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Long-term Field Experiments in Forest Research

Proceedings from a NoLTFoX meeting in Scotland, 5th to 6th of June, 2008

Kristian Karlsson (ed.)

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Abstract
These proceedings are based on a meeting of researchers and data managers working with information on long-term forest field experiments within the NoLTFoX network. Six presentations from one session in the meeting form the main content of the publication. Additional short country reports (8) have been added, one for each member country in the network.

Network members from Nordic and Baltic countries have been working on a database including general descriptions of experiments according to common concepts, rules and classifications. The information has been made available on the internet at the NoLTFoX website at http://noltfox.metla.fi/.

An overview of the work and latest improvements to the database content and functionality is presented. Principles, problems and perspectives are included in the overview. The country status reports add to this information. Some outlines for the future can be found. Expansion to new countries is generally supported and suggested. One way of generating climate data for all included experiments is examined. Plans for improving the content and possible inclusion of other types of information are discussed in several articles.

Forest Research in Great Britain is a new member in this network and they have recently added a lot of information on their experiments to the database. Their forest experiments, experiences and viewpoints are presented in detail. A large project concerning field experiments has been launched in Ireland (NATFOREX). Aspects of locating, evaluting and restoring field experiments and/or related information are described as essential parts of this project consisting of five different work packages. Through this project Irish forest research will connect to the NoLTFoX network.

Most countries/organizations have relied on some kind of domestic database that they use as a base when generating NoLTFoX information. The Latvian and the Swedish 'Skogforsk' versions are presented in separate articles as examples. Some others are mentioned or presented shortly in the country status reports. The information in domestic databases is often more complex compared to NoLTFoX, but the language is often also only domestic and availability may be restricted. Data submitted for public use in NoLTFoX is more general and serves to give database end-users an overall picture of all experiment activities.

Keywords
forest research, field experiment, infrastructure, database, internet

Available at
http://www.metla.fi/julkaisut/workingpapers/2008/mwp105.htm

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Other information
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Preface

People from Nordic forest research organizations have been working on a common database with information on field experiments since the beginning of the 21st century. The work was initiated by the Nordic Forest Research Cooperation Committee (SNS), which also has been the main funding organization.

Later on, Baltic countries joined this NoLTFoX network and during the last years it has started to expand to new countries. Subsequently, the annual meeting 2008 was hosted by Forest Research (Forestry Commission, UK), the latest member in the network. Present were also representatives from Ireland, who were about to join the network as well.

The annual meeting was for the first time arranged with prepared presentations during the morning session and practical and organizational discussions during the afternoon. It was agreed that the presentations should be documented in a publication of the type "working paper". Furthermore, this publication was to include additional short overviews of the status and progress of NoLTFoX related work in each member country.

Bill Mason and Alan Harrison did an excellent job hosting this meeting at Roslin Research Station. The programme also included a guest lecture and presentations during the field excursion to the Highlands of Scotland. Once again, thanks to everyone for their efforts! This visit was certainly a rewarding experience for Nordic and Baltic network participants sharing an interest in forest experiments.

Kristian Karlsson
Network coordinator

An Overview of the NoLTFoX Database

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Introduction

At end of the 20th century research organizations in all Nordic countries were facing the same difficulties to maintain their work with long term forest field experiments. Resources were becoming scarce and experiment activities were gradually slowing down. The Nordic Forest Research Cooperation Committee (SNS) launched an action plan for Nordic cooperation to improve the situation. Activities started in the 2000 and a first version of a experiment database was launched on the internet in 2001. It was called NoLTFoX, an acronym for Nordic Long-term Forest Experiments. The technical work was made by Jukka Pöntinen at Metla in Finland.

The database was further developed and basic information added until 2003. In 2004 a new phase was started as the Baltic States were invited to participate. At the same time the task of finding experiment related literature began. Adding literature has been one major task since then and the work is still continuing. Of course, there have also been improvements to the basic information and database functionality over the years.

The last step in the development of this network cooperation could be called “expansion”. Even from the beginning there was a desire among many participants to get this cooperation network to a European level. At this meeting in Scotland we are finally taking the first real steps in this direction. Along with new members, the name of the network and database has changed from ‘Nordic’ to ‘Nordic and Baltic’ and to the present one: ‘Northern European Database of Long-term Forest Experiments’.

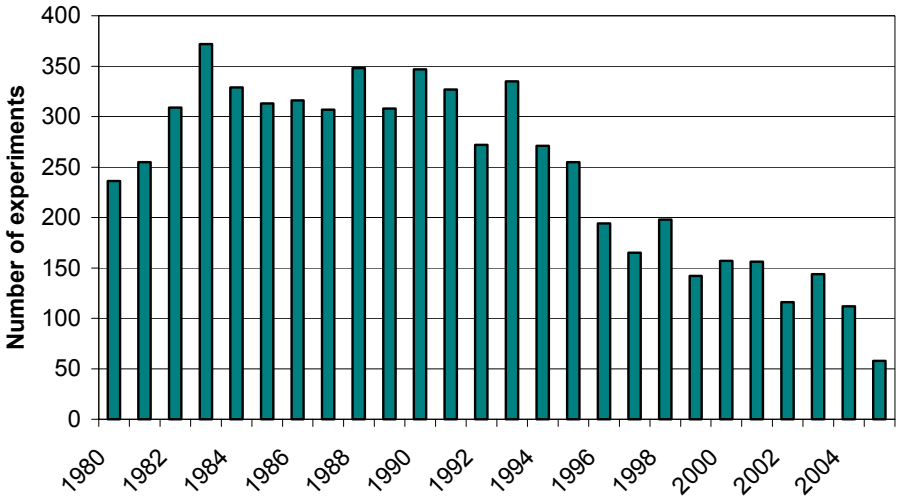

Figure 1. The number of new experiments established each year during a 25 year period according to NoLTFoX data. The decreasing trend is similar for forest research in many countries.

Structure and status

The NoLTFoX database is a metadatabase containing basic information on existing forest experiments. No actual (collected or measured) experiment data is provided. 12 variables describe experimental design and layout, 8 variables are for location and yet 6 variables contain organization and contact information. The number of active experiments is now over 11000. Each experiment is classified according to subject (research topic) and objectives. There can be more than one objective for experiments, but only one subject class. Additional information has been added with keywords, which also have been referred to as "experiment activities". They describe experimental design, type of treatment, technical solutions, measurements etc. etc.

The classification is not a strictly scientific one, organizational and practical issues have affected the chosen system as well. However, looking at the three basic variables together they should generally complete each other. A simple example:

Subject	***Stand treatment***
Objectives	***Fertilization***
Keywords	***N, P, K*** or ***nitrogen, phosphorus, potassium***

'Tree species' and 'stand establishment' (age) are also good complementary basic information. The variable 'Start of experiment' is used for the graph in figure 1.

The largest number of experiments is found for research in "Genetics and Tree Breeding" and the second largest group is for 'Stand treatment, growth and yield'.

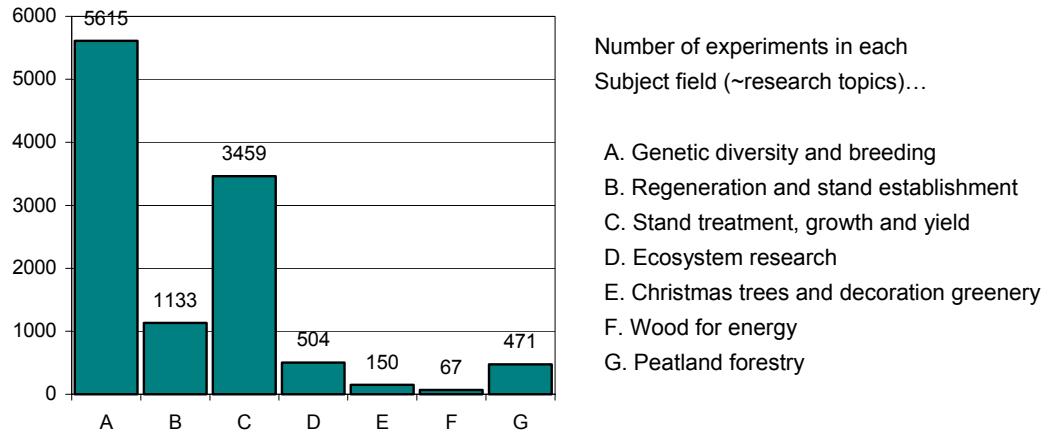

Figure 2. The distribution of experiments according to subject - the same figure is presented for each country in status reports later on in this publication.

Much more information (experiment design, data, processing and results) can be found from literature references which have been added for selected experiments. The list of references is definitely not complete for any country yet. The number of references was about 1500 in the year 2007 and close to 2000 in 2008. Almost 5000 experiments end up with one or more reference when linking references and single experiments together (figure 3).

The type of publications has not been restricted. Included are peer reviewed scientific papers, working papers & proceedings as well as popular articles. There are no links to actual papers, so database end-users need to find the papers themselves. But using the title, author etc. one can quickly find most publications in literature databases. Recent publications are often also available on the internet (abstract or complete) and can be located even with a basic internet search or through a known publisher's website.

It has been regarded far too demanding and time consuming to maintain links from the experiments within the NoLTFoX database to other sources of information, though this also has been discussed several times during the years.

Most forest research organizations have developed and maintain their own databases on forest experiments. Two examples are described further on in this publication. They often contain more information than what has been uploaded into NoLTFoX, but the languages are mostly only the domestic ones and the availability may be restricted to persons within their own organization and/ or to registered clients. Uploading the most basic information from such databases to NoLTFoX provides a general overview of all experiments activities. This information is publicly available on the internet at http://noltfox.metla.fi/.

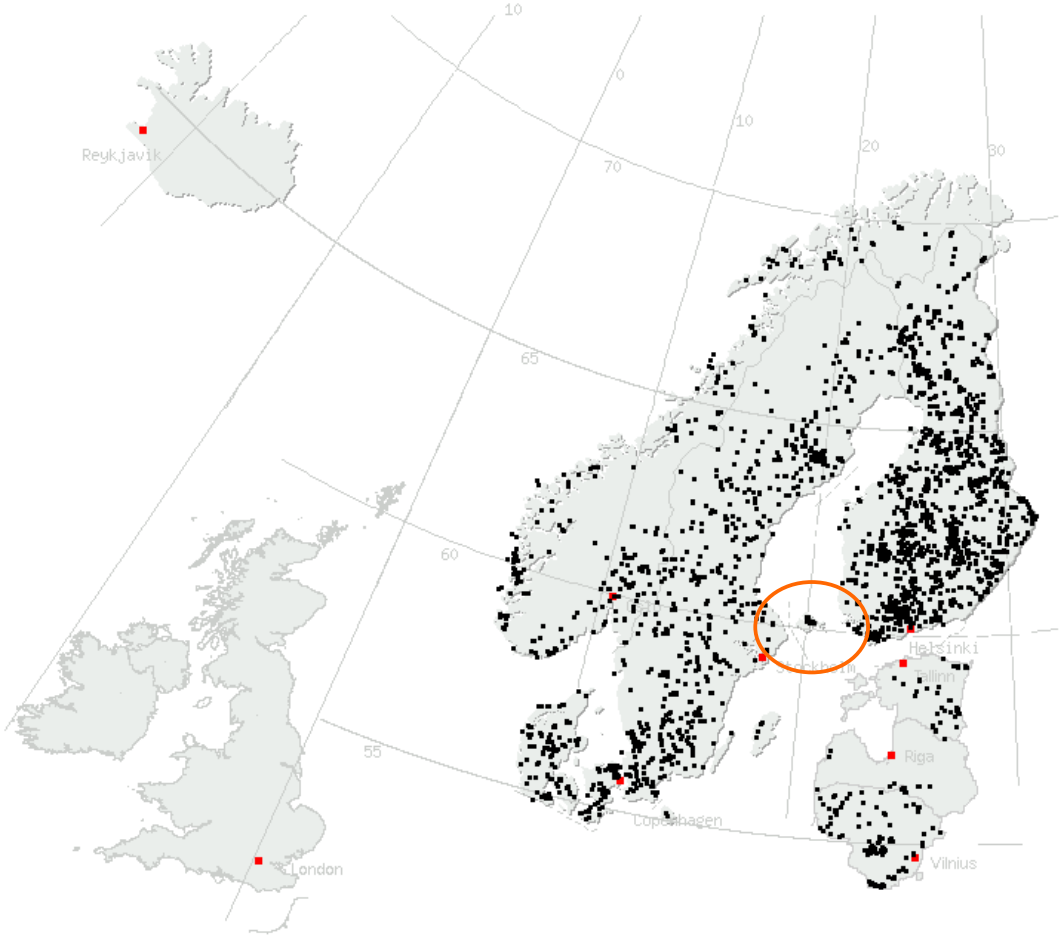

Figure 3. Locations of experiments with literature references added. Go to the NoLTFoX Search Form, and use search criteria '# of references > 0' to get this map and the additional descriptive information. The circled area in orange colour is shown in the next map.

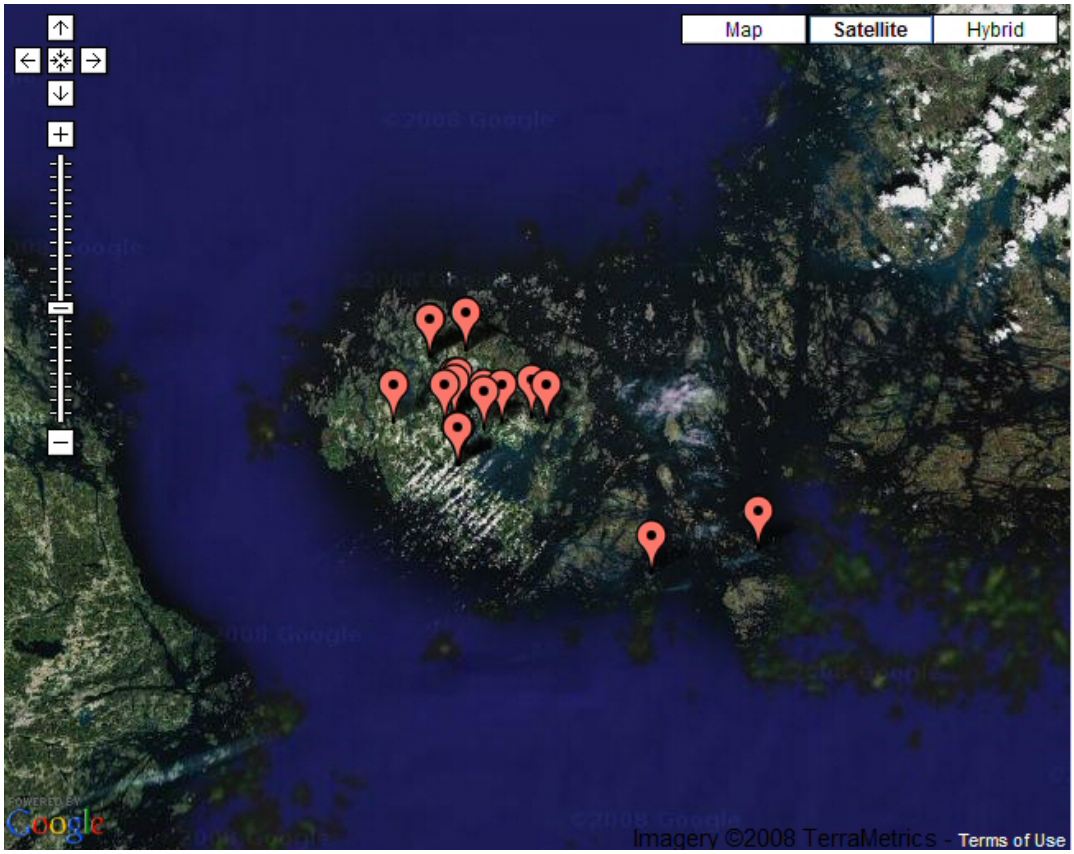

Figure 4. If you narrow down your search with other criteria (to less than 200 experiments), then you can use a Google map presentation as an alternative to the base map. A few experiments located on the Åland Islands are shown here (free text search, county = Åland). Soon we may be introducing forest experiments on the Faeroe Islands and Greenland too.

Challenges

The objective with NoLTFoX has been to develop a database with forest experiment information presented according to some common concepts and standards. The ultimate goals when doing this is to…

- increase cooperation between research organizations in different countries
- improve cost effectiveness by avoiding duplication of already existing experiments and encouraging the use of existing infrastructure and information
- achieve synergetic values by combining information from several locations, organizations and/or different research fields and approaches
- inform about the importance of experiments in general, and to describe the needs and benefits of these activities for funding and other supporting organizations in particular

The final goals are really quite demanding. Some results have been achieved, but continued efforts are needed. Back in 2003 an independent evaluation was made by three scientists. They concluded that the activities have been successful and that there is a need to continue. Furthermore, they presented some guidelines of how to proceed and what to improve. Some of those things have been taken care of but others remain as challenges.

*** More information about the end-user** and their wishes and expectation is needed in order to find the best ways to improve the database and even better meet the objectives stated.

User statistics are collected on the website and generally there has been clear and steady increase in the number of visitors. How the information is used is more difficult to determine. A user enquiry was launched on the website in 2004, but it did not render enough answers to enable analyses. This was not a big surprise, because it is a well known fact that web-enquiries are not popular.

Some feedback has been received by personal communication. One way to learn about the utilization of the database could be to take these personal contacts further and finally describe the experiences as case studies in detail.

*** Literature references have been added, but they cannot yet be accessed directly.** The only way to find references is to "manually navigate" to the end of each page in the search result.

Some people have reported problems finding and using the literature. There has probably even been some frustration, when literature has been advertised but is then not so easily found. A small drop in the user statistics concerning "the number of visitors" has been noted during the last year and this can be related such difficulties. Some search options or other tools need to be added, but they should not move the focus away from the basic experiment information. Specific and complex literature databases are available elsewhere.

*** More basic information could be added for each experiment.** Things that have been proposed are single photographs or datasheets containing experiment layout (map), descriptive data or results – or any combination of those.

The work of producing new material for all experiments can become an enormous job. It is feasible if material already exists in the organizations and/or if they can be submitted to a limited extent as examples of each research subject, or for some very important experiments. All information added should be relatively static, that is, not changing very rapidly over time. Otherwise, updating can become too demanding for many organizations to cope with. The type of information that NoLTFoX contains right now does not really call for more than maybe one update per year.

A demonstration of how to produce climate data for each experiment is presented later on in this publication. The big advantage with this kind of approach and data is that it is a small job to do and it can be done for all experiments simultaneously in one process.

*** The ultimate challenge is to add actual measured data.** There have been some requests for that already both by single scientists and funding organizations. The demand will probably increase for several reasons, one being EU regulations stating that project results (also measurements) are public. This has more or less always been the situation in the US, where government funded organization need to present their data for public use. However, adding measured data has not yet received much support among the NoLTFoX network members, partly because of the large amount of work needed, but also due to ownership issues.

Perspectives

Some of the challenges described above will be met even if NoLTFoX activities continue on a low level in the future. Other practical and technical issues will probably be raised and can be dealt with as well. Strategically it may be wise to look at potential activities within a broader context. Forest experiments are essential parts of research infrastructures. Information systems providing experiment information are that as well, and a lot of focus is put on all kinds of infrastructures right now. Within the EU seventh research framework programme (FP7) "support to existing and new infrastructures" will receive funding. This has already created similar, specific actions in many European countries, regions and organizations.

The NoLTFoX database and network could develop into a more complex information system for research infrastructures or the same could be achieved by collaboration with other existing enterprises.

NoLTFoX is dealing only with experiments. Other related infrastructures could be presented, like research stations & forests, laboratories or other facilities. Older networks (EFERN, ENFORS) have been listing this kind of resources, also research projects and personal, but they have not been able to continue actively over time. There have probably been difficulties to update the information without constantly receiving external funding. Information systems developed within the NEFIS and GFIS networks may contain technical solutions that are more cost effective (less manual processing, etc.). So this can be one way to proceed further.

The database is now covering some parts of Northern Europe. Other neighbouring countries could be included with relatively small changes to the database. However, if a European level is wanted, then map presentations, concepts & standards as well as updating procedures need be adjusted. Continuing "the expansion" just to other countries around the Baltic Sea and the North Sea seems to be the most desirable option for development right now. These possibilities will definitely be examined.

There is also the question of 'commitment' – will the participants continue to develop NoLTFoX or will they eventually be interested in producing more experiment information directly from their own organizations, using their own websites or other projects and networks? It would strengthen our activities knowing that there is support from the top management in all organizations. But there probably need to be some improvements to the NoLTFoX content and functionality to ensure this commitment. New and fancy, but also increasingly effective solutions are produced at a surprising speed and the amount of useful information made available is growing exponentially. Continuous efforts as well as commitment are needed to keep any network alive and productive.

Abbreviations used above…

- NEFIS = Network for a European Forest Information Service
- GFIS = Global Forest Information System
- EFERN = European Forest Ecosystem Research Network
- ENFORS = European Network for Long-term Forest Ecosystem and Landscape Research

Some publications where NoLTFoX has been presented, described or demonstrated

Baliuckas, V. 2005. NOLTFOX – Nordic Database of Long-Term Forest Experiments Now Includes Also the Baltic Countries. Baltic Forestry, 11(2): 118-119 (Chronicle).

Baumanis I., Jansons Ā., Gaile A. 2006. Ilglaicīgo zinātnisko pētījumu objektu inventarizācija, reģistrācija un datu bāzes izveide (Registration, inventory and establishment of a database of long-term forest experiments). Mežzinātne 15(48): 102-112.

Elfving, B., Lindgren, D., Persson, T. & von Sydow, F. 2001. Långsiktiga fältförsök – grunden för vår kunskap om skogens dynamik. FaktaSkog 9: 1-4.

Karlsson, K. 2006. Searching the NOLTFOX database for ash related experiments. Poster presentation at RecAsh 2nd International Seminar 'From Extraction of Forest Fuels to Recycling of Wood Ash', in Karlstad, Sweden, Sept. 26-27(28).

Karlsson, K. 2007. NOLTFOX - a database for long term forest experiments. In: Lingua E. & Marzano R. (eds.). Natural Hazards and Natural Disturbances in Mountain Forests - Challenges and Opportunities for Silviculture. Abstract Book. An International Conference for IUFRO units 1.01.05, 1.05.00. September 18-21, 2007. Trento, Italy. Dept. AgroSelviTer, University of Torino, p. 66.

Karlsson, K. 2008. Locating forest field experiments according to present and future climate. In: International Conference on Adaptation of Forests and Forest Management to Changing Climate with Emphasis on Forest Health. Book of Abstracts. Swedish Agricultural University, p. 112.

Long-term field experiments essential 1999. News and Views. Scandinavian Journal of Forest Research Vol 14(5): 386.

Nordic database for field experiments 2000. News and Views. Scandinavian Journal of Forest Research Vol 15(1): 3.

von Sydow, F. 2005. Sweden. In: Mårell, A. & Leitgeb, E. European long-term research for sustainable forestry: Experimental and monitoring assets at the ecosystem and landscape level. Part 1: Country reports. Cost action E25, Technical report 3. 251-262.

von Sydow, F. (2004). Försöksparker – viktiga för forskning och miljöanalys. Miljötrender 2.

An Overview of Long-term Forest Experiments in Great Britain managed by Forest Research

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Background

The Forestry Commission (FC) was established in 1919 with the aim of restoring the forest cover of Great Britain following several centuries of unsustainable exploitation that had reduced forest cover to about 4 per cent of the land area at the beginning of the twentieth century. Many of the sites that were available for tree planting were in zones of marginal agricultural value where previous generations of private landowners had carried out trials of afforestation, often using species introduced from northern Europe, Japan, and North America (Foot, 2003; House and Dingwell, 2003). However, such trials had often proved unsuccessful, probably because the effect of factors such as poor drainage, impeded rooting, low nutrient status and exposure upon tree survival and growth had not been fully appreciated. Therefore, from the early days of the Forestry Commission, a programme of applied research was implemented that sought to identify the limiting factors to tree growth in various parts of Britain and to overcome them using a range of ameliorative treatments such as site cultivation, fertiliser application and vegetation control. These treatments were typically investigated through forest experiments carried out in different parts of Britain by the FC's own research team (now called 'Forest Research'), often in large experimental reserves of 30-50 ha or more (Zehetmayr, 1954 and 1960). The success of this approach can be seen in the fact that the techniques developed in these trials formed the foundation of the silvicultural practices employed in the period between 1950 and 1985 when the major expansion of the British forest area took place (Foot, 2003). In addition to afforestation, the effects of stand management practices such as initial spacing, thinning regimes, species choice, and management of species mixtures were also investigated using series of replicated forest trials (e.g. Aldhous and Low, 1974; Hamilton, 1976). In the 1980s the controversial expansion of forestry on the deep peat soils of northern Scotland (Foot, 2003) was stimulated by evidence from a series of mixtures experiments that Sitka spruce (*Picea sitchensis* Bong. Carr.) could be grown to marketable sizes on such soils when planted in mixture with lodgepole pine (*Pinus contorta* Dougl.) or Japanese larch (*Larix kaempferii* Lamb. (Carriere)) and without the need for expensive nitrogen inputs (Taylor, 1991). Thus for much of the last century, forest science methodology in Britain was founded on the use of replicated field trials and experiments and a national network of research field stations was created to manage and maintain these experiments (Wood, 1974).

During the 1980s and particularly since the beginning of the 1990s, forestry policy in Britain has begun to place much greater emphasis on the sustainable management of forests for multipurpose objectives. This has required new information about forests such as the retention of stands beyond financial maturity to promote habitat diversity (Humphrey, 2005), the effects of forest management practices upon wider ecosystem services, often at a landscape scale (Humphrey and Watts, 2004), or the interaction between forest management and water quality (Nisbet, 2001). The existing suite of forest experiments was not suited to providing the

information required to address such issues, since typical forest experiments were usually composed of single species plots with plot sizes of 0.05-0.15 ha. The long time periods required to obtain definitive results from manipulating a forest ecosystem precluded the establishment of new field experiments to address this changing research agenda. As a result, the investigations carried out to address the issues posed by the advent of sustainable forest management have tended to use techniques such as mathematical modelling supplemented by campaign field studies and intensive monitoring (e.g. Vangelova et al., 2007). This resulted in a decline in the number of field experiments that were laid down, a reduction in the funds available for the maintenance of existing sites, resulting in the loss of sites through neglect, natural disturbances such as windblow and harvesting. Over the last decade, the establishment of forest experiments has been largely confined to researchers in the fields of tree breeding and genetic conservation, and those working on short-term (i.e. < 5 years) aspects of tree establishment.

However, it has recently become evident that long-term experiments can be valuable in validating the assumptions built into guidance derived from predictive models, as shown by the results from empirical experiments investigating the impact of intensive residue removal on site sustainability and crop growth indicating that the consequences vary with decreasing site fertility (Proe et al., 2001). In addition, old experimental trials can provide useful information for purposes largely unrelated to their original aim. Thus a series of plots established in the 1930s to examine natural regeneration in Scots pine (*Pinus sylvestris* L.) stands, have recently been used to explore aspects of the natural dynamics of semi-natural remnants of native pinewoods, which have high conservation and landscape value (Edwards and Mason, 2006). Old provenance experiments have been used to explore the potential impact of climate change on both native and introduced tree species (Broadmeadow and Ray, 2005). Increasing awareness of the potential value of these experiments has stimulated Forest Research to review its long-term experimental holding, to seek to share the information about these experiments with other researchers both in Great Britain and in other countries, and to consider the best ways to maintain this network for the benefit of future generations. As a consequence of this review, in 2006 we joined the NoLTFoX consortium established by a number of northern European countries for harmonising information on long-term forest experiments and information on our experiments can now be found on the NoLTFoX database at http://noltfox.metla.fi/. The purpose of this short paper is to give an overview of the current experimental holding managed by Forest Research (FR) in Britain, to provide some further examples of recent use of such experiments and to consider issues for the future.

Overview

For the purpose of the review, we defined ‘long-term’ as being an experiment where aspects of the design, principally plot size, would provide useful results on tree survival, growth and yield beyond the end of the establishment phase, which is normally taken to be at 10-15 years. A structured search of FR’s experiment databases, primarily in the silviculture and tree breeding areas, produced a list of about 10,500 experiments established since the 1920’s. This list was sifted to exclude those experiments that were closed or otherwise destroyed, as well as those where a small plot size (normally fewer than 50 trees or 0.02 ha) precluded any long-term interest. Many of those trials looking at aspects of establishment practice as well as tree breeding progeny tests, all of which typically involve small plot sizes were eliminated during this sift. As a result some 520 long-term experiments were identified which now form the core of FR’s long-term experimental holding and are listed on the NoLTFoX database.

To provide an overview of the composition of the experimental holding, the following summaries have been derived from the information in the fields used for the NoLTFoX database. Figure 1 shows the percentage of experiments categorised by the main NoLTFoX subject areas. Unsurprisingly, the majority of experiments are concerned with genetics and silvicultural subjects. About two per cent are classed under Ecosystem research, but these are all concerned with monitoring. The recent increasing interest in energy forestry and woodfuel production is likely to increase the number of experiments in that category. It should be noted NoLTFoX that the experiments listed under stand treatment, growth and yield do not include the network of permanent sample plots designed to provide information to help with the development of tree growth models.

Categorising the number of experiments established in each decade shows that the majority of experiments were established from the 1950s onwards, and particularly in the 80s and 90s (Figure 2a). The apparent small number established this century may be an underestimate as most recent experiments have yet to be evaluated for long-term retention. The majority of experiments are less than five ha in area. Many of the larger experiments are extensive species trials (Figure 2b). The majority of experiments are located on sites below 300 m (Figure 2c).

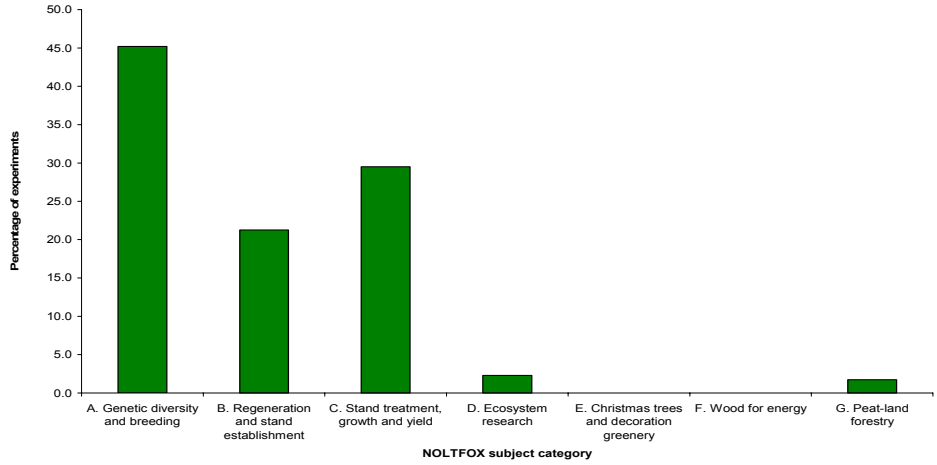

Figure 1. Percentage of experiments in each NoLTFoX subject category.

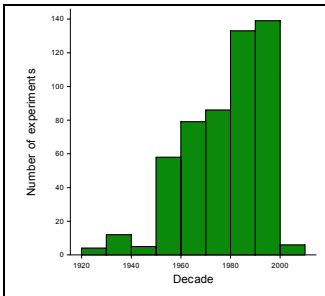

Figure 2a. Nr of experiments established per decade.

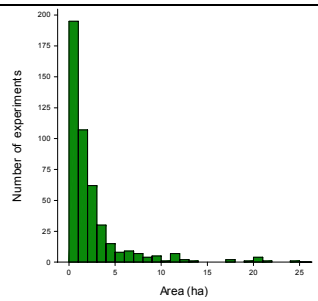

Figure 2b. Distribution of experiments by area.

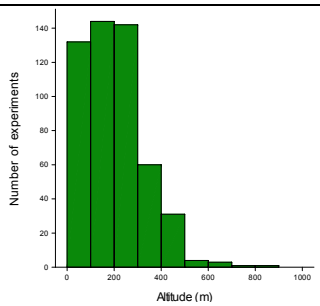

Figure 2c. Distribution of experiments by altitude.

The majority of experiments are located in Scotland (47%) and England (40%), with only 13% in Wales (Figure 3b). Within England, long-term experiments are concentrated in the north and west (Figure 3a). Very few are located in the lowland south east, which contains the most

wooded counties in England. This distribution largely reflects the historic primacy given to research to support afforestation in the upland areas of Britain. The lack of long-term experiments in Wales may reflect the relative absence of long-term experimental reserves in that country, which was not the case in Scotland or northern England (Zehetmayr, 1954 and 1960).

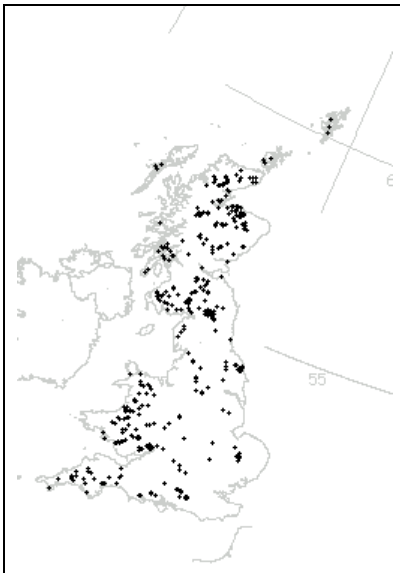

Figure 3a. Location of experiments in Britain.

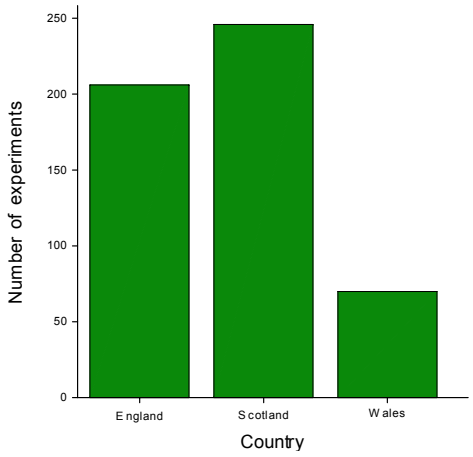

Figure 3b. Numbers of experiments in England, Scotland and Wales.

Sixty per cent of experiments are concerned exclusively with coniferous species, 26% with broadleaves, and 14% contain a mix of both types (Figure 4a.) Within the broadleaved species category, 40% of experiments solely relate to native species, and 54% to exotic species, with the remaining 6% containing a mixture of the two types (Figure 4b). The main exotics include *Populus*, *Eucalyptus* and *Nothofagus* spp. Within conifer experiments, the majority of species are inevitably composed of exotic species since Scots pine is the only one native conifer species suitable for timber production.

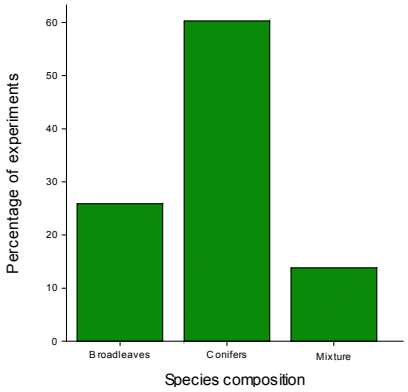

Figure 4a. Percentage distribution of experiments by species groups: exclusively broadleaves or conifers, or with plots of both in the same experiment.

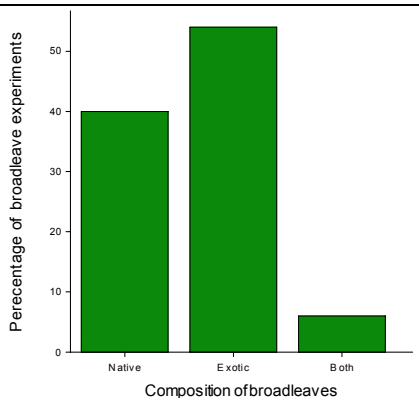

Figure 4b. Percentage distribution of broadleaved experiments by species origin: solely native or exotic, or with both in the same experiment.

The process of identifying experiments is still underway and it is likely that the number of retained experiments will change as more information becomes available for assessing potential value. In particular, some experiments belong to experimental series (e.g. where provenances of a given species are planted on a wide range of sites to test adaptability), and further evaluation may result in retention of the only the best experiments in a particular series. Future work will include: field inspection of experiments that have not been visited in recent years; consideration of more recently established experiments for classification as long-term; screening of officially closed experiments that still exist and are of potential value.

Examples of recent use of long-term experiments

Some recent instances where researchers have made use of the long-term experiments are described above. Other examples include:

a) Demonstrating the actual improvements in sawlog outturn from genetic improvement. The benefits of tree breeding programmes are not realised until the improved material is felled and the timber is processed at the mills. However, tree breeders have to make selections at a relatively early age (typically at one-fifth of rotation age for Sitka spruce) using criteria such as growth rate and form as indicators of final outturn (Lee, 2004). Forest managers tend to be somewhat sceptical about theoretical calculations of genetic gain and may hesitate to pay higher prices for genetically improved planting material unless they can be given direct evidence of yield improvements. A 38-year-old long-term experiment with Sitka spruce containing a standard provenance and three improved half-sib families was felled and the produce converted at a nearby sawmill. The results showed both an increase in log quality and up to 50% greater sawlog volume from using improved material, have given forest managers greater confidence in the gains to be realised from use of improved material, and have resulted in greater planting of full-sib families of Sitka spruce (Lee, 2006).

b) Showing the long-term development of stands managed under Continuous Cover Forestry (CCF). One effect of the greater emphasis placed on multifunctional management of forests is the desire to increase the species and structural diversity of British forests. However, because of the history of afforestation in the last century, many British forests, especially in the uplands, are composed of even-aged stands composed of a few species and these are typically managed on a simple silvicultural system using patch clearfelling (Mason, 2003). As result, forest managers are faced with a major silvicultural challenge when seeking to diversify such forests and make greater use of natural regeneration. One example of a CCF approach is a 60–year-old experiment in north Yorkshire which was originally a species trial where a range of species was introduced into a pole stage Scots pine stand. By the early 1990s, the stand was showing extensive regeneration of several species and was converted to a trial of different thinning regimes suitable for CCF (Mason, 2006). The experiment sits within one of the national trial sites for operational testing of CCF and is frequently used as a demonstration to visiting foresters and other interested stakeholders.

c) Potential species for use in short rotation forestry (SRF) to provide wood fuel. As elsewhere in the world at a time of climate change, there is increasing interest in the possibility of using fast growing tree species as a means of sequestering carbon and providing woodfuel as a substitute for fossil fuels. Amongst the trees being considered for this purpose are a number of cold hardy *Euclayptus* spp. A reasonably comprehensive series of provenances of eucalypts

were trailed throughout Britain in the late 1970s and early 1980s (Evans, 1986) and a number of these experiments survive and are listed within the long-term database. A recent study was carried out in one of these trials (Cope et al., 2008) which showed that provenances of *E. gunnii* from Tasmania had the desirable combination of adequate cold hardiness and useful growth rates. It is likely that further studies of SRF potential will be made soon in other surviving Eucalypt trials as well as in those containing other fast growing species such as *Nothofagus* spp.

d) Examination of the effects of species and species mixtures upon tree growth and ecosystem functioning. The Gisburn mixtures experiment was established in 1955 on upland pasture as part of an afforestation programme in NW England. The experiment contains pure plots of Norway spruce (*Picea abies* Karst.), Scots pine, pedunculate oak (*Quercus robur* L.) and common alder (*Alnus glutinosa* L.) planted in pure plots and in all possible two-species mixtures in three randomised blocks; unplanted controls were also included. Following windblow, the first rotation stand was felled in the late 1980's and replanted with the same species and the same pattern of mixture. The simple and robust design has resulted in a long series of studies examining the impact of trees upon soils, on earthworms and on various aspects of mixture dynamics (see Brown, 1992; Jones et al., 2005 and references therein). More recently, data from the experiment have been used to examine effects of insect herbivory (Vehviläinen et al., 2007) and impacts of tree species on methane capacity in forest soils (Reay et al., 2005).

Conclusions and future developments

Current aims are to complete the overview of the 520 experiments that are listed on the NoLTFoX database, to ensure that all data associated with these experiments are to hand and meet required quality assurance standards, and to provide key references associated with some of the major experiments listed on the databases. We also plan to add web pages describing the experiments and the links to the NoLTFoX database on the Forest Research website. One intention of the latter is to ensure wider awareness of these experiments both within the forestry sector and supporting academic institutions, since they can provide a valuable teaching and demonstration facility for people entering the forestry profession, while providing useful sites for those wishing to carry out more detailed research.

Existing annual funding of about £40,000 is sufficient to allow for regular inspection and maintenance of the most important experiments within the portfolio, but it does not permit regular assessments or extraordinary costs that may be associated with thinning or the restoration of boundary fences. More importantly, current funding does not allow for a systematic approach to establishment of new long-term experiments which can help replace those lost through attrition. We estimate that each decade some 30-50 experiments are likely to be lost because of factors such as windblow, fire, damage from harvesting operations, disease, and other events. Arguably, the present portfolio is still weak in experiments that explore aspects of native broadleaved management, on various aspects of thinning, on the development of mixed species stands, and on the interactions between forest management and the wider ecosystem. Given that new experiments can cost £5000–10000 ha-1 to plant and establish, and that a reasonable size of experiment to address some of the issues noted above is around 2–5 ha, it is clear that existing funding would need to be doubled to allow for new field trials to replace those that are being lost. Although interest in field experimentation has declined over the last two decades, the experience with the whole tree harvesting experimental series (Proe et al.,

2001) illustrates that replicated field experiments are essential to validate the assumptions built into modelling studies, even if the latter can provide faster results.

Forest Research's long-term experiments score highly against criteria like robustness of design, security of tenure, and availability of datasets collected over one or more decades: such features can be invaluable for scientists and students wishing to understand the successional dynamics of forest stands. These experiments are 'long-term' because of the length of time needed to monitor the growth of forest crops, rather than because they were specifically designed for long-term studies of ecological change. Nevertheless, some silvicultural manipulations will have direct and indirect effects on relevant ecological factors, and these experiments are therefore a potential resource for further studies that are unrelated to their original objectives. As such this portfolio of experiments complements existing and future long-term ecological experiments. When properly designed and implemented, experiments that manipulate a forest ecosystem, even one as seemingly simple as a single species plantation, can help identify the causal link between a manipulated variable and some measured response in a way that is not possible through observation, retrospective studies or even modelling. We believe that long term experiments such as those listed on the NoLTFoX database will remain an important element of forest science for many decades to come.

Acknowledgements

We are grateful to the members of the NoLTFoX consortium for the chance to participate in their discussions and learn from their experience. We gratefully acknowledge the contribution of past generations of Forest Research who established and maintained the experiments now within our stewardship and we thank the members of Forest Research's Technical Support Unit who continue to manage the sites in their care.

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NATFOREX - Establishing a National Resource of Field Trials and a Database for Forest Research and Demonstration in Ireland

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Introduction

The NATFOREX project, which is funded by COFORD (the National Council on Forest Research and Development in Ireland) under the National Development Plan, has as the objective the inventory and evaluation of all field based forest experiments in Ireland, and the creation of a data base containing information and data of all experiments, either terminated or on-going. The project will also involve the management and the collection of new data in on-going experiments. The duration of the project is six years, from November 1st, 2007 to October 30th, 2013. The approved budget for the project is 2.7 million euro, while another 0.8 million euros has to be approved in 2010. The lead organisation in this project is University College Dublin (UCD) and the project partner is Coillte Teoranta. It is envisaged that after the completion of the project, the data base will continue to be managed and updated, controlled by COFORD.

Overview

This project involves the evaluation of all field-based forest experiments in Ireland (circa 1500 experiments). However, laboratory and nursery experiments will **not** be included.

Of the field-based experiments, the project involves the maintenance, management and possible assessment of experiments selected for retention. The results of the retained experiments, such as experiment design and data collected previously, will be entered in to a data base, which will be made accessible to (forest) researchers through the COFORD website.

Key personnel

The project team consists of four experienced staff members. The Project Leader is Professor Maarten Nieuwenhuis of UCD. The Project Manager is Ted Lynch of Coillte, while Clare Cullinan is the Data Manager and Donal O'Hare the Field Manager.

The team will be directed by the Project Management Group, consisting of UCD and Coillte staff and a Project Advisory Committee made up of staff members of stakeholder organisations, to provide guidance in terms of priorities, trial retention, gaps in existing experiments, and information transfer.

Objectives

The main objective of the project is to maintain and manage a national network of field trials for the scientific study and demonstration of silvicultural and forest management treatments.

Evaluation is required to ascertain the relevance of existing trials. These trials are part of Coillte's experimental plot network or are owned by the research sections of other organisations in Ireland (Teagasc, National Parks and Wildlife Service, Bord Na Mona, and relevant third level institutes).

A decision has to be made on the feasibility of the analysis of the existing data. This includes analysis of the experimental design and an evaluation of existing data. A decision also needs to be made on the benefits of further data collection in the existing experiments, and on the need to establish new trials.

Carrying out of maintenance work is required on key field trials in order to improve access, signage and labelling and to update the management status of the trials.

New data collection in the existing trials is required where the development of the stand and the research objectives of the specific trial require this.

The findings and data from the trials will need to be integrated into a publicly accessible data base.

Another objective of the project is to identify gaps in the current experiment trial network. The Project Management Group, consisting of key personnel from the project, UCD and Coillte, will report to COFORD on gaps that have been identified, throughout the duration of this project.

Issues concerning existing trial network

Maintenance of trials has been neglected. This is as a result of the voluntary early retirement schemes, which has seen many Research Foresters retire in recent years.

Work is required on-site, to improve access, upgrade signage and labelling and to carry out treatments. Authenticity and relevance of future results will be questionable unless the necessary maintenance and treatments are carried out, and data are collected at the appropriate times.

Some of the trials designated for closure require a final assessment and a report to ensure that end of rotation information is captured.

Some of the closed experiments might (still) be of benefit, especially in relation to the private sector, and as a result of changing management objectives.

There is no central database of these experiments. Information is currently scattered in various files in a number of locations.

Subject matter covered by existing forest trials

The field experiments currently in place as part of Coillte's plot network cover the following subject matter:

Genetics	Species trials, Provenance trials, Inter-provenance lodgepole pine hybrids, Progeny tests, Clonal trials
Establishment	Cultivation methods, Planting method, Planting stock, Planting season, Direct seeding, Leguminous plants, Vegetation management, Weevil control
Silviculture	CCF trials, Farmland trials: mixtures, nutrient nursing, shelter, self thinning, frost protection, timber production
Nutrition	Fertilisation: afforestation, checked crops, pole staged crops, organics, restock, monitoring
Crop Structure	Spacing, Re-spacing, Pruning, Thinning
Forest Protection	Forest health plots (levels I &II), *Fomes annosus* trials

Work packages

The overall project tasks and activities have been divided into six Work Packages for planning and operational reasons. These Work Packages, and the activities that are part of each, are listed below.

WP1 Setting Priorities

1. Review subject matter and objectives of active trials
2. Reconsider the usefulness of some of the closed trials and
3. Determine the priorities

WP2 Selection of Trials

- Collection of all available information on all trials in priority areas
- Decide on trials worth evaluating
- Clear access
- Inspect trials and
- Create reports on the experiments and the data

WP3 Evaluation of Trials

- Evaluate trials based on experimental design, treatments and data
- Decide if trial is worth analysing and incorporating in data base
- Decide if further data collection is relevant
- Decide if completed or rejected trials should be disposed of or maintained as demonstration site

WP4 Management of Trials

- Vegetation control in recent trials

- Silvicultural, management and experimental treatments of retained trials
- Maintain access and signage
- Further data collection and transfer to data base

WP5 Database Development

- Develop database architecture
- Assemble relevant information in the proper format
- Manage the population of the database
- Liaise with other relevant data base developers

WP6 Reporting

- Produce a status report on each (set of) experiment(s)
- Produce Management Plans for experiments that are retained
- Produce project progress and final report

Creating the database

Good database paper design is essential. This is required to provide foundations for the architectural structure of the database. Expert advice from database designers and from the Advisory Committee (which will be made up of members of stakeholder organizations with an interest in forest research) will be sought to confirm stability of database design before populating the database.

The data base will be designed to work well in a networked environment, as it is the long-term objective to make the database available through COFORD's website. This will require a database server, in order to deal with multiple users.

Data population will be achieved through a variety of measures, such as, punching in individual records in the case of old hand written experiment data; importing raw data already available electronically; and scanning in records.

Data should be easily retrievable, without excessive delays. Solutions to deal with this requirement may be the use of drop-down list options and exporting the data in the form of comma-separated values or Excel files.

To make the information in the database as accessible as possible, it will be web enabled. The raw data will be accessible after getting permission from COFORD's database administrator and from the organisation that owns the data.

Constraints of gathering existing data

Prior to the NATFOREX project, no standard existed as to where data from the vast number of experiments should be recorded and stored. Therefore, data exist on paper; on floppy disks; and on operational and redundant hard drives. Some data are untraceable and disks that store the raw data of some experiments have become corrupted.

No standard for the collection of metadata relating to the various experiments has existed in Ireland. Gaps in metadata raise questions of authenticity. This can be overcome by applying a metadata standard, and filling in 'the who, what, where and when', relating to each experiment. Filling these gaps will slow the process of verifying an experiment and of populating the data base.
Some important forest researchers connected with older experiments with a huge knowledge about these trials, have retired or passed away. This may cause problems when going after old files and looking for clarification in relation to specific experiment information.

Conclusion

This project offers an opportunity to carry out an inventory and evaluate the relevance of existing field-based trials in a comprehensive and consistent fashion.

It will provide the forest industry with a key resource for the scientific study and demonstration of silvicultural and forest management treatments.

Furthermore, it will help identify gaps in research and pave the way for plugging these gaps with a rejuvenated research programme into the future.

The work of the project will bring details of all forestry experimentation in Ireland to a central point where it will be easily accessible for the use of all stakeholders.

A Public Database of Forest Experiments in 'Silava', Latvia

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Establishment of national database of long-term forest experiments was initiated and supervised by former director of Latvian forest research institute "Silava", senior researcher, Dr. silv. Imants Baumanis. It was recognized, that due to many institutional changes and reforms after Latvian independence, information about a number of experiments have been lost. Establishment reports were usually stored by responsible researcher, and if he has changed a job or retired, information often could not be recovered. At the same time long-term research plots were proven to be important in discovering patterns and trends in forest in unexpected ways, for example, trial with different hydrology regimes were used to describe effects on plant-species composition and diversity, indicating guidelines for protection of natural diversity.

NoLTFoX initiative has been helpful to raise awareness of the problem and also local funding sources for establishment and maintenance of national database. It has been also encouraging in several practical improvements and continuous development. In order to keep information in as easy understandable format as possible, similar scheme as in NoLTFoX were used also in national database:

- number of experiment – by which responsible research institution could also be identified;
- experimental series and number within series – derived from system of responsible researcher itself;
- priority – defined as in NoLTFoX;
- beginning of experiment, year of establishment;
- last measurement – some of experiments were re-measured also in frames of database establishment projects and for some it was more easy to attract funding for continuous measurements;
- area of experiment, usually including also certain buffer zone;
- number of treatments, replications, plots;
- geographical coordinates, being helpful to link long-term experiments with forest database. It means, that if some silvicultural activity is planned in an area, foresters can see in the database, that it is a research plot, and contact responsible researcher. In this way miss-communication and therefore damages in research area are to large extent avoided;
- subject field; objectives;
- key-words – initially given by researcher, but finally unified after discussion process, to keep variation in reasonable borders and avoid confusion in naming the same process or object in several different ways;
- tree species (Latin name);
- region; municipality; name of location;
- forest district, forest range, block Nr., compartment Nr. – as mentioned, for connection among long-term forest experiment database and forest resources database, GPS

coordinates are used, since due to continuous reforms and inventory in forests it is almost impossible to have the most up-dated information in database;

- land owner – state or private, without details, since private owners are changing and it is impossible to keep this information updated. Also in discussions with private owners NoLTFoX has been helpful – it is more easy to explain a need to maintain research plot, if it is in international databases / so of international interest;
- land user, if known and other than owner;
- number of parcel in land area databases;
- research organization, department;
- responsible researcher – being active in the field, even if experiment was established by other person. Includes also contact-information – e-mail, phone number;
- list of publications, if available.

In a paper format also establishment report and scheme, design of experiment are attached, but for further use it is available only if contacting responsible researcher.

List of information included in database demonstrates also a considerable ongoing effort to maintain information up-to-date. In this respect continuous activities in NoLTFoX are essential to provide additional arguments for local authorities to maintain database and in some cases new private land-owners to maintain experiments.

New experiments, few years after establishment, are included in database and old might be removed, if number of trees per treatment or other problems (like wind-throw) prohibits further research activities.

Numbers of experiments, as listed in national database, are ruinously referred to in project reports, master or doctoral thesis, and in most cases also in publications; in this way also important contribution of NoLTFoX initiative to establish and maintain national database are indirectly acknowledged.

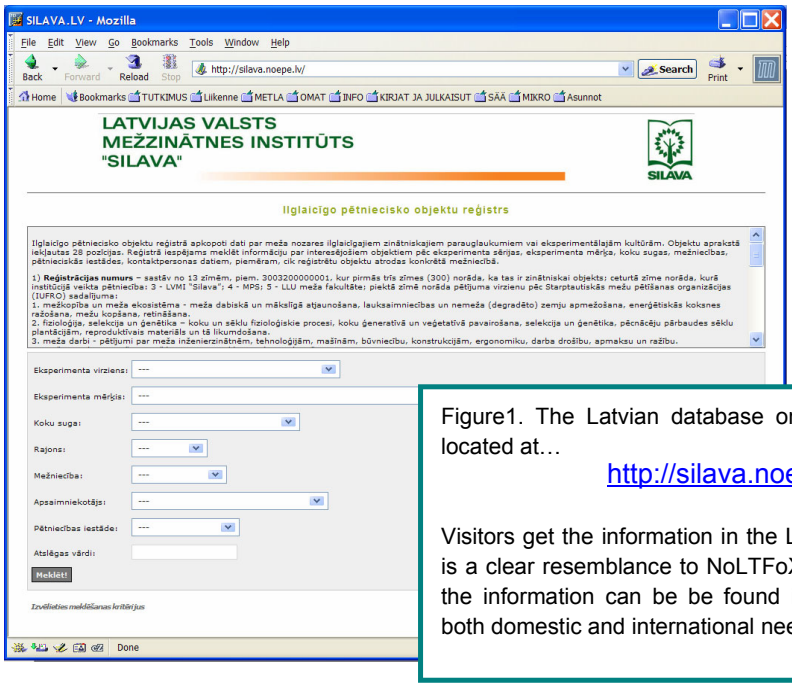

Figure1. The Latvian database on forest experiments is located at…

http://silava.noepe.lv/

Visitors get the information in the Latvian language. There is a clear resemblance to NoLTFoX, where much of same the information can be be found in English. In this way, both domestic and international needs are covered.

Forest Experiment Databases for Internal Use in 'Skogforsk', Sweden

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In the mid 1980's the need for a structured system for data storage and management concerning the large amount of tree breeding field trials at ***Skogforsk*** (The Forestry Research Institute of Sweden) became urgent. Up till then, data concerning the different trials were stored on paper in various archives, book shelves or in the memories of the field workers with corresponding poor possibilities to get an overview of the enterprise.

The solution was a large database – ***Fritid*** (Forestry Research Institute Tree Improvement Database) comprising, not only standard field trial data as name, number and position but also a large number of other information concerning both field and research work. The database is built on an SQL-server solution were all data is stored on the SQL-server placed at Skogforsk headquarters readily reached through out Skogforsk by the end-user interface made in Microsoft Access, through which all data input and output is done. In the Access interface there are a number of prepared reports that can easily be used to print information concerning a specified trial or series. The database can also be queried through Access for any information or combination of information needed provided the user is knowledgeable about the proceedings.

All in all the ***Fritid*** consists of more than 20 tables and 10 "support tables". Major efforts have been made to create "water tight" systems for data input control so that all data is checked for errors either by the "support tables" or by various SQL "triggers" that check for errors like consistence and/or to prevent "loose ends" of information that can't be connected. This facilitates questioning and handling of the database and thus the usefulness.

Apart from normal field trial information as name, number, position and ground conditions for individual field trials, ***Fritid*** includes information about clone archives, pollen archives, seed orchards, plus trees and so on. This makes it possible to find; i.e. what clones are included in a specified seed orchard and from where did the clones come, in which field trial have they been tested and who was their father and mother, where did the parents come from etc., as well as a simple question about what pine trials there are in Stockholm county.

As a complement to the database, an extension to ArcMap (GIS-software) has been done so that ArcMap can extract position and descriptive information from ***Fritid*** and plot it on maps of various scales and substance. This has proved a good way to enhance navigation to individual trials as well as making comprehensive presentations of which, where and why.

The success with ***Fritid*** soon led to another database ***SkogExp*** (Skogforsk's Database of Forest Experiments) which contains information about the production field trials like fertilizing, ash recycling and also some environmental effects of fertilizing. ***SkogExp*** is not as extensive as ***Fritid*** but the solution with SQL-server for the data, and Access as interface is the same as well as the considerable control system to prevent inconsistency with subsequent malfunction in the database.

Updating of Noltfox database is a good example of the usefulness of extensive internal databases. At Skogforsk this is done by 18 SQL questions, first two that gather required data from ***Fritid*** and ***SkogExp*** and then 16 that update the gathered data to Noltfox standard. All questions are run in sequence by a macro initialized by a "One button click". The macro also does some controls and recalculations of positions from the Swedish RT90 format to WGS84 long & lat. Within a minute after button press a table with fresh data from more than 2.000 field experiments, ready for export to Noltfox is opened.

Obtaining Climate Data for Experiment Locations

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Introduction

Any information on climate or soil has not yet been included in the NoLTFoX database. The possibilities to find a common classification of soils that would be applicable and useful in all countries seem poor. Measurements of the conditions at weather stations are firmly standardized so calculated climate characteristics would also be exactly the same for most countries.

Increasing interest in our climate has resulted in a large supply of climate data and some of this can be downloaded from the internet freely without charge, sometimes registration or personal contact is needed. Raw data is available in this way from single weather stations, but also interpolated values for each point in grids of different resolutions.

A simple test of how to use existing grid data to generate climate variables for each single experiment in the NoLTFoX database was carried out.

Datasets and processing

The data used was obtained from Tyndall Centre for Climate Change Research. The grid data had a resolution of 10 arc minutes (New et al 2002) and each grid point had monthly values 1961–90 for 9 variables.

Table 1. Original variables included in the dataset, e.g. monthly values.

Variable	Unit
precipitation	mm/month
cv of precipitation	percent
wet-days	no days with >0.1mm rain per month
mean temperature	Deg C
mean diurnal temperature range	Deg C (also min-max)
relative humidity	percent
sunshine	percent of maximum possible
ground-frost	no days with ground-frost per month
10m windspeed	m/s

Additional variables are available also according to different scenarios for the complete period 2001–2100 (Mitchell et al 2003). That data was also processed, but it is not presented here.

Some characteristics useful for forest research were calculated from the data above. Variables were calculated either as averages or sums of certain monthly values. The main focus would be on describing the growing season, but some variables for autumn and winter conditions were also calculated.

Table 2. New variables generated from the dataset as averages and sums of monthly values.

Variable	month's	
Daily tmp range	6-7-8	avg
Frost days	4	sum
Winter pre	1-2-3	sum
Summer pre	6-7-8	sum
Rainy days	6-7-8	sum
Relative humidity	6-7-8	avg
Sunshine	6-7-8	avg
Winter tmp	1-2-3	avg
Summer tmp	6-7-8	avg
Autumn winds	10-11-12	avg

Thematic maps were generated for these chosen, calculated climate variables using ArcGIS software. In this process any missing values were estimated from neighbouring ones. The 10' grid is relatively coarse. The pixel size in the maps is about 10x18 km at the level of Scotland and 5x18 km at northern edge of Norway.

Using NoLTFoX experiment coordinates, a numeric output - a table, was created from all maps simultaneously (Figure 1). In this table each experiment is on separate rows and all climate variables in the columns following. The table is comma delimited and can be imported in to any ordinary software (like Excel) or databases (like NoLTFoX).

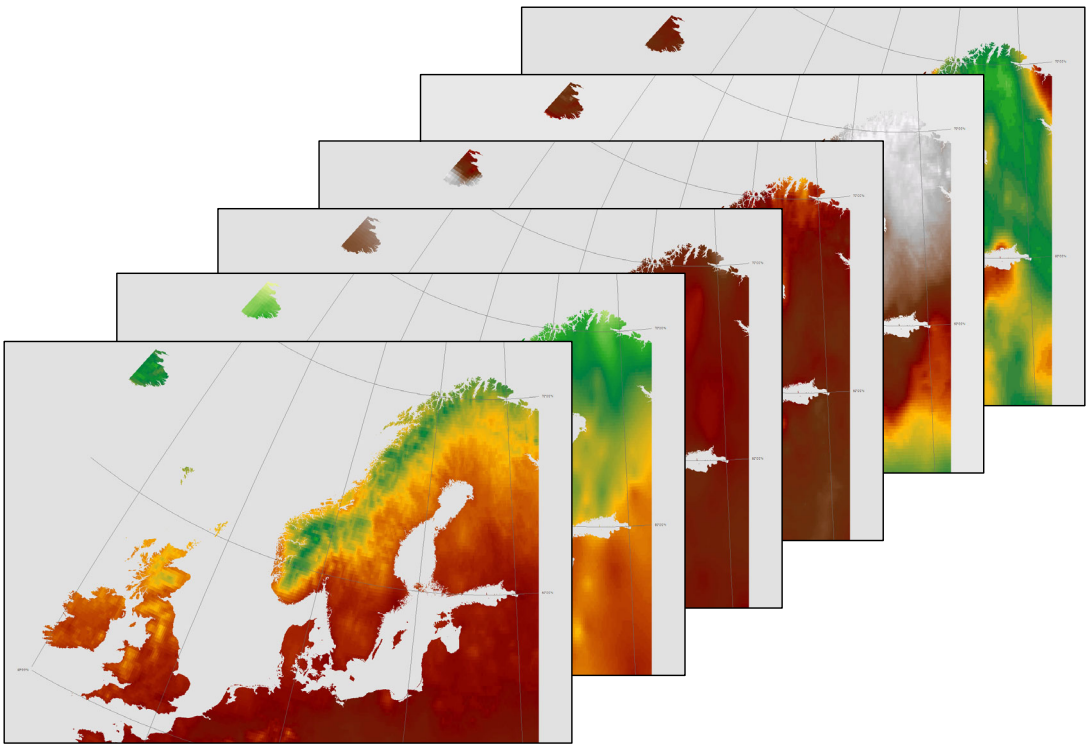

Figure 1. An illustration of the methods used. Six maps of climate variables, with 'summer temperature' in front. Numerical values for each variable can easily be extracted for any point on the maps using lat-long coordinates as an overlay within the ArcGIS program.

Discussion

Each experiment received values for some chosen climate variables by extracting them from map presentations. The same values can be obtained by calculations of the original dataset using custom computer programs. There are, however, several benefits using the methods described here. Maps are visual presentations that give you an instant overview of the conditions and the spatial variation. They can also be used for multiple purposes within the ArcGIS software and the data can be exported in several ways.

Better datasets will probably be made available for public use very soon due to the importance of climate change research. Several presentations during a recent climate change conference (International Conference.. 2008) were based on climate data with better spatial resolution that what we have here: for example 4 x 4 km pixels were used and even 1 x 1 km for some areas of Europe. However, small resolution does not by default mean the same as good accuracy in the data. Sometimes data has been "downscaled" by simple interpolation that does not improve accuracy. The number and distribution of weather stations in the original data is crucial. Complex modelling using altitude, ocean areas and other large water bodies etc. can improve the estimations of local climate values from general weather station data. Such models have been used very much in Finland, especially for estimating temperature sum (Ojansuu & Henttonen 1983). The possibilities to use the same methods in a European scale will be examined as a following step, when we will be looking at the current status of some old modelling approaches (Henttonen & Mäkelä 1988).

Finally: Is climate data useful as a complement to the general experiment information that is included in NoLTFoX? This material seems to be good enough for locating experiments along climate gradients if the distances are relatively long (~large scale). Experiments in extreme conditions can also be found, which is demonstrated with an example on the next page (Figure 2). Some researchers should find a combination of climate data and experiment information useful, even using this relatively modest material.

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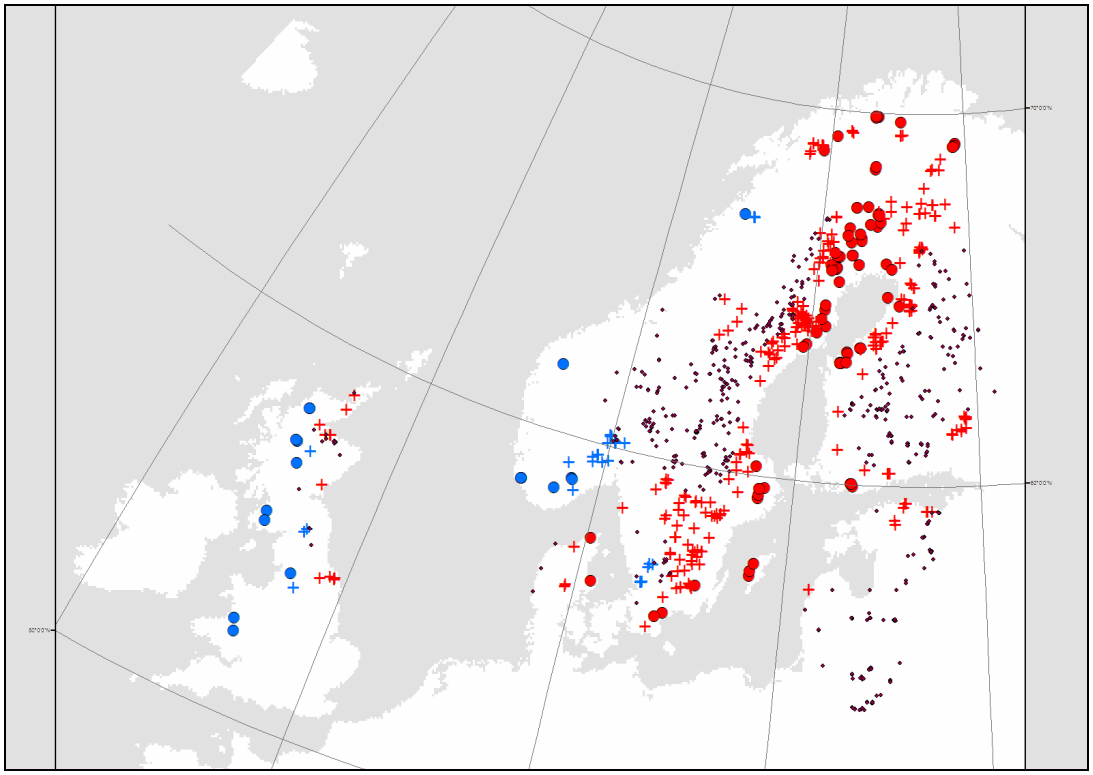

Figure 2. An example using the climate data set generated. The search result of NoLTFoX experiments (Subject: stand treatment, Tree species: Scots pine) has been classified according to the climate variable 'summer rainfall'. Blue dots = experiments in very wet conditions, red dots = in very dry areas, the others in between.

Country reports – status, progress and perspectives

Denmark

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Background

- Denmark was among the initiators and a founding member of NOLTFOX.
- During recent years, all institutions relevant for long-term field experiments in forestry have merged into Forest and Landscape Denmark within the University of Copenhagen.

Datasets described

- The Danish experiments include classical long-term forest experiments as well as experiments on Christmas trees and decoration greenery. At present, no published up-dated overview is available, but principles and guidelines are laid down in the following publication: Skovsgaard, J.P., K.R. Rasmussen & K. Nilsson 1999: Strategi for arbejdet med langsigtede feltforsøg ved Forskningscentret for Skov & Landskab. Forskningscentret for Skov & Landskab, Hørsholm og Vejle. 40 pp. [Title: Strategy for long-term field experiments conducted by the Danish Forest and Landscape Research Institute. In Danish].
- The national equivalent of NOLTFOX goes under the acronym of OLF (Oversigt over Langsigtede Forsøg) and is standardized directly towards similar criteria.
- OLF is currently being updated, with a major revision of research priorities on each experiment.

Progress and perspectives

- For Forest and Landscape Denmark the creation and maintenance of NOLTFOX has been a major benefit. The international cooperation has greatly facilitated the update and standardization of national procedures, databases and overviews.
- Forest and Landscape Denmark strongly supports and promotes the gradual enlargement of NOLTFOX to include all of Northern Europe and, in the long run, possibly even all of EU and other relevant countries in Europe.

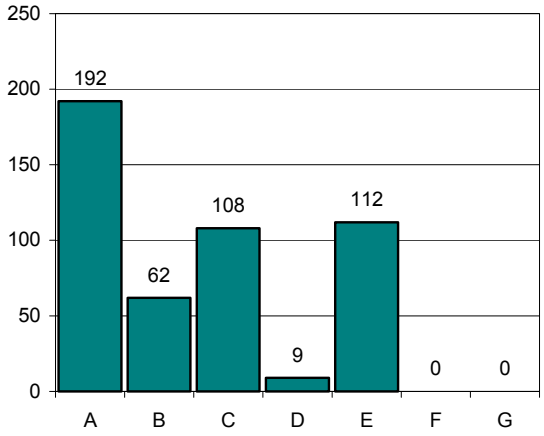

Figure 1. Number of experiments in each Subject field…

A. Genetic diversity and breeding
B. Regeneration and stand establishment
C. Stand treatment, growth and yield
D. Ecosystem research
E. Christmas trees and decoration greenery
F. Wood for energy
G. Peatland forestry

Estonia

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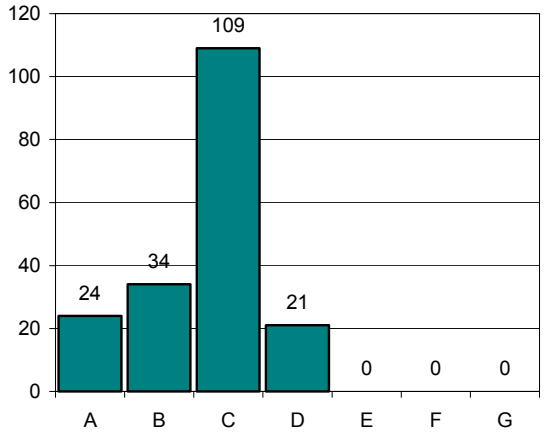
The history of empirical forest research in Estonia can be traced back to 19th century. The establishment of well-designed and documented field experiments for forest research purposes began after the establishment of the Järvselja Forestry Training and Research Centre in 1921. Monitoring of those experiments is continued even now. Hundreds of long-term forest experiments were established by the Estonian Forest Research Institute in 1969-1995. However, after closing the institute in 1996, very limited funding was scheduled for maintaining of the long-term forest experiment. As a result of that, few long-term forest experiments were under control in Estonia before joining NOLTFOX.

After Estonia joined NOLTFOX network in 2004, importance of long-term forest experiments as a national asset became evident to Estonian decision-makers. A project for inventory of long-term forest experiments was launched by the Estonian University of Life Sciences. The inventory resulted that during the period 1995-2004 harvesting or uncontrolled thinning has been carried out on most experimental areas. Also, unclear mapping and poor data recording was met in many cases. Nevertheless, more than hundred abandoned forest experiments were restored and recorded in NOLTFOX database.

At the moment total of 190 long-term forest experiments are recorded in the NOLTFOX data base (Figure 1). Most of them are "revived" long-term forest experiments but the database includes new perspective experiments as well. To avoid uncontrolled operations on the long-term experimental areas, the Estonian NOLTFOX plots are included in National Forest Register which forces forest owners to follow guidelines of research organisation. The references list for Estonian forest experiments includes 19 references at the moment, considerable part of Estonian forest experiments is not published yet. Next, “revival” of abandoned forest experiments will be continued, as well as establishing new forest experiments in Estonia.

Thanks to NOLTFOX actions, discussion on long-term forest experiments designing and maintaining was initiated in Estonia this year. Representatives of all Estonian forest institutions were gathered in spring 2008 and founded a initiative group for maintaining of long-term forest experiments in Estonia.



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Finland

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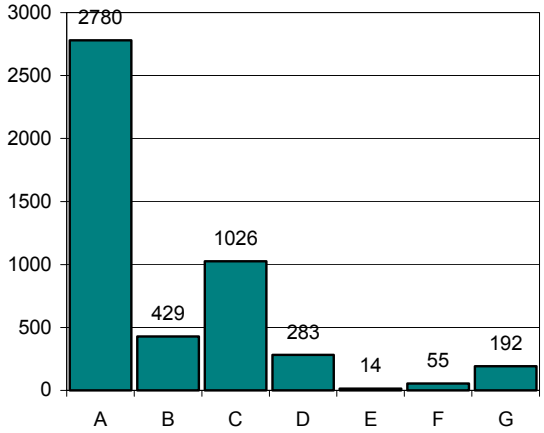
The Finnish Forest Research Institute (Metla) has been dominating experimental forest research during the 20th century in Finland. A decentralized organization with 9 research units in different parts of the country has provided good possibilities to establish and maintain forest experiments in the past.

Two university forest faculties (Joensuu and Helsinki) have their own field stations, where some education and research is conducted using forest experiments. There, ecosystem research based on intensive measurements has been more emphasized than other research topics. The same situation has been prevailing for other natural sciences working with forests. Some forest colleges and other forest organizations may have established forest experiments, but the number must be relatively small. In most cases Finnish forest scientists have been relying on the vast amount of experiment information that Metla has provided and the cooperation has been intensive.

The number of active Metla experiments was very large at the end of the last century. A database was created for internal use some decades ago and that information could be used when preparing data for NoLTFoX. Some features of the Finnish experiment data…

- Many terminated experiments are included. A validation was made in Metla at the same time NoLTFoX activities started. The validation resulted in termination of many preciously active experiments, but they were kept in the NoLTFoX dataset.
- Our internal database is listing a lot of monitoring plots, but they have **not** been included in NoLTFoX. They are basically like any inventory plots: the location is more or less grid based and they do not have 'a priori decided treatment' or any actual experimental design.

In the future, priority classification should still be improved in order to identify the most important experiments. Metla has also relatively good possibilities to include more information on data sheets or even as separate sets of measured data. This can, however, only be done for a limited number of experiments.



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Iceland

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Background

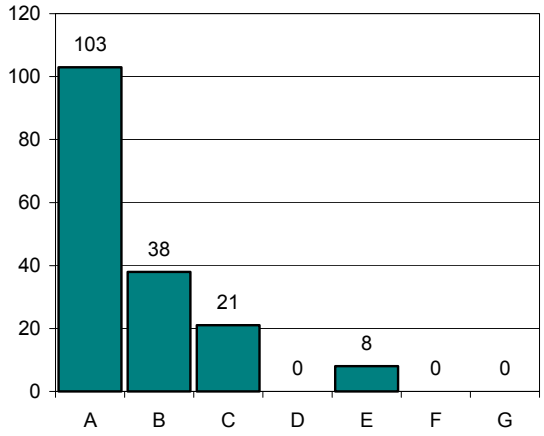
Iceland has been a member of the Noltfox project since it started in the year 2000. The Icelandic delegate was Dr. Guðmundur Halldórsson from the beginning, but he resigned from his position at the Forest Service in 2006. The delegate for Iceland in the Noltfox project is today Dr. Ólafur Eggertsson, a senior researcher at the Forest Service. There is a good and fruitful collaboration between the Forest service and all the other actors in the Icelandic forestry sector. The main actors in forestry are: The Regional Afforestation Projects (managing the government scheme for afforestation), The Forest association, The Soil Conservation Service and The Heklaforest project.

Datasets described

Icelandic entries in the Noltfox database are today 170 (Fig. 1). No references have been listed. The Icelandic partner is now working on the reference list. Some newly established experiments have not been entered into the Noltfox database. An upgraded version of the database will be inserted to Noltfox before Christmas this year. New experimental plots have been established recently in Iceland, for example provenance trials of *Pinus silvestris* and *Larix sp.* and genetic variation trials to study the effects of *Melampsora larici-populina* fungi on different clones of *Populus tricocarpa*. The aim is to find a clone resistant to the *Melampsora* fungi.

Progress and perspectives

The national database for experimental plots was established in Iceland thanks to the Noltfox project. The national database uses the same criteria's as the Noltfox database. The ongoing work is on the reference list related to the different experiments, that work is quite time consuming. It was important from the Icelandic point of view that Scotland joined Noltfox project because we are using some of the same exotic tree species in our forestry as Scotland e.g. *Picea sitkensis*. Results from Scottish provenance trials can be of useful for our forestry in changing climate scenarios.



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Latvia

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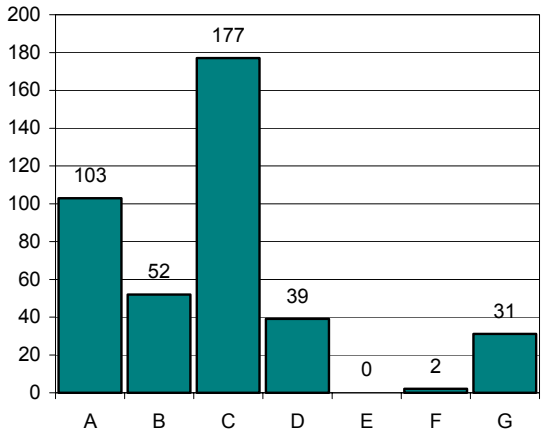
Currently 404 long term research plots are included in NoLTFoX database (Figure 1), which is a sub-set of trials in national database. Intention is not to show all experiments available, but include representative experiments from all spectrum – by subject field, objective, tree species, age; so that anyone interested could find, that such experiments exist in Latvia and contact responsible researcher for further details.

Majority of trials included are experiments related to tree breeding – provenance and ecotype trials, population studies, progeny trials of individual trees. Reason for that is a good statistical design and establishment documentation of these trials. Gradually, as complete information becomes available, more research plots could be added to NoLTFoX database. Also after a careful evaluation few years after establishment, new trials, intended to be long-term, with a good statistical design and plot sizes large enough for long-term experiment, will be added. Mostly such trials are in a way as thinning regime and shelter-wood studies and experiments related to functions of forest as ecosystem – changes in soil due to silvicultural treatments, CO_2 sink-source balance etc.



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Lithuania

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Background

Lithuania has joined the project in 2004. At that time only the group involved in tree breeding was ready to use database on the Microsoft Access platform. At present the major part of forest long-term experiments in Lithuania are registered in NOLTFOX database. Majority of the experiments have been established and controlled by Lithuanian Forest Research Institute. The second main contributor is Lithuanian National Service of Genetic Resources, Plant and Breed Material.

Datasets described

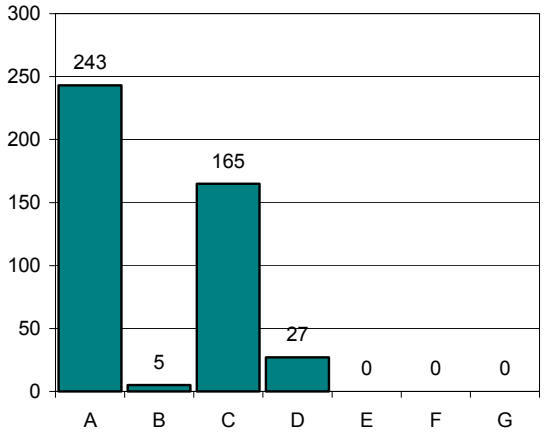
There are 440 forest experiments in Lithuania that are included to the NOLTFOX database. Most of them are tree breeding and gene conservation ex situ objects (see Figure 1). More than 1000 links to the literature sources have been added to the database. Objects of National Forest Monitoring System (level I), which consists of 963 permanent observation plots (POPs), were established in Lithuanian forests during the period of 1987-1988. These long-term forest plots could be included to NOLTFOX database in coming years.

Progress and perspectives

During participation in the project we were able to unify data on existing forest experiments. The NOLTFOX database is used more and more to refer to experimental base in Lithuania. The project activity is also presented on internet page…

http://www.forestgen.mi.lt/content/Noltfox.htm

The cooperation in forest research between the scientists within the country is quite intense, but could be more intense on international level.



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Norway

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Background

The long-term field trials have been fundamental for most applied forest research in Norway since its very beginning in 1916-17. Skogforsk (later Skog & landskap) was a key player in establishing the NOLTFOX-group in 2000/2001. The activity concerning the management of long term field trials in forests in Norway is mostly governed by Skog & landskap, and some minor activities also take place at the University of Life Sciences (the former Agricultural University of Norway, Ås).

Dataset

Up to now and from the Norwegian side we have chosen to include in NOLTFOX experiments that are still running or have been running actively up to year 2000. Presently, the database includes 1116 operative trials (Figure 1) and 147 closed down trials, spread over most of Norway. The number of references covering these experiments counts to approximately 100 papers/articles, but the list is regularly updated. Additionally, during the last years we have prepared information for nearly 300 closed down/low priority trials and literature references referring to some of these. However, these have not yet been included in NOLTFOX. A national overview of field trials managed by Skog & landskap is available in our webpage:

http://www.skogoglandskap.no/temaer/feltforsok/

Presently the distribution of different trials show:

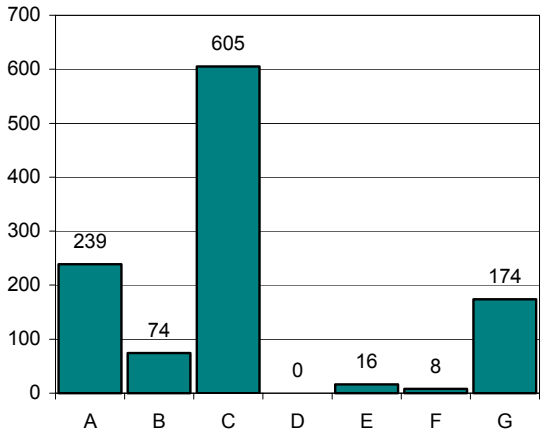
Type of experiment	No of trials
Soil aluminium	1
Genetic, off spring trials	63
Pre-commercial thinning	29
Selection forestry	15
Mountain forest selection	31
Planting distance trial	9
Fertilisation	61
Fertilisation – thinning	3
Fertilisation/whole tree harvesting	4
Whole tree harvesting	4
Christimas trees	24
Clonal trials	5
Peatland trials	156
Planting methods/type	2
Provenance	115
Provenance/cultivation methods	33
Greenery	9
Pruning	26
Tree species	5
Tree species and provenances	11
Thinning – production	417
Sum of trials, Skog og landsk	**1023**

County	No of trials
Akershus	65
Aust-Agder	60
Buskerud	38
Finnmark	17
Hedmark	154
Hordaland	129
Møre og Romsdal	60
Nordland	75
Nord-Trøndelag	79
Oppland	87
Oslo	5
Rogaland	91
Sogn og Fjordane	33
Sør-Trøndelag	11
Telemark	13
Troms	43
Vest-Agder	23
Vestfold	12
Østfold	28
Sum of trials, Skog og landsk	1023

Progress and perspectives

The work in NOLTFOX has clearly strengthened the national focus on the great value of long-term field experiments. The work on maintaining and updating these trials are financed by the Royal Norwegian Ministry of Food and Agriculture.

We have gathered data from different fields of interest, and have been able to present overviews of various types of forest trials – in a broader context. Up to now most of the end-users of the database have been researchers, students, managers and forest owners. The NOLTFOX has been used directly into national reports and applications for various sources: SNS, The Nordic Coucil, The Norwegian Research Council, etc. Recently, a joint application from UMB/Skog & landskap concerning ”Optimal strategies in silviculture for the production of bioenergy” was given support by the Research Council. The value of NOLTFOX was here greatly acknowledged. In 2008 we intend to further update the database with relevant information and literature, and especially focus on including recent experiments within “ecosystem and biodiversity”.



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Sweden

Fredrika von Sydow[1] and Henrik von Hofsten[2]
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Background

Situation of Swedish long-term experiment when joining NOLTFOX

Sweden is the world's third largest exporter of pulp and paper, and the forest sector delivers the largest net export value of all Swedish industry sectors. Therefore forestry and the forest industry are of vital importance for the Swedish economy. About 55% of the land area is covered by productive forests and 67% of the forests are found within the boreal belt. About 85% of the growing stock consists of conifers with Norway spruce and Scots pine as the dominant species.

During the last century forestry has mainly been based upon the principle of clear-felling followed by reforestation. This management system is based on forest research of high international quality and recognition.

Because of the increasing use of forest resources, organized forestry was gradually introduced in the end of the 19th century with extensive logging followed by planting of mainly Norway spruce and Scots pine. The importance of forest research, where the effects of different treatments were followed, became obvious already at the end of the 19th century. Gradually the insight became more and more apparent that the establishment of field experiments required scientific methods to provide the correct conclusions.

From 1902 originates the first field experiments, some of which are still being measured and followed. In Sweden there are today more than 140 forest field experiments older than 70 years mostly within the subject *Stand treatment, growth and yield*. Today the ***Faculty of Forest Science at the Swedish University of Agricultural Sciences (SLU)*** is responsible for these old experiments.

The Forestry Research Institute of Sweden (Skogforsk) is a result of an emergence between two institutes whereof one was an institute primarily oriented towards tree-breeding and the other at forestry operations. Skogforsk is mainly privately financed and has its main emphasize in long-term experiments within *Genetic diversity and breeding*.

These two Swedish organizations, SLU and Skogforsk, have most of the Swedish long-term experiments and take part in NOLTFOX. When the NOLTFOX collaboration was started in 1999, on the initiative of Nordic Forest Research Co-operation Committee (SNS), SLU had no coherent searchable database for its field experiments while Skogforsk had a database internal use only.

Participants and co-operation within Sweden

Forest field research obtains knowledge from the results of manipulations of forest ecosystems in long-term field experiments. The results help us understand the effects of different treatments on yield but also causes of environmental changes and, in many cases such experiments are able to reveal key results. To be regarded as a long-term field experiment, a study is expected to address questions of a long-term nature and to be designed in such a way that a continuity of follow-up is possible. Long-term experiments also constitute a reference material that can be useful in environmental monitoring. Many changes in forest ecosystems take a long time, to secure or reveal results. The time perspective is usually decades or even longer. Thus, results from short-term experiments can often not be used to draw conclusions about long-term changes in forest ecosystems.

An important resource for forest research in Sweden is the Experimental Forests at SLU (Table 1). The oldest of these Experimental Forests dates back to the early 1920s. Over the years, hundreds of field experiments have been established. Many of them are still being studied. This long-term continuity in the study of forest stands makes the Swedish Experimental Forests a unique resource for future studies. Meteorological stations were established in these forests from the start and their data are compiled in annual reports.

Table 1. Experimental Forests at SLU.

Exp. forest	Location	Ecotype	Established	Main research focus
Asa	Lat. 57.1 long 14.7	nemoboreal	1988	Regeneration, yield, climate, water
Jädraås	Lat. 60.8 long 16.5	boreal	1979	Biomass measurements, yield
Siljansfors	Lat. 60.8 long 14.3	boreal	1921	Stand treatment, growth and yield
Tönnersjöheden	Lat. 56.4 long 13.1	nemoboreal	1923	Stand treatment, growth and yield
Skarhult	Lat. 55.5 long 13.2	nemoboreal	1989	Broad-leaved stands growth, yield
Vindeln	Lat 64-67 long 19	boreal	1923	Regeneration, yield, climate, water

Most of the SLU experiments in the Experimental Forests are registered in NOLTFOX. At SLU the Unit for Field-based forest research is responsible for the maintenance of most of the experiments. The on-going field activities at this unit are used by many of the departments at SLU but also open to co-operation with other research organizations like Skogforsk as well as e.g. Swedish Environmental Research Institute (IVL), University of Lund, University of Umeå, Mid Sweden University, Växjö University, and the National Board of Forestry.

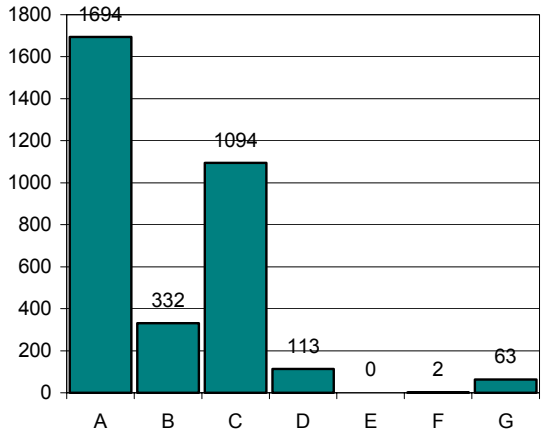
Datasets described

Experiments & references

Initially various old experiments were withdrawn from the dataset since they were not in a sufficient condition to be useful. The next steps of the work were to identify the status of the experiments and sort them into the subjects and objectives that were decided in the NOLTFOX working group. Finally keywords were added to enhance searching.

Skogforsk and SLU in total have 3298 active long-term forest experiments (Figure 1), whereof Skogforsk has 1621 and SLU 1677. Of these experiments 1584 have the highest priority, defined as priority 1: "*Experiments with a good statistical design, a special geographical location or some other reason that makes it of high value for present and future research"*.

Since the start of Noltfox, 23 of the experiments at SLU and 267 at Skogforsk have been terminated for their initial intended use. But since they still contain useful information they are kept in the database. Many of them can still be used in comparisons with other experiments, for other purposes or are included in valuable references. References have been added to many of the experiments. Today, SLU have 531 experiments with one or more references and Skogforsk 197.



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Database development

Updating of the database continues annually. A possible future development could be to link results from the experiments directly to the database. The internal SLU database, that is partly open to the public, to some extent also show results from the research made on the long-term experiments. However, many of the early results are not in English so a direct linking is not always meaningful.

- Forest field experiments in Swedish – http://www.silvaboreal.com/

Progress and perspectives

Benefits achieved with NOLTFOX

The existence of a common database of long-term experiments has increased knowledge about the experiments and the results obtained from the research made on them. It has also made it easier to receive financial support for the maintenance of the experiments. When applying for new projects on old experiments, these can be referred to in NOLTFOX. There are also forest owners that have become aware of the existence of the experiments when they plan their forest managements. NOLTFOX has also inspired the development of other databases e.g. the SLU internal SILVABOREAL and the international TREEBREEDEX.

Example of national benefits with long-term experiments:
During recent decades, results from long-term field experiments have been valuable to national authorities, agencies and to forest owners in various contexts, e.g. selection of genetic provenances and species, environmental impact assessments, strategies of nitrogen fertilizing, forest liming, silvicultural management, whole-tree harvesting and ash recycling.

Example of national research programmes that have used information from long-term field experiments:

- SUFOR Sustainable Forestry in Southern Sweden – http://www.sufor.nu/
- LUSTRA Land Use Strategies for Reducing Net Greenhouse Gas Emissions – http://www.mistra.org/lustra/

Importance of long-term experiments for environmental international efforts:
Studies of soil conservation are largely motivated by large-scale environmental problems such as transboundary pollution or the greenhouse effect. Long-term field experiments have provided useful sources of information during international collaboration, especially for the international conventions which Sweden takes part of. Other experiments are used in different international research projects within the EU.

Protocols and agreements within international environmental conventions often require an extensive knowledge base concerning underlying threats. These requirements may be sharpened in the future. Protocols may also contain clauses on national research and requirements for follow-up of the effects in already entered agreements. Results from long-term field experiments are critical to the following conventions:

- Convention of Long-Range Transboundary Pollution (CLRTAP)
- Framework Convention on Climate Change (UNFCCC)
- Convention on Biological Diversity (CBD)

Example of projects that use long-term experiments

SLU and Skogforsk pursue and participate in a number of field-based projects where the NOLTFOX-registered experiments are being used. Current projects that include studies of:

Genetic diversity and breeding:

- tree breeding improvement in northern Sweden with different tree species and provenances (Skogforsk)
- long-term tree-breeding improvement in southern Sweden of conifers and deciduous tree species (Skogforsk)

Ecosystem research

- nature & environment, effects on fauna, flora, soil and water of the eco-system and different silvicultural treatments (Skogforsk)
- the environmental effects of stump-removal (SLU and Skogforsk),
- reaction of ecosystems to nitrogen deposition (SLU)
- strategies for utilization of land to decrease greenhouse gas emissions (SLU and Skogforsk)

Stand treatment, growth and yield

- effects on earlier made growth increasing efforts on today's stands, in 40-year-old stands with thinning and fertilization and in 40-60-year-old cleaning experiments (SLU)
- effects in old experiments on yield using silviculture without clear-cutting (SLU)
- the effects on growth and yield of Ca and ash fertilization (SLU and Skogforsk in collaboration with Norway and Finland)
- sustainable management in hardwood forests (SLU)
- intensive cultivation of spruce and spruce wood production (SLU)
- utilization of boreal forest in the north of Sweden (SLU)

Future research needing long-term field experiments

The emphasis of forest research will continue to shift in response to society needs. A widened concept of sustainable forest management, an increasing need for renewable resources and changing market demands call for a more differentiated range of products from the forests are examples of causes for this change. The combination of basic science between different subject fields will continue to be of great importance in the understanding of different degrees of management efforts.

The following research themes are of interest for the future forestry and land use:

- ecology, forest genetics and plant physiology
- diversified production methods for sustainable forest ecosystem management
- forest development and protection in a changing environment
- nature conservation in protected and managed forests
- bioenergy: sustainable production
- forest management planning and inventory methods
- forests for protection of subsoil water and water quality

Soil science and soil biology
Three important factors that will affect the future environmental conditions in forest soils are;

- climate change
- the atmospheric chemical composition
- the land use

World-wide, most climate researchers believe that the increased emissions of green-house gases have influenced the earth's climate. A climatic change will affect forest and forestry conditions in many ways. Furthermore, the atmosphere has been affected by emissions of, i.e., acidifying compounds, ambient solvents, heavy metals, and persistent organic compounds. These substances have affected the ecosystems. Recently, the deposition from many pollutants has been reduced, but the effects on forest soils in terms of acidification, leaching of nutrients and accumulation of heavy metals, etc., are expected to be long lasting.

Tree production and harvesting, which lead to mobilization and removal of plant nutrients, will also be of vital importance for the future environmental status of Swedish forest soils and the organisms inhabiting the forest ecosystem. Biomass removal for bioenergy will increase and be of vital importance to future studies.