variety of purposes including the protection of natural areas recognized as having significant outdoor recreation potential; the conservation of distinctive and unique natural landscapes and viewsheds; and the provision of a diversity of outdoor recreational experiences to New Brunswickers. As of 1997, the Provincial Parks system encompassed about 23,000 ha.

2.13 National Parks

National Parks are landscapes established for public recreation, resource conservation and education and are usually characterized by natural features of national and regional significance (e.g. landforms, flora, fauna, etc.). The two national parks located within N.B. total over 45,500 ha in size. National parks allow for a range of activities that compliment the natural resources for which they were intended to protect.

2.14 Stewardship Agreements

Stewardship Agreements are partnerships entered into between a private/corporate landowner and a conser-

vation organization (government and or non-Government) regarding the protection of a unique / endangered natural resources (e.g. wildlife populations and habitat / rare and endangered species and habitat, etc.). The main objective of these agreements is to ensure that the environmental integrity of each site is protected and or enhanced.

Resources managed under these agreements include two coastal salt marsh complexes, endangered species habitat, and a migratory bird staging area. As of 1997, approximately 900 ha of land were subject to such agreements.

2.15 Canadian Heritage Rivers

The Canadian Heritage Rivers Program is administered by Parks Canada and was created to conserve the natural, historical and recreational values of truly outstanding Canadian rivers. Approximately 185 km of the St. Croix River was designated under this program in 1991 and a 55 km section of the Upper Restigouche River has been nominated. A section of the Miramichi River is presently being considered for nomination.

2.16 Other Protected Areas

Numerous other sites over and above those previously described are also being managed with specific conservation objectives in mind.

Several of these are managed by Municipalities while some are owned

and or managed by NGO conservation agencies (e.g. Nature Conservancy of Canada) and industrial freehold interests. The possibilities of establishing other special management areas are presently being identified at the industrial freehold level.

3 Process for Identifying and Evaluating Potential Candidate Sites

3.1 Guiding principles

The major objective of the Protected Areas Strategy was to preserve relatively large undeveloped areas that are typical of the seven- (7) ecoregions found in New Brunswick. To achieve the goal of protecting representative examples of the province's seven ecoregions, the following guiding principles were developed:

- The strategy should be based on the best available scientific information, so that protected areas will firstly contribute to protecting New Brunswick's native plants and animals and the habitats which they need to survive.
- The strategy should have input from New Brunswickers, in its development and implementation.
- A system of protected areas should enable us to understand the ecological interactions within each ecoregion in New Brunswick.

- Within the need for nature conservation, a system of protected areas should contribute to the economic well being of present and future generations of New Brunswickers.
- The borders of New Brunswick are political and not ecological. Thus some types of conservation planning must occur in concert with our neighbors.

3.2 A three scaled approach

3.2.1 Definition of scales

Ecosystems are composed of many interacting scales. For example, climate patterns are global, large watersheds are regional, and the home range of a Pileated Woodpecker is local. Disturbance patterns that form the ecosystems are also variable in scale. It is generally believed that the enduring features and the scale of disturbances, their intensity, and frequency in an area, will create a landscape in which the plants and animals are adapted to, and dependent upon. The landscape is a mosaic of different conditions in which some species are generalists and can live in a wide variety of areas; others are specialized to unique areas, and as such, are found only in a few places. Thus, considerations of protected areas must recognize the inherent multi-scaled nature of ecosystems.

Representativity is an important criterion for selection of protected area, because climate, topographic relief, and soils, the components of representativity, are important determinants of the size and composition

of vegetation patches, and at certain small-to-medium scales, of wildlife habitat as well. Therefore, representativity in a system of protected area ensures the protection of broad classes of ecosystems and the genetic diversity of common species. However, representative areas cannot be expected to capture important features occurring at very fine or very coarse scales. For example, sites of outstanding value containing rare species or features can exist outside representative areas, but still must be addressed in any comprehensive program of conservation. At the opposite extreme of scale, planning within a regional framework ensures that landscape connectivity for wide-ranging species is maintained, and that minimum representation is achieved for all ecoregions.

Because of these scale issues, we have adopted three-scaled approach to a protected area strategy.

3.2.2 The coarse scale - large representative protected areas

We propose that a system of relatively large protected areas (20-25000 hectares) be established to be representative of each of the ecoregions found in New Brunswick. Ecoregions are defined by a combination of the National Ecological Framework for Canada (Minister of Supply and Services, 1996), the Ecological Units of the Eastern United States (USDA Forest Service 1995) and the Draft New Brunswick Ecoregions Framework. Using these data sources, there are 7 ecoregions occurring in New Brunswick of which 6 are shared in part with Nova

Scotia, Quebec and Maine. The goal of these large representative protected areas is that they be protected to IUCN Class 2 standards as provincial parks.

3.2.3 The fine scale – unique features and species

Large representative areas can never protect all the diversity of species and landforms found within a given ecoregion. However, in order to have a comprehensive protected areas strategy, we are proposing that a fine scale approach be developed to complement the large representative areas. This would involve a detailed analysis of the species, plant communities and landforms found within the seven ecoregions.

Comparisons can then be made of how well each of these features is protected within the large representative area. Such an analysis is often called a “gap analysis”, simply because it will identify gaps in the conservation program. We propose that such a gap analysis be conducted for each region and a resulting set of finer scale conservation priorities be established. The conservation priorities can then be addressed by a range of public and private programs, such as the New Brunswick Nature Trust, the Nature Conservancy of Canada, and the New Brunswick Ecological Reserves Program. The fine filter assessment of each ecoregion was not included in this initial review. Instead, we propose to develop guidelines for the gap analysis and identify a time frame for its completion.

3.2.4 The large scale - interregional planning for populations and species movements

Within the Atlantic Maritime Ecozone (NB Ecozones are composed of many ecoregions. The Acadian Ecozone is composed of the provinces of New Brunswick, Nova Scotia and Prince Edward Island, Gaspé region of Québec, and the State of Maine. Each of these jurisdictions has separate conservation programs. The working group proposes that there are many opportunities and efficiencies for these jurisdictions to work together. We propose to approach these jurisdictions to explore the opportunities to work in collaboration. Initially we see several opportunities.

First, there is the opportunity to maximize the level of representativity within ecoregions. This can be done when siting large representative protected areas as well as by cooperating on fine-scale gap analysis, where ecoregions cross provincial boundaries. Perhaps more importantly, at this large scale, is the opportunity to plan for interregional movement of species and genes (by individuals dispersing) on the landscape. For example, the Isthmus of Chignecto connects New Brunswick and Nova Scotia. There is a real possibility that gene flow could be cut off across this geographic constriction. By proper regional land use planning, the role of this area as a functional wildlife corridor can be maintained into the future. Such regional corridors are not parks. Rather they are areas where people live and work. Proper planning for protected

areas must allow individual parks to be functionally linked which simply means allowing some movement of individuals. Animals like lynx and black bear will easily move several hundred kilometers in a single season if the landscape is suitable. The working group does not propose to plan for these regional connections, but rather to establish a set of principles and templates for inter-jurisdictional co-operation.

In addition to the 3 pronged approach described above, we are proposing that the following elements should be developed as part of a comprehensive Protected Areas Strategy for New Brunswick.

- Review of existing legislation and development of new legislation to support the protected areas strategy;
- The development of a land use management strategy that would integrated to concept of protected areas;
- The development of an adaptive management strategy;

3.3 How Were Large Protected Areas Selected?

3.3.1 Selection process

We adopted the following process for the selection for large representative areas:

- 1) The initial goal was to have at least one large protected area (20-2500 ha in size) to be representative of each of the 7 ecoregions of New Brunswick. Some of these ecoregions are already partially represented by existing large

parks. We assessed the degree of representation of each ecoregion that was possible in 20,000 to 25,000 contiguous blocks of land. Degree of representation were determined by assessing the diversity of landscape relief classes, and the diversity of geological/soil types relative to the total diversity of these features found in the ecoregion. This was a GIS exercise where representation was assessed across the entire ecoregion in a systematic process without regard for land ownership patterns or disturbance history. A ranked list of areas of high representivity was generated for each ecoregion.

- 2) Road density (km of roads per forested square km) is a convenient index of landscape disturbance in forested areas. We assessed road density for the province for each 1:12,500 scale forest mapsheet. It was deemed desirable, but not essential, for area in representative protected areas to be relatively undisturbed by clear-cutting.
- 3) Representativity data and disturbance data were merged, and a number of potential representative protected area blocks were identified for each ecoregion. After selection of the potential large blocks, we searched for blocks that had relatively low densities of plantations, recent harvest, abandoned mines, etc.
- 4) Blocks of land that remain screened in after step three were then subjected to a conflict analysis, looking at such things a lease

conflicts (sugar bush, camps), existing forestry operations, etc.

- 5) Other considerations were also evaluated for each proposed site, these included the maturity of forests, recreational or tourism opportunities, and outstanding scenic beauty.

3.3.2 Representativity

A system of protected areas designed at an ecoregion scale can not be large enough to represent all of the variation of ecodistricts within it. As many ecodistricts should be represented by the protected area as is feasible.

Protected areas will never be large enough to encompass the full range of ecological processes. However, integration of the protected area into the surrounding landscape will increase the functional role of protected areas connections between the protected area and natural areas outside will foster movement of species and processes, increase available habitat, and promote co-operation between stakeholders.

3.3.3 Road Density

The density of roads is a good indicator of the extent of resource use in an area. A high density of roads is associated with changes in the landscape and wildlife through increased amounts of forest management, hunting, trapping and fishing, and the expansion of invasive species. By contrast, roadless areas are associated with concepts of wilderness.

3.3.4 Land in Plantation

The intensity of forest management activities varies across the landscape. Plantations typically are artificial

environments with lower species diversity, often on areas that would have had produced a different forest community. Areas without plantations are a partial indicator of more natural conditions.

3.3.5 Forest Maturity

All forests of the province have been influenced by forestry or agricultural activities. However, some areas of the province are more recently impacted and others retain an older forest community. New protected areas do not have to be “pristine” and areas can be restored. Maturity is a partial indicator that could be used to select between similar candidate sites.

3.3.6 Size of Protected Areas

There are several ways to determine the size of a protected area. The size of a protected can be based on the scale of the ecological processes that have shaped the landscape. For example, in a fire-prone landscape, the area of the park should allow some level of wildfire disturbance without the whole park burning at once. Such an area is termed the minimum disturbance area. A review in New Brunswick suggested that protected areas be a minimum of 16,000 ha in some parts of the province where small fires are frequent (Methven and Forbes 1995). A second way to determine park size is to calculate the area required to conserve a viable population of large area-demanding species. The size of areas needed to conserve a heavily trapped population of Fisher may be over 50,000 ha, over 13,000 ha for Marten, and over 20,000 ha for Pileated Wood-

pecker (Methven and Forbes 1995). A third method of determining park size is to use species-area curves. Simply put the larger the area the more species it will contain. However, there are some logical break points. Gurd, Nudds and Rivard (1966 in press) have calculated the minimum area required to contain all mammal species in Atlantic Canada. The absolute minimum area, defined by the lower confidence interval of the species area curve, is 25000 ha. We have put these figures together to recommend a minimum size of large representative areas of 20-25000 ha.

4 Methodology used in identifying candidate sites

4.1 Introduction

A number of biological and historical factors, have influenced the present-day pattern of distribution of plants and animals over the landscape of New Brunswick. Ecosystem character, including climate, topography, and soil type, plays a strong role in determining the distribution of plants and animals. Human influences on the distribution of plants and animals in our region have been strong since the arrival of European colonists.

In general, patterns of diversity of flora and fauna in New Brunswick are related to (1) the pattern of re-advance of plants and animals into

our area following the retreat of glaciers 10,000 years ago (2) habitat variation, defined as climate, landform, and soil variation, and (3) land conversions from natural vegetation cover due to human activities in recent (<200 years BP) time. This report does not address historical factors related to number 1 above. Patterns of diversity related to post-glacial history must be addressed through a *fine-filter* assessment of the type done by The Nature Conservancy and natural history museums, for example. This report addresses climate, landform, and soil variation, with an eye on disturbance, as surrogates for large portions of ecosystem and species diversity.

The *Premier's Round Table on Environment and Economy* recommended the establishment of a system of protected areas "representing the important natural features of all of the province's bio-geographic regions". The reason is to protect biodiversity and ecosystem processes in the regions, and to ultimately better understand human effects on biodiversity and the environment.

In our analysis, we identify candidate-protected areas in the range of approximately 20,000 to 25,000 hectares for the ecoregions of New Brunswick. Candidate areas were rated according to their climatic, landform, and soil variation, and to their degree of disturbance, while taking into account the contribution of the three existing large New Brunswick protected areas.

4.2 Objective

To identify the most suitable sites in each ecoregion of New Brunswick for consideration as representative protected areas from the standpoint of ecoregion representivity and wilderness value.

4.3 Methods

We have performed an initial assessment of the entire land area of New Brunswick to identify areas within the ecoregions of NB that capture maximum landform and soil diversity (representivity) in areas of low disturbance (wilderness value). We have attempted to identify areas within which final boundaries of roughly 25,000-hectare protected areas can be outlined.

4.4 Sampling Protocol

New Brunswick's geographic information data on the forests, topography, and soils is organized into roughly 1800 - 4200 hectare data packets or "mapsheets" arranged in a map grid. This data structure provided flexibility to organize the data into multiple configurations of roughly configured potential protected areas by grouping the small maps together into "sampling quadrats".

The sampling quadrat used was composed of a maximum of 12 mapsheets together comprising nearly 50,000 hectares, configured 3 mapsheet columns by 4 rows. Each mapsheet theoretically forms the

upper-left corner of a potential quadrat that is accepted for further evaluation if its extent inside the ecoregion was at least 15,000 hectares; otherwise it was rejected. In total, 2015 quadrats were evaluated in all ecoregions.

4.5 Representativity

While landforms were not identified in strict accordance with standard CCEA methodology (i.e. the **landscape matrix** *sensu* Iacobelli *et al.* (undated)) a number of variables were generated from topographic and soils data that when considered together will approximate landform diversity in a manner similar to the standard CCEA methodology.

4.6 Soils

Soils data are derived from "The Forest Soils of New Brunswick" by Colpitts *et al.* (1996). While significant areas of deep ablation tills, drumlins, and glaciofluvial deposits exist in the province, the great majority of area is covered by fairly thin (<2m) veneer of basal till. For the most part, the shape of the underlying bedrock controls surface expression, and lithological composition of soils reflects underlying bedrock. Soil lithology is correlated with important ecological factors like pH and texture, both known to effect species composition of vegetation in NB. Lithology is therefore a prominent variable in the soil classification of Colpitts *et al.* (1996), and forms the basis for classification of soils for

this assessment, apart from interval, tidally influenced, and organic soils.

4.7 Ecosites

Ecosites are fine-scale ecological land classification units based on soil and topographic data that approximate landforms. Ecosite maps have been developed for each of New Brunswick's 34 ecodistricts. Ecosites were computer-generated on the basis of studies of the relationship between landform interpreted from soil, slope, and elevation, and vegetation inferred from the province's photointerpreted forest inventory. For more detail on the development of ecosites see Zelazny *et al.* (1997).

4.8 Topography

A detailed topographic surface was computer-generated, and the area in each of 20 elevation classes and in 7 slope classes was summarized for each map sheet.

4.9 Disturbance

On each map sheet the non-urban areas were assessed for road density in kilometers per square kilometer. The extent of road networks is highly correlated with the extent of forest harvesting, plantation establishment, agriculture, and human settlement. Absence of roads is a defining characteristic of wilderness area.

A weakness in the road density data is that some areas are updated with higher frequency than others,

causing bias in the data are. In particular, some private woodlot areas and some parcels of industrial freehold land have not been updated since the mid-1980s, while Crown land and other industrial freehold lands are regularly updated. Recommended areas that have been infrequently updated should be checked for the discrepancy between actual and estimated degree of disturbance and the effect this may have on site priority.

4.10 Ranking Candidate Quadrats

All quadrats in an ecoregion were ranked based on the number of classes found in the quadrat in each of the soil, ecosite, and topographic categories. The mean of these ranks was used to give an overall representivity ranking. Areas of highest diversity of slope classes, elevation classes, soil classes, and ecosites received the highest mean ranks.

Quadrats were also given disturbance rankings, with the highest ranks going to the quadrats with the lowest road density.

Overall quadrat ranks were derived in three ways that varied according to the weight given to representivity and disturbance rankings in deriving the overall rank. One overall ranking scheme gave 80 % weight to the disturbance ranking in calculating overall rank; the second method gave 80% weight to the representivity ranking, and the third was based simply on the mean disturbance and representivity rankings (*i.e.* gave 50% weight to each).

4.1.1 Description and analysis of the proposed candidate sites

As a result of our analysis we identified thirteen (12) potential candidate sites within the seven ecoregions which could form the core of a Protected Areas Strategy for New Brunswick. We are presenting a general description and analysis of each proposed site. The final selection of the site within each ecoregion should be determined following a comprehensive Province wide public review of the proposed strategy.

The following sites were identified as offering the highest potential for the protection of biodiversity within each ecoregion. They are:

- Jacquet River Gorge
- Grand Lake Meadows
- Kennedy Lakes
- Long Lake
- New Brunswick Central Highlands and Mount Carleton Park
- Nerepsis Hills
- Restigouche River
- Upsalquitch Forks
- Loch Elva
- Cannan Bog
- Armstrong Lake
- Caledonia Gorge

5 Development and Implementation of a Strategic Action Framework

5.1 The elements of the framework

Prior to proceeding with the development of a Protected Areas Strategy for New Brunswick a Strategic Action Framework should be developed which will guide the sequential implementation of the strategy. The framework should include the following elements

1. A public review of the Proposed Strategy through a formal Province wide consultation process.
2. The development a public information strategy on the protected areas initiative.
3. The development management guidelines for candidate protected areas.
4. Review and revise the present regulations for protected areas under the Crown Lands Act.
5. Preparation of protected area designation action plan with specific milestones.
6. Develop a research strategy for the Protected Areas Network.
7. Develop a partnership strategy to involve all New Brunswickers in the development and management of a Protected Area Strategy.
8. Develop a funding strategy to support the development of a research strategy for the protected areas strategy

5.2 Planning and Management Guidelines for the Protected Areas

Planning and management guidelines will be developed which will define the roles of the various categories of protected areas (nature reserves, wilderness areas, and provincial parks) and to outline corresponding land management and resource use policies within and around the protected areas.

Management plans should be prepared for each candidate-protected areas according to priorities based on:

- the significance or sensitivity of the candidate area;
- the extent of threats or stresses on the ecological integrity of the candidate area;
- the extent of public interest, particularly at the local level, in initiating a management planning process; and,
- the availability of resources to undertake the management initiatives.

Following are some consideration of management options that could be integrated with each protected area.

5.3 Basic Management Principles

1. The maintenance of ecological integrity, natural ecological processes, and biodiversity is the first priority for the management and use of protected areas.
2. Public use and enjoyment - including such activities as wilder-

ness recreation, nature tourism, outdoor education, and scientific research - will be encouraged as long as these activities are ecologically sustainable and respect the interim management guidelines.

3. Existing land tenure and land use rights (e.g., existing mineral rights and campsite leases) will be honored. However, the activities must respect the protection-oriented values of the area.
4. A wide variety of partnership options will be encouraged in the planning and management of protected areas. Potential partners include, but are limited to:
 - local community organizations;
 - conservation organizations;
 - aboriginal groups;
 - nature tourism interests or wilderness user groups;
 - owners of private holdings or adjoining private properties;
 - holders of existing leases or licenses;

5.4 Potential Recreational uses within the Protected Areas

1. Facilities (such as hiking trails, portages, and tenting sites) developed to accommodate wilderness activities will be kept to a minimum and sited to minimize environmental impacts and to maximize the quality of the wilderness experience.
2. Traditional, long-established patterns of hunting, sport fishing, and trapping will be permitted within the candidate-protected

areas, however, specific guidelines regarding the nature and extent of these activities will be established for individual areas.

3. Travel within candidate protected areas for the purpose of hunting, sport fishing, and trapping will be by non-motorized means.
4. Snowmobiling within candidate protected areas will be permitted only on established trails that are essential links with more extensive trail networks and where environmental impacts are minimal.
5. The recreational use of all-terrain vehicles and motorboats will not be permitted within candidate protected areas.
6. Notwithstanding the preceding statements, in exceptional cases, permits may be authorized by the department to allow motorized travel within candidate protected areas on approved routes and under specific conditions.
7. Signs will be posted at access points to advise visitors that they are entering a candidate-protected area, and to inform them about appropriate codes of ethics (e.g. "Pack it in, pack it out") and regulations.

5.5 Resource Development and Extraction within the Protected Areas

1. Commercial forestry activities will not be permitted within candidate protected areas.
2. New exploration licenses will not be issued within candidate protected areas. However existing

mineral rights will be recognized and honored while they remain in good standing.

3. The termination of existing mineral rights will be negotiated with mineral rights holders who have indicated an interest in entering into negotiations.
4. Mineral exploration will be permitted on existing claims and will be carried out in such a way as to minimize impacts on protection-oriented values. Specific conditions will be determined by the Department of Natural Resources through review of proposed work plans.
5. Mineral rights holders will be given the necessary security of mineral tenure in that they will have the right to develop a mine on current holdings within candidate protected areas, subject to conditions relating to minimizing potential impacts on protection-oriented values and to the outcome of review processes under the Environmental Assessment Act.
6. Any new mineral development proposals will be subject to review under the Environmental Assessment Act. Proponents will be required to register any such mineral development proposals with the Department of the Environment.
7. New roads and utility corridors will not be permitted.
8. Notwithstanding the preceding statement, if a mine is proposed, the proponent will be required to enter into an agreement with the Province of New Brunswick to establish easements for any re-

- quired transportation or power access in a manner so as to maintain consistency with the goals and objectives of the candidate protected area(s) and to minimize potential environmental impacts.
9. Energy resource developments, including hydro developments and associated impoundment, will not be permitted within the candidate-protected areas.
 5. Insect infestations and diseases will be suppressed within the protected areas.
- adverse affects on neighboring lands and resources, the current lack of scientific information on the ecological role of natural fire in New Brunswick, and indications that the majority of forest fires in New Brunswick are caused by humans.

5.6 Adaptive Management Strategies

1. Ecosystems will be managed with minimal interference to natural processes. Active management intervention in natural processes, however, may be considered where the structure and function of an ecosystem has been significantly altered by human activities and where manipulation is the only means to restore ecological integrity. As well, management intervention will be considered to protect rare and endangered species.
2. Where manipulation is necessary, specific management actions will be based on scientific principles. Techniques used will simulate natural processes and results will be carefully monitored.
3. Efforts will be made to prevent the introduction of exotic plant and animal species into candidate protected areas, and to eliminate or limit the proliferation of such species where they already exist.
4. Forest fires will be suppressed in the candidate protected areas. This is due to the potential for

5.7 Crown Land Use Permits, Licenses and Leases

1. New land use permits, leases, and licenses will not be issued for Crown lands within the candidate protected areas, except those as may be expressly required to fulfill the management objectives of these areas.
2. Existing campsite leases that are maintained in good standing will be honored.
3. Campsite leaseholders will be encouraged to play a stewardship role in the candidate protected areas where they hold leases.

5.8 Integration of Protected Areas within the Surrounding Landscape

1. Crown lands within the surrounding “working landscape” will be planned and managed with due consideration to the management objectives of candidate protected areas.

2. The owners of adjoining private lands will also be encouraged to recognize protected area management objectives and to consider complementary management practices wherever desirable and practical.

5.9 Scientific Research Strategy for the Protected Areas

All management requires feedback so it can adapt its actions and become more successful. The proposed core protected areas are to be integrated with surrounding managed lands. We propose making research, monitoring, and adaptive management part of the protected areas strategy. Using the core protected areas as benchmarks, New Brunswick has the opportunity to be a world leader in research in forestry and biodiversity. Using an adaptive approach, the working group sees these areas as ideal experimental designs for forestry and biodiversity management. The information for the protected areas and surrounding adaptive zones can be used by universities, forest managers, and governments.

effectively integrate all of the conservation and biodiversity data within the Acadian Bioregion. Within the limits of available resources, efforts should be undertaken to systematically integrated existing inventory and document significant gaps. The resource inventory should be designed to support protected areas planning, to provide input to integrated resource management planning, and, where possible, to encourage and facilitate private land stewardship initiatives. There is opportunity for co-operative programs with Conservation data centers, industry, universities and existing national monitoring efforts like EMAN. CDCs maintain databases on rare, threatened or endangered species and communities, which are at risk of extinction or extirpation through present threat or natural rarity, and thus require conservation effort.

The addition of GIS capability greatly enhances the CDC's ability to provide data on an area-specific basis, such as application to Protected Areas. Within the GIS, CDC data and PAS sites can be arrayed as digital map objects in thematic layers:

6 Implementation

6.1 Resource Inventory and Data Base Management

The implementation of a Protected Areas Strategy will require the implementation of a comprehensive management strategy which would

6.2 Scientific Advisory Group

The Minister of Natural Resources and Energy will consider the appointment of a scientific advisory committee to the Protected Areas Strategy. The membership will include representation from Universities, Government Agencies and other scientific organisations.

The Scientific Advisory group will act as an advisory group to DNR&E on issues related to protected areas. They will identify relevant research topics and develop a research agenda for the protected areas.

6.3 Development of a Strategic Partnerships Strategy

Public participation is essential to the effective planning and management of protected areas. Partnerships will be actively encouraged for a wide range of planning and management responsibilities. Areas of emphasis include, but are not limited to:

- owners of private holdings and parties holding leases or licences on lands within candidate protected areas;
- owners of adjacent private lands;
- community development interests;
- aboriginal groups;
- conservation-minded organisations;
- nature tourism and outdoor recreation groups; and,
- the scientific and educational community.

6.4 Liaison with Local Communities and Stakeholder Groups

The Department of Natural Resources and Energy will endeavour to communicate and meet with representatives of affected communities,

stakeholder groups, and interested individuals in order to:

- convey information on the status and implications of the Protected Areas Strategy;
- identify areas of interest or concern for future planning and consultation processes;
- seek advice regarding future consultation processes for protected areas planning and management; and,
- identify potential partners for planning, development, and management activities.

6.5 The Role of Private Landowners

Almost 30 % of New Brunswick is owned privately. The role of the individual landowner in preserving our natural areas is extremely important. That's why landowners will be actively encouraged to protect significant natural values on their properties.

6.6 Encouraging Community Development

New Brunswickers, of course, are not the only ones to appreciate our natural environment. Each year, more and more people from around the world choose our province for their "ecotourism" destination.

As a result, our system of protected natural areas can be important in the development of communities and nature tourism. It demonstrates that we are serious about striking a balance between the environment

and the economy; and it boosts New Brunswick's image as a clean, green, and healthy place in which to live, work, visit, invest, and do business.

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Development of an Action Strategy

An action plan should be developed which will translate the broad strategy into clearly defined tasks and priorities and to provide strategic direction for the implementation of the **Protected Areas Strategy**.

Adoption of the Protected Areas Strategy

The adoption of the Protected Areas Strategy by the provincial government is the initial step in the implementation process. Following a pub-

lic review of the proposed strategy, the government should proceed with the establishment of a comprehensive system of protected areas in New Brunswick **with a clearly defined implementation time table**.

Development of Interim Management Guidelines

Interim guidelines should be developed for the management of the candidate-protected areas included in New Brunswick's Protected Areas Strategy. They should remain in effect until legislation is in place and management planning and consultation processes have been completed.

During this interim period, traditional recreational uses will continue. In all cases, activities and developments within candidate protected areas must be ecologically sustainable and respect underlying protection objectives.

Protected Areas Legislation

Protected areas legislation should be reviewed and updated as needed to provide for the formal designation of the network of protected areas.

Technology transfer and training in forest and natural resources education – a New Zealand case study

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Abstract

Education for Forest and Natural Resources has been evolving in the Taranaki Region of New Zealand through a local **Resource Group** formed in 1991. In the new education environment, **strategic alliances** are necessary with institutions and industry to make programmes work. Programmes that must be credible, audible, flexible and suit the end users involved. The tertiary programme described in this paper has been designed to address sustainability and the New Zealand Resource Management Act (1991) with a common link between research, technology, education, skills, people and the land. Adoption of **management systems** and application of appropriate technology to enable people and the community to provide for social and economic wellbeing is currently being instigated and developed. Technologies like **GPS/GIS/Remote Sensing, Internet and Interactive New Media** with decision support systems are now being trialled and integrated into a core Diploma Programme of Forest and Natural Resources. The programme is supported by “**model site**” land based farm forestry locations that provide exemplary forest practices and research opportunities for students and the community to participate in. These model sites feature in the 1999 New Zealand National Farm Forestry Conference in Taranaki.

I Introduction

Effective training for the forest and natural resource industry is only possible through close co-operation be-

tween industry, education, landowners and students.

It is essential to develop structures from the ground up and build on community support that includes en-

vironmental issues suited to local conditions.

The combination of the above components can lead to the formation of practical demonstration areas (model sites). With the addition of distribution technology, plus Internet interactivity concepts, information can be shared on a national and international basis.

For New Zealand, Taranaki Polytechnic has developed the first truly integrated, yet practical learning experience to match and enhance sustainable forest and natural resource needs.

2 The programme

Within New Zealand there are seven Universities and 25 Polytechnics. Polytechnics are educational institutes that offer an increasingly wide range of vocational education programmes from skills training, pre-trade, Diploma and more recently Degree Programmes.

In 1991 a small resource group of individuals and organisations came together to address the formation of a credible structure to support and maintain land based education, skills and research in the Taranaki region of New Zealand. The resource group approached the Taranaki Polytechnic to start a programme. The group could see a role for agroforestry as the traditional farming practices of raising sheep and beef cattle on marginal hill country were becoming less cost effective. Product values for sheep and cattle were decreasing and product costs were increasing. As well, en-

vironmental legislation to enforce sustainable land use such as soil loss and water quality, was being introduced. Historically, marginal land was inappropriately cleared for pastoral farming. As a result erosion control was increasingly required. Strategic afforestation of hill locations and riparian areas was needed.

The New Zealand Government's Forest Research Institute had developed a computer model (Agroforestry Estate Model "AEM") based on a local farm. The farm owner, Jeremy Thomson, is a member of a local resource management group (refer to Programme Infrastructure Illustration Link). He requested a model be developed to illustrate the consequences of varying regimes of livestock and trees on farmland. Another relevant development was a case study in the region co-ordinated by the Taranaki Regional Council (Local Government). The study aimed to apply results of recent research of pasture growth and soil erosion to existing farm systems. The project involved developing a sustainable land use classification system for the region. This system combined with the computer model (AEM) was used by the Regional Council to provide sustainable land management plans for farmers.

The Regional Council, having a role and interest in land conservation, provides the management plans free of charge. The plans incorporate agroforestry in a practical and sustainable way. By 1998, over 100 plans had been completed at the request of farmers. Implementing the plans is the responsibility of the farmer, not the government. A highly

skilled workforce was required. The Taranaki Polytechnic has a model site where the system has been implemented (Fig. 1, Fig. 2).

Thus the scene was set in 1991 with decision support systems and an environment where people wanted to develop the skills and knowledge to afforest land. The Taranaki Polytechnic hired me on the recommendation of the resource group. The group represents the local region through individuals, groups, trusts, forestry contractors, multinational companies, nurseries, sawmills, local government, conservation bodies and indigenous peoples. This group

wanted to authentically address sustainability of the land for future generations and ensure the education of people to take care of it. The farmers felt the education system was failing to recognise their interests. They wanted practical and management skills to be taught – practical skills that included silviculture of special purpose tree species and management that included agroforestry and wider issues than traditional plantation forestry.

A vocational skills programme was started to address the afforestation of hill country land in the region. Members of the farm forest industry

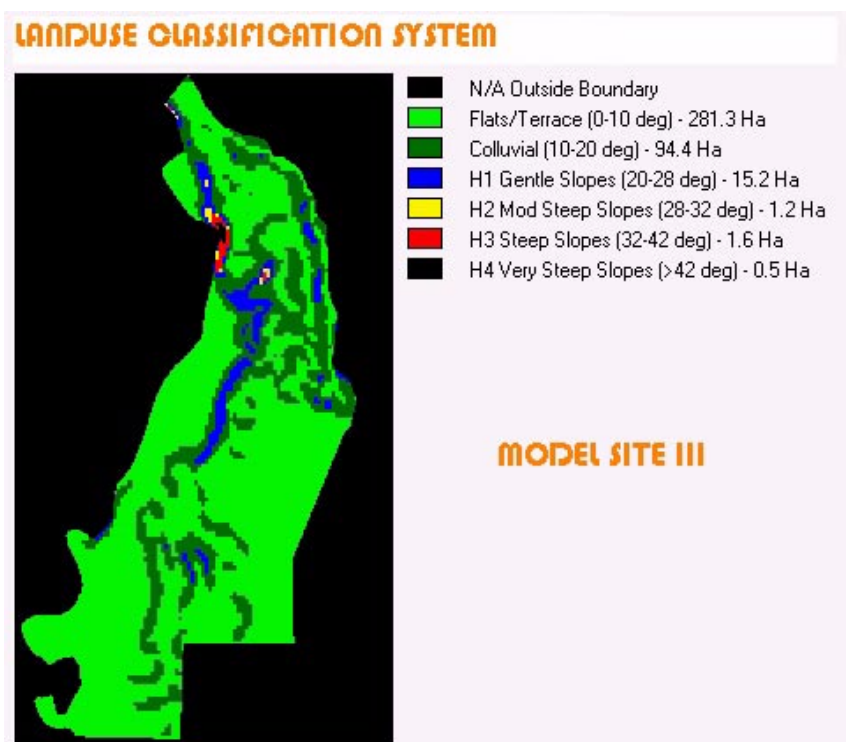


Fig. 1. Sustainable land management plan; a model site at Taranaki Polytechnic.

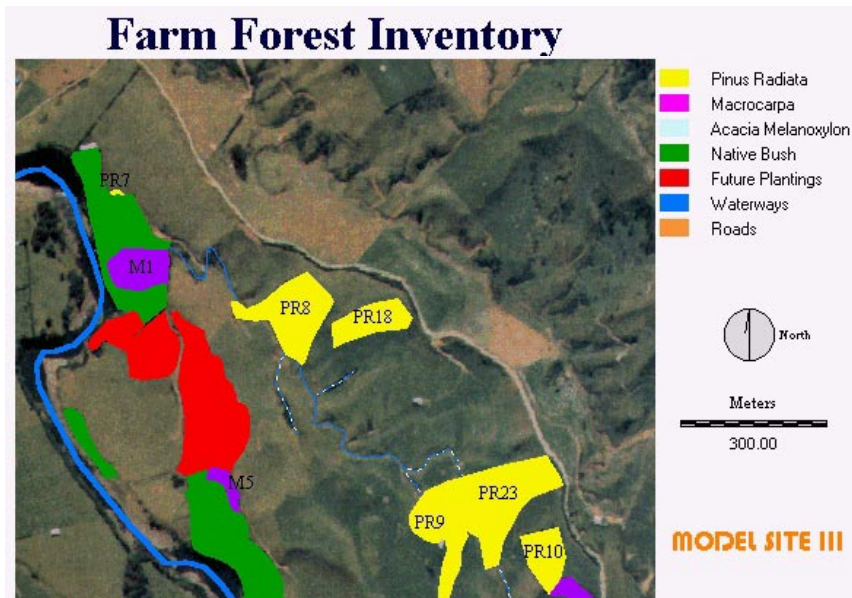


Fig. 2. Planting area's per classification system.

supplied the tools and plantation sites and the Taranaki Polytechnic provided the trainees, supervision and forest management. Upon completion of the skills programme, surveys showed that students were immediately employed by contractors.

As regions throughout New Zealand began to experience a planting boom on farm and hill country land (outside the traditional plantation industry forest land base) it became evident that people with supervisory and management skills were needed. As a response to this, the Taranaki Polytechnic developed and implemented a diploma programme to complement and extend the skills programme. The situation has evolved and continues to develop into a programme of national repute. The stakeholders are satisfied and student graduate surveys clearly

show high employment outcomes. Strategic alliances with the scientific community, forest industry and technology providers have been achieved for the benefit of all. An Integrated Programme Infrastructure has evolved at the Taranaki Polytechnic.

Over the years the New Zealand Farm Forestry Association of its own accord has become increasingly a professional organisation and respected lobby group. Estimates are Association members in the upcoming years may control up to 25 % of the exotic plantation base currently estimated at 1.5 million hectares. A more recent initiative by the Taranaki Association branch is The Tree Growers' Marketing Society. The Society is a co-operative formed and managed by farmers to collectively harvest and market timber.

3 Infrastructure highlights

3.1 The Academic Programme (refer Reference 11) encompasses a two year Diploma in Forest and Natural Resources. Practical forest tending skills, management principles, alongside ecological principles and GIS/RS are all part of the programme. Field training is carried out in model research and development forest and land locations throughout the region. A national certificate in Geographic Information Systems (“GIS”) has recently been designed by an industry training organisation. This two year certificate may be developed by the Taranaki Polytechnic and linked with the current Diploma in Forest and Natural Resources.

3.2 The Tuwharetoa Institute of Learning is an Indigenous people (Iwi) managed organisation that is associated with the Taranaki Polytechnic. Together we have developed and run vocational skills programmes that suit not only their own Iwi but many other people who are involved in the contract forest industry. An objective of the Iwi is to be self sustaining in their education and business environment for future generations.

3.3 To date the **Research Programme** has established over 50 Permanent Sample Plots (PSP) of varying tree species on forest and farm plantation area’s throughout the region (Fig. 3, Fig. 4). These provide a base for initiating growth models and further research opportunities for staff, students and interested parties.

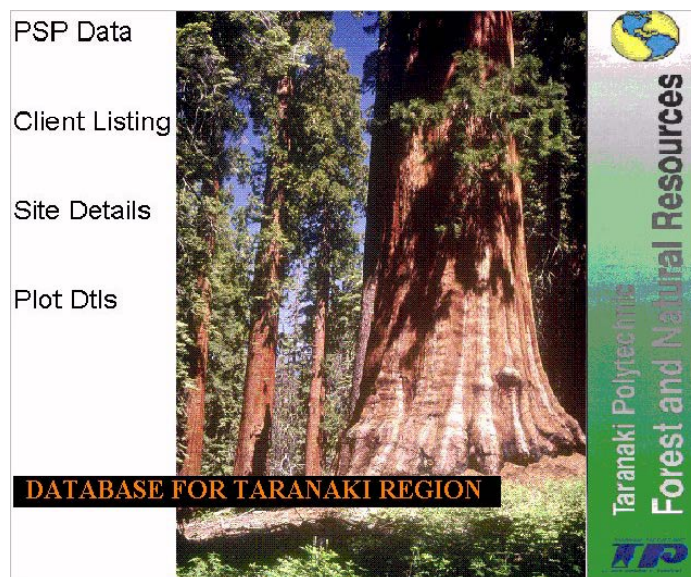


Fig. 3. Permanent sample plots: an overview.

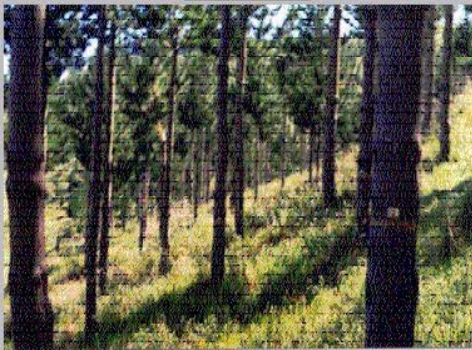
Site Ref	97;2	Date planted	30/06/88
Plot ID	97;2;6;1 & 6;2	Date measured	01/12/97
McIntire			
P.radiata			
Mean DBH	24.4	cm	
Mean Total Ht	14.43	m	
Mean Prune Height	6.48	m	
Mean DOS Ht	4.14	m	
Mean DOS	20.8	cm	
Current Stocking	336	SPH	
Branch Size	20mm		
Dothistroma	0	%	
Canopy Closure	40	%	
Undergrowth	FIT FOR GRAZING		
Comments			
MODEL SITE III THIS IS LINKED TO THE GIS DATABASE			

Fig. 4. PSP database; an example of plot details.

Tree root studies are also being researched on a model location (Fig. 5, Fig. 6, Fig. 7). Wind throw on fertile farmland has been a problem with *pinus radiata*. Preliminary results show direct set seed or direct set cuttings have the best root structures. The maintenance and economics of such results requires further investigation. Recently the Taranaki Polytechnic has been negotiating a research contract with Jiffy Canada to trial their nursery and field products for tree establishment.

Several GIS and Remote Sensing ("RS") Projects have been started

with students using low level Idrisi software to capture and compile attributable data from model sites. For extended learning and industrial applications, this data will be imported into a higher level software package. This will form the basis for spatial technology application and extensions like monitoring or modelling.

3.4 The Model Sites Programme provides areas for the community and students to participate actively, as students complete all silviculture work on the sites. Income from the student work contributes to the pro-

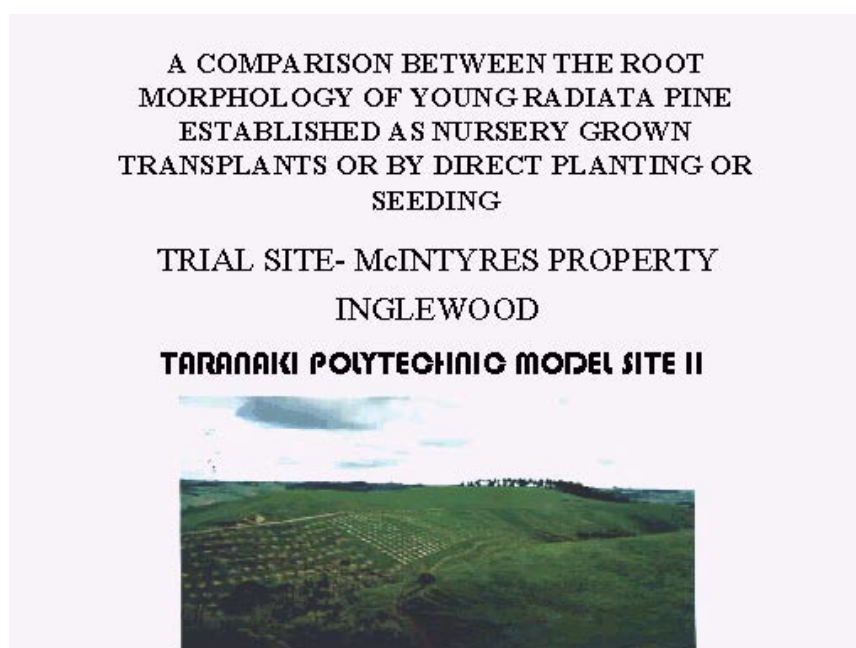


Fig. 5. Tree root studies.

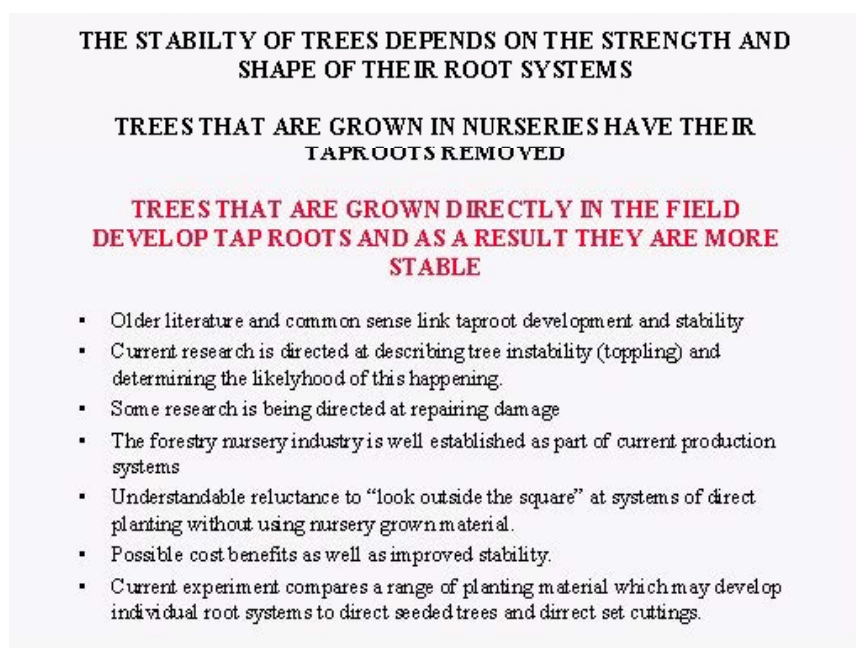


Fig. 6. Root documentation.

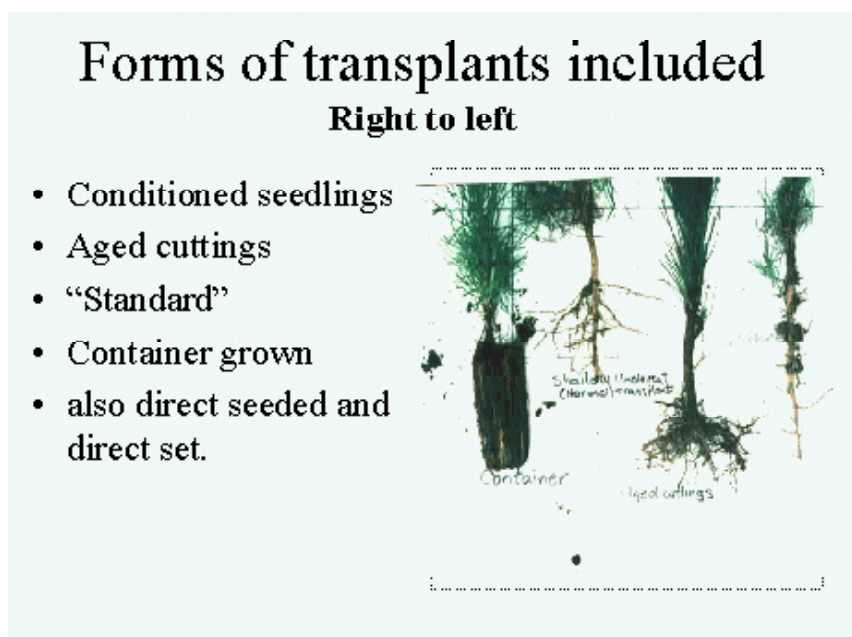


Fig. 7. Seedling roots.

gramme costs and resourcing. The criteria for model sites includes diverse locations of differing geographic, ecological and socio-economic circumstances. A mix of private land, trust farms (Fig. 8, Fig. 9), school and company locations are included. The landowners involved must be enthusiastic and in favour of education and research principles. In fact the programme is so successful we continually receive additional offers of sites. Landowner participants enjoy seeing people learn skills and apply the latest technology on their land (Fig. 10). They are perfectly willing to pay market value for the services provided as long as the workmanship is reasonably guaranteed. Several of the model sites were

featured on the tour programme for the New Zealand Farm Forestry Association Conference in March 1999.

3.5 The Resource Group or Advisory Committee is a statutory requirement of the education system in New Zealand. It is an excellent vehicle whereby the community gets together and decides collectively on their educational needs. The Resource Group comprises the stakeholders referred to in the Programme section.

As Taranaki Polytechnic representative and Programme Manager it is one of my priorities to foster this group and ensure stakeholders are involved in objective setting and feedback.

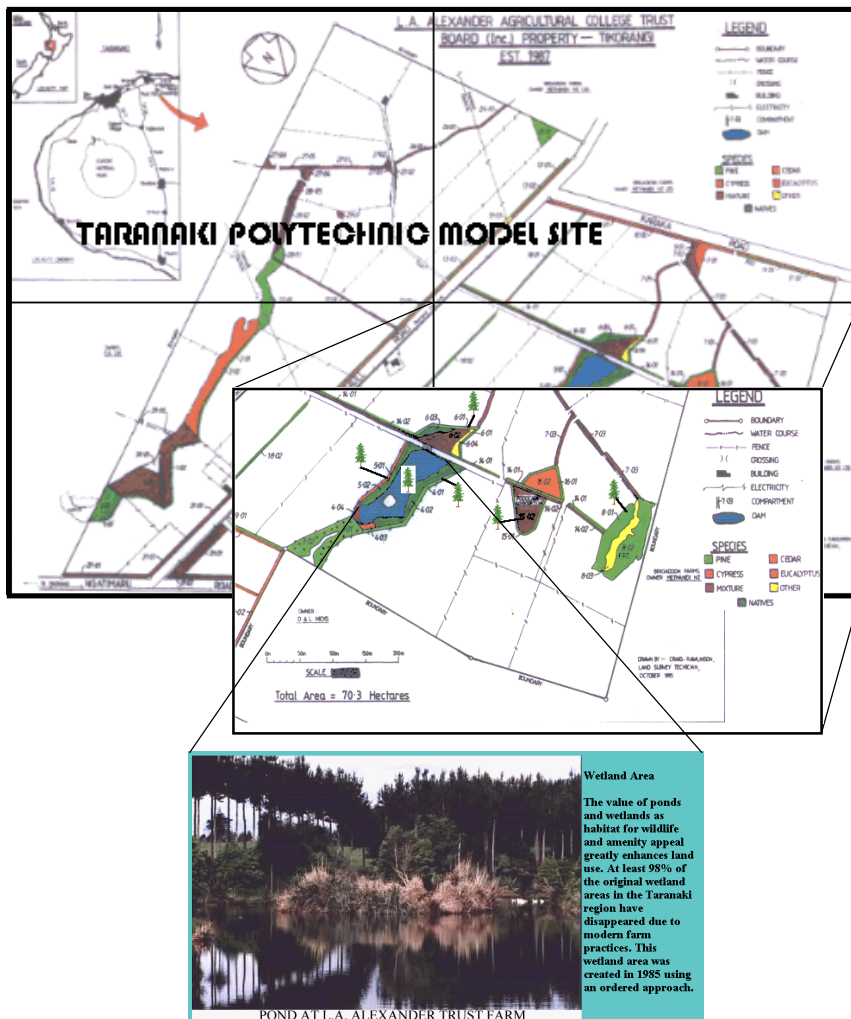


Fig.8.A trust farm (model site).

3.6 The Forest and Natural Resources Programme World Wide Web (WWW) Site is currently being developed by students as a project. It will link directly with the existing Taranaki Polytechnic WWW site and possibly other associated educational or Forestry WWW sites.

The basic format of the site is evolving from the Programme Infrastructure. (Refer to Taranaki Polytechnic Integrated Programme Infrastructure link). Appropriate data from the entire programme structure will be placed on the WWW.



Fig. 9. "Learning by doing"; students at field.



Fig. 10. A plantation at model site IV.

3.7 **The GIS/RS Co-operative** is modelled on the College of Geographic Sciences Programme. Industry specifies GIS/RS research projects they would like done by Diploma students during their course of studies. The Taranaki Polytechnic provides the research facilities, supervision and hardware. To date sponsorship of software is being negotiated with representatives of international companies including Autodesk Inc, ArcView, E.R.Mapper and Map Info. An Australian Software company Digital Mapping Systems has contributed orthorectification software for the co-operative to trial. The co-operative is an ideal environment for strategic alliances to

occur for the good of all stakeholders.

3.8 **The GIS Extramural (Distance Learning) Programme** is a GIS Introductory Certificate offered by the Taranaki Polytechnic to suit people who have distance learning needs. An arrangement was made between the Taranaki Polytechnic and the College of Geographic Sciences, Canada, to import the Canadian Distance Learning Programme into New Zealand. Modification of the data sets to suit local conditions is currently being done. It is envisaged that this localised distance learning programme will be available on the Internet or through the interactive

new media in the future to service New Zealand needs.

3.9 The Forestry Tending and Technical Services have evolved from the active management of over 600 hectares of forest and farm plantation model sites. Taranaki Polytechnic students have planted over one million trees since programme inauguration (Fig. 10). Planting sites vary from farm locations and private investor type ventures to multinational company block locations like Carter Holt Harvey Limited.

This service creates opportunities for the Taranaki Polytechnic staff to practise their profession, students to gain practical skills and the greater community to benefit from work well done (Fig. 11). If the Taranaki Polytechnic can not immediately service the model sites then preferential contractors who hire students pick up the balance of tending work.

As an example of Taranaki Polytechnic training, a small local company that intensively manages and applies silviculture to 18,000 hectares of forest on ex farm land for 1600 investors recently hired two graduates to suit their companies expanding needs. They have since

commented how pleased they were with the graduates who had a good combination of theoretical and practical skills.

3.10 The Nature Tourism component is a more recent element and opportunity in the programme to introduce multipurpose land use. Hundreds of people visit the model sites every year. The Australian Department of Conservation and Land Management stated in their nature tourism programme "People not only want to look at trees but they want to know something about them.". Nature Tourism is proving to be a mega dollar industry. Therefore, it seems opportune to introduce students working on model sites to Tourism (Fig. 12). Interested parties will be able to book their tours on the WWW site!

4 GIS / RS education at Taranaki Polytechnic

GIS/RS education was phased into the programme in 1997. This phase was introduced after core issues of



Fig. 11. Pruning on model site III.

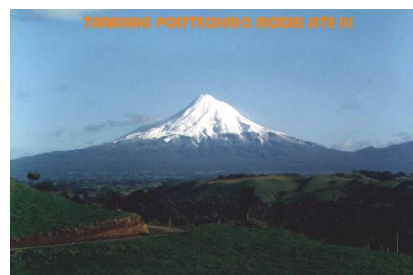


Fig. 12. Model site III; dealing with tourism.

vocational skills training (forest tending) and biological sciences had been established in the programme.

The emphasis on practical skills and experience combined with actual problem solving has produced some excellent students that satisfy industry demands. In the Diploma programme students plan, execute, compile and evaluate real projects. As an example, students are currently completing a forest compartment allocation project for a forest owner. The project is to determine the relationship between slope degrees and aspect to existing tree growth (Fig. 13). Given a relationship, then compartments will be allocated for forest operational purposes. Individual pruning operations are targetted per compartment depending on growth.

In the project area trees were planted in 1994 and pruning will commence this year.

5 Technology use

To date, GIS in New Zealand has not been widely adopted. Computer World New Zealand (1997) stated "First and foremost is the perceived high cost of getting started". From our personal experience and contact with industry we would add the old adage "sworn to caution and suspicious of the untested".

For educational purposes GIS/RS technology products are widely available in the market place. The applications are extensive.

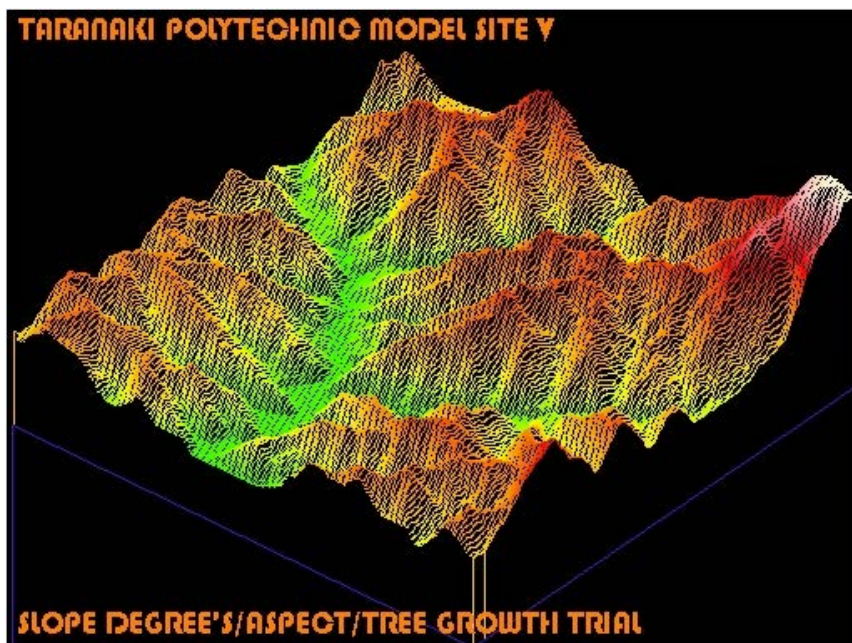


Fig.13. Altitude contour plot of a tree growth trial.

The Taranaki Polytechnic's strategy when adopting software is to ensure:

- It is easy to use
- It can be applied in a diverse range of industries
- It is able to be integrated and combined with other software and data types

Software packages the Taranaki Polytechnic is considering trialling for its programme include Autodesk, ArcView, E.R.Mapper and Map Info just to name a few. Again I emphasise that there is huge product availability from which to select but at the end of the day choices will be cost driven. Software companies have to offer reasonable circumstances for educational institutions to adopt and trial their products.

6 “Interactive New Media”

Established media channels and educational institutions are increasingly being challenged by new forms of distribution and learning. Through information technology, consumers have become aware of an increased range of choice. Developing components of the evolving Interactive New Media may be adopted as a strategy for educational institutes (Fig. 14, Fig. 15, Fig. 16, Fig. 17).

The Taranaki Polytechnic currently offers a Bachelor of Information Systems degree to groups in a interactive new media and internet situation. Recent survey results from the programme seem to indicate face to face contact between student and

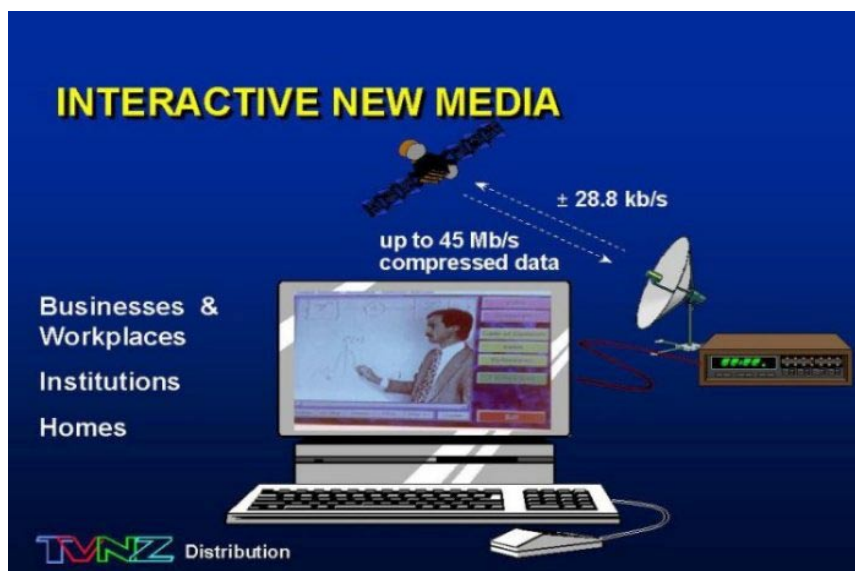


Fig. 14. Interactive new media.



Fig. 15. The global trends.

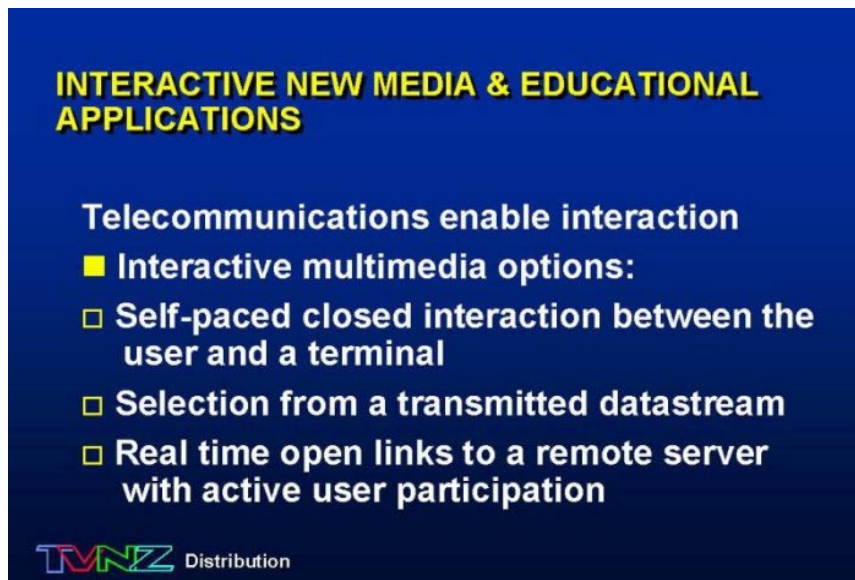


Fig. 16. Educational applications.

INTERACTIVE NEW MEDIA & THE MARKETPLACE	
Business Market	Residential Market
Electronic commerce Information, Publishing, Advertising and Marketing	Multi-choice Television - local & subscription driven
Finance, Banking, Trade, Business services Document exchange	Music, Games, Entertainment, Movies, Sport, News, Internet / WWW, Community information
Tele-commuting/conferencing Tele-medicine/veterinary	Education and Healthcare
Training and upskilling	Shopping, Travel, Banking
	Directories and Advertising
	Betting and Gaming
TMNZ Distribution	

Fig. 17. Business opportunities.

tutor is still the most desired learning means. As a result, the Taranaki Polytechnic's GIS Distance Learning Programme is being investigated. Strategies are currently being developed to include introductory sessions with a tutor in regional centres as well as follow up sessions part way through the year. This will provide opportunity for more face to face contact.

It is planned that databases developed to service the Distance Learning programme and existing Diploma programme will eventually be transferred to server software. Students will have access to this software via an intranet or Internet situation to complete interactive exercises. The server package will be constantly developed and maintained to service educational objectives or strategies using the interactive new media. Ini-

tially data will come from the Forest and Natural Resources programme including current research projects. Data could also come from other organisations that link with the programme.

The challenge for educational institutes will be to constantly update and evolve media products and services to meet the higher expectations of a more educated, better equipped, experienced and diverse customer base. The traditional lines between education and work seem to be diminishing as learning becomes a life long process. The interactive new media will play a crucial role in facilitating future learning.

To remain involved, educational institutions will have to develop professional centres that facilitate peoples' learning. These centres will have to be supported with capital and

skill to gathering and process information appropriate to peoples learning needs. The people component must not be overlooked. People make systems work. Educational institutes will have to invest yet further in the professional development of their staff. Keeping pace with new technology and associated learning is a strain on a system that already has financial limitations.

7 Discoveries

The government in New Zealand and no doubt other governments in the world are reducing educational funding. Further research is needed to conclude the positive and negative outcomes of this and the impending implications. People must address issues that affect our society and the environment in which we live. If our educational institutes reflect in part the health of our society, then collectively people must urgently prioritise what they want to achieve.

Developing and implementing an integrated education programme is a challenge. People from the education and industrial world in our society do not necessarily agree on everything. However, an entity and situation like the Resource Group involved with the Taranaki Polytechnic Forest and Natural Resources Programme, can effectively address educational and environmental issues for the benefit of all. People make programmes or systems work. Time and effort is required by many skilled and experienced people from different disciplines.

Strong structures have to be in place before people will invest their resources. Decision support systems (for example land classification schemes and computer models as used by Taranaki Polytechnic) applied in a practical way with integrity on demonstration (model sites) areas, give people confidence to address issues.

People enjoy and learn best by doing, from being involved in practical situations that suit their immediate and foreseeable needs.

8 Conclusion

Technology and information transfer to the education environment is happening in various forms and rates of progress throughout the world. Collectively, strategic alliances involving all the stakeholders can enhance education both locally and internationally.

The New Zealand Case Study presented in this paper with its evolving programme structure, highlights crucial links that can not be separated anymore. A teaching model can not be developed in isolation and the education system must respond to industrial demands. As a result of this approach, Taranaki Polytechnic now has an effective and multifaceted programme.

It is essential to “develop structures from the ground up” and build on community support and environmental issues suited to local conditions. In practice, the educational component must be credible, audible, flexible and suit the stakeholders

involved. For it is the stakeholders who will support and ultimately decide if positive outcomes are going to occur.

Acknowledgements

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On the way to unique land resources data base of Europe

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Abstract

Last 80th years Russia have been excluded from the world economy and developed separately. Now, when our country try to be incorporated into unique World and European economy, we extremely needed in unification of methods of land resources analysis, which are applied in the World. Only in such way it seems will be possible for Russia to find its own place in the World and European economy. It is known, that Russia occupy near 1/6 of the world territory and near 1/2 of the European territory (in geographical sense). And it seems impossible to create unique land resources Data Base (DB) for Europe without incorporating data from Russia.

The main aim of our investigations is to analyze possibilities of data transfer from Russian land resources DB into mostly known SOTER DB and European Soil DB, which have been created by European Soil Bureau (ESB). Corresponding correlation tables for land resources data transforming have been created. SOTER DB and Soil DB in ESB format have been created for a number of Case Study regions in Russia. Results of investigations can be used as a “key points” for such DB compilation for the hole territory of Russia and for creating of unique European Soil DB. Compilation of SOTER DB and Soil DB in ESB format for Russia opens wide possibilities for modern European land resource assessment technologies transfer to Russia. As an example, land suitability analysis for one of Case Study area have been conducted based on FAO ideology of land evaluation and application of WOFOST crop growth modeling.

The results of investigations could be used for analysis of Russian land resources on the basis of modern western technologies, as well as for analysis of European land resources when based on corresponding Russian approaches. But, of cause, this is only first step on the way to unique land resources DB creating for Europe.

A GIS-based method for landscape ecological forest planning

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Abstract

Geographical Information System (GIS) applications offer many tools by which to produce the information needed in multi-objective decision making. Especially the methods enabling information from different sources to be connected and used in analyses are of central importance in the development of multi-objective planning methods. Cartographic modelling is an area of application for spatial analysis employing concurrent analyses of many sources of information. Combining cartographic modelling, spatial analysis and modern decision-analysis methods based on general decision theory enables closer integration to be achieved among the various objectives and numerical planning methods than has been the case hitherto.

This paper presents a method in which the aforementioned methods and techniques are utilised in order to combine different kinds of criteria affecting the total utility of the forest area in landscape ecological planning. The method is illustrated by way of a simple example in which the purpose is to select targets to be set aside from logging for ecological reasons. In order to succeed in choosing the appropriate forest stands, the decision maker needs to know what kind of habitats the various species require. On the other hand, one has to know how to combine and emphasise the different needs of the species and the different objectives of the various forest uses. The method presented in this study represents an endeavour to select stands to be set aside from logging to enable maximum total utility in relation to the objectives set for the use of the forest area.

Keywords: geographical information systems, landscape ecological planning, cartographic modelling, multicriteria evaluation, spatial analysis

I Introduction

Nowadays, the objectives set for forest use are more diverse than in the past. They vary according to forest owner, but values such as recreation, landscapes beauty and biodiversity have gained prominence alongside traditional wood-production values. These are the results of changes in forest owners' values on the one hand and increase environmental consciousness among the public on the other. More diverse information is needed for decision-making related to forest use because of changes in people's objectives and their relative importance.

Constant research is taking place to produce new knowledge about the impacts that forest treatment has on individual forest uses. The impact of forest treatment for example on the scenic value of the landscape and on the recreational use of the forests has been the subject of study for many years. Lately, the emphasis has been especially on the production of knowledge related to biodiversity. Furthermore, there has been an endeavour to extend the approach to cover landscape ecological planning and thereby to estimate the significance to species of the areas immediately adjacent to their habitats.

Ecological research, for instance, currently produces plenty of knowledge about the habitat requirements of the various species. For this knowledge to be efficiently utilised, we need methods and channels capable of bringing the knowledge into the field of practical forestry. In Finland, a high proportion of commercial forests is within the sphere of

woodlot-specific forest planning, which enables the use of forest planning as a link between ecological knowledge and practical realisation, for instance. The problem at the moment is in that even if there were sufficient data available, it is very seldom that these data are in formats enabling their direct utilisation in multi-objective forest planning. The efficient exploiting of ecological data requires methods whereby data from a variety of sources and differing in format can be linked to numeric forest planning.

This paper presents a GIS-based method in which spatial analyses, cartographic modelling and modern decision-analysis technique are utilised to produce information needed in multi-objective decision-making situations.

2 GIS applications in producing data for multi-objective planning

The term Geographic Information System (GIS) refers to computer-based systems used in entering, analysis management and outputting of geo-referenced data (Aronoff 1989). The status of GIS applications in the management of natural-resource data has strengthened day by day. Most of the organisations dealing with natural resources use georeferenced data. Although the principal use of GIS applications in these organisations is connected to management of georeferenced data and to producing maps, GIS appli-

cations offer many tools for producing the data needed in multi-objective decision-making situations, too. Especially spatial-analysis functions and methods whereby information from different sources can be linked and analysed are important instruments in the development of multi-objective forest planning.

2.1 Spatial analysis

Spatial analysis is the process of seeking out patterns and associations in data that are distributed over space in order to help characterise, understand and predict spatial phenomena (Bonham-Carter 1994). Spatial analysis functions use spatial and non spatial attribute data in combination to answer questions about the real world. Typical spatial analysis functions include the following: various retrieval, classification and measurement functions, overlay analysis; neighbourhood operations, and connectivity functions (Aronoff 1989). Especially overlay analyses, visibility analyses, and the forming of buffer zones have been utilised in the endeavour to produce the data needed in multi-objective forest planning (e.g. Store 1996).

Forming an buffer zone is a technique whereby a new area is generated by surrounding the desired spots, lines or areas within a certain distance (Congalton and Green 1992). Forming an buffer zone has often been used in identifying items which are less than or over a certain distance from a given spot or line (e.g. Hart 1985 et al., Walsh and Butler 1989). Visibility analysis is a matter of determining what areas can

be seen and what areas cannot be seen from a certain spot determined according to level and elevation coordinates (Dangermond 1984). Visibility analyses enable one to determine the targets from which the clear cutting of a certain compartment (stand) would be visible (Davidson 1992 et al.).

In the case of overlay analyses, a new map layer is produced by superimposing two or more digitized map layers one on top of the other. In an arithmetical overlay analyses, the information contained by the map layers is edited by adding, removing, dividing or multiplying the desired values of the map layer using the values of another map layer equivalent in terms of its location. A logical overlay analysis can be used to seek out the targets in which certain conditions are in effect simultaneously. It often happens that overlay analyses are used in the planning land use; they are used to pinpoint areas in which the requirements by the use form actualise simultaneously (e.g. Jensen and Christensen 1986, Siderelis and Tribble 1988).

GIS-based techniques suitable for developing multi-objective forest planning are not usually ready for use as such, but instead comprise a varying number of analyses, which are linked to one another by means of certain rules. This is referred to as cartographic modelling.

2.2 Cartographic modelling

Cartographic modelling is a process of combining maps together by linking several map-algebra statements to form more complex algorithms

(Bonham-Carter 1994). It is a case of application of GIS analysis requiring the integrated analysis of many sources of information. Cartographic modelling has often been used when looking for areas suitable for a specific use form (e.g. Shaw and Atkinson 1988, Reisinger and Kennedy 1990, Wadge et al. 1993).

Usually the objective in land-use planning connected to cartographic modelling is to locate the area or areas where the given criteria apply. Locating of these areas takes place by connecting the map layers by means of logical overlay analyses in numeric format; each map layer then represents one criterion. If the map layers are connected applying absolute Boolean rules, the final result will always be a map in binary format with each pixel containing the value zero or one depending on whether or not the pixel fulfils all the given criteria. The rules applying to connecting maps are usually based on empirical observations and measurements, but sometimes also on the phenomenon's physical and chemical properties.

The final outcome in land-use applications based on Boolean logic is a map depicting those areas which simultaneously fulfil all the set conditions. The problem with the method is, however, that it does not offer any analytical method for examining which of the areas fulfilling the criteria are the most appropriate for the purpose of use in question or which areas are the best beyond the feasible areas. In order that the method might be better suited for multi-objective forest planning, it must also be able to provide information on

how well a given area fulfils the set objectives. To facilitate this, the map layers must be connected using arithmetical overlay analyses and this has to be accompanied by methods developed for multi-criteria evaluation.

3 Multi-criteria evaluation methods and GIS

Multi-criteria evaluation (MCE) methods provide the tools for investigating a number of choice possibilities in the light of multiple criteria and conflicting objectives (Voogd 1983). The methods developed for multi-criteria evaluation may be divided into compensatory and non-compensatory methods. In the case of non-compensatory methods, a low criterion score for an alternative cannot be compensated by another criterion's high score, whereas this is possible when using compensatory methods. Compensatory methods can be further divided into additive techniques and ideal-point techniques. With additive techniques, the total score for each alternative is calculated by multiplying the criterion score by its weight factor and then adding the results together. Weighted linear summation is probably the best known example of this category. The principal problem encountered in connecting map layers is the realisation of the weighting of the map layers and of individual map-layer categories and of combining the criteria measured using different meas-

urement scales or units (Carver 1991).

It often happens when processing GIS and natural-resources related data that the information related to the various criteria has been measured using units and scales which defy direct comparison. This is why standardisation methods have been developed and these enable the user to transform the criterion scores to one common measurement scale and measurement unit. These methods usually enable the variation of a criterion to be scaled between zero and one.

Different criteria often have a different weight values when decisions are made. This being the case, one must be able to evaluate the criteria in relation to one another and to connect to the criteria the weight coefficients reflecting their significance. The said weight coefficients can be derived in a number of ways. Voogd (1983) presents the following alternatives for determining a set of weights: preference analysis, behavioural analysis, direct system description, indirect system description, and hypothetical priorities. Setting the weight coefficients for the criteria usually has a crucial influence on the solution to the decision problem.

By merging MCE methods with GIS-based tools, it is possible to produce an index map instead of a binary map, with the values of the map elements (pixels, areas) on the index map depicting how well it fulfils the set objectives. These maps are produced by merging several map layers together so that some of the map layers serve as absolute constraints

delimiting certain areas from being examined whereas flexible constraints determine how well a certain pixel fulfils the set objectives.

In the simplest form, the map layers are in binary format (a particular map element can obtain only the value of zero or one) in which case each map layer can be weighted with only one weight coefficient. This means that an index map is formed by multiplying every map layer by its weight coefficient and by then merging the map layers using Boolean or arithmetic operators. With multi-category maps, too, binary weighting with Boolean expressions can be used to convert them into binary maps.

With multi-category maps, weighting is performed by multiplying the values of the categories by the weight coefficients related to the map layers. When weighting multi-category maps, each map-layer category can be allocated its own coefficient in addition to map-layer-specific weight coefficients. Sensitivity analyses have been used in some studies to demonstrate to the decision maker the effect that the inaccuracies and the uncertainty included in the objectives and weightings have on decision recommendations (e.g. Pereira and Ducstein 1993).

4 Hypothetical example

The following fictitious example represents one way of using GIS and MCE techniques to classify forest areas on the basis of certain criteria. In the example, the objective is to

prioritise the target area’s old forests with respect to requirements of three species. Based on species habitat requirements, the method first yields an index map for each of the species

with the index value representing the suitability of the area for the species in question. Then the index maps per species are combined to form an index map per species group (Fig. 1).

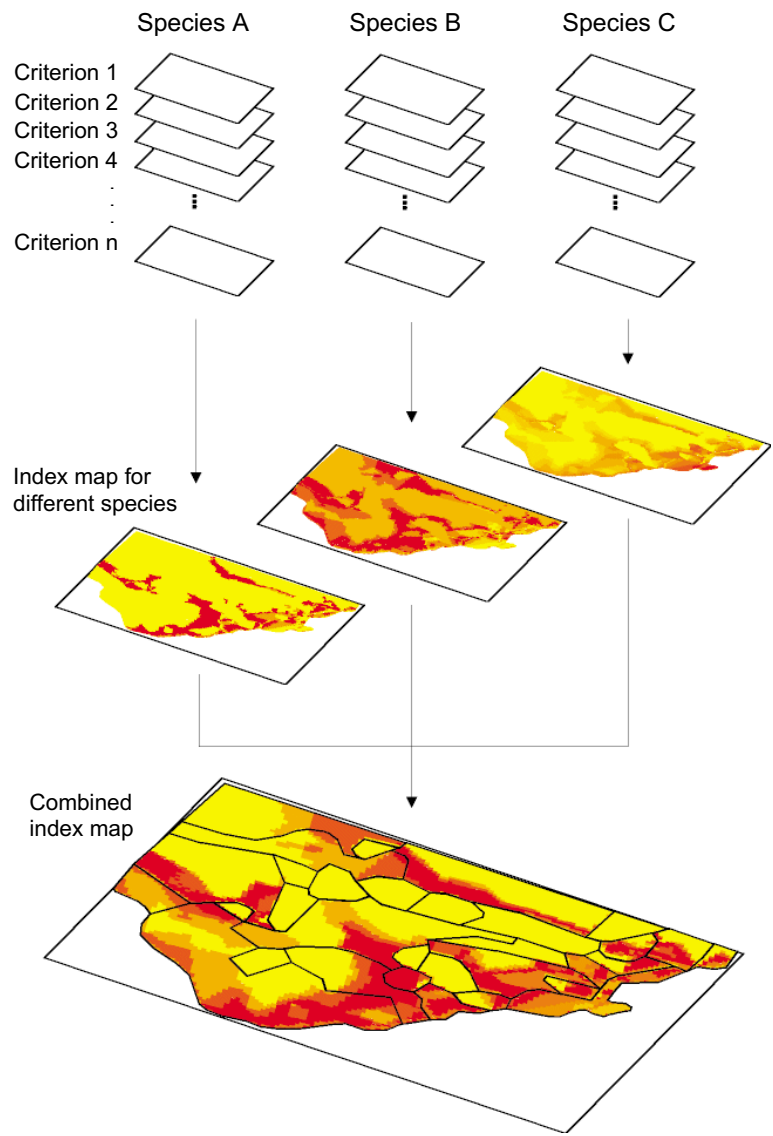


Figure 1. Producing and combining index maps per species to facilitate index maps per species group.

First, the area to be examined is reduced by means of absolute constraints. These absolute constraints can be the same for all the species and they can be related to the habitat requirements of the species or to the technical requirements of planning. In the example, the absolute constraints are the limits of the planning area and the maturity of the forest stands with respect to timber felling. Furthermore, real-life situations often include species-specific absolute habitat requirements. Following the first stage, Boolean logic-based over-

lay analyses are used to choose the areas, which are located within the planning area and carry mature timber.

The majority of habitat requirements can be considered to be flexible constraints. Areas which remain are examined at the second stage of the method and they are categorised using flexible constraints in order of goodness from the point of view of these three species. Fig. 2 shows the categorisation of the areas from the point of view of one species. Following absolute constraints, the distance

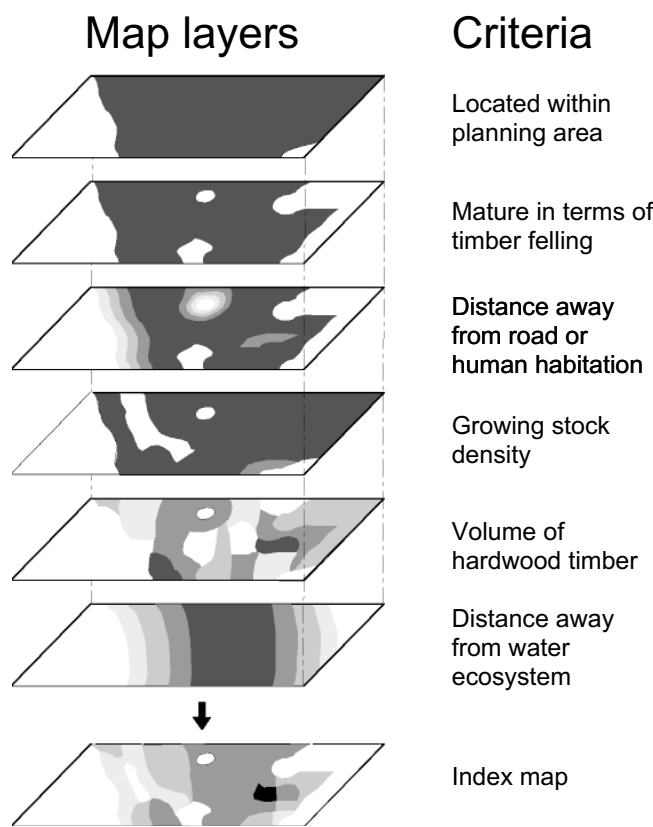


Figure 2. Criterion scores and index map for one species.

away from the road and human habitation, growing stock density, volume of hardwood timber, and distance away from a water ecosystem are chosen as the flexible constraints.

Standardisation of the flexible criteria is carried out in this example by using the pairwise comparisons of the analytic hierarchy process (AHP, Saaty 1980). Standardisation here was carried out by categorising the values of each criterion and by comparing the criteria categories by means of pairwise comparisons. This was followed by replacing the values of the criteria with the standardised category value, category by category. The weight coefficients of the criteria were obtained using a similar technique by comparing the importance of the criteria in pairs. Combining the criteria and the generation of the final index onto the rasterised cells were performed by multiplying the standardised values of the criteria by the weight coefficients and by adding the weighted map layers together.

5 Conclusions

An efficient instrument is needed for solving complex planning problems and conflict situations related to the use of natural resources. Such an instrument should also enable both the management of the information describing a target and the generation of new information to serve as support for decision-making. GIS applications offer such tools, including tools for combining information in different formats and for their numerical analysis. By using GIS-

based tools in combination with state-of-the-art decision-analysis techniques, information more versatile than hitherto can be generated to support decision making. Thanks to this property, GIS applications are gaining in importance as instrument for multi-objective forest planning, for instance.

The method described in the present paper involved combining different georeferenced criteria in generating an index map describing how well a certain area fulfils the habitat requirements of a species group. The use of the index maps of this kind as aids in decision situations adds flexibility to decision-making. From the point of view of successful decisions, this is important because in the field of natural sciences it is extremely difficult, even with detailed models, to include all the factors affecting decisions. With the help of an index map, the decision-maker is able to see the suitability of subareas within a target area for a particular form of use. Having done this, the decision-maker can apply his/her own external evaluation criteria when making decisions.

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Systems design options for linking GIS, modeling and visualization: application to forest management

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Abstract

The conceptual ideal for a manager of a complex, spatially distributed resource includes the data storage, analysis and display capabilities of a geographic information system, the availability of purpose built decision support models or procedures and realistic, real-time, interactive visualization of resource succession and the impacts of management decisions. All should work together in a seamlessly integrated environment. To create such an ideal as an industry specific system without an existing software base would be a difficult task. Separate modules already exist in the form of commercial GIS packages, industry based growth or health models and emerging visualization systems and languages. This paper presents an approach to integration of GIS and visualization using remote procedure calls (RPCs) and a message queue manager to create an integrated client-server environment. Specifically, this paper describes the development of a two-way communication between ArcView GIS and a program developed using the Performer visualization toolkits and the applications of this combined system in a forest management context. Implementation of a forest growth model in ArcView Avenue scripting language allows the model to directly drive the visualization.

Keywords: GIS, interactive visualization, integration methodology, client-server environment, forest management

I Introduction

Environmental and natural resource management is a dynamic, multi-objective and very complex issue. It

typically requires a set of tools which can be used to present current condition of resource, to predict changes over time and impacts of different management processes. GIS, envi-

ronmental modeling and visualization are essential tools for resource management. During the past years, technological advancements in GIS software, computer graphic technology and improved understanding of natural resource process and modeling, have significantly changed resource management and planning.

Natural resource management is spatial in nature. GIS is widely recognized and commonly used tool for geo-reference problem solving. The usage and power of GIS in environmental management has already been proven (see Fedra 1993, 1994, Majuire et al. 1991, Knill 1993). GIS provides a wide range of functions to the users for spatial data capture, storage, manipulation and display. But GIS alone lacks the ability to provide true analytical capability and flexible display. It needs integration with other tools, such as modeling and visualization tools, to support spatial decision making.

Resource management is fundamentally concerned with evaluating of proposed management alternatives. Modeling permits simulation of likely future changes of a resource under its natural succession and proposed management processes. It is an important component of natural

resource decision support system (DSS). However, the use of models as decision support is limited by their inability to handle spatial data. Therefore, it needs to be integrated with GIS to reinforce its spatial analytical abilities. A substantial body of recent research has proved the advantage of integrating GIS and forest modeling for forest decision making (for example, MacLean and Porter 1994, Peng and Apps 1997, Thorn et al. 1997).

Natural resource management involves many and diverse categories of people from different fields with different demands on visualization of data coming from the models or from data bases (Haagsma and Johanns 1995). A decision support system should not only consider their expert users (for example, forest planners) but also non-expert users (for example, general public). Therefore, an ideal system should integrate various forms of visualization (include abstract map display and realistic visualization) to make the system useable by all its users.

The formation of a spatial decision support system (SDSS) for natural resource management can be diagrammed in Figure 1.

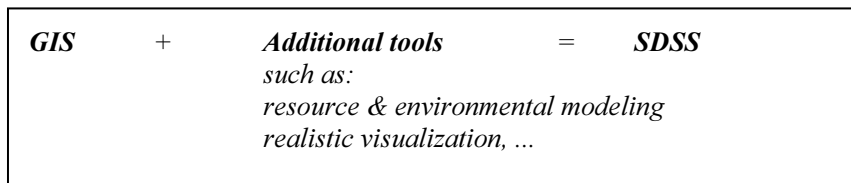


Figure 1. The formation of a SDSS.

To create such an ideal system without an existing software base would be a prohibitive undertaking. In fact, modules posed above already exist in the forms of commercial GIS packages (for example ArcInfo and ArcView), industry based resource models (forest growth and yield models for example) and emerging visualization systems, languages and graphic toolkits (such as OpenGL and IRIX Performer). Integration will bring together a collection of software tools and maximize the functionality of each module. On the other hand, it minimizes the development effort and promises the rapid application design.

Detailed description of the ideal forest visualization system can be found in Tang et al. (1997), thus the following sections of this paper are devoted to the discussion of various issues relevant to general design philosophy and implementation of GIS, modeling and visualization integration in order to achieve such an ideal system.

2 Integration approaches

2.1 Levels of integration

Integration is the way of combining different systems together to provide the functionality users required. It can come in many forms and different levels. This section briefly reviews commonly used methods which integrate GIS with other modules. Lower levels of integration use data exchange method to link different modules. When GIS integrated with modeling and visualization using this method, it often serves as pre/post processor for modeling and visualization data (Figure 2). This integration methodology is implemented in many resources and environmental management systems (see Goodchild et al. (ed.) 1993, 1996). However, since it requires users to be familiar with each system's syntaxes, file formats, conversion programs and operation system procedures, it is not ideally suitable for

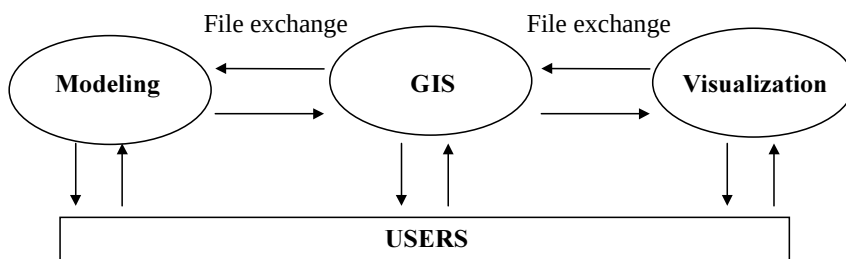


Figure 2. Lower level integration of separate programs through file exchange.

users who have limited or no knowledge of each software module. Higher levels of integration are needed to avoid this problem.

Many applications (for example Buckley et al. 1994, MacLean and Porter 1994) demonstrate closer linkages between GIS and modeling. Models written in a language other than the scripting language of a GIS (such as written used FORTRAN and C language) can be organized and activated by one or more macros in GIS as system calls. Using this integration method, users can take advantage of both GIS and existing modeling softwares, and retain a high degree of portability.

Models can also be embedded into a GIS by writing them as sub-routines or commands using GIS scripting language (such as Avenue in ArcView), therefore becoming extended functions of GIS (Figure 3). In this full integration, GIS provides the framework and essential functions for the implementation of models. GIS and modeling appear to be seamlessly integrated and have the same interface to control program specifications, data conversions and output display. This type of integration achieves speed of operation and ease of use since all data conversions (or translations) between modules

can be performed automatically within the system. It has been widely adopted for integration of simplified models where extensive use is made of the spatial analytical functions of GIS (Liao and Tim, 1994).

2.2 Client-server approach to visualization and GIS integration

2.2.1 Client-server paradigm

The client/server approach is an important design alternative for integrating various existing systems. It applies to any processing environment where one entity requests works to be done and another actually performs the works (Bloomer 1992). In the basic client/server model (Figure 4), a client application requests services from a server application through a communication mechanism, the server then performs those requested tasks and returns process results to its client through the same mechanism. A number of communication protocols exist for different platforms. Remote Procedure Call (RPC) is a standard communication protocol used for handling message passing activities between different software modules.

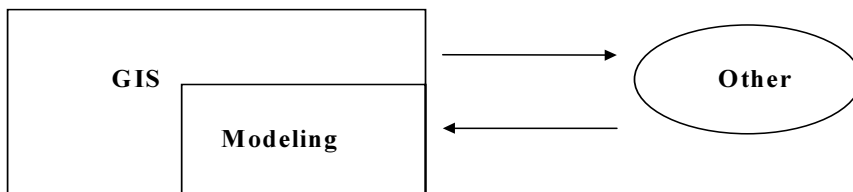


Figure 3. Model embedded into GIS, two modules share the same interface.



Figure 4. Client-Sever approach to system integration.

For GIS to take advantage of client/server technology, it requires an open GIS architecture (Open GIS Consortium 1996) that provides the interfaces and linkages necessary for integration. In recent years, GIS vendors have begun to produce GIS products which include such interfaces that allow developers to integrate GIS with other softwares using client/server technique. ArcView and Avenue support Dynamic Data Exchange (DDE) in Microsoft Windows environment, and Remote Procedure Calls (RPCs) in Unix environment for data (messages) transfer between applications (Razavi 1995).

2.2.2 Messages passing processes

An essential requirement for achieving client/server integration is communications between modules. One approach to enable this communication is using a message passing system (message queuing manager) which is formed by message queues. For each participating module there is a message queue associated with it. A system communicates with others by directing messages to the targeting system's queue using RPCs (Figure 5). The message sent is queued until the targeting system has retrieved it. The message may be a series of command or a bundle of data.

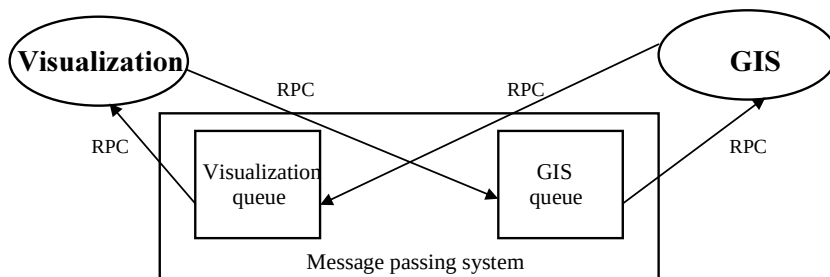


Figure 5. Messages passing processes.

3 Implementation of integration methodology

3.1 Sources of data and supported data models

Spatial data used for forest management is widely available from many different sources in many different formats. Different modules supports different data model. Data models used in our application included ARC/INFO coverages and grid, ArcView shapefile, digital elevation model (DEM) in grid form, visualization object file model (OBJ) and image data (textures).

ARC/INFO coverages include stands, roads and creeks. Among them, the stand coverage is the most important input data for forest modeling and visualization development. It describes ground vegetation (species of forest, age, treatment type, etc) and provides base data for modeling processes. In this polygon coverage, each stand has a unique polygon identification number (PID) associated with it. ArcView also supports shapefile (.shp) format which allows more rapidly display and is easier to work with. Both coverages and shapefiles can be converted to grid to enable further analysis. The grid DEM can be overlaid with other coverages in GIS and can be used together with texture to build 3D representation of forest condition in the visualization module.

Object file is an ASCII file that stores the geometry and other properties (such as textures) of physical

objects in the Advanced Visualizer (Alias|Wavefront, 1995) format. It is one of the data models supported by Performer Toolkit and the forms core of our visualization. GIS data must be converted to OBJ file before it can be used in real-time visualization.

Image data (textures) include aerial photos and satellite images. Those imageries can be combined together and mapped onto DEM to present existing surface conditions in 3D. Other textures needed are the sampled textures which represent certain conditions of forest harvest or health and are used to replace the original condition in a texture mapping strategy for representation (Bishop 1994). The system can then simulate changes of appearance which are caused by management alternatives and modeling processes.

3.2 Implementation of integration methodology

In development of a forest management decision support system, we attempt to integrate GIS with forest modeling and visualization using different integration methods. Two levels of integration are adopted in respect to different characteristic of each system and relationship between them (Figure 6). Modeling process are written using Avenue scripting language and fully embedded into Arcview. Thus GIS and modeling appear to be seamlessly integrated and GIS style's interface can be used to maintain user familiarity.

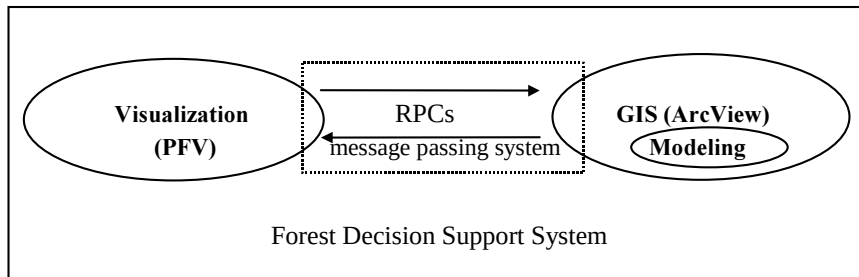


Figure 6. Different levels of integration implemented in Forest decision support system (Tang et al. 1997).

In order to fulfil a wide range of users' needs for GIS and visualization, we adopt client/server technology to integrate GIS (ArcView3.0) and a visualization module (Performer Forest Visualizer – PFV, developed using IRIS Performer Tool-kits). These modules are developed independently with their own set of functionality, specification, interface, data model and data format. Therefore a message passing strategy is considered a proper way to bridge them. This integration can fully retain both visualization and GIS functionality.

In our application, both ArcView and visualization (PFV) act as RPCclients. They direct and retrieve messages while the queue manager (message passing system) acts as RPCserver and stores messages. Messages sent from origin system will be placed in targeted system's queue in queue manager and will be detected and retrieved by the targeted system when it is ready. Messages can be a single command string to activate separate modules or a bundle of data sent to another applica-

tion. After retrieving message, the targeted system will then perform a series of required actions. Each client connects to its server by making remote procedure calls to it. Avenue provides a RPCClient object allowing for this type of communication with external systems. Following are fragments of Avenue script that carry out such processes.

```
aClnet = RPCClient.Make
        ("surface",0x40000001,1)
highlight = aClient.Execute (1,"Highlight
PID",String)
```

The first line of code creates a RPC client object connected to a specified RPC server (specified by three parameters of request Make: host name, server ID and version number). Once this client object created, it can then issue a request to its connected server and request a service by using the Execute request. Execute has three arguments: the procedure ID, the service request and the keyword STRING. It sends a message string (a command and a polygon ID) to the server which will be stored in PFV's queue and wait to be retrieved and processed.

3.3 Communication protocols

Once the communication has been established, message (data) passed must be understood by each of integrated modules. Communications protocols thus needed to be defined to achieve this common understanding. Those protocols define the structure and interpretation of the messages and are understood by the integrated systems. Types of protocols being built into our system contain a command and a polygon identification number as string. Messages passed from ArcView to visualization (PFV) include:

- *Highlight* PID highlights the forest stand(s) with selected PID (Polygon Identification Number), these polygons may be resulted from Arcview identify process;
- *Grow* Years change the height of the stand(s) to represent forest growth;
- *Harvest* PID change texture to respond to the harvest.

By sending those messages to visualization, that object (forest stand) can then be highlighted, raised or have its texture replaced in the visualization window to respond to the different actions taken in ArcView.

3.4 File conversion

The data formats supported by the two different modules are not entirely compatible. GIS data must be converted to the correct format before visualization. We select PID (Polygon ID) as the common identi-

fier which will link different file formats. In the queue manager, there is a link to a C programmed 'PID2OBJ' converter which generates an appropriate object file (base.obj) in which data is grouped according to the stand coverage's PIDs. Hence object representation of forest stand data used in visualization are linked with stand polygon in ArcView.

In ArcView, after object construction (drawing or defining an area), it can be saved in form of a shapefile (.shp) and transferred to object file (.obj) by using another converter (ARC2OBJ) and finally passed to visualization module (PFV). ARC2OBJ needs 2 input files, naming grided topographical data (topo), grided polygon cover (cover). The later organizes grid cells into different groups according to their polygon numbers or section numbers. Output from this program is an OBJ file which represents defined area with risen edge to represent possible growth of the forest. Figure 7 is fragments of such an OBJ file. After receiving the complete object file, the visualization module can then draw, highlight, raise or replace its texture to represent different conditions.

Therefore, visualization can be driven directly by the GIS database and modeling process. The changes in GIS data base will be reflected in visualization. The growth of a stand or result of practices applied to a stand can be directly simulated thus overcoming the major problems of traditional image-based visualization, naming lack of positional accuracy and data/model coupling (Tang, et al. 1997).

<pre># material library mtllib ./usr4/people/tang/from_usr23/ianb.mtl # geometric and texture vertices v 468230.875000 265537.458750 0.000000 vt 0.540000 0.540000 0.000000 v 468330.875000 265537.458750 0.000000 vt 0.580000 0.540000 0.000000 v 468430.875000 265537.458750 0.000000 vt 0.620000 0.540000 0.000000 ... v 468830.875000 265437.458750 311.000000 vt 0.780000 0.580000 0.000000 v 468930.875000 265437.458750 301.000000 vt 0.820000 0.580000 0.000000 ...</pre>	<pre>#material names, group names and #elements (face) information usemtl tximp99 g all tximp99 f 12/12 13/13 2/2 usemtl tximp99 g all tximp99 f 12/12 2/2 1/1 ... usemtl tximp2 g all tximp2 f 28/28 29/29 18/18 usemtl tximp99 g all tximp99 f 28/28 18/18 17/17 ...</pre>
1.	2.

Figure 7. Fragments of an AV OBJ file of sub-area in the forest which includes information about geometric vertices (v), texture vertices (vt), elements (f), grouping (g) and material (mtllib and usemtl).

3.5 System architecture

A few steps which involve data conversions and messages passing needed to be taken before data from one system can reach another system meaningfully. When separate systems seamlessly integrated together, this chain of complex data transformation and messages passing process can be hidden from end users' attention while still remaining transparent in term of its logic. Figure 8 presents diagram of such processes.

4 Application of integrated visualization system

4.1 Forest application

A forest manager may need to visualize existing condition in various ways. Our goal is to develop a system which provides two forms of visualization: abstract map-based

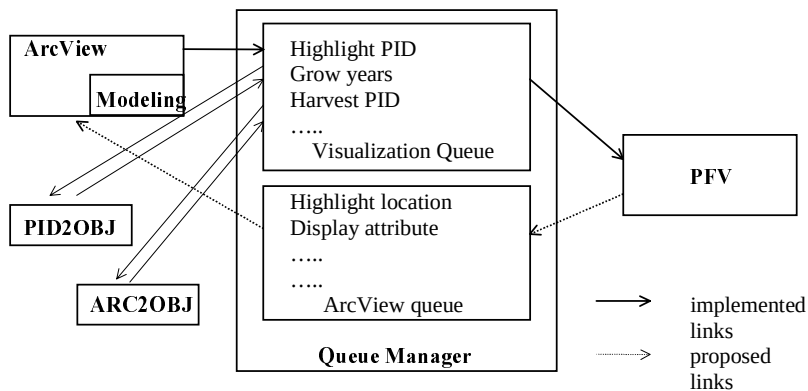


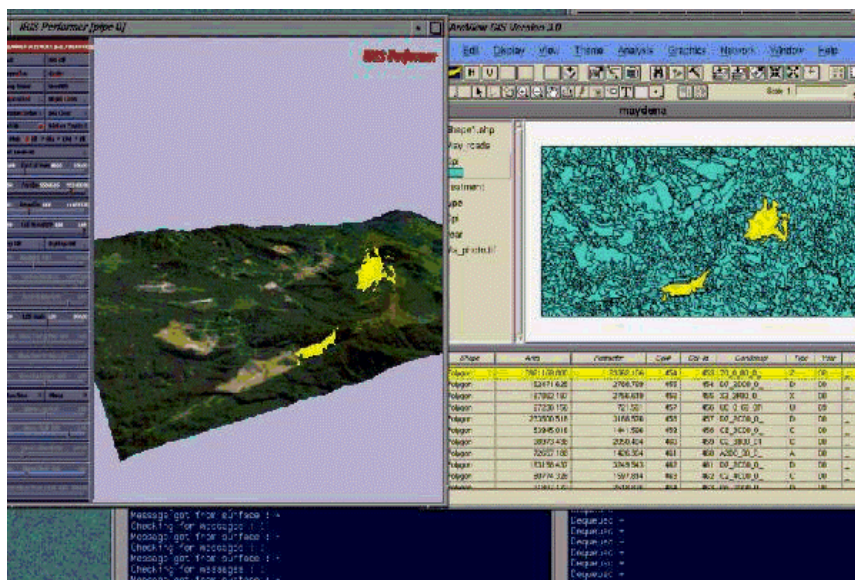
Figure 8. Data and messages passing process.

Forest management is based on evaluations of different management scenarios. Forest managers typically need to ask “What if...?” type of questions. Example scenarios may be a timber harvest schedule derived by conventional harvest planning procedures (e.g. linear programming). This will generate a table of stands with their date and type of cut. Results of these alternatives can be simulated, visualized and evaluated. Insights into the long term plans not available in the conventional plan-

The visual quality objective, amongst other forest management objectives, is gaining increasing emphasis. The aesthetics of harvest cut block shape, size and location have been of primary importance (Buckley and Berry 1997). Thus the use of integrated systems which focus on the linkage between GIS and visualization will clearly assist forest decision making.

Figure 9 is the overview of the developing system. On the right is a ArcView window which has a forest

Figure 9 is the overview of the developing system. On the right is a ArcView window which has a forest



growth model integrated as an added function. Also presented in the ArcView window are buttons which initialize visualization or highlight, grow and change texture for appropriate polygon(s) on the PFV window. On the left is a real-time interactive 3D view visualization window (PFV) generated using IRIS Performer Toolkits. In lower part of the screen, activities of message passing are evidenced on shell windows. Friendly users' interfaces enable easy use of this system by all type of users. The PFV window includes fly/drive/walk controls so that users can use different viewing modes, travel anywhere and view any part of forest. Other viewing parameters such as view point, viewing angles and weather and light conditions can also be changed interactively to simulate the real condition of forest. Users can also take advantage of the animation function of PFV to view sequences of changes over time and the impacts caused by different management alternatives. All actions can be initialized by button clicking or mouse moving.

4.3 Two-way communications

By using RPCs and defining communication protocols, two way's communications between visualization and GIS can be achieved. System development up to date has already achieved GIS communication with visualization and directly drives visualization from GIS data base and modeling processes. Still to be implemented is communication from visualization to ArcView. This will

allow GIS responds to actions taken in the visualization module. These actions include: identify forest stand(s), change of viewing location and change of view point. Function calls in Performer Toolkits permit retrieval of a specified location's PID and coordinates. This information can then be passed to GIS and activate a waiting Avenue script. Hence, attribute associated with the chosen stand can be displayed in ArcView.

5 Conclusion and future works

The successful integration of GIS, environmental modeling and realistic visualization to form a decision support system requires careful consideration of several issues which include the objectives of integration, communication methodology and data structures. Client-server and embedded approaches to such integration promise effective data communication and functionality sharing whilst maximizing the use of off-shelf softwares. The system we described here shows benefits of using such techniques in development of an interactive integrated visualization system for forest planning and management.

While such an integrated system shows promise for dramatically improving forest manager's ability to communicate complex forest planning issues with different groups of users, there is indeed need for further work to increase effectiveness and usefulness. These include:

- 1) generate more known scenarios to cover ranges of management planning and practices for specified application. These may include different type of harvesting, planting, treatment, etc;
- 2) develop more application specified functions that enable users flexibility to design unknown scenarios in real-time interactively;
- 3) further improve visualization realism to match users (specially non-expert users) mental images thus gain more accurate interpretation of information.

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Applying Push technology in the handling of environmental information

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Abstract

The ever-increasing amounts of data make it more and more difficult to get the right information at the right time. The 'traditional' pull technology model is beginning to itself limited for more efficient use of WWW. Specifically requesting information from a particular source, e.g. downloading WWW page with a browser is an example of pull technology. As WWW grows in size and complexity the importance of new information delivery models such as push technology increases. Push technology was created to alleviate problems facing users of the Internet and WWW. Push technology is a data distribution technology in which selected data is automatically delivered into the user's computer at prescribed intervals or based on some event that occurs. The difference between push and pull technologies centers upon the side which is initiating the transaction. The transaction is either initiated on the user/client side (pull) or on the provider/server side (push). This paper describes IDA-PUSH project in which the objective is to implement a push application, where push technology is used to intensify the acquisition and distribution of the environmental information of the European Environment Agency (EEA). The developed system can be applied to many other information services, where efficient use of WWW repository is needed. This paper also contains a table where basic information about different push tools has been collected.

Keywords: Push technology, Push tool, WWW, Web, electronic information delivery, repository, channel

I Introduction

The Internet and WWW (World Wide Web) serve acquisition of information and distribution of the information very widely at the moment. The use of the new WWW techniques has begun in acquisition and distribution of the environmental information, as well.

The IDA-PUSH project utilises push technology in the handling of the environmental information. The purpose of the IDA-PUSH project is to provide a push application for delivering notifications on new documents and events published on a WWW repository. The created system is tested on an environmental intranet of EIONET's (European Environment Information and Observation Network).

The project is carried out in co-operation with European Environment Agency (EEA), European Commission (Directorate-General III), Tieto Corporation, and VTT Information Technology. Tieto is responsible for the overall management of the project and provides the administrative management services. VTT Information Technology is responsible for the technical matters of the project and designs and develops the application. The IDA-PUSH project started at the beginning of the year 1998 and the application to be developed will be completed in the spring of 1999.

2 What is Push?

The 'traditional' pull technology model is beginning to itself limited for more efficient use of WWW. This

model is search-oriented based. This means that the users have to connect to a site, and then read, visit a few pages, and finally get the updated content (if any). This process has to be repeated for each WWW site from which the user wants to get useful information. With an increasing number of WWW sites, combined with the quite slow transfer rate for dial-up users, the task results in a lot of wasted time and a higher telephone bill.

Push technology was created to alleviate problems facing users of the Internet, e.g. information overload and low bandwidth. The volume and dynamic nature of content on the Internet is an impediment to users and has become an ease-of-use issue. Push technologies automatically deliver the information to the desktop thereby eliminating the risk of the user not ever viewing the updated information. The goal of push technology is to deliver the information that you need right to your desktop. Content is delivered through a variety of ways, mainly through a browser either built-in to the push software client or captured by an external browser like Netscape. One possible way is content that is delivered right to your e-mail client.

Most of push technologies use the same outline. An information flow from one content provider is called a channel. User can order a channel and the information specific to that channel starts to flow to user's workstation. The content of one channel can be personalised so that the user gets only information s/he needs. When new information comes to user's workstation, the push application shows it to user in some way.

Most end users are restricted to low bandwidth Internet connections making it difficult to receive e.g. multimedia content. Assuming users are willing to wait 15 seconds for a WWW page to download. This leaves room for little more than text and small graphics. Push technology provides the means to pre-deliver much larger packages of content (with an unattended connection). This leaves plenty of room for multimedia content such as audio, large graphics, or short video clips.

Push technology has been used for a number of years in the financial world, in live news feeds and cable television. One of the more common uses today is the automatic downloading of software upgrades and fixes and the delivery of news information to workstations. Push is beneficial to the end user because it prequalifies pertinent information, thus cutting down on research time. However, it is also vital to the companies or services that use push to sell their products and services. Push is capable of matching prequalified advertising banners to match the specific demographic. This means higher advertising rates and greater profit potential.

3 Push tools

There are several push technologies in competition on the market. Each push technology has its own strength and is better suited for a particular category of users. E-mail is perhaps still the best push technology for delivering time-critical information to a specific audience. Most push tech-

nologies try to be a more serious information tool that changes the look and function of the desktop.

Both Microsoft Corp. and Netscape Communications Corp. are touting competing push standards. Microsoft is pushing the Channel Definition Format (CDF) for defining push updates and content. The actual markup within a CDF file is based on Extensible Markup Language (XML), which is relative to HTML (Hypertext Markup Language) and SGML (Standardized General Markup Language). The CDF format already has some major supporters, including BackWeb Technologies Inc. and PointCast Inc. Netscape is using the Meta-Content Format (MCF). MCF was invented by Apple Computer, and its main architect has since moved to Netscape to work its development. For example Marimba Inc. has begun cooperation with Netscape.

Push tools can be segmented in three different categories

- Server-side only. The server delivers content using some old technologies as email. Users don't have to install any new program to receive the contents. E.g. products like ChannelManager and InfoBeat.
- Client receiver software. The client program fetches the content automatically using http-protocol and shows it later to user. The push channel is easy and cheap to build up because no server software is needed. The drawback is that content providers don't have any control over fetching because they don't know the settings of the client program. E.g. products

like Netscape Netcaster, Internet Explorer 4.0 and PointCast.

- Proprietary client and server. The server sends the content to the client program that shows it to the user. Both users and content providers have control over contents. E.g. products like BackWeb and Marimba's Castanet.

In the IDA-PUSH project it is also reviewed what kind of different push tools are available on the market at the moment, how these tools differ from each other and which of these tools are best suited for the use in the project. One of the push tools is selected to be used as a basis in the application of IDA-PUSH. The push tools about which information has been obtained so far have been listed in Table 1.

4 The IDA-PUSH project

1.1 Objectives of the IDA-PUSH project

We will design and implement a push application for the EIONET. EIONET is a cooperative organizational network of institutions that assists the European Environment Agency in providing the European Community and its member states with environmental information. It also allows electronic interchange of information between these organisations. EIONET is currently an intranet connecting multiple national hosts (intranet nodes). The main interest of the IDA-PUSH project is to manage documents stored into a

workgroup program DSIS-IRC (developed by European Dynamics). This workgroup program enables interest group members to load documents and modify them on the server.

Push technology is desired for managing the changes in the documents by notifying interested users about changes in various channels. The objective is to define the user requirements and to implement the pilot push application that corresponds to the user requirements.

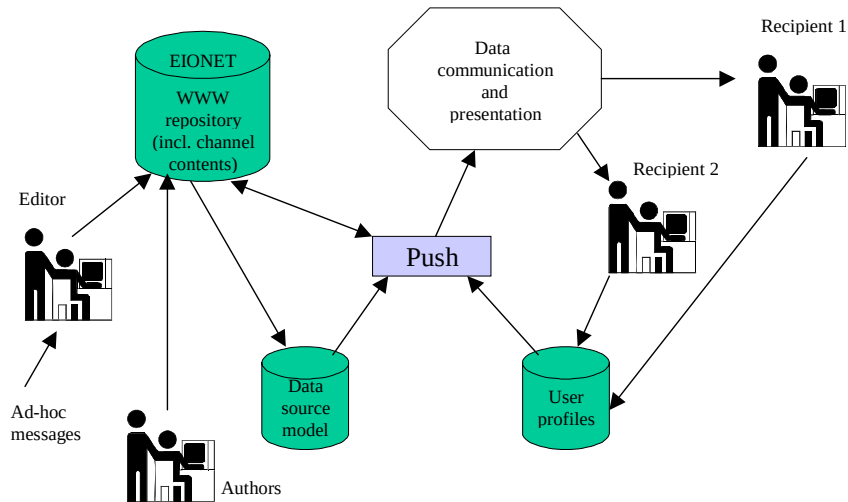
The objectives for the required push functionality and connections to the existing systems are as follows:

- Here push functionality means the ability of the system to inform its users of the changes in the WWW document database that might interest the user.
- The information mediated to the user by push technology can consist of actual data or links to the data.
- The system to be built will be general enough so that it can be applied to different WWW repositories with reasonable amount of work.

Content provider can be in two roles as an author and an editor. The author produces and inserts the documents to the WWW repository and the editor picks up and edits the documents so that the push service can use them. The editor can also insert ad-hoc messages.

1.2 Results of the IDA-PUSH project

The IDA-PUSH application will consist of the following main parts:



Picture 1. A system architecture of the push pilot.

1. The actual push functionality.

This includes mediating information about changes in the database that might interest the user. This will happen either periodically or whenever some relevant changes occur in the database. The mediated information will be the actual changes in the database or links to the relevant structures.

2. User Profiles.

For each user, this contains the user-specific information needed to decide whether information at hand will be passed to him/her. It is assumed that the push module software manages the user profiles. There will also be facilities for the user to view and change the user profile.

3. Data source model.

This will be utilised in deciding whether the

information at hand will be passed to a specific user. User preferences can be seen as mapping from the data source model to the filters in the user profile. For example, in the case of a WWW repository, the data source model includes a contents based mapping into the actual URL (Uniform Resource Locator) addresses.

The editor is attached into the push process for editing and pruning the automatically derived entries of the material to be pushed. Thus the editor edits the channel contents from which the user profile based filtering and personalised push pages are generated. The channel contents is retained and edited under the DSIS-IRC based WWW repository.

2 Conclusions

In this paper, we have described an approach based on push technology to intensify the acquisition and distribution of the environmental information of the European Environment Agency (EEA). We have obtained basic information about more than 40 push products and we have tested several products. We believe that by using push technology we can design and implement user-friendly and effective information delivery systems. These systems can be general enough so that they can be applied to other environments with reasonable amount of work. As WWW grows in size and complexity the impor-

tance of new information delivery models such as push technology increases.

Acknowledgements

We thank the following persons who have contributed to the IDA-PUSH project:

- EEA Mr. Hannu Saarenmaa
- ECMs. Sandy Callagan, Mr. Knud Lonsted
- Tieto Corp. Ms. Kaarina Hakkarainen
- VTT Prof. Seppo Linnainmaa, Mr. Aarno Lehtola, Mr. Mikko Hiirsalmi, Mr. Ilkka Karanta

Some Push References and Sources

<http://www.pushcentral.com/index.html>
<http://pushconcepts.com/pcgeneral.htm>
<http://www.infoworld.com/cgi-bin/displayTC.pl?/980126analysis.htm#contents>
http://www8.zdnet.com/pcmag/features/pushserv/_open.htm
<http://www.zdnet.com/products/content/grids/push.html>
http://seek-p.infoseek.com/Computer/Software/Internet_software/Push_technologies
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<http://www.tcm.hut.fi/Opinnot/Tik-110.350/Tehtavat/essays/push.html>
http://www.cio.com/resources/technologies_push.html
<http://webreview.com/push/>
<http://www.awaken.org/push.html>
<http://webreview.com/97/04/18/addict/index.html>
<http://webreview.com/wr/pub/98/02/27/imho/index.html>
<http://www2.echo.lu/oii/en/push.html>

Table I. Push tools.

Product name	Price/Licence	Company/author	Client platforms	Server platforms	Notification and/or delivery	Document types	Description/ Usability
AfterDark Online	After Dark Online is freeware (ad supported). You pay your Internet Service Provider fees. All of the news channels are free as well.	Berkeley Systems http://www.afterdark.com/	32-bit Internet connections are supported. AOL 32-bit client software is supported. 32-bit Internet browsers are supported, such as Netscape Navigator, Microsoft Internet Explorer, NCSA Mosaic and Netcome Netcruiser. Available for Win 95 and Macintosh.	None	Delivery only		Off-line browser/screen saver for news delivery.
AirMedia Live Internet Broadcast Network	Software comes free with Internet Antenna. Service \$5.95/month.	AirMedia (formerly Ex Machina) http://airmedia.com/	To connect to the AirMedia Live Internet Broadcast Network, you need an Internet Antenna (a wireless receiver, serial port) and AirMedia Live software and service. CD-ROM drive for AirMedia Live software installation. Available for Win 95 and Win NT.	None	Delivery only		Internet's wireless news delivery.
BackWeb	Client software free. Server starts at \$10,500 (one channel-server licence) depending on channel volume.	BackWeb Technologies http://www.backweb.com/ BackWeb has acquired Lanacom, see HeadLiner.	Win 3.11, Win 95, Win NT, Macintosh. A Win95/NT authoring tool to develop the content.	The BackWeb Channel Server runs on Windows NT, Solaris and Irix; the Proxy server runs on Win NT. Server is managed by a remote console running on Win 95/Win NT.	Both	The InfoPaks can be created from a wide variety of sources, such as local HTML pages, Netscape plug-ins, PDF files, multimedia, Java, text, graphics.	BackWeb is a open platform for the development of simple to complex push systems.

Product name	Price/Licence	Company/author	Client platforms	Server platforms	Notification and/or delivery	Document types	Description/ Usability
BroadVision One-to-One	Varies by installation (starting about \$125,000)	Broadvision http://www.broadvision.com/	One-To-One applications can be accessed from any HTTP server that is compliant with either NSAPI, ISAPI, or CGI standards. RDBMS: Oracle RDBMS Version 7.x , Microsoft SQL Server 6.x, Sybase SQL Server (10.x, 11.x), Informix 7.x	Server Hardware and Operating Systems: Solaris 2.x on Sun Sparc, Win NT 4.0 on Intel x86, HP UX 10.x , SGI IRIX 6.x.	Both	HTML, Java, and JavaScript	Development environment for delivering customized information.
Communicator	Free	InterMind http://www.intermind.com/ It no longer offers webcasting products.	Win 95 or Win NT	Any web server	Notification only	Web pages	Creates a personal, interactive connection between Web site publishers and their channel subscribers.
Channel Manager	\$19.500 (100-user minimum); additional users \$195 per seat, volume discounts apply for additional user licences.	DataChannel http://www.datachannel.com/	ChannelManager supports most 32 bit Java and Java-enabled web browsers.	Channel Server platforms: Sun Solaris, Win NT 3.5/4.0, HP MP UX, IBM AIX, DEC Ultrix. Web server: Netscape 3.0 and Constellation, or Microsoft Information Server 3.0, or Microsoft Active Server. Data-bases: Oracle, Sybase, Informix, SQL Anywhere, or MS SQL	Both	Web content, links to Word docs, Excel spreadsheets, PowerPoint, archive files and applications, streaming video (for intranets with lots of bandwidth), live news feeds, stock tickers, and more available over a TCP/IP connection.	To create and manage unlimited number of channels with real-time push. A navigation management tool for files, applications, and web sites, links users and information on a one-to-one basis.
Crayon		NetPressence http://crayon.net/					a personalized newspaper

Product name	Price/Licence	Company/author	Client platforms	Server platforms	Notification and/or delivery	Document types	Description/ Usability
Desktop News	Free (ad supported)	DesktopNews http://www.desktopnews.com/	Operating System Win 3.11, Win 95 or Win NT 3.51, 4.0. Browser Netscape Navigator 3.0, Microsoft Explorer 3.0 or any popular browser that is 100 % compatible with either of these. Disk Space 4 MB for the Desktop News client software plus content updates Network Winsock 1.1. Desktop News accommodates Java, C++, ActiveX, and soon, Microsoft CDF.		Both		Customized news deliveries to the desktop. Desktop News open publishing model allows any content provider to publish to the Desktop News specification and become a Channel selection for users.
Diffusion Server (formerly IntraExpress)	Diffusion Server 2.0 is available with prices starting at \$75,000 per CPU.	Diffusion http://www.diffusion.com/	Supported recipient platforms: E-mail, Fax, Pager, Postal Service, Network Printer, Web Browser Information Sender: Win 95, NT 4.0. Information Recipient Profile Manager: Java-enabled Web browsers such as Netscape Navigator and Internet Explorer, Native Windows support including Win 3.1, Win 95, Win NT 4.0	Win NT 4.0	Both		If you need to send documents to many people who require different delivery methods.
Downtown	\$10,000	inCommon, http://www.incommon.com/	Win 95/NT. Win 3.1 coming soon. Minimum 16 Megabytes of memory. 20 Megabytes of disk space (varies with cache size). 486/66 MHz or higher processor.				Customizable Webcasting--choose from a selection of news and weather channels, or create your own.
Eye on the Web		internet eye on the web http://www.eyeontheweb.com					a personalized newspaper
fishWrap	Free	The Gate http://www.sfgate.com					a personalized newspaper

Product name	Price/Licence	Company/author	Client platforms	Server platforms	Notification and/or delivery	Document types	Description/ Usability
GroupMaster	GroupMaster Server software is priced according to its capacity for subscriptions (5000 ->): \$495 - \$11995. Group-Master Enterprise, unlimited capacity for subscriptions, 16 remote managers, retail \$9,995, 1-yr. maint. \$2,000, package \$11,995	Revnet http://www.revnet.com/	Win 95, Win NT, Win 3.1 To administer the program, you'll need a frames-capable Web browser such as Internet Explorer or Netscape Navigator.	Win NT4.0/3.51	Both	Web pages are delivered in HTML-formatted mail.	GroupMaster can deliver information to email as well as web clients, also stage content delivery depending on when a user subscribes.
HeadLiner	Free	Lanacom http://www.lanacom.com/ BackWeb has acquired Lanacom. Headliner information delivery product still available for free.	Win 95 and Win NT 4.x platforms. For Netscape Navigator (3.x, 4.x) and Internet Explorer (3.x, 4.x).		Both		HeadLiner offers you up-to-the-minute customized news and information from more than 700 web-based news sources (you can subscribe to 40 channels).
Highlights2	\$49.95	Tierra http://www.tierra.com/	Win 95 and Win NT 4.0 For Netscape Navigator and Internet Explorer.	None	Both		Users select web sites and subscribe to particular pages.
HotWired		Wired Digital http://www.hotwired.com/					a personalized newspaper
InfoPager		ZEBRA Pushware Solutions http://www.infopager.com/					a personalized newspaper
Infoseek Personal		Infoseek http://personal.infoseek.com					a personalized newspaper

Product name	Price/Licence	Company/author	Client platforms	Server platforms	Notification and/or delivery	Document types	Description/ Usability
InfoBeat (formerly Mercury Mail)	Free (ad supported)	InfoBeat http://www.infobeat.com/	Email		Delivery only		InfoBeat delivers news on topics you select at the times you've requested right to your existing e-mail box.
Inquisit	\$12.95/month, 24 months \$249.95. For Enterprise Inquisit pricing is agreed differently.	Inquisit (before Farcast) http://www.farcast.com/	Any POP email client.		Both		Customized newspaper using agents to retrieve articles via email.
Intercast		Intel http://www.Intercast.com/		None			Viewing of TV and web content together.
Marimba Castanet		Marimba http://www.marimba.com/datasheets/castanet-ds.html			Both		Designed to distribute and manage applications automatically.
Microsoft CDF (Internet Explorer)		Microsoft www.microsoft.com/standards/cdf.htm					Microsoft's Channel Definition Format (CDF) is a text-based format for letting publishers define channels that point to Web pages.
My Excite		Excite http://www.excite.com/					a personalized newspaper

Product name	Price/Licence	Company/author	Client platforms	Server platforms	Notification and/or delivery	Document types	Description/ Usability
My Yahoo! News Ticker (formerly known as Instant Online News)	Freeware	Net Controls Corporation, http://www.netcontrols.com/	Win 95, Win NT, Win 3.1 For Netscape Navigator and Internet Explorer.				Yahoo! and Net Controls partnered to bring the My Yahoo! News Ticker, a direct feed of the latest news headlines, stock quotes, sports scores, weather reports, and other news feeds that you can select from.
NETdelivery	Free client + subscriptions	NETdelivery http://www.netdelivery.com/	Win	None	Both		In the business-to-consumer environment, NETdelivery's Electronic Delivery Management (EDM) capability supports personalized information delivery to and from consumers.
NETpresenter	\$799 (1 Editor, 20 Player)	NETpresenter, http://www.netpresenter.com/netpresenter/	Win 95, Win NT; 16-bit (Q1 '98)				NETpresenter is a push/pull application consisting of an Editor for designing information channels, and a variety of desktop viewing media, including screen saver, browser plug-in, video and compact (150kB) Player.

Product name	Price/Licence	Company/author	Client platforms	Server platforms	Notification and/or delivery	Document types	Description/ Usability
Netscape Netcaster	Free	Netscape, http://www.netscape.com/netcenter/	Netcaster is now shipping as part of Communicator 4.04 for Win 95 and Windows NT users and is available in beta for Macintosh PowerPC and Unix AIX.	It doesn't need server, but can use Marimba castanet server.	Both	Dynamic Html, Netscape plug-ins, java, javascript, stylesheet	It can be used to load html-pages beforehand and store them to a local hard drive. It offer a information stream to user's desktop (they called it webtop)
NewsEdge		NewsEdge http://www.newsedge.com/					a personalized newspaper
NewsHound		Knight Ridder http://www.newshound.com/					a personalized newspaper
NewsPage		NewsEdge http://www.newspage.com/					a personalized newspaper
Pathfinder Personal Edition		Pathfinder http://www.pathfinder.com/welcome/					a personalized newspaper
Paracel Today		http://www.unc.edu/~fookie/home.htm					a personalized newspaper
Personify (formerly Affinicast)		Personify http://www.personify.net/			Delivery only		Personify Snapshot Server is an online, server-based application that makes Personify Snapshot analyses available continuously, on demand.

Product name	Price/Licence	Company/author	Client platforms	Server platforms	Notification and/or delivery	Document types	Description/ Usability
PointCast Intranet broadcast tools (formerly PointCast I-Server)	Clients free (ad supported)	PointCast http://www.pointcast.com/	PointCast Business Network v2.0 (current version) for NT 4.0, Win95 and Win3.1. Or Internet Explorer (needs atleast 486/33, 8 Mb ram, 10 Mb free disc space, 256 color mode). Includes screen saver too.	Push-data can be on any www-server. PointCast Caching Manager needs: Win NT V4.0 or V3.51, Pentium 75 MHz, 32 Mb RAM, 18 Mb free disk space. PointCast Intranet Manger, PointCast Administrator and PointCast Studio needs: win95 or NT4.0, Pentium, 16Mb Ram, 10	Both	Html-documents. Screen saver documents (Smart Screen) are made with Pointcast Studio.	PointCast is the pioneer of Push. PointCast Intranet Broadcast Solution enables you to define customized, corporate channels.
Posta	\$3,999 for 20 Posta Desktop accounts and the server, plus \$189 for each additional account.	Tumbleweed http://www.tumbleweed.com/			Notification only		The sent document resides on the sender's server, and the recipient gets e-mail notification with a URL for the document.

Product name	Price/Licence	Company/author	Client platforms	Server platforms	Notification and/or delivery	Document types	Description/ Usability
SEARCH97 Agent Server	Varies by installation	Verity, http://www.verity.com/	Users initiate searches and view results using all major Web browsers and client operating systems. Verity also has client-side tools for indexing and searching desktop computer environments.	SEARCH97 is server-based and runs on Win NT and popular UNIX platforms (including those from IBM, Sun, SGI, DEC, SCO, and Hewlett Packard).	Both	Agent Server will filter, index, summarize, and group information from all data sources, inc. Web servers, file servers, relational databases, mail servers, and any Verity collection. Agents can monitor documents in their native format, there is no need to re-format or republish any data in order for it to be searched or pushed to users.	Knowledge management solutions using agent and search technologies for information access.
Smart Delivery	Varies by installation	First Floor http://www.firstfloor.com/	Win 95, Win NT, Win 3.1, Macintosh	Win NT, Solaris	Both		To software developers. FirstFloor's Smart Delivery product line enables client/ server developers to build virtual corporate that deliver mission critical business documents, in their native format, to both corporate office and field organizations.

Product name	Price/Licence	Company/author	Client platforms	Server platforms	Notification and/or delivery	Document types	Description/ Usability
TIBCO		TIBCO http://www.tibco.com/			Both		Multicast IP publishing development environment.
URL-Minder	Free	NetMind, http://www.netmind.com/	An email account and Internet access via a web-browser or online service are all that is required to use URL-minder.				You can enter the Web sites you want to keep track of. When the site is updated you'll be alerted or you can have that page sent as an attachment.
Enterprise Minder (or Minder)	Commercial		Wind NT 4.0 or Solaris 2.5 or above. 32M of RAM is the minimum. A JavaScript enabled browser, such as Internet Explorer 3.0 or higher, Netscape 3.0 or higher is required by the end user. The Wind NT version can be installed and run on Win 95 on an evaluation basis only.				Enterprise Minder is online tool that monitors the information that you select, and sends you an email whenever your selection is updated. This information can reside anywhere on your company intranet or the public Internet.
WavePhore NewsCast, WaveTop	Free (ad supported)	WavePhore http://www.wavephore.com/	A standard PC with a built-in TV tuner or equipped with an add-on TV tuner card.		Both		Hardware-based products to deliver news.
Wayfarer 4.0 (formerly called INCISA)	Pricing starts at \$10,000 for 100 seats with discounts for higher volume purchases.	Wayfarer http://www.wayfarer.com/	Win 95 and Win NT For Microsoft Internet Explorer 4.x and Netscape Communicator 4.x.	Win NT	Both		A tool for companies to create deliveries of business-related information from in-house sources and the Web. Designed for intranets.

Product name	Price/Licence	Company/author	Client platforms	Server platforms	Notification and/or delivery	Document types	Description/ Usability
WebCast	Webcast Professional \$1,995 WebCast Studio, the authoring environment, as a standalone product without WebCast Server for \$495.	Astound http://www.astound.com/	Any desktop system will do, or any system that has write access to your server (such as a network server).	Win NT	Both	A channel can include video and animation (also MPEG, Autodesk (FLC and FLI), GIF89 (with transparency) and, Astound Animator's native format. Audio support includes WAV, RealAudio, and MIDI. Other supported formats include HTML, GIF, JPEG, Java, JavaScript, ActiveX control, and VBScript. The package includes a large collection of media elements in most of these formats.	For developers using middleware tools, such as Cold Fusion. For developers using HTML authoring tools, such as Adobe Pagemill. For anyone interested in creating high-impact Netcaster and Internet Explorer 4.0 broadcast channels, with no scripting required.

Product name	Price/Licence	Company/author	Client platforms	Server platforms	Notification and/or delivery	Document types	Description/ Usability
Web Transporter		Megasoft http://www.megasoft.com/wtsoc.html	Macintosh, Win, UNIX, Java	Win 95, Win NT, UNIX	Both		Web Transporter combines a Java-based push agent and user-activated pull capabilities, security, scheduling and an open, standards-based architecture that can be linked to legacy systems including corporate directories and purchasing systems.
ZD Net Personal		ZDNet http://www.zdnet.com/					a personalized newspaper

EDEN (Environmental Data Exchange Network)

An InfoSleuth Application

*Hannu Saarenmaa, European Environment Agency
Bruce Bargmeyer, US Environment Protection Agency
Warren Meekins, US Department of Defence
Robert Murray, US Department of Energy
Greg Pitts, MCC*

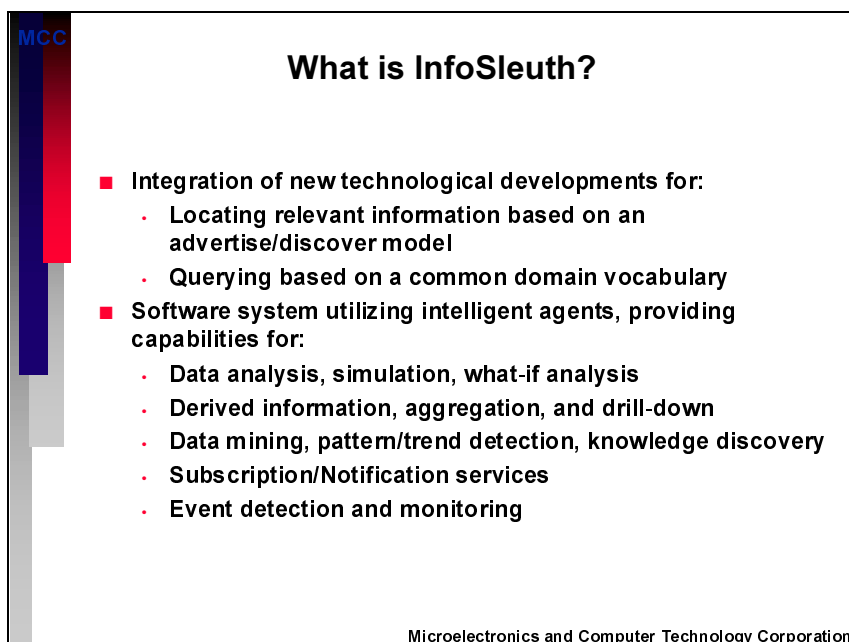
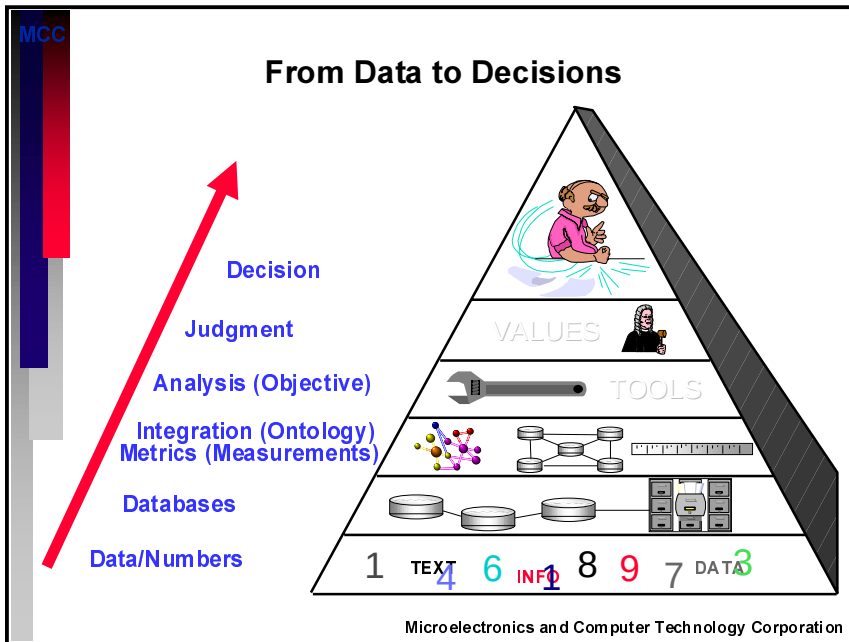
**Resource Technology '98 Symposium
Rovaniemi, Finland, June 8-12, 1998**

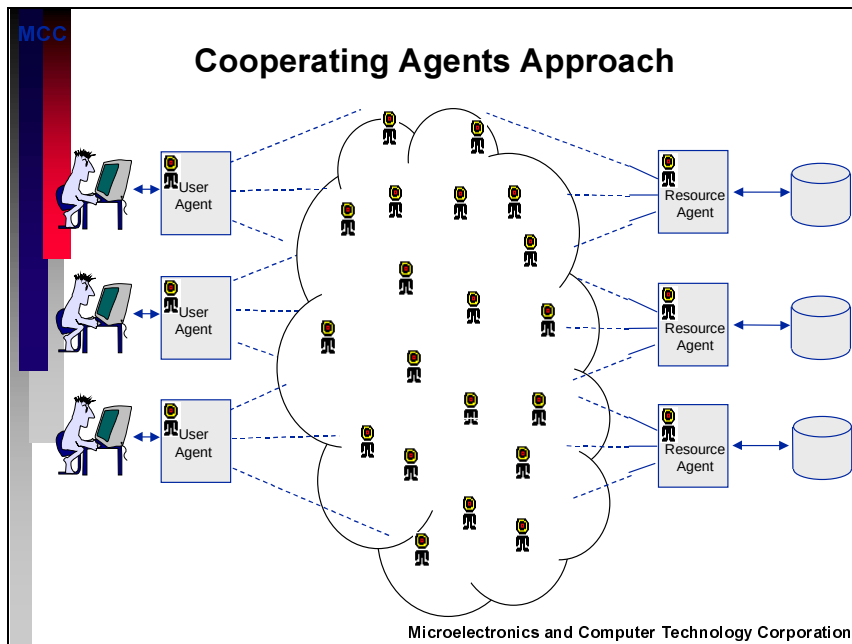
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The Problem: On-line Access to Heterogeneous Databases on Internet

- Internet is valuable because locating information is easy
 - Universal Resource Locators
 - AltaVista Search, Yahoo!, HotBot, etc, have created a new culture
- Also locating data may be possible under some circumstances
 - GILS, G7-ENRM GELOS, Catalogue of Data Sources, Environment Data Registry
- However, *accessing* data is not readily available now
 - Data harmonization needed, differences in data models, coding and concepts to be overcome
 - Distributed data warehousing: access data in place - not only its copy

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MCC InfoSleuth Development

- Result of a multi-year research and technology development project funded by industry and government contracts
 - Sponsors: Computing Devices Int'l, Eastman Chemical, Hughes, National Security Agency, Texas Instruments, Motorola
- Tested in strategic applications, including:
 - Eastman Chemical: daily use by non-computer specialists to access polymer databases
 - NIST Health care: access to health care information including federal, state and local information sources
 - NSA: integration of multimedia databases and unstructured (multilingual) text documents
 - DARPA: BADD (satellite-based information dissemination service) and Advanced Logistics Program

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MCC

What is EDEN?

- EDEN is application of InfoSleuth technology to environmental problems, because...
- Solving environmental problems requires integration of data, information and knowledge from a multitude of sources and from different networks
- There are multiple heterogeneous information resources
 - Diverse hardware and software
 - Heterogeneity in representation of information
 - Permanent, dynamic and opportunistic data
- There is a need to support multiple (and conflicting) classes of applications:
 - Reporting, analysis, research, enforcement, etc.
- There is a need to respect autonomy of information owners
 - Integrated and federated data warehouses are expensive

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Institutional Objectives of EDEN

- Collaborate on the development and demonstration of an improved means for sharing environmental data
- EPA
 - Take full advantage of existing investments in information and data without duplication of effort at each user site
- DoD
 - Harness the technology of the military for environmental cleanup, pollution prevention, etc.
- DoE
 - Share information without incurring the cost of restructuring existing data systems or building new ones
- EEA
 - Harmonization of diverse European data, maximizing use of the Catalogue of Data Sources

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Common Set of Requirements

- Reduce the reporting burden imposed by the parties on each other
- Sharing of best available and most timely information
- Enable users to access information from multiple sources
- Coordinate only the common vocabulary – not the end use of information resources; focus on the inputs with each participant; individually interpreting and communicating outputs

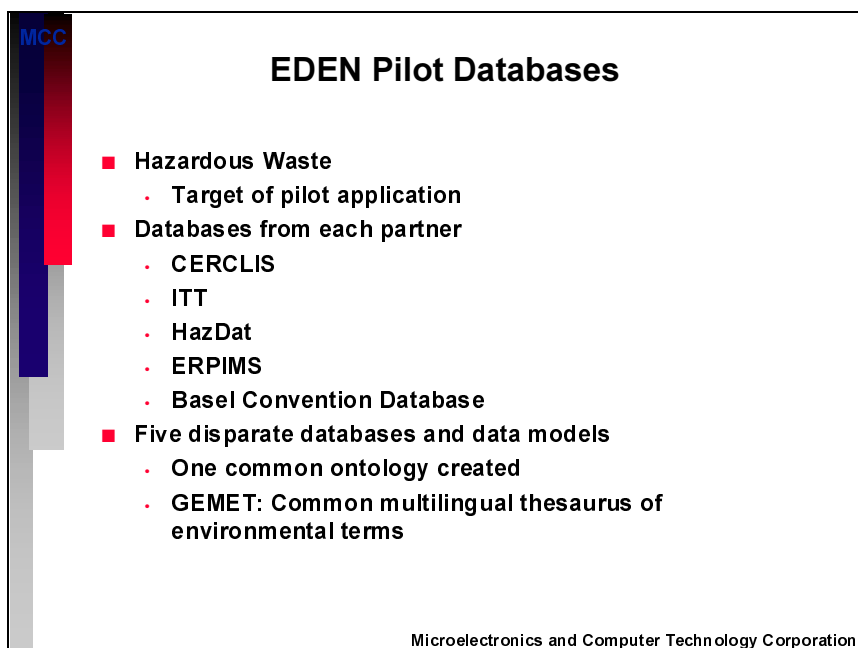
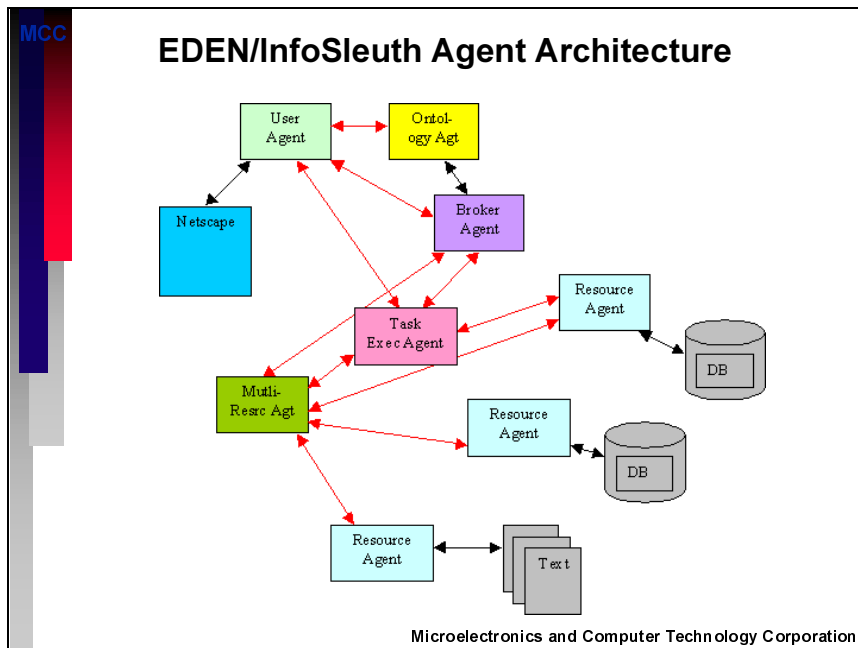
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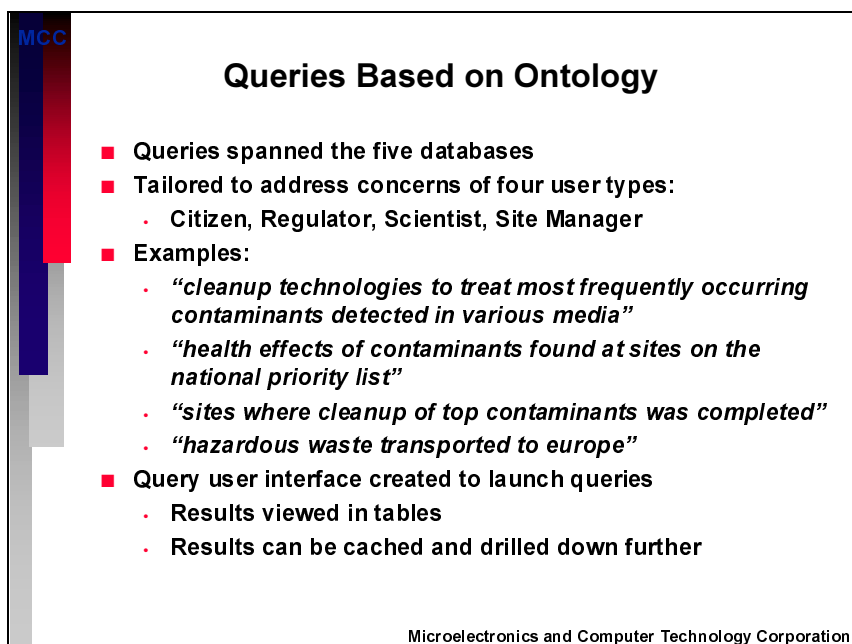
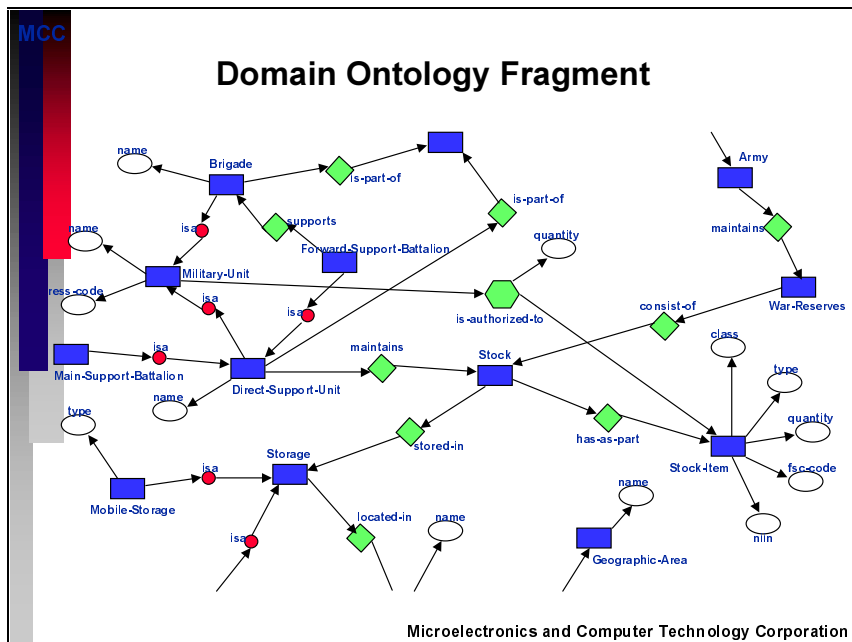
MCC

EDEN Technical Approach

- Build upon agency developments for organizing and describing data
 - The EPA Environmental Data Registry (EDR) for describes data elements and is the foundation for a semantic, conceptual data model
 - The EEA Thesaurus and EIONET provide potential multilingual capability and
- Utilize MCC InfoSleuth technology to achieve uniform access to environmental information resources
 - Access to a specific set of geographically distributed data sources in situ with minimal impact
 - Utilize Internet-capable browsers for cross-platform compatibility

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How to Create an EDEN Infrastructure

- Create a conceptual model, or ontology, that corresponds to the EDR and EEA Thesaurus in the specified domain
- Provide capability for browsing and populating an ontology, mapping and advertising data, query formulating and executing
- Develop resource agents to map sources of environmental information to the common vocabulary
- Develop user agents with query, browsing and data analysis applets
- Document relatability to proposed ANSI X3L8 and ISO SC14 data standards and describe the attributes
- Investigate the utility of integration of data analysis capabilities with agents and web-based text
- Demonstrate a pilot system

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Conclusion

- InfoSleuth is an attempt to go beyond homepages on remote data access
- Scalable architecture to tie diverse data sources to each other
- EDEN is an approach to access to heterogeneous environmental data
- Environmental professionals need data from multiple sectors - and hence EDEN
- Pilot project on hazardous waste has been promising

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Cold climate sustainability: Information Technology to develop a rural community

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Abstract

The challenge to society today is in keeping a high standard of living while using considerably less of its resources. A sustainable society is based on a comprehensive view that utilises both human resources and technical possibilities. Regional development between rural and urban areas in the “Four Corner Region” (municipalities Boden-Luleå-Piteå-Älvsbyn) northern County of Sweden provides special reasons to use IT in order to economise on resources. The idea behind this unique rural project is to show how it is possible, with the help of IT to achieve this in the small village of Lillpite with 751 inhabitants that belong the Four Corner Region. For obvious reasons, it is the aspects of communication (telematics and informatics) and its influence on traditional infrastructures that occupy the most prominent places in this particular project. This project concerns: local networks IT@Lillpite associated with work life, public service and education; as well as to contribute to a broad and deep basis of knowledge for the development of the region with its welfare and quality of life as a goal.

Keywords: Cold climate sustainability, information technology, community, local network, life quality

I Cold climate sustainability

In short, sustainable development implies economic development with the preservation of total productive capacity that also includes environ-

mental values. Luleå University of Technology has taken the initiative to start a research program to increase our knowledge and understanding of society-ecosystem relationships on a regional and local level. The aim is to create interdisciplinary work to suggest criteria and

principle solutions towards a more sustainable development of the Four Corner Region in northern Sweden. The following projects are included in the research program:

1. Seasonal storage of thermal energy.
2. Sustainable transport system.
3. Sustainable water and wastewater systems in a cold climate.
4. Planning indicators for creating sustainable development of the Four Corner Region.
5. Sustainable use of resources from woodland.
6. Ecological footprints of the Four Corner Region.
7. Sustainable development within food resource flows of the Four Corner Region from the perspective of Gender research.
8. Information technology to develop a sustainable Four Corner Region.

The research program will result in number of doctoral theses and master theses during the period of three years. The present project is one part of the multidisciplinary research program Information Technology to develop a sustainable Four Corner Region (see point 8 above).

The Four Corner Region ("4C Region") is inhabited by some 150 000 people and situated on the coast of the Gulf of Bothnia in the northernmost county of Sweden, Norrbotten, just south of the Arctic Circle (Fig 1.). Sweden is about 1600 km in length in a north-south direction, causing major regional differences in climate, etc. The annual mean temperature difference between northern and southern Sweden

is about 10 °C. The 4C Region consists of four local administrative units, municipalities, with the urban centres Boden, Luleå, Piteå and Älvsbyn. The population sizes are 35 000, 70 000, 40 000 and 10 000, respectively, and the population density is low even by Swedish standards.

The natural geography of this boreal region is characterised by a coniferous forest landscape with dominating river valleys from the coast in a north-westerly direction. The major land use is forestry. Agriculture, settlements, and therefore human activities are concentrated to the river valleys and to the coastal zone. The distance from Luleå on the coast to Boden is about 40 km along the Lule River. Piteå is situated about 50 km south of Luleå along the coast, and the distance from Piteå to Älvsbyn is about 60 km along the Pile River valley.

The climate of the region is cold with long winters and snow cover about 6 months of the year, and short summers.

The northern location also means a short period of daylight during winter days and almost 24 hours of daylight during mid-summer.

Today there are about 150 000 inhabitants in the region. About 80 % live in the four urban centres. At the end of the Second World War the Four Corner region had about 105 000 inhabitants and about 40 % lived in the countryside. This is not surprising. It was a development characteristic of all countries in the industrialised part of the world. People left the countryside for jobs in industries, the service sector, trans-

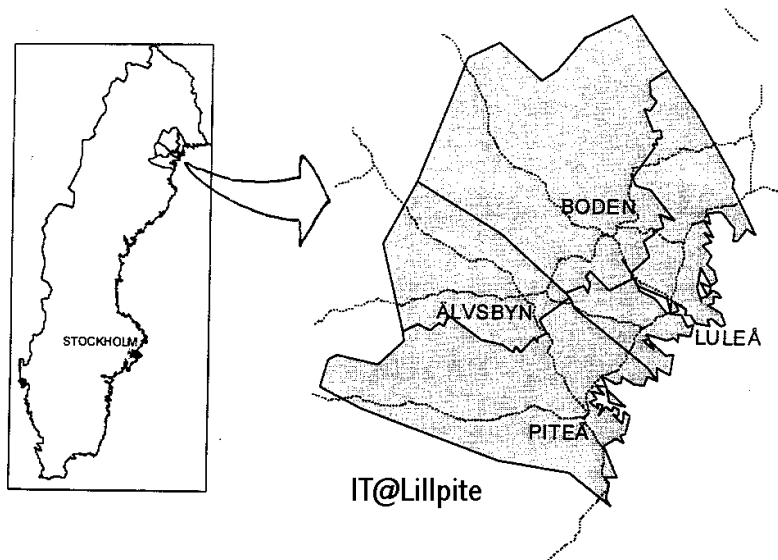


Figure 1. Map of Sweden, "Four-Corner Region" and place of village Lillpite.

portation, etc., and they changed their lifestyles and became materially well off. This development also had another side: a substantial increase in natural resource consumption and widespread pollution of water, air and ground. From a global point of view this has resulted in an alarming situation, the seriousness of which is difficult to assess.

In the previous agricultural phase of our society many resource flows were cyclical on a local scale, thus there was more efficient recycling of resource matter. Many of these "cycles" have evolved step by step over time to form the present linear flow structure. However, what these processes of change actually looked like and why they happened are not very clear on a regional and local scale

and in a cold climate. The role of technology, for instance, in these processes is obvious, but not satisfactorily understood.

The present industrial society is not sustainable in the long run. This is particularly true of certain spatial units, the urban areas, where population, resource consumption and environmental problems are concentrated. Urban areas depend on imported resources from surrounding land and water ecosystems of the region, nation and world. The impact of our cities and their inhabitants' lifestyles on the environment are very complex in space and time.

A sustainable development of our society must, therefore, be based on a solid functional systems understanding (including side-effects) of

these urban-rural systems' relationships in space and time; how resources are extracted from the environment, transformed and transported by technology, used and consumed by (mostly) urban people and finally returned to the surrounding environment as waste. Also essential is an understanding of how humans control these many processes through political and other values, organisational means, etc. Historical knowledge of how these relationships and their control have changed over time is also important.

A fundamental understanding of these systems and resource flow relationships on a *regional and local level* means that the range of solutions towards sustainability is broadened, increasing the possibilities of finding solutions that are highly adapted to specific regional and local conditions and, therefore, more efficient.

2 Information Technology

We are rapidly moving towards an information-based economy and society. The world is moving towards an information society -- a new society that will have a major impact on the way all of us live and work. It will affect both manufacturing and services; it will affect education and communication; it will change health care and it will change government. The information age has not so far contributed to a reduction of inequalities between people, regions and countries.

But how different will our future really be as a result of high technology, and particularly IT? Will it really help to preserve the environment? Will it really improve the basic elements of our lives? Currently, there are countless discussions about the impact of accelerated, structural change which is taking place throughout society.

To ensure that all people will have a stake in the information society, our vision of the Information Society is becoming one of a small Information Community in the countryside of northern Sweden. We are balancing the advantages offered to individuals with a renewed emphasis on the benefits for social groups, communities and societies.

Society depends on the way communities can co-operate, bridge differences, and work for mutual benefit.

A major result of the information age thus far has been the further globalisation of economic, and particularly, financial activity. Technology should fit the circumstances being not only technically and economically appropriate, but also socially and culturally integrated. The approach to the information society should be development that is focused on people.

We need a vision of what sustainable development would be for the information community in the countryside of northern Sweden. Different views are given as proof of the necessity of a particular strategy or action. A sample of this compromise vision is presented in Fig. 2.

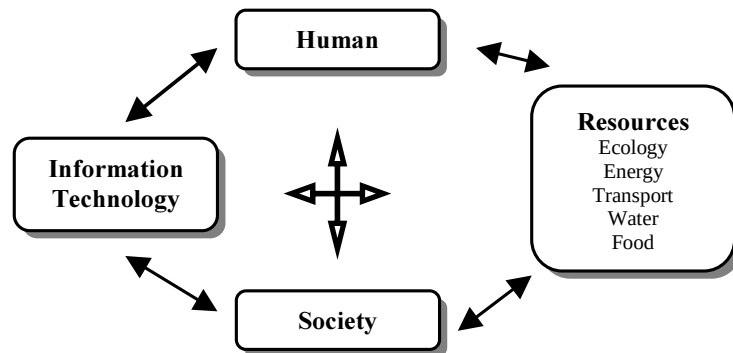


Figure 2. The components of sustainable development in the context of interaction between human-information technology-society-resources.

3 Information Technology to develop a rural community

Lillpite village is located on the Lillpite River, 18 km NW of Piteå in northern Sweden. There are 300 households and of the 751 inhabitants (356 female, 395 male), 408 live in the densely built-up area of the village. Trade, industry and organisations are well developed, adding up to 60 companies and almost 20 different associations. Lillpite is a village with an increasing population. As a result of the increasing number of children the school is now being enlarged (Fig. 1).

The Lillpite school, for pupils between 6 and 12 years of age, is very important for the development of the village. Already in 1989, a computer system for international

communication was installed at Lillpite school. In 1995, a server with a permanent connection to the Internet was installed. The children, therefore, have experience of modern Information Technology (IT). Through the children, the parents have also learnt something about this new technology.

3.1 The objectives of the project

The aim of the project is to develop a local area net for a small village with 751 inhabitants that belongs to the Four Corner Region.

The backbone of the project is an optic fibre net to which each household, company and association of the village could connect.

This contact net makes it possible to find new solutions for cultural development and to develop the village in a conserving and sustainable direction. More efficient communi-

cations with possibilities for distance education, distance work and trade promote the business climate and make the village more attractive for old and new citizens.

The experience of Lillpite will be scientifically documented and evaluated to guide similar projects in other places. We aspire to become an inspiring model for sparsely populated areas in Scandinavia and other parts of Europe.

3.2 Local Area Network of Lillpite

The optic fibre net connecting the village will support different planned applications. As soon as the net has been installed households, companies and organisations will be able to connect to the client server and thus, they will be able to send and

receive information, i.e. to use all the possibilities of IT, shown in Fig. 3.

Some examples of applications on the Local Area Network of Lillpite are shown in Fig. 4.

3.3 Expectations

The greatest benefits of IT will be obtained locally to influence the local economy and the economy of the households.

A Local Area Net that covers most people of Lillpite would have a lot of spin-off effects, since the project in itself is unique in Sweden. We are expecting a number of pilot projects to study especially older and disabled people, e.g. Tele medicine, local democracy.

Education and information about the technology and its possibilities will be available at the Citizens Of-

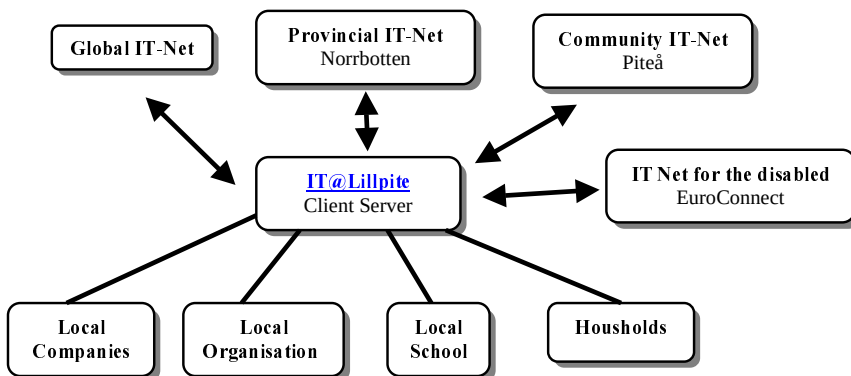


Figure 3. The Lillpite IT-Net.

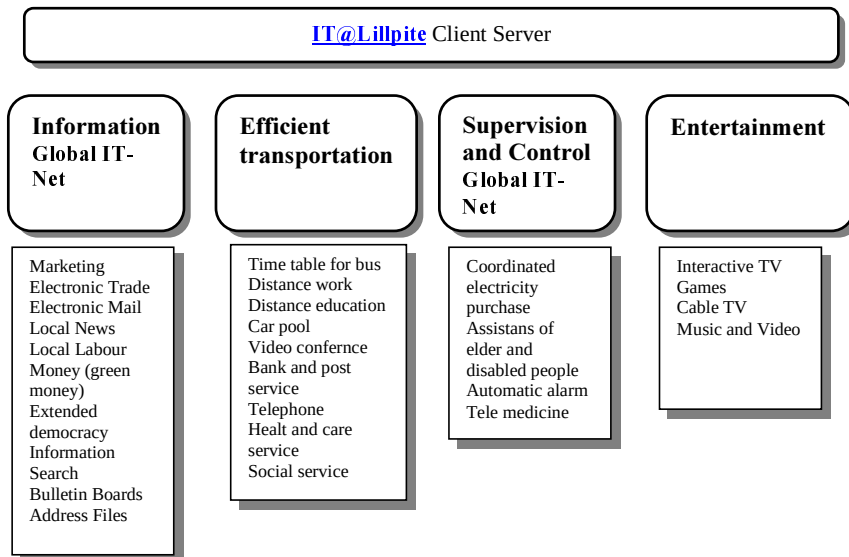


Figure 4.Applications on Local Area Network of Lillpите.

fice (CO) located at the Lillpите School. One of the main tasks is to attract potential users. Special efforts will be made to get younger women involved. This will be done in co-operation with the Lillpите Computer Association. The project group will work to attract women, the elderly and disabled people.

To access new information technology in co-operation with project EuroConnect (<http://alm.arb.luth.se>).

3.4 Education

Before the start of education; the users' computer skills and interests will be investigated. Special efforts will be made to attract retired people and women. The education will be based on classroom teaching and distance education.

Users are going to learn how to use Microsoft Office and Internet. Electronic mail, WWW and also the use of FTP, how to create home pages, advanced searches in databases. After the basic courses the participants, companies, associations can define their own requirements for education.

3.5 Evaluation

Several evaluation methods are selected to review the work from different perspectives and use. Such an approach and procedure is necessary to obtain a sufficiently reliable basis to achieve development, relevant improvements and changes during the project.

Objects of evaluation:

- The ambition is to maintain a high scientific level during the evaluation.
- The evaluation will be focused on the user perspective.
- Internal and external evaluations will be performed.
- The evaluation model will include; demand analysis, objective analysis, resource analysis, effect analysis and an overall analysis of the efficiency.
- Several evaluation methods will be used to study and measure the result of the project.
- The evaluations will be performed in steps following the steps of the project.
- Experiences of the project – mistakes and successes – will be documented during the work.
- The project results will be disseminated via presentations at conferences, seminars and scientific publication.

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Demo

Michael Östling

Environmental Satellite Data Centre

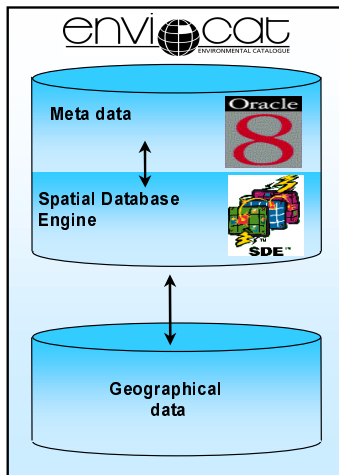
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**...is a catalogue for
environment related
geographical data, with a
user interface that can be
used via the Internet...**

2/12

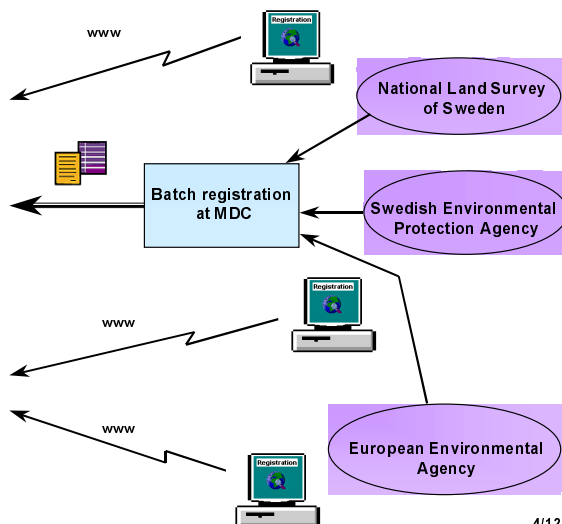
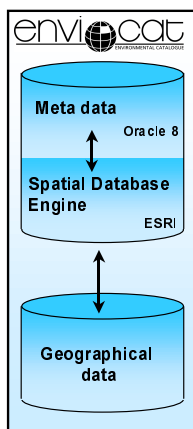
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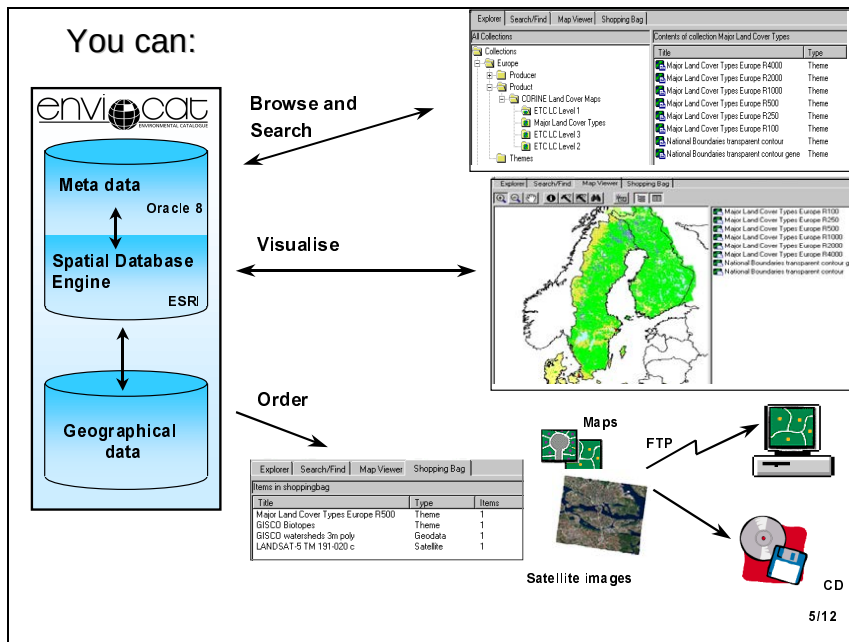
- Data about the geographical data
- Spatial Database Engine
- Geographical data
- Satellite images
- Maps

3/12

Data is registered into EnviCat:



4/12



Register metadata

MDC
Environmental Satellite Data Centre

Developer/2000 Forms Runtime for Windows 95 / NT - [Developer/2000 Forms Runtime for Windows 95 / NT]

Dataset Collections Kontakter Grunddata Avsluta

DATASET

Titel: LANDSAT 5 TM 191-020 c Objekttyp: Satellitbild (Precisions kont)

Översikt: Landsat TM Begränsning: Landsat TM

Status: Landsat TM Utsnitt: LANDSAT-5 TM 191-020 c

Förlag: Satellitbild Publicerings ort: Kuus

Publicerings-datum: 10 MAY 1999 Upphavsman: Ny

Serie: Ny Version: Ny

Utgåva: Ny Aktualitet: Ny

Kortnamn: Ny Annan: Ny

Exempel: Ny citering: Ny

Associerat dataset: Ny Associations typ: Ny

Tidsperiod: 1989-06-23-1989-06-23 Distribution: Ny

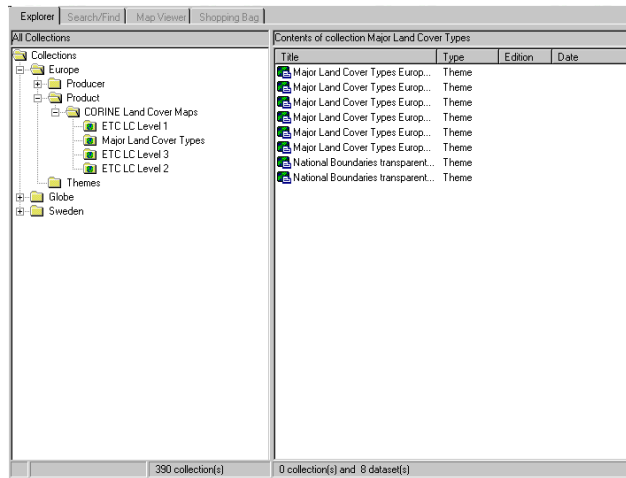
Bearbetning: Ny

Klassificering: Ny

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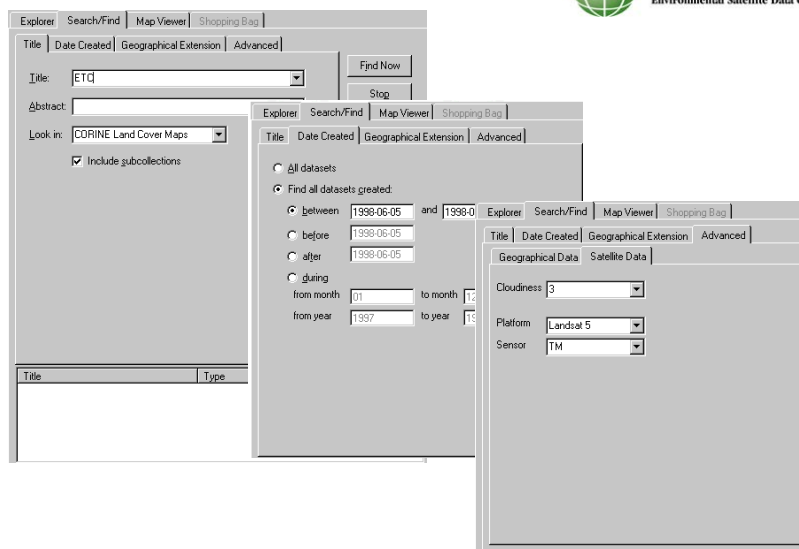
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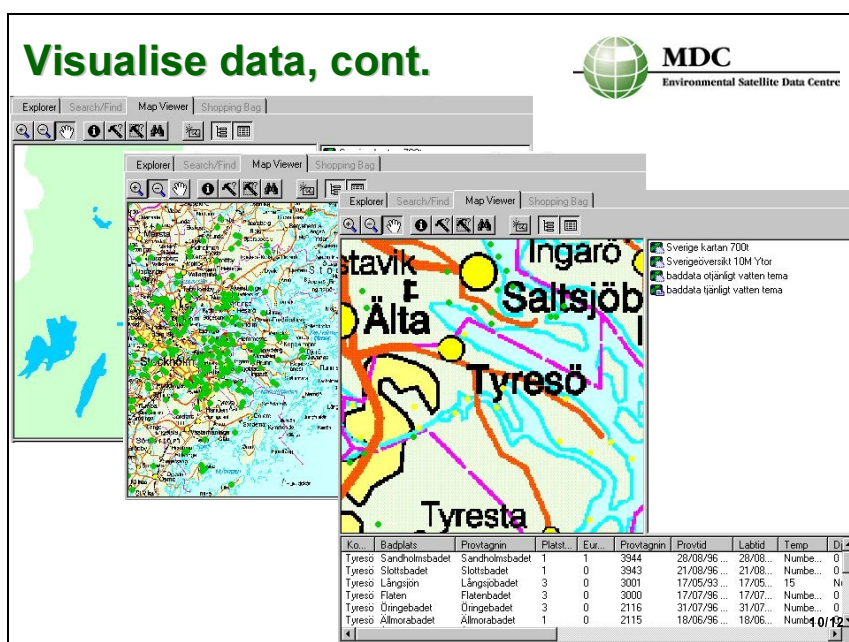
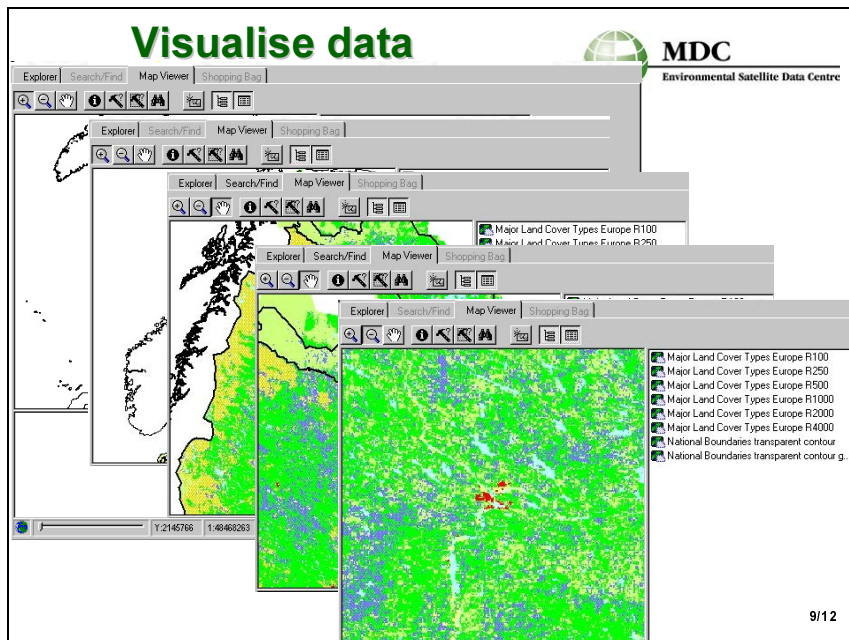
Browse the metadata



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Search the metadata






MDC
 Environmental Satellite Data Centre

Order data

Explorer
Search/Find
Map Viewer
Shopping Bag

Items in shoppingbag

Title	Type	Items	Price
GISCO Biotope Point Dataset	Geodata	1	
CORINE Land Cover Europe R2000 L3	Theme	1	
GISCO Urbanisation 32 poly	Geodata	1	
LANDSAT-5 TM 193-019 b	Satellite	1	
LANDSAT-5 TM 197-019 r	Satellite	1	

Remove item

Remove all

Order items

By mail

By e-mail

Through server

By ftp



Maps



Satellite images

FTP





CD

11/12


MDC
 Environmental Satellite Data Centre

http://www.mdc.kiruna.se/EnviCat



ENVIRONMENTAL CATALOGUE

12/12

Regional management planning of natural resources in Metsähallitus – the Forest and Park Service

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Abstract

Metsähallitus – the Forest and Park Service (the FPS) has introduced a multi-target approach in its forest planning during the last few years. As a result, a model of regional management planning of natural resources, presented in this paper, has been developed. Public participation, decision analysis and modern forest planning tools are utilised in interactive planning processes. The aim of the planning model is to support decision making in practical forestry on the strategic level. Two plans have been accomplished using the model so far. The experiences show that the planning model provides a more comprehensive figure about the planning problem and supports the FPS in making holistic decisions in practical forestry.

Keywords: natural resources, public participation, decision analysis, multi-target forest planning, regional management planning

I Background

Metsähallitus - the Forest and Park Service is a state enterprise, which is holding and managing the forests owned by the Finnish government. The total area of the parcel is about 8.7 million hectares, which covers about 25 % of the total forestry area

of Finland. Also about 3.3 million hectares water is included. The forests are located mainly in the northern part of the country.

The tasks of the FPS are defined in legislation. The FPS has to manage its natural resources in an ecologically sustainable and economically profitable way. Especially the

FPS has to take care of biodiversity and it has also to take into account the interests of the local people and industry. In practice the FPS is carrying out multi-target forestry, its main goals being nature conservation, wood production and recreation. In the northernmost part of the country it is also important to take the cultural inheritance and the special rights of the local people into consideration. All functions of the FPS are realised along the ISO 14001 environment standard.

From the total area of 8.7 million hectares about 3.2 million hectares are commercial forests, used mainly for wood production with multi-use principle. Poorly productive forestry lands with no forestry operations account to about 1.4 million ha. The rest are protected areas (1.2 million ha), wilderness areas (1.5 million ha) and other special areas (1.5 million ha), such as high-elevation forestry areas and areas reserved for future conservation.

On the basis of the international agreements (Rio 1992, Helsinki 1993...), the strategy of the sustainable forestry in Finland (Ministry of Agriculture and Forestry, 1994) and the recent development of forest planning methods and tools, the FPS launched in 1994 a project aiming at integrating its thematic forestry planning with participatory and multi-target forest planning on the strategic level. The project was finished in 1995 and the first two new planning projects were started in 1995 and completed in 1997.

2 Goals of the regional management planning of natural resources

The purpose of the regional management planning of natural resources is to find out the best strategy for the region for the next period. The basic idea is to evaluate the consequences of the alternative strategies in order to work out a strategy that best meets the goals of the FPS and the objectives of the environment. This approach stresses the role of strategic planning as a foundation for traditional (tactical) forest management planning.

Another main objective is to get the acceptance of the environment to the operations of the FPS by involving the environment in the planning process and taking its objectives into account in the plan. The expertise and opinions of the (local) people, communities and customers are gathered by means of public participation and this information (goals, objectives, comments, wishes and hopes) is included in planning.

3 Planning model

The regional management planning of natural resources integrates public participation and decision making analysis with modern forest planning tools. The planning process consists of five main stages. PATI or GIS System, the MELA System, decision support analysis and the methods of

public participation are key tools of planning. The stages are:

1. analysis of the starting point;
2. goal analysis;
3. predictions;
4. selection of the strategy, and
5. implementation schedule.

1. Analysis of starting point

The planning process is launched with the analysis of the starting point. The quantity and quality of the natural resources of the region are assessed through the SWOT analysis (Strengths, Weaknesses, Opportunities, Threats). The analysis is carried out separately from the points of view of nature conservation, forestry, recreation and from those of local people and local economy. The results are also reported from each of these standpoints.

In order to find out a total picture of the resources, analyses are compiled for regions with all different kinds of forests involved: commercial forests, protected areas, recreational areas, etc. The area of the regions is ranging from about 0.4 million hectares in the south to about 2.5 million hectares in the north.

An updated database is utilised in the analysis of the starting point. The standwise database of the FPS is today updated continuously by operations and yearly by growth simulation. The database covers all lands of the FPS and contains in addition to standard forestry data also information about nature conservation and recreation. The SWOT analysis of the starting point is carried out mainly by enquiries and summaries compiled by the PATI System.

2. Goal analysis

In the goal analysis the objectives of the local citizens, communities, industry and other interested parties are gathered through various methods, such as meetings, open house gatherings, working groups, questionnaires, letters, telephone and the internet. The general goals and tasks of the FPS are specified for this particular region and for this special planning case. The resulting combined goal information characterises the desired future management policy of natural resources for the next period in the region.

3. Predictions

Production functions between inputs and outputs illustrate what is possible to attain and the trade-offs between different outputs show how the outputs depend on each others.

Production functions and trade-offs are estimated by the results of alternative strategies. Some (3 to 4) feasible alternative strategies with different emphasis on various goals are fixed. The results are measured by the set of the selected variables (criteria and indicators). The predicted future development of the variables estimates the production functions and the trade-offs.

One of the alternative strategies is that one carried out during the past period, the so-called basic strategy. The alternative strategies compose of feasible land use alternatives accompanied with changes in silviculture and cutting schedules. The PATI and MELA Systems are the key tools of the FPS to find out the state of its

forestry resources today and to seek answers for “what - if” questions of the future development of the forestry resources.

The land use differentiation for alternative strategies is made by the PATI. The projections of the alternative strategies are compiled by the MELA. These projections provide numerical values for the selected indicators and criteria. The calculations are based on the standwise data from the PATI. For calculations the stands with similar characteristics are aggregated into a same stratum. In optimisation also subdomains can have their own restrictions. The main MELA sensitivity analysis used in the FPS are changes in the rate of return and in the rotation age.

The MELA System of the Finnish Forest Research Institute is a well known forest planning tool. Its special strengths are a powerful simulation and optimisation and effectiveness in handling large quantities of data. In the MELA planning procedure several feasible management schedules (programmes of silviculture and cuttings) are simulated for every stand. The optimum solution for the forestry unit is then worked out by means of the JLP Optimisation. The optimum solution provides also the standwise management schedules. (For more information about the MELA the reader is referred to, for example, Siitonen et al. 1996).

4. Selection of the strategy

When selecting the strategy the results of the alternative strategies are evaluated against the goals of the FPS and against the objectives of the

environment. The desired future balance between wood production, nature conservation, recreation and other perspectives is judged by the means of the values of the selected set of criteria and indicators and with the help of decision making analysis.

The selected strategy fixes the land use pattern and the silvicultural and cutting guidelines. Also other principles (such as those concerning buying and selling the land, making cottage zoning maps, taking gravel...) are decided. The levels of main outputs and inputs are confirmed in quantity, some in quality too.

If the consequences of any of the compiled strategies do not provide a balance good enough, the strategy to be implemented is formulated by an iterative process.

The main decision support technique utilised in the FPS so far is interactive decision analysis (IDA). The method is based on the utility theory and the idea of the analysis is to make things expressed in different terms comparable in one single term: utility. In the FPS the IDA contains three steps (Pykäläinen et al. 1998):

- 1) finding out the parties' preferences and describing them in the form of an additive utility function;
- 2) formulating the overall utility function by integrating the parties' utility functions, and
- 3) evaluating the alternative strategies by means of the overall utility function. The sensitivity analysis is an essential part of this step.

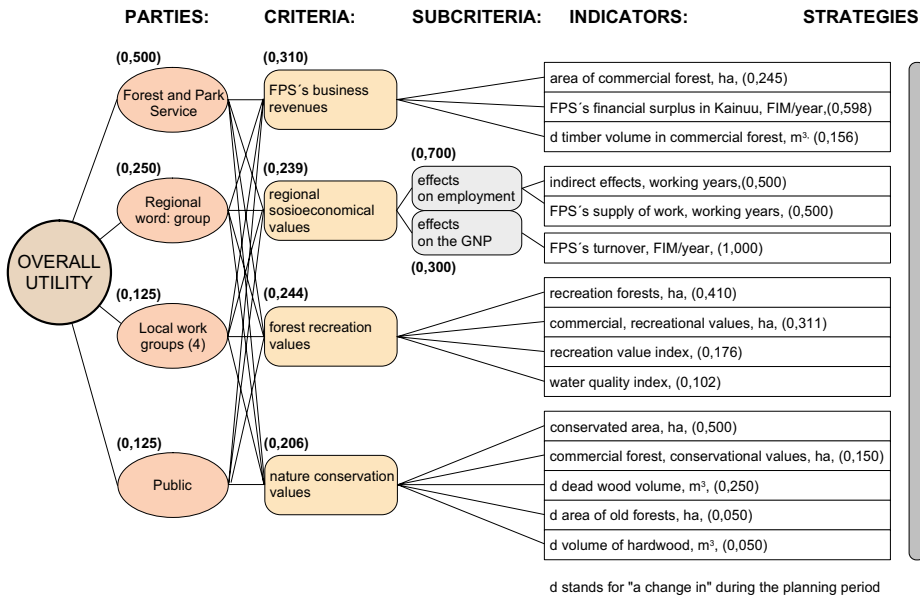


Fig. 1. The decision hierarchy applied by the FPS in the IDA in Kainuu region. The values in brackets comprise the local weights for the decision elements

The overall utility function ranks the strategies along the utility and the sensitivity analysis tells, how sensitive for changes in parameters is the solution (Fig. 1). A decision hierarchy applied in the FPS is an illustrative way to describe the overall utility function (Pykäläinen et al., 1998).

5. Implementation schedule

Implementation schedule is a tactical plan that puts the strategy into operational work. In the implementation schedule the land use is fixed spatially by the PATI and the other principles and guidelines are specified within land use classes. The amounts of the main outputs and inputs are also fixed within land use classes. Some inputs and outputs are defined also in quality.

4 Experiences

The first two regional plans have been accomplished for Kainuu in Central Finland and for Western Finland. The total area of the Kainuu plan is little less than 0.9 million ha and that of Western Finland about 0.4 million ha. The regions differ from each other both in geography and by the goals of the natural resources management. The emphasis of the various goals by different participants is shown in Table 1.

The objectives of recreation and nature conservation have relatively more emphasis in Western Finland, economic objectives in Kainuu.

The best strategies differ as well (Table 2):

Table 1. The emphasis of the various goals of regional plans by different participants in Kainuu and Western Finland.

Emphasis of goals: Participants:	in Kainuu / in Western Finland		
	Citizens	Local Groups	the FPS
Local economy	0,25 / 0,10	0,28 / 0,28	0,20 / 0,14
Nature Conservation	0,13 / 0,30	0,25 / 0,23	0,20 / 0,23
Recreation	0,50 / 0,40	0,21 / 0,31	0,20 / 0,23
the FPS' economy	0,13 / 0,20	0,26 / 0,19	0,40 / 0,40

Table 2. The relative overall utility values of different strategies of regional plans in Kainuu and Western Finland.

Strategy:	Basic	Conservation	Economy	Recreation
	Emphasis on			
Overall Utility Values:				
*Kainuu	0,47	0,34	0,52	0,45
*Western Finland	0,64	0,66	0,66	0,77

Due to the different sub-utilities it is relevant to compare the relative values of strategies only within each region, not between the regions. In Kainuu the strategy emphasizing FPS' economy gets the highest relative value, in Western Finland the one emphasizing the recreational use of forests. Sensitivity analyses show that the solutions are rather stable.

5 Discussion

The planning model presented supports multi-objective decision making in practical forestry on the strategic level. All of us know that multi-target decision making in forestry is challenging. The decisions and selections are basically human judgments, but proper planning can provide valuable support in terms of di-

verse and valid information. There was a goal in the FPS to gain more comprehensive information for holistic decisions through the integrated approach. Key lessons learned so far include:

- citizens and interest groups are genuinely interested in the management of forests owned by the State;
- they have a lot of knowledge and expertise in the matter;
- goals of different groups can be quite conflicting also at the local level;
- non-wood values are hard to express meaningfully in numerical terms, which are most convenient to handle in planning procedure;
- more knowledge about production functions and trade-offs has been gained via the processes in the FPS;

- learning about the trade-offs between different outputs is a broadening process for most of participants;
- a lot of research is needed to gain more accurate production functions and trade-offs, especially in the fields of nature conservation and recreation;
- the decision analysis structures the problem into meaningful parts and stresses the focus on essential factors, on the other hand there is a danger of oversimplifying;
- the decision analysis needs to be developed to more “user friendly”, free of method and forestry jargon; and
- recreation and nature conservation have a strong role in FPS’ forest management planning.

There is quite a common opinion in the FPS that without the applied approach it would have been still harder to grasp a comprehensive picture of the decision problems and to find out solutions accepted by the FPS and the environment. And in spite of the shortcomings mentioned

above the planning model has helped us to make holistic and conscious selections.

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Analytic hierarchy process and positional analysis in participative forest planning

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Abstract

Two decision-supporting methods, Analytic Hierarchy Process (AHP) and Positional Analysis (PA), are briefly viewed and their suitability for participative forest planning is evaluated. Criteria for a decision-supporting method to transmit citizens' values to decision-making are: a) Does the method used enable to formulate and delimit the decision problem comprehensively and clearly? b) Is the method applied able to manage both qualitative and quantitative information when collecting the information? c) Are all the different values associated with the information presented clearly when managing the information? d) Does the method present the standpoints of the different parties and the impacts resulting from following them? It becomes apparent from the evaluation that both AHP and PA have their advantages and disadvantages as decision-support method in participative forest planning. Conclusion is that better results in participative forest planning may be reached by combining these methods.

Keywords: public participation, evaluation, decision-support methods, planning theories

I Introduction

Participative planning in forestry means usually multi-objective forest planning, where citizens' opinions and objectives concerning forest planning are included in the decision-making process. Typical for this kind

of planning is to have high number of decision alternatives. In environmental and social decision-making situations the cost-benefit analysis (CBA) has usually been used to compare decision alternatives. CBA is the most used and probably the most

criticized decision-support method (e.g. Price 1997).

Given this situation, new decision-supporting methods have been introduced in participative planning and multi-objective forest planning (Lidestav 1990, 1994, Mattsson 1991, Kangas 1994, Kangas et al. 1995). Positional Analysis (PA) has been introduced as a method of participative forest planning in Sweden, while Analytic Hierarchy Process (AHP) has been used in Finland for the same purpose (Lidestav 1990, Kangas et al. 1995). These two decision-supporting methods, AHP and PA, are briefly reviewed and evaluated in this paper as participative forest planning methods.

2 The methods

2.1 Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP), originally developed by Saaty (1980), is a mathematical method for analysing decision problems with multiple criteria. In the method, a hierarchical decision schema is constructed by decomposing the decision problem in question into decision elements – goals, objectives, attributes and decision alternatives. The most general goal is at the top of a decision hierarchy, and decision alternatives constitute the lowest level of the hierarchy. The importance or preferences of the decision elements are compared in a pairwise manner with regard to the element immediately above in the hierarchy. Based on these compari-

sons, an additive model on a ratio scale describing the preferences of the decision-maker is estimated. The model is called a priority function. The decision alternative producing the highest global priority is considered the “best” and most satisfactory one and it is the one that is recommended.

In an approach based on representative democracy as presented by Kangas et al. (1995), a level of “players” (i.e. participants) consisting of interest group representatives is placed in the decision hierarchy immediately above the level of decision objectives. The basic steps in applying AHP to participatory planning consist of 1) determining the interest groups participating in the decision-making process, 2) constructing the decision hierarchy for different interest groups, 3) assessing the weights for different interest groups 4) estimating the priority functions for each interest group, and 5) evaluating the alternative management strategies. (Kangas et al. 1995.) In the step 5, by using AHP+HERO - solution, it is possible to evaluate a great number of alternative forest plans. For more details on HERO techniques, readers are referred to Pukkala and Kangas (1993) and Kangas et al. (1995).

2.2 Positional Analysis (PA)

The main purpose of Positional Analysis is to shed light on decision situation (Söderbaum 1986, 1994). It was developed to be open-minded in its relation to all actors and interested parties and it is versatile in its ana-

lytical properties. No consensus regarding valuation rules is assumed, and so one has to refer to valuation rules or standpoints that are possibly relevant to decision makers and those affected, and point to conditional conclusions. (Söderbaum 1986, 1994.)

Depending on the kind of decision situation and the social and institutional context, simplified versions of Positional Analysis may be considered. A more ambitious study would include the following (Söderbaum 1994):

- Description of the decision situation. Historical background. Relationships to other decisions (previous and simultaneous). Identification of relevant institutions (organisations and rules of the game) and interest parties.
- Identification of the problem(s). Reproduction of problem images as stated by different actors and interested parties.
- Design of alternatives and formulation of the problem (choosing a set of alternatives for further consideration).
- Identification of impacts (monetary and non-monetary, in flow and positional terms) and comparison between alternatives in relation to these effect dimensions.
- A study of possible inertia and irreversibilities in non-monetary positional terms. In what way will first-step alternatives influence future options for different affected parties?
- Analysis of activities and interests in relation to the decision situation: identification of activi-

ties that will be affected differently depending on the alternative chosen. Assumption of goal direction (target orientation) for each activity. Activity, together with goal direction, defines an interest. Construction of preference ranking from the standpoint of each activity in relation to each alternative.

- Analysis of prevailing risks and uncertainties.
- Summary of information basis for decisions at the two levels of impacts and activities (with associated assumed interests).
- Articulation of possible valuational standpoints in terms relevant to the study area.
- Conditional conclusions, relating to the expected impacts of each alternative on possible future and valuational standpoints.

3 Framework for evaluation

3.1 Background

Planning theories are usually divided to substantive and procedural planning theories. Procedural theories concentrate on how the given ends are reached. Substantive theories emphasize defining the decision-making problem in its context. Relevant question is how the decision process has been carried out. Means themselves have their value, not only the ends reached by means.

According to the critical planning theory (substantive), in decision-making there is two kind of rationality: instrumental and non-instrumen-

tal. Instrumental rationality is appropriate for goal oriented behaviour within a means-ends structured problem area (Habermas 1971). It tells us how to combine the means to achieve given ends. Applications of analytic techniques in planning are examples of the use of instrumental reason (Sager 1992).

Non-instrumental types of rationality have been identified and analysed as social rationality and communicative rationality. Communicative rationality is found in speech meeting the validity claims of comprehensibility, truth, rightness, and sincerity, and the same time aiming at mutual understanding and agreement (Sager 1992). A community can rationally derive the goals to be collectively pursued. Values and norms, which could not be seen to have any rational founding under instrumental reason, may be established in a communicative rational manner (Sager 1992).

The concept of social rationality works through integrative decision-making to turn personal change into a rational process. In integrative decision-making preferences are attached to the means themselves. Personal change refers to e.g. that desires are changed rather than satisfied, and to personal growth by self-discovery and learning (Sager 1992).

Although non-instrumental rationality concepts refers to changing desires and reaching mutual understanding, they are not meant to be manipulative. On the contrary, at least in theory, they should work to prevent manipulation by emancipatory process, which free people from domination and promotes equality.

From the rationalities presented above, it can be indicated four stages in the decision-making situation with public participation. These can be seen divided even they are contemporary.

- 1) Personal growth i.e. to discovering one's own desires and preferences.
- 2) Communication i.e. transforming preferences and values to decision-making process.
- 3) Mutual understanding i.e. common decision-making.
- 4) Instrumental rationality i.e. combining the means to achieve given ends.

Concerning decision-supporting methods these considerations are formulated as following questions. Does the decision-supporting method help the participants become conscious of their values and to put them in order? Does the decision-supporting method transform the citizens' values to decision-making? Do the decision-supporting method support mutual understanding and undistorted communication? Does the decision-supporting method search means to reach certain goals? In this paper two decision-supporting methods are analysed from the viewpoint of the stage 2.

3.2 Criteria for evaluation

The earlier experiences of public involvement in natural resource management planning has been reported widely (Paldanius 1997). According to e.g. Leskinen and Turtiainen (1988), Leskinen et al. (1991), and

Paldanius (1992) there are several preconditions to successful participative planning process. These preconditions concerns e.g. about timing of the participation, managing information and choosing of the participants. From the viewpoint of these preconditions criteria for decision-supporting methods are formulated. To meet the objective of to transmit citizens' values to decision-making, the decision-supporting methods should fill at least the following four criteria.

- a) *Does the method used enable to formulate and delimit the decision problem comprehensively and clearly?*

For successful public participation it is important that citizens are involved to the planning process from the very beginning (Leskinen and Turtiainen 1988, Miller 1988). The purpose is that a well-based decision should be taken as to which interests and interest parties are relevant to the planning situation. For this to be achieved, there should be a procedure for identifying all the interests and interest parties affected by planning. The decision problem should be modified comprehensively, clearly and openly (Leskinen and Turtiainen 1988, Leskinen et al. 1992, Paldanius 1995).

- b) *Is the method applied able to manage both qualitative and quantitative information when collecting the information?*

The method used should be able to treat all kinds of information. In order to be appropriate in

changing situations, procedures should be modifiable (Paldanius 1995). Information and opinions should be able to express the way citizens are familiar with.

- c) *Are all the different values associated with the information presented clearly when managing the information?*

The method should present important affairs and their grounds (values, preferences). It should become readily apparent which alternatives support which objectives. Evaluation should also be comprehensible and consistent. The consistency of the method means that the information utilized is free of conflicts, or if it is not, that conflicting standpoints are clearly presented (Paldanius 1995).

- d) *Does the method present the standpoints of the different parties and the impacts resulting from following them?*

Clear and comprehensible decision-support analysis should be performed so well, that anyone is able to evaluate the alternatives from his/her standpoint by him/herself (Leskinen et al. 1992). An appropriate "open" method would also produce analysis about the profits and disadvantages of the alternatives from the viewpoints of the different interest parties. Methods, which optimise and make things mutually comparable, hide the value conflicts between interests, and do not show who will be affected and/or how (Miller 1988, Leskinen et al. 1991, 1992).

4 Does the decision-supporting method transform the citizens' values to decision-making? – Evaluation of AHP and PA

- a) *Does the method used enable to formulate and delimit the decision problem comprehensively and clearly?*

AHP does not include any procedures for identifying different interest parties and interests. When AHP is used, every interest party is able to formulate the decision problem by setting their own decision-making hierarchy. Positional Analysis includes procedures for mapping all the interests and interest parties, e.g. "Description of the Decision Situation", "Identification of the Problem(s)" and "System Analysis". AHP has procedure to formulate the decision problem very clearly when PA has better procedure to obtain comprehensive understanding of the problem.

- b) *Is the method applied able to manage both qualitative and quantitative information when collecting the information?*

Both AHP and PA are capable of managing qualitative as well as quantitative information. Different techniques for collecting information and opinions are available in PA. E.g. surveys, inter-

views and meetings. When using the AHP -method participants express their opinions (preferences) setting priorities e.g. by doing pairwise comparisons. This means possibility that other ways to collect participants opinions (e.g. theme interviews) have not the same importance with priorities set in the decision-making process. This might result in inequality of participants.

- c) *Are all the different values associated with the information presented clearly when managing the information?*

In principle both methods can deal with values concerning information. The main purpose of AHP is to identify participants subjective preferences concerning the decision criteria. In AHP, included decision criteria are seen from the hierarchy. PA collects and analyse opinions and reports different viewpoints to decision-making situation. In PA at "System Analysis", "Definitions of Activities and Interests", and "Effect Analysis" reveal, which questions have been included in the process.

In AHP and PA there are some properties that might result in inconsistency and unclear presentation of decision-making situation. In AHP process it is possible that the uncertainty of the priorities and utilities accounted are not always demonstrated and understood.

PA also has consistency problems in assessing impacts. At the step "Identification and Comparison of Impacts", the planner may decide

which kind of impact is valued as being good or bad. To avoid hidden valuation, it is better to identify impacts at this step. The identified impacts should be compared and valued at the step “the Analysis of Activities and Interests” at which point the viewpoint of the valuation can be seen openly.

Sometimes PA can also be too comprehensive and thereby conceal important points. When using Positional Analysis planner has to concurrently attend to compactness and comprehensibility of the analysis. The problem is that analysis easily expands and becomes too comprehensive to be controlled any more.

d) Does the method present the standpoints of the different parties and the impacts resulting from following them?

As a whole, both AHP and PA are capable of analysing and expressing the participants’ standpoints in the planning process. In AHP, every interest party can have their own decision hierarchy and decision alternative, which consequences can be simulated and so directly seen. “Analysis of Activities and Interests” and “Conditional Conclusions” of Positional Analysis shows the standpoints of the participants.

5 Conclusion

It becomes apparent from the evaluation that both AHP and Positional Analysis meet the objective of to transmit citizens’ values to decision-making by their own way. Both

methods have their advantages and disadvantages as decision-supporting methods in participative planning. PA has the procedure for identifying all relevant interest parties. AHP has a tool for modifying the decision problem clearly, when PA has tools for more comprehensive analysis of the decision problem. Both methods are able to manage quantitative and qualitative information. The advantage of PA method is the option for collecting information by different techniques. Both methods can manage values concerning information. Both methods have problems with consistency and clear presentation. PA might be too comprehensive and by that way conceal important points. Both methods show standpoints of the participant groups.

In participative forest planning there seems to be need to same time combine the comprehensive analysis of decision situation and keep the analysis clear and compact. This need can be obtained by combining AHP and Positional Analysis as one procedure. For example,

- 1) By using Positional Analysis “Analysis of Activities and Interests” the comprehensive study of the decision situation is substantiated.
- 2) Only the most relevant points are concentrated and analysed thoroughly by using AHP-method. The consequences of the different decision alternatives formulated can be demonstrated by simulations with AHP+HERO - solution. Different standpoints can be demonstrated by “Analysis of Activities and Interests” and “Conditional Conclusions”.

- 3) After “compact analysis” decision alternatives formulated can be analysed again comprehensively with the help of “Analysis of Activities and Interests” substantiated in the step one.

In this paper two decision-supporting methods were analysed from the viewpoint of the question: “Does the decision-supporting method transform the citizens’ values to decision-making?” The aim of the study was to compare how one qualitative and one quantitative decision-supporting method support the aim of transmit citizens’ values to decision-making process. The future studies will concern decision-supporting methods and other questions introduced in the section 3.1. Also the procedure where AHP and PA is combined will be presented and tested in case study.

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Ecological knowledge in forest management planning

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Abstract

So far, models describing the development of animal populations have rarely been used in forest management planning. A few applications exist, where population models have been used for optimizing the expected size of population. There also exist some applications where expert judgment has been utilized in choosing the best management alternatives. In most of these applications, the uncertainty about the population development has not been taken into account. It is, however, important to know the risk that the sizes of populations fall below acceptable limits, with the management alternatives chosen. This is especially the case with rare species. It is possible to utilize also the information of population variation in planning, either to minimize the risk of the population size falling below a given threshold value, or by maximizing some objective function with the constraint that the population size remains above the given threshold value. In this paper, possible consequences of ignoring the uncertainty about the population development are discussed and an example of utilizing ecological knowledge in forest management planning is given.

I Introduction

In forest management planning the target is to find the treatment schedule which is best according to all objectives of the decision maker. In the recent years, ecological aspects have been given more and more weight in forest management planning. Landscape ecological planning

is a tool by which these aspects can be considered. One key target of the landscape ecological planning is to maintain the viability of the rare and vulnerable species persisting in the planning area. This objective can be dealt with in the planning situation with many different approaches. Each of these approaches have their own benefits and drawbacks.

With basic landscape ecological approach all the species are considered at the same time in a holistic manner, at the landscape level. In this approach the means to maintain the viability of the populations is to promote (or sustain) those forest characteristics that are considered critical for the species. Such characteristics may include, for example, the connections between suitable habitats (so called ecological corridors), amount of dead and decaying wood, or proportion of some hardwood species. The advantage of this approach is that it is (at least in principle) easy to understand and implement.

The basic landscape ecological approach has, however, some disadvantages. For example, when the objectives in the planning are contradicting, it may be difficult to say how much there is room for compromise in order to maintain the population viability. It may even be difficult to say if the viability can be maintained in the first place, even if no compromises are required. The uncertainty about the significance of certain characteristics is difficult to take into account, and the consequences of implementing alternative plans may be hard to predict.

For some species there exists very detailed information. Information about the most vulnerable species or species that represent the reactions of several other species can be utilized to complement the basic approach, to make the analysis more profound. This information can be especially useful for covering the parts that are problematic with holistic approach.

The species-wise knowledge available may include experts' judgments, models, empirical data etc. Utilizing species-wise knowledge has usually been considered as too complicated: the information about one rare species can include several models describing details of the species: its occurrence, fecundity, death rates, immigration, relationships with other species and so on. This huge amount of details is not easy to utilize in planning. In addition, characteristics having a positive effect on one parameter may have a negative effect on another. The information available may also be quite uncertain. On the other hand, using species-wise information gives the possibility to take into account all the information available and also to take into account the uncertainty about the development of the species.

If maintaining the population viability is taken as the main target in planning, the information about a certain species can be condensed so that it is easy to utilize in forest management planning. One such technique is the risk analysis. In the risk analysis, the possibility of the extinction of a population, with any treatment schedule, is assessed. This risk estimate can then be used as a constraint or as an objective in forest management planning.

2 Population models

A simple model by which the development of the population can be described can be presented as (e.g. Burgman et al. 1993)

$$N_{t+1} = N_t + N_t b - N_t d = N_t (1 + r)$$

In this model N_t is the size of the population at time t , b is the birth rate and d is the death rate. Thus, r is the growth rate (discrete time). This model may be used deterministically to predict the development of the population. If birth rate is larger than death rate, the population grows indefinitely, otherwise the population eventually becomes extinct.

The effect of forest management planning can be taken into account in the predictions of population development, if one or more of the vital parameters of the population depend on the characteristics of the forests in the area. For example, the birth rate may depend on the suitability of the area for the population at hand (e.g. Kurki et al. 1997). If the population parameters depend on forest characteristics, forest management has an effect on the development of population. Otherwise, it is assumed that all management options are equally good from the populations point of view.

The number of individuals may not, however, be interesting as such. More important is, whether the viability of the population can be maintained with a certain management schedule. This aspect can be studied by a risk analysis. If the demographic variation (i.e. variation between individuals) is taken into account, the number of individuals that die or born can be assumed to follow a binomial distribution. Then,

$$N_{t+1} = N_{t, \text{survived}} + N_{t, \text{born}}, \text{ where}$$

$$N_{t, \text{born}} \sim \text{BIN}(N_t, b) \text{ and}$$

$$N_{t, \text{survived}} \sim \text{BIN}(N_t, (1-d)).$$

With these assumptions, it is possible to calculate the probability of the population to become extinct. Thus, the risk the population is facing due to demographic variation can be assessed.

The effect of demographic variation is usually relatively small, if the population is large. Variation that affects the whole population, for example weather conditions, may be much more important. Such variation can be described by assuming annual variation in the birth and death rates as (e.g. Burgman et al. 1993)

$$\begin{cases} b_t = b + \varepsilon_{bt} \\ d_t = d + \varepsilon_{dt} \end{cases}$$

In this case it is possible to calculate the risk the population is facing due to variation in the birth and death rates. This risk assessment may be useful in a sense that we know how the population will perform in average. It is, however, not useful in forest management planning unless the effect of forest management on the risk can be assessed (see also McKelvey 1996). Respectively, for assessing the sustainable level of hunting, the effect of hunting has to be taken into account in risk analysis (e.g. Kokko et al. 1997).

In the above mentioned model there is assumed to be only one population. In reality the population consists of several sub-populations. The combination of the sub-populations is called a metapopulation. In a metapopulation the individuals may emigrate from a sub-population to another. This may be described with (e.g. Burgman et al. 1993)

$$N_{i(t+1)} = N_{it}(1 + r_i) - \sum_{j=1}^n E_{ij} + \sum_{j=1}^n E_{ji}.$$

With this model the effect of immigration and emigration on the risk metapopulation is facing can be assessed. If the emigration depends, for example, on the width of the ecological corridors, the width required for keeping the population viable can also be calculated.

3 Ecological knowledge in forest management planning

3.1 LP approach

Linear Programming (LP) is a common method used in forest management planning. In LP method the planning problem is described with an objective function which is to be maximized

$$\max \sum_{j=1}^n c_j x_j$$

subject to constraints

$$\sum_{j=1}^n a_{ij} x_j \geq b_i, i = 1, \dots, p$$

In this formulation, x_j is the area treated with alternative j , c_j is the coefficient which tells how much this area produces the objective variable, a_{ij} is a coefficient which tells how much the area treated with treatment

j produces or uses commodity i and b_i is a coefficient which tells how much of commodity i is required or can be consumed.

The population models can be used in a forest management planning task in several ways. The decision maker may take the size of the wildlife population as an objective or as a constraint. Applications, in which the forest management planning package used contains models also for wildlife populations, already exist. In one such package, FORPLAN, the population size of a few species can be taken as a decision variable (Burgman et al. 1994).

The sizes of animal populations as such may not be interesting, but, more probably, the decision maker would like to keep the populations viable although he/she manages the forests for wood production or recreational purposes. In this case the population size or the risk faced by the population can be used as an objective or as a constraint in planning. For northern spotted owl, there exist studies in which the risk faced by the population has been assessed as a function of the proportion of old growth forests (McKelvey 1996).

The usual LP approach does not consider the uncertainty about the development of animal populations. If this uncertainty is considerable, the obtained solutions may not be feasible. If the constraint is that the risk may not be larger than, say, 5 %, the uncertainty in the calculations may cause the risk in the chosen solution to be much bigger. This can be prevented, if the uncertainty is taken into account. This can be done by formulating the constraint

$$\sum_{j=1}^n a_{ij}x_j \geq b_i$$

again as (Hof & Pickens 1991)

$$P\left(\sum_{j=1}^n a_{ij}x_j \geq b_i\right) \geq \alpha_i.$$

In this formula the probability of the solution to be feasible is set to α_i , which may be, for instance, 95 %. This problem can be solved with the usual LP method, by taking a new constraint level $\tilde{b}_i$, from the 95 % percentage point of the cumulative distribution of b_i . With this formulation the constraint is increased to be on the safe side despite the uncertainty. This means that if a population size is used as a constraint, it needs to be the larger the more uncertain the future development about the population is (e.g. Haight & Travis 1997).

3.2 Utility function approach

If, instead of the LP method, a utility function approach is used in planning, each interesting variable, including the size of the population or the viability of the population, have to be taken into account in the utility function. If the objectives of the decision maker are interchangeable, so that a good gain in one objective can compensate for an inferior result in another, an additive utility function

can be used. If the population size or the population viability is considered as a part of an additive utility function, there is no guarantee that the viability, for example, is above zero in the optimal treatment schedule.

If the viabilities are taken into account as multiplicative parts of an utility function, as

$$U = \left(\sum_{i=1}^p U_i \right) \prod_{j=p}^q U_j$$

the viabilities are already better guaranteed in the optimal solution. A given threshold can be obtained by forming a separate function R (Kangas & Kangas 1998)(Fig 1).

$$R = \begin{cases} 0, & \text{if the given condition is not fulfilled} \\ 1, & \text{otherwise} \end{cases}$$

When this function R is used as a multiplicative part of an utility function, its effect is similar as the effect of a constraint in the LP problem, rejecting all the treatment schedules not meeting the given requirements. Thus, an effective way to guarantee the population viability in an optimal solution is to form a risk function, which takes value zero if the population viability is below a given threshold, say, 95 %, and value one if the viability is at least the given threshold.

Of course, also in this approach the uncertainty needs to be accounted for. If the threshold for the population viability is not accurate, the threshold is assumed to be between given minimum and maximum val-

ues. When this is the case, using the maximum value of the threshold maintains the plans always in the safe side. If the probabilities of the possible threshold values are assumed to be known, the function R may be formulated to be fuzzy: if there is a 0.5 probability that the true threshold is at most a given value, the value of R function is also 0.5. Thus, optimal solution may be found among the solutions which fulfill the minimum threshold value. If all the values are as probable, the R function between the minimum and maximum value is linear. Otherwise, the distribution of the threshold value may be, for example, a normal distribution (Fig. 1).

3.3 Utilizing expert judgments

In many cases the available empirical information is not detailed enough

to form a simulation model describing the population dynamics or to perform a risk analysis. In that case it is possible to use expert judgment to assess the missing parameters. In spite of utilizing empirical data, expert judgment is always required, for example, for choosing the shapes of fitted models etc. If most of the required parameters are missing, it is possible to apply expert judgment to assess the (possible) threshold values directly. Another possibility is to holistically rank the plans from the population's point of view (e.g. Kangas et al. 1993).

If the information available for planning is based on pure expert judgments, the uncertainty is especially difficult, but especially important, to take into account. The uncertainty in expert judgments can be analyzed from the internal consistency of the expert's opinions or from the differences between a group of experts (Alho et al. 1996, Alho &

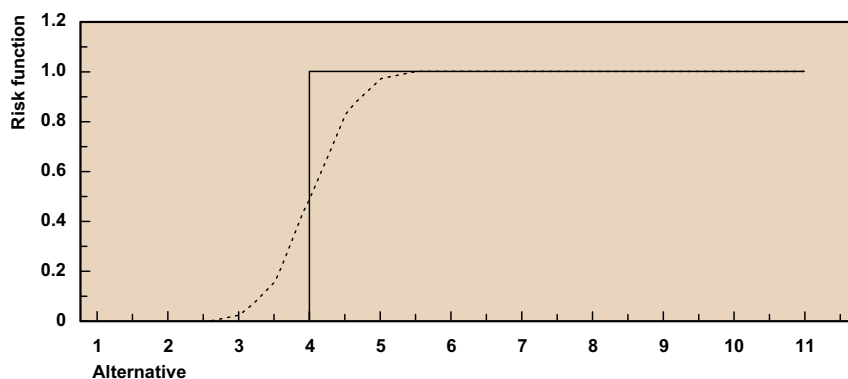


Fig 1. Risk function. The exact risk function is presented with a solid line and the fuzzy risk function with a dotted line.

Kangas 1997). The expert may also be asked to assess, how certain he/she is about his/her judgments (Leskinen & Kangas 1998). These sources of uncertainty do not, however, cover all the uncertainty in the judgments.

4 An example

In the example, the threshold value is not obtained from a risk analysis but on a predictive model which tells the critical value in the proportion of old forest for the capercaillie (*Tetrao urogallus*). It is assumed that the critical proportion is about 25 % in a fine-grained habitat (Rolstad & Wegge 1989). This threshold value is used to form a risk function R (presented above) which is used as a multiplicative partial-utility function.

In the example it is assumed that the utility of the decision maker consists of net income and the viability

of the capercaillie population. Net income is assumed to be the larger the smaller the proportion of old growth forest after the planning period (Fig 2.). In the first case, the capercaillie population is assumed to be viable if the proportion of old growth forest is above the critical value. In the second case the true threshold value is assumed to be between 15–35 %, with 50 % probability that it is larger than 25 % (see also Kangas & Kangas 1998).

In the first case the function R is assumed to be exact. In this case the optimal solution is to maintain the proportion of old growth forests at 25 %. If the value of the true threshold is assumed uncertain, a fuzzy function R is assumed. In this case, the optimal solution is to maintain the proportion of old forests at higher level, to be on the safe side if the true threshold value turns out to be more than 25 %. In the case of the example, the optimal level was 30 % (Fig. 3).

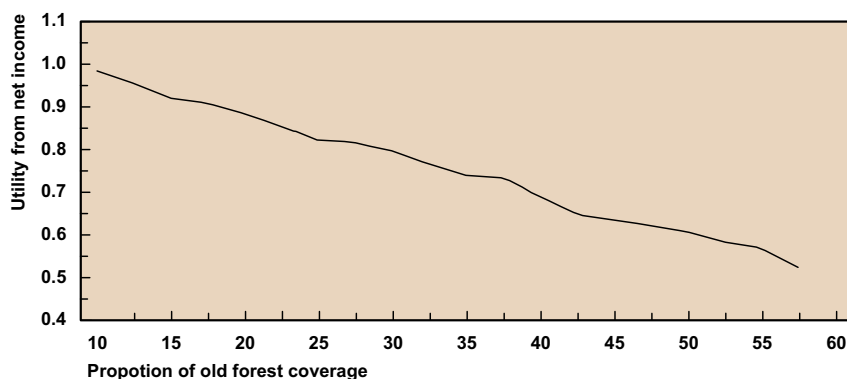


Fig 2. The border of the production possibilities in the example.

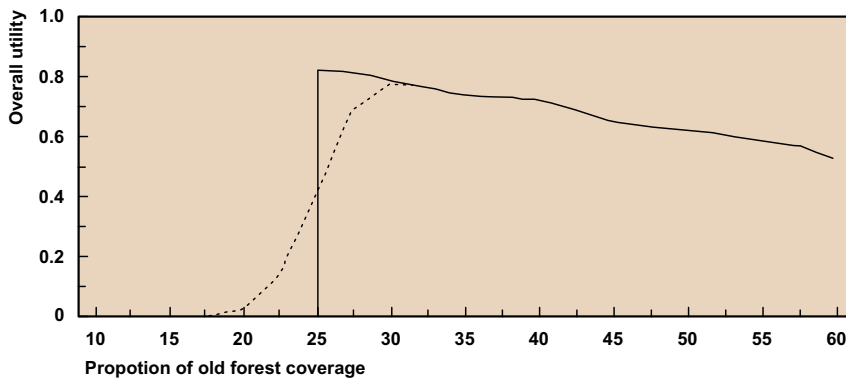


Fig 3. The overall utility with exact risk function (solid line) and fuzzy risk function (dotted line).

5 Discussion

It has often been stated that information about the wildlife populations is too scarce to be effectively used in forest management planning. Information about wildlife populations can, however, be used in forest management planning in several ways, and it need not necessarily be complete. The plans can be compared with respect to the whole ecosystem holistically. Another possibility is to utilize the available knowledge about each species separately. Empirical models or species-wise information are not necessarily required, but the planning may be based on expert knowledge as well.

Models describing population dynamics can be used to optimize the population sizes. If the models are considered too complicated for planning purposes, or if the population size as such is not considered as a relevant decision variable, the information can be utilized in risk analy-

ses. The results of the risk analysis, for example in the form of critical thresholds of certain forest characteristics, can then be used in searching for means to maintain or increase the population viability.

It is also possible to combine expert judgment and empirical information in each of these approaches. In risk analysis, for example, a part of the parameters may be based on experts' opinions. The empirical data available on the occurrence of the species could be used in supporting expert judgments about the critical values of the habitat.

The information about the wildlife populations may also be considered as too uncertain to be useful in planning. Undoubtedly, the uncertainty has to be taken into account in order to obtain useful plans. Uncertainty does not prevent planning: it is not wise to ignore the available information because of uncertainty in it. Plans based on no information at all are, most

likely, not better than plans based on uncertain information, provided that the uncertainty is not ignored.

The uncertainty in the ecological considerations has two main sources: the variability, which is due to the stochastic nature of the system, and ignorance, which is due to the incomplete knowledge about the system (e.g. Ferson & Ginzburg 1996). In risk analysis, the demographic variation and annual variation of birth rate are examples of variability that cannot be reduced. The uncertainty in experts' judgments, on the other hand, is more or less due to ignorance and can be reduced with additional studies. Both of these sources need to be accounted for in planning, but in the most in-depth analysis their effects should be distinguished.

The uncertainty can be taken into account by assessing the probabilities of the possible outcomes and then comparing alternative plans according to this information. When risk and uncertainty is dealt with in a proper way probabilities of a certain plan being better than the others, with respect to the objectives set, can be calculated (Alho & Kangas 1997). And furthermore, also the decision-makers attitude towards risk is possible to consider (Pukkala & Kangas 1996).

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HERO heuristic optimization for forest planning

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Abstract

HERO heuristic optimization method has been developed for purposes of forest planning at area or forest holding level, the area under planning consisting of plenty of forest stands each having several alternative treatment schedules to be chosen among. The idea is to find for each forest stand, or compartment, a treatment schedule that is optimal at the level of the whole area. HERO consists of two main phases: estimation of the utility model to be maximized (i.e. analysing and modelling objectives and preferences), and maximization of the utility model. The variables of the utility model can be selected from parameters that are associated with the whole forest area, such as drain, costs, income, or qualities of the growing stock. Using HERO, also nonlinear functional relationships between forestry parameters and utility can be dealt with. In the estimation of the utility model, techniques of the AHP and multi-attribute utility theory, as well as related methodologies, can be utilized. Applications of HERO include, among others, interactive forest planning, participatory forest planning, and incorporating biological diversity into numerical forest planning. In this presentation, a closer look is taken at the last-mentioned application. Experiences of the applications have been promising. For example, HERO has proved to be a flexible tool in objective setting, and easy to use and understand – also in interactive planning. Due to its area level approach HERO is worth developing further also for purposes of landscape ecological planning.

Keywords: biodiversity, decision support, forest management planning, heuristics, utility maximization

I Principles of HERO

The HERO heuristic optimization method has been specially developed for tactical forest planning mainly at area or forest holding level. The idea is to seek – and to find – such a combination of stand-level treatment regimes for the area or the forest holding as will provide the best end result at the level of the whole area/holding, with respect to the objectives set for forest treatment and utilisation.

Prior to actual optimization, objectives have to be set for forest treatment and utilisation, and each stand has to be provided with a host of alternative treatment regimes for the duration of the planning period (typically 10 to 20 years). The outcomes of the alternative regimes are computed through simulation of forest development.

When applying HERO, selecting the best alternative may be divided into two stages: estimation of the utility model and maximization of this model. HERO uses an additive utility model, the variables of which are management objectives whose coefficients are the objectives' relative importance (weights), scaled to sum equal to one. The weights are estimated applying pairwise comparisons carried out by the decision maker. The relative importance of the objectives can be computed using the eigenvalue method of ratio scale estimation (Saaty 1977). In that, the objectives are compared pairwise using a graphical interface, instead of the verbal scale as proposed by Saaty (1980). The relative importance of two objectives at a time are

defined by adjusting the lengths of the horizontal bars on the computer screen.

The relative worth of the planning alternatives with respect to the objectives are presented in the form of sub-priority functions. The sub-priority function depicts the change in the utility as a function of the objective variable (Fig. 1). The utility model consisting of objective variables and sub-priority functions is a tool enabling different objective parameters to be made commensurable.

The method enables the presentation of objective variables in a hierarchical manner. When this is done, the objective is described using a hierarchically inferior model, whose variables are the components describing the objective in more detail and whose coefficients are the components' relative importance. For instance, the net income from wood production can be divided into net

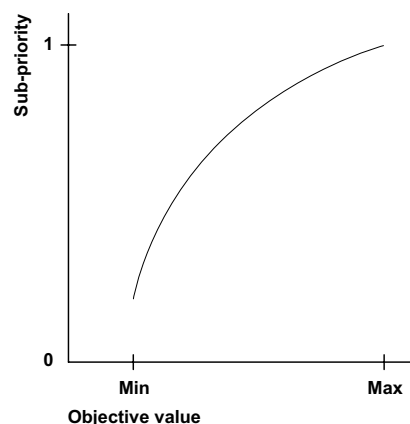


Figure 1. An example of non-linear sub-priority functions describing functional relationship between utility and the value of an objective variable.

incomes of different periods, and biodiversity can be operationalized by means of the components explaining it. This being the case, the sub-priority functions are defined to depict the impact of the components on the utility felt through the objective variables they explain.

When estimating the sub-priority function, first the maximum and minimum values that can be achieved for the objective parameter or component are computed. In addition, a few intermediate values are selected. The desirability of these values is then estimated, e.g., by means of pairwise comparisons and the values are then allocated relative priorities. These priority values define the sub-priority function. A sub-priority function can be non-linear, which is often the case, for example, when describing the relationships between biodiversity and environmental variables (see e.g. Williams & Gaston 1994). The sub-priority functions, with maximum value equalling one, is estimated separately for each component. Estimation can be based equally on expertise or subjective value information. Ratios of values of objectively measurable variables can also be used. Further advantages connected to this manner of estimation are that one operates in real case-wise production possibilities, and ease of operation.

At the “maximization of overall utility” stage, one uses the heuristic direct-search algorithm to search for the best treatment regime for the forest area. In the beginning of the optimization process, one treatment schedule is selected randomly for each compartment. The values and

the sub-priorities of the objectives are computed, as well as the total utility. After that, one compartment at a time is examined to see whether another treatment regime would increase the utility. If this is the case, the current treatment regime is replaced by the one that increases utility. Once all the treatment regimes of all the compartments have been studied in this way, the process is repeated again, starting from the first compartment, until no more schedules increasing the utility are found. In order to ensure that the global optimum is found, the whole maximization stage is repeated several times, and the solution with the greatest utility value is taken as the optimal solution.

When applying HERO, the user has to adhere to objective variables that can be described within the planning system applied. The MONSU software (Pukkala 1998), making use of HERO, currently enables the examination of conventional forestry parameters depicting the growing stock (e.g. volumes by tree species) as well as parameters depicting the amount of decaying timber (standing and fallen), mushroom and berry crops, recreational and landscape values, and certain habitat indices for wild game as well as indices for biological diversity. The range of components is constantly growing as the planning software evolves.

For more details on techniques and qualities of HERO, readers are referred to Pukkala and Kangas (1993). So far, applications of HERO include interactive planning of private non-industrial forestry (Kangas et al. 1996a), public participation in

forest management planning (Kangas et al. 1996b), taking risk and attitude towards risk into account in planning calculations (Pukkala & Kangas 1996), incorporating biodiversity into numerical forest planning (Kangas & Pukkala 1996), taking variation in forest characteristics at both stand and area level into account in calculations (Pukkala et al. 1997), and modelling ecological expertise to be used in optimization (Kangas et al. 1998). Next, one of these applications, namely that of incorporating biodiversity into planning calculations, is briefly presented.

2 An application of HERO: integrating biodiversity with forest management planning

In the case of tactical forest planning with plenty of stand-wise alternatives and, correspondingly, their area/holding level combinations to be chosen among, numerical methods for comparing decision alternatives are required. In the following, the use of HERO as a framework for the integration of biological diversity into calculations of tactical forest planning, and utilizing expert judgments in it, is briefly described. For more details, see Kangas and Pukkala (1996).

The operationalisation of biodiversity for planning calculations can be illustrated by means of a decision hierarchy. Biodiversity is pre-

sented as a decision objective in the hierarchy. The components of biodiversity are added into the hierarchy at the level immediately below the level of the objectives. In the same way as the weights of multiple objectives are determined using HERO, the importance of the chosen components of biodiversity are assessed.

A sub-priority function is estimated as presented above for each component. For example, if the volume of dead and decaying wood (m^3/ha) is taken as a component of biodiversity, a sub-priority function is estimated describing the functional relationship between the amount of dead and decaying wood and the related sub-priority.

If needed, more detailed components can be defined with neither theoretical nor methodological problems arising. In that case, the sub-priority functions are estimated for the more detailed components. In addition, the weights of the more detailed components, with respect to the more general component, should be assessed.

In the above manner, biodiversity can flexibly be operationalized for the calculations of tactical forest planning. The techniques used in the HERO optimization method allow case-wise choice of biodiversity components as well as their weighting and sub-priority functions. The result of operationalisation is a formula for calculating the biodiversity indices for forest plans on a ratio scale. The greater the index, the better the forest plan in regard to biodiversity considerations. The index can be used in planning calcula-

tions as any numerical parameter (Fig. 2). Because of the case-wise calculation procedure involved, biodiversity indices cannot be universally interpreted nor compared.

When operationalizing biodiversity for planning calculations, ecological expertise can be utilized. This being the case, the components of biodiversity are chosen, the weights of the components are assessed, and the sub-priority functions are derived on the basis of expert knowledge; i.e. experts on conservation forest biology make the pairwise comparisons needed in the operationalisation step. HERO serves as a framework where expert knowledge can be modelled and integrated into decision support.

A case study was carried out in eastern Finland covering about 1500 hectares of state-owned forest land and governed by the Finnish Forest and Park Service. Eleven experts were recruited for the planning process. Before making any comparisons, the experts examined the case study area and its potentials in regard to biodiversity management. In addition to the eigenvalue technique, analyses of pairwise comparisons were made also using the variance component modelling approach presented by Alho et al. (1996). The method of Alho et al. enables statistically sound and versatile analyses of the uncertainty involved in the expert predictions. In the case study, a method for combined use of HERO and Delphi techniques was developed, with all the comparisons being repeated three times in order to improve the coherence between the judgements of different experts (Kangas et al. 1998).

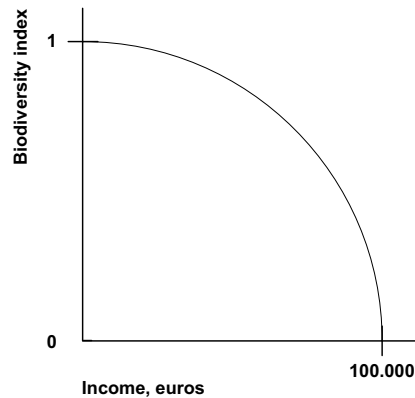


Figure 2. A figure in principle of a production-possibility boundary between a biodiversity index in the end of the planning period and income from cuttings during the planning period, within a forest area under planning.

The mean volume of broadleaved trees, the proportion of old trees, and volume of deadwood were chosen as the components of biodiversity in the case study. These components were regarded to be critical variables with respect to the occurrence of many rare, threatened, and endangered species in the boreal forests of Finland. The final model was constructed after the third Delphi round as a mean model of expert views. The sub-priority functions finally accepted in the case study were all non-linear.

3 Some experiences and conclusions

The initial empirical experiences gained of the applications of HERO in tactical forest management planning have been encouraging (e.g. Kivivuori 1995, Karvinen 1995).

Considering the prevailing planning practice, the experiments made have, however, included a lot of other things in addition to the pure optimization method, e.g. biodiversity assessments. Actually, the conceptual model of multi-objective planning as a whole has been the target of testing. Parties involved – the public, planners, foresters and forest owners – have mainly participated with enthusiasm in the procedural tests. People are putting a lot of trust in the improvement of the quality of planning.

Perhaps the greatest advantage of HERO, from the practical standpoint, is in its flexibility especially regarding setting of objectives and taking case-wise subjective preferences into account in planning. In that, HERO fits with the idea of value focused thinking. This is important both in customer-oriented planning of private forestry and in participatory planning. A further advantage is that, due to the sub-priority estimation procedure, also case-wise expert knowledge is easy to utilize in HERO calculations. Because HERO does not put any demands for the form of sub-priority functions, it can cope with area-level spatial variables having non-linear utility effects more easily than mathematical programming, and other non-linearities.

Some of the methods that are being tested, and the planning system used to apply them, are still prototypes. More development and fine tuning is required before they are ready for application in routine planning work. As we gain more information on the various forest uses, objectives and values, and as plan-

ning systems evolve, the range of variables analytically assessable in conjunction with the formulation of plans will grow. This also means that the ways in which different decision criteria and objectives can be integrated will become more diverse and more specific.

A drawback of any heuristic approach is that the solution may not always be optimal, but only an approximation to it. According to the tests carried out, and experiences gained in applications, this kind of inefficiency does not seem to be a serious problem: most often the global (technical) optimum is found, and the solutions are always close to optimum.

The application of HERO, or any other optimization method, does not produce satisfactory solutions to all possible problems of tactical forest management planning. In addition to calculation executed by computers, the currently available software and the calculations they enable, intuitive input from the decision-makers, and the skills and knowledge of planners and experts are needed. Thus, the planning process as a whole is, in practice, more or less heuristic, no matter what kind of optimization algorithms are used.

Concerning the biodiversity application, the assessment of biodiversity also requires improvement: the approach described above should be seen primarily as a preliminary model and as the starting point for further development, and neither is its application entirely beyond all ecological criticism (see Pukkala et al. 1997). For example, the additive assumption as applied in the utility

model, is perhaps too strong regarding the components of biodiversity. In principle, interactive terms could be added into the utility model. This would, however, make the estimation process much more complicated; too complicated for forestry practice.

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Using AHP and SWOT analyses in assessing priorities of alternative strategies in forest planning

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Abstract

SWOT analysis is a widely applied tool and provides valuable information for strategic decision making. In addition to its common use in enterprise level, it has been applied also in forest planning. A main weakness of SWOT analysis is, that its results are not usually quantitative. SWOT mainly states qualitatively Strengths, Weaknesses, Opportunities and Threats relevant in a specific decision making situation. Therefore, the use of SWOT's results in further strategic planning process can be poor. This paper presents a hybrid method able to improve SWOT's usability in strategic planning: a decision analysis method, the Analytic Hierarchy Process (AHP), and its eigenvalue calculation framework are integrated with the strategic planning process. First, this operation yields analytically determined priorities for the factors included in SWOT analysis and makes them commensurable. Second, alternative strategies can be assessed with regard to factors of internal and external environments. The result is a comprehensive priority for each strategy alternative with respect to the enterprise's operational environment. The applicability of the method is tested in a strategic planning situation of the Finnish Forest and Park Service.

Keywords: decision analysis, forest planning, alternative strategies, strategic planning

I Introduction

Finnish Forest and Park Service (FPS) practices strategic natural resource planning at the regional level. The resulting natural resource plan aims to cover different land use class allocations and multiple objectives of different interest groups and to secure social, ecological and economic sustainability (Heinonen et al. 1997). To implement the planning process, FPS has adopted participatory planning as a planning philosophy. To contribute to the planning process, interactive decision analysis tools have been applied. E.g. Pykäläinen et al. (1998) presented an application, which is based on multi-attribute utility theory and was used to give decision support for constructing a forest strategy which synthesizes national and regional obligations and goals of FPS and objectives of the local interest groups and citizens.

The strategic planning process of FPS includes an analysis of the present state of natural resources, SWOT (the acronym standing for Strengths, Weaknesses, Opportunities and Threats) analysis, definitions of criteria and indicators of sustainability, objective analysis of different interest groups, the production of alternative strategies and the assessment of their overall importances. The selected strategy is further utilized in more accurate tactical (carried out as landscape ecological planning) and operational planning and its implementation is controlled (Heinonen et al. 1997).

SWOT analysis is a commonly used tool for analyzing operational (internal and external) environment

in order to attain a systematic approach and support for strategic planning and decision-making situations (e.g. Kotler 1988, Wheelen & Hunger 1995). Internal and external factors that are the most important to the enterprise's future are referred to as strategic factors and they are summarized within the SWOT analysis. The final goal of strategic planning process, of which SWOT is an early stage, is to develop and adopt a strategy resulting in a good fit between internal and external factors.

If used correctly, SWOT can provide a good basis for successful strategy formulation. Nevertheless, it is rarely used efficiently (McDonald 1993). SWOT analysis lacks the possibility of comprehensively appraising the strategic decision-making situation; it does not include an analytical tool to define the weights of the different factors nor method to compare or assess the overall priorities of alternative strategies subject to SWOT factors. Some examples of weighting and subdividing SWOT lists have been presented (Kotler 1988, Hemmi 1995, Wheelen & Hunger 1995). However, none of these approaches presented a systematic technique for determining the importances. The further utilization of SWOT is, thus, mainly based on the qualitative analysis, capabilities and expertise of the persons participating in the planning process. As planning processes are often complicated by numerous criteria and interdependencies, it may be that the utilization of SWOT is insufficient. In their study, Hill and Westbrook (1997) found that none of the twenty case companies prioritized individual

SWOT factors, one grouped factors further into subcategories, and only three companies used SWOT analysis as an input for a new mission statement. In addition, the expression of individual factors was of a very general nature and brief. Thus, it can be concluded that the result of SWOT analysis is too often only a superficial and imprecise listing or an incomplete qualitative examination of internal and external factors.

In this study, the development of SWOT analysis is connected to a practical strategic forest planning situation. Our object is to look into SWOT analysis in greater detail and more systematically, and by doing so, to increase SWOT’s usability. SWOT analysis, as it was performed as a part of the FPS’s natural resource planning process in Western Finland, is used, and novel decision support is produced from the operational environment’s point of view. Additional value from SWOT analysis is derived by performing pairwise com-

parisons between SWOT factors and by analyzing them by means of the eigenvalue technique as applied in the AHP. In addition, the fit between alternative strategies and SWOT factors and the resulting overall priority of these alternatives is defined.

2 Outline for applying AHP in SWOT analysis

When applying AHP, a hierarchical decision scheme is constructed by decomposing the decision problem into its decision elements. The structure of SWOT offers a quite natural decision hierarchy to be used (Fig. 1). The following definitions help to get a grasp of our application: SWOT groups refer to four entities (i.e. strengths, weaknesses, opportunities and threats) and SWOT factors refer to the individual factors underlying these groups. The method introduced

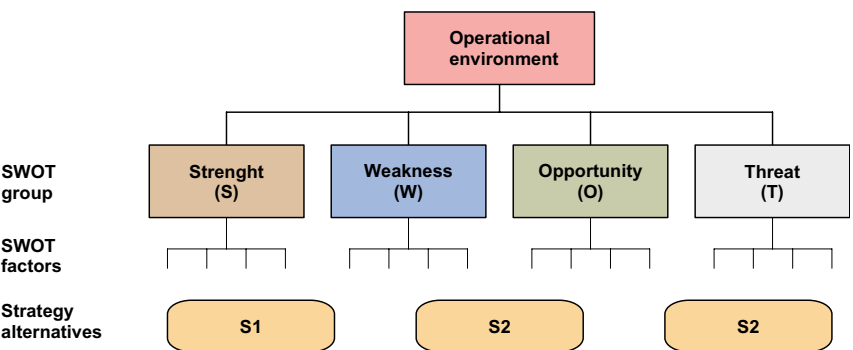


Figure 1. The hierarchical presentation of SWOT analysis.

is an extension of the study of Kurttila et al. (1998) and proceeds as follows:

Step 1. SWOT analysis is carried out. The relevant factors of the external and internal environment are identified and included in SWOT analysis. When standard AHP is applied, it is recommended that the number of factors within a SWOT group should not exceed 10 because the number of pairwise comparisons needed in the analysis increases rapidly (for detailed information on AHP, readers are referred to Saaty (1980)).

Step 2. Pairwise comparisons between SWOT factors are carried out within every SWOT group. When making the comparisons, the questions at stake are, 1) which of the two factors compared is a greater strength (opportunity, weakness or threat) and 2) how much greater. With these comparisons as the input, the relative local priorities of the factors are computed using the eigenvalue method as applied in AHP. These priorities reflect the decision maker's perception of the relative importance of the factors.

Step 3. Pairwise comparisons are made between the four SWOT groups. The factor with the highest local priority is chosen from each group to represent the group. These four factors are then compared and their relative priorities are calculated as in Step 2. These are the scaling factors of the four SWOT groups and they are used to calculate the global priorities of the independent factors within them. This is done by multiplying the factors' local priorities (defined in Step 2) by the value of

the corresponding scaling factor of the SWOT group.

Step 4. Pairwise comparisons are made between alternative strategies subject to all SWOT factors. When making the comparisons, the questions at stake are 1) which one of the two strategy alternatives is better in maximizing or responding to the specific factor (when a factor in question is strength or opportunity), or which one of the two alternatives is better in minimizing or avoiding the SWOT factor (respectively, weakness or threat), and 2) how much better. Now, the overall importances of the strategy alternatives can be computed.

3 A case study – FPS's natural resource planning process in Western Finland

During the FPS's natural resource planning process in Western Finland SWOT analysis was carried out separately by three business units of FPS (forestry, recreation and nature protection) and with respect to three dimensions of sustainability (economic, social and ecological) (Heinonen et al. 1997). For the purposes of this study, SWOT was slightly compressed by combining and removing some SWOT factors. In addition, the dimensions of sustainability were not included in the decision hierarchy as an additional level, although this could have been done.

Four alternative strategies were produced during the planning process. Each of the before mentioned FPS's business units created a strategy, that fulfilled its strategic land use objectives of. The alternatives produced were Forestry Strategy (emphasis on sustainable economic use of forests), Recreation Strategy (emphasis on recreational use of forests and social and economic sustainability), Protection Strategy (emphasis on nature protection and ecological sustainability) and the Basic Strategy (current land allocation and forestry practicing principles). However, all these alternatives were produced in such a way, that they could be considered practically feasible. The main differences between these alternatives were caused by land use allocation principles (e.g. between forestry areas, protected and recreational areas and areas having specific environmental values) and allowed treatments specified for these areas (Heinonen et al. 1997) (Table 1).

These four strategies were taken under closer examination in order to clarify their fit into the operational environment.

Having completed these phases, the priorities of SWOT factors and the fit of the alternative strategies subject to these factors were estimated by pairwise comparisons following the steps presented above. When the weights of the business units were determined, forestry got the weight 0.5, and recreation and nature protection both got the weight 0.25.

In all business units, opportunities, determined by the priorities of the scaling factors, have the highest weight. However, in the nature protection business unit, threats got the same weight as opportunities and also weaknesses are more dominating than in other business units (Fig. 2). The most important internal factors are strengths (know-how, land and water property and planning techniques), but there exist also a few

Table 1. The outcomes of alternative strategies.

	Forestry strategy	Recreation strategy	Protection strategy	Basic strategy
Net income (mill. FIM/year)	109	93	77	101
Commercial forests (1000 ha)	232	216	163	231
Cutting volumes (1000 m ³ /year)	882	814	648	860
Labor input in forestry (working years)	130	108	86	120
Forests age > 60 years (1000 ha)	93	111	112	103
Forests age > 100 years (1000 ha)	25	32	33	30
Recreational index	5.74	6.62	6.39	6.17
Volume of dead wood (1000 m ³)	52	47	56	47
Protected areas (1000 ha)	37	37	58	37
Forests with specific natural values (ha)	6 500	21 400	53 800	6 500

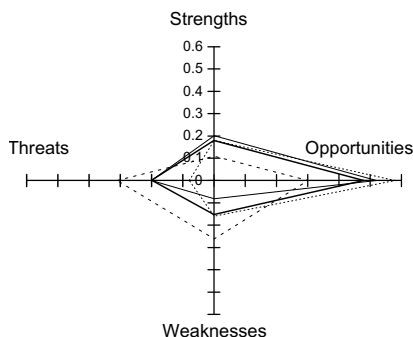


Figure 2. The relationships of SWOT groups by FPS's business units determined by the priorities of the scaling factors.

important weaknesses (lacking information concerning biodiversity due to insufficient planning resources, age and development class structures of forests and negative public image of FPS). Amongst the opportunities, the new planning techniques and new recreational areas are the most emphasized. The most important threat is lack of resources, i.e. the possibility for funding to be cut down (appendix 1). The overall weights of alternative strategies reveal, that recreation strategy obtained the highest

priority, followed by protection strategy. In the business units forestry and recreation, the recreation strategy was the most preferred, but in business unit nature protection, protection strategy achieved the highest global priority (Fig. 3).

4 Discussion

In forest planning, most of the concern has traditionally been placed on the internal environment assuming the external environment to be stable. Recently, applications and methods dealing with changes arising from external environment have been presented and applied in forest planning. These are, for example, connecting the exogenous timber-demand factor and lagged price adjustment to a timber management planning model (Mykkänen 1995), participatory planning (Kangas et al. 1996, Pykäläinen et al. 1998) and including stochasticity with forest planning by using risk and scenario techniques (Pukkala & Kangas 1996). In strategic forest planning, it is sufficient to produce a few dif-

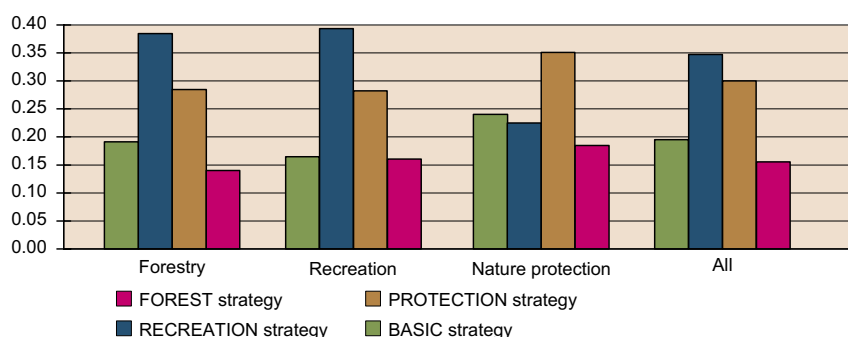


Figure 3. The overall priorities of alternative strategies by FPS's business units.

ferent alternatives that emphasize the main possible courses of action (e.g. Pesonen 1996, Pykäläinen et al. 1998). These alternatives can then be evaluated from different perspectives.

This study presented an application of commonly used strategic planning tool (SWOT) combined with a decision analysis method (AHP). The most important factors being affective in the operational environment were used systematically to give decision support for strategy evaluation. The analysis yielded quantitative values for the SWOT factors and a strategy recommendation, expressed as a quantitative value indicating the overall priority or preference of each strategy option.

The result of our case study should be seen as an illustrative application of the presented method because of the following reasons: (1) SWOT factors were compressed more or less subjectively, (2) all the comparisons were carried out by the same person and (3) our case study was performed after the actual planning process was completed. In practical use, the presented approach should be connected tightly to strategic planning process. The case study, however, proved the usability of the approach and FPS intends to apply a similar method in its future planning processes.

The presented method contributes to the strategic planning and decision making process by quantifying the SWOT factors and by determining the priorities of the alternative strategies. The results from steps 1 to 3 can be utilized when creating strat-

egy alternatives. New goals may be set, strategies defined and implementations planned with respect to the most important factors. The results from step 4 can support decision making in the strategy selection and evaluation process. The suggested strategy alternative can be compared for example to the strategy that has been suggested by participatory planning process. The strategies may emerge not to be the same. However, certain similarities between them may exist and probably new alternatives, having characteristics of both, should be generated.

In practical planning situations SWOT can include numerous factors. The recommendation is that the number of factors within the strengths, weaknesses, opportunities or threats should be limited to ten because of increasing number of pairwise comparisons. However, this probably induces the user to avoid overlapping and carelessness when constructing SWOT lists. On the other hand, the limitation is not so strict, and the problem of having a large number of comparisons can be avoided by at least two different techniques. Firstly, by grouping the factors and adding a new level to the decision hierarchy (Saaty 1980). This was used in this study by performing individual SWOT analysis and comparisons for each FPS's business unit. Secondly, new data recording and analysis techniques offer possibilities to include more factors in decision analysis (e.g. Alho et al. 1996, Alho & Kangas 1997).

One approach to dealing with uncertainties involved in the assessment of future development might be

the application of scenario modeling. In this approach, each possible future scenario would have its own SWOT analysis and AHP comparisons. Appraising the probabilities to scenarios and weighting the SWOT factors and alternative strategies with them could yield a more comprehensive picture of the effects of the various future outcomes. Also Weihrich (1982) proposed a dynamic SWOT analysis, where changes in internal and external factors over time are included by preparing TOWS matrices at different points of time.

According to the experiences got from this study, the results of the combined use of AHP and SWOT analysis were promising. Making pairwise comparisons forces the decision maker to weight the factors properly and to analyze the situation more precisely and in more depth. The hybrid method of AHP and SWOT increases and improves the information basis of strategic planning processes. This new information should be utilized particularly when creating or reshaping strategy alternatives. Expanding the presented method to cover a wider range of decision makers and experts would give access to their ideas and judgments. The Delphi technique could be one means to do this (e.g. Kangas et al. 1997).

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Appendix I. The compressed SWOT analysis of FPS's natural resource planning process in Western Finland and priorities of the SWOT factors and groups.

SWOT groups	Business unit	Local priority	SWOT-factors	Local priorities
Strengths	Forestry	0.200	– benefits from large-scale forestry	0.074
			– organizational efficiency and long customer relations	0.301
			– versatile interest groups	0.169
			– versatile know-how	0.338
			– protected areas and wilderness areas	0.118
	Recreation	0.180	– large land and water property	0.374
			– areas for sportfishing	0.089
			– hiking areas	0.291
			– game (especially forest grouse and moose)	0.245
	Nature protection	0.113	– regional policy importance, e.g. as an employer	0.117
			– landscape ecological planning	0.395
			– participatory planning	0.257
			– many attractive recreation areas	0.078
			– good knowledge from the areas	0.153
Weaknesses	Forestry	0.078	– contradictory objectives and political control	0.208
			– infertile growing sites	0.061
			– age and development class structures of forests	0.177
			– internal cooperation poor	0.102
			– negative image and historical burden (e.g. practised efficient, timber production oriented forestry)	0.452
	Recreation	0.160	– infertile growing sites	0.110
			– age and development class structures of forests (not many old forests)	0.401
			– operations at large areas increase costs, e.g. at waste disposal	0.203
			– recreational areas at outlying districts	0.182
			– not many suitable areas for hunting of waterfowl and field game	0.104
	Nature protection	0.277	– lacking information concerning biodiversity due to insufficient planning resources	0.549
			– fragmented areas	
			– excessive organizational fractionizing (internal cooperation poor)	0.090
				0.131
			– long practised efficient, timber production oriented forestry	0.230

SWOT groups	Business unit	Local priority	SWOT-factors	Local priorities
Opportunities	Forestry	0.522	– new planning methods (natural resource planning, landscape ecological planning, participatory planning)	0.332
			– improvement in profitability and effectiveness	0.061
			– original and multi-objective forestry	0.188
			– broad domestic and international importance	0.136
			– communication and marketing	0.282
	Recreation	0.577	– “multiple use model area”: customers due to diverseness and game	0.302
			– new recreational areas	0.336
			– nature protection areas	0.110
			– concentration of operations	0.174
			– a lot of young forests: good future	0.078
	Nature protection	0.305	– multi-objective forestry	0.103
			– increase in the level of biodiversity	0.141
			– “forest continents” and acquisition of new areas	0.235
			– new planning methods (natural resource planning, landscape ecological planning, Participatory planning)	0.103
			– resources	0.417
Threats	Forestry	0.200	– decrease in the area of usable forests	0.362
			– economic pressures for the utilization of forests	0.103
			– organizational incoherence of FPS	0.232
			– decreasing timber sales incomes (development of price level, decreasing amounts of sold wood, increasing harvesting costs)	0.123
			– homogenization of forest nature	0.180
	Recreation	0.083	– under-estimation of the meaning of commercial forests (their ownership changes from FPS to outsider)	0.320
			– run out of old forests	0.144
			– wear and tear, hullabaloo and unpleasantness have negative influence to users of recreational and protected areas	0.392
			– decline in the amount of forest grouses	0.144
			– decrease in the area of FPS's forests	0.148
	Nature protection	0.305	– lack of resources: staff and funds	0.565
			– economic pressures concerning the utilization of FPS's forests	0.148
			– utilization of non-renewable natural resources	0.065
			– “timber production organization” does not pay attention to the natural values	0.074

Ground-based digital imagery for tree stem analysis

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Abstract

In the USA, a subset of permanent forest sample plots within each geographic region are intensively measured to obtain estimates of tree volume and products. The detailed field measurements required for this type of sampling are both time consuming and error prone. We are attempting to reduce both of these factors with the aid of a commercially-available solid-state matrix camera. This device, along with clinometer angle measurements and distance, can be used to rapidly capture data of an entire tree stem. Subsequent analysis can generate bole heights, diameters, and form measurements. We have found the diameter measurements taken from digital images to be nearly equal to caliper measurements on felled trees. We are developing specifications for both the camera system and data collection protocol. This includes potential sources of error that may adversely affect diameter measurements, which we enumerate in this paper.

Keywords: Digital camera, forest inventory, mensuration, dendrometers

I Introduction

Inventory and monitoring activities have become more important in recent years. Forest resources are being stretched and strained as more resource uses are sought for an increasing population of users. Therefore, knowledge of what resources exist,

where they are located, what their condition is, and how they change over time are critical pieces of management information. To accommodate these management needs, inventory information needs to be more detailed and accurate and must be collected with maximum efficiency to extent fixed budget dollars (Peterson et al. 1994).

In the USA, intensive forest inventory plots are used to collect very detailed information about tree volume and timber products (Cost 1979). While a single diameter and a single height measurement may suffice for most volume estimation, more intensive forest inventories require multiple height and diameter measurements as well as evaluation of sweep, crook, cull estimation, log grading, and crown ratio. Consequently, such plots are only measured at a very low sampling rate relative to regular forest inventory plots. However, field conditions (e.g., climate, insects, terrain) are not conducive to accurate and detailed measurements. Additionally, quality assurance and quality control procedures are difficult to monitor and verify. Accurate measurement systems are needed that can provide this same information quickly and with greater reliability.

Theoretically, the activity of data collection occurs in two stages: (1) data acquisition and (2) mensuration. Traditionally, these two tasks are conducted simultaneously, for example when a diameter tape is placed around a tree. To expedite and improve the data collection process, however, it is important to disengage these activities, with the latter being performed in the office where conditions lend themselves to accurate and repeatable measurement. This methodology has been used for years in photogrammetry and remote sensing, where 2-D images (containing raw data) are acquired remotely and laboratory analyses generate the refined data desired (mensuration). We postulate that the same approach can

used in terrestrial digital imaging to obtain large amounts of highly accurate data quickly.

Most of the literature about forestry applications of terrestrial photography has focused on obtaining upper stem diameters and perhaps tree height (Ashley and Roger 1969, Crosby et al. 1983, Takahashi 1997). Expense is suggested as a drawback to multiple photographs (Grosenbaugh 1963). Recent advances in the field of microelectronics, however, expand the opportunity for terrestrial photography of trees to digital imaging. The invention and development of charged-coupled devices (CCDs) allow the capture of light rays at resolutions almost comparable to film emulsion methods. The output of the CCDs is an image in digital format. The advantages are: (1) expense and time delay for developing and printing is eliminated, (2) storage is much more convenient, (3) image organization can be much easier, and (4) digital image manipulation allows operations that could never be accomplished with standard film technology.

This study compares tree stem diameter measurements obtained using digital imaging to corresponding caliper measurements. Benefits of this approach and potential sources of measurement errors are enumerated and examined.

2 Methods

For this study, images were acquired of the whole face of the stem from four camera stations, each rotated 90 degrees around the stem (Fig. 1).

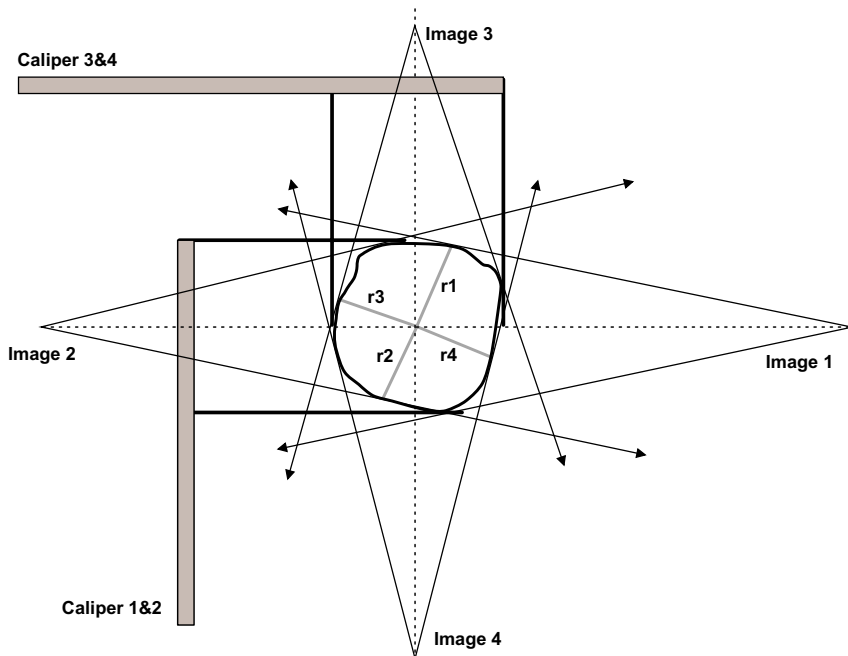


Figure 1. A top-view of data collection for an individual tree stem depicts the relationship between camera images and caliper measurements. At each imaging station, multiple views (images) were captured vertically up the stem to acquire the entire stem.

This provided four measurements of diameter at each height. Typically, two images per side were obtained to acquire the entire length of the stem. Diametrically opposed diameter measurements were later compared to the caliper measurement in the same plane.

2.1 Digital imagery

The camera used was a Kodak¹ DC-120, which is a commercially available, reasonably priced (< 800 US\$), solid-state matrix camera. An 850 x 984 element charge-coupled device (CCD) captures incoming light. Each element is 7.8 x 5.0 microns in di-

mension (Kodak 1997). Filters are used such that each element only detects the intensity of a single wavelength (e.g., red, green, or blue). To convert the information from 836,400 analog measurements to 3,686,400 digital output values (1280 x 960 (pixels) x 3 (colors)) interpolation is necessary, filling in both the spectral and spatial gaps. Details of this procedure are proprietary, which hinders us from being able to determine the actual camera resolution. Virtual pixel size is distance dependent and was determined by measuring objects of known dimension (Clark et al. 1998).

In the office, images were transferred to a computer and converted

to TIFF files. This step “explodes” them to their final output image size and makes them compatible with many software packages. Image Tool, a digital image processing package developed in the Department of Dental Diagnostic Science at the University of Texas Health Science Center, San Antonio, Texas, was used to obtain the image measurements for this study. The images were indexed and their ID numbers and ancillary data (side ID, distance to the base of the tree, and angle of inclination) were recorded in a spreadsheet.

2.2 Data acquisition

Images were acquired and data was collected on four hardwood stems on Middle Mountain in the Monongahela National Forest, West Virginia USA. Species consisted of black cherry (*Prunus serotina*), red maple (*Acer rubrum*), and sugar maple (*Acer saccharum*), though species was not a criterion for selection.

Preceding image acquisition, four faces were marked on the stem using spray paint. This was done in order to ensure proper orientation when true diameter measurements were collected after felling. Diameter measurements were obtained from the felled stem using metal tree calipers and height measurements were determined using a steel tape. For trees with merchantable heights of less than 15.2 m, diameters were measured at breast height (1.4 m) and then every 1.2 m up the stem starting at 2.4 m and continuing until a diameter measurement of less than 10.2 cm was reached, or until the end

of the central stem. For trees taller than 15.2 m, diameter was measured at breast height, every 1.2 m from 2.4 to 6 m, then every 3 m until the central stem ended or reached a diameter of less than 10.2 cm. For each height, two caliper measurements were taken perpendicular to image directions 1 & 2 and 3 & 4 (Fig. 1).

The angle of inclination of the camera was determined by using a Sunnto clinometer placed on the camera body. A digital inclinometer, if built into the camera, would allow the angle to be recorded into the image’s header file. This angle is essential to derive accurate measurements from oblique imagery.

We manually set the focus at one point on the stem in order to reduce the chance that a closer object would interfere with the auto-focus of the camera. In addition, if the tree was more than a few feet away the focus was assumed to be at infinity.

We had heuristically determined that, within limits, the exposure time did not greatly affect diameter measurement results. For this reason, we opted to go with the auto exposure setting on the camera to determine our shutter speeds. By using auto-exposure, we obtained relatively consistent image intensity regardless of ambient lighting (cloudy vs. sunlight) or background light (sky vs. forest). Aperture and shutter speeds are automatically stored by the camera in the images’ header files. The DC-120 also has a picture quality setting, which compresses the images to varying degrees. We selected quality setting 2 out of the possible 4, with 4 being no compression and 1 being the greatest degree of compression.

Reduced resolution in forest conditions of low contrast was the main drawback at the lower picture quality settings.

3 Results and conclusions

In total, 190 diameter measurements were taken from 32 images (4 trees, 4 sides, 2 images/side). These measurements ranged from approximately 10–38 cm at distances ranging from 6–21 m with camera inclination angles from 3 to 63 degrees. The average error of these individual measurements from the caliper measurements was 1.76 mm, ranging from –67.9 mm to 74.4 mm. In a previous report (Clark et al. 1998), an average error of 9.7 mm was re-

ported. This earlier value did not correct for pixel overlap. Because one pixel on each side of the tree is often counted even though the true tree diameter does not extend the full width of each pixel, an extra pixel's width is included in the diameter estimate, on average. By subtracting one pixel width for the average overlap, the average error is reduced substantially.

Fifty-four diameters representing the assumed circular cross-section were calculated and compared between camera and caliper measurements. Diametrically opposed camera diameters were arithmetically averaged. Then, a geometric average was calculated for each pair of caliper measurements and each pair of camera measurements at each height. In some cases, four camera images were unavailable because of obscured visibility. On average, the

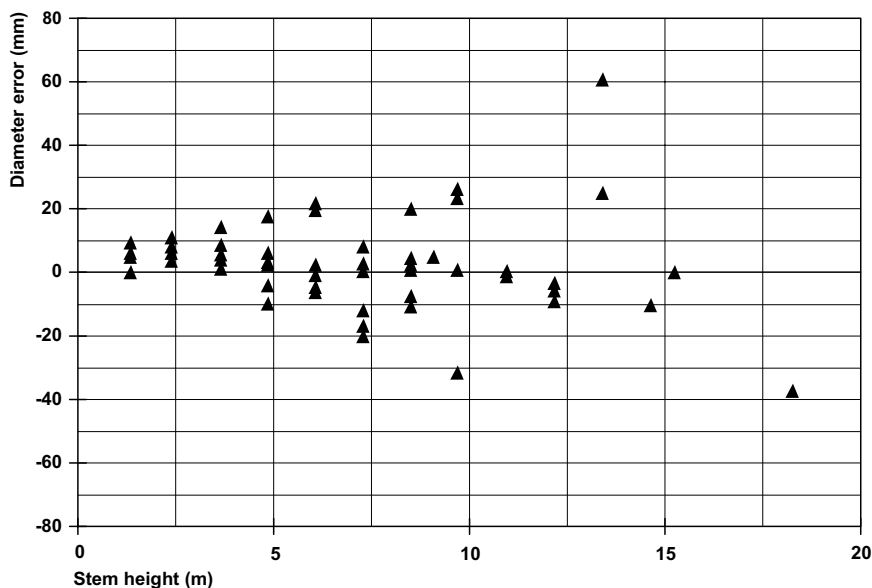


Figure 2. Diameter errors vary by the camera distance to the datum.

camera measurements were 3.4 mm larger than the caliper measurements, with 39 of the 54 measurements within 13 mm of the mean (Fig. 2). As noted above, this bias is much smaller than previously reported due to pixel-overlap correction. Errors increase, however, as stem height increases due to the larger, virtual pixel size that results from greater camera-to-datum distance.

The percent bias, calculated by dividing the difference between the camera and the caliper means by the caliper mean (e.g., Garrett et al. 1997) was only 0.8 percent. The percent inaccuracy, calculated as the square root of the average of the sum of squared percentage differences of the estimated diameters, was 6.9 per-

cent. This result compares well with the percent inaccuracies of other dendrometers reported in Garrett et al. (1997), which range from 5 to 11 percent.

We can plot camera-estimated diameters versus caliper-measured diameters (Fig. 3). From these data, we estimated a regression line to predict caliper-derived tree diameters from camera-estimated diameters. If we assume no bias, i.e. force the regression line through the origin, then we find that the coefficient of the independent variable is very close to unity. In fact, a 95 % confidence interval for this coefficient just includes 1. Therefore, our camera diameters agree very closely with caliper diameters.

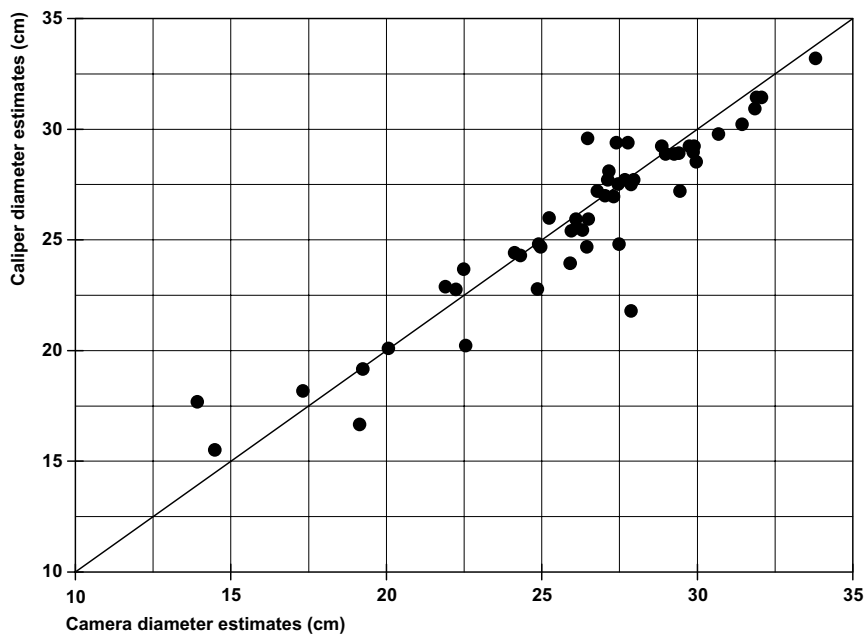


Figure 3. We can treat the diameter measurements calculated with the camera as a way to predict caliper-derived tree diameters. The diagonal line has a slope of 1 beginning at the origin.

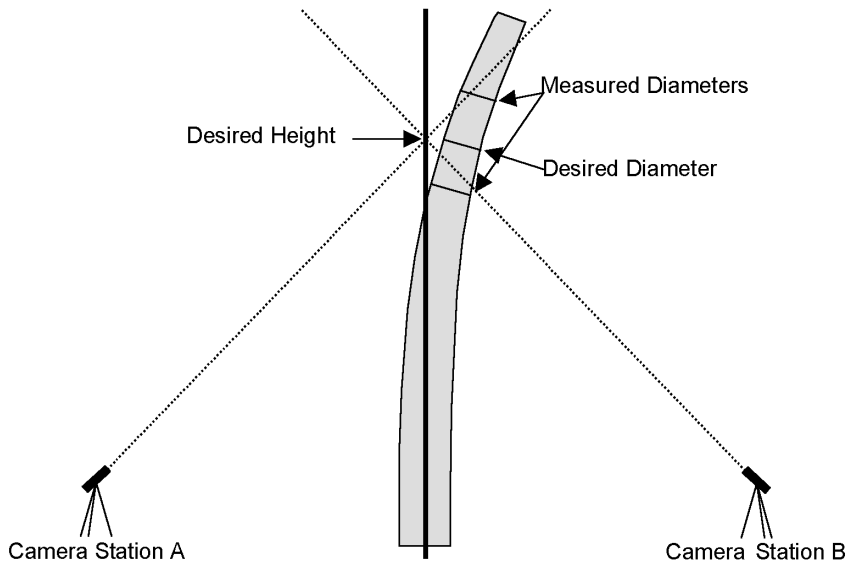


Figure 4. Leaning trees can create significant errors in measurement.

4 Discussion

The above camera measurements do not account for tree lean. As Fig. 4 shows, tree lean can often be quite a significant source of error. It is particularly noticeable in the smaller diameter measurements of Fig. 3. In theory, lean errors partially offset if images are captured in opposite directions using the same datum plane. Tree lean causes one height to be overestimated and the other height to be underestimated. These mis-estimations, however, do not cancel each other exactly. Still, by using a perpendicular photo to locate identical stem heights on opposing photos it should be possible to reduce the error considerably.

Measurement errors from digital images can occur in several other ways. For example, in Fig. 5 an en-

larged portion of a digital image shows how tree edges can be difficult to determine under varying background contrast. When the image



Figure 5. An enlarged portion of an image shows that the tree stem on the left of the image does not have a clear, unambiguous, and straight boundary, which introduces errors into diameter measurements.

background is sky, tree boundaries are clear. When the background includes forest, stem delineation is more subjective. Because each pixel can represent 10–20 mm (depending on camera distance), single pixel errors become significant.

As noted above, virtual pixel size – and consequently, error – increases as one measures diameters farther up the stem. Smaller diameters, which occur higher in the tree, are affected greatest. This results in a much higher percentage error for these measurements. This increased error percentage is offset somewhat by the fact that this portion of the tree has much lower timber product volume and value, so errors are less significant from a volume and value perspective.

Any optical measurement system is going to be hampered by visibility in the forest setting. Along with contrast, light intensity and obscuring objects (e.g. foliage and other stems) contribute to measurement errors. Various image processing operations can adjust for lighting intensity, however, improving object clarity in the image. While not all possible diameter measurements may be available on an image due to obscured stem boundaries, careful examination of an image often leads to discovery of nearby diameters that can be measured instead.

There are a number of important benefits to this type of data collection system. First, accuracy is as good or better than any optical dendrometers available. Second, terrestrial imaging requires much less time to collect hundreds of times more data, i.e., each image contains

a large number of diameter and height measurements. Third, tree images are acquired at one point in time, but measurements can be made many times for multiple purposes. Fourth, quality assurance can be simpler because fewer field operations are required. Fifth, re-measurement from a single image provides for very reliable quality control procedures. Finally, while this report does not address other stem characteristics, such as sweep and crook, it is obvious that camera images can easily capture these grading parameters.

The use of digital imagery and image processing software as a multi-measurement dendrometer offers many advantages over existing optical instruments, while providing accuracy that is equivalent to, or better than, traditional methods.

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Monitoring of boreal forests with active and passive microwave sensors

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Abstract

New inversion methods are presented for active and passive satelliteborne microwave remote sensing. The objectives are biomass estimation, forest and land-cover type recognition in boreal forests. A new indirect inversion method for active sensors was developed for the forest block-wise stem volume estimation from satelliteborne radar images (e.g. JERS-1 and ERS-1 SAR). The inversion results with L-band and/or C-band SAR images showed promising accuracies: the relative retrieval rms error varied from 30 % to 5 % as the size of the forest area varied from 5 to 30000 hectares (the forest stem volume varied from 0 to 300 m³/ha). The textural information of a seasonal set of satelliteborne radar images was studied with the first and second order statistical measures. The multitemporal approach was beneficial for the textural measures in forest and land-cover type recognition. Based on the SAR image texture, the overall classification accuracy for seven land-cover types was 65 % while with the SAR image intensity, the classification accuracy was 50 %, respectively. In the forest type classification based on the SAR image texture and intensity, the overall classification accuracy for four forest types was 66 % while with the intensity alone, the accuracy was 40 %, respectively. With the passive microwave sensor (e.g. satelliteborne SSM/I radiometer), the mixed pixel approach was employed for stem volume (biomass) and forest coverage fraction estimation. The results obtained, show that the pixel-wise fractions of water, non-forested, and forested area can be estimated with a rms errors of around 10 %-units. A new stem volume inversion method for wintertime SSM/I data achieved promising accuracies, the rms error was from 13 to 19 m³/ha per pixel (25 km by 25 km) which was 15 to 16 % of the mean stem volume. In the test area, the stem volume ranged from 40 to 160 m³/ha per pixel.

Keywords: Forest biomass estimation, land-cover and forest type classification, JERS-1 SAR, ERS-1 SAR, SSM/I

I Introduction

The boreal forest belt covers large areas of Europe, Asia and North America forming the largest vegetation zone on Earth. The coniferous trees, such as pines and spruces, are the dominating tree species in this biotype. A large seasonal temperature variation is typical for the area. Therefore, the growing season is halted for winter when ground is frozen and covered by snow. The primary objects of our study are biomass estimation, forest and land type recognition from active and passive satelliteborne microwave images of boreal forests.

Active microwave sensors (e.g. Synthetic Aperture Radar, SAR) have a good spatial resolution, but their radiometric resolution is moderate, because of the coherent measurement method. In contradiction to the active sensors, passive sensor (e.g. radiometer) have a good radiometric accuracy and a wide coverage but the spatial resolution is moderate (tens of kilometres). Therefore, radiometers could be used for global monitoring while SARs provide more detailed local information.

I.1 Characteristics of radars images

The total backscatter of forest is a combination of the backscatter from ground and vegetation. Several studies (Dobson et al. 1991, Ahern et al. 1993, Pulliainen et al. 1996) have shown that the seasonal effects, such as soil freezing and thawing, snow

cover and soil wetness, drastically change the level of the total backscatter in the boreal forest. Thus, the correlation between the biomass and the backscattering coefficient is also dependent on the above mentioned factors. Nevertheless, these seasonal effects may also benefit the inversion if suitable models are used with a multitemporal data set (Pulliainen et al. 1996).

The direct application of the backscattering coefficient for forest biomass inventory is limited by saturation (Dobson et al. 1992, Kasischke et al. 1994, Rignot et al. 1994). The lower SAR frequency bands (P- and L-band) are more suitable for biomass measurements than the higher one (C-band). The P-band would be the most promising for biomass measurements, but it is not available on satelliteborne sensors. The Japanese JERS-1 satellite has a L-band SAR which is the most useful of the satellite radars for forest biomass estimation. The higher frequency (C-band) is more suitable for the recognition of different forest and land types than the lower frequencies.

I.2 Characteristics of radiometer images

The interest towards microwave radiometers is growing because of the introduction of a 90 GHz channel which gives an approved spatial resolution (about 10 km). Moreover, ESA is planning to launch the Multifrequency Imaging Microwave Radiometer (MIMR) which will also have a 90 GHz channel. At the mo-

ment the SSM/I (Special Sensor Microwave Imager) is the only space-borne sensor that can provide space-borne data for the 90 GHz frequency band.

The seasonal snow cover causes relatively large changes on the brightness temperature in the boreal forests. The brightness temperature for forest vegetation is close to its physical temperature while the brightness temperature for dry snow is relatively low at frequencies above 20 GHz. Therefore, in winter the total brightness temperature is related to the forest canopy. Nevertheless, in wet and snow-free conditions this relation is weak because the emissivity of ground and that of forest vegetation are close to each other (Kurvonen et al. 1997).

The main limitation of the space-borne microwave radiometry is its moderate spatial resolution; therefore, only few radiometry studies (Hallikainen et al. 1988, Neale et al. 1990) have been associated with the boreal forests. Moreover, these studies were mainly concentrated on land-type classification.

2 Test site and data

2.1 Test sites and ground truth

Two test sites were selected for the analysis of the SAR images. The test site SAR-1 (Porvoo) was in southern Finland and the test site SAR-2 (Sodankylä) was in northern Finland, see Table 1. The extensive ground truth set included rainfall distribution, temperature, snow, land-use and forest information. The SAR-1 has pine-, spruce- and birch-dominated forest stands, with relatively small age variations due to the industrial use. The test site SAR-1 is a good representative for the Scandinavian forests. The northern test site (SAR-2) is pine-dominated and the stands are more sparse and unevenly aged which is typical at those latitudes. The Finnish Forest Research Institute (FFRI) provided the forest measurements for the test sites.

The spatial resolution of space-borne radiometers is tens of kilometres. Thus, the radiometer test site had to be relatively large to cover

Table 1. SAR test sites.

Test site number	Location	Centre latitude	Centre longitude	Size
SAR 1	Porvoo, southern Finland	60°30'N	25°30'E	100 x 100 km ²
SAR 2	Sodankylä, northern Finland	67°25'N	26°30'E	40 x 40 km ²

several pixels. Therefore, the whole Finland was used as a test site, but it was divided into sub-areas according to snow and temperature conditions. The Finnish National Forest Inventory Data Bank provided the forest information for the whole Finland.

2.2 Spaceborne data

Twenty-two geo-coded ERS-1 PRI-images, 8 for Sodankylä and 14 for Porvoo, were used in the study. Respectively, seven JERS-1 images, five for the Porvoo test site (SAR-1) and two for the Sodankylä test site (SAR-2) were used. The applied radiometer (SSM/I) images covered whole Finland, the images were taken twice a day for 1 July 1993 through 30 June 1994.

3 Methodology and results

3.1 Land and forest type classification with multitemporal SAR texture

Due to resampling and spatial averaging ERS-1 PRI and JERS-1 (level 2.1) images are expected to have a low textural information. Nevertheless, the textural information of the seasonal set of ERS-1 and JERS-1 SAR images was studied with the first and second order statistical measures. For the forest and land type classification, the multitemporal textural measures showed a higher information value than the intensity.

If a single image was used, the textural and/or intensity information was not adequate for a satisfactory classification. However, the textural measures from a multitemporal image set significantly improved the classification of land-use and forest types. Based on the SAR image texture, the overall classification accuracy for 7 land-cover types was 65 % while with the SAR image intensity, the classification accuracy was 50 %, respectively. Table 2 shows the classification for the 7 land-cover types. In the forest type classification based on the SAR image texture and intensity, the overall classification accuracy for 4 forest types was 66 % while with the intensity, the accuracy was 40 %, respectively. Table 3 presents the classification for the forest types. For more details, see Kurvonen et al. (1996) and (1998c).

3.2 Stem volume estimation with SAR

An indirect inversion method was developed to estimate a forest-stand-wise stem volume from JERS-1 and ERS-1 SAR images. The method is based on a semi-empirical backscattering model by Pulliainen (1994). The model presumes, that the backscattering of a forest canopy is determined by (a) stem volume, (b) soil moisture and (c) vegetation moisture. In the inversion process, the area of interest is divided into training (10 %) and test areas (90 %). The stem volume for the training areas has to be known. The inversion algorithm has three steps and it is carried out as follows,

Table 2. Confusion matrix for the land-cover type classification. The rows present the results of the classification in percent and the columns are from the land-use map. The classification is based on the texture and intensity of the ten SAR images.

	Water	Agricul- tural land	Gravel	Clear-cut	Forest	Mire	Open bog
Water	96.7	5.1	0.6	1.9	2.0	1.0	1.0
Agricultural land	0.6	38.7	2.2	1.9	0.7	0.6	0.1
Gravel	0	1.7	67.0	0.4	0.6	0	0.1
Clear-cut	0.5	18.4	6.9	27.2	6.4	4.8	4.2
Forest	1.4	27.3	23.0	47.0	76.0	22.3	12.2
Mire	0	7.0	0.4	15.4	9.5	61.5	19.9
Open bog	0.7	1.8	0	6.3	4.8	9.7	62.5
Number of pixels	6 443	2 901	1 632	17 430	141 416	16 895	38 216

Table 3. Confusion matrix for the forest type classification. The rows present the results of the classification in percent and the columns are from the land-use map. The classification is based on the texture and intensity of the ten SAR images.

	Coniferous	Deciduous	Mixed forest	Mire
Coniferous	74.1	42.4	36.8	23.1
Deciduous	12.1	41.0	12.3	10.5
Mixed forest	6.6	9.4	44.3	4.8
Mire	7.2	7.3	6.6	61.6
Number of pixels	111 390	27 111	2 915	17 072

- 1) For the training areas, the soil and vegetation moisture is estimated from the backscattering coefficient and the stem volume with the model. The soil and vegetation moisture parameters are interpolated to cover the whole area of interest.
- 2) For the whole area of interest, the stem volume is estimated with the model from the backscattering coefficient and the moisture parameters.
- 3) If several SAR-images are used, the stem volume estimates are combined with the multiple lin-

ear regression. The regression equation is defined from the stem volume estimation and ground truth of the training areas.

The results for the stem volume estimation using L-band and/or C-band SAR data showed promising accuracies: the relative rms error varied from 25 % to 6 % as the size of the forest area varied from 10 to 30000 hectares (the forest block wise stem volume varied from 0 to 300 m³/ha), see Figures 1 to 4. For more details, see Kurvonen et al. (1996) and (1998b), Pulliainen et al. (1997).

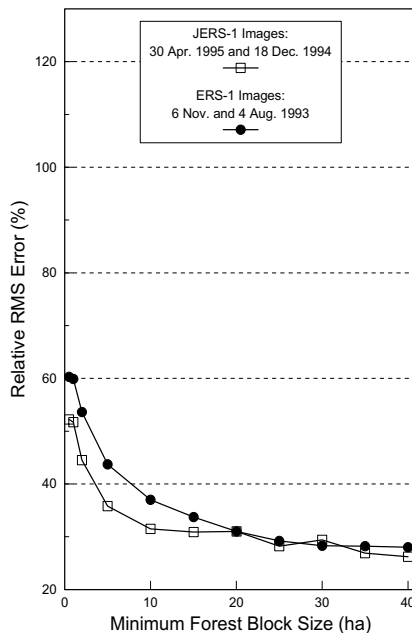


Figure 1. Relative rms error of the stem volume estimations vs. minimum forest block size.

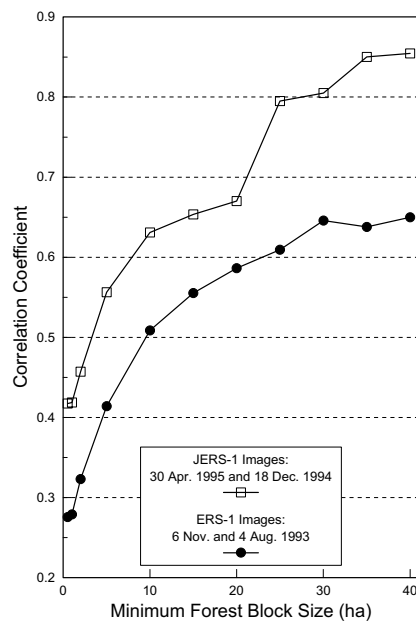


Figure 2. Correlation between the estimated stem volume and the ground truth vs. minimum forest block size.

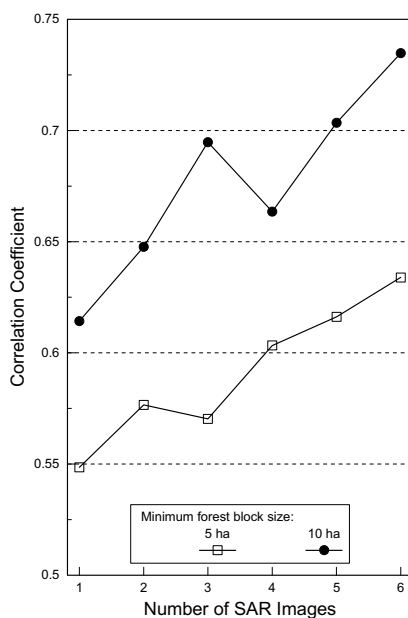


Figure 3. Correlation between the estimated stem volume and the ground vs. the number of employed SAR images. Correlation coefficients are presented for forest blocks larger than 5 ha or 10 ha.

1 SAR image: JERS-1 for 15 March 1995,
2 SAR images: JERS-1 for 15 March 1995 and 23 May 1993,

3 SAR images: JERS-1 for 15 March 1995 and 23 May 1993, and ERS-1 for 6

4 SAR images: November 1993, JERS-1 for 15 March 1995, 18 December 1994 and 23 May 1993, and ERS-1 for 6 November 1993,

5 SAR images: JERS-1 for 15 March 1995, 18 December 1994 and 23 May 1993, and ERS-1 for 4 August 1993 and 6

6 SAR images: JERS-1 for 15 March 1995, 18 December 1994 and 23 May 1993, and ERS-1 for 4 August 1993, 2 October 1993 and 6 November 1993.

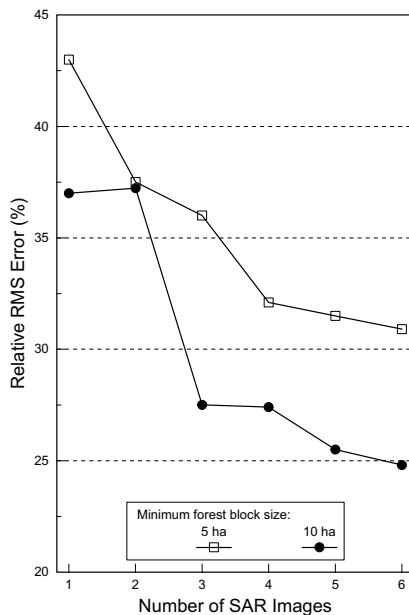


Figure 4. Relative rms error of the stem volume estimations vs. the number of employed SAR images. The rms errors are presented for forest blocks larger than 5 ha or 10 ha.

1 SAR image: JERS-1 for 15 March 1995,
2 SAR images: JERS-1 for 15 March 1995 and 23 May 1993,

3 SAR images: JERS-1 for 15 March 1995 and 23 May 1993, and ERS-1 for 6

4 SAR images: November 1993, JERS-1 for 15 March 1995, 18 December 1994 and 23 May 1993, and ERS-1 for 6 November 1993,

5 SAR images: JERS-1 for 15 March 1995, 18 December 1994 and 23 May 1993, and ERS-1 for 4 August 1993 and 6 November 1993,

6 SAR images: JERS-1 for 15 March 1995, 18 December 1994 and 23 May 1993, and ERS-1 for 4 August 1993, 2 October 1993 and 6 November 1993.

3.3 Monitoring of boreal forests with spaceborne microwave radiometer

Due to the moderate resolution, the mixed pixel approach is used in the analysis of the radiometer data. The three possible mixed pixel approaches are: a) in each pixel spatial fractions of different areas types are known and their emissivities are calculated, b) in each pixel emissivities or brightness temperatures of the different area types are known (or modelled) and their spatial fractions are calculated c) the combination of a) and b).

First, the spectral emissivity behaviour for forest, non-forest and water areas was studied with the

mixed pixel approach. In winter the effect of dry snow was obvious and the emissivity of forest separated well from that of non-forest. In summer the emissivity variation was determined by water areas, while in winter the dominating factors were forest canopy and snow covered ground, respectively.

Even during snow-free conditions, rough estimates for forest coverage could be retrieved with the mixed pixel approach. Nevertheless, the most accurate forest coverage estimates were retrieved during winter conditions. With the combination of summer and winter measurements, the coverage of water, non-forest and forest inside a pixel can be estimated with an rms errors around 10 %-units. See Figures 5 and 6.

An indirect inversion method was developed to estimate the pixel wise stem volume from the winter-time SSM/I data. The method is based on the fact, that in winter forest canopy and snow cover are the dominating factors of the emissivity. Nevertheless, the snow cover emissivity is dynamic; therefore, long term averages are used in the inversion. Additionally, the averaging diminishes the atmospheric disturbances and uncertainties with the physical temperature measurements. The area of interest is divided into a training set (20 %) and test set (80 %). The pixels around the weather stations, referred as training areas, were used as a training set while the rest of the data was used for testing the algorithm. The air temperature, the forest and non-forest

coverage and the stem volume are known for the training areas. The inversion algorithm has five steps and it is carried out as follows,

- 1) The emissivity estimates of the two target types (forest and non-forest) are calculated with the mixed pixel approach from the training set. In the test case, the training set consists of the 15 weather stations and their surroundings. The calculated estimates represent the mean emissivities of the target types. In order to unfold the local variation in the emissivities, local emissivity estimates are also calculated by solving the mixed pixel equations separately for the surroundings of each weather station.

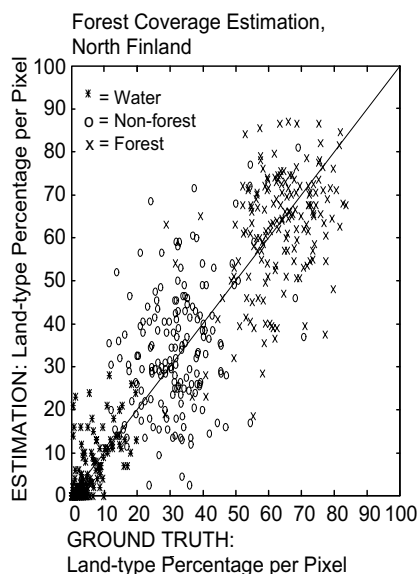


Figure 5. Pixel-wise land cover type estimation vs. ground truth. The estimation is based on SSM/I data for North Finland, July through September 1993 and January through February 1994.

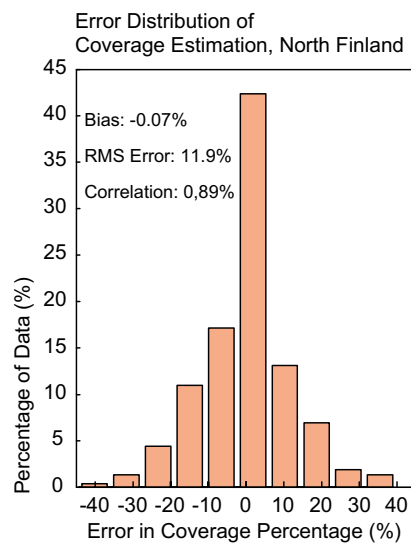


Figure 6. Error distribution of the land cover type estimation presented in Figure 5.

- These local estimates are interpolated to cover the whole test area.
- 2) The spatial fractions of the target types (forest and non-forest) are calculated for each pixel with the mixed pixel approach by employing the measured SSM/I emissivities and the mean target emissivity estimates.
 - 3) The emissivity of forest is calculated from the measured SSM/I emissivity in each pixel by employing the local non-forest emissivity estimate and spatial fractions of the target area types (results from the first and second step).
 - 4) For the training set pixels, a multiple linear regression is calculated between the forest emissivity estimate and ground truth stem volume.
 - 5) For the area of interest, the stem volume estimates are calculated from the estimated forest emissivity with the linear regression equation.

The inversion results for stem volume estimation with SSM/I data show promising accuracies: the rms error was from 13 to 19 m³/ha per pixel (25 km by 25 km) which was 15 to 16 % of the mean stem volume. In the test area, the stem volume ranged from 40 to 160 m³/ha per pixel. These results confirm the assumption that spaceborne radiometer data could be used for large scale biomass estimation in the boreal zone, see also Figures 7 and 8. For more details, see Kurvonen et al. (1997) and (1998a).

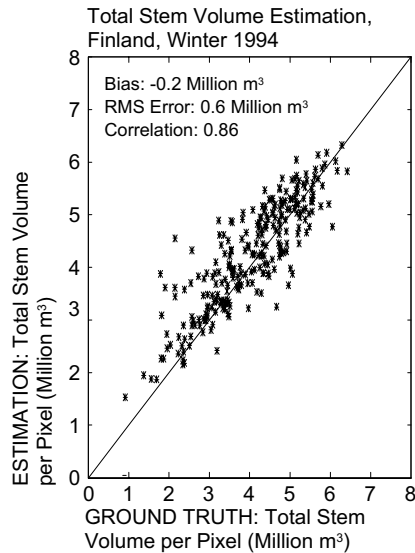


Figure 7. Pixel-wise total stem volume estimation vs. ground truth. The pixel-wise stem volume density estimation is based on the inversion of the SSM/I data covering Finland, January through February 1994. The pixel-wise forest coverage is based on the ground truth.

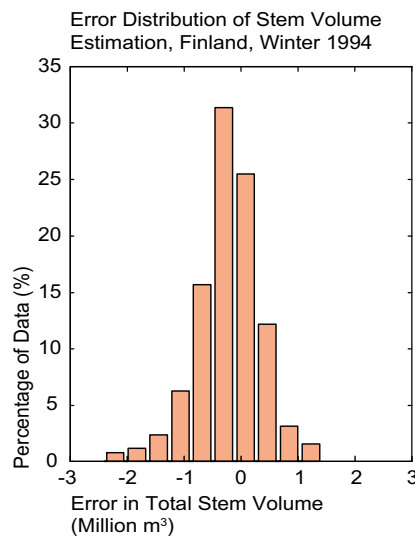


Figure 8. Error distribution of the stem volume estimation presented in Figure 7.

4 Conclusions

Due to resampling and averaging, textural information in ERS-1 and JERS-1 SAR images is expected to be low. Nevertheless, based on the results of this study the textural measures had a higher information value than that provided by the intensity values for the land-cover and forest type classification. The multitemporal approach was beneficial for the textural measures and they significantly improved the classification of land-cover and forest types.

The new stem volume inversion method for radar images removed successfully the seasonal effects from a single SAR image and the stem volume inversion was accurate for the large-scale stem volume estimation. In the single image case, the estimation of small forest blocks is corrupted by speckle. However, the inversion results were improved significantly for small scale estimation when several estimations (based on different SAR images) were combined.

Rough forest coverage estimates can be retrieved from satelliteborne radiometer data with the mixed pixel approach. Moreover, the new stem volume inversion method for radiometer data achieved promising accuracies. Therefore, the results propose that satelliteborne microwave radiometry data has potential for large-scale biomass estimation in the boreal forest zone.

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GPR investigations of glaciers and sea ice in the Scandinavian Arctic

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Abstract

Recent GPR studies of ice have been carried out on glaciers in Svalbard, Norway and Sweden, and also on saline ice in the Baltic Sea, Greenland Sea, and Arctic Ocean. We have used Malå Geoscience and GSSI radar systems with antenna centre frequencies of between 50 and 500 MHz. Long time windows are necessary for receiving echoes from glaciers several hundreds of metres in depth. The 50 MHz Malå antennas clearly detected a bedrock return from glaciers where the ice was close to 0 °C up to depths of about 300 m. The data from these soundings on polythermal glaciers has been unexpectedly informative of the internal structure of glaciers, mapping features such as the boundary between water saturated ice at 0 °C, and colder ice containing no water bodies. The sub-glacial drainage systems of glaciers have been investigated and the potential exists for mapping large internal hydrological features. On the moderately saline ice of the Baltic Sea in the Gulf of Bothnia, helicopter and ground based surveys have been used in conjunction with other geophysical techniques to investigate ice dynamics and forces over a period of 2 weeks. The radar seems to penetrate easily the 1–2 m thick ice normally present in the Baltic, but is much less useful over ice ridges where ice floes collide. In the Arctic Ocean where water salinity is much higher, but the ice is thicker and older and sometimes quite well drained of brine, we have had mixed success.

Keywords: Glacier, Sea Ice, Arctic, Baltic Sea

I Introduction

In contrast to most materials, cold ice is relatively transparent to radar waves, and in glaciology ‘deep’ penetrating radars have been used since the 1950s to map the bedrock beneath glaciers and ice sheets – to depths as great as several kilometres (e.g. Bogorodsky et al. 1985). These radars were specially designed for glaciology and often required skilled use and expert maintenance. However a new generation of reliable factory-made ground penetrating radars (GPR) have been used for glaciology work. These radar’s do not have the capability to penetrate very deep. They have also been used to study internal features of glacial flow (Murray et al. 1997). In this connection, interest in the radar properties of the uppermost firn and ice layers is restricted to determining their radar velocity, which affects the depth calculation.

However, there are other reasons to be interested in the near-surface layers. Shallow or ground-penetrating radar (GPR) has been used to determine accumulation rates by finding datable reflecting horizons in Antarctic firn (Forster et al. 1991), and on temperate glaciers (Holmlund and Richardson 1995, Kohler et al. 1997). In addition, the dielectric properties of near-surface snow, firn and ice are important for interpreting SAR satellite images (Rott et al. 1993), particularly with the emergence of SAR techniques as an important glaciological tool for monitoring ice sheet elevations and flow patterns.

The penetration of radar waves in sea ice is extremely limited because of the absorption of the radar signal by the salty water present in sea ice. However in the low salinity sea ice of the Baltic Sea we expected that we may have more success, or at least be able to observe any snow ice formed on top of the sea ice. This would compliment other techniques of determining sea ice thickness such as low frequency EM sounding or manual drilling.

2 Case studies

1.1 Polythermal Glaciers on Svalbard

Spitsbergen glaciers are traditionally classified as the sub-polar or polythermal type in respect to their thermal structure (Schytt 1969, Baranowski 1977). They have a thick layer of cold ice (with temperatures below the pressure melting point) in their superimposed ice accumulation and ablation zones, underlain by temperate ice at the pressure melting point. In the firn accumulation zone the whole thickness of the ice is temperate with only the winter cold wave lowering the temperature of the near surface firn below freezing. The large difference in dielectric properties of ice and water make radar sounding a useful tool in discriminating ice containing water and ice that is dry – i.e. cold ice. Although the radar reflection in the ice may not correspond precisely with the pressure melting point in the glacier, due to the relative size of the water bodies and radar wavelength (e.g. Ødegård et al.

1997), or to the possibility of water bodies existing in cold ice. The general scheme of sub-polar glacier structure has been confirmed by airborne radar sounding (RES) by Soviet (Macheret and Zhuravlev 1982) and British-Norwegian groups (Dowdeswell et al. 1984). The majority of glaciers in Svalbard were overflowed by one or other of the groups. Ground based radar soundings have provided a more detailed and complex picture of the thermal structure of some of these glaciers, (e.g. Holmlund and Eriksson 1989, Hagen and Saetrang 1991, Bjornsson et al. 1996, Ødegård et al. 1997), in some cases cold ice dominates and only the glacier sole is at the pressure melting point.

1.2 Hansbreen

Approximately 100 km of radar data were collected on Hansbreen in co-operation with the Polish Polar Base in Hornsund in May 1997. A typical section of 50 MHz RAMAC GPR data from Hansbreen is shown in Figure 1. Data were collected as 2048 samples in a time window of 5.303 ms, stacked twice on collection at a resolution of 1 scan per meter controlled by a sledge wheel. The radar was pulled 4 m behind a snowmobile, with data collected on a Husky PC. The internal RAMAC batteries were supplemented by an external lead acid accumulator giving enough power for full days of measurement. No problems were noted even in air

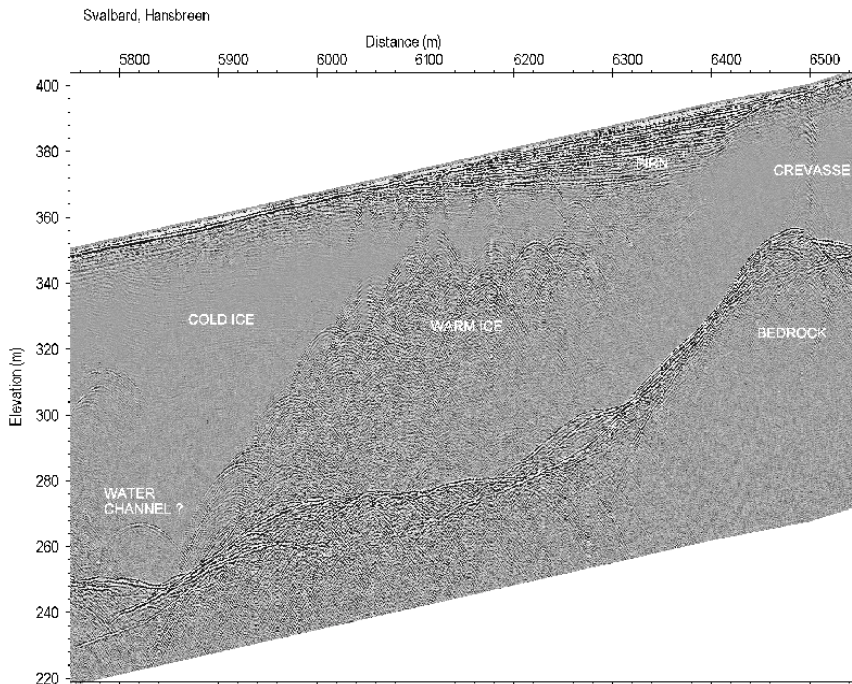


Figure 1. Elevation corrected topography of part of Hansbreen with RAMAC 50 MHz antennas.

temperatures as low as -30°C . The character of reflections is typical of firn between about 6000–6500 m, warm ice associated with much scattering and cold ice with down dipping foliations between 5750 m to the intersection with the warm ice at 6050 m can be seen. A large hyperbolic reflection at 5800 m at 85 m depth is probably a water channel or pocket. A series of sharp hyperbolic reflections near the surface at 6500 m is probably caused by crevasses associated with the bedrock high and change in surface slope.

2.3 Brøggerbreen melt-water tunnel

Brøggerbreen is a small polythermal glacier in northern Svalbard. In the ablation zone near to the front of the glacier there is a large surface moulin about 5 m in diameter that is one of the main drainage features of the glacier. In May 1997 we profiled the glacier around the tunnel and mapped the moulin as it turned from the vertical and crossed the glacier to the close to the side margin. A series of reflections can be seen that corre-

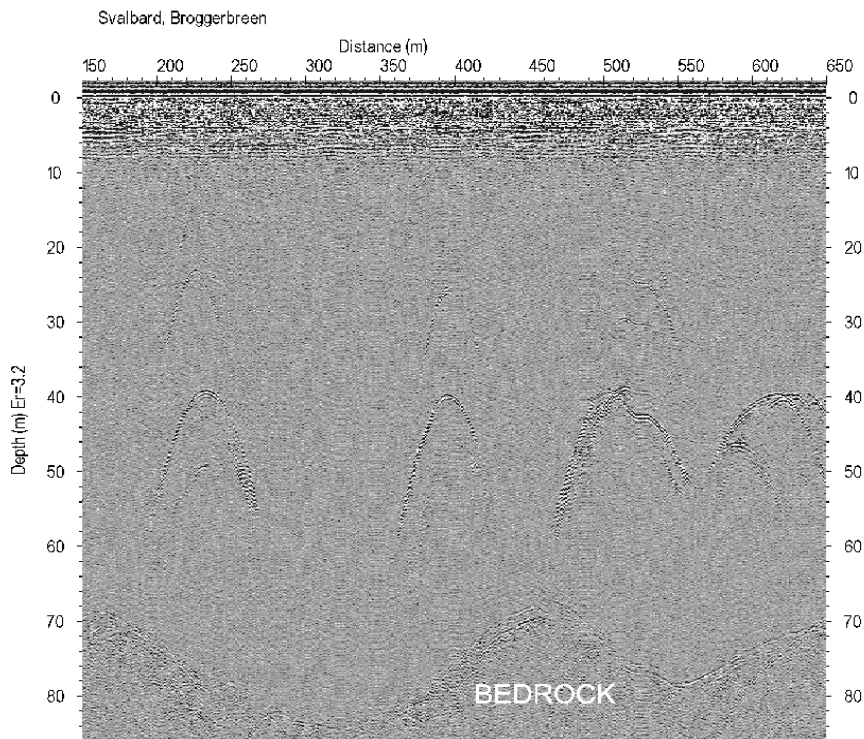


Figure 2. The melt water feature on Brøggerbreen, the path of the radar was a spiral and shows the same feature at increasing distances from the surface moulin measured with RAMAC 200 MHz antennas.

spond to the tunnel as we drove in a complex roughly spiral route from near to the surface moulin to further away. Positions were independently measured by differential GPS and will be processed to reveal the three dimensional path of the melt channel. data were collected using RAMAC 200 MHz antennas collecting 1024 samples in a 848 ns time window collecting 5 traces s^{-1} . It is clear that large meltwater hydrological systems of glacier can be mapped with the GPR.

2.4 Snow depth on Storglacierien

Storglacierien is a small polythermal glacier in northern Sweden. It has been extensively investigated for the

past 50 years, and is regularly studied and measured for mass balance records. We investigated the usefulness of the RAMAC GPR in profiling the near surface snow at 400 MHz to determine if the radar could be used for winter snow thickness measurements in April 1996 (Figure 3). We used a time window of 250 ns with 512 samples and a trace taken every 0.1 m. There is clear evidence of laying visible and it is possible to assign summer surfaces to particular years when comparing the radar data to traditional mass balance techniques such as manual probing to feel the icy summer surface, or by drilling cores and digging pits. Similar work on Hardangerjokullen (Kohler et al. 1997) also showed the potential of radar to determine snow thick-

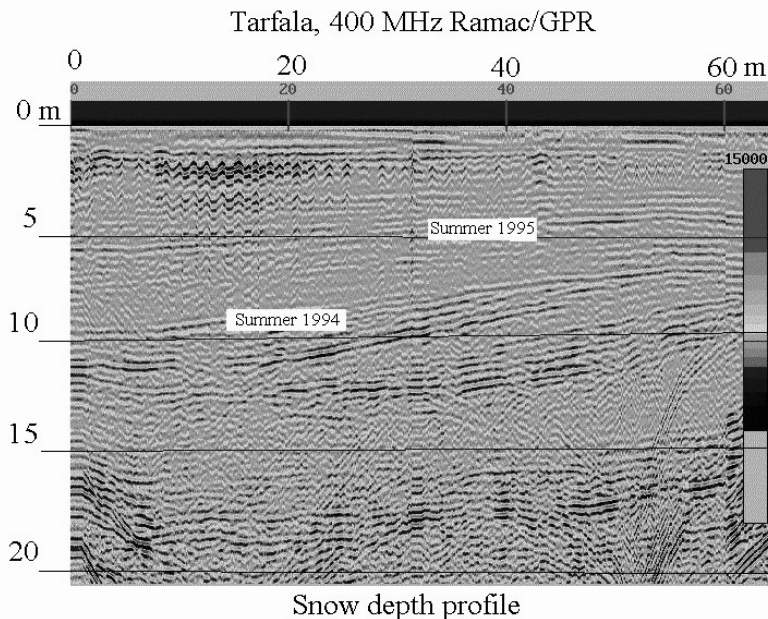


Figure 3. Snow thickness estimates found by identifying summer ice surfaces with the RAMAC 400 MHz antennas using a wave velocity of $220 \text{ m } \mu s^{-1}$.

ness, but it is extremely important to have adequate radar velocity data from profiles of snow density to constrain radar travel times to depths with good accuracy. This constraint means that radar surveys for snow thickness measurements can provide a complimentary method to be used in addition to more traditional techniques, it cannot replace it on its own. The modelling of radar reflections from the upper 10 m of Kongsvegen glacier in Svalbard has been attempted (Moore et al., in press), using dielectric data obtained from ice cores along radar profiles. Modelling does not show very good fits to radar data, which can be most easily interpreted by real variations in ice properties over the metre scale distances sampled by the wide angle GPR radar beams when compared with the 10 cm scale variations seen from a single ice core drilled in the beam area.

2.5 Baltic Sea Ice

The Bay of Bothnia is located at 63–66°N, 20–26°E. Its surface area is 37,000 km² and the mean depths vary between 43 m and 147 m. The water has a very low salinity, in general in the central basin the surface water salinity is 3.5 ppt. Sea ice occurs annually in the bay of Bothnia for 5–7 months and every winter the bay becomes totally ice covered. Maximum ice thickness in the coastal fast ice zone is 50–120 cm. In February 1997, as part of the EU funded ICESTATE project a large field program ZIP97 was carried out in the northern Bay of Bothnia (Haapala and Leppäranta 1997). Radar sound-

ing was done on the ice using all terrain vehicles pulling a sledge, and also from a helicopter. The objective was to study the potential of the GPR systems to determine sea ice thickness from an airborne platform with two different radar systems: the RAMAC GPR with 200 MHz antennas and the GSSI SIR8 with 200 and 500 MHz antennas.

The large experiment allowed comparisons of radar derived thickness measurements to be compared with ground based drillings along an 8 km calibration line from the shore to the edge of the fast ice zone. The calibration line was measured three times with different antenna configurations. On the basis of the data from the calibration line, it was decided that the 500 MHz antennas gave the best data to use on the drift ice. Helicopter flights were made over a set of drifting buoys in the drift ice with the SIR 8 500 MHz antennas, and partially with the other antenna systems. Flight altitudes varied from 6 to 8 m and speed was 13–30 ms⁻¹ depending on wind direction. The GSSI 200 MHz data were taken at 512 samples in a 400 ns time window at 25.6 scans s⁻¹, the 500 MHz data were taken over a 160 ns time window at 51.2 scans s⁻¹.

Clutter from constant reflections from the helicopter was established for each profile by flying to 100 m altitude at which height no reflections from the ground were collected, allowing subtraction of the constant background.

In general the flat ice gave clear continuous reflections (Figure 4), but where ice floes had drifted to form ridges up to 10 m in height composed

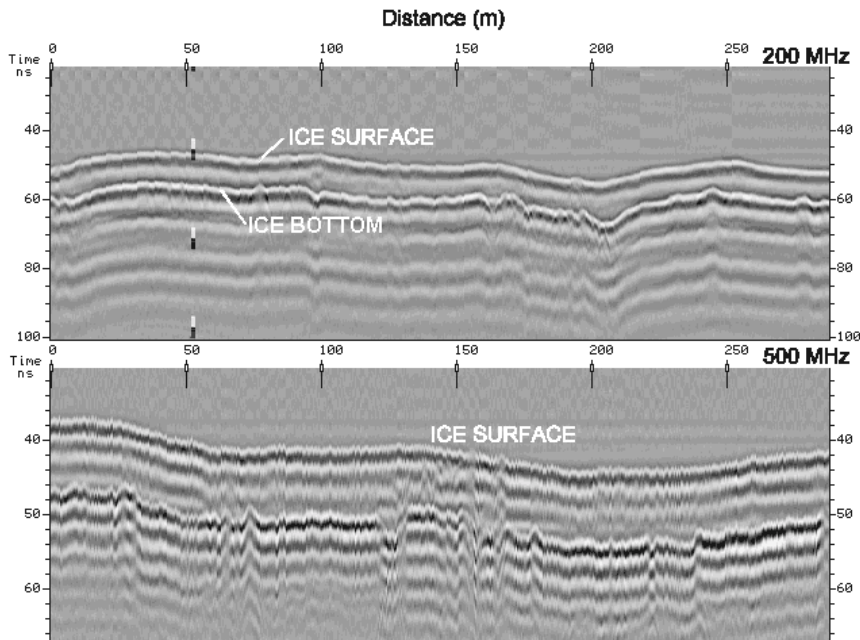


Figure 4. Helicopter-borne radar profiles over fast ice in the Baltic Sea, Gulf of Bothnia with GSSI SIR 8 200 MHz and 500 MHz antennas. The ice thickness is about 60–70 cm assuming a velocity of $160 \text{ m } \mu\text{s}^{-1}$.

of a mass of loosely bonded ice blocks, the scattering from the blocks caused no real penetration of the ridges. One significant problem for interpretation is that in some places layers of ice are folded over each other leaving some cm of water between them. The water causes much attenuation of the radar signal and much scattering from the stacked ice floe surfaces also occurs, so it is possible that sometimes internal reflections from within the ice pack are interpreted as being the floe bottom. However in general comparison with the calibrations from drilling suggest that the radar gives rather good quality thickness data for relatively undisturbed parts of the Baltic sea ice cover.

3 Conclusion

Modern GPR radars provide excellent detail in resolution because of their monopulse nature. The low conductivity and low water content of cold glaciers allows penetration depths sufficient to reach bedrock for many glaciers with 50 MHz antennas. The digital acquisition of data also allows much processing and removal of clutter so allowing subtle features such as the sea ice bottom reflection to be extracted from the larger signals coming from the helicopter carrying the radar. GPR is especially suited to the polythermal or cold high polar glaciers where penetration is considerably better than

in temperate wet glaciers as we have found from radar surveys of Gornerglacier in the Swiss Alps. The contrast in dielectric impedance between warm wet ice and cold ice causes reflections that are very easy to see and provides extremely valuable data in glaciological studies of the hydrology and structural evolution of glaciers.

Acknowledgements

We thank the Thule Institute for financial support for the radar and for AP salary, the CEC MAST III contract MAS3-CT95-0006 supported the sea ice work, Finnish Academy grant 51854 and the TMR Programme of the CEC through the Ny Ålesund LSF supported the Svalbard work.

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Logic model in a problem of designing of distributed information systems

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Abstract

The paper examines a problem of construction of logic model of information networks (IN). The model is aimed at creating non-homogeneous enterprise-wide networks easily and effectively.

Two approach to building such models are examined. Shorts of these approaches are noted and compromise adaptive technique of synthesis of IN is proposed. Necessity of adequate model for this technique is concluded and a new logic model of IN is proposed.

The logic model comprises compositional model and model of structure. Compositional model is defined as decomposition of Information System object. Substantiation of such decomposition has been proposed. According to decomposition five basic object classes are defined.

Model of structure defines four layers of interoperations among IN stations and three basic types of object's relationships.

Two stages technique of model analysis is proposed. The first stage is reflexing user's layer of abstraction and based on analysis of system's goal. Decomposition of the global system's goal is perfomed and finished by reaching of layer of some elementary goals that can be achieved by using ordinary services.

On the second stage IN is examined at system layer of abstraction. A possibility of data communication among servers and clients is analyzed. This analysis is founded on basic relationships among objects.

The offered model, having small dimension and sufficient completeness, can form the basis for development of practically applicable techniques of building of heterogeneous information networks.

I Introduction

It is an obvious fact that today modern information technologies are widely used in various fields of human activity. One of the benefit in applying of IT is a possibility to cooperate data, experts's knowlege and efforts (Kotomin & Putilov 1994). This causes growing actuality of the problem of designing distributed information systems (DIS) aimed to make this cooperation easy and effective.

The report (Structural-algorithmic... 1995) presented the techniques of synthesis the DIS, based on hierarchical model of system. The basic idea of the considered techniques consists of synthesis "from below – upwards", that is elementary components of the system are realized, then they are combined into a complete unit. The idea is quite simple. However, when constructing the systems connected to computer facilities, realization of the formal apparatus is always bounded up with restrictions of opportunities of particular software and hardware means (computers, communication facilities, software). There is a contradiction that is caused by the condition that the developed theoretical methods are inapplicable to real objects.

There are two obvious ways to settle this contradiction. The first is to develop formal models with primary binding to particular facilities. The second is to create new soft- and hardware that are appropriate to developed formal model.

Both approaches, however, have serious drawbacks. Development of a formal model is time consuming.

And when the formal model of the chosen facilities are developed these facilities can become outdated. The second approach is inefficient because of large financial expenses and produces potentially unique hard/software.

2 Adaptive synthesis

A method of adaptive synthesis, stated in the report (1995), can be used as a compromise approach. The idea of the method consists of subsequent application of the two named approaches under condition of their priorities. First, there is made an attempt to determine facilities that are appropriate to the considered objects of formal model taking into account the imposed restrictions. If the given operation fails either designing of new facilities that are appropriate to the model is done or the formal model is corrected. The algorithm of the method is shown in Figure 1.

As mentioned above, the priority in the considered approach to design DIS is given up to use typical (marketed) facilities. One of the most important steps in the considered algorithm is to make a choice of facilities that correspond to the model's objects. To make this choice it is necessary to have the formal model of the system's structure that reflects basic functional blocks and modules of marketed information tools and the networking hard/software. Such a model has to define the main classes of objects and relations among them and has to be simple, low-dimension and flexible to cor-

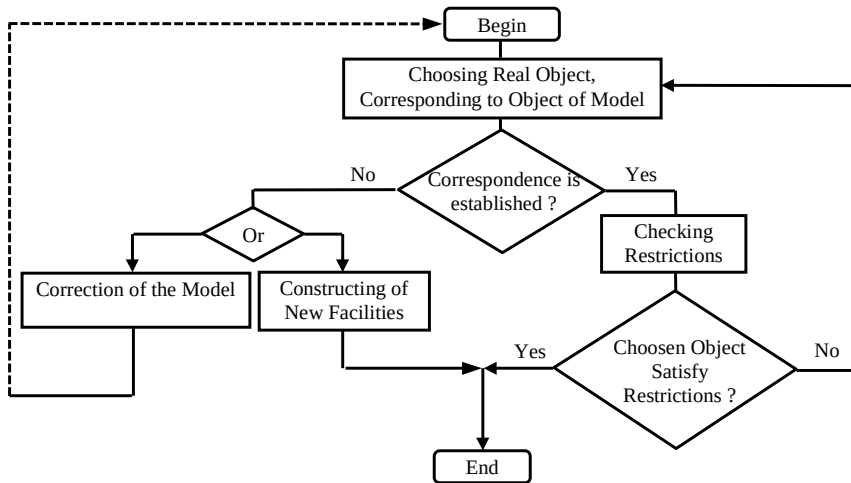


Fig.1. Algorithm of the adaptive synthesis.

respond to as many real objects as possible.

Architecture of information systems is traditionally analyzed using an OSI model defining seven classes of objects and interactions among them. But in case of the problem of choice of marketed facilities this model is not so useful. For example, we can't find any realization of a presentation level protocol and even a transport level protocol that are marketed as standalone facilities. So we have to define a new, more common, model that reflects "reality of the IS market".

3 Results

The following model of DIS based on the comparison of different marketed information tools and networking hard/software and engineering practice is proposed.

The model of the system's structure is based on the decomposition of the global object, namely Distributed Information System that is shown in Figure 2.

The first step of the decomposition is dividing the system into the two subsystems. These are Transport subsystem (TS) and Information processing/presenting subsystem (IPS). The reason of this division is that the principles and techniques of realisation and the aims of the objects of lower four(five) and of the rest of the levels of the OSI model are quite different.

Other steps of the decomposition are made according to the following reasons:

1. By defining the main utilized information resources we can divide all objects of IPS into two classes: Services that realise these resources and make them available for using and Clients that

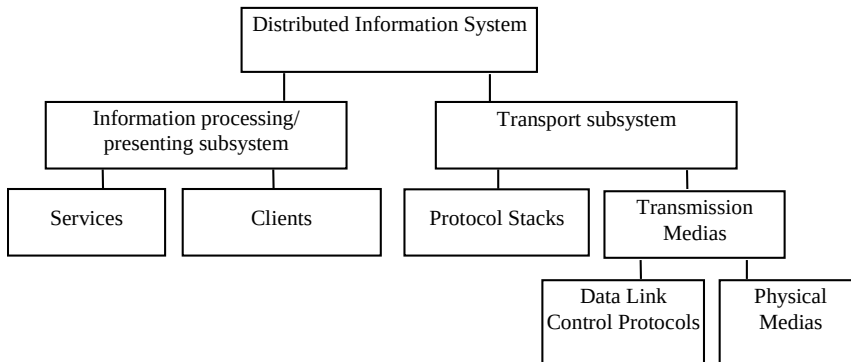


Fig. 2. Decomposition of the system's structure.

utilize these resources generating corresponding resource requests. Subsequent decomposition is not useful because marketed realisations of the considered objects appears as integral facilities and usually we can't choose different separate parts of such servers and clients. For example, if we decide to use NetWare™ file service we can't choose any presentation layer protocol other than NCP (NetWare Core Protocol).

2. The minimal set of components that is necessary to make the information transmission possible is an exchange rules set (Data transmission protocol) and Transmission media. We shall notice, that the same Data transmission protocol can function on different Transmission medias. Subsequent decomposition is unuseful due to the reasons mentioned above - Data transmission protocols appear as integral protocol stacks. For example, TCP protocol realises most of transport layer functions and is hard binded

to the appropriate network layer protocol -IP. The only thing that can be changed there is some auxiliary protocols such as routing protocols. It is proposed to take into account possibilities of using different auxiliary protocols by stating them as object's attributes.

3. Transmission media is formed by Data Link Control protocols and Physical media. Besides we can, for example, make Ethernet to run on a coaxial or twisted pair cable.

Considered decomposition gives a model of system's structure that defines five classes of objects. There is some kind of puzzles and the next task is to connect items in the right order. Now the designer has to choose appropriate real objects of these classes and to combine them into the whole system. To perform this task we have to define relations among the objects.

The following Figure 3 illustrates the four level model of relations among the system's objects.

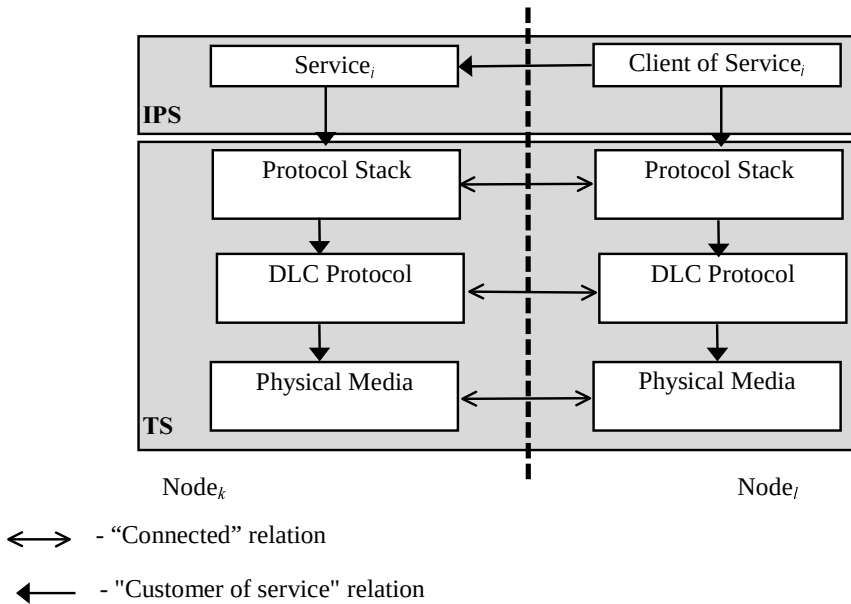


Fig. 3. Model of object's relations.

This model defines three types of binary relations among the objects. They are:

- 1) Symmetric transitive “Connected” relation;
- 2) Antisymmetric “Customer of service” relation (or revers to it “Service provider” relation);
- 3) Relation of equivalence.

“Customer of service” relation defines the role which the given object plays in information exchange.

The relation of equivalence binds the objects with identical functionality. For example, different realisations of the same protocol stack.

The “Connected” relation is necessary for data communications between a pair of objects. This relation can bind the objects as placed in the same network node, as in physically different nodes.

Here comes the definition of three basic situations when a pair of objects is connected.

- Within the given network node a pair of objects is connected if one of them is a customer of service provided by the other.
- Within the given network node a pair of objects is connected if the objects are of the same class and retranslation of data among them is performed.
- The objects are placed on different nodes, both of them are of a DLC (Data Link Control) class and both are connected to the same transmission media.

Other situations when objects are connected are determined by three listed bases. To define such situations

let us introduce the following notions.

O_{ij} - object of i class, where j is an unique identifier of the object within the given class;

$\Leftrightarrow$ - relation of equivalence;

$\leftrightarrow$ - "Connected" relation.

Following Boolean functions define this relations on objects plurality

$$Fe(O_{ik}, O_{il}) = \begin{cases} 1, & \text{if } O_{ik} \Leftrightarrow O_{il}; \\ 0, & \text{else;} \end{cases}$$

$$Fc(O_{ik}, O_{jl}) = \begin{cases} 1, & \text{if } O_{ik} \leftrightarrow O_{jl}; \\ 0, & \text{else;} \end{cases}$$

Using the introduced notions we can write Boolean function determining the "Connected" relation among the objects of i class numbered k, l as follows

$$Fc'(O_{ik}, O_{il}) = Fe(O_{ik}, O_{il}) \wedge$$

$$Fc(O_{ik}, O_{i-1m}) \wedge Fc(O_{il}, O_{i-1n}) \wedge$$

$$Fc(O_{i-1m}, O_{i-1n}), i \geq 2.$$

4 Conclusions

In conclusion a few words about the initial stages in constructing DIS models. To reduce dimension of the model and at the same time to save its completeness it is proposed to use functional-goal approach (Ignatiev et al. 1986). This approach is based on decomposition of the system's global goal. The decomposition is fin-

ished when the layer of some elementary goals (tasks) is reached. In our case these tasks must be performed by appropriate information network services. Thus, the obtained model will potentially correspond to the goals of the designed system.

The offered model of DIS, having small dimension and sufficient completeness, can form the basis for development of practically applicable techniques of synthesis for distributed information systems.

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Swedish EnviroNet (<http://smn.environ.se/>)

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Abstract

The Swedish EnviroNet is the main gateway to electronic data and information about the Swedish environment. The EnviroNet co-ordinate major public agencies, NGO's (non-governmental organisations) and private companies in the environmental field. The information is published at the web sites of the members and the EnviroNet server provides links, metadata and other general services.

The most important user group for the EnviroNet is professionals working with environmental issues in Sweden. But the EnviroNet also fulfil the needs of wider user groups, such as: environmental activists, students and teachers, politicians and the media.

The EnviroNet provides the following services, in Swedish and English:

- An Environmental catalogue with links to documents provided by the members
- A Search function to search the database containing the metadata and full text of all the members' EnviroNet-linked documents
- Electronic conferences
- E-mail directory

The EnviroNet provides links to electronic documents (usually in HTML-format). The contents of the documents are described using a subset of the Dublin Core metadata standard. The EnviroNet provides a classification scheme for the Subject and Type elements in Dublin Core.

Members select documents to be linked to the EnviroNet, and provide these with metadata according to the standards specified by the EnviroNet. A robot regularly searches the sites of each member for EnviroNet documents and collects the metadata and the full text of these documents. This information is stored in a database, which is used in the Search function and is also the basis for building a new link-catalogue upon each new collection of documents.

I Background

The decision to build the Swedish EnviroNet was taken by the Swedish government in December 1996. The building of the EnviroNet was one of several proposals in an Official Report on "Information Technology in Environmental Management" from the Environmental Council. The Report concluded that general search engines and catalogues did not give environmental professionals adequate tools for information retrieval from the Internet. It was felt necessary to co-ordinate the publication of environmental information on the Internet that different Swedish organisations had begun.

The Director General of the Swedish Environmental Protection Agency decided the constitution of the Project Board and Project Organisation in February 1997.

2 Mission

The Swedish EnviroNet shall become the main World Wide Web gateway to electronic data and information on the Swedish environment. The EnviroNet shall provide easy access to information with high quality content.

3 Members

The EnviroNet co-ordinates the Internet publishing of public agencies, NGO's and private companies in the environmental field. These are the so-called members of the EnviroNet. Information is published at the web sites of the members and the EnviroNet server provides links, metadata and other general services.

Only member web sites are included in the environmental catalogue and only member documents are accessible through the EnviroNets search function.

4 Users

The most important user group for the EnviroNet is professionals working with environmental issues in Sweden. But the EnviroNet will fulfil the needs of wider user groups, such as: environmental activists, students and teachers, politicians and the press.

5 Services

- An Environmental catalogue with links to documents provided by the members
- A Search function to search the database containing the metadata and full text of all the members' EnviroNet-linked documents
- Electronic conferences
- E-mail directory

6 Catalogues and metadata

The EnviroNet provides links to electronic documents (usually in HTML-format). The document can contain information or point to other sources that contain environmental information or data, e.g. databases. The contents of the documents are described using a subset of the Dublin Core metadata standard. The Type element is used to describe the resources referred to, i.e. thesis, review, database, advertisement etc. The EnviroNet provides a classification scheme for

the Subject and Type elements in Dublin Core. The classification scheme for the Subject element provides a controlled vocabulary (term lists) for each of the catalogue entrances. Users can search information using several subject entrances organised in the following way:

- Environmental threats
- Sectors
- Nature types
- Chemical substances
- Biological species
- Geographical areas
- General
- Environmental data

Most of the term lists used are internationally or nationally accepted standards. The 14 environmental threats that are used have been used extensively in Sweden. term list for Sectors is based on the classification of economic activities in the European Community, NACE rev 1. The Nature types correspond to the EU CORINE Land Cover classification. Geographical areas correspond to the administrative divisions of Sweden (counties and municipalities), the larger sea basins and the larger lakes. The Environmental data entrance follows the program areas of the Swedish national environmental monitoring.

As the Environmental catalogue grows the Search function will be more used. The Search function offers simple full text searches as well as sophisticated searches where the metadata

Can be fully used to limit the number of unwanted hits. Members can provide documents without metadata, except for a tag that makes

it available for free text searches. These documents will only be available through the Search function.

7 Technical solutions

Members include metadata in their documents according to the standards specified by the EnviroNet. The normal procedure is to include it in the head section of the HTML-document. Some members may want to keep their metadata in a separate database for easier maintenance. The EnviroNet has developed an application that members can use to create and edit metadata. The application (in Swedish) is available at the EnviroNet's web site. The classification scheme for the Type and Subject elements provide the basis for automatic translation of the terms used in classification, so that even though all classification is originally in Swedish, it is possible to search all documents in English also.

Once a week a robot (Harvest) searches the sites of each member for documents that the member has selected to be linked to the EnviroNet. The metadata and also the full text of these documents are collected and stored in a database (BRS/Search). After each such collection the contents of the link-catalogue is updated automatically. The Search function can search the database using the full Dublin Core metadata information and the full text of the documents.

The electronic conferences use a commercial program called Webboard. This program has been translated into Swedish and customised to suit the EnviroNet. It is

accessed through a web browser. The use of News-based programs was not considered as several users might have firewalls that are closed for News traffic.

The Email directory uses the same database engine as the Environmental catalogue and users of the EnviroNet are encouraged to register. There is also a complementary directory service based on a book called "Who is who in Swedish Environmental work?" This directory covers all environmental organisations in Sweden.

8 Results

The Swedish EnviroNet was officially opened on December 11th 1997. In the late spring of 1998 there are more than 50 member organisations linking some 1500 documents. More than 400 persons have registered in the electronic conference system. About 100 000 hits per month are registered. Most of the important governmental agencies are members as well as the major NGO:s. There is an increasing interest from local and regional organisations. The number of private companies is still rather small, but also increasing.

The EnviroNet is now focusing on the quality of the catalogue and search function. The members are the content providers and classify their own documents. More than 70 persons have had a short course on how to classify information for the EnviroNet. The EnviroNet is built in an extremely decentralised way. This will allow the EnviroNet to grow rapidly with a small staff but there is a

considerable risks that a uniform standard in the classification of the information can not be maintained when the EnviroNet grows. The project has therefore closely reviewed how the members have initially classified their information. It is believed that this is a sound investment in the early phase of the work.

9 Future developments

The instruction for the Swedish Environmental Protection Agency (SEPA) was changed on May 1st to include the EnviroNet as a part of the Agencies ordinary activity. A separate board will decide on the development of the EnviroNet and a staff of 3-4 persons located at SEPA will maintain and develop the EnviroNet. It will be funded by the ordinary budget and currently all services are provided free of charge.

The plans for 1998 include fitting a Z39.50 interface to the existing database based on the profiles currently developed through the GELOS initiative and the EEA. This will make it possible for users to query the EnviroNet together with several other environmental databases throughout the world. Z39.50 is an ISO standard for data exchange between databases that have been used between libraries for several years. The databases share a common set of fields, the profile. The user does not have to know where the data is stored or the names of the tables and fields in the different databases. All the databases can be queried with the same client, normally a web page.

SWEIONET

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Abstract

The birth of EIONET (European Environmental Information and Observation Network) coincided with the Swedish entry to the EU. These events triggered the SWEIONET project 1996 at the Swedish National Focal Point to the EEA (European Environment Agency) (residing at the Swedish Environmental Protection Agency). The aim was to develop an easy accessible and informative information package. The medium should be the Internet in connection and co-operation with EEA. Budget constraints were tight and developing time nine months. Five different sections of the web site were developed and launched in December 1996:

- Organisation. Policies and Sectors
- Threats to the Environment
- Nature in Sweden
- Ongoing activities
- EIONET resources in Sweden

The aim of the SWEIONET is to overbridge the gap between the different networks - on one side the existing national Swedish environmental monitoring, assessment and policy developing network - and on the other side the EIONET. The EIONET and the SWEIONET web servers should be complementary to each other. Together they could be valuable information resources for broad user groups including decision-makers and the general public.

At present the DPSIR-model (DPSIR, Environmental State of the Environment Indicator methodology: Driving Forces, Pressure, State, Impact, Response) is evolving, and in the "Threats to the Environment's" section of the SWEIONET, charts or indicators of the state of environment are presented. The aim with the presentations in the "Nature Categories" section is to show the great variety and beauty of Swedish nature. This gives the opportunity to illustrate that Sweden as a very long country shows a span in between alpine mountain regions in the north, over coniferous forests to mid European lowlands in the south.

The indicators show parts of the results of the monitoring network. It has been possible to benefit of the data gathered at remote institutes and to present the results using hyperlinking technique. Further rapid development of this feature is to be expected. Most of the obstacles to overcome are no longer of technical but of organisational character.

I SWEIONET <http://www.environ.se/sweionet/>, background

I.1 EEA, EIONET and NFP

Sweden joined the European Environment Agency (EEA) in 1995 shortly before joining the EU itself. As a member of the EEA Sweden has actively taken part in building up the backbone network of the EEA - the EIONET. The EIONET can be characterised as showing a twin image:

- an institutional and personal network
- a telematic network

The National Focal Points (NFP) in each member state of the EEA are important components of the EIONET. They are appointed by governments and responsible for the organising of national contributions to the EEA (and vice versa) by submitting data and information. In that way the Swedish Environmental Protection Agency (SEPA) has been appointed as the Swedish NFP.

Around 1997 the EEA started the building up of the telematic EIONET. One of its aims was to make information easy available and to present information to experts, decision-makers and policy makers on the environment in order to assist, so that

at the end of the day, better decisions have been made. One specific action in that direction was the introduction of the EEA web site in Copenhagen on the Internet.

I.2 Swedish EIONET activities

The main Swedish nodes of EIONET are situated within the Environmental Protection Agency itself, although many experts and external institutions and other agencies are connected to the institutional network as Main Component Elements (MCE).

I.2.1 Environmental monitoring

Most of the expert functions and managing of the environmental monitoring are administrated by SEPA. The execution of the programmes, however, is taking place at contractors. Some of them are also contracted to be "data hosts" for monitoring data.

I.2.2 Data on emissions and discharge to air, water and soil

Data on these issues are collected and processed by the Environmental Protection Agency often in co-operation with other agencies like Statistics Sweden. In one case an EIONET development is used for data processing, the CORINAIR software.

1.2.3 Dissemination of environmental data

Sweden has not yet published a state of the environment report, but has for many years presented reports on the result and status of many of the different environmental goals. Most often such reports includes not only evaluation but also assessment and proposals for actions for a better environment.

On the international scene Sweden is submitting data and information according to what is requested by different international agreements and legislation. Submissions are channelled either via SEPA or the government itself, in the latter case with SEPA most often being the producer.

1.3 SWEIONET initialisation and objective

The Swedish membership to the EU had created a need for Sweden to express Swedish views, experiences and circumstances abroad with regard to the environment. The birth of the telematic EIONET also called for a similar need.

In order to fill parts of those gaps and also in order to overcome some uncertainty on what should be presented freely to the general public within the frame of the telematic EIONET the Swedish NFP began its work with the SWEIONET project.

The aim became to develop an easy accessible package on environmental data and information. The instrument should be cheap and quick and easy to maintain. There-

fore the environmental friendly Internet solution was chosen.

2 The SWEIONET project

2.1 Strategy for the SWEIONET web site

The Swedish NFP had a feeling that the overall message on Swedish environment should transmit a positive feeling and firstly focus on Swedish nature and its beauty and secondly on problems and possibilities how to overcome them. This approach might slightly differ from what an environmental agency usually follows: action plans and policy making including technical countermeasures or for nature, conserving actions, being the main instruments.

Another area of interest to focus on was the dissemination of statistical material on the environment. In earlier years Statistics Sweden was responsible for the producing of official statistics on the environment. This task, however, was transferred to SEPA a few years ago. SWEIONET was therefore a suitable instrument to help develop official presentations of statistical summaries like indicators etc.

It was decided that the SWEIONET web site should consist of five different sections:

- Organisation, Policies and Sectors
- Threats to the Environment
- Nature in Sweden
- Ongoing activities
- EIONET resources in Sweden

In the effort of reaching the international target group it became evident that the main language for the presentations should be English. However, it was also recognised that many individuals and institutions of interest in the south of Europe had only little knowledge of English and therefore text based key information should also be translated into French.

The Swedish Environmental Protection Agency had earlier by itself launched a web site in the Swedish language with a few translations into English. The information available on this site did not, but to a minor extent, cover the information intended to become available for the SWEIONET. It was therefore considered to be a good idea to present this information on a new web site for the NFP information. By doing so it was also easier to point out the new relationship between the NFP and the EIONET and EEA.

2.2 The development of SWEIONET

A decision to start the developing project was made in early 1996. It was decided to work in co-operation with EEA. Budget constraints were tight and developing time was limited to nine months with a launch on the Internet in late December 1996. The project team was populated with SEPA staff from many different divisions and sections, necessary to create efficient networking.

2.2.1 The Project team

The project leader was Ebbe Kvist, the NFP contact person. A core set

of four key persons in addition to the project leader, formed an inner project team:

- Örjan Lindberg as the technical network expert (Swedish ITTAG member to EEA)
- Manuela Notter as the indicator and environmental monitoring expert
- Bernt Røndell as the expert on environmental statistics
- Maria Sjö as the technical www expert

Besides the project team a lot of contributors both inside and outside of SEPA were contacted. Altogether about 50 people brought about their different contributions.

2.2.2 The Project work

The main objects to collect and present on the SWEIONET web site were that kind of informative material that an agency like SEPA already has produced and published.

2.2.3 Nature information

Sweden is a long country (1557 km). The climate varies from warm temperate (nemoral) in the southern coastal areas to arctic-alpine in the Scandic mountain range, where valley glaciers occur at the highest levels. The aim has been to make presentations of different nature categories in the "Nature Categories" section thus to show the great variety and beauty of Swedish nature.

Different texts already written for different purposes were collected within SEPA and edited and translated. Pictures were chosen to add

good feeling to this section (e.g. Fig. 1). A few informative maps on for instance salinity in the Baltic and forest regions were also produced.

2.2.4 Environmental statistical data and text

To present data and statistics on the environment is to throw oneself into the very rapid development that currently takes place in this field. Data and information should mirror the development in important aspects to the environment and to the society as far as policymaking and decision making are concerned. Both the OECD and the Nordic Council of Ministers have initiated and carried out developments. The EEA has adopted the indicator idea and makes use of it in the report on the "European Environment, the 2nd Assess-

ment", that was just presented last week (2nd of June 1998).

At present the DPSIR-model is evolving among evaluators and assessment makers. In the "Threats to the Environment's" section of the SWEIONET, charts or indicators on the state of environment are presented (e.g. Fig. 2, Fig. 3). The selection has been made to fit the present political agenda. Just recently this agenda has been changed from a problem oriented approach with 14 specified threats to the environment, towards a more object oriented evaluational approach. The objectives and the evaluational objects are still under development in the political corridors, but SWEIONET will eventually shift towards the new approach when the political decision is made.



Figure 1. From "Marine Environments Section": The Baltic coast at Haväng in Skåne. Photo: Ebbe Kvist.

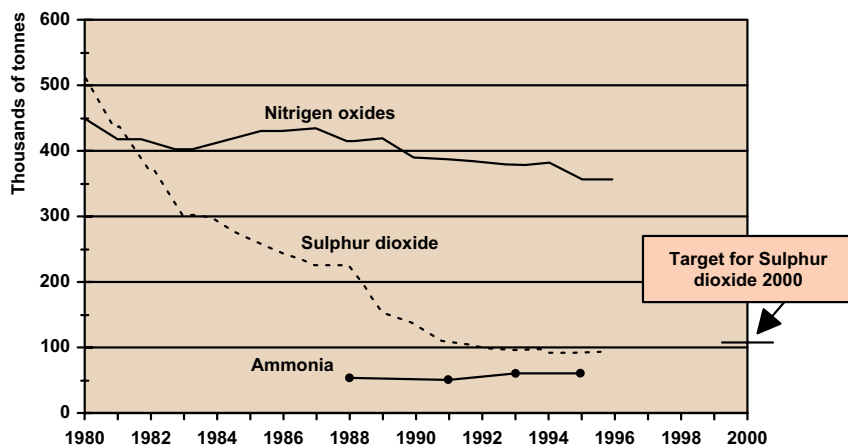


Figure 2. From "Threats to the Environment Section": Acidification, emissions of acidifying substances

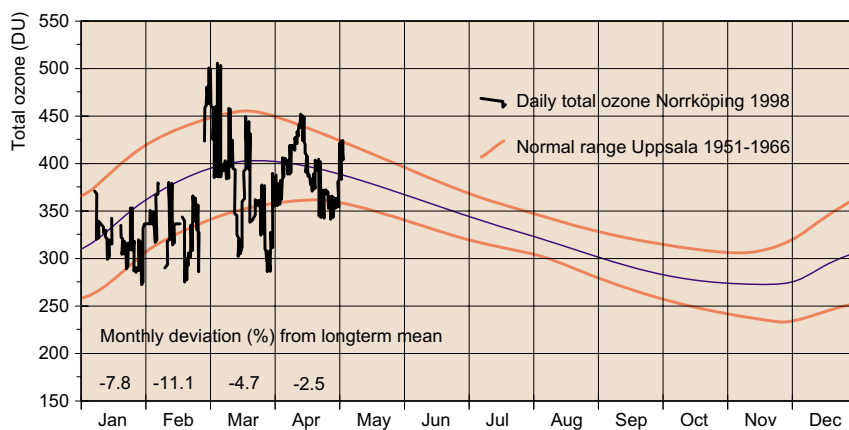


Figure 3. From "Threats to the Environment Section": Depletion of the Ozone layer. The chart, a result of the monitoring programme, is available and maintained on the EIONET member SMHIs web site.

Although SEPA has recognised the development work that has to be undertaken on environmental statistics in the years to come, the presentation of statistical material on SWEIONET put still another spell on

the SEPA organisation. It became evident that frequent maintenance of the published material was necessary. Building up of the maintenance organisation is still going on. At the same time other actors in addition to

the EEA, are asking for contributions regarding the same or similar material. In these development activities, SWEIONET has become one of the driving forces.

2.2.5 Co-operation with external institutions and members of the Swedish EIONET

The SWEIONET project made contacts with different agencies responsible for major environmental issues such as Swedish Civil Aviation Administration, Swedish National Road Administration and the National Chemicals Inspectorate in order to find texts describing their environmental policies and to administrate links to their home pages.

Most Swedish MCEs (members of the Swedish EIONET) are data hosts and holders of environmental monitoring data. Data hosts are generally required to maintain data sets and make them available. This can be done on the Internet or in another medium if more appropriate. During the last few years such a development has taken place, although we have not yet fully reached the goal. During the SWEIONET development Swedish MCEs were contacted in order to get access to links and charts already published on the Internet. At the time of the development not many data hosts had made such data sets available in the form of charts on their web sites. However, it was in a few cases possible to present a few such charts using hyperlinking technique from remote institutes. They contribute considerably to the immediateness of the SWEIONET web site since they are

updated very often, sometimes on a daily basis.

3 Future developments

3.1 Information resources

The aim of the SWEIONET is also to bridge the gap between different networks – on one side the existing national Swedish environmental monitoring, assessment and policy developing network - and on the other side the EIONET. The EIONET and the SWEIONET web servers should be complementary to each other. Together they could be valuable information resources for broad user groups, including decision-makers and the general public. In order to achieve this goal the EEA also will have to develop its web site towards a more strict environmental information approach with direct pointers to relevant information, indicators and data. This development is already underway and might be one of the outcomes of the present annual work programme of the agency.

The indicators shown on the SWEIONET web site are partly results from monitoring activities. Further rapid development of the indicators is expected with regard to both domestic and international presentations. Presently EEA are developing a product known as the “Yearly Indicator Report”. This report may consist of a set of core indicators within the DPSIR framework. Member states are supposed to contribute to the report, either by submitting

their data directly to the EEA or via other international bodies already recognised as recipients for national data. SWEIONET will seek to present (or link to) national Swedish data on the web as soon as the Swedish contribution is available. The SWEIONET vision in this respect comprise a public access to most Swedish data sets produced for the policy and decision makers at European level. In addition core data sets of only national interest should be available on the SWEIONET web server. The current political work in Sweden on environmental targets and objectives should end up in a Parliament decision this autumn on what indicators to be chosen for the evaluation process.

3.2 Metainformation

Accessibility to SWEIONET data is very important. One way of increasing the accessibility is to make use of metainformation. Already most of the SWEIONET pages are accompanied by metainformation, meta tags, in the head section of the HTML pages. Two separate approaches are followed.

The Swedish EnviroNet (SMN) approach requires an indexing with a specific indexing scheme with regard to environmental issues. The Dublin Core technique and format is used for this. In the future we hope to develop a link between the Swedish EnviroNet and the Catalogue of Data Sources (CDS) at the EEA. The SMN search tool is available at URL: <http://smn/environ.se/miljonat/english/index.htm>

The Nordic Web Index (NWI), an initiative among Nordic libraries, with an on-line Dublin Core meta-information generator, has been adopted by SWEIONET. Also NWI makes use of the Dublin Core format. Unfortunately there is a slight difference in standards between the SMN and NWI systems even at a basic description level. The NWI search tool is available at URL: <http://nwi.lub.lu.se/?lang=en>

The Royal Library (National Library of Sweden) has recently launched a web search project on top of the NWI with the aim of creating a database covering all Swedish quality web sites. The indexing technique is Dublin Core metadata and harvesting on the Internet via robots.

3.3 Information flow

It is essential to develop routines for information flow within the EIONET, with regard to environmental data from the monitoring programmes and the production of statistics on emissions and discharges. This is an organisational matter to be dealt with by SEPA.

The EIONET User Group has already presented a couple of pilot project with regard to information flow. At national level this implies that national reporting and evaluation systems must be ready to meet the demands from the EIONET. In addition to the EIONET, several other international fora are requesting pieces of information on various issues, at a steadily increasing activity. Besides the international requests the national system also puts forward specific demands.

In Sweden, the data hosts participating in the monitoring programmes are governed by contracts. Recently renewals of these contracts have been initiated. The crucial thing now, is to secure that requested information should be processed in suitable ways to fit into the web production. Articles on this must be forwarded into the contracts.

To be able to fulfil its task as an easy and quick core information provider for European decision and policy makers SWEIONET must rely upon its data and information providers, and so must other bodies including the Ministry of Environment. In fact then, SWEIONET becomes one of the bodies that request information. SEPA in particular will have to rearrange its statistical production and the methods of presenting results from the environmental monitoring. These processes have just begun. In the few years to come it could be estimated that the staff working on the production of statistical data must be increased considerably if the user demand is going to be met.

3.4 Technical aspects

The overall rule for further development is that SWEIONET not should be technology driven but make use of easy, cheap and easy maintainable tools. We do not feel there is a need to create the most fancy web site ever found. It is of much more importance that the information presented is correct, updated and easy retrievable. Of course this should not prevent us from present SWEIONET on the web with a nice layout, but fancy

technological solutions are not sought to be included *per se*.

We are hesitating to introduce frames as we think that maintenance costs might increase and additional problems at the user end might decrease user friendliness. Cascading style sheets, though, may be introduced as well as JavaScripts.

One technique that we would like very much to develop further is hyperlinking between nodes in the national network. It might also be possible to develop a database retrieval technique for disaggregated data sets like time series of emission data.

4 Obstacles and possible solutions

Most of the obstacles to overcome are no longer of technical but of organisational character.

For SWEIONET, the most important development for the future is to create information **provider awareness** so that the information flow in the Swedish part of EIONET will flow without obstacles. One part of this awareness creation could be that SWEIONET act as an information broker between users of information and data providers and different monitoring programmes.

The **slowness in administrative systems** with regard to the introduction of new routines and forms of presentations is a true problem. Even if you meet with an organisation having a high degree of adaptiveness, it takes a long time for a big organisa-

tion to reallocate resources and give new priorities. In addition **new competence** in web technology must be introduced to many people.

Now **administrative routines** must be introduced to secure the availability to data. Such routines must include proper contracting pro-

cedures with regard to monitoring programmes, so that future contracts stipulate **accessibility to URLs** and means for their updating. Further the contracts should stipulate picture and chart **formats** and **layouts**, and solve questions on **copyright** issues.

Planning the transition from reporting on paper and diskettes to using the web

Use of EIONET from a member state viewpoint

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Abstract

This paper describes plans and prospects for use of EIONET, the European Environment Information and Observation Network. A priority list of tools and facilities for data flow and communication is presented, including a new tool for document upload and discussions called Circle. Other facilities needed are a/o an e-mail phonebook with addresses, net based work plans for the data providers, a multilingual keyword list, news software, and a common look and feel.

Recommended formats for file exchanges are presented, and the need for standardised data exchange formats are discussed. The architecture for EIONET based databases is likewise discussed, followed by a case showing the magnitude of the challenge of turning the EEA into the one stop shop for data on the environment. Finally the plans for content on the three different types of EIONET servers are presented.

I Introduction

EIONET, the European Environment Information and Observation Network, is an Internet based network established to facilitate flow of access to environmental data and information. The EIONET servers connecting the European countries with the European Environment Agency (EEA) will be used for exchange of

data and information to go into regular EEA reports on the environment.

The requirement for such an interstate network is that it should be of real help for the member states in their work, see also <http://www.nedev.com/ned-04-1998/ned-04-develop.p.html>, and that its structure is transparent for the end user. The ultimate goal for the network is that member states in the future will

only report once, in one format, to one recipient.

The way towards this target and the present plans will be the theme of this paper, as seen from a member state.

2 EIONET

2.1 Tasks of the EEA

The European Environment Agency is a/o established to record, collate and assess data on the state of environment, and according to the coming revision of its Regulation to promote the use of new telematics technology in its dissemination of information.

2.2 EIONET

EIONET is an Internet network connecting the EEA and its member states plus consultants. In 1997 the 15 EU countries joined the network, while the 3 EFTA countries and the European Topic Centres (ETC's, consultants to the EEA) are setting up their server this year.

Simultaneously the Eastern European countries – the PHARE states – are setting up their national servers, summing up to a total of around 50 servers in 1998.

Finally, up to 10 National Reference Centres per member state will join the network as users, meaning that EIONET in summer 1998 will have more than 500 users. In a foreseeable future additional employees at member state administrations may join in.

2.3 Member states

The member states have very disparate working conditions and not necessarily the same needs and possibilities as the EEA for exploitation of the network. Their environmental monitoring systems are likewise very different, even within the EU where efforts on harmonisation have been underway for years.

However, now each country has a National Focal Point (NFP) with the main objective to ensure optimal national co-operation with the EEA, and specifically ensure national delivery of high quality data.

In the member states National Reference Centres (NRC's) are established with the task to deliver data and information within their specific topic to the EEA or the ETC's. The NRC's will also evaluate the realism of project and monitoring proposals from the EEA, and provide scientific commenting of draft EEA reports.

This means that they need to be well informed about the activities in the EIONET.

As of today the following NRC's are in regular action, as the EEA has established a major activity within their field: NRC's for air quality, air emissions, inland surface waters + groundwater, marine and coastal environment, nature conservation, land cover, soil, and waste.

2.4 National Focal Point servers

As mentioned above, each member state now has an Internet server, equipped with Netscape Suitespot

3.1, plus a conferencing and document management package called Circle (see below).

The servers have not been much in use yet, but their future use has been discussed. In summary – for details see later – the NFP servers will be used as a repository for national deliveries – primarily to the EEA but later also to other international bodies.

Today the EIONET is an extranet, with access only provided username and password. The NFP will provide access and oversee the national data flow.

The running and maintenance costs of the NFP servers are at present estimated at 33.000 ECU's per year per country, including service contract, software updates, depreciation of hardware and personnel costs. As this is not an insignificant amount, only a success of the dataflow over the servers can assure continuous operation of the EIONET with so many servers.

Therefore a careful implementation of the dataflow is of utmost importance. Simultaneously the EEA should assure the well functioning of all the servers and their software by continuously supporting the server operators.

3 Data flow tools and communication facilities

The development of the electronic EIONET has to be driven to meet the needs for reporting from mem-

ber states to the EEA and reporting by the EEA, and this is also to a certain degree the case. For the most recent development plan see Norup (1997).

All the servers are equipped with Netscape Suitespot and Circle. However, when it comes to software on the end-user PC's the list of software is infinite. Therefore, any tool to be provided to the end-users has to consider this situation, and generic tools are preferred.

An actual priority list of tools and facilities is presented below:

3.1 Document upload, and discussions

Priority number one is a tool for upload and download of files. This tool – Circle – is now being installed. Circle may be described as an overlay to the Suitespot sub-programmes.

Circle serves mainly as a document library and as a discussion forum. Circle bypasses the bottleneck of a web master by allowing the NRC's to upload files directly into a document library accessible by a normal web browser.

Circle enables uploading and downloading of documents (text, spreadsheets etc.), has bulletin boards for organised discussions, notifications for new uploaded documents or discussion threads, keyword search for any information, and a directory of users provides fine-tuned access control on documents in protected group collaboration areas of projects.

The main benefit of these functions is that working documents are maintained in hierarchies by the au-

thors themselves. Other collaborators can immediately check the status of the documents, and versions of documents can be organised and changes can be discussed on the shared bulletin boards.

But even though the new kind of Internet-based document management is the core function of Circle and EIONET, electronic mail still has a role. Automatic e-mail lists are being used for time-critical announcements that might go too long unnoticed in the bulletin boards of Circle.

3.2 Quality assurance of Circle and data flows

What is needed now in EIONET, after taking hundreds of new users aboard, is quality assurance, assuring that the users really can use the network and consider it useful.

The EIONET UserGroup has for 1998 planned 3 data flow cases - in air quality, air emissions, and inland waters - and these cases will show if Circle fulfils the needs. Member states and ETC's will need support from EEA for these data flow experiments.

We know already that access is not always possible, due to many reasons, but the problem is mainly with the EEA as its communications do not reach their target.

Likewise the facility for getting a notified document through an e-mail request has to be tested for all users, as it looks like firewalls may give problems for some users.

Another problem is that the existing interest groups in Circle are

requiring different usernames and passwords for the same person. This has to be solved by synchronisation of the access criteria. An even more elegant solution could be provision of a shareware tool like "Password Tracker De Luxe", so the enduser can access Circle groups with just one double-click.

And finally, as the document libraries grow their contents should be maintained and organised like any book shelf.

An operational problem is that some countries do not have the necessary time and/or knowledge to maintain their servers – and the coming Circle – sufficiently well. A solution could be that even if Circle is installed on every server, the only Circle used for the first year is that on the EEA server. Meanwhile, or in return, this server with its Circle is maintained as a highest priority by the EEA, so users never will have problems with it. If users are happy with using EIONET, then the EIONET is a success, and this is what we all should strive for.

If wanted, or necessary for sufficient speed of access, the EEA Circle could be replicated overnight to all the other sites. Such a replication is by the way a mechanism that should be studied further, as countries do not necessarily have the time or know-how needed for a sufficient maintenance of the servers.

One might argue, that the success of Circle within a year is the primary target, and that resources should be directed to this task as far as necessary.

3.3 Directory or phonebook

Much needed is also a phonebook where the e-mail addresses, and maybe also addresses and telephone numbers of all the EIONET members can be looked up. Such a tool already exists as a database searchable through the web, but it is not integrated into the desktop of the end-user yet.

What is needed is a facility to find an e-mail address through the mail client. Such a solution could be to use LDAP directories as part of the e-mail client, a solution explored at the EEA today.

Another possibility could be to exploit the possibility of connecting Outlook 98 with Microsoft Access. However, this solution would require all sites to install MS Office, a solution discussed many times but refused for many reasons.

A facility enabling access to addresses through any word processor would also be most welcome.

3.4 NRC work plans

A product much needed, and now underway, is a table for the NRC's describing the deliveries and other tasks for the coming year – a work plan for the NRC's. Every year at the presentation of the 2nd draft of the forthcoming AWP, the EEA should publish on the network a one-page table describing the tasks of the National Reference Centres (see Appendix). The tables should describe the expected deliveries and activities so the tasks are clear for everybody within the national administrations

without the need for detailed knowledge of the subject. The minimum is a clear reference and hyperlink to the legal framework (directories or conventions) or the topic within the EEA work programme. The reference should then describe the context and show the parameters, stations, methodology etc. to be used in case of data update or collection.

A proposal for such a table is in the following page.

Given such a table for the NRC's the task of planning the national work and assuring the needed national resources will be straightforward for the member state authorities.

3.5 Thesaurus

The EEA is now nearly completing a multilingual list of environmental terms, a thesaurus. It will come in very handy to assist in for example quality check of translations to national languages, to be used for keyword searching in EIONET text pages, and for the indexing of new records for the Agency catalogue of data sources. The thesaurus will be available this year in most of the Western European languages.

3.6 General information for EIONET partners

Tools for informing the member state partners in general are needed. Tools like PointCast are now being explored by the EEA in a pilot project, studying their feasibility for easy and direct delivery to NFP's, NRC's and ETC's of useful information on EIONET.

3.7 End-user training and ease of use

As most national administration employees are not experienced Internet surfers training is needed whenever a new tool is introduced. This is the case right now, where all NRC's are invited by EEA to be trained in Circle; hopefully dataflow will start not so late after this event, so the trained know-how can be used.

Equally important is continuous training of system operators in the member states.

3.8 General ease of use

Any tool introduced into a network like EIONET should be extremely easy to use, and maintained continuously by the EEA.

At the present state of the electronic EIONET it is not clear if anything else on the servers but Circle will be used to any significant degree for the first year or two. However, if member states start to make HTML pages to any significant degree, then a proposal for a common look-and-feel of the web sites is needed, including recommendations on the use or not of XML, CSS etc. A freeware web site programming and management tool like Frontier, <http://www.scripting.com/frontier5/>, should also be considered.

3.9 Chatting real time

Users could chat over the Internet on actual problems with products like ICQ, <http://www.mirabilis.com/>, substituting difficult and expensive

telephone meetings. The tools are there, but they have not been exploited yet, as many are not so experienced Internet users.

3.10 The more distant future

In some years we might see tools for network computing, for example for scenario modelling over the web. A product like Tarantella from SCO, <http://tarantella.sco.com/info/info8.html>, could be a solution for this by its making a PC into a dumb terminal in relation to a model software server.

GIS systems will also be part of EIONET in some years, and we may exploit tools like GeoMedia Web Map, <http://www.geoplace.com/print/gw/1997/0997/GW970900feat4.html>. It produces real vector based maps in WWW format with direct link to a GIS database, and thus avoiding the trouble of making graphic copies of vector maps. For further references see http://www.blm.gov/gis/metadata_doc.html.

Workflow tools to help build process-automation solutions have been studied for EIONET purposes for some time and the emergence of the Simple Workflow Access Protocol (SWAP) http://biz.yahoo.com/prnews/980413/ca_netscap_1.html, a standard for interoperable workflow products from multiple vendors, is welcomed. SWAP will be an extension of the HTTP 1.1 standard.

4 Internet reporting – topics and problems

4.1 Topics

The EIONET UserGroup has as mentioned above identified 3 cases where dataflow should be initiated and experimented with.

The two air topics both have a long history, as they have been reported for up to 10 years – air emission reporting has been carried out under the CORINAIR programme, and air quality under various conventions and directives. Under construction is EUROWATERNET – a network for monitoring and data collection on inland waters.

More networks are to come, as the long term plan is to use EIONET for any compliance reporting under the various environment related EU directives. In the nearest future NATURA 2000 – nature conservation – may be in operation through the EIONET too, and later on comes networks for reporting on a/o soil and waste.

4.2 Text exchange formats

There has been much discussion on the file formats to use in EIONET. The most recent proposal is the following:

- always use the DOS convention for names (8.3)
- for text files use HTML or PDF
- if this is not possible use Word 6 or Excel 5 or PowerPoint 4/95

Always to be remembered is that the EIONET is so diverse that the recipi-

ent easily may have software and operating systems differing from the senders.

4.3 Data exchange formats

When databases are more used in the net we will need standard formats for data to go into the databases. Two internationally recognised formats for marine data exchange exist, one called FGDC, described at <http://fgdc.er.usgs.gov/index.html> and another named DIF. Standards for other topics should be identified for use in EIONET.

However, even if direct database input is not used, a common format for data is advisable to simplify aggregation. The Topic Centre for Air Quality, Air Emissions, and Inland Waters are all working on this issue right now.

The air topic centres are currently making input software to be installed on the PC's of the data providers, while the inland waters topic centre specifies the layout of the spreadsheet to be used for reporting.

The European Topic Centre on Catalogue of Data Sources has recently finished input software for the provision of data on national reports. This software may also be of inspiration for the rest of the topic centres.

A recent development is the facility in Adobe Acrobat for making electronic forms for replacement of questionnaires or for input forms. They should allow automatic input into databases. Reference is <http://www.adobe.com/aboutadobe/publicrelations/HTML/9801/980126.pdfforms.html>.

4.4 Databases on the Internet

Countries have for years collected environmental data and stored them in databases but these databases have been more or less inaccessible, and it has been practically impossible to see what was available within a given area or topic.

The technical reason for this problem is to be found in varying data structures, different names for identical parameters, and lack of physical access to data. Other reasons are to be sought in copyright considerations and security concerns.

Databases are typically presented on the Internet as metadata catalogues without access to the real database with the raw data. However, tools are now available to publish databases on the net without much trouble.

One solution for an Internet database is to publish it in two parts – as metadata and as parameters. The metadata give information on the topics, measuring stations, time periods, institutions, contact persons etc. There is public access to the metadata part, but password is required for access to the parameter part containing the measurements.

This approach has been used in the DemoWad project (www.dawad.dk), a result of the tri-lateral Wadden Sea co-operation between Denmark, Germany and The Netherlands. 3 databases are created, with one in each country, and with equal database structure. National data are transferred to these databases, and a common home page allows access to each of the databases.

Identical user interfaces are provided for each database, allowing search by topic, station, area or time period.

The REMSSBOT project, <http://www.netor.gr/remssbot/index.htm>, uses a different approach, with different database software on the involved servers. Access (data retrieval and filtering) is provided through CORBA (Common Object Request Brokering Architecture), which only requires a certain minimal common data structure. The same functionality is provided by the DCOM architecture.

The REMSSBOT main objective is sharing environmental information, not by building a centralised data warehouse, but by keeping the data at its original location.

Still to be experimented with, and later decided on, is whether single databases, distributed databases, or replicated databases are most feasible in EIONET.

4.5 Case: Air emission reporting for Dobris+3

As a case to illustrate the complexity of dataflow in EIONET and the size of the challenge is below described the data collection in relation to air emissions during the preparation of the newest EEA report “Europe’s environment; the second assessment”, also called Dobris+3.

Several data sources were available, namely CLRTAP/ EMEP (the Geneva convention), UNFCCC (the climate convention), the EU greenhouse gas monitoring mechanism, HELCOM, OSPARCOM, and CORINAIR.

These data collections serve different purposes and contain somehow different data. Some provide national totals and/or subtotals for sectors. Some have very detailed sector data, data are from 1980 to 90 or 95, and countries covered are EU15 or some EU countries or more countries - even up to 30. The list of parameters consists of one or several among SO₂, NO_x, CH₄, NMVOC, CO, NH₃, HM, POP, and the date for reporting is not the same.

Such a situation is really a challenge, when none of the data sets are enough for the purpose.

It is therefore clear that the goal is to have one reporting system covering all needs within air emissions, and CORINAIR is planned to be this system – the core annual European air emission inventory. CORINAIR includes a guidebook, software, and a fixed nomenclature.

The plan is that EEA will be the official rapporteur to UNFCCC and UNECE, and measures towards this goal are underway by negotiating with the international bodies and the member states.

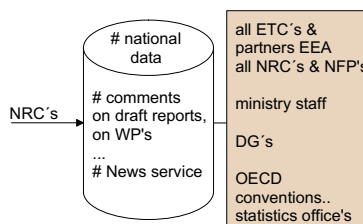
An evolution towards such a system may be foreseen within all topics, also as EU has ratified several international conventions and as a consistent EU reporting is needed.

4.6 Proposed use of EIONET servers

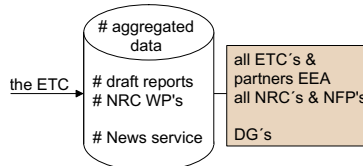
In a hearing of the EU15+3 member states November 1997 all countries agreed to a proposal for use of the EIONET servers (Fig. 1).

Whether some data will be put on servers at the data owners – the National Reference Centres – or whether all data will go to the NFP server has to be shown.

Use of NFP servers



Use of ETC servers



Use of EEA server

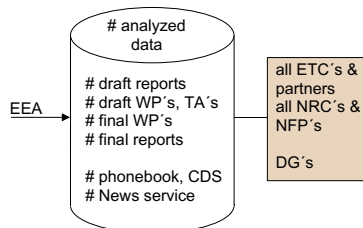


Figure 1. The use of EIONET servers.

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Appendix. National Reference Centre activity plan.

National Reference Centre activity plan					
Topic: (for example Air emissions)					
Event/activity	Event date	Response deadline	Expected output	Expected output date	Contact person
<i>short name of the delivery</i>	<i>date for dispatch of request</i>	<i>date for deadline</i>	<i>name of final product – where can the national delivery be found or where is it integrated</i>	<i>date for final product</i>	<i>name and e-mail of person to contact at the EEA or ETC</i>
	<i>exact description of the requested delivery (requester, legal context, annual or multiannual work programme topic, or technical report)</i>				
examples:					
Data updates					
EU15 emission inventory, GHG, 1996 data	March 1998	15 April	submission to UNFCCC + Corinair96 data (Technical report)	May 1998	
	request done by DGXI, with ETC/AE assisting in data collection, validation and reporting for both the Monitoring Mechanism and the EU15 estimates for UNFCCC				
EU15 emission inventory, GHG + other gases	December 1998	31 December 1998	EU submission to UNECE/ CLRTAP + Corinair97 data (Technical report)	Jan-March 1999	
	request done by UNECE/CLRTAP with ETC/AE assisting DGXI to prepare EU15 estimates				
Questionnaires					
to be described as above					
Draft reports for review					
Corinair 1990-1996 emission inventories	1 June 1998	1 July 1998	Topic report	July-Aug 1999	
Workshops					
name of workshop					
	who should attend, who pays for expenses				

EIONET: Intranet, Extranet, and beyond

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Abstract

The European Environment Agency (EEA) is the environmental information centre of the European Union. Its main instrument is a large network, called EIONET (European Environment Information and Observation Network). EIONET is both an organisational and telematic network. The core of EIONET is an began as an Intranet that connects a total of 40 National Focal Points, European Topic Centres, and Phare NFPs with EEA. However, the Intranet concept was soon abandoned for a more flexible Extranet architecture that also allows hundreds of National Reference Centres, Topic Centre partners, European institutions to actively participate. Beyond this, EEA coordinates some collaborative activities, such as information locators and global clearing-houses, in the public and semi-public Internet.

The paper discusses mapping of this diverse organisational network into an effective telecommunications structure that takes into account the rapidly changing needs of users, working group dynamics, and advancement of technology. To meet this challenge, structured forms of communication such as discussion forums and project homepages where documents are uploaded, are being implemented. A distributed directory service with linkages to environmental information sources is also essential. Further developments include a push technology channel for news webcasting and development towards an electronic reference centre for all environmental information. EIONET also provides building blocks for setting up national environmental networks.

I Introduction

In 1990, the European Council passed the legislation to establish the European Environment Agency

(EEA) as the environmental information centre for the European Union. At the same time it was deemed that the EEA be a small nucleus of a large network, which was named the

European Environment Information and Observation Network (EIONET).

The main purpose of EEA and EIONET is to report on the state of Europe's environment so that the European Union and the Member States have a solid basis for developing their legislation. Hence, the EEA's main customers are governments and their decision-makers. The regulation on EEA also charges the EEA to use its network to ensure that the citizens are properly informed about the environment. *Dobris Assessment*, the first holistic report was published in 1995 (Stanners and Bourdeau 1995), and its next version is due out in June 1998. This and other reports are also available at EEA's website (<http://www.eea.eu.int/>).

Producing such colossal overviews requires an effective telematic network – the EIONET – to be set up. This means that the EEA necessarily accumulates expertise and know-how on telecommunication and networking. These are now recognised as the vehicles to further develop new kinds of products and services. Indeed, the first review of EEA and EIONET made by the European Council in 1997 determines that EEA shall especially become an electronic reference centre for environmental information. With the rapid advances in Internet, such as push technology and powerful information locators, there are very good prospects for this. Beyond the horizon, the new digital satellite vision holds a promise totally new types of environmental information services.

2 The onion model of EIONET

The EIONET has already evolved considerably during its short life. It consists of four main types of nodes. A National Focal Point (NFP) is typically a small unit in a Member State's environmental administration that coordinates European activities. There are NFPs in all EU, EFTA, and Phare countries. National Reference Centres (NRC) are major research institutes that collaborate with the NFP to provide the information to Europe-wide databases. European Topic Centres (ETC) are special contractors of EEA who coordinate activities in their thematic areas. Currently there are ETCs for air quality, air emissions, soil, inland waters, marine and coast, nature, land cover, waste, and cataloguing of data sources. Each ETC has a number of partners. In Phare countries, Phare Topic Links provide the same function and extend the ETCs.

There are no less than 600 nodes nominated officially for EIONET, but less than 200 have been actively participating. Mapping this diverse organisational network into an effective telecommunications structure, which takes into account the needs of users, working group dynamics, and the necessary security measures, has been a major challenge. A layered model (Figure 1) with some different rules for the different zones, and the most widely adopted technological standards (i.e., Internet), have been adopted for EIONET.

The core of EIONET is an Extranet that connects the NFPs, ETCs,

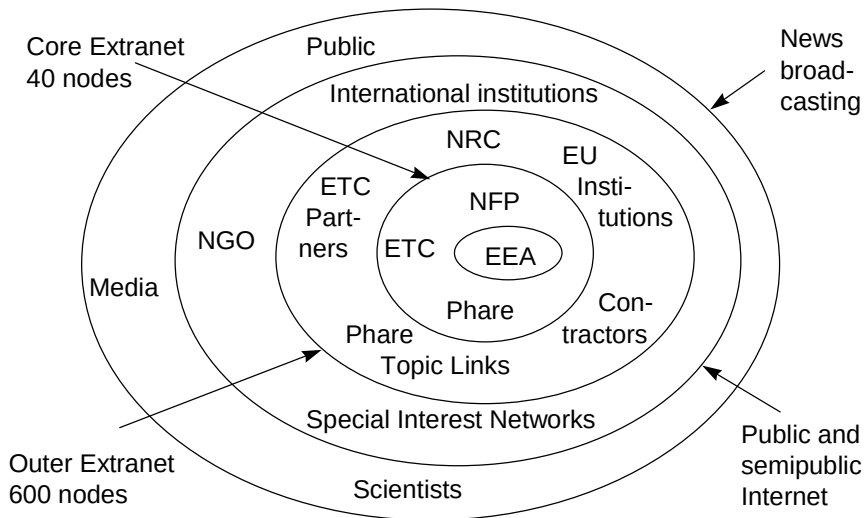


Figure 1. The EIONET consists of layers for core Extranet, outer EIONET, semi-public networks, and open information dissemination. For abbreviations, see text.

and Phare NFPs with EEA. By definition (<http://whatis.com/>) an Extranet is a username/password protected collaborative network of information suppliers and consumers on Internet. The main functionality on core EIONET is document management. The content is dominated by drafts and final reports on state of environment, information on project co-ordination, addresses, meetings, and meta-information. It has been built by EEA and its contractor, Finsiel SpA., in 1995-98 with the support of European Commission's DGIII IDA Programme (Europe's Environment Network 1997) and that of DGIA. EIONET that now consist of 40 physical nodes, is one of the pioneering Extranet projects among European institutions. Initially the core

EIONET began as an Intranet, which is a physically protected corporate network governed by a common security policy (<http://whatis.com/>). However, this model was soon found too restrictive, when connections beyond the core EIONET were needed, and a pure Extranet architecture was adopted.

The outer EIONET, which also is an Extranet (Figure 1), has a somewhat different group of users and functions than the core. It mainly consists of working groups at national level and within the partners of ETCs. Document management again is important, but the needs for database management, especially the possibility to upload extracts from operational databases at NRCs to data warehouses at NFPs and ETCs

become important. However, currently these services are still being shaped.

EIONET is also an Internet player, actively promoting Special Interest Networks (<http://www.csu.edu.au/links/sin/sin.html>) such as BALLERINA (<http://www.baltic-region.net/>) on the environment in the Baltic Sea area, and collaborating with international institutions with their network-based efforts, such as the project on the Clearing-house of the Convention on Biological Diversity (<http://www.biodiv.org/>). Although all the finished documents that have been produced within EIONET go to the through the public websites (<http://www.eea.eu.int/>), the public dimensions of EIONET still await a full implementation during 1998–2000. Beyond the present Internet of passive web sites, EIONET is looking

at emerging technologies for actively pushing and broadcasting environmental news to the widest possible audience.

3 Services that support group collaboration

The functionality on the EIONET is provided by the full range of Netscape server technology on Unix. In order to achieve a full-function network, the services will have to be built with a layered approach so that more advanced forms of communication build on top of the basic ones (Figure 2). At the top of the services there is a groupware package called CIRCLE (Centre for Information Resources for Collaboration on Environment). It ties all the other serv-

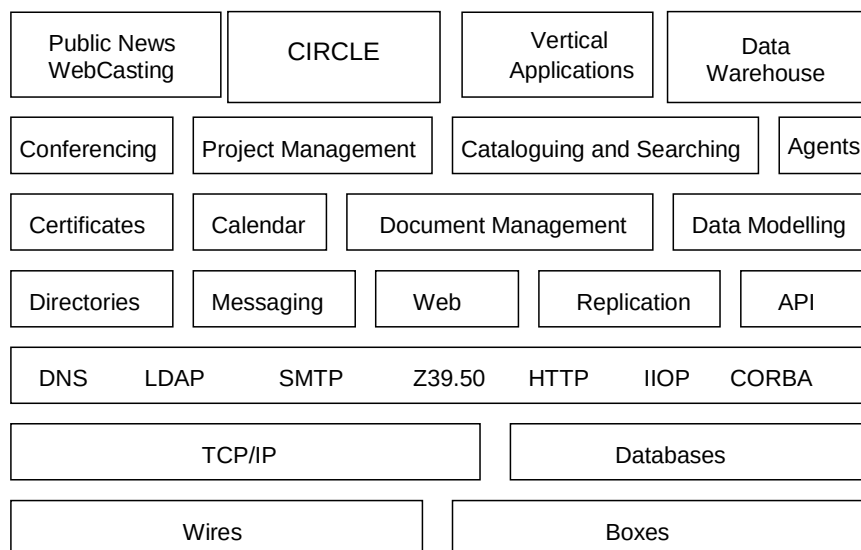


Figure 2. The layered architecture of EIONET's services.

ices together, and provides the shared group collaboration areas for projects, which are called Interest Groups (Figure 3). CIRCLE is a generic service that has been developed by European Dynamics S.A. (<http://www.eurodyn.com.gr/>) for the IDA Programme (Europe's Environment Network 1997). It is being installed on all EIONET servers.

Few aspects of these layered services are worth discussing here. Electronic mail has become a major contributor to information overload lately. Therefore, more structured

forms of communication such as discussion forums and project homepages where documents are uploaded, are being implemented. A full-blown distributed directory service across all the hundreds of EIONET organisations is also essential. In document management, the web-master has been bypassed entirely, and users themselves do document uploads to Interest Groups on CIRCLE servers.

Out of the vertical applications being built on top of EIONET platform, the most central is Catalogue

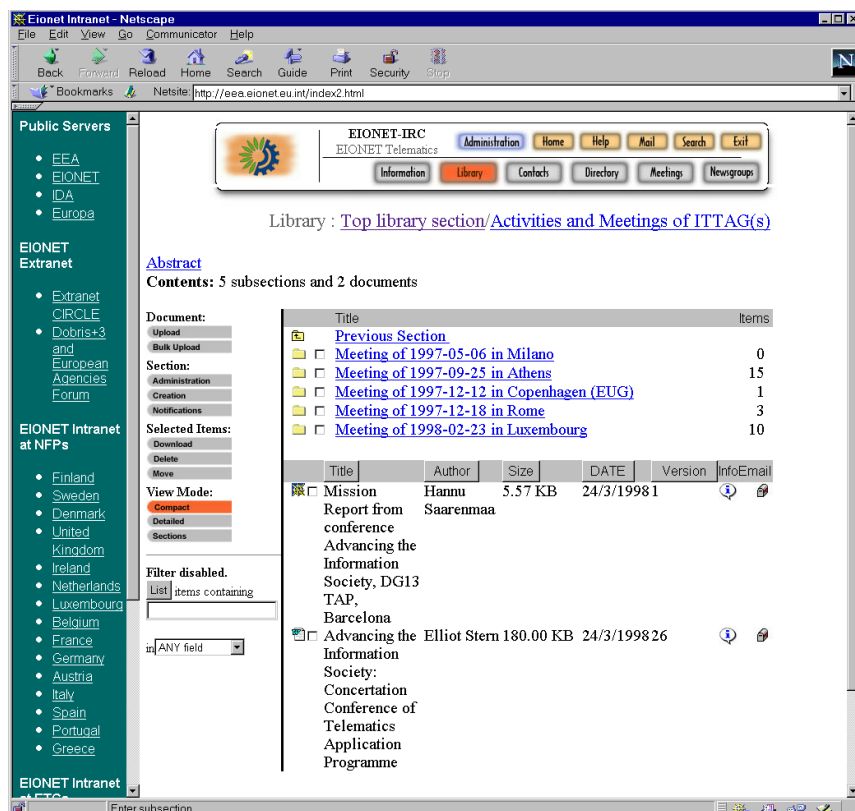


Figure 3. A screen from EIONET showing the document management functions of CIRCLE.

of Data Sources (CDS), which consists of a data directory, address database and a multilingual thesaurus (<http://www.mu.niedersachsen.de/system/cds/>). It serves as the key link to all the other data sources on EIONET.

4 Dataflow automation – towards one-stop reporting

The current state of online databases on EIONET is not very advanced – only a few are publicly available, such as prototype web front-ends to the legacy CORINE land cover and biotope databases (see <http://www.eea.eu.int/>; also on CD-ROM). Unlike some services like the U.S. EPA Envirofacts (<http://www.epa.gov/envirofacts/>), there is not yet a central database on EIONET. Instead, a distributed data warehouse system is being set up (Figure 4). This is done to alleviate the problem that in Member States, the same people will have to report same or slightly different data repeatedly to various data collection systems, such as those of Eurostat, European Commission, EEA, OECD, and various conventions. For historical reasons, overlapping dataflows have been set up on an ad hoc manner, but now need to be connected. The data warehouse functionality on EIONET servers should streamline this by making EIONET server the single place where data will be reported. The various users of data could then access it from there.

New networks can now be built directly on top of this existing EIONET infrastructure, avoiding overlapping and duplication of effort. This is now happening with the Clearing-House Mechanism (CHM) of the Convention of Biological Diversity (<http://www.biodiv.org/>). Instead of again erecting an independent data collection network in Europe, it has been planned that the CHM will be hosted on EIONET.

This approach will give good possibilities for automating the dataflows in small steps. EEA is also working on projects that in future may employ intelligent agents to locate and retrieve data from EIONET to the users (<http://www.mcc.com/projects/infosleuth/>).

5 EIONET as an integrative platform

Environmental issues are cross-cutting and the New Treaty demands that sustainability be taken as a guide for all economic activities. This means that users of EIONET who study the environmental impacts increasingly will need data and information from adjacent economic sectors such as energy, transport, forests, agriculture, etc. Lots of sectoral networks have been created in Europe lately, and many of them are migrating to an Intranet/Extranet way of operating just now. These developments are very relevant for EIONET, because if there is a well operating network on a sector adjacent to EIONET, it may be possible to tap

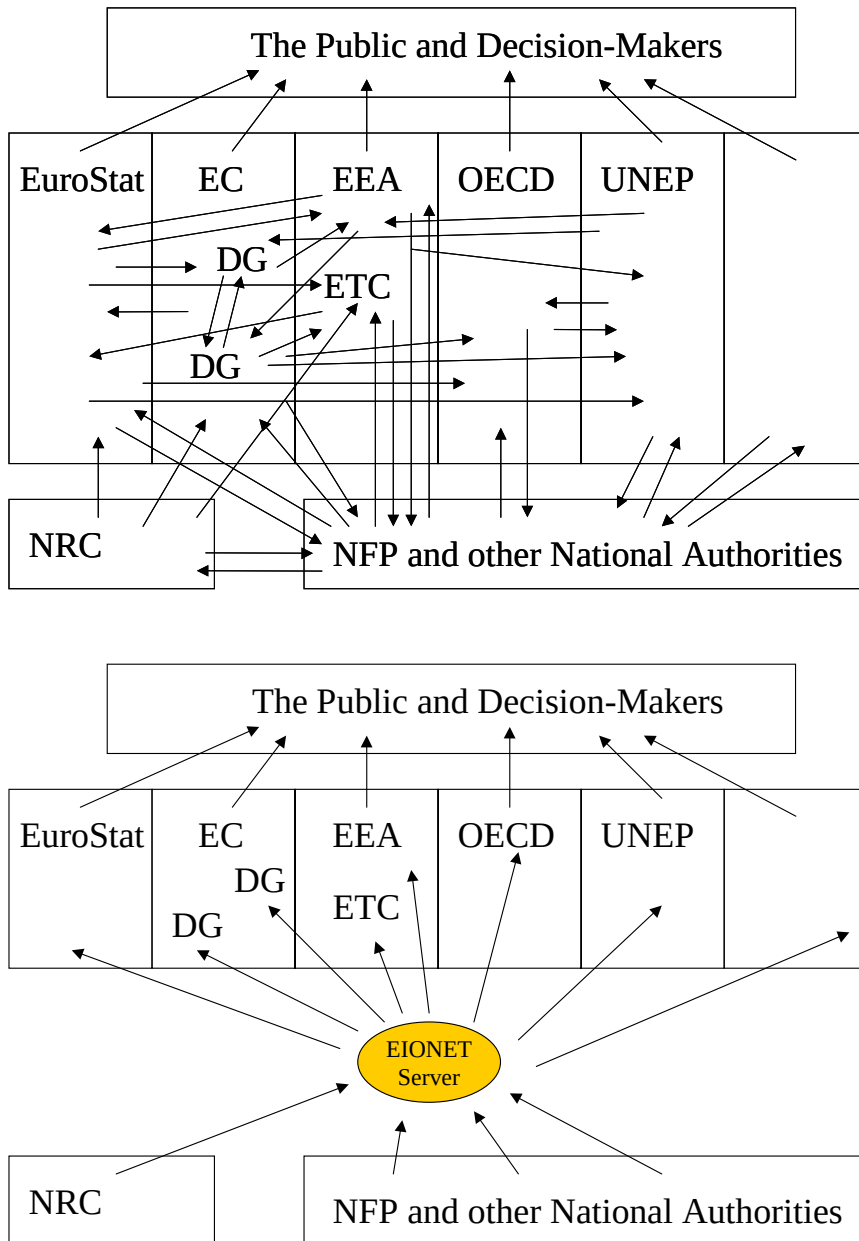


Figure 4. The upper picture illustrates the current situation with historically born ad hoc dataflows on floppies, email, fax and letter. These overlapping dataflows can be streamlined into EIONET's common infrastructure.

in its dataflows instead of creating a redundant reporting system on EIONET. However, there danger that overlapping networks will be born will have to be watched carefully, and for this reason, for instance, the new network for the Clearing House of the Convention of Biodiversity should be hosted on EIONET. The current convergence of technology to Internet will make it increasingly easy to integrate different networks. The solutions chosen for EIONET, Extranet and group collaboration on CIRCLE, are very generic and could easily be duplicated on other networks. In essence, we need to clone EIONET to other economic sectors.

EIONET also can provide a platform for new telematics applications. There is a large user base, well-developed authentication services and increasingly there will be a data base that can be used for automatically generating syntheses of the state of environment.

6 Conclusion

EIONET started as a closed network but is increasingly opening up to new partners. We are still taking the first steps in opening up the information sources on environment and connecting to the real sources of information. In future these connections will be reinforced and increasingly automated.

The best available environmental information is not always with gov-

ernments, but with museums, research groups, NGOs, etc., for which a place must be found in EIONET. Open access to environmental information is the best guarantee that improvement in the state of environment can be achieved. When information is released, it will create positive pressure from the citizens towards those who place stress on environment. It will also lead into increased quality control on the information itself. New forms of electronic democracy are being created around the discussion on the state of environment.

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The system of forest management in Croatia

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Abstract

Forest management in Croatia has a very long tradition and a prominent role in the history of forestry, particularly in the post-communist period and in the process of denationalization. The numerous activities of the 150-year-old Association of Forestry Engineers and Technicians include the publication of a scientific-specialist paper “Forestry Journal”, which has been coming out for 120 years. The foundations of present-day forestry were laid down in the Austro-Hungarian Empire, when Maria Theresa issued a legal order called “Urbarium”. Today, modern forestry is based on the system of forest management which unites and complements other systems in forestry. The introduction of new technologies for data collecting, storage and communication, accompanied with training forest staff in the usage and transfer of know-how in practice, has enabled the creation of a new system of forest management.

Keywords: forest management system, natural forests, new technologies, data base, remote sensing, Croatia

I Introduction

I.1 The history of the system of forest management

The first written documents in Croatia are contained in the statutes of coastal towns dating from the 13th century. All these statutes (Korčula 1214, Trogir 1240, Dubrovnik 1272)

prescribed measures for forest protection, banned or regulated felling activities and pine bark removal, and other items (Meštrović, 1992). Felling on the hill of Marjan was banned by the Statute of Split (1312). The Poljice Statute (1333) defined the problems of grazing, firewood, pastures and hunting.

“The First General Forest Act” (1451) originates from Istria. The establishment of oak reserves for the need of arsenals and the building of

waterways was regulated by the law from 1470.

Cutting down forests and turning forestland into ploughfields, meadows and pastures was banned by the laws from 1475 and 1495.

In order to ensure the success of these provisions, the Council of Ten (1538) appointed the timber official for Istria, Kvarner, and Dalmatia, and issued an order for an accurate cadaster to be drawn up in six months' time.

A new, more detailed cadaster plan about some taxation elements was based on the 1568 Decree. It was revised every 20 years until 1801. Forests were divided into annual felling strips and the felling ripeness was determined. Seed bearers were always left standing, while acorn collecting and grazing were banned for certain periods of time. In other Croatian regions most of the forests were owned by feudal lords until the 16th century.

Parts of forests were excluded from feudal ownership by the Segregation of 1876, thus leading to the formation of land communities.

By the Act of 1871, the right to use parts of state forests was bought off, and forests were divided into state and municipal ones/forests of income municipalities).

In 1769, Empress Maria Theresa issued a "Legal Forest Order" in the Croatian language, where methods of forest division into annual felling strips were prescribed, and rotations determined (oak: 200 years, maple: 100–150 years, beech: 120–150 years, poplar, linden and elm: 30–50 years, birch: 30–50 years, willow: 20–30 years, alder: 40–50 years, fir and spruce: 80–100 years). On the

basis of this Order, management bases were drawn up in 1769, 1853, 1875, and 1881.

In 1852, the "General Forest Law" was completed, which provided a cornerstone for forest management in general. The first forestry school in the Slavic south was established in Križevci in 1860. An "Instruction for mensuration, assessment and tending forests in the income municipalities in the Croatian-Slovenian Krajina" was passed in 1881. It prescribed the regulation of annual cuts according to the Austrian tax of 1788, which determined sale values of forests. The method was aimed at establishing a normal growing stock in forests so that the principle of sustainability could be maintained.

In 1894, a "Law regulating the appointment of expert staff and the use of forest management in forests of special public interest" was passed, while, a "Decree on the compatibility of management basis and programmes, and annual felling and tending programmes", with its component part "A direction for drawing up management bases and programmes" was passed in 1903. The direction gave a detailed account of all steps to be taken in dividing forests into management units (management classes), felling sequences, departments and divisions. A sustainable yield was prescribed with rotations of absolute maturity, as well as felling methods (clear, regeneration, selection, group cutting). A "combined area and growing stock method" was prescribed for high forests with clearcutting and regeneration

cutting, and a “norm method” for high selection forests.

“The Instruction” from 1903 was applied to all forests except the state ones. On the basis of Forest Law from 1929, “Guidelines for the management of state forests” were drawn in 1931. They prescribed management entities which were divided into management units, which were further divided into departments and divisions, while a “method of age class” was prescribed for high regular forests with stand management. A control method was prescribed for selection forests. As these were impractical to use, the “Instructions for tree marking and determining yields in selection forests” were passed in 1937.

In 1946, “Temporary instructions for forest inventory” were passed, and in 1948, “General instructions for forest management”, prescribing the drawing up of a general plan for a forest area and of a special study for each management unit. In 1961, a “New system of managing selection forests” was drawn up by D. Klepac, based on the optimal state.

A new Forest Act was passed in 1967, followed by a “Regulation on drawing up forest-economic bases, forest management bases and forest improvement bases” in 1968. In 1976, a new “Regulation on drawing up forest-economic bases, management bases and forest improvement bases” was passed.

Based on the Forest Act (1977), a “Regulation on methods of drawing up area forest management bases, management bases for management units, and forest management programmes” was passed in 1981.

A new “Regulation” was passed in 1985.

A new Forest Act was passed in 1990, a new Regulation in 1992, and the latest valid “Regulation on drawing up the management plan” (Meštrović 1978, Meštrović et al. 1992) was drawn up in 1997.

Piškorić and Vukelić (1992) mention the following important dates:

- 1860: the agricultural-forestry school was established in Križevci,
- 1876: the Croatian-Slavonian Forestry Association was founded,
- 1877: the first issue of Forestry Journal came out,
- 1898: the Forestry Academy was established,
- 1919: the Agriculture and Forestry Faculty of Zagreb University was founded,
- 1945: the Institute of Forest and Hunting Research was founded in Zagreb,
- 1947: the Institute of Karst Afforestation and Amelioration was founded in Split,
- 1949: the Institute of Timber Industry Research was founded,
- 1969: the independent Forestry Faculty of Zagreb University came into being,
- 1974: the Forest Research Institute was established in Jastrebarsko.

1.2 On the system and method of forest management

Contemporary theory and practice utilizes two methods of determining yields in high forests. One is the old, classical, well-established method based on age, rotation and age class. The other is a newer, biologically and economically more adequate method suitable both for forests of unequal composition and for selection forests. This method uses increment and volume grouped according to diameter classes (Miletić 1987).

Modern forest management aims at utilizing manifold functions of a forest by taking into account physical, economic and social criteria. Apart from direct benefits from forests, indirect ones, which often surpass the former, are also regarded, especially in terms of the protection of the environment (Klepac 1987).

Miletić (1987) writes about various methods of forest management and their systems used for shorter or longer periods in Croatian forestry.

Klepac (1980) writes about the measures undertaken to promote forestry development in Croatia in the spirit of the message from the Fifth World Forestry Congress in Seattle.

Klepac (1984) talks about the system and method of managing forests in the "Plitvice Lakes" National Park, based on the management programme for these forests, where the selection method was adopted.

Forest management in the light of the achievements in forestry science and economic development was the

subject of a symposium held in 1985 (Meštrović).

In the fifties, Horvat and Bertović (1961) introduced a new interdisciplinary approach to forest management in Croatia, which was later further developed and applied in practice by Cestar et al. (1979). Scientific disciplines of geology, pedology, phytocoenology, forest management, silviculture, and forest economics were united under a discipline called forest typology. Today, forest typology has become a new integral scientific discipline, which is based on an extensive data fund collected in about 3 000 plots over a period of 30 years (Krznar 1991). This has led to the formation of a modern data base (BAZA EGT RH) backed by technological support (Bekić et al. 1992). The data base has enabled a new approach to analysing and studying structural elements in forest ecosystems, and, with the use of modelling tools, has provided a foundation for checking (confirming) old results and drawing up new models in today's changed circumstances.

2 New technologies

Several centuries of managing forests and forestland, regulated by legislative measures, has resulted in the present state of forests in Croatia, which are mostly of natural origin. This provided a base for the creation of a system of forest management with a modern organizational form which follows world developments and adapts them to conditions in Croatia. In Croatia, forest manage-

ment is a leading scientific discipline which utilizes the latest and the most modern technologies in forestry.

2.1 Data base

There are several data bases in Croatian forestry, of which the most important are BAZA EGT HR of the Forest Research Institute in Jastrebarsko (Bekić et al. 1992), his fund containing data on the forest fund of the State Enterprise "Croatian Forests" and Hydro-pedological Base of the Forest Institute in Jastrebarsko.

2.2 Remote sensing

A photographic interpretation key was drawn up for individual tree species and for degrees of damage by using infrared colour aerial photographs (CIR) (Pernar 1994). The relationship between the degree of damage in pedunculate oak, determined by aerial photographs, and the colour of recordings per components, provided strong correlative links which can be shown with linear regression equation. Analyses showed that data do not differ from terrestrial data. The photographic interpretation key enables a completely objective photointerpretation of infrared colour aerial photographs used in damage assessment in pedunculate oak trees and stands.

The degree of forest tree and stand damage was assessed with the ICK interpretation of aerial photographs in beech-fir forests. The level at which satellite photographs in

Croatia are used today was described, and guidelines for their introduction and use in the Croatian forestry were given (Kalafadžić et al. 1993).

Kalafadžić and Kušan (1993) consider the possibility of obtaining information on forests from artificial earth satellites.

Scientists have used CIR aerial photographs for manifold applications: for example, for determining forest condition in large areas (Kalafadžić and Kušan 1990), for forest damage assessment (Kalafadžić et al. 1989a, 1989b, 1990a, 1990b, 1991, 1993, Kušan et al. 1994, Pernar 1994, Kušan and Pernar 1996), for estimating structural elements in a stand (Benko 1993, 1997, Benko et al. 1996a, 1996b, Benko and Szivovics 1998), Kušan and Pernar 1996), for digital photographic interpretation (Kalafadžić and Kušan 1988, Benko and Biljecki 1998), for the application of satellite photographs (Benko et al. 1993, Kušan and Lampek 1994, Lampek and Kušan 1994, Kušan et al. 1997), and others.

2.3 Geographic information systems

The foundation of the Yugoslav GIZIS project (geographic and land information system) in 1987 marks the beginning of GIS in Croatia. The founding members of the project were, along with five institutions from Slovenia, INA-Projekt, the "Ruđer Bošković" Institute, Faculty of Geodesy, Infosistem, Faculty of Forestry and INA-EOP, all from

Zagreb. When the representative office of the ESBI company, the GISDATA, was founded in Croatia, the market was open for GIS programme packages, and a more systematic study of GIS technology began. So far, a number of institutions have obtained GIS programme packages, and several have made pilot projects in the following fields: horticulture, war damage, spatial categorization with regard to site quality, spatial planning.

Several examples of GIS technology application have been made in the Croatian forestry so far:

- the GIS model for NPŠO “OPEKA” (Kušan et al. 1992a),
- the GIS model applied in forest management (Kušan and Kalafadžić 1992),
- the GIS model applied in forest exploitation (Kušan et al. 1992b),
- pilot-project for the application of GIS technology in grouping forests in Croatia for the needs of seed production (Benko et al. 1993).

The application of GIS on forestry as one of the layers for a global problem solution was presented through the use of satellite photographs. (Benko et al. 1993).

Pernar (1997) made a grid GIS model for the National Park “Risnjak”, composed of 30 thematic layers with attributive data bases.

Proposals for the introduction of GIS into forestry were given by Ananić et al. (1994), Kušan (1996), Benko et al. (1993), and Kušan and Kalafadžić (1994).

2.4 GPS

The GPS was first used for forest mapping in karst regions in the course of drawing up programmes of forest management. The first results were presented at a seminar on forest management, but they have not been published yet.

2.5 Networking

Of all network systems, the most developed is the one of the State Enterprise “Croatian Forests”, connecting about 600 personal computers in forest stations, forest management offices and forest headquarters. Data are exchanged via e-mail, and are based on modem communication with switch telephone lines.

3 Application

3.1 Modelling and simulating

A regression model for the assessment of pedunculate oak stand volume in aerial photographs was made by Kušan and Krejči (1993), Benko (1997), and Benko et al. (1996), and that for the evaluation of Aleppo pine volume by Benko et al. (1997).

Lukić et al. (1988) dealt with the simulation of pedunculate oak development, while Čavlović (1996) simulated system dynamics in planning the management of even-aged forests.

3.2 Mapping

Digitalization and scanning have lately been used for forest and forestland mapping. A digitalized pedological map was drawn up for the forests along the river Drava in north-west Croatia (Mayer and Bušić 1996), a compilation of digital and scanned layers of the management map was made for the Borik park forest (Benko et al. 1997), a pedological, phytocoenological and typological map of a section of forests around Pakrac was digitalized for the needs of forest zoning (Benko et al. 1993), mapping of land use by interpreting satellite photographs of a narrow area in Lonjsko polje was conducted (Kušan and Lampeš 1994), and most recently, the first digital orthographic map in Croatia was drawn up covering a narrow section in the west of Island Korčula (Benko and Biljecki 1998).

3.3 Forest inventory

So far, no forest and forestland inventory has been made in Croatia at the national level. For the moment, the system of forest management involves partial inventories carried out in management units every 10 years. Forests and forestland are divided into about 650 management units, each of about 500–5,000 ha in size, depending on terrain configuration, complexity, ownership, historical background, tradition and accessibility of forests. Each year, inventories and management is carried out in about 1/10 of management units.

Kalafadžić and Kušan (1991), together with numerous other authors, propose improvements in forest inventories in Croatia based on the experience of other countries and the results of the latest research and new technologies.

3.4 Forest damage

A systematic forest damage assessment is carried out terrestrially every year in bioindication points distributed according to the Gauss-Kruger network. Lately, forest damage assessment has been conducted using the CIR aerial photographs, but only in small areas. The problem was studied by Kalafadžić et al. (1989a,b, 1990a,b,c, 1991, 1993a,b, 1994), Kalafadžić and Kušan (1990, 1989), Kušan et al. (1994), Pernar (1994), Kušan and Pernar (1996).

3.5 Data availability and potential users

The results of research and their application are stored in the IBM compatible personal computers, mostly in the Windows programmes. A part of the data is available to all Internet users through the Croatian Academic network CARNet. The rest is being prepared and adapted for inclusion into these network systems.

The SE “Croatian Forests” data base was made in FOX programme package, while the one of the Forestry Institute (BAZA EGT RH) was made in Access (MS Office 97). Both data bases are continually complemented with new and old data

(BAZA EGT HR) collected in the last 30 years.

The potential users are all scientific institutions, and other governmental institutions and organizations, state companies and all those interested in the matter.

4 Discussion

In the turbulent course of the last eight centuries, starting from the first written documents on forests in these regions, forestry has developed into a modern, well-organized discipline, accompanied and supported by scientific thought and study. On its long path, it has encountered numerous obstacles and been exposed to various foreign influences. Despite all this, it has managed to fulfil its manifold goals: the satisfaction of people's needs for timber and forest-wood, the preservation of its identity, and the maintenance of natural ecosystems. As natural ecosystems account for over one third of the Croatian territory, they provide a fundamental and permanent source of forests and forestland for future generations to use in their various forms. Sustainable management, as the principal and permanent aim of forest management, and stable systems, contribute to meeting the needs of all those living in these areas.

New technologies in data collecting, storing and communicating are growing in use on a daily basis. There are certain difficulties in their mass application, but so is the case in all transitional countries. The availability of information, know-how and research results through various

communication systems, the formation of expert staff, and the transfer of the former into practice, will enable the creation of a new system of forest management. This will be a long-term and slow process, affected by various elements in economic policy, but it will provide a sound groundwork to the benefit of all.

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Statistical nature resource analysis based on the modern spatial server technology

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Abstract

Forest and Park Service is surveying during 1996–1998 biotopes and geomorphology in the northernmost Lapland. The complete data set will contain nearly one million spatial features, most of these are biotope regions covering about 2,5 million hectares of the land area administered by the Forest and Park Service. Along the nature survey the FFPS is designing and building a modern spatial information system and DBMS to manage surveying information of both spatial and non-spatial features of northern nature. Because standard RDBMS's does not support neither complex spatial data types or topological relations between objects, and a data volume of a normal spatial database is very large compared to traditional operational, modern spatial server technologies have been developed to avoid those problems: spatial middleware has a functionality to model and store complex spatial information as well to index the data spatially using e.g. R-Trees. Spatial SQL3-functions cover data retrieval within a spatial aspect, various geometric overlays and metric calculations which can be used directly from the client applications with no spatial interface.

Keywords: Forest resources, arctic environment, spatial server technology, ecosystem mapping, spatial statistics

I Inventory systems pilot of Forest and Park Service

I.1 Nature survey of the northernmost Lapland

Finnish Forest and Park Service (Metsähallitus, the FPS) is surveying biotopes and geomorphology during 1996–1998 in the northernmost Lapland (Fig. 1). The complete data set will contain nearly one million spatial features, most of these are biotope regions covering about 2,5 million hectares of the land area administered by Forest and Park Service, which is about 30 % of the total coverage administrated by the FPS. Along the nature survey the FPS is designing and building modern spatial information and database management systems (DBMS) to manage surveying information of both

spatial and non-spatial features of northern nature. The geographical information system (GIS) development is carried as a pilot project for the 3rd generation integrated GIS in the FPS.

A biotope is a region or a group of regions having homogenous attribute values. Biotope regions are almost similar to forest stands, but much more information is collected about flora and site properties, especially on peat lands and mires. The size of a biotope polygon varies between 1 to 100 hectares. The aspect is hence to document natural resources from a view of nature protection instead of foresters.

I.2 GIS pilot project

Current 2nd generation's geographical information systems (forestry, land use) of the FPS are based on an Oracle RDBMS and a Swiss-

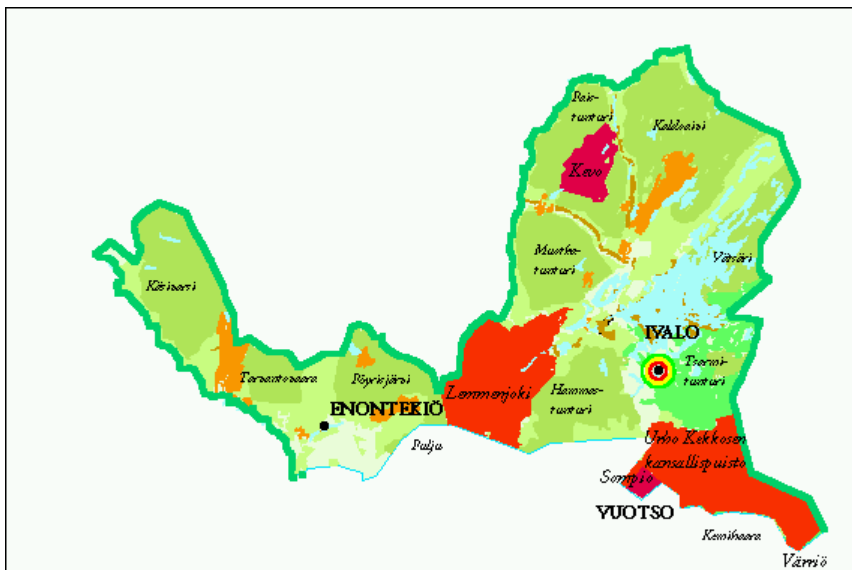


Figure 1. Nature survey area.

German product **Gradis-GIS**, which is an object oriented software for managing seamless spatial databases in a multi-user environment (unix). The system development ended in 1996.

During a product and technology survey in 1997 the FPS studied two main technologies: systems based on a heavy GIS-product (SmallWorld GIS, Xforest/GISBase) and client/server solutions based on GIS engines (MapInfo SpatialWare and ESRI's SDE). The FPS made a decision to go further with c/s-architecture.

The pilot system is based on the modern **MapInfo Spatial Ware** server technology and used clients are standard applications like **Microsoft Excel** (visualisation of simple thematic maps and tabular work sheets) and **MapInfo Professional** desk-top GIS-installations. Attribute values are handled and maintained in the form oriented **PowerBuilder**-application (a prod-

uct of Sybase inc.), which is also a core for the statistical reporting.

Our goal is to produce very complex statistical reports and thematic maps driven by attribute values stored in the biotope database. It is possible to study freely defined regions of interest using the state-of-the-art spatial server technology and low cost desk-top mapping packages, such as MapInfo.

1.3 Work flow of refining field data to integrated information

The inventory survey is done by field surveys of pre-selected key stands (summer) and stereo interpretation (winter) on IR aerial images. The ratio between surveyed and interpreted biotope areas is about 15%. Biotope polygons are then drawn from aerial photos on the base map transparency (Fig. 2). A consulting

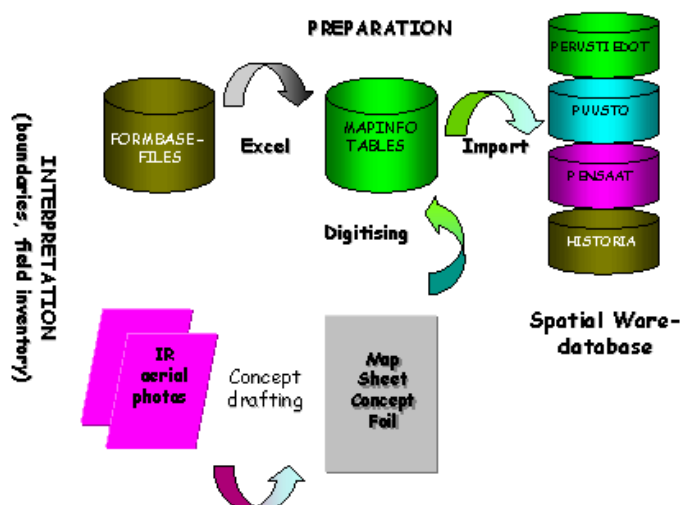


Figure 2. The work flow of data capture

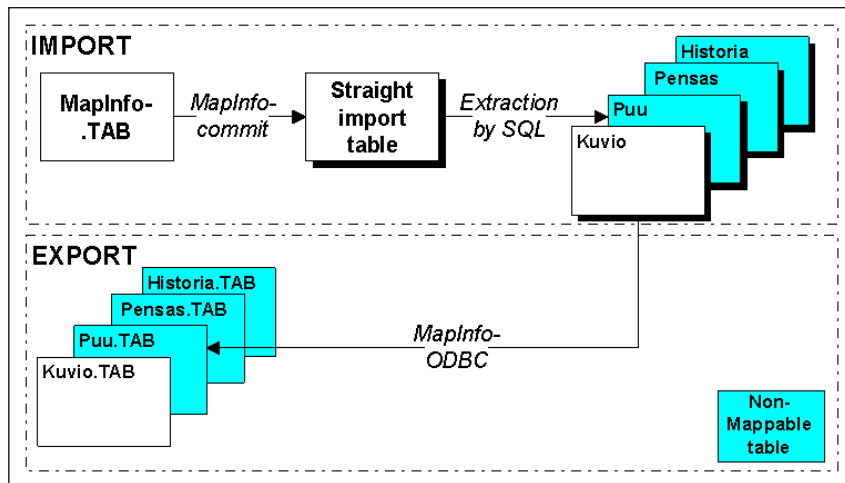


Figure 3. The Import/Export of mapping data

company is digitising map sheets (ca. 400 sheets of 10x10 km²) into simple MapInfo databases.

The data capture environment is very low cost and it did not require much programming or design work. Attributes are entered by using a Xerox's card file software **FormBase** v1.0. FormBase databases and single map sheets can be coupled together in MapInfo for simple thematic map production or inspection of data quality.

Map databases of the first phase are not yet relational. The next task is to load tabular data into the relational environment managed by the Spatial Ware server.

The data model (Fig. 4) and a simplified representation about a data flow process (Fig. 3) are shown above. The first import table is just an image of a plain MapInfo-database table. The data is moved from MapInfo-tables by using a unix level import utility, which is part of Spatial Ware core software. After that the

data is checked and loaded into four relational tables with an aid of sequence of SQL-selections. During the final import it is possible to check and repair topological inconsistencies on a polygon network.

1.4 Current status

A development team set requirements for the system about 1,5 years along field inventories and data capture. The system planning and design on a spatial server environment started in November 1997 with consulting database experts. The work was finished in January 1998, and the implementation phase took a time span of 3,5 months, from February to May. The pilot installation is now made and it is in use until the end of August.

The captured data is in the MapInfo format and FormBase attribute tables can be read and linked directly to the map data. Linked ta-

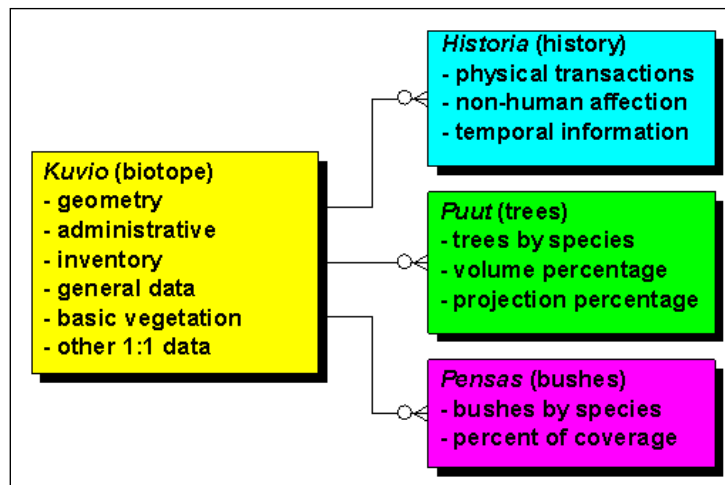


Figure 4. The relational data model of a biotope

bles are to be loaded into the centralised and seamless database. This work is in progress.

2 Introduction to the spatial server technology

2.1 Spatial Server technology

Standard RDBMSes do not support neither complex spatial data types; areas and linear features, nor topological relations between these objects. A data volume of a normal spatial database is very large compared to traditional operational databases, which reduces the performance of spatial queries and retrieval.

Modern spatial server technologies have been developed to avoid problems mentioned above: spatial middleware has a functionality to **model** and **store** complex spatial in-

formation as well to **index** the data spatially using e.g. R-Trees. Even the server application itself contains no graphics, it can perform analysis tasks by using SQL3-extensions. Spatial functions cover **data retrieval** within a spatial aspect, various geometric overlays and metric calculations which can be used directly from the client applications.

Spatial servers can be considered as standard interfacing layers between client applications and spatial databases. Servers have the full GIS-functionality except map visualisation. Separate client software is used as a map interface.

2.2 Server functionality

The server itself is one unix process per client. The server takes care about tasks described in the following chapters. Tools are delivered with a server there for system management, spatial queries and analysis (Fig. 5).

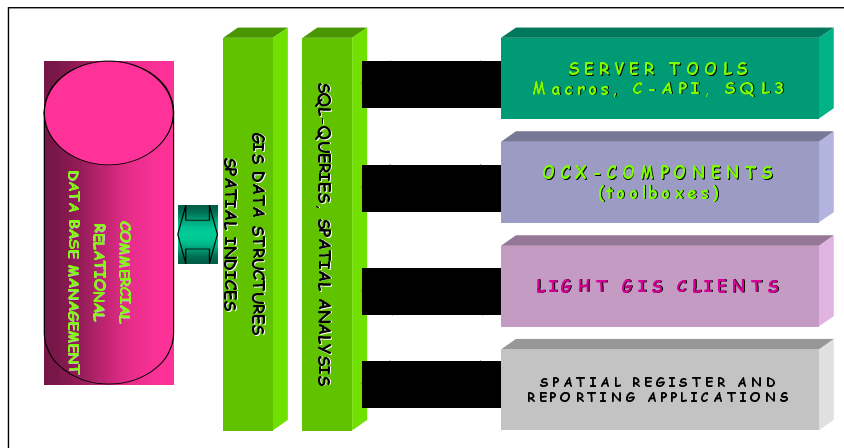


Figure 5. Server architecture

A unix level SQL3-interface (sql_spatial-program) comes with server software. This can send spatial SQL3-queries and encode geometric information. An ODBC-driver uses the same SQL-syntax than the line oriented SQL-interface.

Applications can be developed under unix with a Tcl/Tk-scripting language, which contains interfacing layers to graphics and SQL3. Part of supporting software is made by using Tcl/Tk. Other possibility on the unix level is to use C-API-library, which can be linked to applications.

2.2.1 Spatial data types

A primitive entity of the spatial data is a co-ordinate point. Higher geometric entities, such as linear and area features are constructed of point sequences. In a standard relational database the only spatial entity which can be modelled directly in the data model is a point (x, y, z). Complex geometry hierarchies must be de-

coded and stored into binary fields of relational tables by a server functionality. The decoded geometry data can not be used via standard database tools.

2.2.2 Spatial indexing

Even a small spatial database contains a very large volume of information compared to conventional information systems. A performance of retrieval of query results is better if a data field to be queried is indexed. Because the geometry is stored in one binary field, that can not be indexed as a normal relational 1-dimensional attribute.

The server system creates and maintains a spatial R-tree index of multi-dimensional geometry. With these indices the performance of spatial queries and encoding of geometry is hundreds of times better than without indexing.

tations. Functions which calculate new geometry as a result: *Adjacent()*, *Buffer()*, *Centroid()*, *Contain()*, *Geometry_union()*, *MER()*, *Overlap()* and *Skeleton()*.

Special spatial comparison operators return a logical value. These are predicates between compared value formulas in the where-clause of SQL syntax. Instead of comparing just values of attributes (**a** is greater than **b**), spatial predicates use either geometric or topologic properties of spatial objects (i.e. a point is **located** inside of an specified area). Predicates supported by Spatial Ware: AT START OF, AT END OF, CONNECTED [TO], OVERLAPS, CONTAINS, [IS] CONTAINED [BY] and [IS] ADJACENT [TO].

In the Figure 6 are shown endangered species (bird and tree symbols) and biotope stands. A study area (re-

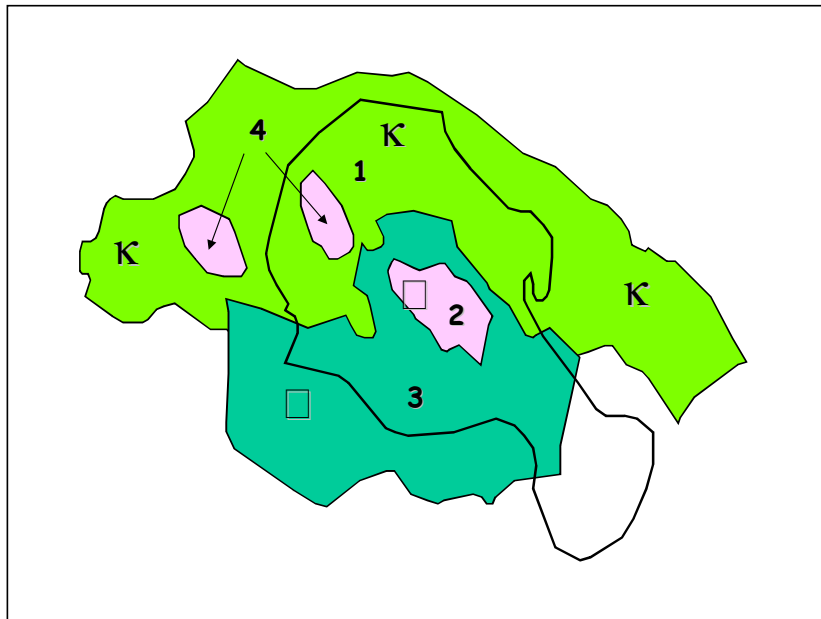


Figure 6. An query example of SQL3.

gion-of-interest) is marked as a black solid border. It is possible to calculate overlapping biotope areas and retrieve any point which is inside the study area (X) without a map interface, just using SQL3 directly or from a client application through ODBC.

```
SELECT area(Overlap(biotope_area,
                    study_area))
FROM biotope_table, study_table
WHERE biotope_area OVERLAPS
      study_area AND study_area = x;

SELECT object_data
FROM endangered_table
WHERE endangered IS CONTAINED BY
      study_area AND study_area = x;
```

2.2.4 Server Interface

One major task of the spatial server is to be a uniform interfacing layer to all client applications. The interfacing is described more detailed in the chapter 2.2. A basic idea is that the server does not have to know anything about client applications, but the connection (a messaging layer) between clients and the server database is standardised. The data integrity is maintained either by using constraints of the RDBMS or it is programmed in the interface layer on the server's side. That will always secure the integrity even the client software can not take the full advantage of all features of the data.

The server can perform analysis requests from the client, too. This makes possible to integrate spatial functionality into applications which don't have any map interface or spatial functionality.

3 Client applications environment

Client applications are scalable with a functionality and intelligence. The application itself does not have to have any spatial functionality, the spatial processing can be done on the server's side. Or a client can be a full scale GIS-system which only needs an interface to the pure spatial data. The most relevant clients are described in the following chapters.

3.1 Essential clients for integrated usage

Clients are communicating with the database through ODBC-compliant database drivers or linked programming libraries, like C application interfaces (C-API, see Fig. 7).

The FPS has defined four categories of client applications. These are

1. Server tools for snapshots or spatial queries.
2. Non-spatial ODBC-clients (register, reporting and data warehouse applications).
3. Customised spatial applications built with spatial toolkits.
4. Professional stand-alone software packages using the centralised data.

Server tool is either a command line SQL3-interface or a simple Tcl/Tk-script. Non-spatial applications (often form based) can use spatial data and functions through an ODBC-connection without a visible map. Essential spatial functions consist of area or other metric calculations and intersection calculations and selec-

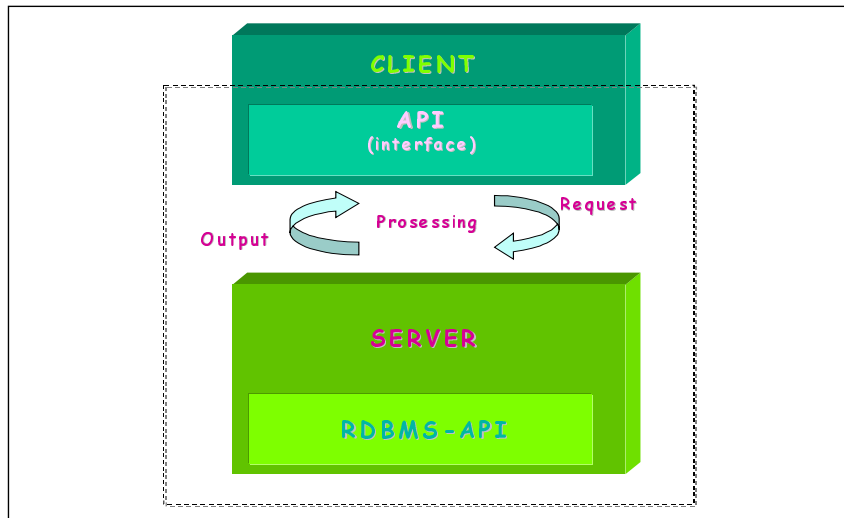


Figure 7. C/S concept (A simplified model)

tions with a spatial aspect. Spatial toolkits are program libraries containing an interfacing client API for the database. A part of the functionality can be linked other applications. MAP/X is a commercial product for the MapInfo Spatial Ware-environment.

The clients of the pilot are MapInfo Professional 4.5. as a map client and a PowerBuilder ODBC-client as a register and reporting application. These sub-systems work in conjunction (see Fig. 9). Objects can be equally selected from the map or form views and the selection is reflected on-line to an another application through a DDE- or OLE-link.

A MapInfo client is slightly customised version (with an ODBC-driver) of a standard MI Professional product. Even single objects can be uploaded from the database with the link. A conflict mechanism detects and reports concurrent manipulations

of objects during a download process.

LUOTI Register Application is a client which is made with PowerBuilder. The attribute data is processed and the integrity is maintained by LUOTI application. It has a form based interface to the data. Register Application uses spatial functions of the server for selections and area calculations. The area value of a polygons or virtual polygons (polygon overlays) is not stored in the database but calculated on-the-fly whenever needed.

Various statistical reports about classified areas, timber volumes etc. can be generated with LUOTI. The basis for reporting is a *virtual polygon* which is an overlay between a statistical area (watershed, nature park, municipality, reindeer district...) and an overlapping biotope polygon.

The report is a non-formatted ASCII file which is opened and formatted automatically with VBA-macros of Microsoft Excel. The final formatting with statistical column and row information is finished and formatted in the Excel application. In the future the MS-Map for Excel will be used to visualise map data in this environment.

3.1 Metadata

Metadata is information about the data and its logical structures. The spatial data should be uniformly described for client applications, especially in environments of multiple users and various client products.

Neither the Spatial Ware- server nor MapInfo- client software support real metadata management. During the implementation the Metadata Management Service has been implemented on the server's side.

The metadata engine (Fig. 8) is used to uniform the conceptual data model and different models used by clients.

The data model describes a conceptual architecture. The physical description is how the data is stored in the server database and client objects are for the implementation in the MapInfo client.

3.2 Feature classification

The feature class is the primary attribute for every object. That tells, what the object is in the real world. The data model will finally contain approximately 1000 primary feature classes. Every feature class belongs to a feature group where the attribute structure is homogenous.

The naming convention makes the data model hierarchic. I.e. an feature class "G11-01 (motorway)" is constructed the following way: the first letter *G* is *semantically* an application group *Base Map*. G1 stands for all traffic networks. G11 means the road network (physically a table). A code 01 is an attribute value of class and stands for a *motorways* feature class. With that notation is possible to select all roads (codes from

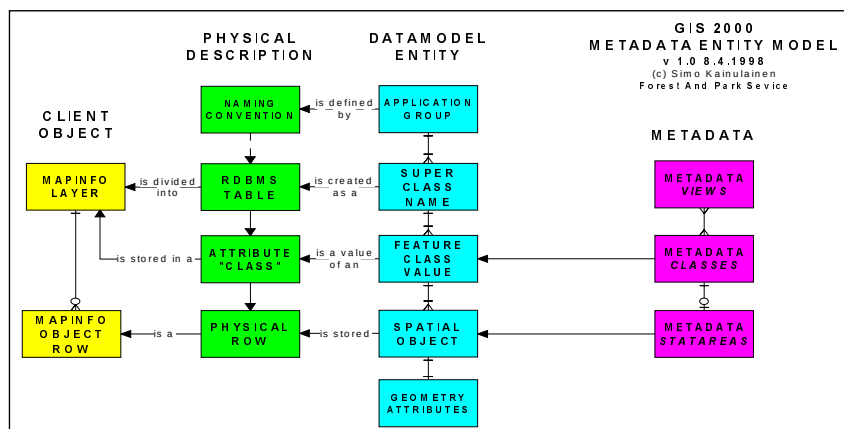


Figure 8. Different conceptual levels of the metadata engine

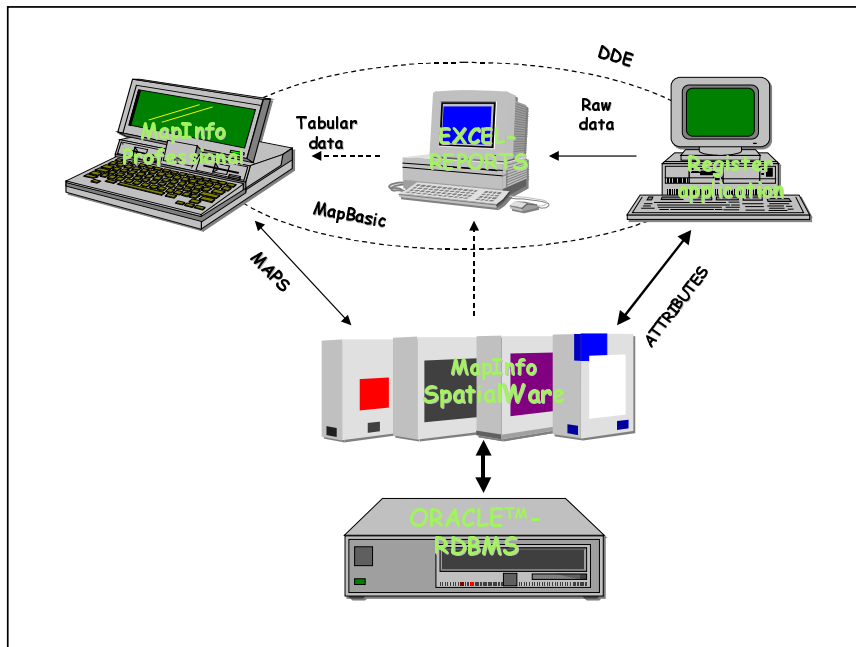


Figure 9. Data interchange and messaging between sub-systems

G11-01 to G11-06) or all traffic networks (codes starting with G1).

The classification and descriptions is stored in the *meta classes* table. For a usage it's convenient to group set of classes inside a *meta view* and select them all together into the application. Some of feature classes are statistical areas for reporting. The list and description of those are stored in the *meta statareas*.

3.3 System design

The system implementation is based on industrial standards which are supported by the Windows NT-operating system. All connections be-

tween client systems and the servers are realised by using the ODBC or DDE links. The data which goes through client applications confront all OLE/COM requirements.

When a user selects an object in the mapper client, the unique id is sent to a register application through a DDE link. If a new object is selected in the register application, a mapbasic command is sent to select same object on the mapper automatically. It is also possible to create and store user definable **working sets** of objects and name and store them in the database table, which is open to all applications.

Decision Support System for predicting co-natural forest stand development

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Abstract

There is a long tradition of co-natural forest management in Slovenia. Since the end of the second world war clear cuttings are forbidden and site specific, environmentally oriented forest management is applied in our concept of work. Researchers, scientists and field workers are aware of the importance to preserve the only renewable natural resource – forest. They take great effort in finding new directions and developing modern tools for keeping diverse and healthy forest. Our forest management system is based on forest management, silviculture and operational planning. Planning process and forest information system are closely related. The input data for planning process are provided by forest inventory and mainly these data are used in decision making process.

A Decision Support System (DSS) for predicting forest stand development using different management scenario is represented. Computer supported DSS provides prediction of stand structure and cutting volumes by using different production periods and different thinning operation intensity in forest planning process. Co-natural development is provided by goal function which is determined with potential natural structure of tree volumes defined by site requirements (vegetation association). A step of ten year time period is used for predicting stand dynamic. Output data on stand structure, cutting volumes compared with model optimal situation are provided. We calculated the difference between actual and potential natural stand structure. Index of co-natural stand structure based on difference was used to determine thinning intensity for next prediction period and also for evaluating success of management scenario. DSS provides data which could be used in all three components of our planning process. Its application is not limited by area, but only by availability and accuracy of input data. DSS was tested using real data and results are represented for mountain forests in model forest enterprise unit (cca. 5 000 ha) for a time period of one hundred years.

Keywords: computer model, forest stand development, forest planning, decision support system, production period, prediction, scenario

I Introduction

Slovenian forests have always been under strong influence of human needs concerning wood extraction and lately also under strong influences of industrial emissions which have impact on natural environment. Forest and human must and should live together and therefore it is not possible to avoid some consequences which are shown as changes in forest structures caused due to reactions of human impacts on forests. Most obvious changes caused by human management activities are changes in tree species, social stage and age structure of forest stands.

At the beginning there was a silvicultural uncontrolled process of wood extraction, forced only by current needs and extraction possibilities. Later, when wood shortage occurred, a man had to think of sustained wood production. In different stages of history silviculture treatments had various aims. The influence of human activities was so huge that nowadays we could not find forests with purely natural development with primary association and selection of plant and animal species.

On the basis of research results concerning vegetation succession during time period and data for past forest management activities it is possible to reconstruct an image of potential vegetation type - that is forest stand structure, tree and plant species which are mostly adopted to micro and macro requirements on each specific forest site. Site requirements are defined by ecological influence factors (floor, climatic, relief and other conditions). Plant and ani-

mal species with their structures defined by potential forest vegetation type represent optimal combination with self controlled mechanism for sustained providing various functions of forests and there is no need for human interference. There are cases where production potential of wood in potential vegetation type structures is lower than the production of managed forest in pure commercial manner. Precondition for sustained "overproduction" of wood is caring out forest management activities which accelerate human desired components in natural developments of forest stand structures.

Nowadays computer equipment and information systems enable objective predicting in future development of various systems. We have to know the most important influential factors, their values, form and direction of correlation between each factor and system development. A lot of scientific researches and operational uses in form of decision support systems (DSS) and other computer models are present in today forestry (Siitonen 1994, Petraš 1994, Bevins 1994). A range of forest estate modeling application has also been reviewed (Manley 1998). At the beginning we should provide input data on initial stand structures in defined computer databases, choose desired goal (aim) and incorporate in model algorithm natural trend of forest (stand) development (Fig. 1).

The representation of DSS which could be used for evaluating different forest management activities follows. Basic characteristic are written in following lines:

- Predicting future forest stand structures for time period of one hundred years
- On each step management strategies are defined by difference to potential optimal stand structures.
- There is no human planting of these new plant species which are part of relevant potential vegetation type.
- Forest management activities are predicted using an internal 10-year step to determine log volumes in thinning and final cutting operations.
- Basic cell of simulation is a forest section which is the smallest unit in our forest inventory.
- Successfulness of scenario is measured by index of co-natural stand structure derived by difference between actual and potential optimal stand structure.
- Growing stock compared to model on each time step, is a growing stock of tree species related to the share of forest association and seral stage in each forest section.

DSS is a collection of computer procedures written in program language FoxPro™ and additional modules for enabling link to geographic information system (GIS) analyses (IDRISI™). The structure and the form of input data are the same as those in computer databases of Slovenian forest inventory (Mikulič 1990).

2 Method

2.1 An analyses of actual and the definition of desired goal forest stand structure

The accuracy of every forest scenario modeling depends on reliability in initial information concerning stand structures. Accurate input data on tree volumes, age classes, spatial distribution and areas have to be disposed. Actual values of studied variables must be so precise and complete that they could be used for input data in model with desired accuracy of output data.

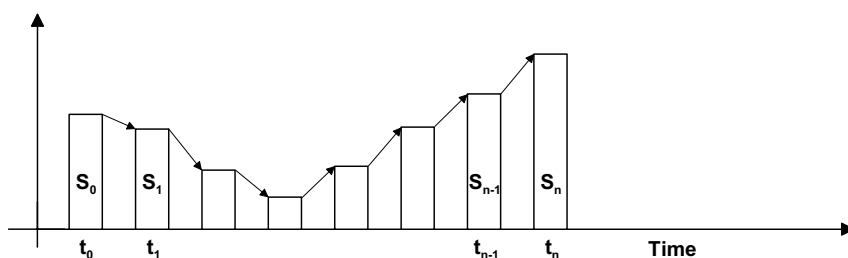


Figure 1. Projection of initial structure (S_0) into new structure (S_n) depends on intermediate structures sequences, natural trend in forest development and forest management activities, defined by desired management strategies ($\rightarrow$).

All results shown in paper are derived by a model study in forest management unit Jezersko which comprises about 5000 ha forest land for the time period from 1990 to 2080. The management unit is divided into 225 forest sections and 197 of them are forests with wood yield. The rest 28 sections are forests with protective or other special functions where no wood yield is planned. The average area of forest section is 23,96 ha.

Goal (desired) structure of tree species growing stock was defined by site conditions (potential forest association) – that is potential vegetation type. For each forest association an optimal share of tree species growing stock was provided. Tree growing stock structure on estate (forest management unit) level was calculated using weighted share of tree species in forest association (Table 1, Table 2). Weights are provided by the sum of forest association areas. In calculation different optimal tree volumes for different forest association are taken.

Table 1. Structure tree species growing stock in forest management unit Jezersko (forest inventory data).

Tree species	% GS*
Spruce	67.89
Fir	2.34
Larch	9.90
Other softwood	0.8
Beech	17.9
Oak	0.02
Other hardwood	1.14

* growing stock

2.2 A simulation of growing stock dynamics in forest stands by tree species

We used sinus function ($\sin(\text{age})$) for the approximation of growing stock development. Final cut was simulated in three sequential ten year steps. In the first and the second step we took 40 %, and in the last third step all (100 %) tree growing stock (Fig. 2).

Prediction of future growing stock by tree species was calculated from actual stand data (forest inventory), actual wood increment for different diameter compartments and predicted cuttings (thinning and final cuttings). Calculation was made for every ten year step consequent from results of prior step.

Seral stage distributions are stabile during simulation - prognosis based on assumption that initial (actual) relation of forest seral stages continuously changes from young to old stages. There are five different classes in structure of tree diameter

Table 2. Model goal structure of tree species growing stock defined by area of forest associations.

Tree species	% GS*
Spruce	6.3
Fir	16.9
Larch	0.2
Other softwood	0.4
Beech	70.1
Oak	1.5
Other hardwood	4.6

* growing stock

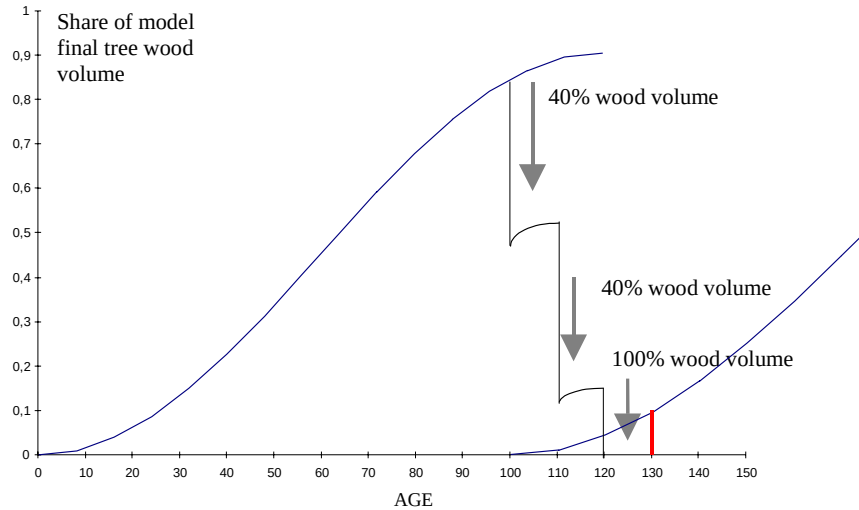


Figure 2. Model for approximation of growth stand growing stock for predicting co-natural forest stand development.

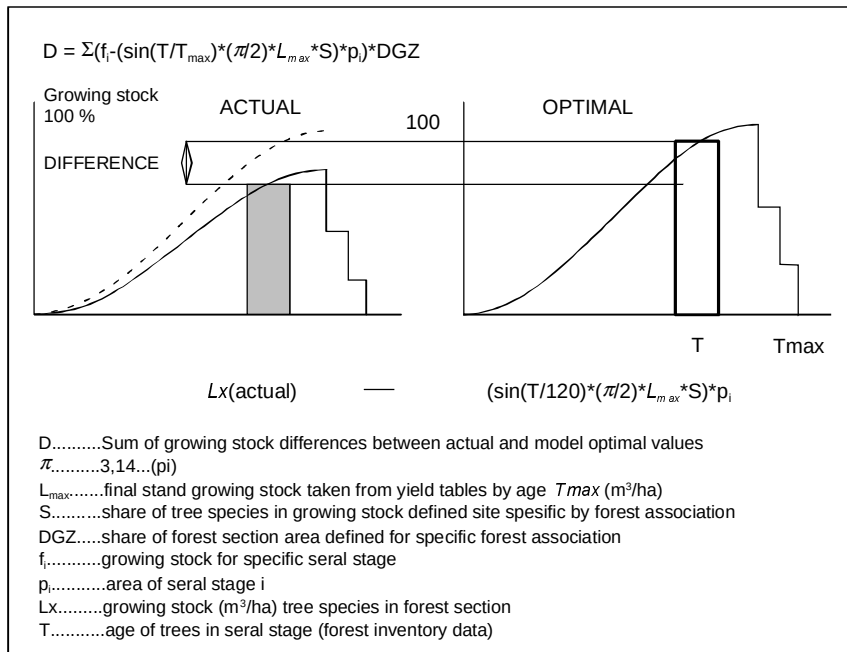


Figure 3. The calculation procedure of sum of growing stock differences by tree species between actual and model optimal values.

related to tree age: young growth (younger than 25 years), early I (from 25 to 50), early II (50 to 80 year), mature (80 to production age – 20 years) and old growth, (production age – 20 years to production age)

2.3 A procedure for comparison of actual and optimal growing stock structure

Every step (ten year) in prognosis had a comparison between actual and potential optimal growing stock. Growing stock was compared to those of model optimal values by the same age. For every forest association in forest section a sum of absolute difference in m^3 was calculated. Absolute difference was used for deriving index of co-natural stand structure.

4.4 A method for determination of index of co-natural stand structure.

Forest section comprises mostly three forest associations. The procedure for comparison of actual and optimal growing stock structure repeats for every tree species three times (three forest associations) (Fig. 4).

2.5 Assuming various management scenarios

We analyzed different management scenarios for approaching desired forest stand structures. Scenario was

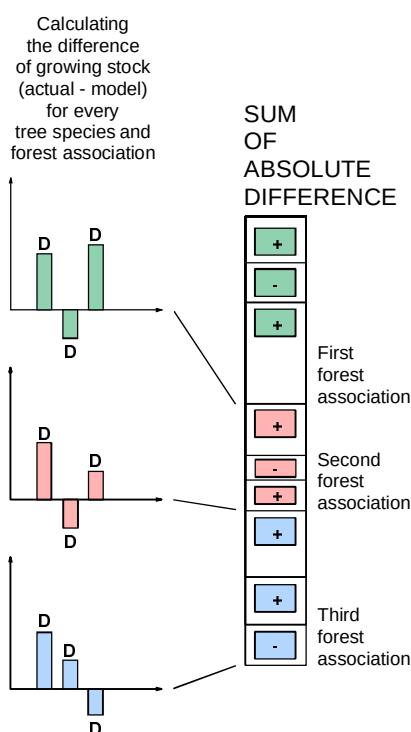


Figure 4. Procedure for summing differences between actual and model growing stock by tree species and forest associations.

determined by three different thinning intensity and also application of three different production periods (Table 3). Yields (harvest volumes) by thinning operation are determined in relation to difference between actual and optimal growing stock of tree species (Fig. 5). Different production ages (120, 140 and 160 years) were applied for scenarios (Fig. 6).

Yields determination for thinning operations is related to difference D (Fig. 3) between actual and optimal growing stock of tree species for forest association. Independent variable

Table 3. Scenarios for predicting forest stand structure development related to different production period and thinning intensity.

Thinning intensity	120 years	140 years	160 years
Low	Scenario 1	Scenario 2	Scenario 3
Medium	Scenario 4	Scenario 5	Scenario 6
High	Scenario 7	Scenario 8	Scenario 9

(Ddv) is share which represents difference (D) in comparison to final optimal stand growing stock (KLZ)

$$Ddv = D/KLZ * 100$$

Concerning Ddv value, we determined wood volumes for thinning operations which are measured with a share of actual increment of tree species (i) as it is shown in Fig 5.

Procedure of harvest volume determination for thinning operation has three typical intervals related to Ddv value:

- I. In case of shortage ($Ddv < 0$) there is no wood supply from thinning operations.
- II. In case of equal actual and optimal wood volumes there is an advance determined share of current wood increment ($Ddv = 0$).
- III. In case of surplus ($Ddv > 0$) there is linear increase of harvested wood.

Harvesting volumes for final cutting are provided by model approximation, (Fig. 2) where in three subsequent ten year periods all volumes are cut regardless to difference in growing stock structures.

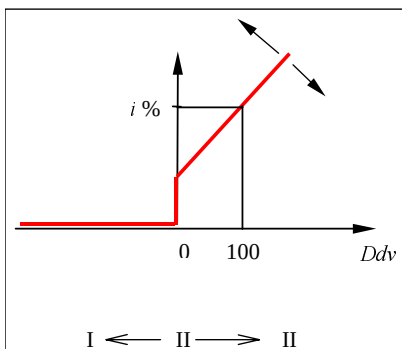


Figure 5. Harvest volume determination for thinning operations related to degree of structure changes in growing stock by tree species (Ddv).

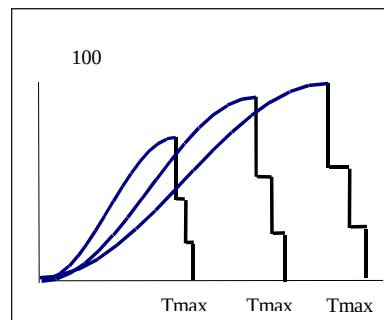


Figure 6. Different production periods (T_{max}) for alternative forest management scenario.

3 Results

DSS enables prediction of growing stock, harvest volumes and approximation of co-natural stand development for different forest estate and management activities. Quantitative data for management scenario (Table 4) are derived from voluminous databases which could be used for prediction of future conditions in various forest estate levels. Data for higher estate levels are derived by analysis from data on basic level of simulation represented by forest section.

Scenarios with different production age have most significant differences in prediction results. It can be concluded from fig. 7 that today average production age is approximately 140 years. Short production ages (120 years) would decrease, longer (160 years) would increase today average growing stock.

Model optimal growing stocks are lower than predicted. The situa-

tion can be explained by tree species, because today dominant spruce has a higher growing stock than more site convenient beech (Tables 1 in 2).

Index of co-natural stand structure showing co-natural development of growing stock was also observed. We derived index by dividing the sum of absolute differences (D) in volume structures (Fig. 4) with actual optimal growing stock in forest section. Average values for forest management estate index of co-natural stand structure comprises Table 5.

Best results concerning adoption to site requirements were achieved by scenario seven (120 year production with high intensity of thinning operations). Results were expected because shorter production period operates with lower average growing stock, which corresponds to model optimal requirements. Approaching natural stand development is worst by longer production period. Even by using high intensity of thinning op-

Table 4. Today value (1990) and prediction of average growing stock (m^3/ha) for different forest management scenarios and model optimal values defined by forest association (level of forest management unit).

Year	120 years				140 years				160 years			
	Model	Sc*1	Sc*4	Sc*7	Model	Sc*2	Sc*5	Sc*8	Model	Sc*3	Sc*6	Sc*9
1990	331	323	323	323	312	323	323	323	273	323	323	323
2000	203	325	319	314	254	346	339	332	291	369	360	352
2010	176	280	270	260	241	334	320	308	291	392	375	359
2020	160	227	214	202	222	311	293	277	282	402	379	358
2030	152	229	215	202	204	316	294	276	264	407	378	353
2040	149	226	211	198	185	323	299	280	241	413	379	351
2050	164	219	204	192	168	324	299	279	216	422	385	355
2060	188	229	213	201	155	331	304	284	191	444	402	370
2070	216	241	223	210	162	337	308	286	166	463	416	381
2080	240	246	227	214	178	353	321	298	147	483	431	393
Average	198	255	242	232	208	330	310	295	236	412	383	360

*Scenario

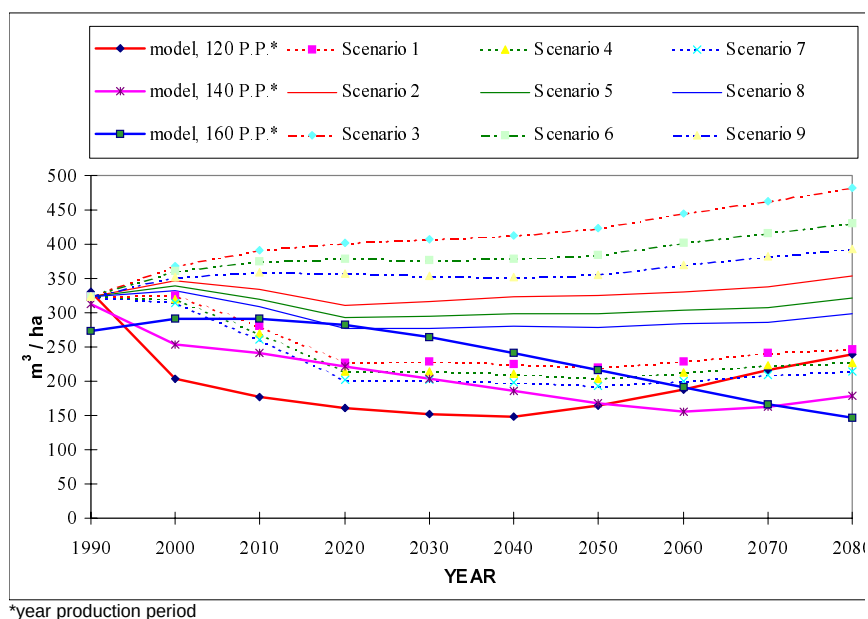


Figure 7. Potential optimal and prediction of growing stock structure (m³/ha) in forest management unit for time period from 1990 to 2080.

Table 5. Prediction for index of co-natural stand structure for different scenario in forest management.

Year	120 years production period			140 years production period			160 years production period		
	Sc*1	Sc*4	Sc*7	Sc*2	Sc*5	Sc*8	Sc*3	Sc*6	Sc*9
1990	1.74	1.74	1.74	1.85	1.85	1.85	2.04	2.04	2.04
2000	2.44	2.41	2.39	2.11	2.09	2.06	1.98	1.95	1.92
2010	2.40	2.35	2.29	2.07	2.02	1.97	1.89	1.83	1.77
2020	2.09	2.01	1.93	2.19	2.10	2.03	1.99	1.90	1.83
2030	2.11	2.00	1.91	2.30	2.19	2.12	2.21	2.10	2.01
2040	2.42	2.27	2.15	2.62	2.46	2.34	2.67	2.53	2.41
2050	2.52	2.37	2.25	2.47	2.29	2.15	2.79	2.60	2.44
2060	2.09	1.96	1.86	2.87	2.62	2.45	3.21	2.95	2.76
2070	1.87	1.74	1.65	3.63	3.38	3.17	3.27	2.96	2.73
2080	1.63	1.52	1.45	2.96	2.70	2.50	4.17	3.71	3.37
Average	2.13	2.04	1.96	2.51	2.37	2.26	2.62	2.46	2.33

*Scenario

eration a gap to natural stand structure grows rapidly. It is not possible to avoid planting new (site convenient) tree species.

4 Discussion

In the paper part of DSS is represented which predicts growing stock, harvesting volumes and co-natural stand development for future. Results can be used in ecological and economical analyses. Economical part includes mainly relations in cash flow, ecological viewpoint maintains non-timber function of forests (protection, hydrological, climatic, recreation, tourist, aesthetic and other social benefit functions) which have important influence on successfulness of management activities. Management plans and forest operations should give both sides equal attention because consequences of management activities have in most cases opposite reactions (results).

Primary purpose of DSS is supporting forest management planning on different level of forest estate. Input data are provided by national wide forest inventory. Predictions for forest stand development are made using real (field) data. It is also possible to provide national wide prediction on future values for some macroeconomics interesting data related with forestry. Rather than predict what will happen, we are able to predict what can happen under specific assumptions. Forest service has a computer database with primary data for over million hectare forests in Slovenia, divided in 80,000 forest sections (basic data cells). Compre-

hensive and valuable data provided by forest service could be, through DSS, better (objectively) included in forest management planning process. National wide results could be implemented in investment strategy in wood processing industry (potential future wood supply) and also for maintaining forest communication network. Development strategy of DSS is modular oriented. Parallel to forest stand dynamics, we work on module for economic assessment different management scenario concerning silvicultural treatment and production period. Cash flow using different working method in forest operation, skidding means, quantity and quality of harvested volumes can be compared.

Data processing possibilities are almost unlimited. Every important decision should be supported by objective calculations including also ecological and economical viewpoint for alternative possibilities.

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Use of equation parsers in forest information systems

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Abstract

A parser is a piece of software which takes a string and makes a syntactic analysis of it. An equation parser is a special type of parser which takes an equation as a string, parses and solves it, returning the result as a value. Currently available equation parsers can handle logical, mathematical, trigonometrical and statistical functions and they can solve very large, complex expressions with numerous levels of parentheses. Moreover, many of these parsers support variables.

Nowadays, there are equation parsers for all the most common programming languages. In the WindowsTM environment, an equation parser can be very easily embeded in other programs as an add-on control (*e.g.* as a dynamic link library).

Rigorous testing of any parser with complex mathematical equations is an essential phase, when deciding on applicability of it. Moreover, the function of constants and variables has to be tested to avoid erroneous results. Many evaluation versions of equation parsers are obtainable via the Internet.

A reliable equation parser is an invaluable tool to use when programming workable systems for many purposes where equations are required. From the developers point of view, use of equation parsers makes code writing easier: if formulae are needed, these can be just written into relational database tables as they are in books. By using equation databases and parsing, one can in principle build up a forest information system which can be used in Finland as well as in Wales. The main problem is to ensure that tree species names and their equations are properly written into relational database tables and the order of computing is just the same. Practical uses for equation parsing can be found in application development, research and education.

Keywords: Equation parser, Forest information systems, Programming

1 Introduction

A parser is a piece of software which takes a string and makes a syntactic analysis of it. Parsers have long been studied in programming science and have been applied in syntactic and semantic parsing of languages: the language may be a so-called natural language or a formal language, such as a programming language. An equation parser is a special type of parser which takes an equation as a string, parses and solves it, returning the result either as a value or a string. Currently available equation parsers can handle logical, mathematical, trigonometrical and statistical functions; and can solve very large, complex expressions with numerous levels of parentheses. Moreover, many of these parsers support variables. The most common use of parsers can be found in programming compilers; equation parsers are also found in spreadsheet applications, where a cell value is solved by parser.

In forestry information systems many different kinds of mathematical equations are applied by writing algorithms straight into the programme code. Because similar model structures may be appropriate e.g. for different tree species, the most common method has been to write separate parameter files in which the values of parameters are stored. But this method allows change of the entire model form only if the form of the new model is known in advance (and this requires lot of *if-else* statements in the code). An equation parser will substitute all these computing rules.

2 Testing of equation parser

Nowadays, there are equation parsers for all the most common programming languages (e.g. C, MS Visual Basic and Borland Delphi). However, rigorous testing of any parser with complex mathematical equations is an essential phase, when deciding on its applicability. A dealer's promises concerning functionality of an equation parser are not always realistic: for example trigonometric or statistical functions embedded in complex mathematical equations do not always work as promised. Therefore, a programmer should always first test the candidate parsers. A sensible starting place is to study the order of precedence of the operands. The common order in computing is the following (in Pascal language, see Saikkonen & Voipio 1981):

```
NOT
^
*, /, DIV, MOD, AND
+, -, OR
=, <>, >, <, <=, >=
```

where

```
^ = power
DIV = division (integer part)
MOD = division (fraction part)
```

Moreover, the function of constants and variables has to be tested to avoid erroneous results. One possible source of error is that so-called double precision numbers (16 bits) which are rounded to fewer decimals (8 bit numbers). The function with upper and lower case letters in variable names should also be studied. Here

is an example of function of two commercial equation parsers.

Parser 1

Input string: $\ln(2)$
Result: 0.693147181

Input string: $\ln(2) + \ln(3)$
Result: #ERROR

Parser 2

$d = 20.0$ (diameter, cm)
 $h = 23.1$ (height, m)

Input string: $0.036089 * d^{\wedge} 2.01395 * 0.99676^{\wedge} d * h^{\wedge} 2.07025 * (h - 1.3)^{\wedge} (-1.07209)$
Result: 181783811.92 (wrong)

Input string: $0.036089 * (d^{\wedge} 2.01395) * (0.99676^{\wedge} d) * (h^{\wedge} 2.07025) * ((h - 1.3)^{\wedge} (-1.07209))$
Result: 344.72 (right)

In the previous example parser 1 could not solve the equation, in which there was more than one function call and parser 2 made the calculations in an unconventional

order, corrected only when the exponentials were separated by parentheses. However, if these kind of errors are found, the programmer of equation parser is usually very willing to fix them.

3 Equations in relational database

Equation can be written into a relational database table as a string nearly the same way as they are written in books. The variable names must be fixed, and the values of the parameters are written into the table (Table 1).

If the user of an application is to be allowed to make changes to model database, then the checking of syntactics must be carried out before computation. Moreover, the allowed limits of variables can also be stored into the database table, if the equation in use supports logical functions (Table 2).

VolumeModel2: Taulukko		
Code	Equation	ModelSource
2	$0.022927 * (d^{1.91505}) * (0.99146^d) * h^{2.82541} * ((h - 1.3)^{-1.53547})$	Laasasenaho 1982
3	$0.011197 * (d^{2.10253}) * (0.986^d) * (h^{3.98519}) * ((h - 1.3)^{-2.659})$	Laasasenaho 1982
1	$0.036089 * (d^{2.01395}) * (0.99676^d) * (h^{2.07025}) * ((h - 1.3)^{-1.07209})$	Laasasenaho 1982

Table 1. Equations in relational database table. This table includes single tree volume functions for Scots pine (code 1), Norway spruce (2) and birch (3) (Laasasenaho 1982).

HeightModel: Taulukko				
Code	Equation	Y_dependent	ModelSource	Rules
1	$1.3+d*((A+B*d)^2)$	$d/((h-1.3)^{0.5})$	Näslund	AND(h > 1.3, d > 0)
2	$1.3+A*d+B*d*d$	$(h-1.3)/d$	Polynomic	AND(h > 1.3, d > 0)

Table 2. Example of checking rules in database (field *Rules*). This table includes tree height curve equations.

In Table 2 the parameter values are omitted, because this table is used as a tool for solving a tree height curve. The parameter values are computed by using simple linear regression formulae

$$\hat{Y} = A + B \times d$$

where

$$\begin{aligned} \hat{Y} &= \text{predicted value of the} \\ &\quad \text{dependent variable} \\ A, B &= \text{parameters} \\ d &= \text{tree diameter} \end{aligned}$$

The dependent value is solved first by equation parser for each tree in the group of sample trees, then the regression analysis is carried out and values obtained for the parameters. After this the diameter value and parameters are inputted to the equation (in Table 2, field *Equation*) which will give out height value of a tree. This result is also solved by the equation parser.

Equation parsing can be easily applied to many static and dynamic models used in forestry applications. More programming is needed, if special jump command to different equations are needed when for instance maximum limits are exceeded. In the Windows (TM) environment, an equation parser can be very eas-

ily embedded in other programs as an add-on control (e.g. as a dynamic link library or ActiveX control). Many evaluation versions of equation parsers are obtainable via the Internet.

4 Conclusions

A reliable equation parser is an invaluable tool to use when making workable computing systems for many purposes where equations are required. From the developer's point of view, use of equation parsers makes code writing easier: if formulae are needed, these can be written into relational database tables just as they are in books. By using equation databases and parsing, one can in principle build up a forest information system which can be used in countries as diverse as Finland and China. The main problem is to ensure that tree species names and their equations are properly written into relational database tables and that the order of computing is still correct. Practical uses for equation parsing can be found in application development, research and education and the use of equation parsing is likely to make forestry applications more universal.

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Development of GIS database and interface for IM network

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Abstract

Development of assessment and monitoring techniques at integrated monitoring sites in Europe is a project financed by EU's LIFE foundations. The project is based on intensively monitored reference sites of the UN/ECE International Cooperative Programme on Integrated Monitoring. The IM network presently covers 21 mostly European countries and the database containing the measurement data includes data from 61 sites.

One aim of the project was to improve the availability and use of GIS data from the IM network. The implementation of the project included the development of a GIS database covering all the IM sites and an interface for this database. The GIS work was done in Finnish Environment Institute (FEI).

Both the already existing GIS data and new data received from the participating institutes were processed and included in a common database. The user interface was built to facilitate the use of digital data. The GIS database will improve the transfer of vegetation, soil and other site information to various modelling and assessments groups as well as the use of IM data at the IM Programme Centre. A modelling group can for example select suitable IM sites for a modelling projects, use GIS data in modelling, analyse and visualize GIS data using this interface.

I GIS database

There were very few GIS data from the IM sites available at the Finnish Environment Institute (FEI) before the project started. Most of the digital data were from Finland. There were, however, many paper maps

which had a very heterogeneous quality. Some maps did not have any coordinate system or even scale bar. The digital data were not organized in any database, all the data available for one country were stored separately. An accurate and well-organized database was needed to

improve the use of this data. The ARC/INFO GIS software was selected as main tool for building the database.

In the beginning of the project a questionnaire was sent to all the participating institutes to make a survey of the available GIS data and paper maps. The most interesting themes for the database were area boundaries, soil, vegetation, catchment borders, elevation, permanent plots and aerial photos. After the availability and status of the data from each country was obtained, the institutes were asked to forward the existing data and maps together with information about map projection and coordinate system to FEI. The digital data were transferred from National Focal Points to FEI via FTP or using e-mail. All the themes mentioned above were received from only one site and from some sites no data were received. Additional themes like lakes, streams, land use, surface deposits, geology, tree specification, development classes of trees, base map, monitoring stations, circular plot and monitoring trees were also received from a few of the sites. The total number of the layers presently included in the database is 326.

Various tasks had to be carried out depending on the individual map/data, before a map layer could be stored into the database. Paper maps with good quality were digitized by a consultant. Some ASCII and Excel files were manipulated to get new map layers. The map layers which were in other GIS/CAD formats had to be converted into ARC/INFO format. Some coordination transformations

were made in order to have all the themes of one IM site in the same coordinate system. In the database most of the map layers are stored in the national coordinate system of the country, where the monitoring area is situated. Original maps of some IM sites did not include any coordinate points and for that reason a new coordinate systems has been created for these sites. Different themes of the same site were made compatible so that for example lake boundaries are same in every theme. That required so called "rubber-sheeting" and replacements of some map features by corresponding features of the other layer. The map layers and layer attribute items (columns, fields) were named according specific naming conventions so, that they are suitable for the database and that the names are as clear as possible. The database is organized so that, if new sets will become available, they can be easily appended into the database and be used by the interface.

Because the software for the database is ARC/INFO, all the GIS data are in ARC/INFO format. Most of the data are in vector format (ARC/INFO coverage) and some data are in raster format (ARC/INFO grid). Also some images (TIFF, BIL format) and dBASE files having information about sites are included into the database. The quality of the GIS data is quite heterogenous, but yet the data are the best data available. A file containing a description of the layers has also been created. The description includes the source of the data, original scale, map projection and coordinate system when this information has been available.

2 GIS interface

An easy-to-use interface for GIS database was developed side by side with building the database. The idea is that the interface has necessary functions to ease the use of the GIS data without having any unnecessary and confusing functions. The software for the interface was originally chosen to be ArcView2. The work started with ArcView2, but as a new version ArcView3 was released at the end of 1996, the interface was completed using ArcView3. The interface has all the functions of the basic ArcView3 and additional functions to facilitate the use of GIS data from IM sites. The additional functions were made by programming scripts with ArcView's own Avenue language. The interface is so called 'ArcView extension'.

When the user starts the interface, he gets a view, which contains all the IM sites with their codes as labels and the borders of the European countries. The user can get the basic information from a selected IM site by clicking on it. To get a closer view from a specific site the user can select it by clicking on it or giving its name or code. A new view is created and all the themes (map layers) of the site are collected from the database for the view. The different themes of the site are drawn to view using menu choices. Colouring of the

theme is based on one attribute item, which classifies the features (point, line, polygon) of the theme (for example: soil class). The user can obtain information related to a selected feature by clicking on it.

The user can easily print maps and make image files to be used in an other software. Some GIS analyses like intersections of themes can be made. The user can for example make a new theme by intersecting soil and vegetation themes. Intersecting themes function helps also, when the user wants to have a layout, where for example the soil polygons inside the watershed are shown, but not those outside the watershed. The user can also easily make an Excel file from a theme's attribute table, so that the file contains the selected records (features) and fields.

In the future the relational IM database containing the measurement data and the GIS database could be joined and the GIS interface used for data handling. So far this has not been possible, due to a lack of a compatible driver.

Use of the GIS interface requires an ArcView licence. The data in the GIS database can as well be used directly in ARC/INFO. The data in the GIS database can also be converted into other GIS formats. So, if the user has neither ArcView nor ARC/INFO, but he has some other GIS software, he can still benefit from these GIS data.

Environmental Monitoring System Data on Lithuania's Web Sites

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Abstract

Lithuania's Environmental Monitoring Programme (EMP) was created in 1991–1992. At present, when the changes in environment components are going on quickly, the monitoring data acquires great significance not only for the evaluation of environment quality and making of decisions but also for the analysis and prognosis of anthropogenic changes of environment.

The improvement of Environmental Monitoring System (EMS) is being defined in the Lithuanian Environmental Strategy.

A new the Environmental Monitoring Programme adapted to the changes of environmental, economic and social conditions was prepared by the Environmental Protection Ministry in 1997.

EMP is being assigned for monitoring of environment quality, taking into account the existing international obligations and regulations, which are being described in the Environmental Strategy. Environmental Monitoring Information System (EMIS) is a part of EMS. EMIS must to ensure the optimal and purposeful employment of monitoring data on estimating of ongoing processes and it's status.

An evaluation of environmental situation requires the collection of many types of data, which need to be presented in an organised way. The Internet and WWW technologies can help in this case. The EMS data on Environmental Information System Web Site is an attempt to join and represent all available environmental monitoring system information. The Environmental Information System Web Site address: <http://neris.mii.lt/>.

Planning and management in the Baltic Sea region with land information from EO

– BALANS

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Abstract

The Baltic Sea Region consists of a drainage basin shared by 14 different countries. There is a growing need for basic geographical data that is homogeneous and comparable across national boundaries to monitor the environment. The BALANS project is a co-operation between seven organisations in Sweden, Norway, Finland and Poland where both customers and Earth observation expert organisations are represented. The goal of the project is to produce and test the generation and use of land cover information from EO for the entire Baltic Sea Region, tailored to the needs of specific organisations. The project is divided into four phases. The first two phases concentrate on user requirements and the generation of a prototype database and user products. In the third phase the prototype products is tested with specific customers in demonstration case studies. This allows for iterative improvements to be made, and provides experience in integrating the products with other datasets and with the customers' day-to-day routines. The final phase provides a cost/benefit analysis and an assessment of the requirements and possibilities for a future operational situation.

I Objectives

I.1 Background

The Baltic Sea Region consists of a drainage basin shared by 14 different countries. Fundamental change occurring in some parts of the region

put the whole Baltic Sea environment at risk if economic growth is not combined with measures leading to sustainable development. The protection of the Baltic Sea environment is overseen by the Helsinki Commission (HELCOM), of which all countries in the region are members.

HELCOM is an executive organisation, and has a limited operational role. Most actions are carried out on its behalf by the member nations. Operational entities such as environmental protection agencies, national mapping agencies and meteorological offices are among those who carry out such actions. To support the regional approach, there is a growing need for basic geographical data that is homogeneous and comparable across national boundaries.

Using earth observation it can be possible to provide regular, homogeneous, regional land cover information. Such information is expensive to collect by traditional means, and existing information is difficult to integrate because of differences between national standards.

The BALANS project will address this need of information. The project is a co-operation between seven organisations in Sweden, Norway, Finland and Poland and is selected by the European Commission to receive funding for a period of 2½ years.

1.2 Project aims and measurable project objectives

The goal of the BALANS project is to produce and test the generation and use of land cover information from Earth Observation (EO) for the Baltic Sea Region, tailored to the needs of specific organisations. Such information must be readily updateable and include information on changes.

Customer-specific products are required that must have a relatively high spatial and thematic information content, while the approach adopted must make it technically and economically possible to establish a sustainable information service in the longer term that regularly provides such products for the whole region. These requirements suggest the creation of a Baltic Sea land information database, based upon medium-resolution EO data, from which a range of customer-adapted products can be generated.

The measurable objectives of the project are intended to form the basis for a possible future land monitoring system for the Baltic Sea Region:

- documentation of the detailed requirements of specific customer organisations for land information relevant to sustainable management initiatives in the region
- documentation of the state of the art in regional land cover mapping and monitoring from EO, including land cover nomenclature issues
- design and creation of a prototype land cover database and derived products
- validation of the database and products for specific test areas in the region
- execution of demonstration case studies in the region with specific customer organisations using tailored prototype products
- a cost-benefit analysis carried out in close co-operation with the customer organisations

2 Customer requirements

2.1 The customers' situation today

The BALANS project is targeting the land information needs of multiple users in the Baltic Sea Region (BSR). Thus, we first briefly describe some prominent characteristics and development features of the region, before turning to the major user categories and their current situation and future needs for land information.

2.1.1 Basic Baltic facts

The Baltic Sea Region covers an area of around 1.8 million km², of which one fifth is the surface of the Baltic Sea itself - the world's second largest brackish water body. Geopolitically, the region is highly diverse, with a mix of EU, EFTA, PHARE and TACIS countries. The Baltic Sea is surrounded by nine riparian states - Finland, Russia, Estonia, Latvia, Lithuania, Poland, Germany, Denmark and Sweden - and five peripheral states - Belarus, Ukraine, Slovakia, the Czech Republic and Norway. The total population is around 85 million. Since the 1970s the Baltic Sea Region has been looked upon as a model for regional environmental co-operation and pollution combating.

2.1.2 Recent development trends

Starting with the disintegration of the Soviet Union and the unification of the two German states in the early 1990s, the BSR - its countries, ac-

tors and population - has and still is undergoing many rapid changes. As a result, there is increasing demand for transboundary land information. Some areas with particular relevance for the BALANS proposal are:

- Major changes in land use practices in several countries. Notable examples are the Estonian abandonment of agricultural land due to the removal of agricultural subsidies, changing agricultural practices in EU countries due to the Common Agricultural Policy, and clear-cutting forestry in Russian Karelia.
- The upsurge in new and expanded Baltic-wide activities and initiatives. These are characterised by increased possibilities for an integrated view of various economic and sectoral activities in the drainage basin, both as they concern joint environmental management activities and exchange of data and information.
- The clear trend in the BSR for increased recognition of the interconnectedness between economic development, land-use practices and environmental problems. This is influenced by increased international efforts to seek much broader solutions to environmental problems. The concept of sustainable development, as re-invented by the Brundtland Commission in 1987, has been crucial to this understanding, as demonstrated by VASAB 2010 (Visions and Strategies for the Baltic Sea Region 2010), and the Agenda 21 initiative for the region – Baltic 21.

- The greater accessibility of various application software has resulted in a strong increase in the capacity of most users to handle georeferenced data. Tools and data accessible via Internet have also contributed. BALLERINA - the environmental information gateway to the BSR on Internet - has paved the way for a more informed Baltic community by providing an internationally recognised focal point with links to all kinds of environmental and sustainable development information.

2.1.1 Customers and information needs

The customers for Baltic land information in the BALANS project can be divided into a small number of general categories that are also more generally applicable (Table 1). These groupings are useful since they help distinguish the different ranges of geographical coverage each customer type requires.

Table 1. Customer types in the BALANS project.

Customer type	Example type members	Needs for Land Information
Baltic-wide inter-governmental policy bodies/initiatives	HELCOM, VASAB 2010, Baltic 21, EEA	Policy support and monitoring of Baltic-wide environmental programmes and initiatives
Transboundary policy-related bodies and projects	Green Belt, Lake Peipsi and Lielupe Transborder projects, Oder Protection Commission, EU INTERREG 2C projects	To analyse ecosystems and landscapes in an environmental management and spatial planning context over larger sub-areas of BSR spanning international borders
Scientific bodies or projects with relevance to the Baltic	Baltic Basin Case Study, POPcycling, BALTEX, BASYS, Baltic HOME, Environmental Protection Agencies	Input to models and analyses for themes including energy and water balances, water pollution, meteorology, and persistent organic pollutant with coverage from national/sub-national areas to whole BSR
The general public	Environmentally concerned citizens, education, NGOs, mass media, politicians	Desire for environmental awareness - easy access to maps, statistics and other information on land cover and use in BSR for local areas to whole region

Specific customers and their responsibilities

Seven customers for Baltic Sea land cover information are involved in the BALANS project. They represent a broad sampling across the four customer types, different scales of interest – from national to the whole

BSR – and a selection of different geographical locations and situations around the BSR. These customers are the basis for the demonstration case studies later in the project. A description of these customers and their relevant responsibilities are presented in Table 2.

Table 2. BALANS customer descriptions and responsibilities.

No.	Customer description	Responsibility
1	Part of EPA responsible for scientific projects involving environmental impact and risk assessment <i>Finnish Environment Institute</i>	assessment, analysis and reporting on environmental risks associated with agriculture and forestry
2	Multi-nation transboundary river basin management project reporting to multi-nation <i>Daugava River Commission (establishment 1998)</i>	development of GIS-based Decision Support System for policy-making and monitoring
3	National organisation with responsibility for scientific projects/tasks including operational hydrological modelling at national and regional scales <i>Swedish Meteorological and Hydrological Institute</i>	assessment, analysis and reporting of water-borne nutrient loads for policy-making and follow-up activities at national and Baltic-wide levels
4	International project with specific responsibilities in an ecologically sensitive transboundary region <i>UNEP/GRID-Arendal</i>	providing information for preparation of protection plans and environmental policy in threatened areas
5	Organisation with national responsibility to contribute to scientific assessment of the state of the nation's environment <i>National Land Survey of Finland</i>	analysing and reporting on changes in patterns of land cover and land use at a national level every 3-5 years
6	Secretariat of multi-nation Baltic-wide spatial planning initiative <i>VASAB 2010</i>	to provide initiatives for the building up of a monitoring system for spatial development
7	Organisation with national and European-level responsibilities for providing the general public with access to environmental information <i>Environmental Satellite Data Centre</i>	repository and access point for various national and international environmental datasets

Customers' situation and needs

The types and general needs of the BALANS customers have already been described in the previous section. However, it is important to understand the specific activities that are linked to these responsibilities,

the current situation in terms of input land cover information, and the true requirements of the customers. Table 3 describes the needs of the specific customers involved in the BALANS project and demonstrates that the 250-metre resolution is appropriate.

Table 3. Customer activities, current situation and true requirements.

Cust. No.	Activities	Current situation	Requirement
1	modelling of drainage basins, sub-drainage basins and NUTS areas using input data including land cover, soil type and DTM	land cover information generalised to 200 m, only available within national boundaries, previous versions not comparable	land cover data, approx. 200 m resolution, regularly updated and comparable in time, complete for all drainage basins flowing through country
2	assembly and integration of Daugava river basin datasets, including watersheds, pollution sources and levels and land cover	no consistent, comparable land cover data available for the region; includes four different countries	consistent, seamless land cover information for the river drainage basin at scale of up to 1:500,000
3	operational modelling of water and nutrient transport using meteorological, physiography (i.e. land cover) & emissions data	local and national-scale modelling; specific Baltic-wide modelling project, lacks appropriately detailed physiography data	up-to-date Baltic-wide physiography data at approximately 200 m resolution
4	detection, monitoring and mapping of ongoing forest changes associated with commercial forestry activities	sporadic coverage only of changes from field visits and some EO data	systematic & economic method to monitor forest changes over large area (100 x 1000 km), up to annually
5	comparison and analysis of land cover/use data at national scale to detect and assess changes	land cover/use available ('87-88 @ 25 m) and ('92-93 @ 25 ha), scales and nomenclatures incompatible	land cover/use product, 200 m resolution, comparable in time, updated at least every 3 years
6	development of system and/or services for national and regional planners providing relevant up-to-date spatial planning data, including land cover information	system/services under definition; need for Baltic-wide land cover information. BSR vector data (e.g. national boundaries, watersheds) separate development	regularly updated (every 5 to 10 years), homogeneous land cover information for the Baltic Sea region at scale of at least 1:1 million
7	provision of data access through Internet-based catalogue and browse services	no current Baltic-wide dataset on WWW, or with any interaction or extraction capabilities	up-to-date, widely applicable Baltic-wide environmental information

3 Work content

3.1 Project approach

Although available for some time, the potential of medium-resolution satellite data to provide useful information has yet to be fully exploited. The concept of a database of infor-

mation from such imagery from which products are subsequently derived is a major innovation in this project.

3.1.1 Study logic

Fig. 1 shows how different tasks integrate to complete the project. Four phases define the project:

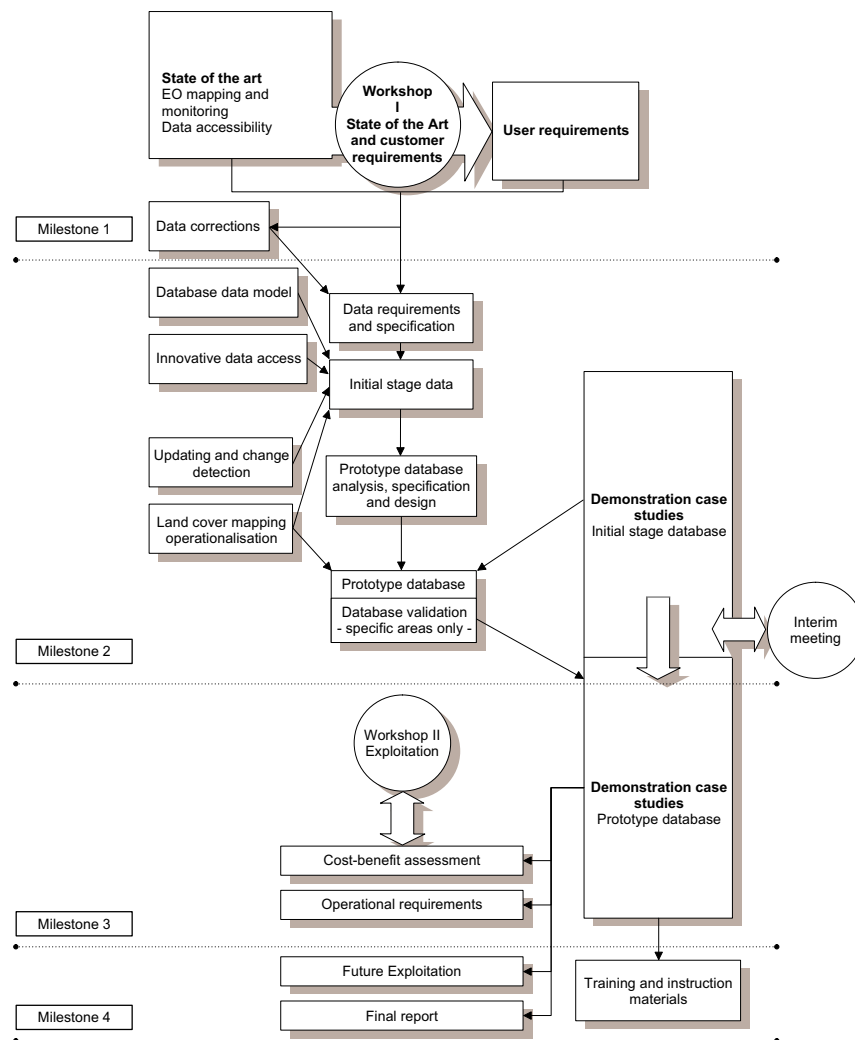


Figure 1. The study logic for the BALANS project.

1. *Customer Requirements and State of the Art.* The detailed analysis of the Customer Requirements is carried out in co-operation with the organisations involved in the demonstration case studies later in the project. These customers and other invited organisations contribute to this process through discussions and enlargements at a workshop. The various themes in State of the Art provide essential background information on technical feasibility and related issues.
2. *Initial specification, design and development and initial run of case studies.* Knowledge of the requirements and technical possibilities are used to create an initial database and derived products covering only part of the Baltic Sea region, which are then tested in the demonstration case studies (Fig. 2). Methodological development activities addressing the data model, data access, updating and change detection and automation contribute to this development.
3. *Demonstration case studies and Prototype database.* The initial products are tested by the customers and improvements implemented to create a Prototype database and derived products. Demonstration case studies are run again for the customers to test the products using more complete coverage of all areas, up to and including the whole drainage basin where appropriate. This leads to a critical review and final test conclusions.

Cost-benefit, future exploitation and operational requirements
A cost-benefit analysis is carried out in close co-operation with the customers (Nordic KVANTIF 1987), the exploitation plans are drawn up in detail and the consequent operational requirements are determined.

3.1.2 Project innovations and methods

Sustainability

It is of key importance that the BALANS project is not an end in itself, but the beginning of a sustainable activity. This alone is a major innovation in the world of land cover information, where one-off projects are the norm. The long-term development of a healthy and growing customer base is a clear priority for all of the project partners. Establishing strong relationships with key organisations in the BSR is of paramount importance. In many cases, initial contacts have already been made during the proposal preparation.

Updates and change information

Land cover and usage are dynamic phenomena, so any land information dataset has a very limited period of actuality. Lack of an updating strategy is one of the greatest weaknesses of most land cover/use products, and a major area of concern for many BSR customers (Langaas, 1997). As an important part of achieving sustainability, the BALANS project will develop methods and strategies for regular updates. Such activities make possible the generation of

change information products of relevance to a number of customers.

Data acquisition

The BALANS project will principally use medium-resolution optical satellite data. High-resolution imagery will be used in specific areas, mainly as a validation source. Six of the seven test cases concern specific areas within the BSR. For the initial phase of the database medium resolution data will be acquired for these areas only. High-resolution data, or reference land cover products derived from such data, is already available over these areas. Mosaicked JERS-1 SAR data from the GBFM project will also be available.

An hypothesis in BALANS is that the classification of optical imagery is best carried out using Summer "peak green" imagery. Some forest classes and discrimination of agricultural land may be improved if seasonal data is used. However, the seasonal approach is less robust in that it requires several cloud-free passes over the same area during a year. It also implies a more expensive method.

A complete coverage of the Baltic Sea Region is planned for the later, prototype database stage in the project. If possible, the data for this coverage will be compiled from data acquired during a single year. The history of each pixel in the database

will be recorded so that the source of a specific pixel in the database can be traced.

Prototype Database

Land cover data is applicable in a range of contexts. These differ in the combinations of spatial and temporal resolution, and sophistication of classification scheme required. One customer might require the whole Baltic Sea drainage basin at 5 km resolution (i.e. a generalised product), while another might require a resolution of 250 m. For long-term exploitation of the results of the BALANS project a relatively large number of customers need to be attracted. They are likely to have a wide range of requirements. In order to meet such requirements an approach will be demonstrated in which prototype customer-specified products are derived from the database. Techniques such as generalisation will be used to facilitate the range of different products, analogous to approaches developed for CORINE Land Cover in Sweden and Finland (Paulsson 1994, Jaakola 1997).

To be able to support the production of a range of products from a common database, data needs to be stored at various intermediate stages. A complete BSR radiance or reflectance maps will be built up by compositing satellite images. To fa-

Complementary data in the BALANS project will include a combination of:

National land cover/use datasets
Topographic maps
Forest inventory data

CORINE Land Cover products
Regionalisation and stratification data
Datasets from customer projects

cilitate this, there must be full knowledge of each pixel. To this end, an innovative approach is planned where metadata is stored for each pixel so they can be traced to their original source image.

The core elements of the pixel tracing functionality can be prototyped and tested for a modest effort using an object-oriented technology such as Java. This is planned within the BALANS project. In the post-project exploitation phase, a true object-oriented database management system will be required, representing a significant development

step that is required before BALANS results can be brought to the marketplace.

Demonstrations

The Demonstration Case Studies in the BALANS-project are designed to test the generation of customer-specified products from the source database and the use of the customer-specific products in the day-to-day activities of the target customer.

A total of seven demonstration case studies will be carried out with seven different customers. An initial

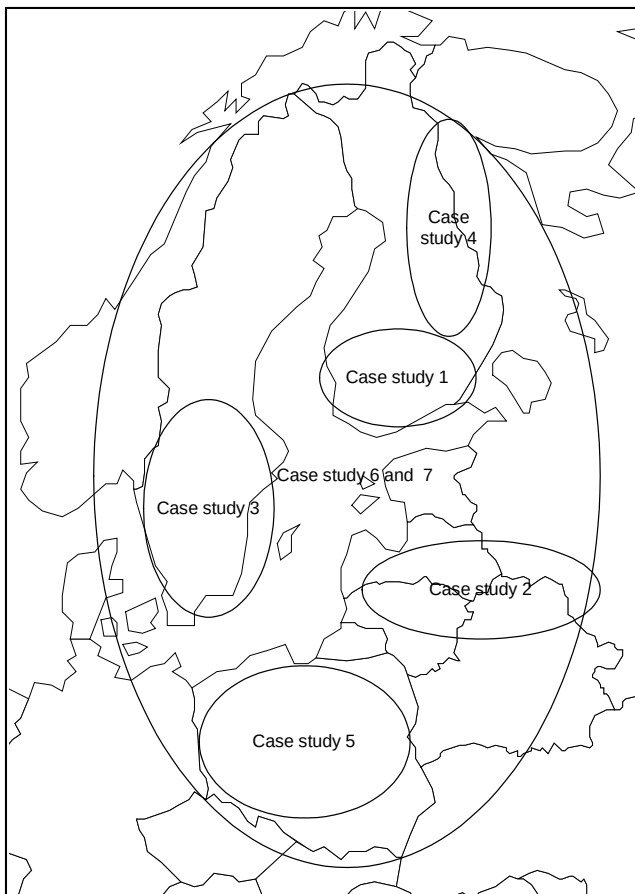


Figure 2. Demonstration case study locations.

run of the case studies will only involve five of these. A later run, where a prototype database of the whole BSR is available, will involve all seven. The locations and geographical extent of the case studies is indicated in Fig. 2.

3.2 Work schedule

The planned work schedule for the BALANS project is shown in Fig. 3.

4 Project structure

4.1 Project team

The BALANS project team consists of the following seven partners, of which three are Earth observation expert organisations and four are customer organisations.

- Swedish Space Corporation, (SSC), Sweden. (project co-ordinator)
- Finnish Environment Institute (FEI), Finland
- GRID-Arendal (GRID-A), Norway

- Environmental Satellite Data Centre (MDC), Sweden
- National Land Survey of Finland (NLSF), Finland
- Swedish Meteorological and Hydrological Institute (SMHI), Sweden
- UNEP/GRID-Warsaw (GRID-W), Poland.

4.2 Advisory group

An Advisory group will be linked to the project, for advising on general recommendations for the rational and sound realisation of the BALANS project.

4.3 BALANS Network

Additional to this, there will also be a network of national contact points for the BALANS project, the BALANS Network. This network will be spread over the countries within the region, both members and non-members of the European community, which not already are covered by partners of the project or by

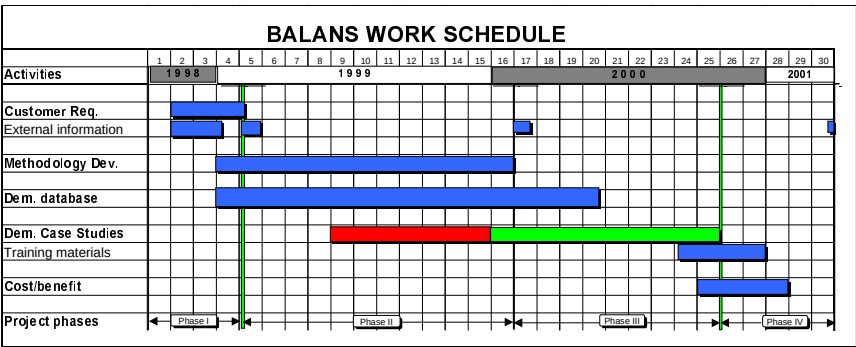


Figure 3. Demonstration case study locations.

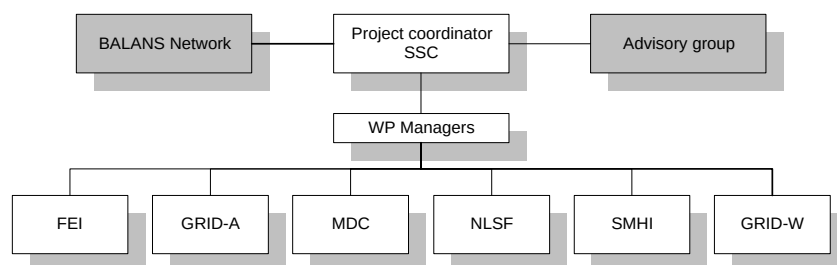


Figure 4. Structure of the BALANS project.

the Advisory group. The network will act as contact points and will have the role of receiving and passing information on to their own national networks. The members of the network will be invited to workshops and other meetings of relevance. The work on user requirements will especially benefit of this network, taking their specific needs and requirements in consideration. Fig. 4 shows how the project team, advisory group and BALANS Network are linked.

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Acronyms and abbreviations

BALANS	Planning and Management in the Baltic sea Region
BALLERINA	Baltic Sea Region On-line Environment Information Resources for Internet Access
BALTEX	Baltic Sea Experiment
Baltic 21	The Agenda 21 for the Baltic Sea Region
BASYS	Baltic Sea System Studies
BGIS	The Basic Geographic Information of the Baltic Drainage Basin
BSR	Baltic Sea Region
CORINE	Co-ordination of Information on the Environment
EEA	European Environment Agency
EFTA	The European Free Trade Association
EPA	Environmental Protection Agency
EU	European Union

FEI	Finnish Environment Institute	NLSF	National land Survey of Finland
GBFM	Global Boreal Forest Monitoring	SMHI	Swedish Meteorological and Hydrological Institute
GRID-A	Grid-Arendal	SSC	Swedish Space Corporation
GRID-W	Grid-Warsaw		
HELCOM	Helsinki Commission	VASAB 2010	Vision and Strategies for the Baltic Sea Region 2010
MDC	Environmental Satellite Data Centre		
NGO	Non-governmental organization		

The information system of the Kola Science Centre RAS as an element of the integrated information structure of the Barents Region

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Abstract

The Kola Science Centre of the Russian Academy of Science (KSC RAS) includes 11 research institutes and is the biggest scientific institution in the Barents Region. That's why the integration of the KSC RAS' information system into common information structure of the Barents Region is of grave importance.

In the report which follows, the description is given of the information system (IS) of KSC RAS. The system ensures the information access to the national and international resources.

The IS KSC consists of local area nets of the institutes which are integrated into a common information system by means of the communication centre. Recently the KSC network is integrating of 270 computers. Spatially, the IS KSC represents a "star" with the communication centre in the middle, and local nets of the institutes in the periphery. Such connection enables the fluent diagnostics of break-downs and their removal without switching-off the whole system.

The solution of these tasks is assured by the use of three separate subsystems in the frames of the communication centre:

- the file-server
- the server of applications
- the server of global communications.

The file-server is carrying out the storage of common information funds, as well as the router of the information flows. The server of applications is guaranteeing the access to the IS KSC resources via commutated telephone channels. The server of global communications is intended for arranging of information exchange in course of on-line and off-line access to the resources of Internet and Relcom networks.

I Preface

Information system of the Kola Science Center (KSC) is developed to improve the efficiency of researches by creating integral system of information support. Science is a major “manufacturer” and at the same time consumer of information, so it is very important to make efficient information support system available for scientists. This means creating and giving to end-users (researchers) efficient tools for information intercommunications, publishing and access. The system aims to make this tools easy, reliable and speedy.

Generally, an information system may be considered as the aggregate of information transportation means and set of different information services aimed to store, process, represent and interchange information. Modern information systems are based on computer networks. In this case data communication network is transportation medium and computers - are information storage/processing platform.

Modern computer based information technologies is subject of rapid development. Computer hardware and software and data communication technologies are changing for the better. Development of information system (IS) of KSC mirrors these changes.

2 Pre-history

According to progress of information technologies, IS KSC was developed in several stages. At the first stage it was based on territorial isolated computers. Punched cards, punched and

magnetic tapes were used for information interchange. There were not efficient means of computer-user interaction. Information services was limited by file storage systems.

Appearance of multiuser and multitask operating systems marks next stage in IS KSC history. Centralized computation model with distributed terminals became available. At this time the core of the system was based on two IBM-compatible computers interconnected by common field of peripheral devices. This systems had dialog users interface and relatively big computation power. But technology of processing and representing of information still left much to be desired.

Big improvement of information technologies became possible when personal computers became widely available. A possibility of creating distributed information systems based on computer networks had appeared. At this time, the development of Information system of KSC was used in its present meaning.

At this time the differentiative trends was popular in KSC. Since 1989 subdivisions of KSC have been funded separately. Probably that is why local networks of separate Institutes and subdivisions were formed spontaneously and asynchronously. So, by 1993 we had several independent local networks with its own information services. But later it became obvious that for further development it is necessary to integrate isolated information networks of KSC’s Institutes and subdivisions into a common information infrastructure. Fortunately, there was great popularity of Novell NetWare

network operating system (NOS) and of Thin Ethernet cable system. Therefore local networks had similar cable systems and based generally on Novell NetWare NOS that made their integration easy.

3 Present condition

Due to extremely limited funding of Russian science the main criteria for choice of technical solutions was as minimum cost of integration as possible.

It is clear that we didn't need to change from NetWare NOS to any other. Shared files and printers were the mostly used network resources

as well as E-mail was the mostly used service. NetWare is able to serve all of them. In addition NetWare is able to route IPX and IP traffic (for the same price).

As was mentioned above, information system based on data communication network in general consists of two main parts – data communication infrastructure and information services running on it. Let us see IS KSC from this point of view.

3.1 Data communication infrastructure

There are several subnetworks connected to one communication centre (Fig 1). As can be seen, interconnec-

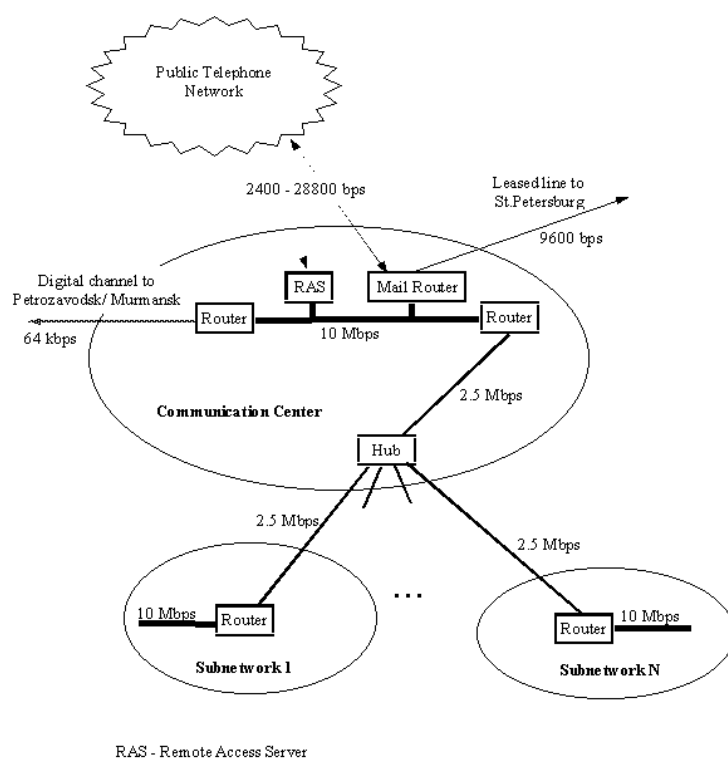


Figure 1. The general communication infrastructure of IS KSC.

tion is made by ARCnet network. Internal software routers of network servers are used to route internetwork IP and IPX traffic.

Such a structure gives the following advantages:

- Subnetworks are able to be developed relatively independently.
- Troubles in one subnetwork does not directly affect any other (because of a general star topology).

At present we use following communication channels and technologies for local and remote communications.

3.2 Local communications

Local networks are dispersed within a radius of less than a kilometer. For interconnection an ARCnet network on coaxial cable had been used (Fig. 2).

ARCnet isn't a very fast network. Coaxial isn't the most reliable. But we relied on their following perfect characteristics:

- Low cost
- Maximum covered distance is acceptable (1.2 kilometers for star topology)
- Token passing media access method that ensures real channel throughput available for each network station
- Star topology that facilitates troubleshooting

3.3 Long distance channels

At present we use analog leased line to St.Petersburg to communicate with our neighbour UUCP host. The quality of this channel leaves much to be desired. Using two absolutely identical V.32bis modems on both

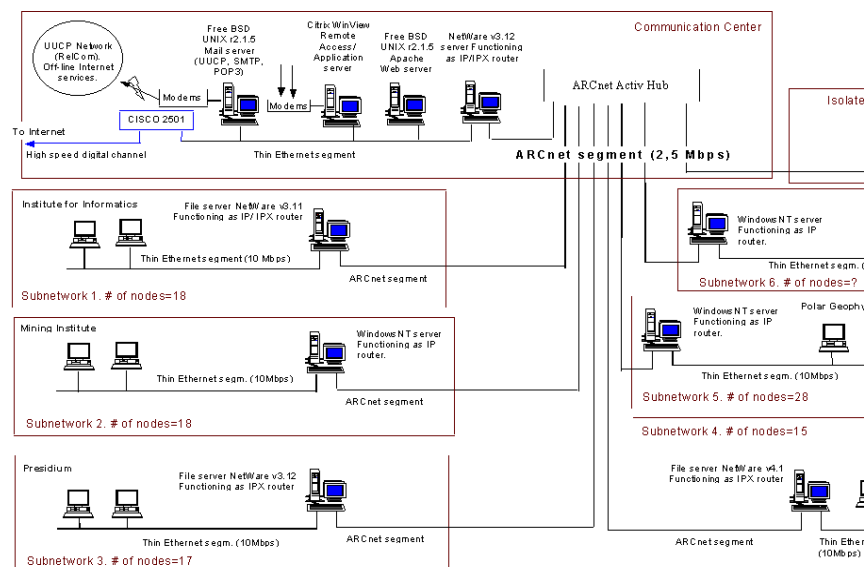


Figure 2. A detailed view of the network infrastructure of IS KSC.

ends of the line we've got only 9600 bit rate.

As can be seen, long-distance communication channel, we to use for Internet connections, has got a capacity of 64 Kbps. This is digital channel to Petrozavodsk and further to RUNnet (256K to St.Petersburg/Moscow).

We have to note that such decisions of communication channels problem give us really working system with very low cost. But the question of communication throughput is rising. Let us see communication infrastructure of IS KSC from this point of view.

Rough calculations show that for internetworks communications inside KSC there will be available 2500 Kbps–64 Kbps » 2.4 Mbps (It is assumed that Internet connected channel is used at its maximum throughput). Dividing this value to the number of ARCnet connected stations (six) we get 400 Kbps available for each subnetwork. These 400K will be used for internetwork communications inside IS KSC and for Internet connections. It isn't very much but as we think it is enough for the beginning. In addition, at the point of IS/Internet router (Cisco2501) we have ratio of 96 % local traffic to 4 % cross-over traffic. This indicates that long distance channel in this circumstances is bottleneck.

3.4 Information services

To answer needs of efficient information support of science researches IS must consist different information processing means, such as informa-

tion interchange, representing, searching and other. IS KSC aims to provide following main information services:

- Information interchange (E-Mail);
- Access to IS for remote users;
- Access to outside information sources;
- Granting access to local information sources for outside users.

Nowadays most used, most efficient and most quickly developed information technologies realizing such services are ones called Internet technologies. This fact and possibility of global range communications through global network Internet makes very attractive to use such technologies for building information system. Therefore, IS KSC nowadays represents some kind of Intranet-information system based on local area network and Internet information technologies. At the same time Novell networking technologies are still been used for file and print services and NetWare file servers are used as internetwork IP and IPX routers.

To minimize expenditures and to simplify management, expensive hardware and software facilities are installed on the communication center (Fig. 1, Fig. 2). This facilities are shared by all IS's clients. Shared servers installed in the communication center are used as providers of most popular Internet services such as WWW, FTP, SMTP mail. Follows the list of shared servers.

- The Apache Web server running on FBSD Unix machine. A FTP server is installed on the same machine.

- The Mail routing server running on another FBSD Unix machine. The Sendmail software is used to route mail messages. Server can route mail to the UUCP and SMTP ports. POP3 server is installed on this machine too.
- The Citrix WinView Remote Access/Application server is used generally for remote access to IS KSC through telephone lines.
- The Novell NetWare 3.12 server is used for routing network traffic. It is planned to use it as a platform for network applications too.

This structure of the IS covers today needs of users in information services. But information technologies are rapidly developed and user's necessities grow. This forces us to consider further development of the system.

4 Prospects

Further development of the system assumes extending and improving both communications infrastructure and information services running on the system.

The first and major task of developing of the IS KSC's communication infrastructure is to make it's full value connection to Internet. It is a problem of high speed long-distance channel to Internet provider. Due to weak development of communication infrastructure on the North-West of Russia this problem is not so simple. But we hope to get digital channel with capacity 128 Kbps in near fu-

ture. For the first time capacity of the long-distance channel - 64 Kbps, but further development of the system envisages establishing faster communication channels both for local and remote communications.

As mentioned above, developing of the local communications infrastructure assumes establishing faster communication channels connecting IS's subnetworks. In addition, perspectives of extending the Information system by connecting additional subnetworks is being envisaged.

In spite of merits of the present IS's communications infrastructure, it has several disadvantages. One and maybe worst of them is that it is platform dependent because software routers are used. So, with further growing of the system perhaps we will face up with necessity of comprehensive rebuilding of the local communications infrastructure.

In field of developing of information services major problem is to make information services efficient and at the same time easy accessible for local and remote users.

Accessibility of the services depends on information technologies used. Best results can be obtained if standardized technologies are used. The most popular modern information technology is WWW and information representation standard - is HTML. In addition this technology is very flexible due its perfect features such as refers and possibility of binding with other types of data formats.

5 Conclusion

The information system of KSC is an example of obtaining maximum practical results with minimum cost and minimum efforts. This system have both advantages and disadvantages, but looking to IS's structure and information technologies used we have to remember that funding of developing of the system was extremely limited.

Further development of the system depends much on solving of financial problem. But science and engineering potential accumulated in KSC in addition to some kind of enthusiasm of people involved into the system developing allows to hope that this system will live and be developed in any case.

Computer-based learning modules on remote sensing application for the Baltic and Sub-Arctic regions

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Abstract

The UNESCO project on computer-based modules in coastal and marine remote sensing is supported within UNESCO endeavour 'Environment and Development in Coastal Regions and in Small Islands' (CSI) and is realizing for the Baltic region in St. Petersburg. Each computer-based module is prepared as self-extracted package of:

- the image processing software,
- an introductory tutorial on how to use the software,
- lessons on the applications of remote sensing to oceanography and coastal management,
- satellite and airborne RS images to accompany the lessons.

The original DOS-based Bilko software has served students of oceanography, coastal management and environmental and other sciences well through five modules published between 1989 and 1996 in English, Russian and Spanish. Four lessons had been prepared in electronic and printed form in Russian with associated images and other teaching materials on "applications of satellite and airborne image data to coastal management".

The CSI UNESCO has a mirror site (in English and Russian) in St. Petersburg, that contains teaching materials and on-line services of interest to earth and marine scientists.

In 1997 the image processing software has been re-written for the Microsoft Windows user interface with considerable enhancements in both capabilities and presentation. A higher degree of lessons' user-friendliness and interactivity was achieved, responding to the needs of the individual user.

The first Bilko for Windows modules 6,7 (A.Edwards, Newcastle University, U.K.) and 8 are now available for trial. The module 8 in English and Russian for the Baltic region comprises the following materials:

1. Introduction (A.Edwards and I. Robinson).
2. Visual interpretation of images with the help of colour composites using NOAA images for the sea ice studying in the sub-arctic regions
3. Sea ice edge location on the base of digital satellite images
4. Using images of satellite “ALMAZ-1” in coastal areas:
 - land surface complex processing in the coastal areas using visible,
 - infrared and radar data
 - internal waves in the Lake of Ladoga

The Module 8 have been compressed and archived into “zip” files which can be downloaded using Netscape or another browser and unzipped using pkunzip or WinZip.

The strategy guide: a SIN for conserving Europe's biological and landscape diversity

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Abstract

The European Centre for Nature Conservation (ECNC) is a Network organization that aims at conserving nature and especially biodiversity in Europe. It is an organization that links both policy and science and that strives to integrate nature conservation considerations into other sectors. In doing so it provides various information services and uses Internet communication and information technology.

In recent years, ECNC has gained experiences with developing and managing a Special Interest Network (SIN) on ecological networks (LYNX), a topic that is being covered in one of the programmes of the organization. This paper describes the lessons learned from this 2-year experiment and highlights issues that a network organization is faced with while operating as a network.

Based on the experiences gained, ECNC is developing, in co-operation with the Council of Europe and UNEP, a communication and information network for the Pan-European Biological and Landscape Diversity Strategy. This Strategy provides the policy framework for the conservation of nature and landscapes in Europe for the coming 20 years, and is concentrating on various priority Action Themes. The organizational structure of the Strategy requires sound communication and information exchange between the parties involved in implementing this Pan-European Strategy. It also provides an ideal basis for a distributed approach using Internet communication and information facilities. This clearly reflects a structure that is comparable to a SIN. This networked information system will provide an answer to the communication and information need of the stakeholders in the Strategy process, taking into account the lessons learned from developing LYNX. Also, the information system does not stand by itself. The Strategy Guide will complement existing initiatives relevant to Europe, in particular the Clearing-House Mechanism for the Convention on Biological Diversity

and the Environment Information and Observation NETwork of the European Environment Agency.

Keywords: Special Interest Network, Pan-European Biological and Landscape Diversity Strategy, Clearing-House Mechanism

I Introduction

It is some three years ago, in October 1995, that the European environment ministers gathered in Sofia, Bulgaria, to discuss their joint European environmental policy. At this Pan-European conference, flagged “Environment for Europe”, they endorsed the Pan-European Biological and Landscape Diversity Strategy, a long title for a long-lasting policy framework. This Strategy sets out an innovative and proactive framework towards the protection of Europe’s biological and landscape diversity (Council of Europe et al. 1996). Drafted for the Council of Europe by the European Centre for Nature Conservation (ECNC) together with various other international organizations, it forms a Pan-European response to the Convention on Biological Diversity (CBD), the global nature conservation policy adopted in Rio by the United Nations in 1992 (UNEP 1992).

The Pan-European Strategy covers a time-span of 20 years; it started in 1995, and is structured into four 5-year Action Plans. The first Action Plan (1996–2000) concentrates on 11 priority areas requiring immediate action, the so-called Action Themes. One of the Action Themes (number

3) specifically addresses raising awareness with policy makers and public involvement in the conservation of Europe’s nature and biodiversity. This includes the issues of communication and information, both relating to furthering nature conservation or promoting the Strategy itself. This is where the Strategy Guide comes in, as will be demonstrated further on.

As it is necessary for implementing an international policy framework such as the Pan-European Biological and Landscape Diversity Strategy, an organizational structure has been set up in an early phase. Three organizational bodies were created initially for the overall implementation and follow-up of the actions undertaken as part of the Strategy: the Strategy Council (54 states), the Executive Bureau (13 geographical regions), and the Joint Secretariat for the Strategy.

As the Strategy itself has a hierarchical and sequential structure (Strategy composed of four Action Plans of which the first one is composed of 11 Action Themes) also the organizational structure is hierarchical in nature. In addition to the above-mentioned bodies each Action Theme is co-ordinated by one or a few international organizations. Within the Action Themes working

groups might be created and numerous projects are undertaken by a variety of organizations and institutes. The implementation of the Strategy hence involves an international, interdisciplinary network of people and institutes, between whom various types of information are or should be communicated in multiple ways. This also is where the Strategy Guide comes in, since it serves information dissemination and it provides communication tools.

The year of endorsement of the Pan-European Biological and Landscape Diversity Strategy is also the year the exponential growth of the Internet and more specifically the World Wide Web started (see for example Zakon 1998). With the advent of the World Wide Web an enormous amount of information could be made available to an audience bigger than ever before in a way that was increasingly becoming accessible to the entire world. Exponentially the Internet conquered the world in all levels of society, and can be expected to also be used increasingly by policy makers. Hence gradually the idea ripened to use this tool to its full potential in the implementation process of the Pan-European Strategy concerned. The Strategy Guide turns this idea into (virtual) reality.

2 Implementing the strategy

After three years, progress has been made in the implementation of the Strategy, although to a lesser extent than was hoped for. The organiza-

tional structure has been in place since 1996, each Action Theme has at least one lead organization coordinating its activities, the Strategy bodies meet regularly, and information is exchanged. However, as it became clear during a workshop in October 1997 (Expert meeting to structure information & communication for the Pan-European Biological and Landscape Diversity Strategy, Scheveningen, the Netherlands) an important condition for success when working in a decentralized framework is proper information flow to keep the process alive, efficient and co-ordinated (IUCN/CEC 1997). Several of the recommendations resulting from this workshop, that was organized by IUCN – the World Conservation Union together with ECNC on behalf of the Dutch Ministry for Agriculture, Nature Management and Fisheries, concerned the use of the Internet, notably E-mail (including distribution lists and discussion groups) and a dedicated Web site for the Strategy. Although it was recognized that not all parties involved in the implementation of the Strategy have access to the Internet or use it regularly, it was agreed that a Web site on the Strategy would support the promotion of it as well as the implementation of it.

As is mentioned above, numerous parties are involved in implementing the Strategy and its components. The further down in the hierarchical structure of the Strategy, the more concrete this implementation gets by way of the actual carrying out of projects that form part of Action Themes. In the process of implemen-

tation the results of the projects (ongoing, completed or planned) are reported to the co-ordinator of the respective Action Theme. This co-ordinator in turn assembles the results and reports to the Executive Bureau and the Strategy Council through progress reports that also cover general Action Theme progress. The information gathered through these progress reports and through other media, such as conferences or President overviews, is compiled by the Strategy Council and is forwarded to the triennial Pan-European ministerial conferences "Environment for Europe", as foreseen by the Strategy itself (Action Theme 0: setting up the Strategy process). This all illustrates the need for good communication tools and information dissemination services for good co-ordination and co-operation.

At the meeting of the Executive Bureau of the Strategy in November 1997, ECNC proposed to start the development of an information and communication system that would support the implementation of the Strategy. The proposal was welcomed informally by both the Council of Europe and UNEP and the proposal was successively elaborated to become the development of the Strategy Guide.

3 The strategy guide

3.1 Objectives

The subtitle to the Strategy Guide summarizes its objectives: an information, communication and monitor-

ing tool in support of the implementation of the Pan-European Biological and Landscape Diversity Strategy. Of this description, the major objective is to support the implementation of the Strategy. This implies that the primary target group is those involved in the implementation process, notably the Strategy Council, the Executive Bureau, the Joint Secretariat, the Action Theme co-ordinators, and the institutes or people carrying out actual projects.

Breaking down the major objective results in the following objectives:

- to provide information – operational, strategic and referral – about the Strategy and its implementation;
- to provide communication tools for those involved in the Strategy process;
- to monitor progress in implementing the Strategy and its components.

3.2 The concept

The method used for developing the Strategy Guide is based on a number of factors:

- the experience of ECNC with setting up and managing a Web site (Delbaere et al. 1996) and other Internet services, and the development and maintenance of a Special Interest Network.
- the natural networked structure of the Pan-European Strategy requiring a distributed approach
- the relationship with similar clearing-house approaches such as the

one for the Convention on Biological Diversity and EIONET.

As the Pan-European Strategy itself is a policy framework, the Strategy Guide provides a framework for exchanging information and providing communication tools. It is constructed in such a way that a central node forms the gateway to information that is residing on remote sites. Most information that concerns the overall Strategy and its implementation is stored centrally, whereas the information on individual Action Themes is provided and maintained by remote information holders, the Action Theme leaders or persons designated by them. This distributed approach (combination of retrieval and referral function) is one of the main characteristics of a Special Interest Network (SIN), of which the original definition by Green (1994) has been fine-tuned by Langaas (1998) to be formulated as follows:

A Special Interest Network (SIN) is a group of people and/or institutions who collaborate to provide comprehensive information about a particular subject by means of various information activities on the Internet.

Also other aspects of a SIN are reflected in the Strategy Guide, notably the four functions that are being served by the system: publication, library, on-line services and communication. These functions are also provided by a clearing-house, in which they are more loosely applied. As this is also the case for the Strategy Guide it might as well be referred

to as a clearing-house. In this respect its organizational structure is comparable and compatible with systems such as the Clearing-House Mechanism for the Convention on Biological Diversity and EIONET for the European Environment Agency. It differs from these systems in its content (the Pan-European Biological and Landscape Diversity Strategy) and its primary target group (those implementing the Strategy).

The central Web site for the Strategy Guide aims to have the information on the Action Themes provided by the respective Action Theme co-ordinators (cf. co-ordinating centres in a SIN; national focal points in EIONET; national clearing houses for CBD-CHM). In order to do so and to have the information provided in a transparent way, standardization, training and capacity building is being proposed and agreed to present to the Action Theme co-ordinators. Standardization of the Web document layout and structure as well as on the content can be achieved through proper agreements in the form of memorandi of co-operation or terms of reference. Also quality control should be guaranteed through these types of agreements.

Not only will a distributed approach be adopted through a thematic division (the Action Theme co-ordinators) but also by way of geographical co-operators being national government and organizations. The Strategy Guide will cover Pan-European including the individual countries who will play a major role in information provision and in the entire implementation process. Also this type of co-operation involves

matters such as quality control, standardization and potentials for uploading or posting documents.

The aspects mentioned above are not applied from scratch, they result from experiences gained by ECNC with developing and maintaining a SIN on ecological networks, called LYNX (Delbaere 1996). The development of this SIN has been inspired by a talk by David Green during a workshop at the European Forest Institute in 1995 (Saarenmaa & Kempf 1996) and on the expertise that was available within ECNC on the topic of ecological networks in general and the development of the Pan-European Ecological Network in particular. The SIN was initiated in spring 1996 and followed the SIN rationale very tightly; it provides the four SIN functions in a recognizable way and it is structured of co-ordinating centres and a co-ordinating node. The lessons learned from this experience will be discussed in paragraph 4.

3.3 The content

The Strategy Guide provides three types of information:

- Operational information: this is mainly supporting the implementation of the Strategy (primary target group, see 3.1) and comprises information such as meeting documents, calendar of events, a progress monitor and a contacts database;
- Standard retrieval information: although also useful for the primary target group this type of information is mainly interesting

for secondary target groups, i.e. those that do not know the Pan-European Strategy (well enough) and that want to learn more about it. It contains information such as a general description of the policy framework, the full text of the Strategy and related initiatives;

- Referral information: being a distributed information network it is inherent that much of the information will consist of mere hyperlinks to other Internet information sources. These will in the first place contain the separate Action Themes (semi-internal information) and in the second place hyperlinks to Web sites of organizations involved in the Strategy or to related initiatives on the Web.

The content of the Strategy Guide can also be classified according to the SIN functions mentioned before:

1. Publication: many formal documents that form part of the Strategy process (e.g. meeting agendas and minutes) will become readily accessible through the Internet;
2. On-line library: this Virtual Library will in a first phase be the least developed component of the Strategy Guide. It will basically consist of a document containing links to related initiatives;
3. On-line services: in a first instance these services will comprise an on-line contacts database, a progress monitor and a 'help desk' (which overlaps with the communication function);
4. Communication: in addition to the one-way communication pro-

vided by the Web site some interactive communication tools have been built in:

- comment form: a standard Web form through which users can send additional information or ask specific questions;
- E-mail distribution lists: centrally maintained lists used for broadcasting information on the Strategy to a wide audience;
- E-mail discussion group: a forum for discussion provided by a list server;
- On-line contacts database (see also on-line services);
- Traditional tools: the Strategy Guide is not restricted to the Internet, it also uses traditional tools such as a newsletter (Strategy Bulletin, published by the Council of Europe) and standard mailing.

The progress monitor requires some extra attention since it relies on one of the most important characteristics of the Internet: the easy updating of information. The Strategy Guide will be used as a monitoring tool to indicate in how far the Strategy is implemented, what the differences in progress of implementation are between the various Action Themes, and how this progress is being qualified by various bodies. Criteria for monitoring this progress might include deadlines that have been met for projects, resources allocated by governments and other financiers, meetings that have been held and a validation of their outcome, a quality stamp for work plans that have

been developed or concrete nature conservation successes through the Strategy. The monitor will be a visual representation of the score given to the various criteria to be developed and can be updated daily if required.

The content of the Strategy Guide makes that it will serve the implementation of the Pan-European Strategy but also, because of the objectives of this Strategy, nature conservation in Europe in general. In doing so the Strategy Guide will act as a true clearing-house on nature conservation in Europe, covering activities to conserve ecosystems, species, landscapes, etc.

3.4 Non-Internet users

As the primary target group for whom the Strategy Guide is developed still can be expected to be largely non-Internet literate and as decision-makers need information that can be absorbed quickly without the need for special tools or expertise (WCMC 1998) the Internet will not be the sole information carrier. Although intentionally focussing on using the Internet facilities in addition to existing traditional information sources such as the Strategy Bulletin two approaches are developed to also target at those that are not familiar with using computers or the Internet in their daily work.

The first approach is rather straightforward and classical and is in place since the endorsement of the Strategy in 1995. It consists basically of all the printed material that has been produced in the process, such as a version of the Strategy with col-

our illustrations (Council of Europe et al. 1996), an explanatory brochure about the Strategy (McCloskey 1997), the Strategy Bulletin (Council of Europe 1997), numerous meeting documents and project reports.

The second approach is more proactive in that it stimulates the use of the Internet, preferably also by policy makers. It is an approach which would consist of training sessions, demonstrations on how to use the Strategy Guide, capacity building in those countries that have less developed Internet infrastructures, promotion of the system at conferences and other events, etc.

4 Lessons learned

From the ECNC experiences in developing and maintaining a Web site and a Special Interest Network some lessons are applied while setting up the Strategy Guide. All of these are related to the networked approach that is naturally adopted when developing an Internet information and communication system.

Admittedly, the Special Interest Network on ecological networks is currently not used to its full extent. The first year after its establishment showed a lively evolution: information was regularly updated and added to the Web site, people got subscribed to the E-mail distribution list, through which questions were answered occasionally and events were announced, the on-line expertise database grew steadily. However, co-operation with the co-ordinating centres in the network was not practised.

There were basically three reasons for this:

- the co-ordinating centres are all institutes with their own projects, with much educational work in the universities, and very little time to voluntarily be spent on initiatives like this, disregarding the enthusiasm with which it was welcomed;
- the co-ordinating node had a similar problem. Funding did not allow to put a full time staff member on the project and the activities as part of the SIN got snowed under with other work.
- the topic of the SIN was not linked to any formal process or initiative whatsoever. Although informally supporting the Action Theme 1 of the Pan-European Strategy there was no formal backing or linkage for the project. This made the input and updating of information a more or less ad hoc activity without a real driving force.

The lessons learned from the above mentioned problems are applied in the Strategy Guide as follows:

- the information and communication system is directly linked to a formal policy framework, the Pan-European Biological and Landscape Diversity Strategy, of which the implementation provides the driving force for keeping information updated;
- as has been discussed before, the Strategy has a hierarchical structure including Action Theme leaders who are invited to report to the Joint Secretariat of the Strategy, which provides a good

basis for a continuous information flow towards the Strategy Guide and back to the Action Theme leaders;

- the Joint Secretariat for the Strategy forms the support role as an official co-ordinating node, whose task it is to disseminate information about the Strategy and its implementation to those involved in the Strategy process and to the wider public. With the Strategy Guide being developed they have a strong additional tool to support this task.

5 Conclusion

The discussion presented in this paper introduces an Internet application in support of a European policy framework for 54 countries. The application concerned, called the Strategy Guide, builds on Internet experiences gained at the European Centre for Nature Conservation and on the hierarchical structure of the policy framework concerned, the Pan-European Biological and Landscape Diversity Strategy. As the system is yet to be presented at the ministerial conference "Environment for Europe" in Aarhus, Denmark, on 23 June 1998 it is too early to report here on the usefulness or usage so far. It is expected however that the Strategy Guide will form a useful addition to the traditional communication media that have been used so far. With the continuous increasing use and access to the Internet, also by policy makers, the Strategy Guide might become a very efficient tool

in making the Pan-European Strategy successful.

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EFICS (European Forest Communication and Information System) – networked statistical and geo-referenced forest information?

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Abstract

No common forestry policy has been implemented in the EU, therefore forest strategies and forest activities are dealt with in a rather dispersed manner within the European Commission. In 1989, EFICS (European Forestry Information and Communication System) was established via a regulation, which stated that the EC had to set up the system before the end of 1992; this date was later postponed. The objective of the EFICS is to “collect, coordinate, standardise and process data concerning the forestry sector and its development.” The main work on implementation of the EFICS Regulation has been carried out in DGVI-FII.2 in close co-operation with other DG’s, EUROSTAT and with international forest organisations. The Standing Forestry Committee and the EU Working Party on Forest Statistics have supervised this work. In 1995-97 the European Forest Institute (EFI) led a consortium which performed a major study on the user requirements for forest information and on the need for harmonisation of European forest statistics. The results of this study constitute an important base for the future development of the EFICS. The FIRS Project of the Joint Research Centre was established in 1994 to assist EFICS in analysing the possibility to use remote sensing (satellite and air-borne) techniques for providing geo-referenced data and information on the forest and other wooded lands of Europe.

Keywords: Forest information; Earth Observation

I Introduction

Approximately 30 % of the European land surface is covered by forest, the exact figure depends on the definition: If all land covered by woody biomass is included, the figure probably will be close to 35 %, if only timber productive areas are considered the area is much smaller.

Traditionally, the assessment of the forest area and the quantitative and qualitative “description” of the forested areas have been of a statistical nature. National and regional strategic planning has been based on statistics. The local management, on the other hand, has been based on mapped information at large scale. The statistics have for many years served the needs for national and international information, as statistics can give rather precise estimates on the forest reserves and their productivity, and because the compilation of large scale maps is very expensive when large area coverage is required.

In the recent years, the explosive development in the needs for information on the environment has slowly started to create a shift towards the provision of geo-referenced national and international forest information. A single number, stating the total forest area of a country may be sufficient for strategic and economic planning, but, will be of very limited use in regional and environmental planning. The forests have, so to speak, moved from being a total private issue into being an important environmental planning and protection issue of general interest for the society. Since efficient

regional environmental planning can rarely be achieved nationally due to the fact that most components needed in the planning are linked to landscape features, which are trans-boundary, then geo-referenced information has to be provided as generally available information, and preferably in a harmonised way, using a common nomenclature etc.

The development in the information needs goes hand in hand with the development in new technologies for data collection and data handling. In the case of forestry, remote sensing (RS) techniques and geographical information systems (GIS) have been very powerful instruments. The TREES (Tropical Ecosystem Environment Observation by Satellites) Project of the European Commission (Achard and D’Souza, 1994) which covers the tropical belt with small scale mapped information on the forest area is now developing into a tropical forest information system, and is slowly being developed into a global small scale forest cover map. A recent initiative by the G7 Committee on Earth Observation Satellites (CEOS) to establish a Global Observatory on Forest Cover (GOFC) as part of the International Global Observing Strategy (IGOS), constitutes a first step in the direction of providing global geo-referenced multi-scale forest information based on earth observation (EO) data, (<http://lcluc.gecp.virginia.edu/strategies/strategy3.html/>).

2 Forestry in the EU

Wood, was not part of the products in the list for common market policy

and regulations when the Common Market was created, accordingly no common forestry policy was established. However, in the early 60'ties a division for forestry was created in the Directorate General for Agricul-

ture. This division is the main stakeholder in the forestry organisation within the European Commission, but also many other units and divisions deal with aspects of forestry, see Figure 1. This rather dis-

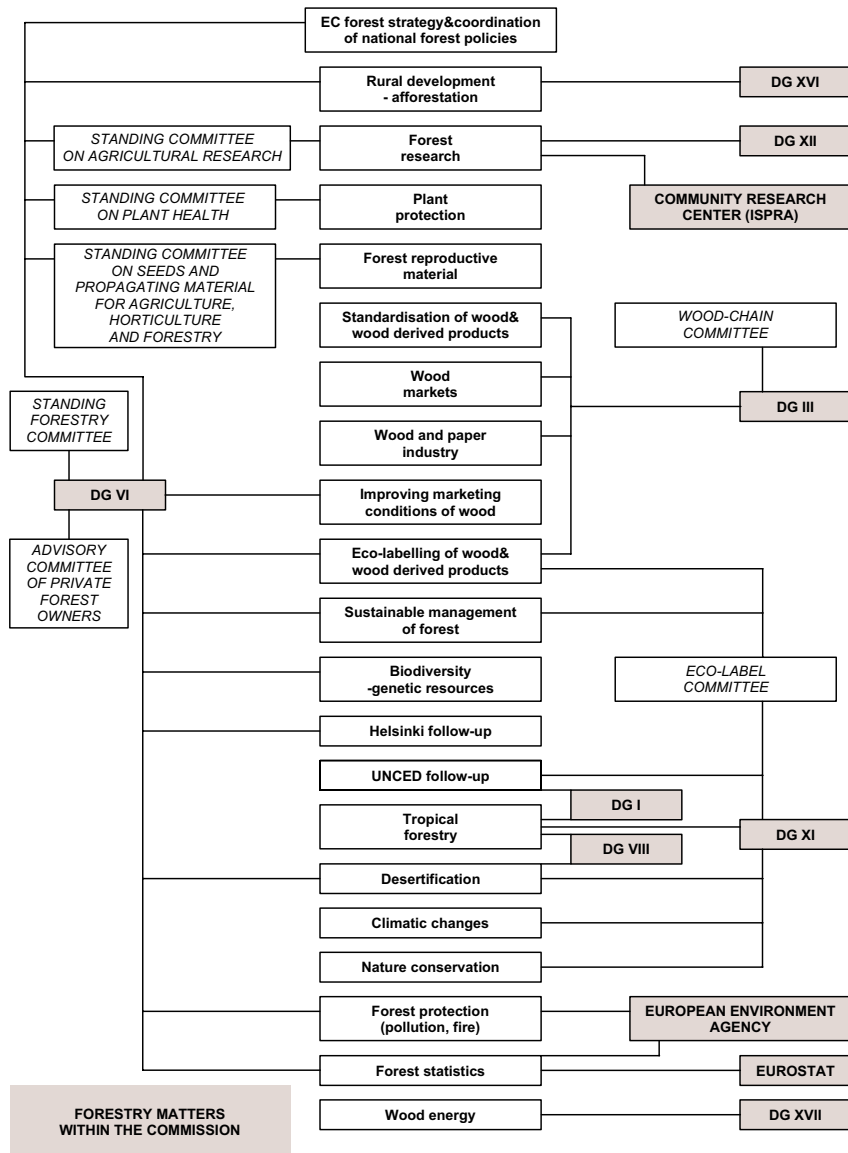


Figure 1. Overview of the main structure of the forestry activities within the European Commission.

perse responsibility clearly underlines that many different interests are linked to the forested lands of Europe, and clearly stresses the need for easily accessible and reliable information.

As no common forestry policy exists within the EU, the single Member States decide upon the type of forest information, which is made available for the general use within the EU. The Member States also decide the frequency with which the information is collected. The information on the European forest land is national, provided by the national forest inventories (NFI), and is generally available only for administrative units. This means that there exists a need for mapped forest information, which has not – and which will probably not be met in the near future by the same institutions unless both political and financial support is provided. It should perhaps also be realised that the present conditions stem from a time when forest was considered a national strategic issue, which may have created a degree of inertia in adjusting towards the needs of today. This could be one of the major reasons why the whole forest sector slowly seems to be moving from the agricultural authorities to the environmental authorities – a process accelerated by the request for bio-diversity and sustainable development and the permanent monitoring hereof.

Except for the NFI's of the Member States, which of course are the foundations and corner stones of any EU forest information system, the major stakeholders of the Commission are:

DGVI – Forestry activities in relation to the Common Agricultural Policy, rural development etc.

DG I and DG VIII – Relations to forestry outside the European Union
EUROSTAT – Provision of European forest statistics

DG XI and the EEA – Forestry in relation to environmental protection

DG III – Wood and wood-product industry

DG XII and JRC – Research and development.

2.1 EFICS

The European Forest Information and Communication System (EFICS) was established in 1989 via an EU Regulation (CEE, 1615/89), which stated that the Commission had to set up the system before the end of 1992; this date was later postponed until the end of 1997. The objective of the EFICS is to “collect, co-ordinate, standardise and process data concerning the forestry sector and its development”. It was stated that EFICS should “take account of existing data, and in particular statistics compiled by the statistical office of the European Communities, and shall make use of information available in the Member States, in particular data contained in national forest inventories, and of any database accessible at community and international level”.

In 1996, the Commission realised that the actions undertaken so far to introduce the EFICS had been hindered by the lack of information on the various systems in Europe for the

collection and processing of forestry data, and not least the differences between them. Therefore, a study aiming at providing a comparative analysis of forestry inventory procedures in European countries was launched; this study should also provide a proposal, or alternatives, to improve the reliability of forest statistics at the European level. The study was carried out via a contract with a consortium led by the European Forest Institute.

The study clearly showed, and thereby confirmed the results of a study under the FIRS project (Köhl and Päävinen, 1996), that “The current situation is characterised by differences in inventory, sampling and assessment procedures, data sources utilised, nomenclature (e.g. measurement rules, definitions), models (e.g. volume estimation, estimation of growth components, forest structure), analysis techniques, inventory organisations and responsible bodies and inventory cycles. However, a system of international data collection, which makes use of national forest resource assessments, has some advantages. They are often based on sound statistical techniques, they provide representative data on both wood and non-wood products and services for an entire region or nation, and the costs of the assessment have already been covered by the individual countries. A high degree of expertise exists in the national bodies. These advantages encourage the search for methods integrating different techniques and to harmonise procedures and nomenclature, with the objective of compiling national forest resource information,

and establishing a reliable and consistent data base at the European level.” Furthermore “The EFICS-study found that there are clear needs for comparable information at the international level. This is due to the international initiatives originating from the RIO Global Convention. But also due to the needs of information of various private and public organisations in the member countries, as shown in the information needs assessment carried out as a part of the study”. Further, “EFICS is urgently needed to close information gaps concerning European forests and the forestry sector. It has potential to become a focal point of forestry in Europe and could have the capacity to provide the information on forests, their sustainable management and their environment, which is needed by different categories of users” (DG VI, 1996).

It was highly recommended on the basis of the above mentioned study that EFICS, together with the forest authorities of the Member States, among other things should guarantee reliable and comparable information at the European level. This could be achieved by harmonising methods and nomenclature, which would require both development of common conversion factors, but also new European definitions for certain key attributes assessed in the national forest inventories. In some cases, special EFICS surveys parallel to the national assessment could be a feasible solution. It should be taken into consideration that the application of remote sensing techniques could both facilitate the assessment, and provide harmonised

Europe-wide information. The storage of the data was not considered a major problem, the data availability is the main issue. The set up and configuration of the data dissemination and analysis facilities should be considered very carefully. Both flexibility data security and user requirements have to be taken into consideration.

2.2 FIRS

The FIRS project of the JRC was established in 1994 to assist EFICS in analysing the possibility of using both satellite and airborne remote sensing techniques for providing geo-referenced and statistical data and information on the forests and

other wooded land of the Pan-European area (Kennedy e al.1994, 1995) (<http://www.emap.sai.jrc.it/firs/>).

The concept of the FIRS project is shown on Figure 2. The basic idea was, and still is to create a toolbox. The toolbox will provide the necessary information, methods etc. for extracting useful information from earth observation (EO) data, for combining EO data with other data types, for assessing accuracy, for using GIS techniques etc.

The internal structure for the FIRS project consists of several modules, Figure 3. The first foundation action, which was completed in 1996, has provided several data sets covering the Pan-European area at a small scale. These data are

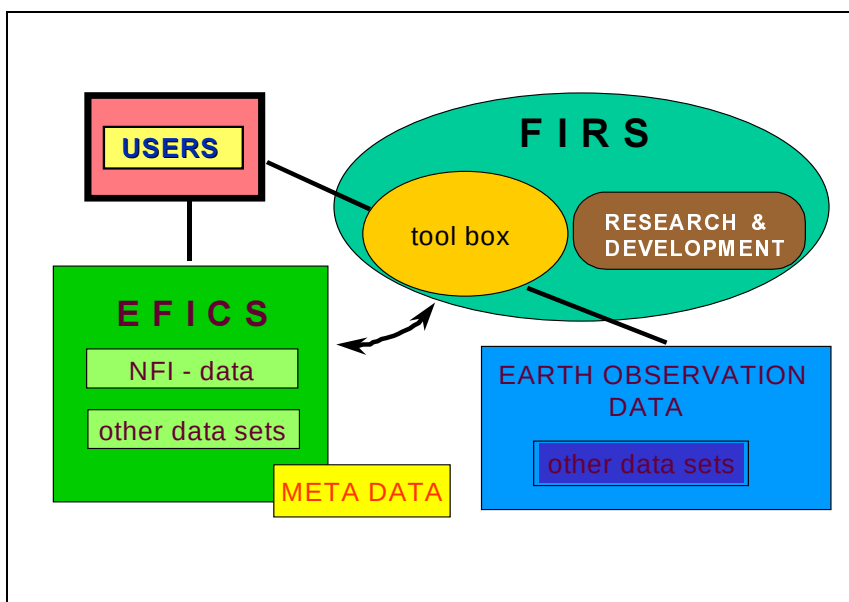


Figure 2. The role of the FIRS project is to assist EFICS in providing the necessary tools and methods for extracting useful information from earth observation data.

publicly available. The forest nomenclature study carried out by the European Forest Institute (Köhl and Päivinen 1996), is available on, (<http://www.emap.sai.jrc.it/firs/>). The third foundation action is continuously being supplied with new data from the various forest projects financed or co-financed by the Commission. Only some of the data from this foundation action will be publicly available. A steering committee under DG XII is looking into the problems linked to the publication of test area data coming from the various research and development share cost projects. As most data from test areas will be large scale, some data will be considered restricted, which may add some complications.

The software package, SILVICS, (McCormick, 1998; McCormick and Folving, 1998) developed in-house for forestry applications is publicly available. SILVICS is a user-friendly software package, which runs on most computer platforms, and which provides advanced techniques for the geometric and radiometric correction, structural and statistical analysis, and classification of multispectral satellite imagery. The software is freely available, under standard copyright conditions, on request to the Space Applications Institute's EMAP Unit.

Thus, the first part of the FIRS project has provided the very basic tools for the application of EO data within the frame outlined in Figure 2.

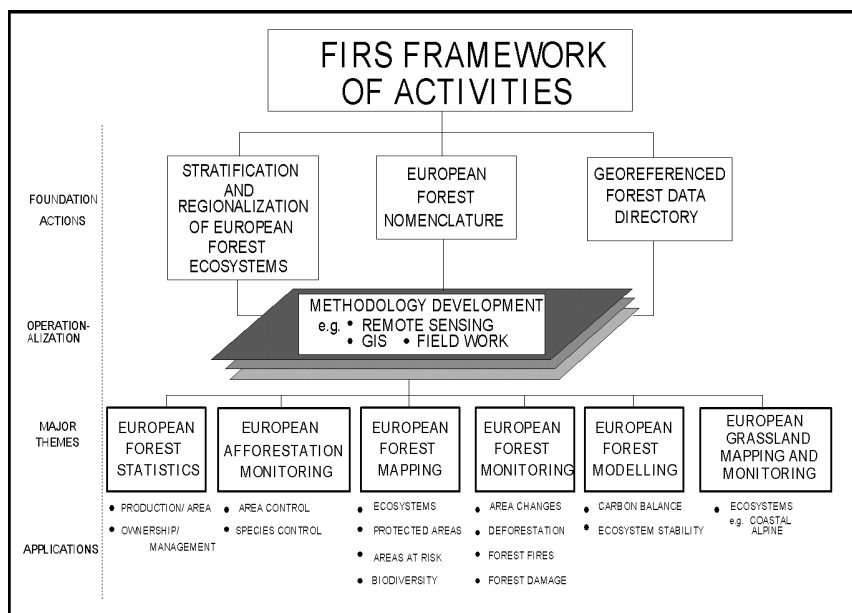


Figure 3. The structure of the FIRS project. Three foundation actions provide the input for the development of methods, which are used in the thematic applications.

Funding for the originally defined thematic application modules was not provided. However, other services of the Commission have launched projects which cover some of these modules or parts hereof:

1. DG VI launched a study on forest change monitoring (corresponding to a major part of FIRS Theme 4) and structural diversity mapping (corresponding to parts of FIRS Theme 3). The first part, forest monitoring has the objective to develop and demonstrate a system to detect and identify significant changes in forest cover. The major focus is on the detection of changes that differ from the normal vegetative succession of the ecosystems. The system will be as independent from ground data as possible. The key part of the study is to demonstrate the performance of the monitoring and change detection system in at least two different and representative forest regions of Europe.

The monitoring and change detection system is based on optical satellite images. It includes both large scale and small scale monitoring. Other types of spaceborne remote sensing data such as ERS-SAR images will also be considered as additional data sources. The detection system is aimed at producing both change maps and statistics of the changes. The monitoring system that will be developed and proposed should also include an assessment of the accuracy of the information produced and address the cost-benefit compared to other

methods, for instance ground based registration. The output of this study will be: 1) A description of the monitoring and change detection system; 2) A description of the accuracy of the system; 3) Sample maps of the results; 4) A description on how the change information can be utilised to update general statistical information of forests; and 5) An assessment of extrapolation possibilities.

The main aim of the second part of the study, structural diversity, is to define, develop and test a system for monitoring the structural diversity of the forested areas. The diversity in forest structure is believed to be an important indicator of bio-diversity and may be assessed and monitored using remotely sensed data at least two to three different levels (regional, community and population). This pilot study is carried out using the same regions as used in topic 1. The system will be based on high and medium resolution satellite data. It will be able to detect forest patches and to classify and describe both with regard to content and shape. The system will be linked to, and if possible integrated with, the change detection system developed under topic 1. The output of this topic will be: 1, A description of the system used to detect and describe forest structure (including the algorithms used for detection); 2, sample maps of the results; and 3, a description of the links and integration into a monitoring and change detection system.

2. The CEO project is financing two projects, which correspond partly to FIRS Theme 3 – forest mapping, and to FIRS Theme 1 – estimate of volume and above ground biomass. The objective of the FMERS study is to develop and implement methodologies for the provision of standardised geo-referenced information and statistical information to describe the forests and other wooded land in Europe using optical and microwave space borne remotely sensed data. The target variables are forest and other wooded land as well as proportions of major tree species groupings. The mapping part of the study is divided into two phases: phase 1 in which the methodologies are developed and compared at six representative study sites across Europe; and phase 2 in which two large regions will be mapped according to results and requirements from the first phase. The main outputs of this phase are 1) quantitative evaluation of the potential of different satellite data types in discrimination of the target variables and 2) the proposal for a procedure to accomplish European forest mapping using medium resolution satellite data. (<http://www.vtt.fi/aut/rs/proj/fmers/>).
The second part of the study, assessment of above ground biomass and volume, is just being launched, (spring 1998). It will provide research based experimental data sets from two test sites which will be included in the forest databases of the Space Applications Institute.
3. The EMAP (Environmental Mapping and Modelling) unit, to which the FIRS project belongs, has launched a project under FIRS Theme 4. This project will supply a forest probability map of the whole Pan-European area. The scale will allow an estimate of the probability of a single NOAA-AVHRR pixel (approximately one square kilometre) belonging to the class wooded land (forest and other wooded land). Thus the project will provide a Pan-European database consisting of both the probability values and the calibrated original satellite data.
4. The Decision Support and Integrated Assessment (DeSIA) Sector in the System Analysis and Modelling unit of the Institute for Systems, Informatics and Safety (ISIS) at the Joint Research Centre is now using the existing FIRS data base for modelling (FIRS Theme 5). The DeSIA Sector uses the data to obtain a first estimate of the upper and lower bounds of the carbon dioxide sink strength of the European forests and is thus giving substantial support to the FIRS theme on forest modelling. (<http://www.unitus.it/eflux/euro.html>). The co-operation between DeSIA and FIRS does not only mean that DeSIA is responsible for part of the modelling theme of FIRS, it also means that FIRS will assist DeSIA in providing best possible data for future carbon modelling activities.

3 European Forest Institute's databases

The European Forest Institute (EFI) in particular is committed to compiling and disseminating forestry information at the European level. The institute has started to develop and implement an effective and well-organised information service for the European forest sector.

The EFI information service consists of both a forest information system presented as a user-friendly interactive database, and direct services through information specialists which compile information according to requests.

The forestry data are compiled, validated and stored in the main database using a '*Structured Query Language*'. Presentation tools are developed according to the type of input data. The general database structure is based on linking different data sets, which are part of the EFI databank. This concept is currently being implemented and will eventually allow the retrieval of all available information on a selected topic by specifying one query to the main database. All the data that are stored and "value added" by EFI, are processed and utilised in agreement with the data owners or original publishers. The rights of ownership are respected by clearly indicating the source of the data.

The UN-ECE/FAO Forest Resources Assessment of the Boreal and Temperate Zones, 1990 and the COST Action E4 project 'Forest Research Reserves Network' are men-

tioned here as examples held at the EFI databases.

- 1) The forest resources database allows the user to extract data on forest resources by selecting from the list of UN-ECE/FAO categories and countries using different web browsers. The query is sent to the database resulting in a summary table. Other features such as maps, graphical output (bar charts, pie charts) and a list of UN-ECE/FAO definitions can be selected. In its current form, full database services are available to EFI members, and the public has access to parts of them. (http://www.efi.fi/Database_Gateway/Forest_Resources/). Similarly, work is ongoing to develop both, forest products and timber trade flow interactive databases.
- 2) The 'Forest Research Reserves Network' database has been developed as an interactive, user-friendly, on-line questionnaire, which stores the data directly in the database after submitting the data input. Access to the input of new data is restricted to the participants of the COST E4 action. With the help of an interactive search tool, the information can be extracted from the database according to individual user needs. The search function is open to the general public. The 'Forest Research Reserves Network' allows the retrieval of general information on forest reserves, suitable for research. The design and functionality of the network contributes to the exchange of research results and assists in finding nec-

essary research contacts in the field of forest reserves research (http://www.efi.fi/Database_Gateway/FRRN/).

4 Networked forest information

It should be taken for granted that today all entities needing forest information are using digital equipment linked to some standard network. This should at least be the case for professional applications. The organisation of the databases, or rather the networking of the databases is very technology dependent, theoretically there should be no, or few limitations for cross-referencing of data, so it is in fact only the data availability that should be addressed.

To make the data available on networks does have severe implications for the data owners. They have to organise the data and decide on the availability, and they often have to redefine data responsibilities and perhaps even to take the possible uses of the data into consideration.

User requirements are slowly but continuously changing. We have few user requirement investigations and the ones we have are heavily biased towards the requirements from traditional forestry professionals, thus a large potential forest information user group is missing, namely the persons engaged in landscape planning and rural development who have no professional background in forestry.

4.1 User requirements

Two major European forest information user requirements studies have been made as mentioned earlier, one by the FIRS (Köhl and Päävinen, 1996) and one by DG VI – the EFICS study (DG VI, 1996). The latter study principally addressed the hard core forest community, international, governmental, regional and local forest authorities, and forest companies and forest organisations, but also a few NGO's were included. The FIRS study addressed three major groups, the production group, the environmental user group and a group engaged in the broader land cover planning aspects, however, all from the forestry community.

The EFICS study revealed that the two forest attributes “forest area” and “tree species composition” were the most important variables seen from a data user point of view. But, also that the “productive functions” of forest were of high importance. The fourth priority was “volume and annual increment and cut” followed by “biological richness and diversity”. The sixth and seventh priorities were “volume and its change” and “health condition” respectively.

When asked to score very broad groups of forestry information types, the user replies were distributed as follows:

- 1) Wood resources: 83% of the users gave very high priority
- 2) Forest policy: 71 %
- 3) Research and development: 70 %
- 4) Forest industry production: 64 %.

This result indicated that not only wood and forest resources, but also

Table I. The priority list of forest indicators and their need for harmonization. The three groups correspond to the user categories mentioned in the text.

Variable and variable-group	Harmonization needs
'PRODUCTION' VARIABLES	
Actual forest area	yes
Stand structure	yes
Diameter	no
Height	minor
Volume	yes
Drain / removals	yes
Timber quality	yes
'PROTECTION' VARIABLES	
Land cover	high
Health	no
Damage	high
Vegetation types	high
Water resources	high
Protection status	high
Naturalness	low
Threats to species diversity	
Environmental impact	
Wildlife habitats	
LAND USE PLANNING VARIABLES	
Land cover	high
Actual forested area	yes
Other wooded land	high

other information is of interest for most potential clients of EFICS.

The results of the FIRS study did not differ significantly from the EFICS study, however, the user group was divided according to “main responsibility” – see above. Table 1 shows the most needed attributes according to the user groups.

It is characteristic that the forest cover is the most wanted variable. It is probably also characteristic that the production oriented user groups puts higher priority on variables related to volume, drain etc. than the two other groups, which give higher pri-

ority to environmental indicators, such as protection and bio-diversity.

Both studies clearly revealed that the most important variables should be updated on a two to five year basis. The 10 year updating cycle which most countries now aim at does not seem to supply the information, often enough, to meet the user requirements.

Even if the users were not directly asked whether mapped information would be essential, both studies indicated a big interest in the availability of geo-referenced data. An earlier study clearly indicated that local

foresters needed regularly updated mapped information (Folting et al. 1992). The EFICS study user group was asked which variables after forest area they needed as mapped information. The reply showed the following priority: 1, protection and conservation; 2, species composition; 3, forest condition and damage. No doubt that the Criteria and Indicator (C/I) on sustainable development and, especially, on bio-diversity, would have much more weight to day and that a large user group should be included, i.e. managers dealing with risk assessments and hydrological planning and management – but working in entities not normally linked to the forest sector.

4.2 Implication for organisation

National forest inventories are supposed to build the basis for the EFICS initiative and the EUROSTAT databases are, according to the regulation, considered to be a key entity. It can thus be foreseen that the supply and updating of the statistical data reported for administrative units will be continued.

The European Environment Agency is obliged to provide information on the status of the Pan-European environment at regular intervals and has thus a need for forest maps, and maps of key forest indicators on, amongst other things, biodiversity. Already the CORINE Land Cover database includes important mapped forest information following the specific CORINE methodology.

EFI, as described above, WCMC and other important NGOs have

compiled valuable forest information including maps serving various interests and needs. At a global level FAO is going to be a very important supplier of data on almost all forest aspects following the TBFRA2000 and FRA2000. This will be statistical information. EFERN (European Forest Ecosystem Research Network) is a very good example on a network, which is primarily dedicated to ecosystem research (<http://efern.boku.ac.at>). In the future EFERN will most probably serve a much larger user group that originally aimed at. IUFRO also provides valuable forestry information for Europe (<http://iufro.boku.ac.at/>)

Potentially all ingredients for the EFICS are existing. In reality, only the NGO's have had the necessary funding, and administrative and political freedom to get organised. The key issue for EFICS is not to have a large central database, but the availability of the data. It does in principle not matter where the data are stored as long as they are available. Available for whom? – is an important issue.

To become efficient EFICS should be supplied with the necessary possibility to co-ordinate the “data availability”. And EFICS should have the possibility to assist the NFI to supply the data, which can be made public. As the application of EO data has been included in the EFICS regulation, co-ordination of the development and production of the new geo-referenced data and information types will be needed too. EFICS should also supply the necessary links to global data sets in order that European users easily can

access global forest information, and in order to make European data easily accessible for non European users, research and modelling networks.

4.3 Implication for the data

Both the EFICS and the FIRS studies very clearly revealed that the majority of the forest data cannot be directly compared at the European level. Most countries use their own set of definitions and methods. Therefore most variables or indicators need to be harmonised if correct comparisons are to be made (see Table 1). The EFICS study indicated four different alternatives for improving the situation:

1. To rely on existing national forest inventories;
2. To introduce a set of harmonised attributes in national forest inventories;
3. To carry out harmonised assessments at the national level in addition to the national assessments;
4. To conduct an independent EFICS survey at the European level.

The FIRS study, which was carried out before the four alternatives were set up, provided a proposal for a nomenclature to be used in forest resources assessments using EO data, which in fact fits very well with each of the last three alternatives.

At least for the variables and the indicators on bio-diversity, which easily can be assessed and monitored by the use of EO data, a new nomenclature and set of definitions should be implemented. Not least, because

remote sensing can be foreseen to take over in the future as a cost effective data and information providing tool. For the variables and indicators on bio-diversity, which will still be relying totally on traditional field assessments also in the future, several possibilities exist for making the data comparable. The necessary conversion methods could easily be included in the FIRS toolbox mentioned previously.

For all data, regardless of the method with which they have been collected and provided, it should be clearly stated in the database how, when, by which method etc. the assessment was carried out. The high standards as used by for instance EUROSTAT and FAO today should always be the aim for any data provider. This may seem to be a rather redundant statement, but it should be clear for a user whether he finds raw data and observations or modelled and derived data. Hopefully, eventually, the reliability, or more precisely the accuracy and precision of the single data layers can be stated - both for the statistical and the mapped data.

In statistics there exists a long tradition for collecting and calculating data for administrative units and for arranging sampling to provide a single number for a single administrative unit. The EU forest statistics is given for various levels of NUTS. The National Forest Inventories are set up in the same way. Several key variables and indicators can today be provided as mapped information using EO data. The still growing demand for geo-referenced environmental data makes it much more ob-

vious to choose a natural geographical unit for reference. The catchment or watershed seems to be an obvious alternative. In fact, the catchment is the only useful reference area when we are dealing with the terrestrial surface and the direct influx to the sea and lake areas. This solution, which favours the EO data, so to speak, also forwards new requirements for the NFI data. These data have to be provided in a geo-referenced format for the sample plots, so that they can be used for “calibrating” and “training” in remote sensing applications. This might perhaps constitute a minor political problem, which could be solved by securing that the entities carrying out the national forest inventories also were given the task and needed funding for providing the EO data derived mapped information.

5 Concluding remarks

When EFICS was defined 10 years ago, probably no one had foreseen, even imagined the growth in networked information in general. The very first estimates on the costs of running such a communication and information system came up with so high costs, that the momentum and interest from the Member States were lost.

The CORINE Land Cover map was used as an argument for not getting further involved in European forest mapping, and later the principle of sustainability made mapping at small scale a national item. It is of

course correct that the CORINE map does supply much valuable information on the forested area and that the potential use is big; it is also correct that other forest variables are needed for many purposes. The Member States can easily supply all needed mapped information, however the comparative studies have shown that the users need harmonised information and that some organisation has to take the lead to secure common nomenclatures etc. The Standing Forestry Committee could secure this through EFICS.

During the 10 years, the need for an efficient forest information and communication system has grown tremendously. The many diverse initiatives mentioned above prove this. At the same time new possibilities in applying EO data have emerged. These data can be used for providing a part of the needed information more efficiently in a synoptical way with much shorter intervals than is normally possible though NFI's. They can also, to some extent assist in providing new insight in forest eco-variables. The demands for new types of forest information definitely prove that a need for an efficient communication system is existing.

The possibility for providing access to data with variable level of authorisation should make it easier to organise the data bases and should make it easier for data suppliers, as these would have to worry less about the sensitivity of the data and the derived information. Maybe it would also be considered beneficial if official data would be readily available, both in order to secure a high level of standard, but also in order to avoid

“invented” forest data and misinterpreted information.

There do indeed exist a need for a European Forest Information and Communication system, which can combine statistical and mapped data and derived information on the forests and other wooded lands in the Pan-European area.

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Off-line interactivity – bridging the gap between those with and without direct access to the World Wide Web

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Abstract

Information is power, is an old adage. The rapid growth of Internet, and particularly the World Wide Web (WWW or Web) has left many observers wondering how this new media is influencing the balance of information power. As a majority of the world's population lack even access to electricity, the situation is obvious: most people are left out. It is for this reason that connectivity is getting so much attention in international development circles. Another part of the equation which is in urgent need of being addressed is information flow in and out of the Internet, especially the WWW. This paper takes a look at a few methods of off-line Web interactivity, particularly e-mail to Web systems, including GetWeb, Mailing List WWW Gateway (LWGate), and the Association of Progressive Communication (APC) Conference-Newsgroup gateway. Some Lotus Notes/Domino applications are also mentioned. All these methods can help bridge the gap between those with and without direct access to the Web.

Foreword

This paper is meant to be a contribution to the discussion of off-line access to the Web. No attempt has been made to examine all methods of off-line access nor to take a comprehensive look at the topic.

I Introduction

“Information is power,” is an old adage. The rapid growth of Internet, and particularly the World Wide Web

(WWW or Web) has left many observers wondering how this new media is influencing the balance of information power. As a majority of the world's population lack even ac-

cess to electricity, the situation is obvious: most people are left out. It is for this reason that connectivity is getting so much attention in international development circles. Another part of the equation which is in urgent need of being addressed is information flow in and out of the Internet, especially the WWW. As many people do not have on-line access to the Internet, methods of off-line interactivity with the Web are an important component of access to information on the Internet.

The concept of “off-line Web interactivity” may seem like a contradiction in terms. This is because, normally, access to the Web only occurs while “on-line” - or connected to the Internet. Though there is a variety of software that can capture and store Web information on a local hard disk, these programs can of course only be activated when on-line. Thus, the contradiction persists. Further, though viewing a Web site from a floppy disk or CD may be considered interactive from the perspective of letting the user choose what to view, no opportunity exists to submit information back to the Web site copied onto the floppy or CD.

The term “interactivity” can mean many different things. Thus, following first is a discussion of what is meant here by “off-line interactivity” and why it is important. Some comments are then made about off-line viewing of basic HTML Web sites. The next section addresses e-mail access to the Web and the GetWeb software. Included is a brief mention of a listserv-Web program called Mailing List WWW Gateway (LWGate), as well as the Association

of Progressive Communication (APC) Conference-Newsgroup Gateway. Then, some of the features of the Lotus Notes/Domino e-mail to Web to e-mail discussion forum are introduced, followed by a description of the Lotus Notes/Domino built-in off-line interactivity and a brief conclusion.

2 What is it and why is it important

Off-line Web interactivity can loosely be defined as any method of viewing or receiving information from the Web and/or submitting information for later inclusion on the Web, while off-line. Using this definition, simply viewing or reading a print-out from a Web site is off-line interactivity. For purposes of discussion is it useful to call this “one-way interaction” or to be more precise, “non-computer-originating, receiving-only interaction”. In the same manner, sending an e-mail that appears on a Web site in one format or another, e.g. in a discussion forum or guest book, can be called “computer-originating, sending-only interaction” – and is also one-way interaction. However, two-way interaction is also possible, both originating and not originating from computers.

An example of achieving two-way interaction without originating from computers is when an article in a magazine about a Web site is read by someone who writes a letter to the Web site publishers, who then type in the letter, publish it on the Web site, make a print-out of the Web page with the letter and mail it to the au-

thor. There are numerous variations of this example. However, a drawback of one or two-way, non-computer originating interactivity is that it can be much more labor and time intensive than either a combination of computer and non-computer originating interactivity, or only computer originating interactivity. It is the latter type of interactivity that is examined here, i.e. computer originating interactivity for both the receiver and sender. None-the-less, non-computer originating interactivity remains the only option for most people in disadvantaged regions.

Among those in disadvantaged regions who do have access to the Internet, many more have access only to e-mail than have access to e-mail and the Web. As well, those that do have access to the Web may have only limited access due to financial constraints from on-line fees.

3 Off-line viewing of basic HTML Web sites

Basic HTML Web sites can easily be viewed off-line if certain design considerations are taken into account. The word “viewing” was carefully chosen here. Looking at a Web site off-line requires much less technical sophistication than submitting or downloading information to a Web site off-line.

Though it is standard practice to preview at least part of a Web site off-line during development, it is not standard practice to design Web sites for easy off-line viewing. The reason for this is more likely due to a

lack of awareness of the concept, rather than conscious design choices.

Basic requirements for viewing a Web site off-line include using the same directory structure locally as on the server, making internal links local rather than virtual, and taking into consideration case sensitivity and number of characters in links.

3.1 Directory structure

If during an on-line session, a group of HTML files and any images they include are saved to the same directory, if any of the files or images were in different directories on the server, the links to the files won't work nor will the images show up, though all files and images were transferred from the Web to the local hard disk. For the links to function, the HTML code must be edited, or the directory structure must be made and files moved to their proper place. Both methods can be very time consuming. There is of course a limit to how many files can be easily managed in one directory. Large Web sites require some sub-directories. In any case, using the same directory for related files, including images, makes off-line browsing much easier.

3.2 Link considerations

When a Web site is accessed on-line from a server, internal links function in the same manner whether they are virtual (`href="http://www.sei.se/whatsnew.html"`) or local (`href="whatsnew.html"`) (the full HTML code is not used here as it would not be seen in the Web version of this document). However, when a Web

site is accessed off-line from a local hard disk, links must be local as links that point to a Web server do not function off-line.

Another aspect of using local links are considerations for operating systems that don't support file names of more than eight characters and an extension of more than three characters (referred to as the 8+3 system). If there are more than eight characters in a link, it won't work on a Windows 3.x operating system as the file name will be shortened to eight characters when accessed. Further, since link addresses are case sensitive and Windows 3.x operating systems do not allow capital letters in file names, it is important to only use lower-case file names.

The four character ".html" file extension can however be used in links for both Window 3.x systems and systems that support long file names (e.g. Windows 95 and 98 and Mac operating systems). The files names will be shortened to ".htm" in Windows 3.x systems but most Web browsers when operated on Windows 3.x systems interpret .htm the same as .html. Operating systems that do support long file names will, for example, treat `whatsnew.html` differently than `whatsnew.htm`.

4 E-mail access to the Web

Many Internet services, including the Web, can be accessed via e-mail. Bob Rankin from the U.S. has summarised the situation well.

If you don't have direct access to the Internet through your

BBS or online service, you're not alone. Many of the world's countries with Internet connections have only e-mail access to this world-wide network of networks.

But if you think that sounds limiting, read on. You can access almost any Internet resource using e-mail. Maybe you've heard of FTP, Gopher, Archie, Veronica, Finger, Usenet, Whois, Netfind, WAIS, and the World-Wide Web but thought they were out of your reach because you don't have a direct connection.

Not so! You can use simple e-mail commands to do all of this and much more on the Internet. And even if you do have full Internet access, using e-mail services can save you time and money. If you can send a note to an Internet address, you're in the game.

Source: Rankin, Bob. March 1998, 7th Edition. "Accessing The Internet By E-Mail, Doctor Bob's Guide to Offline Internet Access." WWW: [http:// www.cis.ohio-state.edu/hypertext/faq/usenet/internet-services/access-via-email/faq.html](http://www.cis.ohio-state.edu/hypertext/faq/usenet/internet-services/access-via-email/faq.html)

The International Development Research Council (IDRC) in Canada has a project called Uganisha that includes operation of a server for accessing the Web via e-mail. The following was recently downloaded from the Bellanet Web site (<http://www.bellanet.org/>):

IDRC: UGANISHA: Activities

1. Web-to-Email Server

Given that a large proportion of IDRC grant recipients have access to email but not access to the World Wide Web and given the veritable plethora of resources available now on the World Wide Web; the Uganisha established a Web-to-Email server that allows anyone with access to email to access pages from the World Wide Web. They can also conduct searches via email and fill out web forms. The server has been extremely successful since it's inception. The development of the server was done in collaboration with Bellanet using GetWeb software produced by Healthnet.

Source: <http://www.idrc.ca/uganisha/services.html>

4.1 GetWeb

GetWeb is a server program that can receive requests via e-mail to access Web addresses and e-mail back the documents requested. It is worth noting that some GetWeb servers can even handle Web pages that contain fill-in forms. The following description is from the HealthNet Web site:

GetWeb enables the user to request the text content of any Web document via electronic mail. The user can also use GetWeb to utilize commercial search engines like AltaVista and Yahoo!, navigate through links, submit forms, and search databases.

Sources: <http://www.healthnet.org/info/info.html#internet>
GetWeb: <http://www.healthnet.org/dist/getweb/help/indexgw.html>

[org/dist/getweb/help/indexgw.html](http://www.healthnet.org/dist/getweb/help/indexgw.html)

5 Mailing List WWW Gateway (LWGate)

The following quote summarises the nature of LWGate:

About the Mailing List WWW Gateway

The Mailing List WWW Gateway was created by myself, David W. Baker, basically to bring mailing list functionality to the Web and take advantage of the easy-to-use characteristic of WWW interfaces. I've found that few people are comfortable with mailing list commands and hope that this program can make mailing lists more useful to their subscribers. Please send me mail if you have any comments, questions, or concerns.

Source: <http://www.netspace.org/users/dwb/lwgate.html>

6 Association of Progressive Communication (APC) conference-newsgroup gateway

The Association of Progressive Communication (APC) (<http://www.apc.org>) has a text-based conference system accessible via Telnet that can be set up to allow submissions via e-mail and viewing of all submissions in a public or password

protected Internet Newsgroup interface. The Newsgroup readers included in many Web browsers or specialised software can be used. The text-based conference system has functioned since the early 1980s. The Newsgroup interface was launched in the mid-1990s. It is of note that this conference system pre-dates public access to the Internet and existence of the World Wide Web. A feature of the conference system is that the world-wide network of APC servers regularly transfer information with each other, and thus act as continually updated mirrors of each other. This is the same type of feature referred to as “replication” by Lotus Notes/Domino.

7 Lotus Notes/ Domino e-mail to Web to e-mail discussion forums

Features of Web interface discussion forums made with Lotus Notes/Domino are that they can be set-up to: receive submissions via e-mail; distribute via e-mail the full-text of submissions via e-mail or the Web; and allow user-configured, e-mail distribution of only the author, date, and subject line of submissions (where users can choose to be notified only of messages by certain authors or when specific keywords are used in the subject line). Thus, two-way interaction can be achieved using only e-mail or the Web, or a combination of the two. These features are being used in the Global Water Partnership Water Forum Web site (<http://www.gwpforum.org>).

8 The Lotus Notes/ Domino built-in off- line interactivity

Web sites built with Lotus Notes/Domino software have built-in off-line interactivity via a Web browser. Lotus Notes is the client software that operates on an individual user’s computer and Domino is the counter-part server software. In late 1997, version 4.6 of the both the client and server was released, and marked a turning point in possibilities for viewing information off-line using a Web browser. One of the innovations in this new version was that all information could be viewed off-line with a Web browser using only the client. Up until that point, off-line browsing required running the server version at the same time as the client. This meant not only the added expense of purchasing the server version, but also placed high system requirement demands (i.e. processor capacity, RAM, and hard disk space). Further, running the server and client on the same computer requires some advanced knowledge of the software.

A Web site designed with Lotus Notes can include such features as forms for submitting information (including discussion forums), automatic sorting and categorising of information submitted, registering and logging in, individual and group password protection for all or parts of the site, full-site and sub-site searches, and uploading and downloading files – all of which function via a Web browser when off-line.

There is an additional feature called “replication” that makes it possible to submit information off-line and then go on-line and incorporate the new information into a Web site accessible via the Internet, while at the same time receive any changes to the Web site (such as submissions via the Web, e-mail, or intermittent replication of the whole site from others). Domino servers connected to the Internet can be set to replicate with each other at regular intervals, resulting in continuously updated mirrors of interactive Web sites.

One scenario for achieving off-line interactivity is as follows. A computer is set-up with client versions of Lotus Notes and Netscape in a public location, say a university library in a disadvantaged region without an Internet connection. At the library, people interact with the Lotus Notes built Web site by reading information that was at some point previously submitted via the Internet, submitting items to discussion forums, uploading and downloading files, adding events to a calendar, posting employment requests and vacancies, etc. All submissions made at the library are stored on the local hard disk. Every few days someone transfers the Notes files making up the Web site to some type of storage media (e.g. floppy disks or zip disks), copies the files onto a computer with a modem, makes a dial-up connection to the Internet, and replicates the files with those on a Web server permanently connected to the Internet. Once the replication is complete, the files on the local computer are identical to those on the

Web site on the server. The new files on the local hard disk are then copied onto some type of storage media and transferred to the computer in the university library, which then has an updated version of the Web site. The floppy or zip disks could even be sent back and forth between the North and the South via snail-mail, a courier service, or even diplomatic pouch. The interactivity achieved would not be instant as occurs when connected to the Internet, but interactivity would be achieved.

9 Conclusion

Simply viewing or reading information printed-out from a Web site can be considered interactivity. As well, standard HTML Web sites can be stored on floppy disks or CDs and easily viewed off-line if certain design considerations are taken into account. More important though is that there are several methods of interacting with the Web off-line via e-mail. Use of GetWeb servers is a viable option for e-mail access to the Web, as is participation in APC conferences, listserv-Web gateways and Lotus Notes/Domino discussion forums. It is more difficult to achieve interactivity off-line using Web browsers. Web sites built with Lotus Notes/Domino have off-line interactivity with Web browsers built-in. Implementing them as a solution though requires somehow transferring the data to a computer with Internet access. All these methods can help bridge the gap between those with and without direct access to the World Wide Web.

An information service to support global forest policy

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Abstract

There is increasing global consensus that forest management must take into account the multiple values and benefits derived from forest resources, not simply timber and other wood products. Access to improved information on forests is key to making this possible. Indeed, the conclusions of the Intergovernmental Panel on Forests recommended "...the development of improved forest information systems with a view to enhancing co-ordination and data sharing...".

In response, the World Conservation Monitoring Centre, one of the principal sources of global information about forests in the conservation context, has initiated development of a Global Forest Information Service (GFIS). GFIS is designed as a consortium fostering collaboration and links among many diverse data providers to deliver the full range of forest-related information most useful to decision-makers through a single entry point, both on the internet and in other forms. A conceptual framework has been constructed to highlight the essential issues common to all types of forest-related decisions (resources and services, management, and pressures or demands), and a full range of information on these issues from many sources will be made available through this single unifying structure. The service will continue to evolve as a result of the diverse collaboration and input anticipated. As part of the development process, WCMC has proactively sought feedback from potential users of GFIS on the suitability of a prototype model for meeting their needs. The results have suggested that the framework is a useful one, not only for delivering forest information at regional and global scales, but also as a model for the development of national forest information services. The presentation will introduce the conceptual framework and prototype Global Forest Information Service, and include an analysis of who will be the principal users of global forest information on the Web and what their needs will be.

Anticipating the strategic role of EU law in the development of communications technology in a fragile natural world

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“In a culture like ours, long accustomed to splitting and dividing all things as a means of control, it is sometimes a bit of a shock to be reminded that, in operational and practical fact, the medium is the message.”¹

I Introduction

Law is a formidable and powerful force in society. Accordingly, knowledge of legal dynamics is directly relevant to both the regulation of communications technology (CT) and the regulation of environmental and natural resources, including the protection of indigenous peoples. Furthermore, the development of regional legal communities such as the European Union, as part of the globalisation process is extremely important. However, the role of law as a strategic force is often ignored, by both lawyers and non-lawyers, partly as a result inertia and stagnancy associated with the protectionism of the legal profession.

The European Union itself, and through the World Trade Organisa-

tion, will play an important role in the shaping of the context in which both communications technology and protection of the environment operate. The EU is setting the agenda in relation to the development of the ‘information society’, the establishment of a single market, the development of ‘Trans-European Networks’, the liberalisation of telecommunications, the maintenance of competition, the establishment of technical standards, the initiation of regulation of the internet, the protection of the environment, the protection of human rights and possibly the protection of indigenous people. Failure to understand the present influence and to anticipate the future trends of developments within the European Union, will probably undermine the coherence of any strate-

gic approach to the world of information.

This paper will outline the role of the European Union in the development of the global approach to the regulation of information networks, in a world which is increasingly sensitive to the fragility of the natural world. It will explore the nexus between them, and also propose some basic strategic considerations to implement the objectives of protection of the natural environment in a time of unification of information networks. It suggests the need for not only operational knowledge of EU, but also strategic.

2 The need for strategic awareness of law

People and organisations are aware of law to varying degrees. Obviously there will be greater awareness in relation to areas that directly concern them. It is clear that operationally, law is the water in which we swim. Apart from areas of direct involvement, or operational law, there is a vague sense of its pervasive presence, but often without perceiving the exact dynamics involved. Familiarity with law is not unlike familiarity with the weather. Certain implications are understood. If it rains, bring an umbrella. Certain patterns are clear. There might be less rain in summer time. Certain indicators may help such as experience or weather forecasts. Thus it might be argued by analogy, that individuals do not need to understand the process, but only

the product. However, in relation to law this would be to ignore the regressive role of the legal profession.

It is axiomatic that all early law-givers claims authority from divine sources. The lawyers tended subsequently to operate as elite groups, like a priestly class. The contemporary profession in many European countries, still manifest the mantle of the magician. The aura which is reflected from the power of State apparatus is complemented by the deliberate cultivation of a mystique of tradition and complexity to justify the anachronistic perpetuation of an often medieval ethos. The factors which promote the persistence of this culture are mainly economic. Professions seek to protect themselves from competition, and in particular from new entrants.

But that should not spread a fog which obscures the reality, relevance and ramifications of law. Because the profession has become inert rather than proactive, seeking to cushion itself from competition, the need for awareness of the strategic role of law, necessarily devolves to those who prepare projects. There needs to be an awareness of how legal developments will impact on the total context in which projects operate, particularly in dynamic domains of contemporary significance. This makes knowledge of law imperative for designers of projects in relation to CT and the environment, or both.

In summary,

- There is a need to appreciate the strategic importance of law, in addition to but apart from its operational importance, particularly in

view of the regressive nature of the legal profession, and especially in relation to dynamic areas such as CT and the environment

3 Unique nature of the EU

In the story of the ‘Elves and the Shoemaker’, the shoemaker in the morning discovers the shoes, but did not know how they got there. Similarly in relation to the EU, many people may know what the result is, but not be very sure how it happened. High profile case such as Defrenne (which established enforceability of the requirement of equal pay) emphasise, in a very graphic way, the practical significance of decisions of the European Court of Justice (ECJ)². The EU is unique among legal communities, especially in its earlier incarnations. Arising from the smouldering ashes of Europe, the blood spilt by the warring States, and the nightmares of persecution and pain experienced on the continent, it was destined to be unique, novel and bold. Legal concepts are an oft-ignored part of the tapestry of consciousness that informed the paradigms that contributed to the destructive momentum in pre-war Europe. Likewise, they have been underestimated as part of the solution. The EU’s unique nature arose from its unique legal construction. While emphasis may be placed on its political, economic or social dimensions, we must identify it as a legal creature. Legal and political realities,

which had become hardened and immutable in warring Europe, needed to be relaxed, re-interpreted and re-assessed.

Accordingly, it is both necessary and useful to sketch briefly some of the basic legal framework of the EU. The European Union refers to the Union which emerged after the Maastricht Treaty, building on the existing Communities which has been developed such as the European Coal and Steel Community (1951), the European Atomic Energy Community and the European Economic Community (1957). Accepting that the original driving force behind the enterprise was the avoidance of war in Europe, the mechanism to achieve this objective was via the integration of the peoples and their political structures, based on the core concept of the common market, or the internal or single market at it became known later.

All of the cases establishing the major principles of Community law have arisen, directly or indirectly from the establishment of the common market and the maintenance of principles of free movement³. This legal nature of the Community was explained by the ECJ in the Costa case, which came before it, in the process of explaining how Community law could not be over-ridden by domestic law, where it stated that,

“by creating a Community of unlimited duration, having its own institutions, its own personality, its own legal capacity and capacity of representation on the international plane and more particularly, real powers stemming from a limi-

*tation of sovereignty or a transfer of powers from the States to the Community, the Member States have limited their sovereign rights, albeit within limited fields, and have thus created a body of law which binds both their nationals and themselves”*⁴

This principle of supremacy of Community law, is complemented by the principle of ‘direct effects’ articulated in the Van Gend En Loos case, where the ECJ explained the legal basis of enforceability of rights by individuals, stating that,

*“the Community constitutes a new legal order of international law for the benefit of which States have limited their sovereign rights, albeit within limited fields, and the subjects of which comprise not only Member States but also their nationals. Independently of the legislation of Member States, Community law therefore not only imposes obligations on individuals but is also intended to confer upon them rights which become part of their legal heritage”*⁵

Galileo’s trial came of at the mid-point of the 30 War (1618–1648)⁶. The technology of the telescope, which enabled him to make the astronomical discoveries he revealed in *Sidereus Nuncius*, *The Starry Messenger*, would also help define the boundaries of thought and reveal the illusory nature of national boundaries, as the communications satellite would do over 300 years later. Inde-

pendently of the technological development, the Peace of Westphalia, after the 30 Years War is seen to represent the beginning of the concept of the State as we know it, and the development of fundamentally related ones of jurisdiction and sovereignty⁷. The momentum behind the EC and the movement towards the EU, manifesting new legal constructs, began to bury some of the basic legal concepts that shape the world we live in, much as Galileo’s discoveries did, when the reflections of the starry realms were seen on the mortal and mundane.

CNN and all the other bulletin boards of the global village constantly reveal the failed harvest of 17th century concepts in contemporary contexts. Mass movements of people occur, as with the fall of the Berlin Wall or the events in Rwanda. De-centralised and diffuse wars, and growing international crime, hasten the calls for global solutions. CT defies national legal control. Environmental problems, such as global warming and the hole in the ozone layer, ridicule and render irrelevant the sanctified concepts of jurisdiction and sovereignty. The development of indigenous rights, new regional communities and world trade institutions further erase the artificial human borders on the globe of our imagination and reality. The EU is in the vanguard of the process. The ground-norms which it utilises are essential contours of the world in which we now live. With the combined force of its members, its agenda becomes hugely important in any assessment of the strategic forces at work in the foreseeable future.

In summary,

- The EU is a legal construct
- The EU is unique as a legal construct
- It re-defines legal concepts
- It provides the model for other regional developments
- It is necessary to be familiar with the strategic as well as the operational consequences

4 The EU. National, regional and global

Experience may be a useful master. It may also be a poor one, especially if some central ingredients have been altered. One of the dangers, in this context is that of the denial of the efficacy of law, because of the experience of the inefficacy of international law. However, the crucial distinction derives from the unique nature of EU law as explained above. The operationalisation of globalisation is not as easy as the theoretical prediction of its essence, inevitability and emerging reality. Rather it is regionalisation that has been, the key operational force in the short-medium term. The debates about the reality of globalisation as an economic phenomenon are keen ones⁸. The debate about the nature and consequences of regionalisation are also heated. Preusse, argues that

“Taking the number of new or enlarged regional agreements during the 1980’s as an indicator of region-building, a new world-wide move towards

regionalization can be diagnosed.”⁹

But it is legal regionalisation that is central. Whereas international communities and structures had faded into the background due to a lack of enforcement powers and inappropriate legal constructs, the novel appropriately-designed legal community is different.

Both the development of CT and environmental awareness are central parts of the process of regionalisation and globalisation. Both suggest the actuality and necessity of a global, unified perspective. Furthermore, the integration of peoples is part of a deeper re-unification process. As Carl Sagan wrote, from his scientific and humanist perspective,

“Human history can be viewed as a slowly dawning awareness that we are members of a larger group. Initially our loyalties were to ourselves and our immediate family, next, to bands of wandering hunter-gatherers, then to tribes, small settlements, city-states, nations. We have broadened the circle of those we love. We have now organised what are modestly called superpowers, which include groups of people from divergent ethnic and cultural backgrounds working in some sense together-surely a humanizing and character building experience. If we are to survive, our loyalties must be broadened further, to include the whole human community, the entire planet Earth. Many of these who run the na-

*tions will find this idea unpleasant. They will fear loss of power. We will hear much about treason and disloyalty.”*¹⁰

But apart from those losing power, there are other serious challenges. Chomsky believes that free trade regional bodies and multilateral bodies are conspiracies which will degrade further the position of poorer countries¹¹. He also believes that agreements such as NAFTA, ignore environmental considerations while they protect investor rights ‘in exquisite detail’. Free trade and environmental protection are often seen to be incompatible or antagonistic. The fact that regional bodies such as the EU and perhaps MERCOSUR in South America and NAFTA in the North, have been successful as new legal mechanisms, does not mean that they are desirable, welcome or inevitably good. The Zapatistas, fighting in the jungles of Mexico, base their resistance on indigenous rights in the face of NAFTA policies that are destroying the indigenous economy, once again. They present a curious relevance to this topic by their appearance in the jungled hills with a modem in one hand and a molotov cocktail in the other. From such a perspective, the regional bodies are newer, nastier types of machine to perpetuate and pursue the rapacious policies that have characterised the history of the relationship between Euro-America and indigenous people around the world.

The decline of the nation state, and the Zapatista phenomenon might suggest that post-national terrorism will be directed against perceived

monolithic regional bodies. Both the left and right have already joined in condemnation of Brussels imperialism. It might be predicted that dissident groups in the future may turn their attention to the EU. Wherever speculation may bring us, it is clear that minority considerations and concerns must be woven into any Union fabric, for it not to fail or be flawed. Protection and promotion of diversity, pluralism and inclusivity, must be mediating values which need to be part of the macro-thinking behind constructs of the nature of the EU. This is so particularly where minority groups have some central contributions to make to necessary solutions. For instance, by ignoring the complexity of traditional cultural knowledge, we have not only disregarded the culture of other peoples, but also impoverished our own understanding of the environment. In relation to traditional environmental management Posey explains,

*“Scientists use the term indigenous knowledge systems (IKS) to describe the totality of information, practices, beliefs, and philosophy that is unique to each indigenous culture. Such a system may be commonly held within a community or indigenous society, or it may be known only to specialists, tribal elders or lineage groups. The term traditional ecological knowledge (TEK) describes those aspects of an indigenous knowledge system that are directly related to the management of and conservation of the environment.”*¹²

In relation to TEK, Johnson explains that it is

“ ... a body of knowledge built by a group of people through generations living in close contact with nature. It includes a system of classification , a set of empirical observations about the local environment, and a system of self-management that governs resource use.”

We in Europe, perhaps can learn from such experience, now that we are a little better able to listen. Those seeking to promote excluded, marginalised or alternative views must engage with, and input into new legal constructs, in order to direct them away from trodden paths to new integrative policies. Legitimate environmental concern has often been communicated as catastrophic, cataclysmic inevitability by choirs of cassettes, content with the dire warnings, in lieu of attainable, bold or imaginative action. The issues are not ones of the opposition of irreconcilable forces so much perhaps as the failure of the imagination. Failures of the imagination may occur when our mental furniture appear as fixtures and not as furnishings which are moveable. The legal concepts have been re-arranged already. Many may not have realised. The fluid nature of the transitions mean that it is opportune to input new thinking to condition the re-alignments that are occurring, recognising the reality of the national-regional-global momentum and the opportunities provided. An holistic conception of the processes requires an understanding of

the realities and an appropriate response.

In summary,

- The move has been national-regional as well as national-global
- The regionalisation implications for the environment and CT are related to but distinctly from the inherent globalising nature of both considerations
- The EU is the best example of legal regionalisation
- The construct of the EU facilitates input, which non-legal processes of globalisation may not seem to do

5 EU and the environment

Concern for the fragility of the natural world was a concern whose gestation paralleled the birth of the EU. After the conflagration of the Second World War, the concerns were more about the keeping the ‘dogs of war’ locked up and the machinery of destruction quiet. The Cold War shifted attention in the West, to the process of uniting against a perceived common enemy. As the awareness of environmental degradation permeated the popular and political consciousness, the EEC (as it then was) was in a good locus to channel some of the energy which was emerging. Legal regionalisation is believed to be leading to a deeper degree of integration than that occasioned by multilateral organisations. Thus it is argued, that the protection of environmental interests is secured in a more effective way by regional bodies, of the nature of the EU¹³.

Initially the legal base for action was the formation of the common market. As this was unsatisfactory in the long term, the Single European Act saw the insertion of the environment into the Treaty provisions. This was elaborated in the Maastricht Treaty, which outlined the role of the Community in relation to the environment. This represents a clearly defined legal base, although it is not the exclusive legal base for matters which may in some way concern the environment. Thus Article 130r says (inter alia),

1. Community policy on the environment shall contribute to the pursuit of the following objectives:
 - preserving, protecting and improving the quality of the environment;
 - protecting human health;
 - prudent and rational utilisation of natural resources;
 - * promoting measures at international level to deal with regional or worldwide environmental problems.
2. Community policy on the environment shall aim at a high level of protection taking into account the diversity of situations in the various regions of the Community. It shall be based on the precautionary principle and on the principle that preventive action should be taken, that environmental damage should as a priority be rectified at source and that the polluter should pay. Environmental protection requirements must be integrated into the definition and implementation of other Community policies.....

This gives an indication of the base of legal action. The new Article 3c of the Treaty of Amsterdam continues the integration of environmental issues into every aspect of policy making. Thus,

Environmental protection requirements must be integrated into the definition and implementation of Community policies and activities referred to in Article 3, in particular with a view to promoting sustainable development

The environmental consideration is now a pervasive one. This is consistent with the judicial approach before the Maastricht Treaty. One example is the case of the Commission v Denmark¹⁴. In this case it was accepted that the protection of the environment could be invoked as a legitimate qualification to the principle of free movement of goods under Article 30 in certain circumstances, despite its absence from the list of qualifying considerations laid down by Article 36.

The EU has made a significant contribution to the development of an environmental agenda. It is necessary to understand this, to anticipate the complexion of the politico-legal environment in which environmental issues operate. Of course this is not an argument for a Euro-centric view of the world. An holistic approach to environmental issues, and the reality of global interdependence would render such an approach unsustainable. Viewed from the Arctic, the world has different spheres of common interest. Finland and Sweden may have more in common

with Canada than the Canaries. But regional developments within the EU should assist people engaged in the struggle for environmental enhancement in corresponding parts of the globe¹⁵. In particular, the combined and synergistic relationship of the Member States should facilitate the use of leverage to promote environmental concerns in international contexts.

In summary,

- The EU protects the environment
- It may achieve a deeper level than multilateral level
- The policy will become conditioned by and integrated with other policies
- Failure to anticipate the impact and cross-fertilisation of other factors will impair understanding

6 EU and communications technology

In the EU, CT is regulated from a number of perspectives. The facilitation of the attainment of the single market is the foremost force dictating the regulation. Thus the free movement of CT goods, and the free movement of CT services have been important¹⁶. The general harmonisation of technical standards has been of crucial importance. The promotion of research and development in relation to CT to improve the living standards of the Community and its competitive advantage with regard to the rest of the world, has been a key goal. The provision of protection for Intellectual Property Rights has been as a central plank of policy¹⁷.

Some contours of future development as a result of law are clearly discernible such as,

7(a) *Liberalisation* – The trend in relation to liberalisation of national CT concerns established principally by the Conservative party in Britain in the 1980s, has spread far and wide rapidly. On a regional level, the *raison d'être* of the EU will support further and deeper liberalisation. This is reinforced by multilateral developments such as the World Trade Organisation. Thus competition is enhanced, and ultimately the consumer should get the best service, produced by the most efficient undertakings at the lowest price.

7(b) *Competition Law* – Liberalisation and de-regulation emphasise the need for strong competition or antitrust law. This is the net which Microsoft is currently enmeshed in. It provides a useful control on the possibility of free market abuses. Enforceable rights also derive from some directly effective provisions. Unlike national competition law, which has been fairly toothless, EC competition law can escape claustrophobic, national political contexts to reach decisions. Undertakings can be fined up to 10 % of their turnover worldwide.

7(c) *Culture* – The emerging legal concept of culture will play an important role in the evolution of CT. Spearheaded by the French, it was introduced to qualify a purely economic analysis of film, in the first instance and is now to be found in Article 128 of the EC Treaty.

7(d) *Content* – The emergence of concerns about pornography and the exploitation of children, and the perception and realisation of the need for regional and multi-lateral solutions, combined with greater institutionalisation of the European Convention on Human Rights, will mean that there ultimately will be a shift of interest from infrastructural concerns to content issues¹⁸.

7(e) *Intra regional, regional development* – The EU, based on the idea of the single market, was always aware of the competitive disadvantage of peripheral regions. The suitability of CT to the solution of the imbalance, will mean that it will play a significant part in the networking equation.

7(f) *Return on Investment/commercial exploitation* – The EU, particularly through the ‘upwards harmonisation’ demonstrable in relation to Intellectual Property, is concerned that those who create IP, receive a just reward, in order to enhance research and development, promote protection of economic rights. Indeed, if anything, rights are so well protected in the EU now, that it could interfere with artistic creativity and other social goals.

7(e) *Convergence* – Not only will the technologies converge, but there will be a convergence of policy and legal compartments. This is developed below.

In summary,

- CT will develop consistent conditioned by legal principles of the EU

- The anticipation of the development of CT must be informed by awareness of EU developments

7 CT and the environment

The development of CT, a major societal-shaping force will impact on the approach to environmental issues. Thus CT developments and the environment are inherently linked. There has always been a direct link, in the sense that CT has been an instrument of expansion, often part and parcel of the process of colonisation, as well as of war. A benign balance will be restored as the pendulum is poised to return. CT is an important aspect of environmental management from the perspective of prevention, monitoring, identification and communication. CT can help monitor, detect, illustrate, demonstrate and prevent. The satellites that define the CT era, that Arthur C Clarke understood would effectively erase national boundaries, have been utilised to assist in crucial environmental research. They also enhance the perception of the inter-dependent nature of the globe, which has implications for receptivity to environmental initiatives. Paradoxically perhaps, the global village does not frighten the indigenous movement.

*“As the Indian movement gathers momentum ... it will become apparent that not only will Indians survive the electronic world of Marshall McLuhan, they will thrive in it.”*¹⁹

Debate about the development of CT has been polarised by perspective. One analysis suggests an over-industrial-commercialised infrastructure, predicated on economics and commerce, leading to CT honey-pots and hubs, and marginalised voices in an environmentally-degraded world. CT interests become a cuckoo in a nest of limited resources. This leads to a fragmented, commercially-dominated and reactive agenda²⁰. Another analysis suggests that CT could be utilised to promote environmental values in an integrative, communitarian, pluralist, and proactive way. CT then is the swallow that foretells the summer. This is reflected sometimes in the debate within CT which suggests the choice between the broadcast model of technology characterised by Kapor as breeding ‘*Consumerism, passivity, crassness and mediocrity*’ or the internet model which breeds ‘*critical thinking, activism, democracy and quality.*’ These dualistic debates are important, but often pay scant regard to the signals from the legal world.

The composite, constituted networks may not be inherently positive or negative, but are capable of being either, depending on perspective. The important point is the degree of positive or negative inputs or re-inforcers for any particular perspective. There are some signals. Over-protection of copyright, suggests a surrendering to the forces of commerce, unmitigated by other social considerations. However even then, there are traps for the unwary, of which competition law is the most obvious. Part of the environmental movement seems to prefer to play the

prophets of doom, keening direly on the precipice of disaster, rather than act as proactive participants in strategic partnerships, to exploit opportunities presented by new legal structures.

In summary,

- The development of CT is part of the response to environmental issues
- Proactive input into the equations must be made by those pursuing pro-environmental agendas

8 The EU, citizens, human rights and indigenous people

The EU is ultimately about people, or so it would claim. The development of EU citizenship and the steady consolidation of fundamental rights within the EU underlines this. The protection of the environment is often predicated on the rights and interests of the people in it²¹. The protection of the fragile natural world will revolve around the experience of people. Article 130 emphasises the role of people, as do other headings such as the protection of public health. International environment conventions, often place the individual or group as the *raison d’être* for their existence. It has been people who pollute and destroy, kill and maim. It is people who suffer the consequences of environmental degradation. It will also be people who can repair and protect the environment.

One group whose fortunes will parallel the fortunes of fragile habitats are the indigenous peoples. Again, the EU may be significant for them. A combination of the principle of supremacy of Community law in Costa, complemented by the principle of direct effects articulated in the Van Gend En Loos combined with the EU protection of fundamental rights suggests a possible path to the enforceability of rights for them. The ECJ has independently accepted that it has a duty to protect human rights as an inherent part of its competence and jurisdiction. Thus the decision of the ECJ in the Nold case is important where it emphasised that,

*“As the Court has already stated, fundamental rights form an integral part of the general principles of law, the observance of which it ensures. In safeguarding these rights, the Court is bound to draw inspiration from constitutional traditions common to the Member States, and it cannot therefore uphold measures which are incompatible with fundamental rights recognised and protected by the Constitutions of those States. Similarly, international treaties for the protection of human rights on which the Member States have collaborated or of which they are signatories, can supply guidelines which should be followed within the framework of Community law.”*²²

If the international development of indigenous rights continues, then it is likely to be recognised by the ECJ once a justiciable matter arises, and where appropriate locus standi requirements are met. Arguments fashioned from international conventions could be based on self determination, protection of bio-diversity, cultural rights or religious freedom for example. The European Convention on Human Rights might also be relevant.

Parallel to the development of the ECJ's jurisprudence in the area of fundamental rights, the European Commission is actively developing a policy on the external dimension of human rights. One of their priorities as expressed in a *Communication on the External Dimension of Human Rights Policy* is the protection of indigenous people. This may also ultimately enhance the possibility of enforceable rights. It is clear that the Commission conceived indigenous rights as a purely external matter. There are clearly identifiable indigenous people within the EU, such as the Saami in Finland and Sweden, who could not surely receive less protection than those outside?

Apart from the direct fundamental rights avenue, there is the possibility of reliance on international legal obligations in the context of environmental protection to qualify trade in goods and services. The protection of the environment is the legal darkroom from which the majority of indigenous rights are emerging. This is particularly relevant where the international obligation

has been implemented by a legislative measure within the EU²³. The linkage of trade and environmental considerations may create a niche for arguments associated with protection for indigenous people to emerge²⁴. The EU has been an important arena for the development of enforceable legal rights in relation to the environment²⁵. This development may provide an additional distinct basis for protection of interests of indigenous people in a more general sense²⁶. The greater the feedback loops, the greater the opportunity to inform the community dialogue with regard to the optimum protection of the environment. Emergence of an over-arching legal infrastructure, expands the input possibilities.

Likewise, the impact of other areas, such as CT, on people is increasingly significant²⁷. The EU is providing leadership here again, as national control is futile, while multilateral control is not feasible., in the short term at least. As with the environmental context, the rights and duties which inform the digital age and the information society will be largely conditioned by EU and other regional bodies, informing the emergent international consensus, through dialogue, consensus and leverage.

In summary,

- The protection of people's rights is an avenue to promote environmental concerns
- The EU is increasingly protecting human rights
- This will condition all policy areas
- Particular group rights, such as indigenous rights which may en-

hance environmental protection, may be afforded greater protection through the EU

9 Other areas, Trans European Networks, culture and trade

The emergence of Trans European Networks is one obviously important, possibly impacting area. Also, the development of a legal concept of 'culture', is another vein which may be mined to produce legal arguments calculated to impact on the development of IP rights. The French objections to the inclusion of film in the GATT negotiations on the basis of the culture argument was a signal of the possible implications of the inclusion of culture in the legal construct of the EU²⁸. The ECJ accepted in the *Cinéthèque* case²⁹, an argument based on culture in order to dilute the application of the *Dassonville* definition³⁰ (of measures of equivalent effect to quantitative restrictions) to restrict free movement of goods. Article 128 (inserted by the Treaty of European Union) recognises the need to promote culture, and contemplates co-operation with third countries and cultural exchanges. Thus other forces may be summoned to assist in the development of a pervasive, environmental-protection agenda.

In external trade and competition law, the European Commission sees an opportunity for leverage, deriving from combined strength. Because

of deeper environmental protection, the logic would suggest that greater integration and leverage could provide the vehicle for linkage with trade development. The environment has been largely left out of the World Trade Organisation equation, although other linkages were established such as between trade and IP, through the concept of TRIPS. This was to satisfy US calls for greater IP protection. IP has a greater political momentum behind it, than human rights or the environment. Thus there is a clear channel for promotion of an environmental linkage, utilising existing regional leverage.

- Thus other provision of the Treaties will affect the development of CT, the environment and both together, enhancing the possibilities of linkage

10 The convergence

Perhaps the central illuminating theme, that reveals the grain of developments is the idea of convergence. The idea of convergence also helps to unify and suggest the nature of the development of the CT and the environmental agenda. Convergence needs to be understood on a number of levels.

- 10 (a) Convergence of Technologies* – The orthodox, mainstream conception of convergence relates to the technological interaction of formerly separate and discrete technologies.
- 10 (b) Convergence of Economies* – The process of globalisation, as understood principally by econo-

mists, seems to refer to the liberalisation of trade in goods and services, which they would see as an economic phenomenon.

10 (c) Convergence of Legal Systems – Lawyers would perhaps understand the concept of convergence as relating to new models of sovereignty, representing a shift away from the nation state. Even the development of GATT would be seen as revolving ultimately around a legal instrument.

10 (d) Convergence of Policy – Within the new regional communities, the pooling of sovereignty allows and requires a convergence of national policy. The process of economic and monetary union within the EU is perhaps the best contemporary example.

10 (e) Convergence of Concepts – To ensure the attainment and functionality of new legal constructs, new legal concepts are necessary. One example would be the emergent concept of commercial communications.

10 (f) Convergence of Strategic and Design Responses – In view of the above convergences, it is obviously imperative for those operating within the new parameters to re-define strategic and design functions.

10 (h) Convergence of the Convergences – All the convergences lead perhaps to an overwhelming undercurrent of unification.

The key document in recent times is this area in the EU, is perhaps the *Green Paper on the Convergence of the Telecommunications, Media and Information Technology Sectors, And the Implications for Regulation. To-*

wards *An Information Society Approach*³¹. As the policy areas begin to merge, so will the substantive areas of law. The convergence complements the linkage that is happening between areas which hitherto were kept somewhat separate. On a multilateral scale, linkage has occurred most noticeably between Intellectual Property and trade in the WTO. Linkage will allow modification of policies. Linkage will be utilised by those who have leverage. Leverage will come from the combined force within regional arrangements, such as the EU, NAFTA, MERCOSUR, or SADC³². Examples of the use of leverage to attain linkage is best exemplified by recent attempts by the EU to link trade and human rights. Without the regional leverage, such a policy would be ineffective. The example of the recent claims of extra-territorial jurisdiction in relation to the airline industry, is another example.

Another convergence, on a deeper level, will be the modification of European conceptions by exposure to perspectives from elsewhere. CT must be about communications. Communications must increase the diversity and plurality of perspective. This should ultimately enhance the values which counteract negative, divisive forces of the type that engender the divisions which have beset Europe for centuries. On a deeper psychic or psychological level, CT or the internet model of CT, may help avoid the historic mindset that were seen to be so important in the development of attitudes hostile to the environment.

In summary,

- Convergence must inform any approach developed to deal with issues associated with CT and the environment, in particular in a legal sense
- This leads to the significance of leverage and of linkage

10 Conclusions

*“Generally, he who occupies the field of battle first and awaits his enemy is at ease, and he who comes later to the scene and rushes into the fight is weary. And therefore, those skilled in war bring the enemy to the field of battle and are not brought there by him.”*³³

Thus it is important to be aware of the fusing of forces in a spiral of formerly separate concerns. The global village may be a brash, blaring, garish, MTV marketplace, but it must and can be sensitive to the fragility of the world it operates in. The EU will be the force that shapes the evolution of forms. Systems which are not consistent with the conceptions, ethos and trends of EU, will fail, or be sub-optimum. Those charged with intellectual responsibility for input into the development of CT in a fragile natural world, cannot afford the luxury of a lack of awareness of law, irrespective of how foreboding, complex or uninteresting it appears. There needs to be awareness, appreciation and integration to provide for coherent and feasible solutions. Ironically, contemporary concep-

tions of digital webs, and networks, are closer to older conceptions of the universe. Laurens Van Der Post talked of the deep desire to unite what is oldest in us with what is newest. It is not that leap of comprehension that will be the greatest challenge. Rather it is the whereabouts of the glass bridge between the present and the future which is sometimes difficult to see, in the swirling mists of incessant change. The EU could be the main avenue to the crossing point.

In summary, therefore, for those concerned with the role of CT in a fragile natural world, it must be remembered that,

- There is a need to appreciate both the operational and strategic relevance of law
- Strategic legal thinking may be difficult to encounter
- The EU is a unique legal construct, which provides a blueprint for other regional and multilateral legal communities
- In view of the above, it is helpful therefore to return to the basic EU legal grundnorms
- The EU has a unique role in the evolution of CT and the environment
- The EU is developing a jurisdiction in relation to the protection of human rights which may be a source of rights in relation to CT and the environment
- CT is directly relevant to environmental issues
- Convergence, in the widest sense, will define the growth of most EU policies and create opportunities for leverage and linkage
- The lessons of study of the strategic role of the EU should be inte-

grated into the planning and preparation of projects, in particular those associated with CT and the environment.

Finally, it is appropriate to remember the context, here within the Arctic Circle, and draw upon more traditional, clearly defined strains of wisdom.

*“Just as one tree standing alone would soon be destroyed by the first strong wind which came along, so it is impossible for any person, any family or any community to stand alone against the troubles of this world.”*³⁴

¹ Marshall McLuhan, *Understanding Media*, Sphere, 1964 at 15.

² Defrenne v SABENA Case 43/75 [1976] ECR 455. Bosman.

³ The European Community is the central pillar of the construct of the European Union.

⁴ Costa v. Ente Nazionale per L'Energia Elettrica (ENEL) (case 6/64) [1964] ECR 585; [1964] CMLR 425 at 455.

⁵ Van Gend en Loos v. Nederlandse Administratie der Belastingen (Case 26/62) [1963] ECR 1; [1963] CMLR 105 at 127.

⁶ Codex 1181, Proceedings Against Galileo Galilei. See Bronowski, *The Ascent of Man*, BBC, 1973. Chapter 6, The Starry Messenger.

⁷ See Shearer, *Starkes International Law*, Butterworths, 11th ed, 1994 at 11.

⁸ Van Bergeijk and Mensink, 'Measuring Globalisation', *Journal of World*

- Trade, Vol 31. No 3, June 1997, at 159.
- ⁹ Preusse, 'Regional Integration in the Nineties; Stimulation or Threat to the Multilateral Trading System', *Journal of World Trade*, Vol 28, August 1994, No 4. 147 at 159.
- ¹⁰ Carl Sagan, *Cosmos*, Futura, 1980. To seek corroboration of his prediction of treason and disloyalty from two poles of the UK political perspective in relation to the EU, see the speech of Tony Benn, House of Commons. 20 November 1991, and Margaret Thatcher, College of Europe Speech, Bruges, 20 September 1988.
- ¹¹ See Chomsky, *World Orders, Old and New*, Pluto, 1994.
- ¹² See Posey, *Indigenous Rights to Diversity*, Vol 38 *Environment*, 8, Pg 8. Johnson, *Lore: Capturing Traditional Environmental Knowledge*, Dene Cultural Institute, 1992, Pg 4.
- ¹³ Steinberg, 'Trade-Environment Negotiations in the EU, NAFTA, and the WTO: Regional Trajectories of Rule Development', *American Journal International Law*, Vol 91 and 23.
- ¹⁴ *Commission v Denmark*, Case 302/86 [1988] ECR 4607.
- ¹⁵ See for example, Kassi, *A Legacy of Maldevelopment. Environmental Devastation in the Arctic*, in Weaver (ed), *Defending Mother Earth, Native Perspectives on Environmental Justice*, Orbis at 72.
- ¹⁶ See for example, *Cotidel v Cine Vog*, Case 62/79 [1980] ECR 881.
- ¹⁷ For example, Council directive of 14 May 1991 on the Legal Protection of Computer Programs.
- ¹⁸ See for example *Com 96 (483)*, Protection of Minors and Human Dignity in Audio-Visual and Information Services.
- ¹⁹ Vine Deloria Jr, 'Consolidating Indian Efforts', (Standing Rock Sioux) in Moquin and Van Doren (eds), *Great Documents in American Indian History*, Da Capo, 1995 at 383. Also see Long, 'Nomads and the Net', *The Geographical*, March 1997, at 28.
- ²⁰ See Yeomans, *Learners on the Superhighway*, NIACE, 1996, p 18-19.
- ²¹ See for example Boyle & Anderson (ed), *Human Rights Approaches to Environmental Protection*, Clarendon Press, 1996. Also *Sequihua et al v Texaco Inc*. 847 F. Supp. 61. United States District Court. S. D. Texas, Houston Division (Jan 27 1994) West Doc and *Maria Aguinda et al v Texaco Inc* 93 Civ 7527 (11 April 1994) Lexis Doc 4718.
- ²² *Nold K G v. Commission* (Case 4/73) [1974] ECR 491, [1974] 2 CMLR 338.
- ²³ See for example the *Commission v France* [1990] ECR 1-4337, with regard to the use of Article 169 enforcement proceedings to ensure compliance by France with their obligations under a Council Regulation (EEC) No 3626/82 of 3 December 1982, which implemented the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), of 3 March 1973.
- ²⁴ For an introduction to the EU and international relations, see Mc Goldrick, '*International Relations Law of the European Union*,' Longman, 1997.
- ²⁵ For a description of the development of EU environmental agenda, see Pocklington, 'The Role of Environmental Action Programmes in the Development of EU Environmental Legislation', *Environmental Law and Management*, Dec 1995.
- ²⁶ For a recent comprehensive article with regard to likely developments in general, see 'Towards an Environmental Constitutional Law', *European Environmental Law Review*, April, 1997 at 113.
- ²⁷ See for example, *Living and Working in the Information Society*. Peo-

ple First COM (96) 389. and Protection of Minors and Human Dignity in Audio-Visual and Information Services, COM (96) 483.

²⁸ See Puttnam, *The Undeclared War. The Struggle to Control the World's Film Industry*, Harper Collins, 1997.

²⁹ Cinéthèque v Fédération Nationale de Cinémas Françaises, Cases 60, 61/84 [1985] ECR 2605, [1986] 1 CMLR 365.

³⁰ Procureur du Roi v Dassonville, Case 8/74 [1974] ECR 837, [1974] 2 CMLR 436.

³¹ COM (97) 623, Brussels, 3 December 1997.

³² SADC (the South African Development Community) ECOWAS.

³³ Sun Tzu, *The Art of War*, Wordworth Reference, 1993 at 11.

³⁴ Haida Chief Skidegate March 1966 Communique No 12, Traditional Circle of Indian Elders and Youth, Haida Gwaii, Queen Charlotte Islands, Skidegate Massett.

Visualization in forest landscape preference research

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Abstract

This paper deals with the needs that landscape preference research has concerning visualization techniques. It compares the benefits and disadvantages of different means of visualization (original and manipulated photographs, virtual landscape simulators). The paper is partly based on experiences gained from landscape preference research, in which different illustration methods have been used both in long-distance and near distance views.

Today digital image editing and virtual landscape simulators offer the most sophisticated means of visualization for landscape preference research. With the aid of these methods it is possible to control the variables that are not in the focus of the study. Landscape simulators are less labour-intensive and offer flexible movement between different viewpoints. Simulators are not restricted to represent limited areas in the manner of photographs; they are also able to link images with forest inventory data and planning systems. However, the illustrations do not correspond to the real world, whereas digital image editing produces images corresponding to the realistic qualities of the original photos.

In the future, virtual landscape simulators will be the easiest and most flexible means of visualization in landscape preference research. However, research purposes also require more realistic illustrations, which sets a need for large photographic databases, as well as integration with different sources of spatial data. The future prospects of research also include the use of virtual reality techniques with multi-stimulus representations of landscapes. More research is needed so that the usability of different visualization media in research purposes can be evaluated and compared.

Keywords: landscape preferences, digital photo editing, landscape simulators

I Introduction

The quality of landscape is important for people's mental well-being. Its importance can be seen especially in stress recovery and in the formation of restorative effects (Hartig et al. 1991, Ulrich et al. 1991, Kaplan & Peterson 1993, Korpela & Hartig 1996). According to Schroeder (1990), aesthetic enjoyment may actually be the greatest advantage of urban forests. Therefore landscape designers and managers need knowledge about people's perceptions and interpretations of the landscape, as well as about their reactions towards different landscapes. It is important to know both what kind of landscapes generate positive feelings and enhance people's well-being and recreation and also what kinds of stimuli generate negative feelings and views. As the landscape is constantly modified, planning requires knowledge about people's reactions to changes.

Participatory planning is a rather recent development in practical planning situations. Different visualizations of the landscape, produced by alternative planning options, can be shown to different interest groups and/or landowners, which makes it possible for them to decide or at least to participate in decision-making concerning such issues as what kind of landscapes will be created in the area under planning or how much emphasis is put on the landscape when evaluating alternative options. Here the number of participants is rather limited. As all visitors and users of the area under planning cannot be consulted, more general knowledge about landscape prefer-

ences is also needed for planning purposes.

Numerous approaches have been used to study people's aesthetic reactions to landscapes. Yet the difficulty of amenity values is that there are no exact methodologies that could be used in their description and prediction. However, in all approaches the visualization of the landscape can be a good instrument: while people are usually good at understanding images, they tend to have difficulties in understanding information presented in other forms.

The quality of the landscape is always determined by human appraisal. The landscape can be evaluated by either experts or the public. Zube et al. (1982) have divided the large variety of landscape perception research into expert, psychophysical, cognitive, and experiential paradigms. Daniel and Vining (1983) use a similar classification. They have defined the methods of assessing landscape quality as ecological, formal aesthetic, psychophysical, psychological, and phenomenological models. A modification of these groupings is presented in Table 1. The difference of the approaches lies in their conception of the human being; the way in which the human being is comprehended affects the choice of the medium of visualization too.

In the expert model skilled and trained experts evaluate the landscape according to the principles of art, design, ecology, or management. The experts evaluate either the ecological or formal aesthetic landscape variables.

Table 1. Different approaches to landscape perception research.

Expert evaluations	Opinions of the public
educated experts	psychophysical human beings as recipients
principles of art, planning, and ecology	cognitive human beings as constructors and interpreters
	phenomenology human beings as active participants

In the psychophysical model the human being functions as a recipient and passive observer of the environment. The visual elements of the landscape are measured, e.g., the amount of logging residue, the diameter of the stands, and the basal area. The respondents are asked to evaluate the quality of the landscape, usually with a single psychological response such as landscape preference, scenic beauty, or scenic quality. The connections between the features measured and the preferences observed are searched by the means of statistical analyses. Many studies do not specify any psychophysical functions but describe the characteristics of preferred and less-preferred landscapes in general terms (Daniel & Vining 1983). In this context preference is defined as a desire to have, to do, or to select one thing rather than an other because the respondent likes it better or because it appears as more convenient for him/her.

The cognitive (or psychological) approach involves a search for human meaning and information associated with landscapes. Cognitive theories emphasize the informational

content of the environment and how this information is organized, processed, and interpreted by the viewers (Ruddel et al. 1989). The cognitive model refers to the feelings and perceptions of people: it does not aim at defining the physical features of landscape that would affect evaluations. The aesthetic quality is only one of the several dimensions of human response (Daniel & Vining 1983).

Cognitive research is also often based on the presentation of the object. The respondent may be asked to evaluate the object through such perceptual, cognitive, and affective concepts as mystery, unity, coherence, and complexity. These variables are not separate features in the landscape but they describe the landscape as a whole. The relationship between variables and preferences is examined in order to find out the psychological basis of landscape preferences.

Phenomenological (or experiential) research considers human beings as active participants. It emphasizes the interaction between the human being and his/her environment

and (mental) states that both affect each other. The phenomenological approach seeks to understand the total experience of the individual when s/he interacts with the landscape (Herzog 1985). In its way it tries to determine the meaning and significance that the different aspects of a landscape have for a particular person (Daniel & Vining 1983).

In phenomenological research, objects that have been created in the interaction between human beings and the environment are studied. Zube et al. (1982) also classify aesthetic and geographical studies, e.g. studies concerning the sense of place, under this rubric. Personal interviews and verbal questionnaires are often used as methods in phenomenological research. While visualization can be used in phenomenological inquiries, it does not have such an emphasised position here as it does in the approaches mentioned above. Here visualization functions more as a stimulus for the respondent who can then produce his/her own representations, interpretations, feelings, and experiences of nature. Phenomenological research focuses more on the relationship between landscape and a person than on the comparative assessment of different landscapes (Daniel & Vining 1983).

The purpose of this article is to analyze the demands set for visualization in psychophysical and cognitive research. These two approaches can be labelled as landscape preference research proper. Furthermore, the article will also assess the suitability of advanced forest landscape simulation methods developed or used in Finland for the purposes of preference research.

2 Landscape preference research and its requirements for visualization techniques

While also other senses influence the perceiving and experiencing of landscape, the main part of landscape perception occurs through the sense of sight (Jubenville et al. 1987). Thus visualization is the primary method in the description of landscapes; visualizations can also be combined with sounds and smells, for example. Yet visualization and the choice of the medium of visualization is only one aspect among other choices that have to be done in preference research. One key question concerns the choice of settings, as the respondents' judgments are affected by the range and mixture of landscapes presented (Brown & Daniel 1987).

Preferences are usually explained through the physical features of the landscape and variation between respondents tends to receive far less attention. However, the variation between settings does not explain all variation in landscape preferences. There is individual variation in the evaluation of visual landscapes, based on different individual experiences as well as on social and cultural background. There are also other factors that affect assessments and that can be related to the moment of evaluation: the respondent's mood, for example. (Brush 1976, Karhu & Kellomäki 1980, Lyons 1983, Knopf 1987). Despite individual variation we may also be able

to find some general principles in landscape perception and preference.

In landscape preference research the respondents are generally non-professional as images evaluators, which sets the visualization a high demand for realism. Although the landscape is experienced as an entity, its details (e.g. special shapes of trees, undervegetation, stones) attract the viewer's attention and create experiences. Therefore the medium of visualization should be able to capture the details too. In addition, landscapes should not be romanticized but the illustrations should correspond to the conditions in nature. In reality, trees are often ill-shaped or injured, and the ground cover may be trampled.

The cognitive approach in particular needs a medium of presentation that is able to capture the whole richness of the environment, as the explaining variables (e.g. complexity and mystery) describe the wholeness of nature. This is in contrast to psychophysical research: in the latter the explaining variables are separate physical features in the environment and it may be more reliable to explain preferences if the number of variables seen in the images is more limited. However, the variables should be illustrated realistically and all explaining variables, as well as their variation, should be seen clearly in the images (Hull and Revell, 1989). Furthermore, because one's impressions of a setting vary because of the location and distance of viewing, it is important that the same object can be seen from different viewpoints.

One aim of preference research may be the clarification of people's reactions to changes in the landscape: these may include forest felling or field afforestation. In order to determine the effect of any particular change, it is important that only one aspect of the landscape changes at a time. A study may also aim at discovering the meaning of variation in different landscapes, i.e., one may ask such questions as in what ways different landscape spaces affect the experience when a person is wandering in the landscape, and what is the optimal variation. Perceptions and a person's relationship with nature are also dependent on the rate of speed, on the means of transport (on foot, by car, by bike, on horseback), and on the activities performed (hunting, sightseeing, camping) (Wagar 1974, Brush 1979, Levine & Langenau 1979, Zube et al. 1982). In order to be able to account for this kind of variation, preference research requires such means of visualization that are able to simulate different ways of moving in landscape.

Although the landscape is always dynamic and changing, in some landscapes movement appears more characteristically than it does in others. Therefore the choice between static and dynamic visualizations should depend on the characteristics of the landscape studied. If every landscape to be compared with other landscapes is motionless and static, static visualization may prove to be adequate. If, however, some of the landscapes include dynamic features such as waterfalls, we need dynamic representations in order to be able to study the differences between static

and dynamic landscapes (Hetherington et al. 1993).

The persons' emotional ties connected with their living environment or everyday landscapes are usually strong. While people are, indeed, very sensitive to all changes in the familiar landscape, in non-familiar environments their affective responses are remarkably weaker (Wagar 1974, Brush 1976). Thus the level of realism in the visualization of the landscape is set very high requirements if the relationship between the landscape and a person is long-standing and the person knows the landscape with its details thoroughly. This is the case with local residents and people visiting a particular setting frequently.

3 Forest landscape visualization methods and their suitability for preference research

Such visualization media as models and drawings have been used for hundreds of years. In Finland, photographs have been the most frequently used tool in landscape preference research during the last few decades (e.g. Savolainen & Kellomäki 1981, Pukkala et al. 1988, Hallikainen 1995, Karjalainen 1996). More recently the digital editing of photographs (photomontage) has been used, for example, in the studies of preferences concerning different field afforestation options and that of forest felling alternatives

(Tahvanainen et al. 1996, Karjalainen & Komulainen 1998a, 1998b, Tyrväinen et al. 1998). Yet it is only within the past decade that more sophisticated technological innovations, including computerized visual simulations, have been introduced. At present, applications for practical planning purposes are being developed by numerous different institutions, including consultant agencies and universities.

If compared to on-site visits, visualization has several advantages (Table 2). It is not only cheaper but it also offers laboratory conditions where many aspects affecting site evaluation can be avoided (heat, cold, mosquitoes, sun, rain, wind). As all evaluators share the same conditions, it is easier to assess which variables have in the end affected their evaluations. Although many studies have shown that slides and photographs are acceptable substitutes for on-site visits if they include most of the scenic elements of the landscape (Shafer & Richards 1974, Shuttleworth 1980), opposite results have also been obtained (see Hull and Steward 1992). Visualization has also been criticized because it is not able to represent the whole richness of real nature. Photographs, for example, are not only less complex and less multidimensional but they also offer less interaction than real scenes. Furthermore, despite careful attempts to control, there are often noticeable differences between photographs (e. g. shades of light and colour), which makes it difficult to make comparisons.

Digital image editing makes possible the study of the effect of a par-

Table 2. Features of forest landscape visualization methods in preference research.

Application	On-site visits	Photo graphs	Digital image editing	Video	FORSI (Forest simulator)	MONSU (multiple use forest planning)	Smart Forest
Realism	excellent	very good	very good	very good	good	fairly good	fair
Choice of viewpoints	flexible	one	one	flexible	flexible	four viewpoints	flexible
Movement	easy	–	–	easy	fairly easy	fairly easy	fairly easy
Simulation of changes	–	–	labour-intensive	labour-intensive	fairly easy	easy	fairly easy
Use of forest data	–	–	–	–	fairly easy	easy	fairly easy
Tree symbols	–	–	–	–	digitized photo-graphs	vector symbols	geometric objects
Under vegetation illustrated	–	yes	yes	yes	yes	to some extent	no
Other elements	–	yes	yes	yes	yes	to some extent	no

ticular change in landscape and the control over other variables (light, colours, shade and so on) that often vary between photographs. Digital image editing uses computer software in the manipulation of video or photographic images which have been either digitized or originally taken with a digital camera. The images produced are photorealistic. Yet the problem of the method is that images are static and the method cannot be easily automatized; detailed changes in original images are also time-consuming and costly. Furthermore, the pictures produced are, to a certain extent, open to inaccuracy because of the subjective evaluations present in the modification of the original pictures. Since it is difficult to estimate the effect of change in the landscape on the basis of a photograph, without the help of spatial data, the visualizations are mere ap-

proximations of the effects of change (Table 2).

Virtual landscape simulators are based on the use of a digital terrain model and some kind of a map and/or forest data, as visualization requires. The main advantage of their use in research is their flexibility; the observer is not limited to any predetermined viewpoints. Moreover, automatized visualization reduces the production costs of illustrations. There are, however, certain limitations in the capabilities of visualization systems. One of the main problems is the quality of the illustrations.

The methods needed in the study of dynamic landscapes include animations and video. While video images are realistic and inexpensive, the simulation of change is labour-intensive. Furthermore, at least at present, animations rely on advanced computing equipment.

An example of the forest landscape simulator is the multiple-use forest management planning system (MONSU) developed at the University of Joensuu (Pukkala 1998). The program is developed for the purposes of teaching and forest planning at the farm level. The illustrations of forest landscapes in the MONSU system are automatized computer drawings based on tree and site parameters included in present forest planning systems. Tree symbols are differently coloured two-dimensional graphic symbols, whose species and size distribution correspond to the local tree populations as described in inventory data. The distinct areas of field, forest, and water are expressed with different ground colours. The program also displays topographical variation and even perspective, which are based on digitized contour lines and a chosen vantage point. The program is also able to illustrate the effects of seasonal change.

The MONSU program is easy to use, inexpensive and it can be run on a PC. Its main advantage is that it is connected with a forest planning system, which means, among other things, that the evaluation of the scenic impacts of alternative forest plans becomes possible. The method also enables a flexible assessment of both close-ups and long-distance scenes with updated forest data. As the program produces illustrations from the main cardinal points, the assessment of landscape from several viewpoints is also possible. In addition, movement in the forest can be simulated by choosing viewpoints along a path and by illustrating the landscape scenes selected.

Although the illustrations include some elements of the undervegetation such as berries and mushrooms, the special features and details of a particular landscape (roads, buildings, shrubs, stones, special shapes of trees and single trees) are absent. Thus MONSU produces more or less standard landscape pictures, which causes that it not really suitable for areas which have for example special scenic values.

Smart Forest is an interactive, three-dimensional visualization system developed by the University of Illinois (Dept of Landscape Architecture) and the USDA Forest Service. The main advantage of the system is that it allows flexible real-time movement in forest landscape. The user may view the ground level, walk between the trees, view large forest areas from user-defined aerial height, and classify stands and trees by highlighting them with different colours (Uusitalo et al. 1997). The simulations of forest operations are realized through a manipulation of tree data.

Its main disadvantages include that the illustrations are based on rather simple three-dimensional tree symbols and that the elements of undervegetation are excluded. Therefore, at the present time the system lacks an ability to address detailed issues of forest management. According to Orland (1994), the high degree of interactivity has resulted in the fact that the tree symbols have been kept rather simple. While the program operates only in an UNIX environment at present, a development project being carried out at the University of Helsinki, Finland, is developing a PC version; they also

aim at improving the quality of illustrations by presenting the ground and trees with realistic textures.

FORSI, a commercial landscape simulator that can be used in a PC environment, is intended to fulfil the needs of practical visualization in different forestry organisations. The system has been developed by the Finnish private consultant and development enterprise Plustech Ltd. The functions of the program are based on map information, an elevation model, compartment data of the target area, and visual objects. The advantage of the program lies in its realism and flexibility. The two-dimensional visual objects represent the main elements of a forest landscape (trees, shrubs, undervegetation, logging residue). The objects are generated from digitized photographs. While the program has a rather large tree library, it includes for the time being only the main tree species in Finland. However, other tree species and additional objects (houses, recreational facilities) can be added to the library and included in the pictures manually.

FORSI allows for nearly real-time movement in the landscape, and the choice between different viewpoints is flexible. The simulations of individual forest operations such as clear cuts and thinning can be illustrated by manipulating the compartment data manually. Although the program produces rather realistic images, in particular when describing scenes from a distance, it visualizes standard trees photographed in commercial forests in southern Finland. Because FORSI is a commercial product, its price is significantly

higher than that of other visualization tools.

4 Conclusions

Today digital image editing and virtual landscape simulators offer the most sophisticated visualization methods for the needs of landscape preference research. With the help of these methods it is possible to control the variables that are not in the primary interest of the study, e.g. colours and shades. The advantages of landscape simulators include that all pictures can be produced much quicker and that they offer extremely flexible movement between different viewpoints. In addition, simulators are not restricted to represent a limited area in the manner of the photographs. Furthermore, virtual landscape simulators are able to link images both with forest inventory data and with the planning systems of forestry and agriculture. However, their main disadvantage – especially that of those based on vector graphics – is that the images do not correspond to the real world well enough. Indeed, the quality of photographs produced by digital image editing corresponds to the quality of the original photos.

In the 1980s Zube et al. (1987), when comparing the effectiveness of communication in different modes of presentation, found computer-generated line graphics to be the least understood one. More recently Oh (1994) compared perceptual effectiveness of four types of computer simulations (wire frame, surface model, combination of surface model

and photographic images, and image capture technique) and came to the conclusion that the image capture technique was the most effective one in portraying reality. However, computer graphics systems, often linked with forest planning programs, have recently been under rapid development.

In some cases the images produced by landscape simulators are already today adequate for the needs of the study of the relationship between separate physical variables and observed preference. While Abello et al. (1986) have stated that it might first be preferable to understand simple environmental representations in which the number of possible explaining variables is low, the case is different when the focus of the research is on cognitive variables describing the landscape as a whole: in this case the demands for visualization are remarkably higher.

Today the quality of the images produced by computer line graphics may be adequate for the use by experts, who can be expected to be able to understand the medium of presentation better than the layman. Furthermore, some studies have suggested that computer graphics may also be an adequate presentation format for public evaluation (Nousiainen & Pukkala 1992, Tyrväinen & Tahvanainen 1998, Nousiainen et al 1998). In the study of Nousiainen and Pukkala (1992), computer graphics and slides proved to be almost equal methods for the ranking of forest trails on the basis of amenity properties. However, they also found out that the recreational value of forest trails cannot be easily evaluated on

the basis on computer graphics, presumably because low bushes, dwarf shrubs and obstacles on the ground were omitted from the illustrations.

At present computer graphics seems to be more suitable for illustrating distant sceneries than near-views. In the study of Tyrväinen & Tahvanainen (1998), images illustrating impacts of afforestation produced by the MONSU multiple use forest planning system and panoramic slides were evaluated by land-use experts and landowners. Nousiainen et al. (1998) tested the use of vector graphics in a participatory planning context in North-Carelia, Finland. These studies suggest that computer vector graphics is an adequate medium in the comparison of different large-scale agricultural landscapes and management alternatives for practical planning purposes. In large scale landscapes small landscape elements are not so important and merge easily with the background scenery.

The present forest landscape simulator models have been developed for commercial forests and the illustrations are approximations of real conditions in nature. However, often the areas which are of main interest for researchers are frequently used and visually sensitive areas: urban forests, recreation areas, national parks, and other scenic environments. In such landscapes the illustration of such details as the special shapes of trees and the spatial variation of undervegetation remains also very important. Detailed illustration is also necessary when the respondents are familiar with the environment, as the case is in urban

forests. Furthermore, the incorporation of ecological management and nature protection into forest planning sets new requirements for visualizations too. Therefore, for research purposes, original or manipulated photographs are so far the best means of visualization – the case is so in particular when studying close-ups with their special features.

The main requirement for visualization media to be effectively used in landscape preference research is that the images correspond to the visual reality of observers. In addition to realistic images, preference research requires from simulations a flexible use of forest inventory data, real-time movement in the landscape, a flexible change of viewpoints, and interactivity. A good visualization tool illustrates the changes in the environment in a realistic manner both from the near and the distance. While many of these properties exist in current landscape simulators, they should be incorporated in the same program.

It seems that forest simulators will be the best, easiest, and most flexible means of visualization in future preference research. The development of the current simulators should also take into account the needs of research. Landscape preference research requires more realistic illustrations; it also needs a large photographic database (library or tree symbols and other objects) as well as integration with different sources of spatial data. All domestic tree species and regional features of forests (tree shapes and undervegetation) should be included in the database. In addition, three-dimensional tree

symbols would greatly improve the quality of images.

At present, the application of landscape simulators is confronted with the problems of access and the price of the data. In Finland, the data collected for forest planning may be difficult to obtain, because it, in principle, belongs to the landowner. In addition, forest inventory data do not have the details and richness required if we are to create realistic images. Therefore, more accurate information should be collected in the context of the forest inventory concerning e.g. forest edges, undervegetation, individual big trees and their shapes, and stones should also be included. However, the inventory usually has restricted resources.

Even at its best the visualization of the landscape cannot fully re-distribute the real landscape experience. The future prospects for landscape research may include a use of virtual reality techniques with multi-stimulus representations of landscapes. However, more research is needed in order to evaluate and compare the usability of different visualization media for research purposes.

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Visualising changes in historic landscapes

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Abstract

This paper describes the methods used to visualise landscapes in two study areas in the United Kingdom at multiple dates since 1946. The principal source of data was reconnaissance or air survey quality aerial photography with which high resolution digital elevation models and orthophotographic mosaics were derived. These enabled the creation of models for viewing in real time and for the creation of video fly-throughs to illustrate changes in landscape over the time period. In addition to visualising landscape, the effect of a change in landscape due to afforestation was evaluated using a predictive preference model for scenic landscapes. The results of the work show the potential for developing packages of educational and research material for exploring and communicating information about landscape and landscape changes.

I Introduction

Appraisals of the type and extent of the natural resources of an area are required for effective decision making in environmental management from local to a national level. An appraisal for a single period in time provides valuable information, but only with information for additional years can assessments be made of natural or man-induced change in the landscape (Simmins and Hunsacker

1993, Hester et al. 1996) Such change may be historical or proposed and consideration of the nature and rate of change in landscapes is of importance to land managers and planning authorities. Typical uses of information on changes in landscape include its monitoring or surveillance to assess the effectiveness of policy decisions, such as changes within areas classed as priority natural habitats in the EC Habitats Directive (EEC 1992) or on the visual impact

of afforestation and forest management (Haider 1994).

Methods for the identification, measurement and communication of changes in landscape may be grouped within five categories: textually descriptive, statistical, mapped, photographic (terrestrial and aerial), and modelled (usually, but not exclusively, with computing techniques). Often, it is a combination of different approaches which provides the most comprehensive impression of change and the principal issues, common to all, are: data capture (including census and sampling techniques); data processing for ensuring consistency in classification, geometry, reference system and level of detail; interpretation and measurement of features or classes; and presentation of the results. One limitation of many of the applications of these approaches to assessing landscape change is committing a three-dimensional environment into two by the process of mapping and subsequently limiting the presentation and analysis of the results (Orland 1994, Berger et al. 1996).

The objective of this paper is to illustrate a combination of methodologies that enable the visualisation and evaluation of changes in the landscape. The methods are a coupling of geographic information systems (GIS) and a landscape preference model, for which digital photogrammetric techniques have been used to derive the input data for two areas which have undergone different types of land cover changes over time periods of approximately forty years. Therefore, the photographic data provides the basic data for the

visualisation of the landscape at different dates and the input to the landscape preference model which enables an evaluation of the landscape at each date and thus a quantitative assessment of the change in the preference for the landscape over the time period.

2 Study areas

Examples of work in two study areas are presented: Glen Feshie in the Cairngorm Mountains of Scotland and Cwm Berwyn in mid-Wales (Figure 1). Both areas are rural and in the uplands but the landscape and landscape change is different in each area. The time periods between the earliest and latest datasets are approximately the same (forty-two years and thirty-eight years).

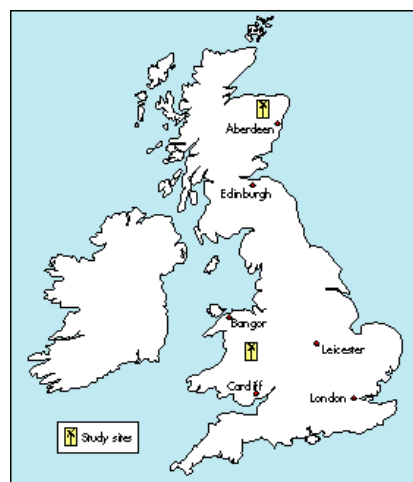


Figure 1. Location of the two study sites.

3 Methods

Aerial photographs were draped across Digital Elevation Models (DEMs) to provide input data for visualisation software with which:

1. single perspective views of the terrain were derived;
2. the model was manipulated in real-time to enable viewing at different resolutions, scales, perspectives and orientations; or
3. sequences of views compiled into video fly-throughs.

The aerial photographs used were for different dates for each area and thus comparisons could be made of the views of the landscape and change interpreted. The evaluation of the impact of afforestation on the preference of a view of the landscape used a landscape scenic preference model (Wherrett 1997) applied at times of pre- and post-afforestation.

3.1 Hardware and software

The digital photogrammetric software used was the ERDAS Imagine OrthoMAX product (ERDAS 1995) (licensed from Vision Inc. a subsidiary of Autometrics Inc), mounted on Sun Sparc stations 4/20 and 10/20, with 128 or 164 Mbytes of core memory. The processing times required for the production of the elevation models and orthophotographs are summarized in Tables 1 and 2. It was not possible to dedicate either of the machines to the and the principal impact of multi-users on the processing times will have been on the time taken to “swap” data in and out of memory. Consequently, the “user” time for the production of the datasets will have been greater than would be expected although the CPU time should be the same.

Table 1. Details of the data for the study site at Cwm Berwyn, Wales.

Date	1957	1975	1992	1995
Scale	1:20,000	1:26,000	1:10,000	1:10,000
Nomical Resolution (m)	0.6	0.82	0.31	0.31
DEM Resolution (m)	—	2	1	1
Orthophotograph Resolution (m)	1	1	1	1
Horizontal Accuracy (RMS, m)	+/-2.3	+/-1.3	+/-1.1	+/-0.9
Vertical Accuracy (RMS, m)	—	+/-1.1	+/-0.9	+/-0.7
Number of models	10	2	4	4
Total CPU time for DEMs (decimal hours)	—	36.4	24.9	27.3
Host Memory/Processor Speed	128 MB/ 120 MHz	128 MB/ 120 MHz	164 MB/ 200 MHz	164 MB/ 200 MHz

Table 2. Details of the data for the study site at Glen Feshie, Scotland.

Date	1946	1988
Scale	1:10,000	1:24,000
Nomical Resolution (m)	0.3	0.77
DEM Resolution (m)	–	2
Orthophotograph Resolution (m)	1	1
Horizontal Accuracy (RMS, m)	+/-3.9	+/-2.1
Vertical Accuracy (RMS, m)	–	+/-1.8
Number of models	9	4
Total CPU time for DEMs (decimal hours)	–	29.3
Host Memory/Processor Speed	128 MB/120 MHz	164 MB/200 MHz

3.2 Elevation models and orthophotographs

Aerial and terrestrial photographs provide a media for recording the content and patterns within a landscape at a level to which the scale and resolution of the photographs are capable. To ensure geometric registration of photographic imagery orthophotographic coverage has been derived for each set of aerial photography. Orthophotographs are photographic images which have been corrected to remove the effects of tilt and the topographic relief on the geometry of the photograph using photogrammetric software.

The photogrammetric software Erdas OrthoMax (Erdas 1995) was used to derive a model of the topography from the stereo photography to create a Digital Elevation Model (DEM). The DEM is subsequently used to correct the original digitized photographs to produce the orthophotographs. The output can then be

processed to a specified scale and used as though it were a map, on which other map-based information, such as national topographic mapping data, soils or compartment maps may be overlaid. DEMs were derived for each date of photograph.

Figure 2 illustrates a DEM and associated orthophotograph for an extract from the Cwm Berwyn site. Features such as roads, rides, clear fellings and thinning lines can be identified from both the DEM and photograph. The value of deriving and using such large scale DEMs lies in resolving the detail of the changes in elevation sufficient to identify individual landscape features in the landscape in three dimensions (Miller, et al. 1996, Dralle 1997).

The photography available for Cwm Berwyn for 1975, 1992 and 1995 was near vertical, with focal lengths of approximately 152 mm, with two scales, 1:10 000 and 1:25 000. The 1957 photography was low oblique, 1:20 000 scale. For Glen

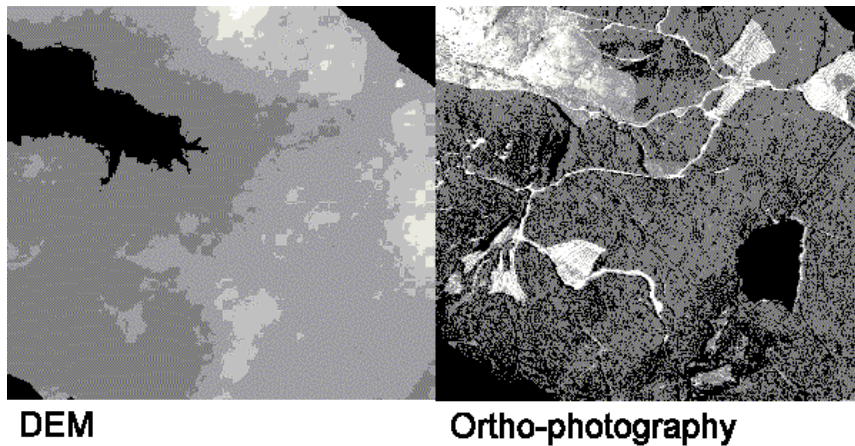


Figure 2. DEM and orthophotograph for an extract from the Cwm Berwyn study area (resolution 1 m vertical, 0.5 m horizontal).

Feshie, the 1988 photograph was near vertical, at a scale of 1:24 000, and the 1946 photograph was of the same low oblique, fan photography as that for 1957 for Cwm Berwyn. At least five fiducial marks on each photograph, for each of the three dates of vertical photography, were distinct and their locations easily measured and all four on the 1946 and 1957 photography. However, it was not possible to observe as many as eight fiducials on each photograph due to insufficient contrast between the mark and the background over which it was superimposed.

The photographs were scanned at 800 dpi, providing a ground resolutions of between 0.25 m and 0.8 m. The scanning resolution was selected to be higher than the spacing between the trees in the afforested sites, compatible with the accuracy of the ground observations and the manageability of size of the data files (Miller et al. 1994).

GPS (global positioning system) and large scale (1:2 500 or 1:10 000) map data was used for the ground control points, which were identified on the most recent aerial photography. The processing was in reverse chronological order. Therefore, for the Welsh site, once the data for 1995 was processed and checked additional points could be selected from the photography of that year to control and check the results for 1992. Similarly, the 1975 and 1957 data was processed and checked using the GPS observations and additional observations taken from the more recent years. The same approach was used for the Scottish site because of the relatively few control points identifiable on base maps of the area.

Creation of the orthophotographs for 1946 and 1957, using the RAF reconnaissance photography, required camera calibration information to be obtained from a museum but no details were available for

tracking the specific camera that was used in the photographic sortie. This will inevitably lead to a lower geometric accuracy for these orthophotographs. However, this, low oblique, photographic data covers over 95 % of the United Kingdom and it provides the most comprehensive source of data for interpreting land cover in the period 1945 to 1960.

Tests were conducted on the geometric accuracy obtained, in a regular pattern across the datasets, taking account of different slopes and aspects with respect to the principal point of the camera. Results of the test showed errors of up to 6 metres relative to the co-ordinates of the equivalent point at another date. The

global accuracy for these datasets was an RMS of ± 2.3 m for Cwm Berwyn and ± 3.9 m for Glen Feshie, whereas the error for near vertical photography was between ± 0.9 m and ± 2.1 m.

Figures 3 and 4 show the sequences of orthophotographs, in plan view, for each site over the periods from 1957 to 1995 (Cwm Berwyn) and 1946 to 1988 (Glen Feshie). In each case, only panchromatic images have been produced, although some of the photography was taken in colour. Panchromatic output was selected due to the additional requirements for disk space of two dates of colour photography for a total of eight photographs.

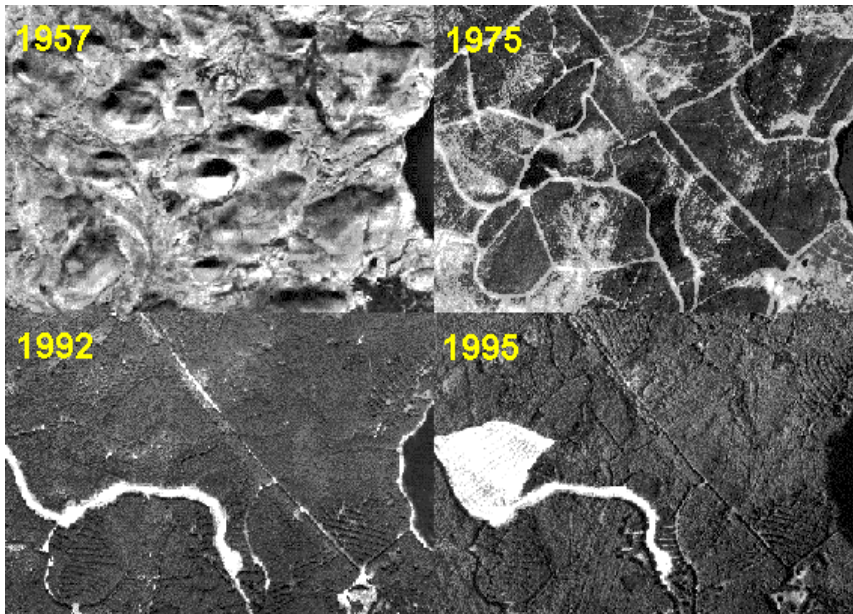


Figure 3. Orthophotographs of an extract of the Cwm Berwyn study area of each date: (a) 1957; (b) 1975; (c) 1992; 1995.

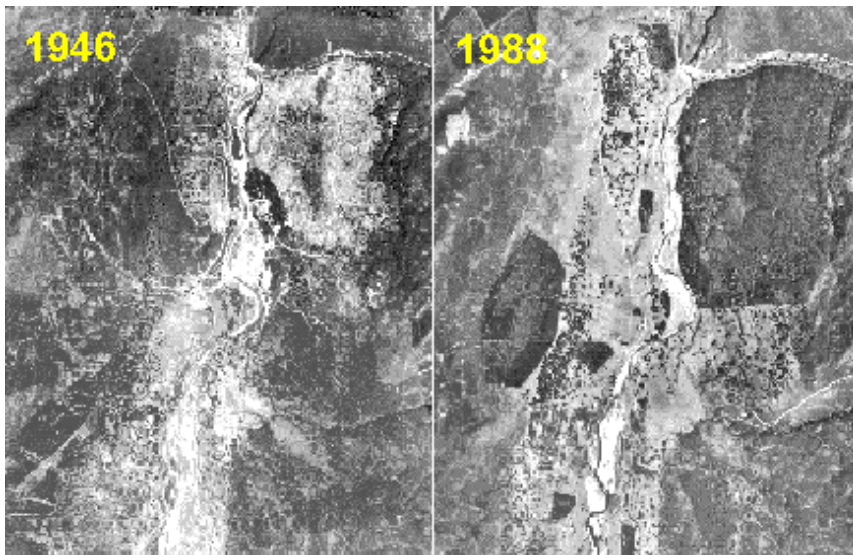


Figure 4. Orthophotographs of an extract of the Glen Feshie study area of each date: (a) 1946; (b) 1988.

3.3 Photographic mosaics

The illustrative quality of the orthophotographic mosaics was maintained by minimizing the possible disjunction in appearance between adjacent photographs. This is achieved by either, using the same photograph for two adjacent models, thus ensuring that the common boundary of the models is ‘seamless’ or, where a choice exists, selecting those photographs which have the most consistent tonal, colour and reflective appearance. No processing of the digital photographs has been undertaken to reduce or remove the effects of shadowing whether due to the topography, at the edges of the canopy or in the wider spacings of the thinning racks.

In those cases where two different, adjacent, photographs are required, two steps are taken in the

orthophotographic production: (1) matching the contrast levels of the two photographs; and (2) clipping the line of intersection between photographs to follow, so far as is possible, linear surface features which can be used to camouflage any mismatch at the boundaries. In an afforested landscape, there is considerable scope for following the edge of tree lines at ride, tracks, thinning and compartment boundaries.

One aspect of mosaicing aerial photograph which is independent of the reflective appearance is that of the geometry of the photograph with respect to the tree canopy. The pattern of the tree canopy, in a location which has been viewed from two directions, may result in an apparent mis-match. This has been mitigated by attempting to mosaic the photographs along a line, approximately bisecting the area of overlap.

3.4 Landscape preference model

The landscape preference model is a psychophysical predictive preference model for natural scenic landscapes. It uses objective measures of landscapes to predict how the general public would, on average, rank a number of landscape images. In summary, these models establish precise quantitative relationships between physical features of environmental stimuli and human perceptual responses (Daniel and Vining 1983). The creation of such a model is detailed in Wherrett (1998).

The particular model to be used in this research requires the measurement of eight variables, all of which are either the area or perimeter of a landscape component. The landscape image is divided up into seven landform types: flat land, low hill, steep hill, mountain, obscuring vegetation, water and sky. Unlike some other models created by Wherrett (1998) this model does not use variables related to colour or complexity in the landscape, and may there-

fore be used on models which are abstractions of reality, rather than direct photographic representations of landscape.

This model scores images between approximately +/- 2, with 2 being a high preference score and -2 being a low preference score. The model has an R^2 of 0.724, therefore explaining roughly 72 % of the variance in preference scores of the sample used to create the model.

4 Landscape change

4.1 Area I: Changes in a Scottish Glen

The study site lies within the Glenfeshie Estate and an aspect of particular interest in this area is that it forms part of the east-coast (Speyside) native pinewood area described by Steven and Carlisle (1959). The area forms the high-lying hinterland south-west of the Cairngorm mountain range (Pimm 1979) and pine-woods are located on gentle to steep slopes from about 360 m to 500 m in altitude. Steven and Carlisle (1959)

The landscape preference model has the following form:

$$\begin{aligned}
 Y = & \text{const} - a \cdot \left(\frac{1}{\text{perimeter\_mountain\_landform} + 1} \right) \\
 & + b \cdot (\text{areas\_of\_steep\_land} + \text{mountain\_land}) \\
 & - c \cdot \left(\frac{1}{\text{perimeter\_low\_hill} + 1} \right) - d \cdot \left(\frac{1}{\text{area\_flat\_landform} + 1} \right) \\
 & - e \cdot \text{area\_of\_flat\_land}^2 + f \cdot \text{area\_of\_obscuring\_vegetation} \\
 & + g \cdot \ln(\text{area\_of\_sky}) - h \cdot (\text{area\_of\_sky}) \\
 & - j \cdot \left(\frac{1}{\text{area\_of\_water} + 1} \right) + k \cdot \text{perimeter\_of\_still\_water} \\
 & + \frac{m \cdot \text{area\_of\_sea\_water}}{\text{perimeter\_of\_sea\_water} + 1} - n \cdot \text{perimeter\_of\_sea\_water}^2
 \end{aligned}$$

recorded few trees under 130 years old with the oldest being around 200 years old. Very little regeneration was noted at the time. The study area was fixed by the limits of the aerial photographs used and covers 256 hectares of the estimated 445 hectares of the Glenfeshie native pine-wood area.

The study area was segmented into sub-areas using a regular, square, grid and individual trees, or clusters of trees, were identified on the most recent photograph and the positions recorded as points, with two attributes: 1. identifying if the point was an individual tree, grouping of 2 to 5 trees or clusters of greater than 5 trees; 2. a subjective assessment of the degree of confidence in the interpretation. The point data was used as an overlay, draped across the orthophotographs for each of the other years and changes in tree presence (or absence) were added to the dataset. Gross areal changes were interpreted as polygon features.

Woodland was identified and mapped, with reference to the Forestry Commission definition of a pinewood as having at least 200 trees that are capable of inter-pollination and cone production (Forestry Commission 1991), and as points for individual trees, for each date, recording the confidence level with which they were interpreted. General land cover classes were also mapped and the boundaries compared with an analysis of the variability in the model by image processing techniques. A comparison of the datasets together reveals:

1. The loss and regeneration of native pine trees in each area;

2. The change in both spatial distribution of woodland and its density;
3. Identification of areas in which the (predominant) loss or (small) gain in woodland is most visible and a measure of the relative visibility of each land cover class.

Results of the interpretation show that about 18 % of the mature tree cover died between 1946 and 1988 with recruitment into the canopy over the same period of just over 2 % giving an overall loss over the period of the study of 16 %, equating to about 0.4 % per annum. The main losses appeared to have occurred between the 300–400 m although this may be the result of unrecorded fellings on the more accessible lower slopes. While recruitment was found to be greater on the lower elevation sites, it was not sufficient to balance the overall loss. The imbalance between losses and recruitment has been put down to the intensification of management within the study area during the period of the study and particularly in the 1980s.

Other features which are interpretable from the historical photography include:

1. The areas of clear-felling which occurred during World War II (WWII) by Canadian workers, which were replanted in subsequent years; replanting which took place around the individual pine trees that were not felled. Indeed the logging camps which were inhabited by the Canadian workers, and the current pattern of shelter woodland which since have been planted around the camps are also visible, one of

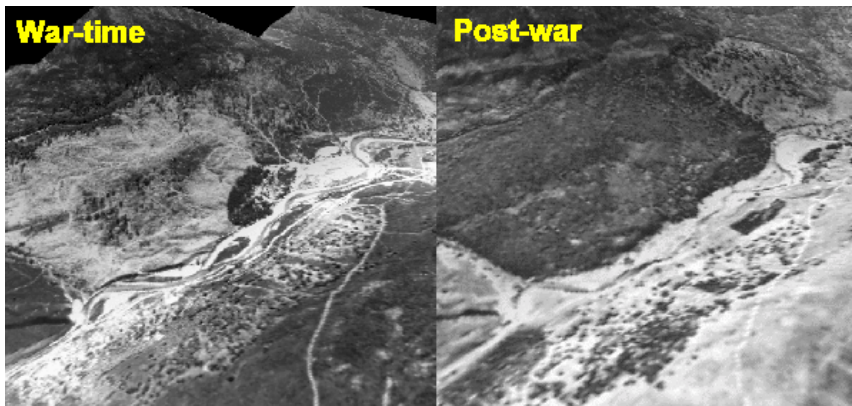


Figure 5. War-time / post-war replanting.

which remains in use as a farm in 1988. Figure 5 illustrates an area of clear-fell in 1946 in which individual pine trees have been left on the hillside. In 1988 the woodland has been replanted with the new woodland surrounding, but leaving the existing trees.

2. The pattern of muirburn on the hills, which would have been undertaken pre-WWII and with which comparisons can be made with more recent burning patterns (indicating almost no change in the rate of burning). Changes in the patterns of muirburn between each date can be related to changes in activity in land management such as grazing levels (Hester et al. 1996).
3. Comparison between the patterns of erosion and scree on the hill-sides in the higher parts of the Glen for each date show where increased levels of erosion have occurred.
4. The vegetation patterns that occur on the geomorphological fea-

tures such as moraines, kettle holes and alluvial fans.

5. The braiding of the river and changes in the route of its main channel between each date. This Glen is frequently subjected to flooding and changes in the route of the river will have occurred on many occasions over the forty year time period. Therefore, the routes identified at each date of photograph will be snapshots of a feature which experiences high frequency change.

4.2 Area 2: Growth of a plantation forest

Aerial photographic coverage of the study area for four different dates was used for a period of 38 years (Figure 4), which spanned the dates during which the land use was converted from upland grazing to forestry. Figure 6 shows perspective views of the area at each of three dates, created by draping the ortho-photographs over the DEMs. The

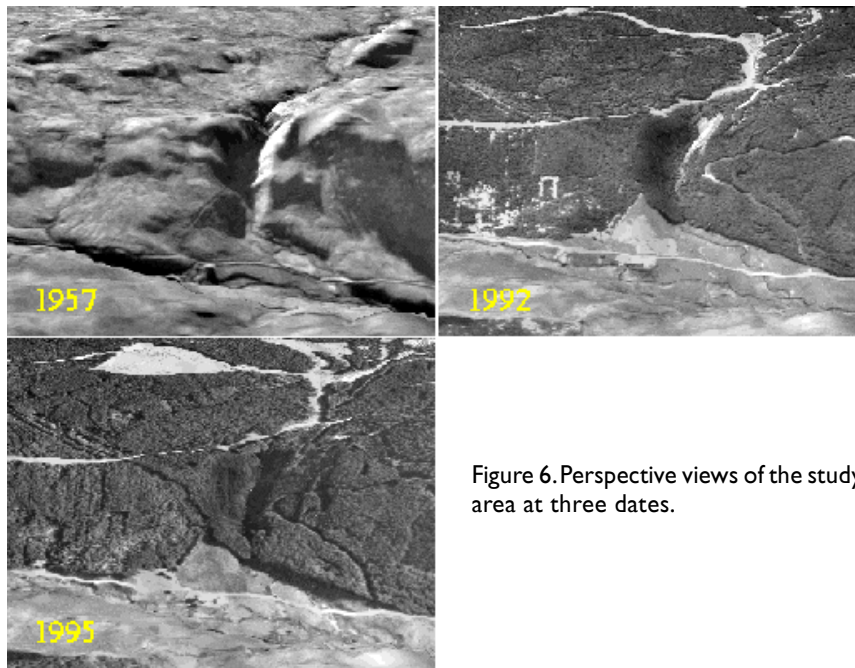


Figure 6. Perspective views of the study area at three dates.

embedding of the surface relief and height of the forest stand within the DEM provides a greater degree of foreground detail. The combination of the resolution of the photograph and the DEM enables the viewer to identify the patterns in the forest canopy due to thinning, clear-felling and wind-damage.

The changes in land cover and use over the time period are summarized below.

1957: Pre-planting, the land use was predominantly one of agriculture. The land around the Cwm and on the hill tops was used for sheep grazing and there were no trees in the area. An area of peat bog is interpretable to the south of the Cwm. On the lower slopes, in the valley which runs towards the west the land is en-

closed and used for improved pasture and certain foraging crops.

1975: Planting or ploughing has taken place across almost all of the area since 1959, concentrating upon the hill tops and the land around the Cwm. However, some valley sides, previously below the head-dyke (the upper area of enclosed land) on the northern side of the valley has also been obtained for planting. The northern part of the peat bog has been planted but the southern half has been left untouched. The principal stocking species are also present as mixtures (Sitka Spruce/Lodgepole Pine and Sitka Spruce/Japanese Larch) across large areas of the forest with tree heights expected to be a maximum of approximately 8m. The stocking density across most of the

forest is 2500 per ha (a spacing of approximately 2 m).

1992: By 1992 the trees were up to 33 years old and were measured in the field as being up to 20 m. The management of some areas has included selective thinning but no large areas of clearfelling. The canopy has closed across much of the forest, but some areas remain more open. Some areas can be identified as having a sparse canopy cover and are interpreted as under-performing. There is evidence of some wind induced damage, especially towards the north-east of the Cwm.

1995: By 1995 (36 years since first planting) the majority of the canopy was closed. Three large areas were felled between the dates of photography in 1992 and 1995 and the number, and extent, of the management units which have been thinned has increased substantially. Tree growth on the peat bog has been unproductive, with shrubs predominating. The areas damaged by the wind increased both in areal extent and in number.

5 Presentation of landscape changes

To aid in the presentation and communication of the changes in landscape over the forty years fly-through and video sequences were created for replay on either a Silicon Graphics video format or a PC (using QuickTime format and player). The use of a Silicon Graphics workstation (Onyx Reality Engine) provided a high quality, large format, visualisation facility, however, the portability

of the PC format enables a wider dissemination and use of the videos sequences and so both outputs were produced. Movie sequences of flights across the landscape at different dates was created, visiting certain locations where either, change was dramatic over the time period or, key landscape features were highlighted.

The software used for the creation of the video sequences was the ERDAS Imagine VGIS package, housed on a Silicon Graphics workstation. Flight paths were defined and viewing parameters selected to highlight the occurrence of landscape features and changes within the study areas. The movie sequences, recorded by the software were in SGI video format allowing the editing and compilation of combinations of sequences using the SGI 'Video Edit' package. This package is rudimentary and it is not possible to significantly modify the files. Therefore, editing requires to be kept to a minimum and thus the onus is on the preparation and recording phases of the video creation using VGIS. Conversion into a PC video format used an RLE animation compression to reduce the size of the files when creating the QuickTime movies.

The value of such an output is in the communication of issues associated with landscape management and natural processes and man-induced processes in the uplands. This provides materials which can be used in, research, education and dissemination of information to a wider public. An example of a fly-through for the Cwm Berwyn area using photography for 1995 is **accessible here**.

6 Evaluating the change in landscape

The landscape preference model was applied to views derived from two dates of photography, pre-and post-afforestation. The viewpoint was se-

lected for the Cwm Berwyn study site in the vicinity of a newly created visitor information point. A height of 2 m above ground level was selected and a westward direction of view. Figures 7 and 8 show the derived views for each date, with the growth of trees producing an obscuring ef-

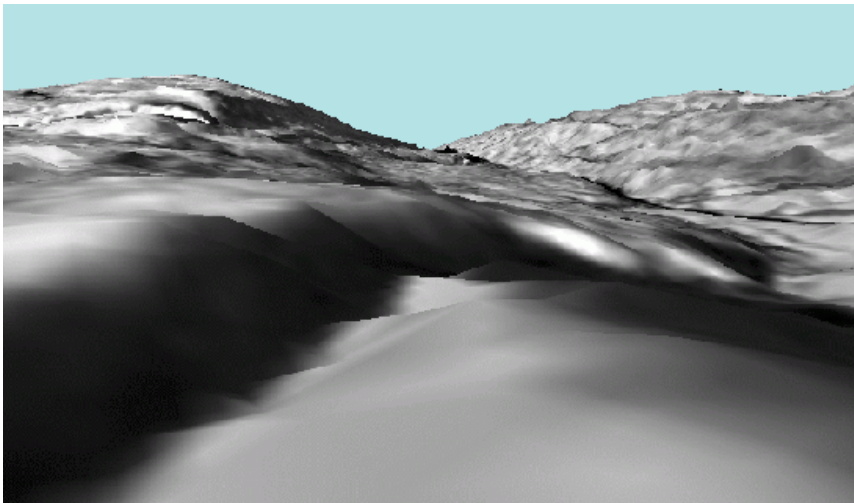


Figure 7. Cwm Berwyn, 1957.

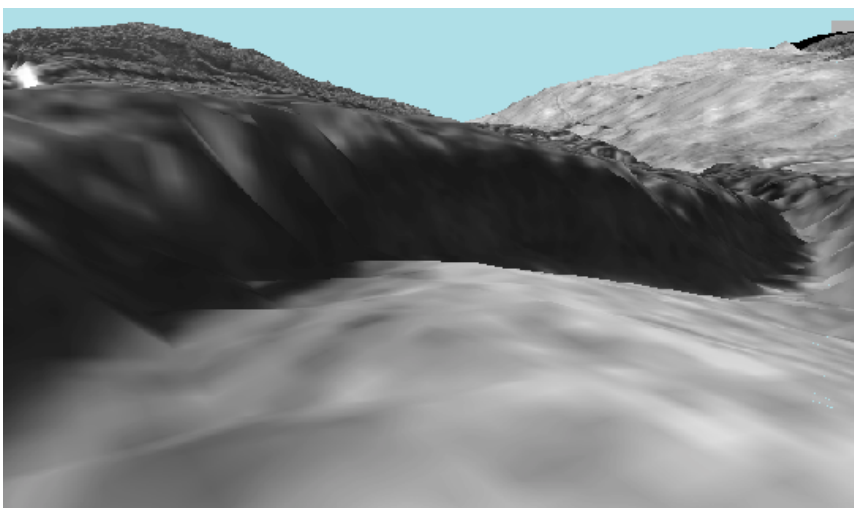


Figure 8. Cwm Berwyn, 1988.

Table 3. Landscape Component Measurements: Cwm Berwyn, 1957 and 1988.

Variable*	1957		1988	
	area	perimeter	area	perimeter
Low Hill	718	120	451	112
Steep Hill	207	101	156	102
Sky	162	95	124	94
Obscuring Vegetation	0	0	352	102
Scores	-0.4894		-0.3415	

* All variables are measured in WLC Units, of which there are 1080 in an image.

fect in the foreground of the 1995 view. Analysing each picture, the only variables from the model described in section 3.4 which are non-zero are low and steep hill, sky and obscuring vegetation (Table 3).

The results from the model show that the 1957 image has a lower score than the 1988 image, by around 0.15. In terms of the range of possible scores, this is a relatively small increase in score for the 1988 image, and implies that the preference for this landscape may have marginally increased.

7 Discussion

The visualisation and landscape preference modelling presented in this paper requires further development to produce a robust system for use in supporting decision making in issues of landscape management. However, there are several specific areas in which improvements are required and limitations may be significant for prospective future use.

7.1 Digital elevation models

The time taken to produce a DEM for the entire model varies by 15–20 % according to the power of the processor available. These figures will vary further where access is to a remote, rather than a local, disk. It would seem inevitable that the time taken for deriving a DEM will reduce with increased in computing power and sophistication of computer hardware and the processing times experienced are likely to be towards the maximum of the timescale required. Indeed a lower spatial resolution could be tolerated for some applications. However, the images used in testing the evaluation of the landscape required a level of detail sufficient to incorporate the shape and size of the forest stand and thus the obscuring effects in the view that it provided. Therefore, processing DEM data and associated orthophotographs would appear to be a practical exercise for individual forest stands.

7.2 Orthophotography

The quality of the original aerial photography, both in terms of geometry and reproduction quality, impacts on the quality of the output. The issue of quality is most significant when selecting a study site for which aerial photographic cover is required. A balance is required to be struck between the issues associated with the photography (geographic extent of the coverage, the temporal sequence available, the geometry of the photographs including scale and flying height and the quality of the photographic copy) and the requirements of the user.

The experience from the visualisation of afforestation described in this paper suggests that the low oblique, reconnaissance photography taken in the United Kingdom until the late 1950s can be used successfully for the creation of orthophotographs, however, their value for deriving DEMs has been lower due to the lack of detailed information on camera calibration. A more significant problem for applications in visualisation is that of the consistency and contrasts within the photographic copy when constructing mosaics. Fortunately, the quality of the photographs used within this study posed few such problems. However, photographs which are forty or fifty years old, for which the original negative may be missing or deteriorated over time may not prove to be useable.

Maintaining sequences of photographs for areas of particular interest would allow comparisons to be

made between landscape views taken at different times. Information interpreted from one year's photography may be compared to that of another year. Areas of planting and clear-fell, for example, can be viewed with respect to the underlying topography and, interpretations of the land cover, from a historic perspective. Naturally, such views may be derived for locations and in directions selected by the user; these may include points that are currently inaccessible on the ground but which are of potential future importance. If the focus of interest changes, the landscape study is not restricted as it has been using conventional methods, by views selected for historic terrestrial photographs.

The cost of obtaining extensive aerial photographic coverage necessitates their use for multiple purposes, such as forest inventory, land cover mapping and impact assessments. The trade-offs that may be involved in satisfying multiple objectives of data capture could limit the value of the data for any one use. A cost-benefit assessment is required on the use of photographic and DEM data as described in this paper to contribute to the specifications of the data capture. The experience gained in the studies reported in this paper would suggest that scales of aerial photography in the range of 1:10 000 to 1:25 000 are suitable for visualisation of the landscape, but to obtain a sufficiently high resolution of DEM, scales of 1:10 000 and larger will yield the better results.

7.3 Visualisation

It is unclear what level of detail and realism is required for a user to recognize what is being presented and the key differences between competing options for a plan for the landscape. Therefore, gross changes, such as patterns of clear-fell, maybe presented in relatively simple illustrations. However, the landscape impression left by patterns of line thinning may be more subtle and require a greater degree of content and detail. An increase in detail in an image may require an increase in the associated degree of realism. For some applications, an increase in content, realism and detail may result in undue clutter and noise which may have one of two consequences: either, improving the information on the context within which any change in land management is taking place, or confusing the overall picture and complicating a decision making process.

7.4 Videos

There are several limitations associated with the creation of the video sequences. These include data quality (both geometric and visual), processing time, editing of frame sequences, disk space and configuration of the presentation media. Most of these issues are essentially hardware and software related and they can be overcome with suitable improvements. As an example of the files produced, a nine minute sequence, at 15 frames per second, for viewing on a Silicon Graphics workstation, using panchromatic imagery

a video compression of 75 % of the original imagery, occupies 1.1 Gbytes of disk space.

The strength of this means of presenting the changes in land cover, use and thus landscape over time is the ability to create a tour of the landscape, viewing it from different locations and the opportunity to view the same pathway across the area at different dates. Thus it is possible to aid in the communication of the essential differences in the landscape.

However, its principal limitation is the lack of flexibility in viewing offered to the user. Except for moving through scene views at different speeds and directions, there is no opportunity for the viewer to modify the area in view and thus they are entirely dependent upon the choice of views presented by the movie maker. The extent to which this is a significant limitation will be dependent upon the use intended. For education and public dissemination of information, the constraint will be minor. However, for research into the directions and forces of landscape change, the constraint may be significant and the video merely an introduction to the area to be replaced by access to a modelling package and data.

7.5 Landscape evaluation

The use of a predictive preference model for landscape preference allows changes in relative preference to be calculated. However, it must be remembered that the figures obtained from such models represent only an average of the general population and that the models explain only around

70 % of the variance in the preference scoring of a sample population. However, such models are still a useful indicator of preference changes and may provide constructive input to decision support in the landscape planning arena.

8 Conclusions

The work presented in this paper demonstrates one approach to visualising and evaluating the landscape at different dates, when there is suitable aerial photographic coverage of the area. An ability to orthorectify and register multiple dates of photographic imagery, including reconnaissance imagery with little or no camera details, to accuracies of approximately 2 m is a significant step towards realising additional value from the collections of historical photography available for many places.

The hardware and software configurations and processing requirements for creating models that may be viewed interactively or as video sequences are increasingly common and available on low cost PCs. Therefore, there is considerable scope for compiling a package to permit the throughput production of products similar to those presented in this paper as part of a larger package for exploring the effects of changes in landscape.

Applications have been explored in the area of education and there appears to be an opportunity to develop demonstration packages, targeting specific areas and time periods of interest. Future availability of

high resolution satellite imagery may add greater opportunities to the options available for input data. The next challenge will be to derive interactive models of each date of imagery using technology such as that offered by the Virtual Reality Modelling Language (VRML) which would enable a significantly more flexible output for the user to explore.

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Visual interactive planning in the private forests of Finland

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Abstract

Finnish forest owners are more and more interested in the scenic value of forests, diversity of the landscape, and other non-numerical management goals. At the same time, people are less and less familiar with forestry concepts. This situation calls for visual planning, which is easily understandable to everyone. Visual planning means realistic presentation of the information; the present and future states of the forest are shown as computer illustrations, aiming at photorealism. However, visual planning is not only landscape simulation. It also means presenting numerical goals and their interactions with diagrams, guiding the optimization process through graphical interface, etc. Visualization does not mean replacing numbers by illustrations, but converting the results of numerical calculations into graphical visualizations. Several projects on forest visualization are going on in Finland. This article describes the work which has been done for visual interactive forest planning in the research projects at the University of Joensuu. The work has resulted in a new user-interface of a planning software. The interface enables the participation of several decision makers in the planning session.

Keywords: forest visualisation, decision support, forest planning, optimisation

1 Introduction

Forest owners and others are more and more interested in the scenic value of forests, diversity of the landscape, and other non-numerical management goals. At the same time,

people are less and less familiar with the forestry concepts such as volume per hectare or stocking. One more feature of the present and future Finnish forestry is that many forest holdings are owned by a group heirs who have different opinions and ex-

pectations. There are also instances in which it is preferable to plan simultaneously the management of several neighbouring forest holdings. Landscape level ecological planning is a typical example of these instances.

The present situation calls for visual interactive group planning in the private forestry of Finland. Visualisation is needed to make the impacts of management decisions understandable to everyone, and to evaluate non-numerical goals. Interactive planning is needed because all decision-makers can not express their objectives precisely and without ample feedback from the planning system. Interactive planning includes, besides interactive optimisation, also two-way communication between forest owners and the planning consultant and among the decision makers (Pykäläinen 1998). A simple and easy-to-use interface of the planning software is a key issue in this context.

Group planning is required because there are often more than one decision maker. Group planning is negotiation, compromising and adjustment rather than straightforward optimisation. The number of objectives is often high because of many stakeholders. Thus, the planning task may be very complex. Furthermore, all the stakeholders are not equally educated and experienced in forestry. In group planning, the need for visual and interactive decision support is even greater than in the case of a single decision maker.

Ideally, group planning with a visual interactive interface is like driving on the production frontier of the forest (Pukkala 1997). The location of the plan on the frontier can be changed by driving toward increasing income, scenic beauty, land expectation value or any other goal. The interface gives immediate feedback about the effects of a move on the values of objectives. The effects

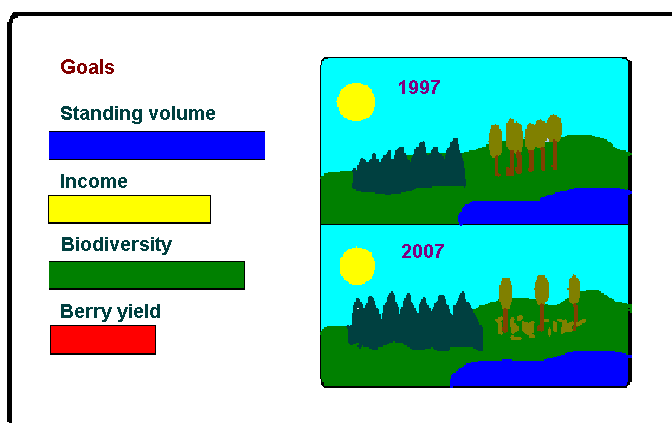


Figure 1. The ideal interface for interactive multi-objective forest planning is visual and simple to use (Pukkala 1997). The Importances of management objectives are altered by adjusting the bar lengths with the mouse. The landscape visualisation is automatically up-dated.

of forestry operations on the future landscape are seen visually on the computer screen (Fig.1).

The software for interactive planning should not require complicated data preparation steps, technical skills or understanding of special planning concepts such as simulation or mathematical programming (Pukkala 1997). The apparent simplicity of the system is not achieved by forgetting complicated analysis, but by automating the analysis and concealing complicated calculations behind an interface that is easy to use and understand. The software should run on portable computer so that the planning sessions can be organized in a location which is convenient to the forest owners.

This paper describes a new visual interactive interface for the MONSU planning software (Pukkala 1998). Visualization is utilized when defining the objectives of the stakeholders, and for illustrating the present status of the forest and impacts of forestry operations on the future landscape. The interface is currently being tested in forestry practice in eastern Finland.

2 The interface

2.1 Planning process

The forests of an individual landowner are divided into sub-areas for planning and management purposes. These sub-areas are called stand compartments. They are homogenous with respect of site, growing stock and future management. A compartment may have several management options, which in planning

jargon are called treatment schedules. The task of forest planning is to find such a combination of treatment schedules for compartments which best meets the objectives of the forest owners when evaluated at the level of the whole forest property. Searching for the best combination may be done by using numerical optimization.

With our method, the outcomes of different treatment schedules of compartments are predicted by the planning software prior to optimization (Fig. 2). This information is collected into planning model together with the management objectives specified by the decision makers. The planning model is then solved using numerical optimization. The result is the first proposal for a forest management plan. This plan may be improved by adjusting the management

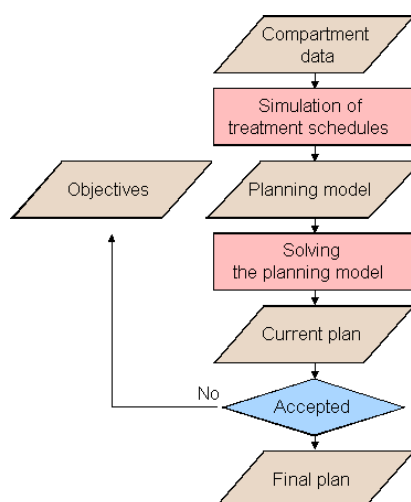


Figure 2. Flow chart of goal-based interactive forest planning.

objectives and their importance and resolving the problem. This process is called interactive optimisation.

2.2 Interactive optimization

In our system, the comparison of decision alternatives is based on an application of multi-attribute utility theory and a heuristic optimization algorithm (Pukkala and Kangas 1993).

The total utility of a plan (U) depends on the utilities that decision makers would experience if the plan is implemented:

$$U = \sum_{k=1}^n w_k u_k \quad (1)$$

in which n is the number of decision makers, and w_k and u_k are the weight and utility of the k th decision maker, respectively. The utility that a single decision maker expects from the plan is computed from

$$u_k = \sum_{i=1}^{m_k} a_{ik} u_{ik} \quad (2)$$

in which m_k is the number of objectives of decision maker k , a_{ik} is the importance of objective i , and u_{ik} is the sub-utility obtained through objective i .

Optimisation begins with the specification of decision makers. Every decision maker has the same initial weight, i.e. all the w_k are equal. Then, every decision maker estimates his or her utility function by selecting the goal variables from a list presented by the planning software, giving approximate relative importances for the goals (a_{ik} in

Equation 2), and forming a sub-utility function for every goal variable. The sub-utility function is determined through the smallest and largest possible values of the objective variable, its target level, and the relative priorities of the smallest value, target level, and the largest value (Fig. 3).

The software then produces an initial solution by maximising the total utility (Equation 1) using the heuristic algorithm of Pukkala and Kangas (1993). The solution is displayed as a dialogue (Fig. 4) which enables the users to change the importances of goals (a_{ik} in Equation 2), or the weights of decision makers (w_k). The users change the lengths of horizontal bars that indicate the

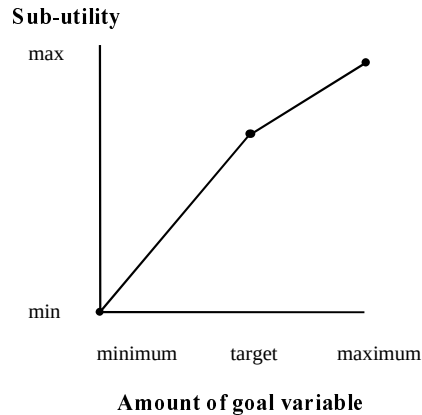


Figure 3. A sub-utility function is used to compute the partial utility from a management objective. The planning software automatically finds the minimum and maximum value of the objective variable using single-objective optimization. The decision maker enters the target level. He or she also gives (or accepts) the relative priorities of the minimum, target and maximum value.

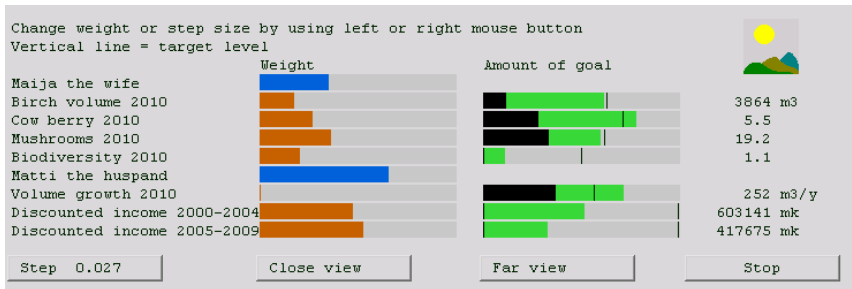


Figure 4. Interactive optimization is guided through a dialogue which allows the user to change the weights of decision makers and the importances of goal variables. The mouse pointer is moved on the bar and its length is changed with the left (decrease) or right (increase) mouse button. The step size of a change may be adjusted. Changing a given bar keeps the relative lengths of the other bars unchanged.

current values of w_k (blue bars) and a_{ik} (brown bars). The problem is resolved after every change and the new solution is immediately displayed. This gives an impression of travelling along the production possibility boundary of the forest. The decision makers have an easy and full control of the process, and they can immediately see the effects of adjusting w_k or a_{ik} .

2.3 Visualization

The dialogue used to control interactive optimization has buttons for distant scene and close scene (Fig. 4). These buttons enable the user to see visually the predicted development of the forest if the current plan is implemented. Visualizations help laymen to understand the consequences of accepting the current plan, and they ease the evaluation of non-numerical objectives. *Far view* button shows the forest from a viewpoint which not in the forest. An ob-

lique aerial view is typically wanted. When displaying *close view*, the viewpoint is on the ground in the forest.

With both views, the user may change the season of the year and the location of the viewpoint. The far view window shows two separate visualisations which the user may specify independently (Fig. 5). One visualisation may show the present landscape and the other the same landscape at the end of the planning period. It is also possible to display two alternative plans (e.g. previous and current), the same area seen from different directions, etc.

The close view window allows the user to move in the forest. It is possible to adjust the distance of the viewpoint from the front edge of the area drawn, this allowing one to find a suitable viewing position. The view is shown in the beginning of the planning period, and at the end of user-specified sub-periods (Fig. 6).

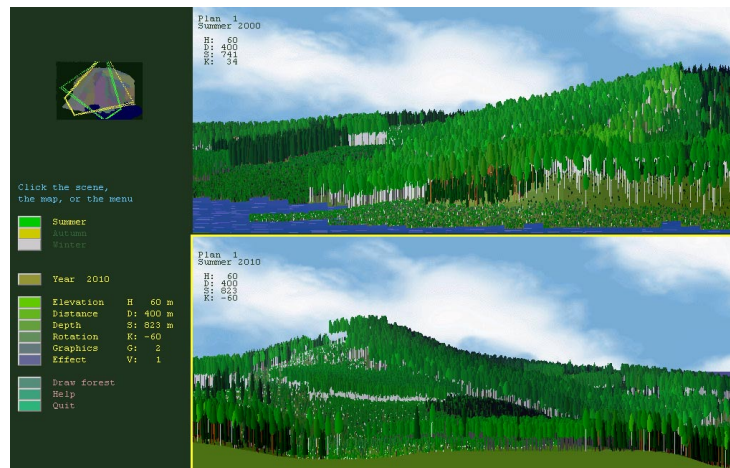


Figure 5. The *Far* view window of the user-interface. The user may proceed to optimization or to close view, and change the parameters of either of the two landscape visualizations.

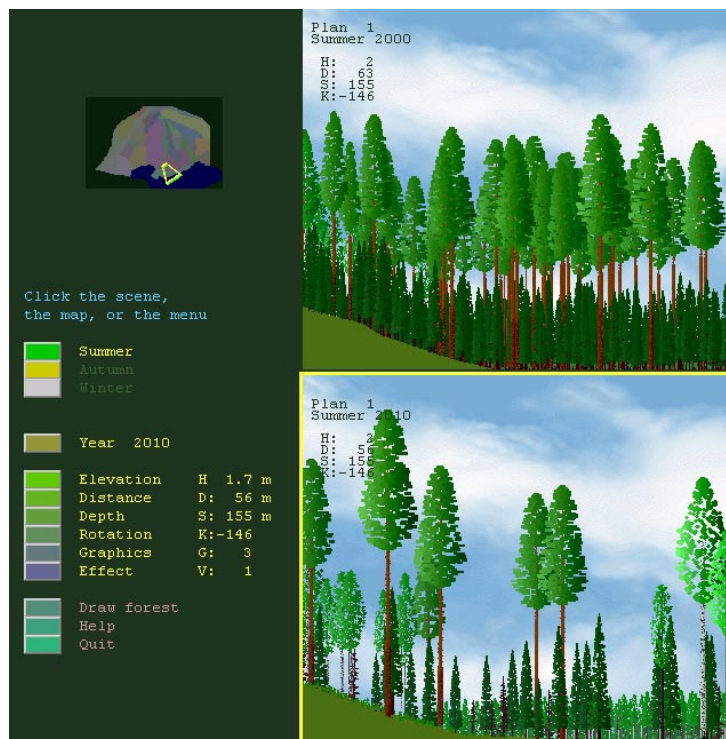


Figure 6. The *Close* view window of the user-interface. The user may proceed to optimization or to far view. The area shown is selected from the map with the left mouse button. The right mouse button displays information and visual output on the current treatment schedule of the compartment.

Landscape visualisation uses three sources of data (Fig. 7). The first is a digital terrain model which contains the elevation of the terrain, forest holding number, and compartment number at regular intervals in x and y directions (e.g. at 10-m or 20-m intervals). The second source is the predicted stand development in the alternative treatment schedules of compartments. The third source of information is interactive optimization; the current solution tells which schedule of each compartment is included in the plan.

Visualisations are created by drawing tree symbols on the terrain model. Information on the species composition and size distribution of trees is contained in the description of treatment schedules of compartments. Because stand development is described using individual trees, creating of visualizations is straightforward. Current solution tells which treatment schedule is to be utilized in drawing. Holding and compartment numbers in the terrain model

form the necessary link between the terrain data and tree stand data. When producing the close view, the number of drawn tree symbols corresponds to the true number of trees in the front area, but fewer and fewer symbols are drawn with increasing distance. The same is true for the distant landscape, but the correspondence between displayed and true number of trees is weaker.

3 Discussion

The visual interface described in this paper is tightly integrated with a forest planning system. This is an advantage when using landscape visualization in practical applications. The effects of different plans on the landscape can be immediately seen on the screen.

The interface offers negotiation support for group planning. The importance of objective variables as well as their values are seen as graphical bars and numbers when

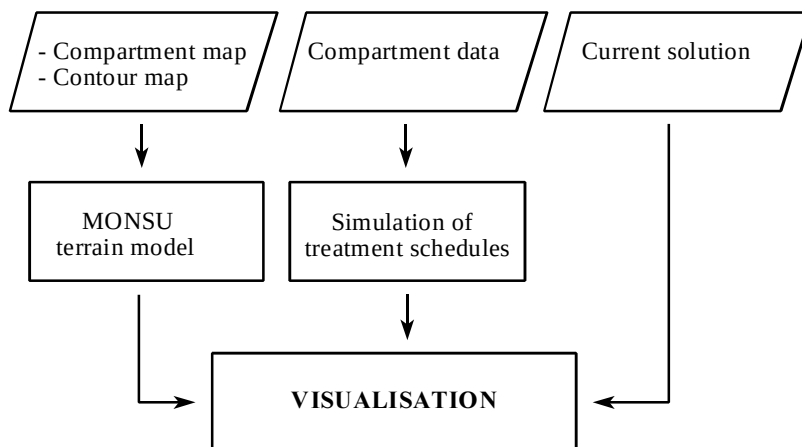


Fig. 7. The data sources of landscape visualisation.

negotiating about the plan. This is an illustrative way to show the relationships between objective variables. The decision makers can see whether the variables are competitive, indifferent or complementary. The users may also inspect what would be the effects of changing the weights of decision makers. This lessens unnecessary arguing in the case of indifferent and complementary objectives. It also guides a decision maker to stay passive until achieving his or her own objectives becomes endangered. With purely qualitative planning, this kind of conflict avoiding is not possible.

The stakeholders may have varying knowledge about forestry. Because of this, some of them might be in weaker position than the others when negotiating about the plan to be implemented. By using the interface presented here, this kind of inequality can be mitigated. Avoiding forestry jargon in planning interfaces and interpersonal communication is also an important means to increase the knowledge and understanding of the participants.

The interface described is under continuous development. Most probably it will develop towards multi-

media utilizing sound and animations as additional ways to convey information. The user may be guided through the planning process via spoken sound files, and animation may be used to show the temporal development of the forest or to simulate trips in the present and future forest. No doubt visualization can also be used in a more sophisticated way in the preference analysis.

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Multimedia as a documentation tool of forest planning

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Abstract

A forest plan is traditionally presented as a paper document to the forest owners and other stakeholders. The documents have been difficult to understand and even boring to read. Applying multimedia in forest planning could change this situation. Hyper text allows flexible reading. Visualizations, animations and sound can be used to communicate forestry information. The forest owner can see how the forest grows and how the landscape changes as a consequence of forestry operations. Multimedia can also be used during the planning process. Especially in participatory planning of public forests, this presentation media is an interesting and potentially efficient way to present alternative plans to the public; this can be done through a computer net. The computer net may also be used to collect people's opinions about alternatives. This article presents an application of multimedia as a documentation tool of forest planning. The plan was produced for a private forest land owner in eastern Finland.

Keywords: forest plan, hyper text, visualisation

1 Introduction

Forest planning is changing due to several reasons. One driving force is technical development. Computer and information technology now offers possibilities, which were hard to imagine some years ago. One of the new possibilities is to apply multi-

media as a tool to present forestry information (Pukkala 1997).

Traditional forest plans are paper documents that are full of numbers. These reports are difficult to understand to many forest owners. A general tendency in reporting is to produce hypertext documents, which can be read interactively with software that is easily available to eve-

ryone. Hypertexts may be linked to a computer net, this enabling remote and flexible reading and efficient dissemination of information. Hypertext editors and multimedia tools make it possible to include visualisations, animations, and sound in the document. By reading a multimedia forest plan the forest owners can see in a realistic way, as computer animation, how the landscape changes as a consequence of tree growth and forestry operations. In the near future, they can also hear the sound of wind, rain, birds, and harvesters.

The majority of the present forest owners are still much more familiar with paper documents than hypertexts. However, the situation is changing rapidly if the present trend in the frequency of Internet usage continues. Very soon the owners expect receiving the forest plan as a multimedia document on CD-ROM.

This article reports an attempt to report the content of a forest management plan as a multimedia product.

This product was prepared with a combined use of a forest planning software and multimedia tools that were available in the Internet.

2 A hypermedia plan

2.1 Structure of the plan

We used HyperText Mark-up Language (HTML) to produce a forest plan in the hypermedia format. The HTML is well known through the Internet, because it is the page description language (PDL) in World Wide Web documents. It is a simple and easy-to-understand PDL and it enables one to use pictures, sound and animations in electronic publications. It is also hardware-independent; one only needs a simple text editor to make an HTML document.

The data for our electronic forest plan (Figure 1) come from a traditional forest plan prepared with the

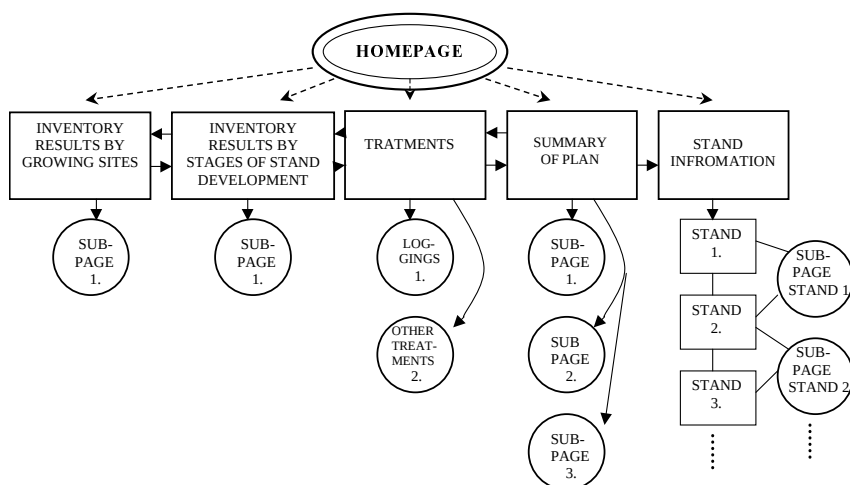


Figure 1. The page structure of the electronic forest plan.

MONSU forest planning software running in Windows 95 or NT (Pukkala 1998). We tried to make the hypermedia document easy to read use and understand. We used much visualisation to bring the forest on to the computer screen. Forest visualisations and tabular information were taken directly from MONSU output. The help files for the hypermedia plan were sound files recorded with a PC; when the reader clicks the help-button the voice message gives instructions of how to proceed.

The main page of the hypermedia plan is the homepage (Figure 2). It was prepared using frames, which enable the editor to split the screen into multiple parts, each part contain-

ing a different HTML document. Frames make the page making process easier and quicker if the electronic publication contains a fixed part, which is included on every page. WWW browsers like Netscape 2.0, Internet Explorer 3.0 and their later versions support this option. The homepage has links to pages showing the present forest status by growing sites or stages of stand development, loggings and silvicultural treatments, summary of the plan, and a map of tree stands (Figure 1). These primary pages include some text but majority of the information is conveyed through images. More information is made available through charts and tables on sub-pages (Figure 3).



Figure 2. The homepage of the electronic forest plan. It contains the general information of the forest holding. The landscape visualisation in the middle is animation showing the view when one flies over the forest. It is based on computer graphics produced with the MONSU planning software.

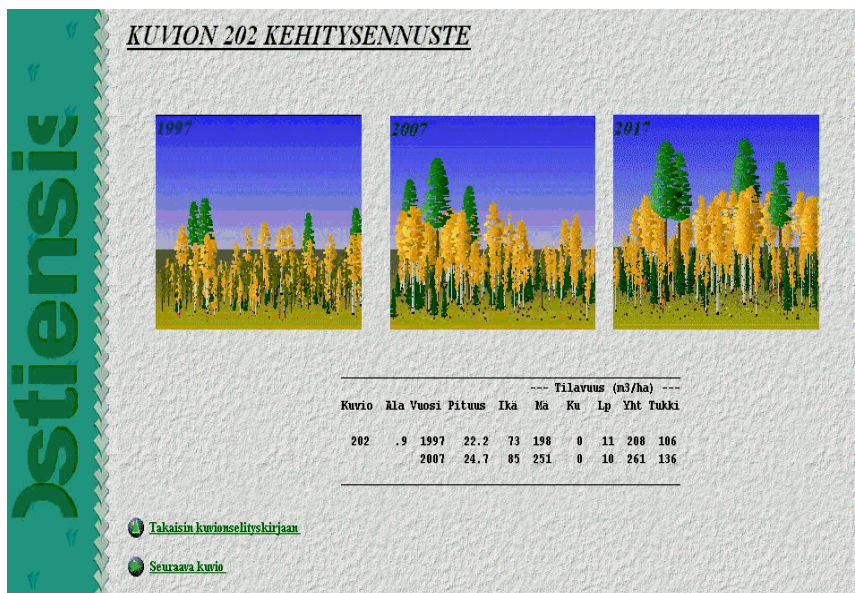
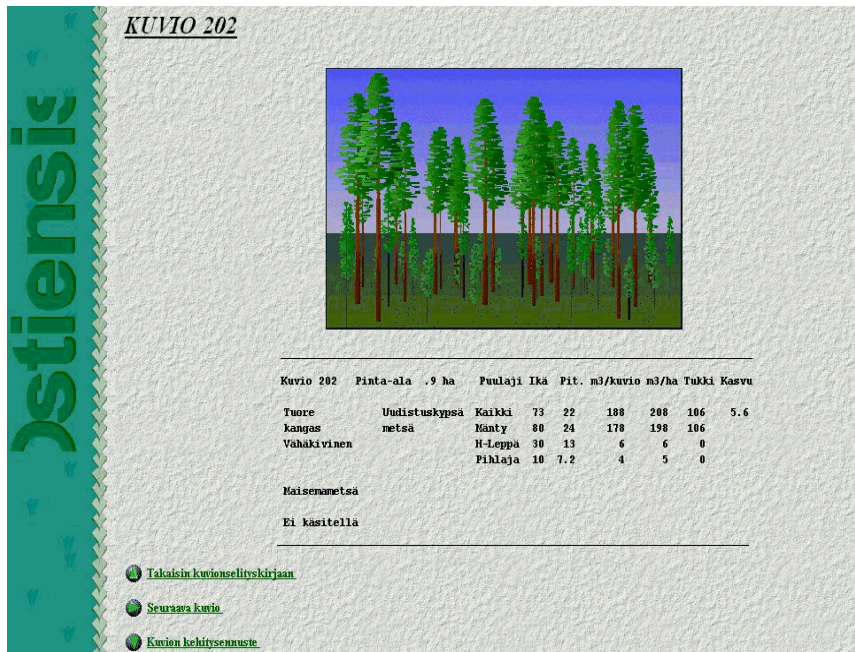


Figure 3. The stand main page (above), and a sub-page (below). One of the stand pictures on the sub-page is animation showing the stand development during the planning period.

2.2 Software used

An HTML document can be written with any word processor that can save text in the ASCII format. A web browser is used to view the final product. Different programs are needed to produce, use and edit pictures, sounds, animations, and interactive images. There are a huge variety of these programs available in the Internet. Almost every program used in our exercise was downloaded from the net for the evaluation period. The following introduces some of the programs used. In addition to the programs discussed below, common word and image editors such as Word 97 and Paint Shop Pro 4.12 were used.

Hippie 97

Hippie (HTML Interactive Personal Page Editor) version 2.0 is an interactive HTML editor, which needs Internet Explorer 3.02 to work properly. It is available for at least Windows 95 and Windows 3.x operating systems. Hippie 97 includes all the most typical tags as toolbar buttons. When creating an HTML document with Hippie 97, one uses the split-screen option and observes in real time how the document looks like in a web browser. With the help of HTML editor one quickly gets used to the HTML language and process web sites in a flexible way. But one also needs to learn the HTML properly, especially in the case of errors.

Mapedit

The interactive images of the hypermedia forest plan were prepared with the Mapedit software. An interactive

image is a picture, the parts of which serve as links to other documents. With Mapedit the picture can be segmented into several active parts each of which can be a link. The segments may have different shapes such as circle, rectangle or polygon. These parts are called as hot spots, which are based on the coordinates of the picture. After hot spots and links are defined, the web browser recognises, which segment the mouse is pointing to. If the segment is clicked with the mouse the web browser opens the web site where the link points. The interactive images that we used were Client Side Image maps, which do not need a Common Gateway Interface program (CGI) to handle the coordinate information of the picture. In the Client side image maps the coordinates are embedded straight in the HTML document. For example, the stand map (Figure 4) was made with this method; clicking a stand opens the first page of the stand. The latest versions of web browsers (Internet Explorer, Netscape) support this function (Sirola and Veistola 1997). This is an advantage in such environment where one cannot use a server, for example in CD-ROM environment.

GIF Construction Set

The GIF Construction Set (32-bit version 1.0) is a versatile image-processing program. One can make transparent images, small-scale animations with the animation wizard, different kinds of banners, spinning images, and interlaced images. A transparent image is prepared by making one colour transparent to the web browser. This colour is then re-

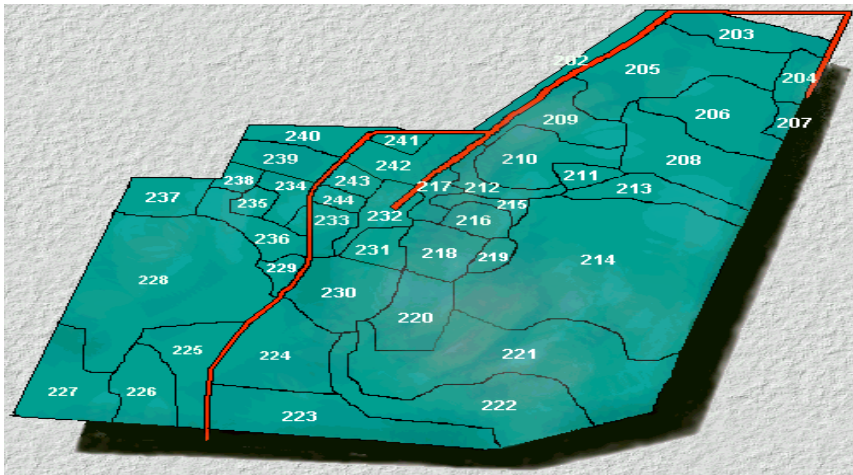


Figure 4. A Client Side Image map prepared with the Mapedit software. Clicking a stand opens the first page of this stand.

placed with the background colour or background image of the HTML document. When an interlaced image is loaded to the web browser the picture is drawn line by line on the screen. Images must be in the GIF format if one wants to edit them with the GIF Construction Set. We compiled all the animations and majority of the pictures with this software.

3 Conclusions

Our trial can be regarded as the starting point of a continuous development work. The multimedia product will be gradually improved, and forest owners' attitudes towards this type of plan will be tested. Our experience from multimedia was that the techniques needed for this kind of reporting are easily learned. An equally clear observation was that

there is plenty of software available for the production of forest plans in multimedia format. As the readiness and willingness of forest owners to read multimedia documents is rapidly increasing, forest planning organisations should be prepared to the production of forest plans in this format. The information content of a hypermedia plan is several times higher than with a traditional plan, and the ample visual information of the multimedia plan is often more relevant and more easily understandable to the owners than the numbers of a paper document. An additional advantage of using hypertexts is that the document can be linked with the Internet. This offers interesting possibilities to develop people's participation in the planning of public forests and in the negotiation process of group decision making.

The most tedious step in our exercise was data preparation. Very much handwork was needed to produce the output with the MONSU planning software, store it, and transform the output into visualisations, animations, etc. However, once the format and outlook of the multimedia plan has been agreed upon, it is possible to automate the production of information needed for the hypermedia plan. Some parts of the plan are constant while the others are replaced with material that the planning software produces automatically. Thus, it may be concluded that the production of a hypermedia plan can be made almost as easy as the production of traditional plans.

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Using data visualization to evaluate economic/aesthetic trade-offs in forest plantation management

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Abstract

Commercial forest plantations have long been an important component of the New Zealand economy. Increasingly, international tourism also provides significant economic benefits. In some locations the effects of forest management have come in conflict with the landscape visual quality expectations of tourists, as well as arousing considerable negative response from local residents and from New Zealanders who visit forest areas for recreational pursuits. Responsible plantation management and specific provisions of New Zealand's Resource Management Act require careful balance among economic, environmental and aesthetic effects. Computer models for projecting plantation growth and economic models that schedule harvests to optimize net monetary benefits were combined to estimate the economic benefits associated with four possible management scenarios for a multiple-stand forest site. Using a combination of GIS, analytic data visualization (SmartForest) and digital video (photographic) imaging tools, visualizations were created for each of the four management scenarios. Visualizations were incorporated into a perceptual survey experiment to be presented over the WWW. Participants in the experimental survey are presented with visualizations in pairs, and record preferences on the basis of "perceived scenic quality." Subsequently the same respondents see composite visualizations along with printed information about the economic effects of each alternative and indicate which alternatives provide the best "overall outcome," considering both economic and visual aesthetic factors. Results

to date confirm the potential for integrating forest growth and economic models with data visualization techniques to obtain valid measures of public preferences for alternative management alternatives. The perceptual survey experiment is continuing on the WWW, with several content and procedural parameters being systematically varied and evaluated.

I Background

A successful forest industry based on intensively managed *Pinus radiata* plantations has been part of the New Zealand agricultural economy for over 30 years. Currently the 1.5 million hectares of plantation forest is the third ranking contributor to the New Zealand economy. Forest products have a market value in excess of \$2.6 billion (NZ) annually and provide employment for twenty eight thousand people. Typically, management options involve mechanical and/or chemical site preparation and planting of genetically improved seedlings, followed progressively by thinning and pruning, and then clear-fell harvesting within rotation intervals of approximately 20 to 30 years (McLaren 1993).

Forest plantations are also important to the scenic beauty of the New Zealand landscape, a key contributor to the quality of outdoor recreation experiences and to a growing tourism industry. Commercial forestry practices, especially large scale clear cutting and site preparation practices, are encountering increasing objections from tourists, recreation visitors and from more sensitive local residents, particularly in areas with high visibility and use.

The responsibilities of the commercial forest industry for visual/aesthetic value protection have been

unclear in New Zealand's past. Nevertheless, forest managers have historically forgone scheduled harvests in some visually sensitive areas or have used techniques such as landscape screening and amenity planting in an effort to mitigate visual effects and maintain desirable public relations (Lucas 1987, Moore et al. 1991, Sissons and Conway 1991, Tasman District Council 1997). The more recent dedication of the forest industry in New Zealand to the improvement of visual environmental quality can be largely attributed to the Resource Management Act (RMA, Parliament of New Zealand 1991), where aesthetic protection is specifically required. Thus, the provision of tools capable of effectively projecting and assessing the visual aesthetic consequences of alternative forestry practices is essential for the modern forest manager to aid the development of appropriate policies and practices, and presents a challenge for researchers.

The RMA controls activities such as use, development or protection of the natural and physical resources of New Zealand. The Act strongly emphasizes the investigation of the *effects* of proposed activities, rather than prescribing which activities shall or shall not be allowed. It includes the ethnic philosophy of *Kaitiakitanga* – the exercise of guardianship of the land and, in re-

lation to a resource, includes the ethic of stewardship based on the nature of the resource itself. In addition to consideration of effects, any mitigation efforts must be communicated clearly among the forest operator, regulatory authorities and other interested parties.

The reasons for public objections to commercial forestry practices are diverse and complex, but visual impacts are a substantial contributor (Kilvert and Hartsough 1993). Abrupt alterations of scenic environmental settings (Thompson and Weston 1994) may pose direct threats to tourist and recreation industries, as well as residents' environmental quality expectations. In addition, visual effects often precipitate public concern for other potential environmental and cultural impacts.

Generally the public are able to readily identify visual change in the landscape (Benson and Ullrich 1981, Swaffield 1994, Kilvert 1995a, 1995b) and visual images are considered an excellent and valid medium for communicating the effects of forestry operations to the public (Daniel and Boster 1976, Daniel et al. 1990, Orland 1988, 1992). The idea of using computer-generated images calibrated to known resource attributes to derive human values is not a new one. Malm et al. (1981) used image-processing techniques to develop images of air pollution plumes in the Grand Canyon (USA). Plume parameters were based on the output of numerical models of atmospheric dispersion of visible pollutants from regional sources. The images were used in surveys to determine human perceptions and evaluations

of the scenic impacts predicted for an array of air pollution scenarios potentially affecting views in the Canyon. This study established the effectiveness of computer imaging techniques, but used computing resources beyond the means of typical natural resource agencies. Subsequent studies have developed and used techniques available on more widely available personal computer platforms. Examples in the forestry context include Baker and Rabin's (1988) study of the visual effects of limb rust damage, the Orland et al. (1993) study of the impacts of bark beetle damage and silvicultural prescriptions in high-elevation spruce forests, Orland, Daniel and Haider's (1994) application to the visualisation of forest harvesting alternatives in Northern Ontario (Canada), and visualizations of alternative commercial forest management practices in New Zealand (Thorn et al. 1997).

The above and additional studies have shown the effectiveness of computer visualizations for representing the visual implications of natural and management-induced changes in forest landscapes. When these visualizations are incorporated into carefully designed perceptual survey procedures, quantitative measures of public preferences for alternative future forest conditions can be obtained. Critical to the reliability and validity of these measures of public perception and preference are 1) accurate projection of the visually relevant bio-physical changes in forest conditions associated with each studied management alternative; 2) accurate translation of projected bio-physical changes into realistic visual

representations; and 3) a survey design that employs appropriate psychometric procedures and analyses, respondent population sampling, and a relevant judgement context (e.g. Brown & Daniel 1987). Even when these criteria are met, however, the public preference indices that result only address the visual/scenic features of the alternatives considered. That is, when respondents are limited to a visual representation of the alternatives, their expressed preferences should not be taken to represent evaluations of non-visual aspects of the alternatives represented (such as environmental or economic consequences).

Forest management decisions (as all significant environmental management actions) have multiple consequences. While visual/aesthetic effects are universally recognized as important, and visualization-perceptual survey techniques have successfully addressed this environmental value dimension, a larger question is how visual effects should be “traded-off” with other important effects in the selection of environmental management alternatives. The study described here presents an initial investigation of methods to combine visualization and perceptual survey

methods with more conventional verbal survey techniques to determine how public audiences combine visual-aesthetic concerns with economic objectives in deciding the “overall” preferability of forest management alternatives. In particular, the long term value of the forest estate (expressed as present net worth) and employment related statistics (number of full-time equivalent jobs) were modeled for a set of New Zealand forest plantation management alternatives. These economic indicators are presented in conjunction with visualizations of the same alternatives to both New Zealand and international survey participants over the WWW. Participants express preferences among alternatives, based on scenic values alone and (separately) on the combination of scenic and economic effects.

2 Method

A panoramic landscape scene was chosen to represent typical forest conditions in New Zealand (Thorne et al. 1997, see Figure 1).

The selected scene was located in the Golden Downs Forest near Nelson, NZ. The terrain within the study



Figure 1. Panoramic view of study site prior to simulation/harvest.

viewshed was moderately complex, with the view extending across a rolling valley bottom then rising in the background to a steep valley side. Multiple stands of radiata and contorta pine, with a range of age classes formed the production forest cover. Forest harvesting plans for the landscape scene were developed in consultation with forest managers.

2.1 Alternative harvest scenarios

Individual scenarios for forest harvest and re-establishment were developed within constraints imposed by conventional forestry practices, including species selection, silvicultural optimisations, roading and hauler locations and ecological, riparian margin and landscape design considerations. Four different landscape management scenarios were created by varying combinations of harvest timing, cutting block shapes and sizes and site preparation and planting practices. Each scenario was developed in detail and represented by a series of maps designating which components of the scenario were to be implemented at each of 5 temporal stages. The four management scenarios were: 1) a “standard practice” (coded STD harvest sequence and pattern; 2) the standard scenario modified slightly to accommodate ecological and environmental considerations (STD-ENV), principally by leaving uncut strips along streams; 3) a variation from the standard practice (VAR) that breaks the scene up into smaller cutting blocks with less regular boundaries; and 4) a modification of the VAR

scenario to include the buffer strips along the streams for ecological and environmental considerations (coded VAR-ENV).

2.2 Modeling Future Forest Growth

The New Zealand forest industry uses sophisticated forest management decision support systems (DSS) for growth and yield predictions, valuation and estate modelling. For our study, future forest stand conditions under each of the four management scenarios were predicted using STANDPAK (Whiteside 1990), a DSS designed to model individual stand growth and yield while optimising silvicultural management alternatives. A specific silvicultural regime was determined for radiata pine (*Pinus radiata* D. Don) and for Douglas fir (*Pseudotsuga menziesii*) and held constant over the modelling exercise.

Silvicultural regimes consistent with expected future management schemes and log product classes were developed in consultation with silvicultural foresters. The radiata pine regime was specified as: plant 600–700 stems per hectare of GF25-28 tissue cultured seedlings with two pruning lifts at an age of 6–7 years to a height of 2–3 m for 350–400 selected stems and a further lift at age 8–9 to 6 m for 250 selected stems, followed by thinning to 300–350 stems/ha at 8–9 years. The Douglas fir regime was defined as planting 1 200 stems per hectare, followed by a sequence of pruning at age 11, 12 and 13 and a thinning at 17 years on

mean top height basis to 500 stems per hectare.

2.3 Determining forest estate value

To establish the changing forest value as the individual scenarios were sequentially harvested and re-established and subjected to silvicultural operations, models were developed for each of the four scenarios within the FOLPI (Forestry-Oriented Linear Programming Interpreter) estate modelling system (Garcia, 1984). This modelling system has been used in a wide range of forestry applications and has evolved in response to experience gained while assessing long-term strategic and tactical planning over a time horizon of 60-90 years (Manley et al. 1991). FOLPI analysis enables yield regulation, management strategy evaluation, processing plant scenario evaluation, investment analysis and forest valuation leading to the determination of the optimum strategy for harvest sequence and rotation length. By constraining harvest ages to comply with each landscape management scenario harvest sequence, and allowing optimisation of the subsequent rotations until the year 2055 we were able to predict the NPV (based on a 60-year modeled life) for each of the scenarios. This extended model period was needed to portray the full economic implications of the different plans, at least through two full crop rotations. A discount rate of 8 percent was used to estimate NPV associated with the time steps/stages (1996, 1998, 1999, 2008, 2012, and

2016) associated with the visualizations. The NPV may be interpreted as the “price” one would expect to pay at the indicated time for the future economic benefits (revenues minus costs, discounted at a rate of 8 %) associated with the respective management options.

The FOLPI estate model system normally uses linear programming to find an optimal management strategy, by maximising the specified objective subject to user-defined constraints. Because of our requirement to mimic the pre-determined strategies we utilised the system as a simulator by constructing four models, corresponding to the four scenarios. A separate data file was required for each, incorporating the yield tables for the existing stands and those for the stands to be established under the relevant planting plan. In each case, constraints were entered to ensure that the existing stands would be harvested at the correct time, and the appropriate areas would be replanted.

FOLPI uses the concept of the *croptype* as the basis for modeling, where a *croptype* is an aggregation of forest stands which may differ in age and time of harvest, but are regarded as uniform with respect to future silviculture, yield production and the associated streams of inputs and outputs. In this case, aggregation was not required as the *croptypes* were defined by the management units assumed under each cutting and planting plan.

Data requirements for each *croptype* (Table 1) were assembled as follows:

Table 1. Number of croptypes identified for each scenario by operation.

Scenario	Number of croptypes		
	Cut Plan croptypes	Planting plan croptypes	Total croptypes
Ec	13	18	31
Ee	13	32	45
Vi	14	26	40
Ve	14	37	51

Area

An age class distribution is required for each croptype. For croptypes represented in the cutting plan, the current area was determined from the GIS analysis used to establish the stand boundaries. Stand age was determined for the forest managers' database. The area for croptypes which represented stands to be planted in the future was set to zero.

Yield table

A yield table was derived for each current and future stand using the stand prediction model, STANDPAK (Whiteside 1990). STANDPAK generates medium to long-term predictions by simulating growth, harvest-

ing and processing on a stand basis. For this exercise, STANDPAK was used to generate yield tables, for radiata pine and Douglas fir. There was no differentiation in growth between stands of the same species. As all four scenarios assumed that the *Pinus contorta* stands would be felled and replanted to Douglas fir in the first year, a simple yield table was constructed for these stands which assumed a) a yield of half the radiata yield at the equivalent age, and b) only pulp logs produced.

Costs and labour

Labour requirements for and costs of silvicultural operations (Table 2) are generalised values for New Zealand

Table 2. Silvicultural regimes, costs and labour requirements.

Radiata pine

Age	Operation	Cost (\$/ha)	Labour (days/ha)
0	Planting (including seedlings)	960	1.2
6	Prune	300	2.5
8	Prune	350	1.9
9	Thin	160	2.2

Douglas fir

Age	Operation	Cost (\$/ha)	Labour (days/ha)
0	Planting (including seedlings)	1 100	2.0
11	Prune	400	3.4
12	Prune	360	2.4
13	Prune	300	3.1
17	Thin	180	1.6

Table 3. Expected stumpage prices by age, log grade and species.

Radiata pine prices

Age	Pruned	S1S2	S3L3	L1L2	Pulp
1 to 24	48	68	68	68	68
25 to 26	68				
27 to 28	88				
29 on	108				

Douglas fir prices

Age	Pruned	S1S2	S3L3	L1L2	Pulp
1 to 38	86	86	86	86	86
39 to 42	106				
43 on	126				

Pinus contorta prices

Age	Pruned	S1S2	S3L3	L1L2	Pulp
All	68	68	68	68	68

which in practice may vary on a regional basis in response to factors such as terrain and hindrance (Knowles et al. 1996, Hjortsø 1997, West, pers. comm.). The values used for Douglas fir regimes have been adapted from high stocking radiata pine regimes, while those used for radiata are from the low stocking regime.

Log prices

Expected stumpage prices for the five log grades (Table 3), predicted

by the STANDPAK modelling runs, were determined in consultation with the forest managers.

2.4 Economic Projection

Forest value (NPV) was generally lowest for the two “standard” scenarios during the time steps that were visualised (Table 4). This is primarily the result of the early harvest at age 20 years of the foreground stand, in contrast to the optimum harvest age for the region of 28 years.

Table 4. NPV (8 % discount rate) by scenario and time step: 1996, 1998, 1999, 2008, 2012, 2016.

Scenario	STD	STD-ENV	VAR	VAR-ENV
Year				
1996	\$5,781,647	\$5,724,136	\$5,824,358	\$5,763,977
1998	\$5,472,465	\$5,401,107	\$4,610,234	\$4,531,024
1999	\$1,775,413	\$1,687,051	\$3,595,241	\$3,506,470
2008	\$3,556,029	\$3,378,028	\$3,797,067	\$3,611,672
2012	\$1,635,826	\$1,393,594	\$5,171,178	\$4,918,482
2016	\$2,237,832	\$1,906,921	\$2,503,507	\$2,158,657

The variation scenarios resulted in somewhat greater and more stable estate values over the simulation period, which is linked to the multiple harvest of smaller stand units and the optimisation of harvest to more mature stands.

2.5 Employment opportunity

The employment factor assumed was 0.0002 FTE/m³, where FTE = Full Time Equivalent based on 235 days/year and 8 hours/day (Hjortsø 1997). Total FTE employment was computed for each of the four management scenarios.

Projected employment opportunity over the simulation period (Figure 2) is strongly linked to silvi-

cultural operation and driven by the area of treatment within the year. Thus the employment opportunities for the STD-ENV and VAR-ENV scenarios are slightly less due to reductions in harvest area through retirement of riparian margin areas and the area above an altitude of 850 m which is considered unproductive.

The similarity of the pattern of employment requirements for the two standard scenarios and for the two variation scenarios, respectively, is due to both pairs of simulations utilising the same basic harvest strategy. Comparisons with the associated “environmental” scenario for each basic plan indicate the loss of jobs due to the small riparian areas excluded from the harvest. While the differences are not large for this

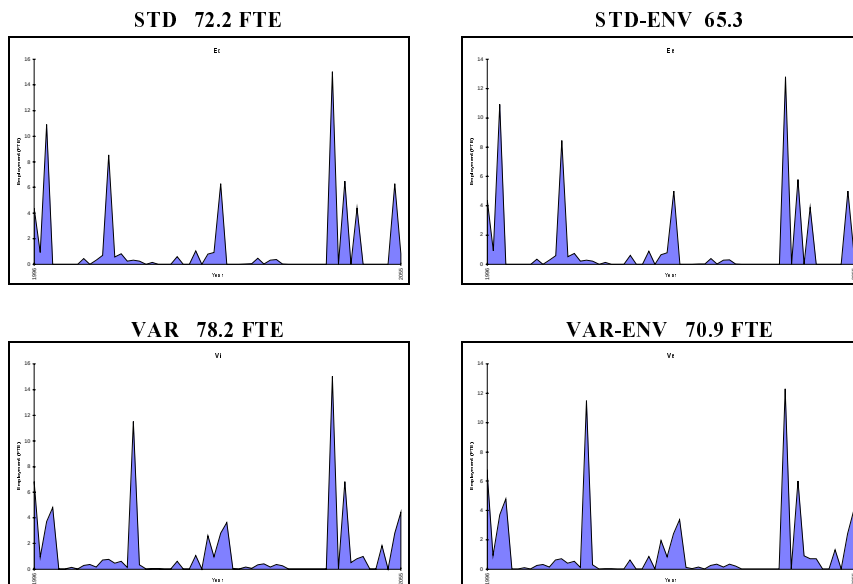


Figure 2. Projected employment opportunity 1996–2055 for alternative management scenarios.

small study area, each scenario projected an unique labour requirement for the simulation period, and the differences might be quite significant if projected for the much larger New Zealand forest estate.

2.6 Data visualisations

Each of the four harvesting plans and their respective projected future plantation conditions were mapped and entered as layers in a GIS data base. This database was used to direct the visualization process. Standard perspective view routines in GIS do not adequately display the height of “layers” of trees on the landscape so that visibility can be verified, and the thickness of linear graphical elements is such that boundaries seen at oblique angles cannot be differentiated. In our study a great number of attributes needed to be accurately represented visually, but equally significant was the interaction of those attributes in the visual display. For example, the size of a forest cutting operation cannot be separated from the forest type where it occurs, the shape and location of the cut, what is left as residual, or the amount of

regrowth after the cut. Thus, a special software system was used to create schematic analytic 3-D representations to match specifications from the scenario prescriptions and to verify the appropriate spatial relationships among the attributes to be visualized at each stage of each of the four management scenarios modeled.

SmartForest II (Orland 1994) is a landscape visualisation software package capable of displaying a schematic representation of tree density, size and homogeneity of stand composition in correct visual perspective (Figure 3). The system was designed for application to planning forest landscapes at large scale, while at the same time being able to develop specific management strategies at a small, tree-by-tree scale. Rapid display of viewsheds and the capability to move viewpoints within the “scene” data space makes the tool eminently suitable for landscape planning applications. The software requires a workstation platform and is available via the World Wide Web at <http://imlab9.landarch.uiuc.edu/SF/SF.html>.

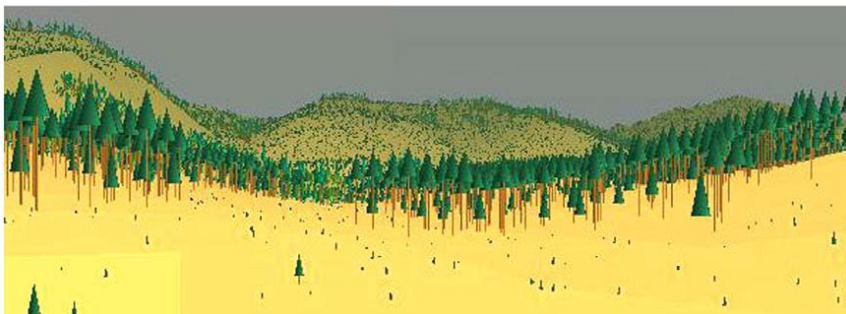


Figure 3. SmartForest II data-driven analytical visualisation for STD 1999 projection.

Source data for the SmartForest II modeling was compiled from several sources (Thorn et al. 1997). A digital elevation model (DEM) was generated from elevation data stored as contour coverages in a GIS, ARC/INFO® (ESRI, 1991) to provide topographical data for creating the landform features. Location and shape of stand boundaries for each of the landscape management scenarios were developed using TerraSoft® GIS (PCI, 1996) before being translated to ARC/INFO® stand boundary coverages. Records of the vegetation to place in each stand cell location were generated for each age class to be represented in the visualisations (0, 2, 3, 8, 10, 20 years). Growth at each stage was modeled with STANDPAK software for each management alternative.

SmartForest II is effective at showing significant structural changes in canopy configuration, such as edge conditions created in harvesting and the effects of near-view tree growth on visibility (or screening) of more distant stands. Through use of false colour, non-visible characteristics such as size class, age, species distribution and silvicultural history of trees/stands can also be shown. SmartForest II visualisations were stepped through the modeled time sequences to generate analytical simulations for each stage of all four management scenarios. The analytical simulations (Orland et al. 1997) provided geographically rectified templates to guide photo-realistic image editing. This approach provided a data driven and defensible linkage between landform, forest cover, and forest man-

agement effects displayed in the final visualization products.

2.7 Source image library

An important step toward creation of the final visualizations was to develop a library of imagery representing forest conditions (harvest, site preparation, planting, thinning, pruning and regrowth) that would be components in the visualizations. Care was taken to collect images for the library that were photographed from a similar viewpoint, aspect and distance as the selected simulation scene. During the spring of 1994 more than three thousand photos of forest conditions were collected around Golden Downs and Rai Forests near Nelson, and Whakarewarewa Forest near Rotorua.

Images were collected in the field as 35 mm color slides using a handheld Nikon 8008 with autofocus and auto exposure. The majority of photos were taken at a 50-mm focal length setting. A moderate telephoto lens of 85-mm focal length was used at times for finer detail. The film was Kodak Ektachrome Elite, a 100 ASA semi-professional colour film with good colour rendition. A polarising filter was used at all times and camera direction of view was, to the extent possible, held between 15 and 60 degrees of a line directly opposing sun bearing. These latter two measures were to maximise colour saturation. Three hundred images were selected from the entire set based on an appraisal of image quality as well as suitability for filling the experimental design requirements. These source images were trans-

ferred to Photo-CD format using commercial processing by Kodak. Source images were stored at a resolution of 768 x 512 pixels with 24-bit colour depth, a compromise between quality needed and the size and concomitant complexity of the large image database. All images underwent histogram equalisation to achieve the best consistent contrast and colouration throughout the image set as it was clear at the outset that the study design would necessitate considerable image editing and the use of an extensive source image library. Adobe Photoshop™ software on Apple Macintosh computers was used for image manipulation. Orland (1988, 1993) has described the evolution of typical uses of these tools, the basic techniques, and issues of image validity and utility.

2.8 Creating calibrated images

The assembly of the final visualizations was a guided artistic process of taking appropriate image components from the source imagery files and combining them in the ini-

tial panoramic scene to fit the SmartForest II 3-D analytic templates. The templates assure geographic accuracy in the represented features, but the choice of specific image elements (instances of harvest, site preparation, etc) is largely up to the expert judgment of the visualization creators. A team of experienced Forest Research Institute and industry scientists and managers evaluated and critiqued each generation of the visualizations. Indicated modifications were then made and the revised visualizations were re-evaluated. This process was repeated until acceptable representations of the four management scenarios were achieved (Figure 4).

2.9 Validating visualizations

An important component of the New Zealand studies was to validate the visualization process by monitoring the progress of harvest and other management actions actually implemented. The planned approach was to implement one of the simulated management alternatives and then compare actual photographs taken at



VAR 1999

Figure 4. Example of photo-realistic visualization.

the end of each stage of operations to the projected visualizations of those same stages. In the end, because of business and other practical considerations the management procedures implemented and the temporal staging did not exactly match any of the simulated plans. However, as Figure 5 shows, the visualizations of projected conditions are clearly comparable to the actual conditions. Comparisons will continue in future years, but the indication is that the visualizations created to represent the four management alternatives are valid representations of actual conditions that would occur if those plans were implemented on the study site.

In the final visualizations, each management scenario was represented by a set of six panoramic images. The first image showed the projected effects immediately after the initial operations on the study site (modeled as 1996) followed by representations of forest conditions projected for subsequent stages at years 1998, 1999, 2008, and 2012. The final stage (2016) showed full canopy closure over the scene, with distinc-

tions among the regrown stands visible only as subtle texture differences.

2.10 Perceptual survey experiment design

The visualizations and the economic data for each of the four scenarios will be combined into a three-part perceptual survey. In the first part participants are presented with pairs of individual panorama scenes and are instructed to choose the scene that they judge to provide the “best scenic quality.” Pairs always contrast two management scenarios, each at the same stage of their respective management plans. In the second part of the experimental survey each management alternative is represented by a five-scene set, as illustrated in Figure 6.

In this second part of the survey experiment participants choose the member of each pair that provides the “best overall scenic quality,” considering all represented stages of management. In the final part of the survey, the same four scene sets are presented again, but with the appro-



Actual Photograph of New Zealand Study Site 1998

Figure 5. Actual conditions for the study scene in 1998 (digitized).

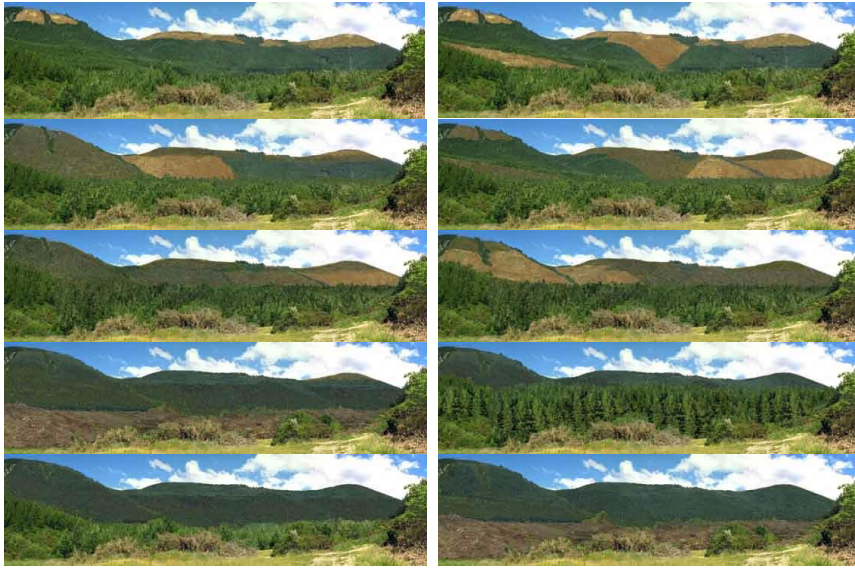


Figure 6. Example of paired five-scene sets.

appropriate economic data (present net worth calculated for 1998 and/or total FTE jobs over the model period) printed under each alternative. Participants are instructed to choose the member of each pair that provides the “best overall results, taking both scenic quality and economic benefits into consideration.”

The introduction to the experimental survey briefly reviews key aspects of New Zealand forestry, emphasizing that coniferous trees (“pines”) are “exotic” species that are typically grown in commercial plantations for the purpose of producing material for wood and paper products. The importance of forest plantations to the New Zealand economy is noted, as well as the role of the plantation forests as a significant scenic component of the landscape. It is

explained that New Zealand law requires the management and harvest of forest plantations to take a number of environmental and social effects into consideration. In particular effects on visual aesthetics, an important contributor to quality of experience for tourists and for New Zealand residents who live or recreate in the vicinity of these plantations, must be considered.

The background instructions also point out that economic and environmental effects of forest management are typically measured and controlled by appropriate scientific and technical analyses, but that the scenic quality component requires the participation of people like themselves. Respondents are told that the judgments that they make in the survey will be very helpful in identify-

ing what visual effects of plantation forest management are the most (and least) preferred by people who view these landscapes. It is emphasized in these components of the survey that respondents should only consider the scenic quality differences among the alternatives presented, as the other factors were being assessed by other methods.

Immediately before the third and final part of the experimental survey participants are told that we needed their help in determining the best “combination of visual and economic effects.” They are instructed that, unlike the earlier parts of the questionnaire, they should consider both scenic and economic effects of each alternative and choose that alternative that achieves the “best balance” of effects.

2.1.1 Status of perceptual survey

The perceptual survey is being implemented as a continuous experiment on the WWW at <http://ag.arizona.edu/EPLab/>. The goal is to sample participants from throughout New Zealand, as well as interested individuals elsewhere in the world – with the latter assumed to represent potential international tourists who might visit the country and see the results of the forest plantation management practices similar to those represented in this study. Readers are invited to review the survey, and the full set of visualizations at the address shown above.

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Implementing SmartForest forest visualization tool on PC environment

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Abstract

A forest visualization tool can be implemented on a large scale only when it can be integrated with other forest planning systems such as growth simulators, GIS, etc. Since the forest management systems in Finland are mainly running on the PC environment, there will be a growing need for advanced PC-based forest visualization tools. Concurrently, PCs equipped with appropriate graphic accelerators are gradually achieving the efficiency needed to run advanced visualization software. The Forest Visualization Laboratory at the University of Helsinki has an ongoing project intended to convert SmartForest, originally developed at the Imaging Systems Laboratory, University of Illinois, to the PC environment. This paper describes the PC version of SmartForest and the process of converting UNIX-based into PC-based SmartForest.

I Introduction

The capacity to apply data visualization in forestry is improving rapidly. Escalation in computing power, development of computer graphics and image editing tools enables construction of forest visualization or even virtual forest with sufficient fidelity has been brought within the constraints of almost any university

research project or commercial application. Today, personal computers (PCs) equipped with appropriate graphic accelerators are gradually achieving the efficiency needed to run advanced visualization software. As the graphic performance of PCs accelerates, it is obvious that more complicated forest visualization systems, even virtual reality (VR) solutions, will be integrated with exist-

ing forest management tools and spatial databases.

The potential of applying data visualization to various forest management tasks has already been demonstrated in numerous papers. Forest visualization can play an important role in assessing the effects of pests (Orland et al. 1990), evaluating the visual effects of various forest harvest practices (Heasley & McNamara 1990, Orland et al. 1992, Thuresson et al. 1996), judging the visual quality of the landscape, assisting wood procurement managers in industry to buy stands that meet market needs (Uusitalo et al. 1997). As stated earlier (Uusitalo et al. 1997) a forest visualization tool can be implemented on a large scale only when it can be integrated with other forest planning systems such as growth simulators, GIS, etc. Since the forest management systems in Finland are mainly running on the PC environment, there will be a growing need for advanced PC-based forest visualization tools.

SmartForest, developed at the Imaging Systems Laboratory, University of Illinois, meets the requirements needed for an advanced forest visualization tool in many respects. The user can view forest areas from any user-defined location, “walk” between the trees, assess the visual character of the forest with realistic tree and ground textures and interact with the underlying data. SmartForest, written in C and using OpenGL library and X-windows was originally been developed for use only in computers using the UNIX operating system. The program and its origins are described elsewhere

(Orland 1994, Uusitalo, Orland et al. 1997). This paper describes the PC version of SmartForest and the process of converting UNIX-based into PC-based SmartForest.

2 SmartForest features

SmartForest enables a variety of ways to move in a forest setting. In most cases the user moves the cursor within the view while holding different mouse buttons to achieve longitudinal, rotational, and vertical movement. Having reached a new position, each of the location and height parameters can be adjusted further by either more keyboard input or by dragging slide bars. The location may also be defined by a separate map window (Figure 1) by clicking the desired viewing point. The map window, overlaid either by shaded relief or stand polygons, facilitates a quick and easy orientation to the forest by showing the location and the direction of view with an arrow-like indicator.

To enhance interaction speed, a number of compromises have been made. First, the program displays a reduced number of trees while moving. On ceasing movement the remaining trees are drawn. Another means of enhancing interaction speed is to reduce the “horizon” in the image. A less extensive landscape will draw more rapidly, allowing faster interaction until a point of interest is reached at which time the horizon can be extended to give a complete landscape-scale view.

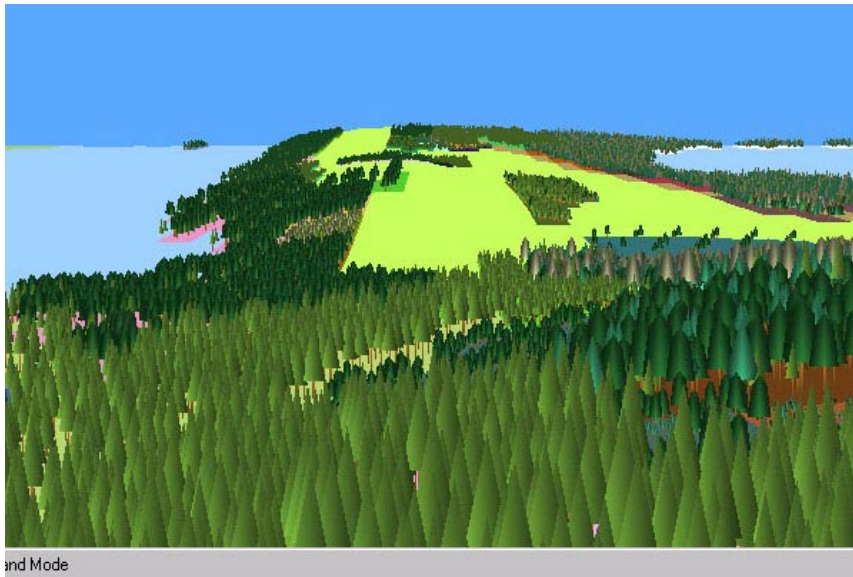


Fig. 1. The SmartForest Management mode. Trees are presented as simplified icons to facilitate quick analyses.

SmartForest comprises two different modes: management mode and landscape mode. Management mode is a simplified presentation of the real forest conditions that helps the manager quickly and efficiently query and analyze the various characteristics of the forest stands and single trees (Fig. 1). Reduction of the realism enhances the moving capabilities, speeds the analyses and enables the user to observe detailed information about large forest areas at one view. Landscape mode is a realistic one-view presentation of the real world. Trees are presented as texture-mapped objects and the ground is wrapped with realistic 2-D ground images. Landscape mode facilitates the evaluation of the visual effects of different forest harvest practices.

The desire for realism reduces the speed, which however should not be a problem, since landscape analysis is usually restricted to a couple of crucial viewpoints (Fig. 2.)

SmartForest can be used to visually classify trees according to many different tree characteristics. This color-classification enables the manager to efficiently envision the especially advantageous characteristics of a stand or forest holding. For procurement officers and mill-owners these features may be critical in determining the feasibility of particular purchasing or harvesting plans.

The strength of SmartForest lies in its capability for providing a tool for several types of forest management task. One of the major recent developments has been improvement



Fig. 2. The SmartForest Landscape mode. Trees are presented as texture-mapped objects and ground is wrapped with realistic ground textures.

of texture mapping, allowing for better landscape management. The program is now able to vary ground textures by site type. Moreover, to eliminate graininess of the ground textures appearing in front of the viewer, the size of the texture maps of each 30 x 30 m grid has had to increase to 512 x 512 pixels. This has, of course, markedly increased the response times, causing a lot of frustration with large horizon views. One way of speeding up the response times may be using the same texture map with different pixel sizes depending on the distance between viewpoint and each texture map. In any case, the latest improvements have markedly increased the fidelity of views, facilitating judgement of the visual quality of landscape.

3 System development tools

The SmartForest system comprises three types of program element:

- Graphical user interface programmed in Microsoft Visual C++
- Routines for file operations, navigation and visualization written in C
- 3D graphics by OpenGL

Microsoft Visual C++ is one of the most popular development environments for 32-bit Windows platforms (Win32), including Windows NT and Windows 95. Writing applications with the Visual C++ system is based on the Microsoft Foundation Class

Library (MFC) and on several fully integrated Windows-hosted development tools such as wizards and resource editors. The class library is a set of C++ classes that make up an application framework by encapsulating a large portion of the Win32 application programming interface (API). The Visual C++ tools enable programmers to visually design resource-based user interface elements and to easily connect these elements to code.

The message handlers of the application framework make calls to functions for navigation, visualization and file handling. All these functions are implemented in C since most of them have been ported from the original Unix-based version of SmartForest written in standard C language.

SmartForest is an OpenGL application. That is, SmartForest uses the OpenGL graphics and modeling library to draw a 3D forest environment. OpenGL is an industry standard 3D graphics API developed and optimized by Silicon Graphics, Inc. (SGI), and supported and further developed by many vendors, including Microsoft, IBM and Digital. OpenGL contains approximately 120 commands and functions that are used to draw graphics primitives such as points, lines and polygons in three dimensions. In addition, OpenGL supports lighting, shading, texture mapping and other special effects such as blending and fog. OpenGL is used for a variety of purposes, from CAD engineering and architectural applications to highly complex flight simulators.

4 Conversion process

The process of porting SmartForest from a Unix platform into the PC/Windows environment was facilitated by two important facts. First, the Unix version is written in C, an extremely portable programming language compatible with most environments for Windows development, including C++ and 4GLs ('fourth-generation languages') like Delphi and Visual Basic. Second, the original source code consists of several separate modules each of which is responsible for a certain task such as reading data inputs, navigating through the forest and drawing the scene as texture-mapped. This modular structure made it much easier to understand and reuse the code.

The conversion process was started by building an SDI (Single Document Interface) shell application with AppWizard, a code generator included in Visual C++. Though the skeleton application created by AppWizard is a full-fledged Windows program, it does not automatically support OpenGL graphics. In order to run OpenGL under Windows, the initial AppWizard shell application had to be provided with the mechanisms that associate OpenGL drawing commands to a Windows window (rendering context, pixel format, etc.).

In the second phase, the code for handling information inputs (an elevation map file, a stand file and tree list files) and initializing data structures was customized for the PC environment. Each relevant source

code file was examined row by row and all the bugs and illogicalities discovered were fixed, and the X-Windows/Motif-related code blocks were eliminated or replaced with Windows-specific code. At the same time, the code was generally refined by improving the support for handling anomalous situations, known as 'exceptions', and by building procedures for processing program arguments.

Since the X-Window System differs completely from MS Windows, the whole graphical user interface of SmartForest had to be reconstructed for the PC environment. In the PC version, the Forest Window, the main window of SmartForest, is a normal frame window created by AppWizard while all the other windows, including the Map Window and the Control Panel Window, are either modal or modeless dialogs. Unlike the Unix version, dialog boxes, menus, icons, strings and other UI components are not created programmatically during the execution of the SmartForest PC version but are all resources loaded from the executable file into the memory only when those components are used for the first time. Using resources saves system memory, simplifies the maintenance of the program and helps develop different language versions from the program.

In the final phase of the conversion process, the functions for building a 3D forest scene and handling user interactions (e.g. sliding the mouse to move through the forest) were cleaned and localized into PC architecture and then linked together with the rest of the application. The result of the linkage was the pilot

version of SmartForest that runs on both the Windows NT and Windows 95 operating systems.

5 PC vs. Unix in speed

After the initial tests, all the presumptions that the PC runs advanced visualization software in efficiently have to be revised. The PC version seems to be even faster than its predecessor written for Unix although some code has been reprogrammed more efficiently. Response times with texture-mapped forest seem to be basically dependent on the quality of the graphic accelerator and texture buffer. Tests with a typical PC with a P233 MMX processor, 64 Mb RAM and Matrox Mystique graphic accelerator with OpenGL support provided response times equal to the cheapest UNIX-computers with support for texture mapping, but 10–100 times faster than to similar class UNIX-computers without support for texture mapping. In a typical case rendering the forest with our P233-equipped PC varies from a couple of seconds (horizon 3 %) to some minutes (horizon 100 %).

6 Conclusions

Although new technologies are capable of bringing forest visualization or even virtual forest applications onto forest managers' desks, there are still several obstacles to be removed. We still have insufficient knowledge about the advantages and

disadvantages that the use of these advanced technologies could provide. Consequently, proper validity and utility analyses of forest visualization should follow development of forest visualization techniques. This will give us further vital feedback for future development.

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Managing scenic resources: modelling natural landscape preferences

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Abstract

As scenic resources worldwide are depleted, it is necessary to find ways to protect, manage and enhance those areas which remain. In order to prevent further loss, methods of minimising negative change and enhancing already degraded landscapes must be found. It is therefore critical to know how to quantify “scenic” and how the general public perceives these landscapes.

One approach to this problem is to produce a mathematical model which can predict the general public’s preferences for a number of landscapes. This paper will chronicle the creation of such a model, from the collection of preference data for a known set of landscapes, the analysis of those landscapes, to the testing of the model and its application to a hypothetical change in landscape.

Keywords: landscape, preference, scenic, Scotland

I Introduction

This work is part of a PhD project into techniques for natural landscape evaluation; the aim of this project is to produce a planning aid to assist those wishing to alter the landscape, or study its change, to do so in a manner sensitive to the perceived scenic qualities of the landscape. Such an aid would help in monitoring the scenic and cultural qualities

of the landscape in both the present and the future with respect to potentially deleterious landscape changes.

If a landscape is to be altered, it is important to be able to visualise that change and model how a negative affect can be minimised to alleviate a decline in the scenic quality of the landscape. If the general public’s preference for landscape can be quantified, then their relative preference for a changed landscape may

also be quantified and compared. The development of a landscape scenic preference model will allow such 'scores' to be assigned.

This paper describes the creation of a predictive landscape preference model, from inception to application. Firstly, the thought process that must be gone through before any data gathering can begin, are discussed. Secondly, the methodology for data gathering is noted and alternative methods suggested. Finally, the statistical creation of the model itself is stated and discussed.

The model that will be created is based on ideas used in the work of Shafer et al. (1969); the model will be a psychophysical model: using preference data gathered from people (the psychological data) with landscape component data, objectively measured from photographs of the landscape (the physical data); and relating the former to the latter in a mathematical manner.

2 Model genesis

Before attempting to create a predictive preference model, several matters need to be considered. The rationale behind the model must be addressed, and the motives for creating the model examined. The equipment which will be required to make the model is detailed, this depends heavily on the methodology employed to undertake the survey. Finally, it is necessary to consider the samples used: both geographical locations of landscapes and the sample of respondents to be used. This paper will discuss the creation of a

preference model using the Internet to collect the initial preference data. Other methods will be only briefly mentioned.

Reference will be made to research undertaken by the author where appropriate, and details of the creation of a landscape preference model by the author will be denoted by shaded text boxes.

2.1 Equipment required

The equipment needed to create a landscape preference model is detailed below:

- Camera (SLR or 35 mm film compact camera with 35 mm or 50 mm focal length)
- Scanner (capable of 200 dpi (dots per inch))
- Alternatively Digital Camera (capable of 640 by 480 resolution and 16 bit colour)
- Computer (any platform) with suitable graphics and text editing packages
- WWW Server
- Geographical Information System (GIS) (optional)

It is important to use the same equipment throughout the gathering of the photographs and the graphic editing. If print film is used, the same brand must be used throughout the research; the same or similar cameras should be used throughout and the focal length and field of depth settings should on no account be altered. Software drivers, for example on the scanner, should remain identical, even if faster, more efficient products become available.

2.2 Model rationale

Before starting any fieldwork or analysis it is necessary to determine why the model is needed. If it is for a specific purpose then it may require a selection of landscapes tailored to that purpose, for example, the model may be required to assess changes to fairly low elevation agricultural landscapes, in which case mountain scenes are not relevant to the study.

Alternatively, the model may be used generically for a wide range of landscape types, in which case there should be as wide a geographical range as possible. In this case, the width of this region needs to be determined; in terms of Scotland, is just Grampian large enough, or is the whole country required? Is the model looking at a specific type of Scottish landscape, such as arable farms within the Grampian region? Once these questions have been answered, the geographical region within which photographs can be taken can be defined.

The model was required to be generic to the Scottish landscape, therefore requiring samples to be taken throughout the country. The map below (Figure 1) demonstrates where these sites were in Scotland.

2.3 Respondent sample

As well as determining the type of landscapes needed, the sample needs to be considered. Is the survey going to look at the preferences of the people within the region used, or will a world-wide sample suffice. If the sample is required to be representative of the general public, rather than

the general 'Internet public', it may be more beneficial to use a traditional paper-based questionnaire instead of an Internet based survey.

As this research focuses on methodology rather than the model output, it was decided that a world-wide Internet sample would suffice. It was accepted that this sample would not be representative of the general public. The Internet general public differs from the standard general public in several ways: age groups and gender ratios are particular examples. It should also be remembered that occupations will differ significantly between the two groups, and that certain socio-demographic classes will be over-represented.

Figure 2 illustrates the geographic areas from which responses were gained.

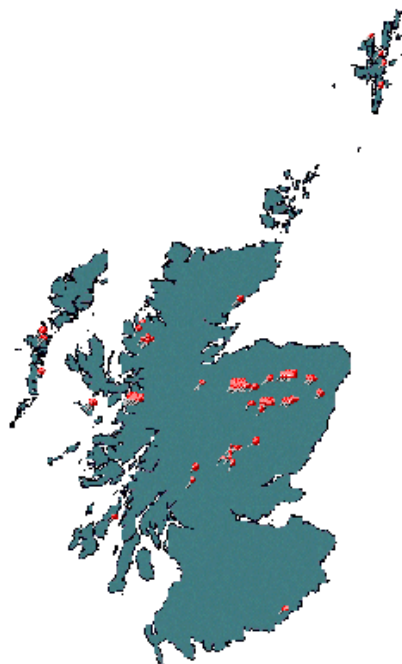


Figure 1. Map of sites in Scotland.

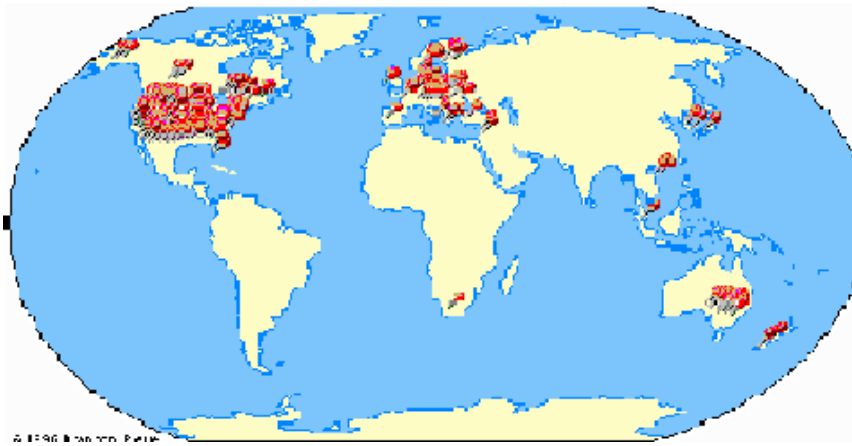


Figure 2. Geographical location of respondents.

3 Data collection: landscapes

3.1 Landscape component variables

Depending on the types of landscape chosen, there are many possible variables which may be used. Area and perimeter measurements of landscape components are often used, and may be combined with different distance zones (immediate, intermediate and distant). There are many references which may be consulted for information on uses of different variables: Linton 1968, Shafer et al. 1969, Morisawa 1971, Crofts 1975, Propst and Buhyoff 1980, Brush 1981, Patsfall et al. 1984, Kaplan et al. 1989, Bishop and Hulse 1994, Buhyoff et al. 1994, Hammitt et al.

1994, Orland et al. 1995, Wherrett 1997a, 1998.

Commonly used tangible variables include vegetation and non-vegetation (Shafer et al. 1969), flat, low hill, steep hill and mountain landform (Linton 1968, Brush 1981), obscuring vegetation (Hammitt et al. 1994) or visible land (Propst and Buhyoff 1980), sky (Propst and Buhyoff 1980, Hammitt et al. 1994) and water, which may be divided into different types, such as still, sea and moving (Wherrett 1997a). Colour variables may also be measured, in terms of red, green and blue bands (Propst and Buhyoff 1980). Intangible variables may include mystery, coherence and complexity (Kaplan et al. 1989, Orland et al. 1995, Wherrett 1998).

The variables chosen to be examined were:

- Landform Variables (see Figure 3): Area and Perimeter:
 - Flat landform
 - Low Hill landform
 - Steep Hill landform
 - Mountainous landform
 - Obscuring vegetation
- Sky and Water Variables (see Figure 3): Area and Perimeter:
 - Sky
 - Water
 - Moving Water
 - Still Water
 - Sea Water
- Colour Variables: Mean and Standard Deviation:
 - Red
 - Green
 - Blue
- Complexity Variable: Bytes per pixel in GIF image
- Coherence Variable: Number of polygons in each image over 1 % of the total area

3.2 Landscape photographs

Once the geographical region and variables have been set, the photographs can be collected. Depending on the rationale of the exercise, these can be collected during different seasons and weather conditions, or can be collected in identical weather conditions. It should be noted that it is almost impossible to collect photographs in identical conditions in countries such as Scotland, due to the unpredictability of the climate.

The photographs collected should display a wide range of the variables chosen. It is therefore necessary to collect more photographs than re-

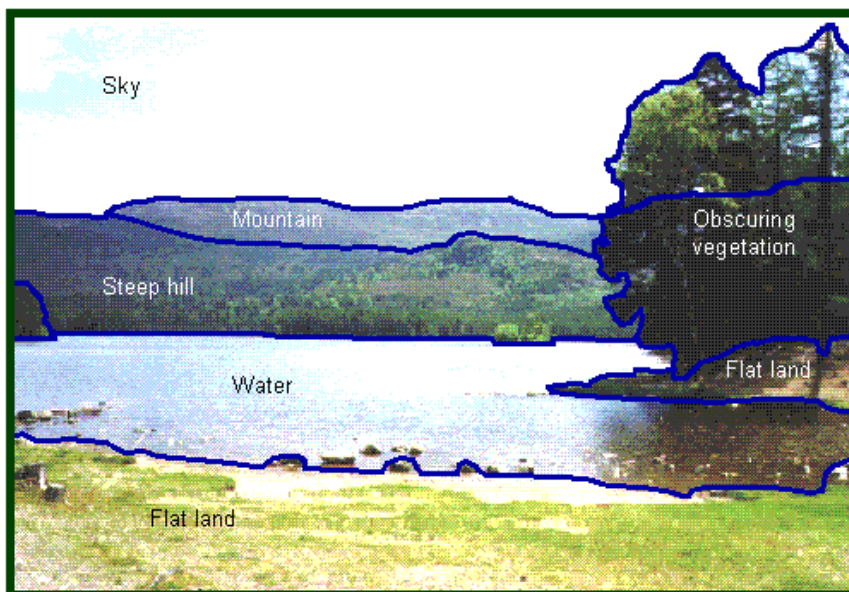


Figure 3. Example of digitised image with landform variables.

quired, in order to be able to choose the most suitable images for the survey. It may therefore be possible at this time to set aside a collection of images to be used to validate the model created in Step Seven. If a film camera is being used, care should be taken to use identical film throughout and have the photographs processed by the same company. If a digital camera is being used, the settings should be chosen before any photographs are taken and should not be changed afterwards.

The images require to be input to the computer, either through direct download or scanning. If scanning is required, images should be scanned at the highest possible resolution, depending on the availability of storage space; 200 dpi is considered the minimum resolution useable. Once the images have been stored, they must be manipulated by the graphics package. All images should be of an equal size ratio (length to width) and may therefore require some cropping to remove any accidental items (such as fingers). The images should then be saved in GIF87 format for transfer to HTML documents.

Photographs were taken over a number of years, in a variety of seasonal and weather conditions, using a Nikon 35mm Automatic camera and Kodak film and developed at the same branch of a major photographic company. Ninety of these images were then chosen for use in the survey.

The photographs were then scanned at 200 dpi and manipulated to be of the same length-width ratio.

3.3 Validation survey photographs

If no useable photographs remain from the initial photograph collection, a second, smaller set of photographs will need to be collected. These should ideally be from slightly different sites than the original photographs. The same process as used previously should be used for these photographs, to ensure all external variables are kept constant.

Once the quota of responses for the original survey has been completed, the validation survey images should be swapped for the previous images. The survey will continue to collect responses as before. Respondents should not be informed of the difference.

A second, completely new, set of photographs was collected from areas of Scotland not previously represented by photographs. 36 images were then placed in an Internet survey. The survey was not, however, sent out to the general Internet public as before, but used the Macaulay Land Use Research Institute Open Day in June 1997 to collect data. Members of the academic professions and of the general public were invited into the Institute and many were able to take part in the survey.

4 Data collection: preference scores

If the rationale chosen allows the survey to be undertaken electronically, an Internet survey can now be started. Otherwise, an alternative method of survey will have to be

sought; possible suggestions include the work of Shafer et al. (1969) and Daniel and Meitner (1997) using images seen either in the field, on monitors or shown by slides. It should be noted that a traditional technique will be less environmentally friendly (i.e. require the use of paper and/or extra sets of photographs).

There are countless methods of constructing an Internet survey. One approach is to follow the work of Wherrett (1997a). The respondent is introduced to the survey and given basic instructions. They are then encouraged to practice scoring, to ensure they understand the levels of score which may be given. The technique then used is similar to the Scenic Beauty Estimation method (Hull 1986). All images are first seen by the respondent and then scored on the chosen scale; popular choices are 1 to 7 and 1 to 10.

Using HTML (hyper-text mark-up language) and a PERL (practical export and reporting language) script to return the data to the survey manager, this type of survey is simple to set-up and execute, requiring only a text editing package to write the documents. The URL (universal resource locator) of the introduction page can be submitted to search and broadcast engines, or can be sent by e-mail to a pre-determined sample.

An Internet survey was written, allowing each respondent to see 20 images. A randomising process was used to allocate respondents one of nine different sets of photographs. The URL was then sent to search engines and user groups, as well as to the Internet section of a major hardcopy newspaper. Screen snapshots of the introduction and scoring pages can be seen in Figures 4 and 5.

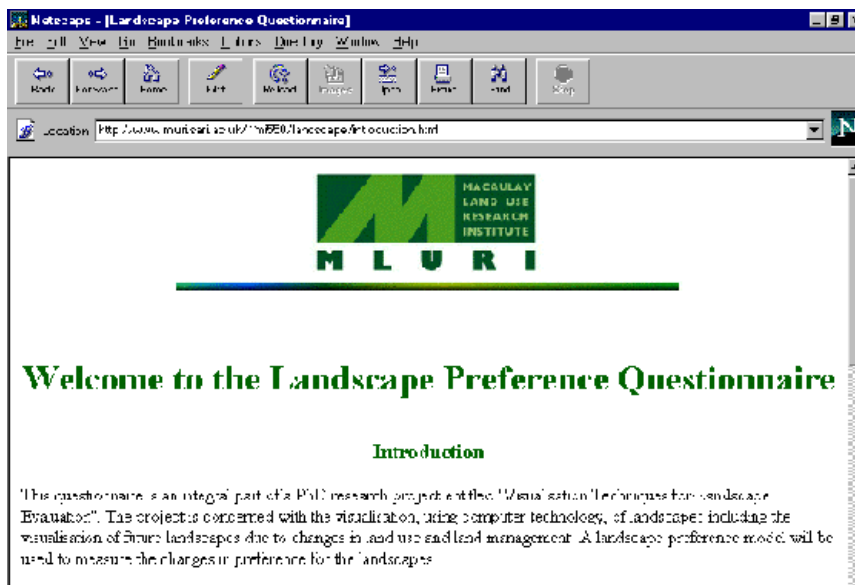


Figure 4. Example of introduction page.

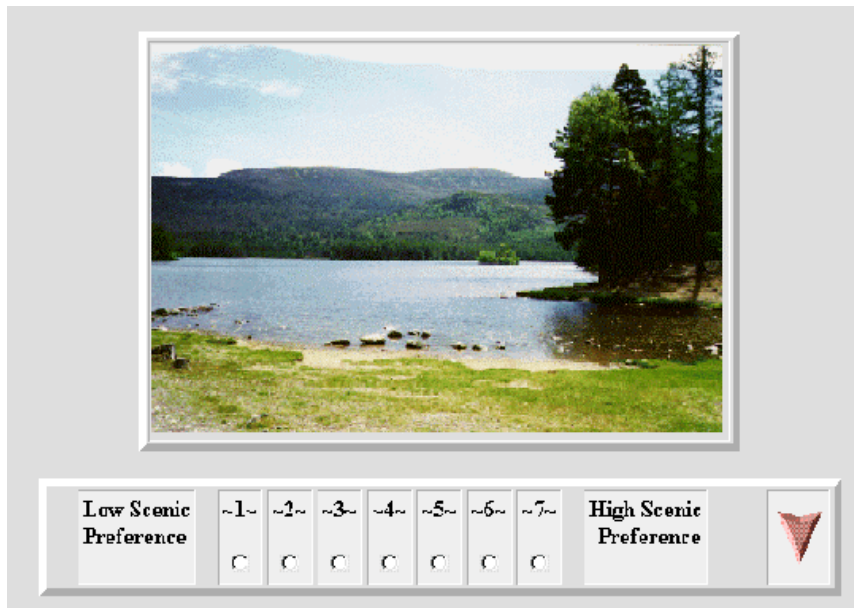


Figure 5. Example of scoring page.

5 Data analysis

5.1 Variable measurement

Whilst the survey is running on the Internet (or, if using a traditional technique, whilst associates are collecting preference data) the images may be digitised and the landscape components measured. The tangible variables being used can be measured using a GIS such as ERDAS Imagine (ERDAS 1994). All images should be re-sized to an identical size for comparability.

Areas and perimeters may be calculated using this method; results may then be transformed to any unit wished. Shafer et al. (1969) and Wherrett (1998) used units corresponding to an image of 40 by 32 and

40 by 27 units respectively. Colour means and standard deviations, if being used, may also be calculated using this software.

If intangible variables are being used, the method for measuring these will need to be defined. For example, a measure of complexity could be the size of the GIF image divided by the number of pixels in the image (Wherrett 1998). It is also possible to add other, non-natural, components. Structures such as pylons or farm buildings may be used (Tan 1997).

The variables were analysed using ERDAS Imagine. All were converted into TIFF format and thence into IMG format, at a size of 580 x 395 pixels. The chosen variables were then digitised or calculated, in

the case of colour and bytes per pixel variables. Figure 6 shows an example landscape being digitised. The measurements of areas and perimeters in pixel units were then recorded and converted to WLCUs (Wherrett's Landscape Component Units), of which there are 1080 in any photograph. Figure 7 demonstrates an example landscape being converted to WLCUs.

5.2 Analysis of preference score results

There are a variety of methods for collating preference score data. Scores may be averaged, normalised or weighted. Once this has been done, any effects caused by socio-

demographic types should be examined; for example, age and gender have been shown by some researchers to be important factors (Balling and Falk 1982, Lyons 1983, Hull and Stewart 1995).

The validation data will not require any socio-demographic analysis, although it should be compared to the original data for percentages of the various factors to ensure similar samples.

The scores from the first survey were analysed; two methods of normalising were employed – one by respondent and one by questionnaire (see the following equations). These two methods produced slightly different results and thus allowed the creation of models from both sets of results.

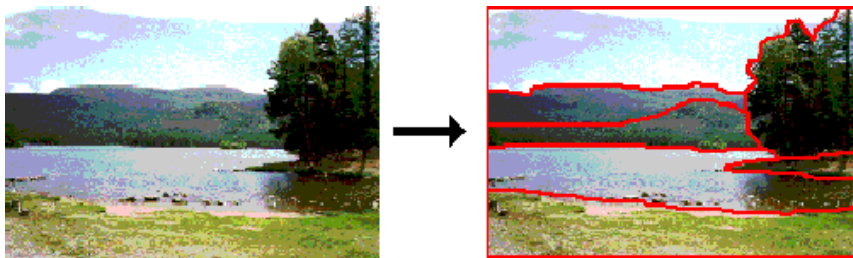


Figure 6. Animated GIF of photograph being digitised.

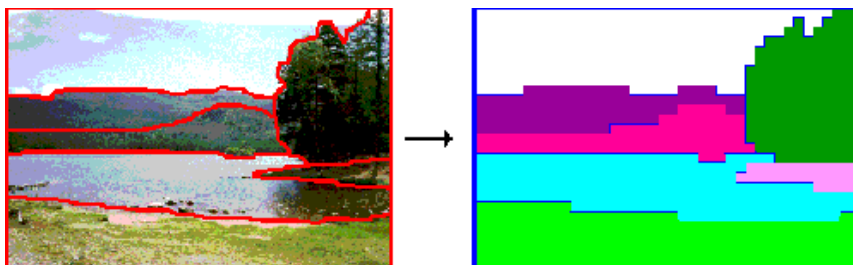


Figure 7. Animated GIF of digitised photograph being converted to WLCUs.

Normalising per questionnaire

$$\text{Score} = \sum_{\text{all questionnaires}} \frac{(\text{Photograph mean} - \text{Questionnaire mean})}{\sqrt{(\text{Count of respondents} * \text{Mean Square Error from ANOVA})}}$$

Normalising per respondent

$$\text{Score} = \sum_{\text{all respondents}} \frac{(\text{Photograph score} - \text{Respondent mean})}{\text{Respondent Standard Deviation}}$$

The socio-demographic information was analysed and none of the variables were found to be significant in determining score.

6 Model creation and validation

6.1 Multiple regression modelling

Once all landscape components have been measured and the preference data is complete, principal component factor analysis can be run on the landscape variable data to indicate which variables are most likely to be good preference predictors. As well as undertaking this for linear variables, it is wise to also use mathematical transformations and combinations of the variables, such as natural logarithms, squares and inverses; however, care must be taken to avoid any mathematical errors, such as divisions by zero.

Multiple linear regressions on the variables thus chosen will create multiple versions of models. Criteria for ideal models should therefore be set. The number of variables used should be kept low, while the regression fit should be kept as high as possible, resulting in no outliers in the residual plots. Using these and other criteria will allow the choice of a few models which may then be further examined.

Further examination includes analysis of how the model is working, which variables are acting as positive or negative predictors and if any combinations of variables are combining to become a quadratic factor.

The following example is one of the models created by this analysis.

Preference $Y = \text{Constant} - A/\text{bytes per pixel} + B * \text{red variance} - C/(\text{perimeter of mountain landform} + 1) - D/(\text{area of water} + 1) + E * \ln(\text{area of steep landform} + 1)$

where A,B,C,D and E are constants and $R^2 = 0.640$

The terms of the model can be explained in reference to their implications for landscape preference.

- The second term involves the negative inverse of bytes per pixel, which is a proxy for complexity; this term therefore states that as complexity increases, the preference becomes less negative so implying that complexity is a positive predictor for landscape preference.
- The third term states that red variance (i.e. the square of red standard deviation) is positive for landscape preference, i.e. that a wide spread of red colour in the image will improve the preference.
- The fourth term, alike the second, states that the perimeter of mountain landform is a positive landscape preference predictor, which is intuitively sensible.
- The fifth term, again involving a negative inverse of a variable, again implies a fairly obvious statement - that water is a positive landscape predictor, a result found by the majority of researchers.
- The final term, using the natural logarithm of steep landform, suggests that steep landform, as well as mountain landform, is a positive landscape preference predictor.

7.2 Model testing

The models which fit the pre-determined criteria the closest should now be tested on the preference data gathered from the validation survey. Correlations between the predicted

scores and ranks and actual scores and ranks should be calculated. If correlation coefficients above 0.6 are achieved, the model is working well.

The model detailed in section 7.1 was compared to a second set of 36 photographs, as described in section 3.3. The correlations between these two sets were 0.604 and 0.605 for the scores and ranks of the 36 images respectively. These results validate the utility of the model.

8 Example of an application

One application of a predictive landscape preference model is to give indications of how preferences for a scene might change due to a change in land use management or policy. The model may be employed to show if the aesthetic value of a landscape is more probable to increase or decrease due to a change the landscape.

The following is an example using the model previously described. The landscape shown is the area around a popular beauty spot, Loch an Eilein, near the town of Aviemore in the Scottish Highlands. In this example there is a proposed land use change, which will involve the planting of a number of tree species around the loch, as shown in Figure 8.

Figure 8 shows the loch as it is now, and a photomontage of how Loch an Eilein might look if the proposed planting strategy went ahead. The loch is completely obscured, thus removing all water from the view. As water is a positive factor in

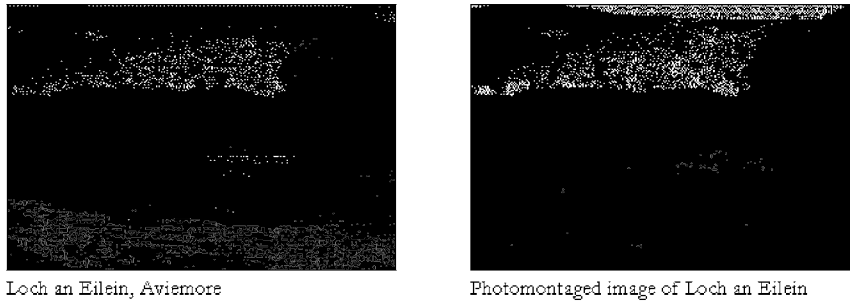


Figure 8. Loch an Eilein: before and after.

Table 1. Loch an Eilein landscape components variables.

Variable	Actual view (WLCUs)	Proposed view (WLCUs)
Bytes per pixel	540	650
Red Variance	5776	5625
Perimeter of Mountain Landform	48	52
Area of Water	214	0
Area of Steep Landform	129	33
Preference Scores	0.4353	0.1171

the predictive preference model, it is expected that this will decrease the scenic quality of this landscape.

The results from this analysis show that the preference of the general public for the proposed view is likely to be lower than that for the actual view. There would, therefore, be a presumption against the proposed change in land use, in terms of the aesthetic appeal of the landscape to the general public. As an alternative to this proposed change, another could be formulated which increased the preference score, thus increasing the scenic beauty of the area.

9 Conclusions

This paper has shown how a predictive preference model for natural scenic landscapes can be created in a straightforward and environmentally friendly manner. Such a model may be made in a number of days or over several months or even years, depending on the requirements set out in section 2.

A model created in this way could aid in aesthetic landscape planning. The methodology used to create the model is a highly flexible system, which can be easily extended to specific landscape or development

types, allowing a variety of landscapes impacts to be examined. The use of a psychophysical model which uses tangible landscape attributes allows the predictive model to be objective and able to be automated to some degree. Predictive models, such as these, will never be able to exactly determine relative landscape preference, and they do not claim to do so. They can, however, give a highly useful guide to a general level of appreciation for, or discontent with, a natural landscape.

The use of the Internet as a medium to undertake the required survey work has several advantages: the availability of a geographically wide sample of respondents; the wide accessibility of the Internet; it requires far less paper and stamps than a traditional paper-based survey; and is a highly flexible method of data collection. Correspondingly, there are also disadvantages: the sample may have a non-ideal socio-demographic profile and will be limited to those who have access to the Internet. These and further issues are discussed by Wherrett (1997a, 1997b); the Internet has a place in visual preference research, but its limitations must be remembered.

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Concluding words: “From the consul of Spain to RT ’98”

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”... Supported by an ignorance concerning the Northern regions, the Southern imagination creates at will images of Scandinavia in which people cower under blankets of snow and step out only every once in a while to take in some fresh air while at the same time smoking a cigar and having a jovial conversation with reindeers, bears and seals...”. It was a hundred years ago that Angel Ganivet, a philosopher-cum-writer and diplomat, used these and other words when writing letters from and about Finland to his friends in Granada (Ganivet; “From the consul of Spain”).

Angel Ganivet wrote numerous letters from Finland to his countrymen during the two years (1896–1897) he spent here. In the letters, the state of being a Finn took shape in what proved to be very accurate analyses of Finnish society. The contents of the letters varied from descriptions of the everyday of the liberated Finnish woman and the political situation to national customs, from swimming

in a lake in hole made in the ice to, of course, drinking and eating habits, and of course to the essence of love. A matter of special interest is Ganivet’s amazement at the enormous enthusiasm the Finns showed for the recently invented telephone. According to him, and therefore already a hundred years ago, the telephone appeared to be more common a tool in households than appropriate kitchen equipment! – But it must be noted that the telephone in those times was not a portable device.

Resource Technology 98 symposium has now been brought to its conclusion. I feel confident that the participants have found the occasion to have been both interesting and inspiring. It has been observed that the basic technologies, which have evolved during the last 10 years, have been widely applied and that the focus in development has shifted to the processing of issues one step higher in diversity than hitherto. In place of the immediate introduction of technology, we need solutions for organising and coordinating co-operation, utilisation of networks and the formulation and maintenance of functional policies.

The technological issues involved in the systematic use of natural resources and monitoring of the environment are part of research in Western countries. Scientific problem setting is dominated by the mainstreams of research policy. The sufficiency of natural resources, the impact of mankind on the environment, global processes (such as climate change, fixing of carbon and biodiversity), all these provide applicable frameworks of reference. Modern-day research means that the development of data processing systems is problem-centred. Information management is no longer merely a matter of technological solutions, but instead an important part of correct understanding of the field of phenomena being examined.

On the basis of the RT98 Symposium, it can be said that most of the current orientation options in science underscore the necessity of utilisation and development of information technologies. The subjects addressed in this symposium support the aforementioned themes. The papers presented have emphasised the needs of the producers and users of information to find new technological channels and procedures. A lot of credible solutions have been presented. It would also appear that the question of how to be able to efficiently access this information, which has bothered researchers for some decades, has reminded among the foremost subjects of thanks to the intensified exchange of information over networks. The increase in information production, the flood of information resulting from the banalization of the offering of information over networks, and support sought from the Internet by data systems

have ensured that the final solution to this relatively simple general issue is a matter for the future.

As a scientific occasion, this symposium is a success. Simply the fact that we have had representatives from twenty-six nationalities, with Brazil (the future world champion in football I guess) as the last to register, is indicative that the scientific commission of the symposium has worked well in their task of selecting the ninety papers from among those offered. The demonstration of state-of-the-art technology has further supplemented the presentations and made tangible the subjects dealt with.

The functioning of the symposium arrangements merits praise of its own. Even though we here in Finland have, indeed, become accustomed to highquality levels in conference arrangements, it should be noted in this connection, too, that these services are not possible without the organisers shared enthusiasm and the commitment by the expert executive team to the outcome of the project. I wish to congratulate each and every one of the organisers of the symposium for their co-operation. Hopefully, our guests have gained the impression that at least part of the early enthusiasm of us Finns for applying telecommunications and information technology is still alive and well. Also, it is my hope that you will all, in the manner of Ganviet, whom I cited in the beginning, be pleased to convey your feelings and sensations concerning Finland to your countrymen.

Thank you all!

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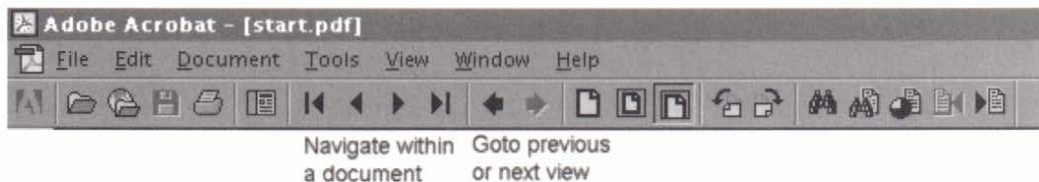
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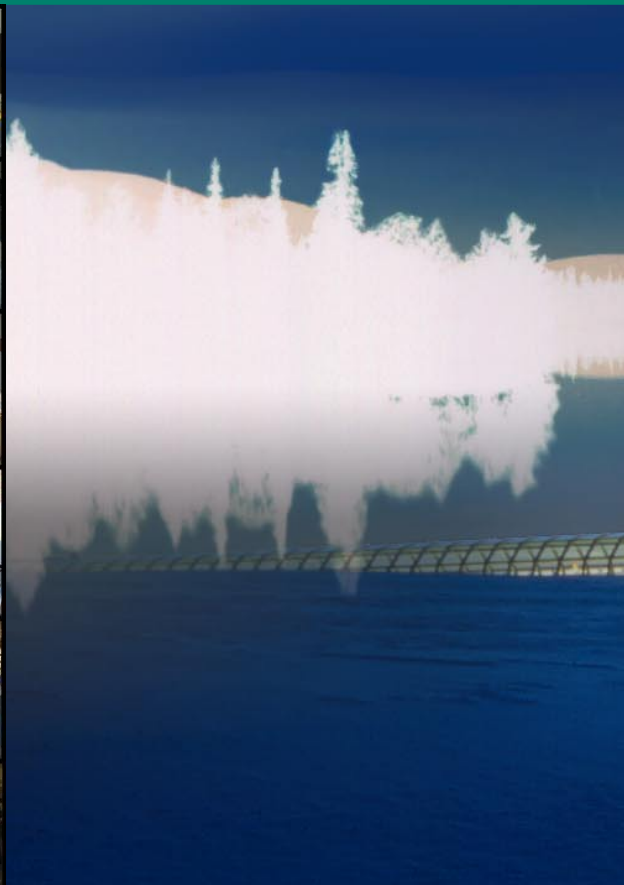
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