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Sustainable use of forest resources and bio-energy for mitigating and adapting climate change

Finnish–Japanese Forest Seminar
Abstracts and Conclusions
Joensuu, Finland, 7–9 September 2009

Markus Lier, Anne Luhtala and Arto Rummukainen (eds.)

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Title

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Hannu Raitio, Director General of Metla, 1 February 2010

Abstract

This issue of Metla's Working Papers is a compilation of the abstracts and presentations of the first Finnish–Japanese Forest Seminar on "Sustainable use of forest resources and bio-energy for mitigating and adapting climate change" held in Joensuu, Finland from 7–9 September 2009. The main goal of the seminar was to discuss the impacts of climate change on forest recourses, the adaptation of forests to climate change and their contribution to mitigation.

The forest seminar was a great success, increased the general knowledge base on climate change issues of both countries and helped Finnish and Japanese researchers to create a new research network or to deepen already existing relations. Altogether 30 participants from the Finnish Forest Research Institute (Metla), the Japanese Forestry and Forest Products Research Institute (FFPRI), Nagasaki University, the University of Tokyo, the Japan International Research Center for Agricultural Sciences (JIRCAS), the Advanced Industrial Science and Technology – Biomass Technology Research Centre (BTRC-AIST) Japan, Finnish Wood Research Oy and the Seinäjoki University of Applied Sciences participated in the first seminar.

Timely and important topics have been chosen for the next Finnish–Japanese Forest Seminar organized by FFPRI in autumn 2010 in Japan. The seminar will focus on three main issues: ecosystem services and public goods; physical and chemical properties of wood; and promoting private forestry. The preparations are already underway. The Academy of Finland financed the publication of this issue.

Keywords

Climate change, sustainable use of forests, bio-energy

Available at

http://www.metla.fi/julkaisut/workingpapers/2010/mwp144.htm

Replaces

Is replaced by

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Contents

Preface

The idea to organize a yearly scientific forest-linked seminar between Finland and Japan arose during the visit of Kazuo Suzuki, the President of the Japanese Forestry and Forest Products Research Institute (FFPRI), and his delegation at the Finnish Forest Research Institute (Metla) in 2008. The two organizations wanted to intensify their co-operation that started already in 2007. The aim of the seminars is to combine and develop knowledge of researchers in both countries on important and timely forestry related research topics.

The impacts of climate change on forest recourses, the adaptation of forests to climate change and their contribution to mitigation reflect important issues for both countries. These were the reasons why “Sustainable use of forest resources and bio-energy for mitigating and adapting climate change” was chosen as the topic for the first forest seminar. The seminar was organized in Joensuu, Finland 7–9 September 2009.

The forest seminar was a great success, increased the general knowledge base on climate change issues of both countries and helped Finnish and Japanese researchers to create a new research network or to deepen already existing relations. Altogether 30 participants from Metla, FFPRI, Nagasaki University, the University of Tokyo, the Japan International Research Center for Agricultural Sciences (JIRCAS), the Advanced Industrial Science and Technology – Biomass Technology Research Centre (BTRC-AIST) Japan, Finnish Wood Research Oy and the Seinäjoki University of Applied Sciences participated in the first seminar.

The abstracts and presentations of the first Finnish–Japanese Forest Seminar are published in this issue of Metla’s Working Papers. The Academy of Finland financed the publication of this issue.

Timely and important topics have been chosen for the next Finnish–Japanese forest seminar organized by FFPRI in autumn 2010 in Japan. The seminar will focus on three main issues: ecosystem services and public goods; physical and chemical properties of wood; and promoting private forestry. The preparations are already underway.

We would like to take the opportunity to thank all the participants for their contributions and effort in making the first Finnish–Japanese seminar a successful event.

Markus Lier, Anne Luhtala and Arto Rummukainen
Finnish Forest Research Institute (Metla)

Programme

Monday 7 September 2009

09:00–09:30 **Opening**
Welcoming *Hannu Raitio, Metla Director General*

Greetings from FFPRI *Isamu Okochi, Vice President*

10:00–11:30 **Session 1 Monitoring forests to understand impacts of climate change**
Chairs: Hannu Ilvesniemi, Metla and Ken Sugimura, FFPRI

Sustainable use of forest resources and bioenergy for mitigating and adapting to climate change in European Union *Jari Parviainen, Metla*

Monitoring of impacts of global climate change and human activities in vegetated area by satellite remote sensing *Haruo Sawada, University of Tokyo*

Carbon sequestration to fine roots in forest ecosystems *Leena Finér, Metla*

Impact of climate change on C and N transformations in organic soils *Tytti Sarjala, Metla*

12:30–13:30 Demonstration on the root laboratory research in Metla *Leena Finér, Metla*

13:30–17:00 **Session 2 Utilization of woody biomass for mitigating climate change**
Chairs: Antti Asikainen, Metla and Tomoko Sugimoto, JIRCAS

Production of 2-pyrone-4, 6-dicarboxylic acid as a novel polymer-based material from lignin by metabolic engineering of microbial functions *Yuichiro Otsuka, FFPRI*

Improving maturing process of compost using ozonated Japanese cedar as auxiliary feedstock *Tomoko Sugimoto, JIRCAS*

Research topics for expanding the use of logging residues in FFPRI *Hirofumi Kuboyama, FFPRI*

Utilization of woody biomass: future feedstock for biorefining *Antti Asikainen, Metla*

Process estimation of liquid fuel production process from woody biomass *Shinji Fujimoto, BTRC-AIST*

Future biorefinery *Hannu Ilvesniemi, Metla*

Tuesday 8 September 2009

09:00–12:00 **Session 3 Evaluating forest value under changing climate condition for sustaining healthy forests**
Chairs: Tytti Sarjala, Metla and Kentaro Yoshida, Nagasaki University

A stated preference approach to value ecosystem services of forests *Kentaro Yoshida, Nagasaki University*

Nature-based recreation in Finland *Tuija Sievänen, Metla*

Research projects for cultivation of Tricholoma matsutake in FFPRI *Takashi Yamanaka, FFPRI*

Ectomycorrhization of Tricholoma matsutake and two major conifers, and a field investigation in Finland *Lu-Min Vaario, Metla*

Bioactive compounds in endophytic fungi *Katja Viitala, Metla*

Wood construction in Finland – natural way of mitigating climate change *Henrik Heräjärvi, Metla*

13:00–14:00 Discussion on future forestry cooperation between Finland and Japan

14:00–16:30 Demonstration on European Forest Institute (EFI) activities *Risto Päivinen, Director EFI*

Wednesday 9 September 2009

08:00–18:00 **Excurssion**
Mitigation of Climate Change – Use of wooden bioenergy in Finland
- Harvesting forest biomass
- Case study Eno Energy Power Plant

Urpo Hassinen, forest energy adviser Forestry Centre of North Karelia
Antti Asikainen, Metla

Integrating biodiversity in multifunctional managed forests – Forest Biodiversity Action Programme for Southern Finland (METSO)
Hannu Lehtoranta, forest adviser Forestry Centre of North Karelia
Jari Parviainen, Metla

Matsutake growing site
Eira-Maija Savonen, Metla

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Session 1 Monitoring forests to understand impacts of climate change

Sustainable use of forest resources and bioenergy for mitigating and adapting to climate change in the European Union

Jari Parviainen

Finnish Forest Research Institute (Metla), Joensuu Research Unit, jari.parviainen(at)metla.fi

The goal of EU climate policy is to curtail global warming so that the average increase in global temperature does not exceed 20th century levels by more than 2°C. This threshold would mean that the level of CO_2 in the atmosphere should stay below 450 p.p.m.

EU targets in addition to those set under the Kyoto Protocol by 2020 (The climate and energy package European Parliament 17 December 2008):

- greenhouse gas emissions should be reduced by 20% compared to 1990 levels;
- the share of renewable energies should be increased to 20% of the EU's final energy consumption;
- energy efficiency should be increased by 20%;
- the share of biofuels should be increased to 10% of transport fuels;
- the EU is promoting a new target for developed countries – to reduce greenhouse emissions by 30% by 2020 compared to 1990 levels. If an international agreement is reached, the EU will sign up to it.

Forests cover 31% of Europe's land area and it is estimated that they sequester approximately 10% of Europe's annual CO_2 emissions. European forests have been functioning for several decades now as carbon sinks because their annual growth has exceeded fellings, thus helping to slow the build-up of CO_2 in the atmosphere. This means that over the last 40 years the average forest utilisation rate, or ratio of felling to growth, was less than 60% within the European area. These facts indicate that there is considerable potential for expansion of the use of wood for construction and also for forest bioenergy purposes (even when biodiversity considerations are taken into account).

At the request of European Commission Vice-President Margot Wallström, the European Economic and Social Committee (EESC) has adopted an opinion "The role of forests and the forest-based sector in meeting the EU's climate commitments" in its plenary session in March 2009. The main recommendations of EESC are that the EU should take measures to:

- endeavour to use wood in different ways and for different purposes, by promoting, for example, the use of sustainably produced forest bio-energy, increasing information about using wood in construction on the basis of life cycle calculations and common construction standards and by the Member States making wood construction part of their national timber procurement policy;
- be more active than at present in international forestry policy and to take the lead in promoting sustainably managed forests worldwide;

- set up a European committee of leading experts made up of representatives from the forestry industry, those framing forestry policy, researchers, forest owners and other key forestry, environmental and climate protection players. Its brief will be to enhance and widen the scope of dialogue on forestry issues and improve the transfer of know-how and decision-making;
- make every effort to meet the requirements for greenhouse gas reporting in the post-Kyoto period by the acceptance and inclusion of carbon stored in sustainably manufactured wood products as a mandatory instrument in carbon balance calculations, and by the development of a REDD [Reducing Emissions from Deforestation and Forest Degradation] instrument as an effective carbon trading tool and its acceptance in carbon balance calculations of land-use changes, particularly with a view to preventing forest loss in developing countries.
- support research, inventories of forest reserves, the mapping of risk areas susceptible to the effects of climate change and the development of systems for monitoring the condition of forests and to ensure funding for these.

In addition EU Member States should develop forest management contingency plans for the prevention of forest damage caused by extreme phenomena (storms, drought, forest fires, damage by insects) and for remedying the effects of such damage, in addition to increasing information about the importance of forest management.

In Finland the latest climate and energy strategy was accepted by the Government on 6 November 2008. This strategy covers climate and energy policy measures in great detail up to 2020, and in brief thereafter, up to 2050.

The main effects of expected climate change in Finland's boreal vegetation zone are: The growing season is likely to lengthen; forest growth may increase; wind damage will become more prevalent; and in the temperate zone insect pests are expected to spread northwards, possible causing damage on a massive scale. Good and timely forest management is the main way of improving the ability of forests to adapt to climate change. Strong emphasis has been put on the mitigation issues by promoting the use of wood. These actions include the increased use of wood-based bioenergy (including biofuels) and wooden construction. In the land use, land-use change and forestry (LULUCF) sector Finland has a sink of carbon that amounted to -25 million tons of CO_2 during 2007. That sink originated mainly from a sink in the tree biomass, which is driven by the amount of annual fellings – i.e. the sink is greater when annual fellings are less.

The EESC opinion can be downloaded by all the EU member states languages on the address: http://eescopinions.eesc.europa.eu/EESCOpinions.aspx , selections NAT, opinion no 626.

Appendix

Presentation: Sustainable use of forest resources and bioenergy for mitigating and adapting to climate change in the European Union

Finnish - Japanese Seminar

Sustainable Use of Forest Resources and Bioenergy for mitigating and adapting the Climate Change

7.-9. September 2009, Joensuu Metla House

Jari Parviainen
Finnish Forest Research Institute (Metla), Joensuu

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Sustainable Use of Forest Resources an Bioenergy for Mitigating and Adapting the Climate Change from the Finnish perspective in EU-27

Content:

European climate commitments

Impact, Adaptation and Mitigation

Actions at European level and Finland

Monitoring and verification issue

Sustainable forest management (SFM)

Criteria and indicators of SFM

Conclusions

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EU targets in addition to those set under the Kyoto Protocol by 2020:

The climate and energy package (EP 17 December 2008)

- greenhouse gas emissions should be reduced by 20% compared to 1990 levels;
- the share of renewable energies should be increased to 20% of the EU's final energy consumption;
- energy efficiency should be increased by 20%;
- the share of biofuels should be increased to 10% of transport fuels
- the EU is promoting a new target for developed countries – to reduce greenhouse emissions by 30% by 2020 compared to 1990 levels. If an international agreement is reached the EU will sign up to it.

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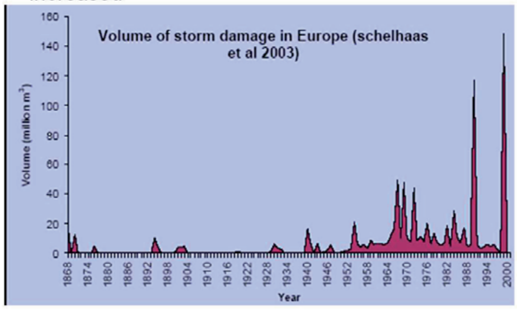
Extreme weather phenomena such as drought, forest fires, storms or snow damage: frequency increased



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BASICS FOR THE EU'S CLIMATE COMMITMENTS

The goal of EU climate policy is to curtail global warming so that the average increase in global temperature does not exceed 20th century levels by more than 2°C. This threshold would mean that the level of CO_2 in the atmosphere should stay below 450 ppm.

FACTS: The average annual temperature of the air near to the earth's surface has risen by 0.74 °C over the past 100 years. Similarly, the proportion of CO_2 in the atmosphere increased from 280 ppm in 1800 to 380 ppm in 2005, i.e. by more than 35%.

ESTIMATIONS ? The average temperature of the atmosphere is estimated to increase by between 1.1 and 4° C by 2100.

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The impact of climate change on forests (Regional differences)

Regional differences:

- in the **Mediterranean region** it is likely that dry, hot periods will increase, resulting in a shortage of fresh water and an increased risk of forest fires and desertification;
- in **central Europe** the growing season will become longer; forest growth may increase; the proportion of broadleaved trees is likely to grow; rainfall amounts may decline and drought occur; climatic extremes, notably storm damage, will become more prevalent;
- the growing season in the **northern coniferous zone** is likely to lengthen; forest growth may increase; wind damages will become more prevalent; and in the temperate zone insect pests are expected to spread northwards, possible causing damage on a massive scale.

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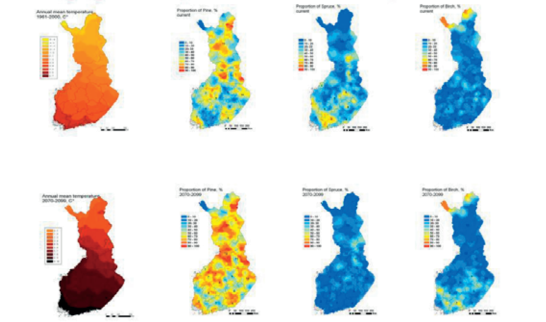
Success of Scots pine, Norway spruce and birch under changing climate (FINADAPT A2 scenario, Kellomäki et.al.



The role of forests in adapting to climate change (Management)

Major issues:

- Forest management (tree species, regeneration, native tree species, mixed forests, conversion, restoration)
- Biodiversity
- Alien species
- Damaging plant pests
- Forest protection/commercial forests
- Integrated forest protection

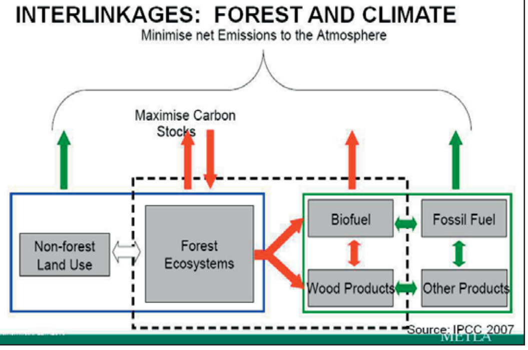
The role of forests in adapting to climate change (Management)

Good forest management is the main way of improving the ability of forests to adapt to climate change. Awareness of the importance of forest management in adapting to climate change must be increased among members of the public, forest owners and those responsible for forest management.

Forest management contingency plans, funding options for covering any damage and operational models must be drawn up so that the industry is prepared for the detrimental effects of sudden and extreme weather caused by climate change and the damage it causes to forests.

Areas that are particularly at risk from such extreme weather conditions must **be mapped** out in advance. Operational models also need to be drawn up for dealing with sudden increases in timber felling and for ensuring the smooth functioning of timber markets.

The role of forests in curbing the climate change (Mitigation issues)

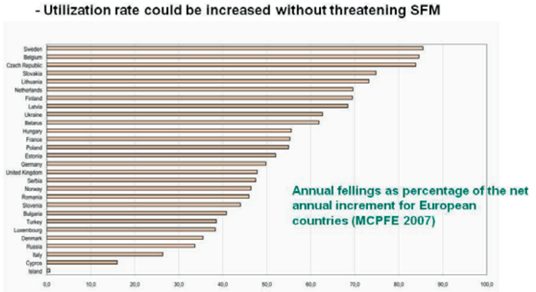


Use of wood for construction (life-cycle, standards)

For Metla House the carbon sequestration capacity and the substitution effects were calculated. The amount of used wood was 2000 m³, which correspond 1460 tons carbon dioxide. In compare to the similar building from concrete the construction of Metla House has saved 620 tons of CO_2

Forest utilization rate in Europe is about 50%

- Net annual increment of growing stock amounts 1350 million m³
- amount of wood available in forests has continued to increase
- Utilization rate could be increased without threatening SFM

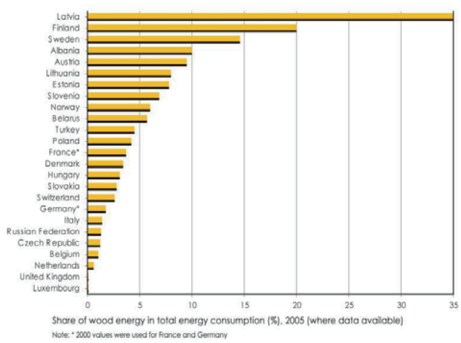


Bioenergy from wooden biomass

Wood-based energy (heating, electricity, biofuels)

- resources, availability, harvesting, transportation and logistics

Forest Resources for energy in Europe



Actions
White paper "Adaptation package"1st April 2009

- White Paper «Adapting to climate change: Towards a European framework for action»
- Accompanied by sectoral Working Documents
  - *Adapting to climate change: the challenge for European agriculture and rural areas*
  - *Human, animal and plant health impacts of CC*
  - *Climate change and water, coasts and marine issues*
- Long term, phased approach
  - *Phase 1 (2009-2012): groundwork for a comprehensive EU adaptation strategy*
  - *Phase 2 (2013 →): implementation*

EU Forest Action Plan is the main instrument (2007 – 2011)

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Green Public Procurement (GPP)

The **European Commission's communication** for public procurement released on 16th of July 2008.

- **Goal:** to provide guidance on how to reduce environmental impact caused by public sector consumption and to stimulate innovation in environmental technologies, products and services
- 10 sectors have been identified as the most suitable for implementing GPP. Out of these, **four sectors (construction, paper, furniture and energy)** are relevant regarding wood and wood-based products
- Verification includes for timber the principles "legal and sustainable"

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EU RES Directive /December 2008

Requirements:

1. Greenhouse gas emissions savings

   Minimum requirement for GHG saving in relation to fossil fuels at least 35%, and from 2017 50%.

2. Biofuels/bioliquids not from raw material from land with high biodiversity value
3. Biofuels/bioliquids not from raw material from land with high carbon stock

Economic operators have to show that environmental criteria have been fulfilled

Verification issues not yet specified

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Finland's Political Actions

- Long-term climate and energy strategy by Finnish Government until 2020, partly until 2050

National Forest Programme 2015

- The latest programme NFP 2015 was adopted by Finnish Government **27 March 2008** together with METSO Programme (Forest Biodiversity Programme for Southern Finland)
- These two programmes (NFP and METSO) secure that the economic use and biodiversity can be taken balanced in consideration
- The main aim of the NFP is to increase the annual domestic use of wood with 10-15 mill. m³ for pulp/paper, mechanical wood processing and bioenergy. Extensive financial support for private forest owners for voluntary safeguarding of the biodiversity in forests

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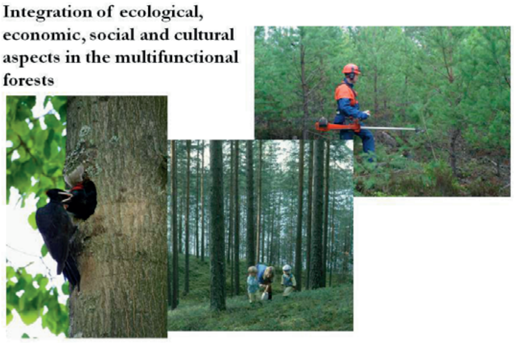
Sustainable Forest Management (SFM)

Integration of ecological, economic, social and cultural aspects in the multifunctional forests



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Uncontrolled use and overexploitation of forest in Europe led to establishment of organized forestry systems in 1700

"Sustainability"

The term "sustainable" was first related to sustainable yield of forest resources and probably first mentioned by the German

Hans Carl von Carlowitz in 1713

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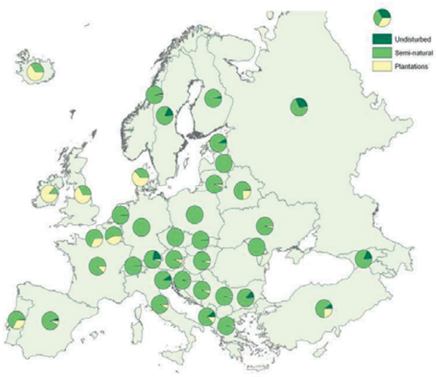
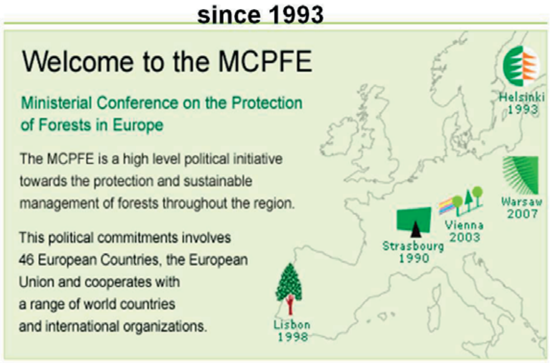
Forest area by classes of naturalness in 2005 for countries where data available



Modern concept for sustainability in forests since 1993



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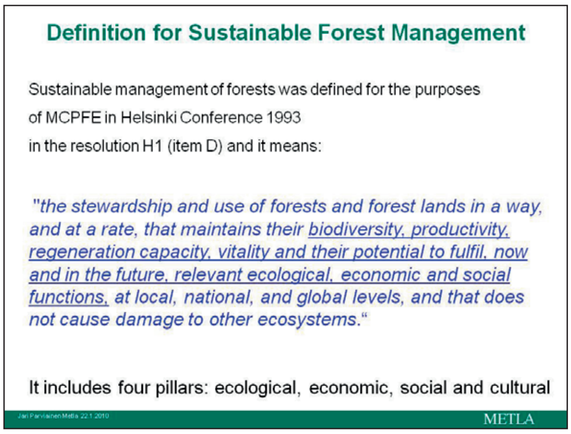
Definition for Sustainable Forest Management
Sustainable management of forests was defined for the purposes
of MCPFE in Helsinki Conference 1993
in the resolution H1 (item D) and it means:
"the stewardship and use of forests and forest lands in a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfil, now and in the future, relevant ecological, economic and social functions, at local, national, and global levels, and that does not cause damage to other ecosystems."
It includes four pillars: ecological, economic, social and cultural
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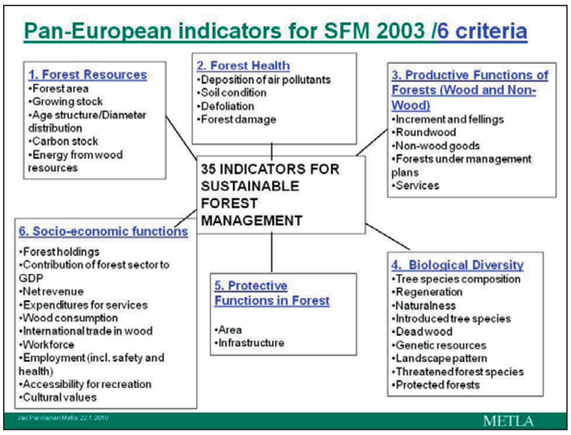
Pan-European indicators for SFM 2003 /6 criteria
1. Forest Resources
•Forest area
•Growing stock
•Age structure/Diameter distribution
•Carbon stock
•Energy from wood resources
2. Forest Health
•Deposition of air pollutants
•Soil condition
•Defoliation
•Forest damage
3. Productive Functions of Forests (Wood and Non-Wood)
•Increment and fellings
•Roundwood
•Non-wood goods
•Forests under management plans
•Services
35 INDICATORS FOR SUSTAINABLE FOREST MANAGEMENT
6. Socio-economic functions
•Forest holdings
•Contribution of forest sector to GDP
•Net revenue
•Expenditures for services
•Wood consumption
•International trade in wood
•Workforce
•Employment (incl. safety and health)
•Accessibility for recreation
•Cultural values
5. Protective Functions in Forest
•Area
•Infrastructure
4. Biological Diversity
•Tree species composition
•Regeneration
•Naturalness
•Introduced tree species
•Deadwood
•Genetic resources
•Landscape pattern
•Threatened forest species
•Protected forests
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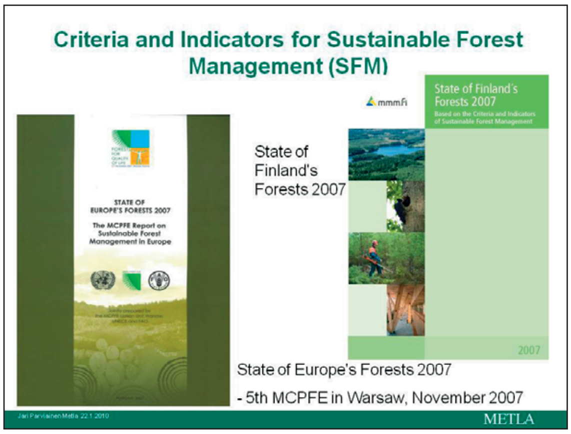
Criteria and Indicators for Sustainable Forest Management (SFM)
State of Finland's Forests 2007
State of Europe's Forests 2007
- 5th MCPFE in Warsaw, November 2007
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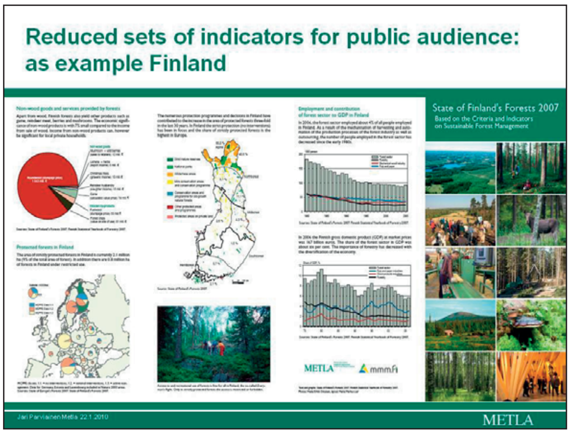
Reduced sets of indicators for public audience: as example Finland
State of Finland's Forests 2007
Based on the Criteria and Indicators on Sustainable Forest Management
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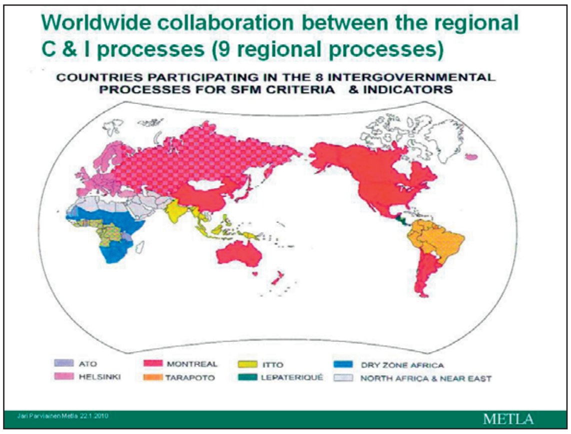
Worldwide collaboration between the regional C & I processes (9 regional processes)
COUNTRIES PARTICIPATING IN THE 8 INTERGOVERNMENTAL PROCESSES FOR SFM CRITERIA & INDICATORS
ATO
HELSINKI
MONTREAL
TARAPOTO
ITTO
LEPATERIQUE
DRY ZONE AFRICA
NORTH AFRICA & NEAR EAST
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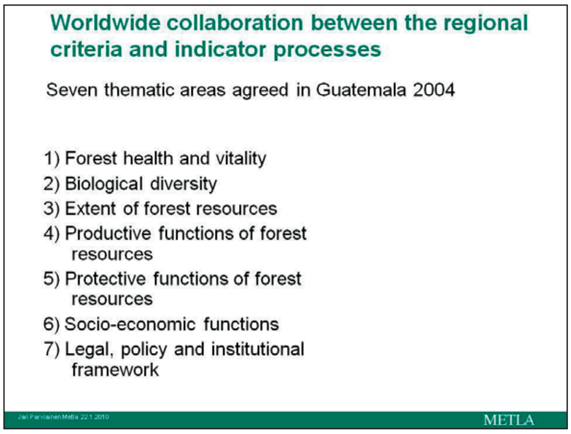
Worldwide collaboration between the regional criteria and indicator processes
Seven thematic areas agreed in Guatemala 2004
1) Forest health and vitality
2) Biological diversity
3) Extent of forest resources
4) Productive functions of forest resources
5) Protective functions of forest resources
6) Socio-economic functions
7) Legal, policy and institutional framework
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International and country reports of SFM
Forest Report 2005
State of Finland's Forests 2007
STATE OF THE WORLD'S FORESTS
2003
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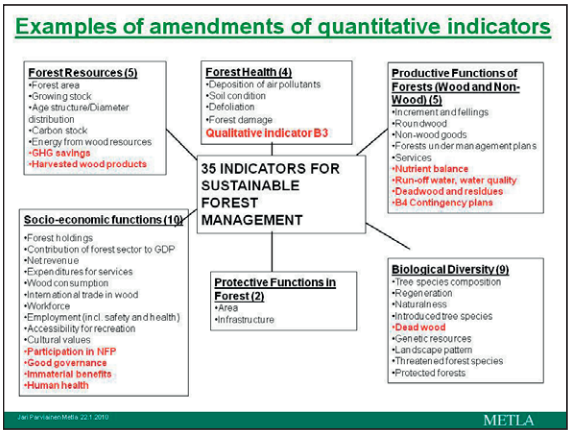
Examples of amendments of quantitative indicators
Forest Resources (5)
•Forest area
•Growing stock
•Age structure/Diameter distribution
•Carbon stock
•Energy from wood resources
•GHG savings
•Harvested wood products
Forest Health (4)
•Deposition of air pollutants
•Soil condition
•Defoliation
•Forest damage
Qualitative indicator B3
Productive Functions of Forests (Wood and Non-Wood) (5)
•Increment and fellings
•Roundwood
•Non-wood goods
•Forests under management plans
•Services
•Nutrient balance
•Run-off water, water quality
•Deadwood and residues
•B4 Contingency plans
35 INDICATORS FOR SUSTAINABLE FOREST MANAGEMENT
Socio-economic functions (10)
•Forest holdings
•Contribution of forest sector to GDP
•Net revenue
•Expenditures for services
•Wood consumption
•International trade in wood
•Workforce
•Employment (incl. safety and health)
•Accessibility for recreation
•Cultural values
•Participation in NFP
•Good governance
•Immaterial benefits
•Human health
Protective Functions in Forest (2)
•Area
•Infrastructure
Biological Diversity (9)
•Tree species composition
•Regeneration
•Naturalness
•Introduced tree species
•Dead wood
•Genetic resources
•Landscape pattern
•Threatened forest species
•Protected forests
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Forest certification

PEFC is based on the internationally agreed concept on sustainable forest management (thematic areas of nine regional C&I processes) and internationally used rules and procedures on certification processes.

The FSC certification system uses ten general principles of good forest stewardship.

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CONCLUSIONS

- **Forests and wood-based products have an important as a cost-effective measure to tackle climate change**
- **Forests have been functioning several decades as carbon sinks because their annual growth has exceeded fellings, thus helping to slow the build-up of carbon dioxide in the atmosphere.**
- **The use of sustainably produced wood should be promoted** in different ways and for different purposes,
  - the use of sustainably produced forest bio-energy,
  - increasing information about using wood in construction on the basis of life cycle calculations and common construction standards
  - by making wood construction part of their national timber procurement policy

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MORE INFORMATION:

http://www.eecs.eu

OPINION of the

European Economic and Social Committee

The role of forests and the forest-based sector in meeting the EU's climate commitments

Adopted 25 March 2009

Prepared by the Section for Agriculture, Rural Development and the Environment

Expert: Jari Parviainen Rapporteur: Seppo Kallio

METLA

Thank you!

jari.parviainen@metla.fi
www.metla.fi/jo

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Monitoring of impacts of global climate change and human activities in vegetated area by satellite remote sensing

Haruo Sawada

Institute of Industrial Science, The University of Tokyo, sawada(at)iis.u-tokyo.ac.jp

Although human activities have developed natural landscape and established agricultural land and expanded cities, human life still depends upon natural blessings, for example, forest products, fuels, natural food, and water. Even when we consider these environmental issues in a country, it is necessary to consider global environmental changes which affect each country. Global environments including atmosphere and ocean (ex. temperature, precipitation and sunshine), are very much correlated with terrestrial environment. Especially, vegetation reflects these environment conditions in time and space. Therefore, if we monitor natural vegetation with appropriate way by remote sensing, we may get the environmental information as well.

There are several ways to monitor natural environmental parameters. Meteorological station has a long history of such measurement. Flux tower offers sophisticated ways of measuring the interaction between ecosystem and atmosphere. The AsiaFlux is one of such groups who are promoting the flux measurement. The collected data are quite useful for evaluating the relations between global environment parameters and response of ecosystems. It is also unique information for evaluating global models to predict future environmental problems.

In these activities, remote sensing plays important role to apply the plot based information into broad area, named as the scale-up process. Satellite remote sensing allows us to observe the Earth with the same instruments, such as TM, MODIS, and AVHRR. Therefore, we have the possibility to compare the data in various observation areas with the same instrument for a certain period of time. It is a good characteristic of remote sensing to share data of the same quality with people in different countries and different fields. We have several project in Asia and South America and found that information with the same quality is essential for mutual understandings in regional issues.

Remote sensing data offers some indices which help us understanding the situation of land covers and their environmental parameters. NDVI, NDII, SAVI and other indices are very popular ones to monitor vegetated area. Land surface temperature (LST) is also obtained from the satellite data. It must be useful to understand the global warming and its influences on the Earth. SAR makes us possible to get clear images even on rainy day. The full polarimetric SAR provides three indices which correspond to one-bounce, two-bounce and multi-bounce layers. The colour composite image of these three channels forest structures.

The modelling methodology LMF-KF for time-series remote sensing dataset allows us monitoring seasonal changes and phenological aspects of land surface. The impact of global environmental changes is shown as phenological changes of vegetation at the first stage. The LMF-KF allows us to monitor the vegetation conditions very frequently. The LMF-KF applies the combination of cyclic functions to time-series satellite data. The combination of NDVI and LST of the processed data provides good colour composite images of the world. The combination can create various datasets which are useful for zoning the area from the ecological point of view.

One of the major objectives of our studies is to establish the integrated network of forest ecosystem observations including environmental parameters using flux tower as well as remote sensing. The network may integrate the information in both time and space and contribute the conservation of natural ecosystem through the monitoring of impacts of global climate change and human activities in vegetated area.

Impact of climate change on C and N transformations in organic soils

Tytti Sarjala

Finnish Forest Research Institute (Metla), Parkano Research Unit, tytti.sarjala(at)metla.fi

Impact of climate change on C and N transformations in organic soils
Tytti Sarjala

Finnish-Japanese Seminar
Metla, Joensuu 7.9.2009

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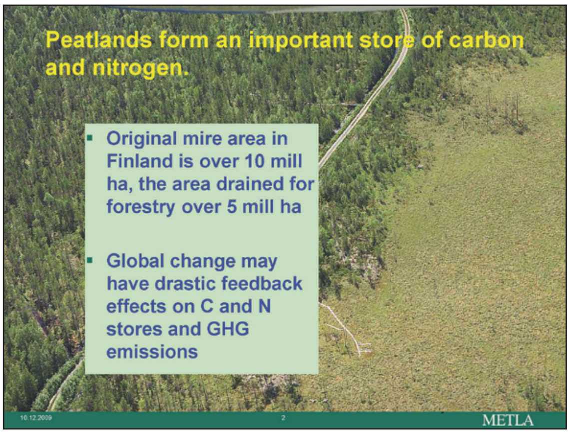

The aims of the project:

We assess the impacts of

- rising temperatures
- changing ground water level
- peat N concentration

We measure the effects on:

- transformations and allocation of C and N in peat
- soil greenhouse gas exchange

We use the results to:

- to evaluate the growth conditions of peatland forests
- to improve methods in national greenhouse gas inventory

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Carbon pathways in peatland

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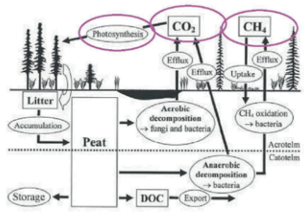

Fig. 1. Major carbon pathways in peatlands and the microbial groups (fungi, bacteria) responsible for the dominant biogeochemical processes.

Thormann, M.N. 2007. Can. J. Soil Sci. 86: 281-293

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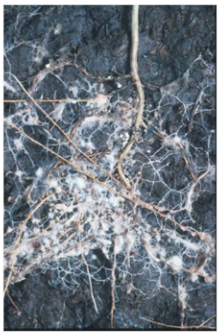
The role of fungi is important in peatlands

- extensive hyphal growth
- they have faster growth rates than bacteria
- ability to translocate nutrients through their hyphal network.



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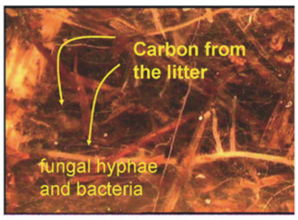
Saprotrophic fungi

- Decombosers (saprobes) significantly influence carbon dynamics by degrading organic matter via the synthesis of extracellular enzymes.
- They are dependent on carbon input from organic litter into soil



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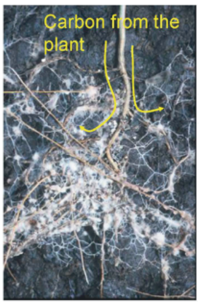
Mycorrhizal fungi, symbiotic relationship between fungus and plant

- If mycorrhizal symbionts consume on average 15% of photosynthates, then plants allocate carbon to mycorrhizal fungi more than the sum of all human-caused C emissions. (Langley et al.2006. Ecol.Lett.9) → LARGE SINK OF CARBON
- Mycorrhizae are dependent on C input from the host plant, but not on C from the litter layer



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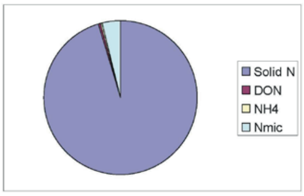
Nitrogen in peat



- Total N in peat usually 0.7-3.5% of dry mass
- Dissolved inorganic N (NH_4^+, NO_3^-) < 0.5%
- DON (dissolved organic N) (e.g. amino acids, proteins, amines, aminosugars) < 1%
- NO_3^- concentrations are very low or zero

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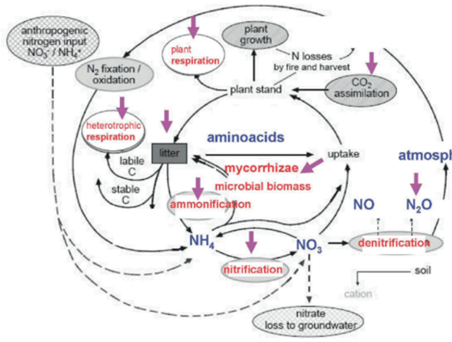
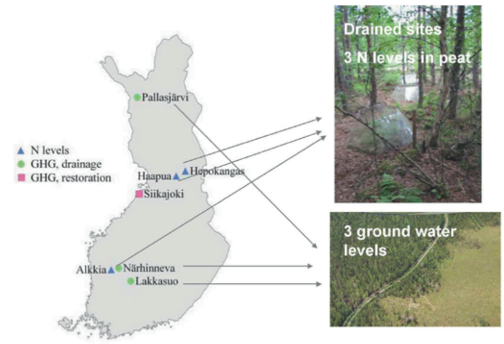
Nitrogen transformations in ecosystem



Schulze (2000)
Ecological studies 142: Capter 1

Experimental areas



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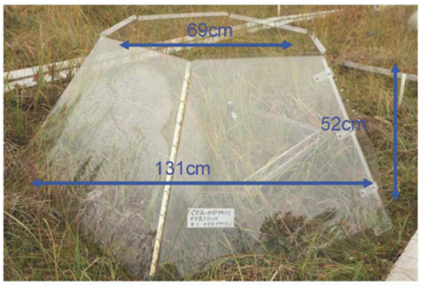
Open top chambers



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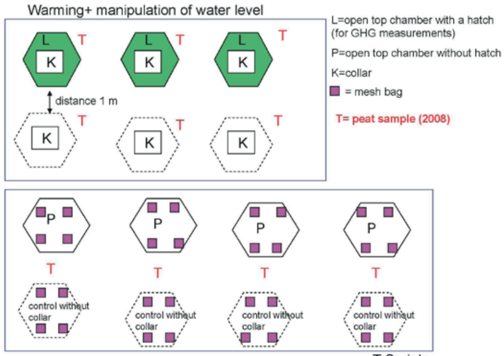
Närhinneva, Lakkasuo, Pallasjärvi, Siikajoki

Warming+ manipulation of water level



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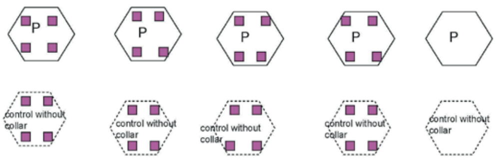
Alkkia, Hepokangas, Haapua

Warming and N levels in drained sites

- open top chambers without hatch, no GHG measurements
- minirhizotron tubes for fine root observations
- cellulose strips for decomposition measurements

P = open top chamber without hatch
■ = mesh bag



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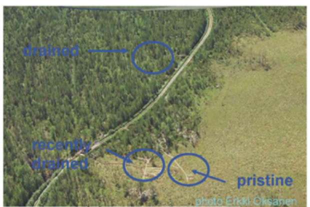
Närhinneva

Experimental setup in 2008:

- ground water level: a) pristine, b) recently drained, c) drained
- warming: a) open top chambers b) controls

We will measure:

- temperature (loggers, +2m, +30cm, -5cm, -15cm, -30cm), ground water level
- peat samples in autumn 2008: nutrients, microbial biomass, pH
- fungal biomass in peat (total, extramatrical mycorrhizal mycelium with in growth mesh bags)
- GHG (CO_2, N_2O, CH_4)
- vegetation
- root biomass
- litter decomposition
- microbial biomass and activity
- fungal biomass and community



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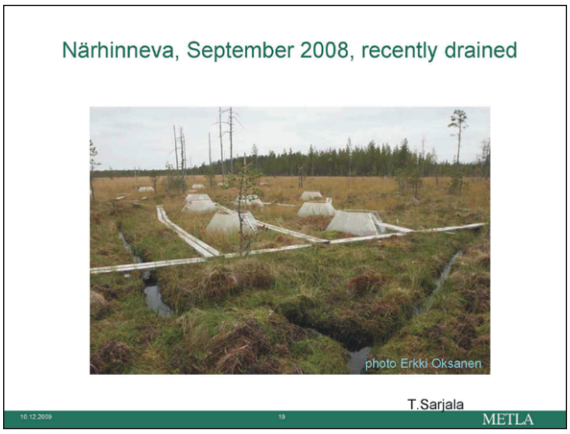

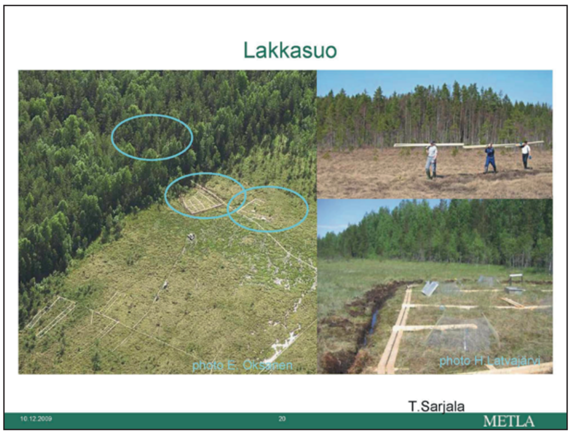

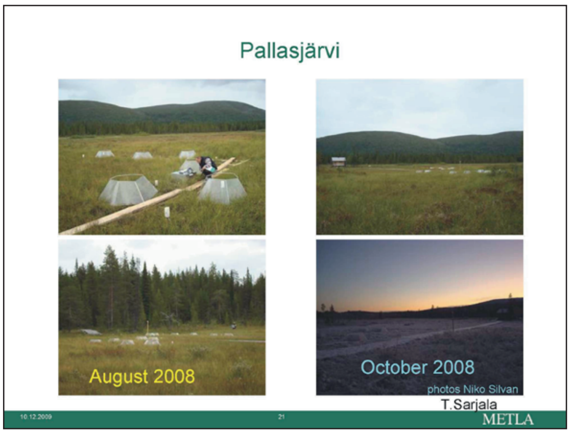

Temperature effect in open top chambers during the growing season in 2008:

- on open mire +1.1 °C in average at 30cm above ground
- + 0.7 °C in average in soil (5-30cm below ground)
- on drained sites +0.3 °C in average at 30cm above ground
- + 0.1-0.5 °C in average in soil (5-30cm below ground)

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The first results from GHG measurements in 2008 in Närhinneva

- seasonal CO_2-C sequestration slightly decreased due to water level drawdown caused by the shallow drainage. Also warming treatment decreased slightly the CO_2-C sequestration in pristine and drained sites.
- Shallow drainage decreased slightly CH_4 emission and almost no CH_4 emission was observed on the drained site.
- Temperature treatment had only a weak effect on CH_4 or N_2O emission. On pristine site N_2O emissions were lower than on shallow drainage or drained sites

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Our preliminary results from one year 2008 and one site (Närhinneva):

Both hydrology and temperature affect at the same time on GHG emissions and drying of the surface peat due to increased temperature has to be taken into account when interpreting the results.

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Acknowledgements

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Eeva-Stiina Tuittila
Kari Minkkinen (VAPO)

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Session 2 Utilization of woody biomass for mitigating climate change

Production of 2-pyrone-4,6-dicarboxylic acid as a novel polymer-based material from lignin by metabolic engineering of microbial functions

Yuichiro Otsuka[1], Masaya Nakamura[1], Seiji Ohara[1], Eiji Masai[2], Kiyotaka Shigehara[3] and Yoshihiro Katayama[3]

[1]Forestry and Forest Products Research Institute (FFPRI), Tsukuba, Ibaraki, Japan, corresponding author: yotuka(at)ffpri.affrc.go.jp
[2]Nagaoka University of Technology, Nagaoka, Niigata, Japan
[3]Tokyo University of Agriculture and Technology, Koganei, Tokyo, Japan

Lignins are the most abundant aromatic biomass in nature. Utilization of this abundant biomass has been expected but has not yet been established. One of the practical ways to utilize lignin is to degrade it using the chemical reactions or enzyme reactions of microorganisms to produce utilizable aromatic compounds such as vanillin for aroma or polymer-based chemical. However, these chemical or enzyme reactions concurrently produce various aromatic compounds from lignin not only vanillin and also vanillic acid, syringaldehyde, syringic acid and other mono- or di-aromatic compounds. If we utilize lignin in this way, it is necessary to purify the target compounds from various aromatic compounds mixture. As yet, an efficient system for utilizing lignin has not been established.

The soil bacterium, *Sphingobium* sp. SYK-6, which can degrade various low molecular weight compounds derived from lignin, metabolizes these substances via 2-pyrone-4,6-dicarboxylic acid (PDC). We focused on this metabolic intermediate as a raw material for novel bio-based polymers. We cloned the genes encoding aromatic compound metabolic enzymes from SYK-6, into a broad host-range plasmid vector, pKT230MC. The resulting plasmid, pligVABCvanAB, was introduced into the PpY1100 strain of *Pseudomonas putida*, and we found that PDC could be reliably produced from various aromatic compounds such as vanillin, vanillic acid, syringaldehyde and syringic acid, and accumulated.

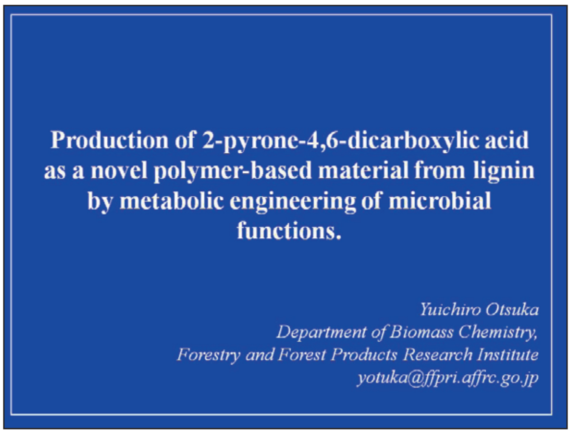
PDC has a unique structure (pyrone ring and two carboxyl groups) and its synthesis method had not been established by artificial chemical reactions. Now that we have mass-produced PDC for the first time, various polymer studies and applied research will be able to proceed. Using the PDC as a raw material, it is expected to lead to the development of novel PDC-based plastics and fibers, etc. just as they can be obtained from petrochemicals. In addition, PDC is one of major intermediates of aromatic compound metabolic pathway in various soil bacteria. Therefore, it is considered that the PDC-based materials are biodegradable materials. Now that we have established a production system of PDC from vanillin, vanillic acid, syringaldehyde and syringic acid, it will be possible to organize the systems of PDC production from various other compounds found in lignin derivatives by further application of the metabolic pathways of SYK-6. We expect that in future we will be able to produce PDC from lignin that is abundantly present in woody biomass and to produce bio-based polymers in further studies.

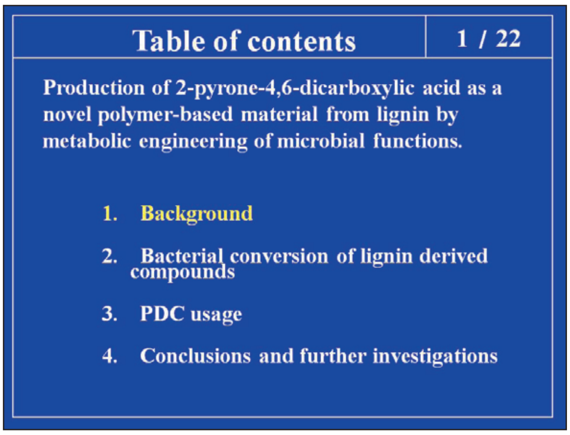
Reference

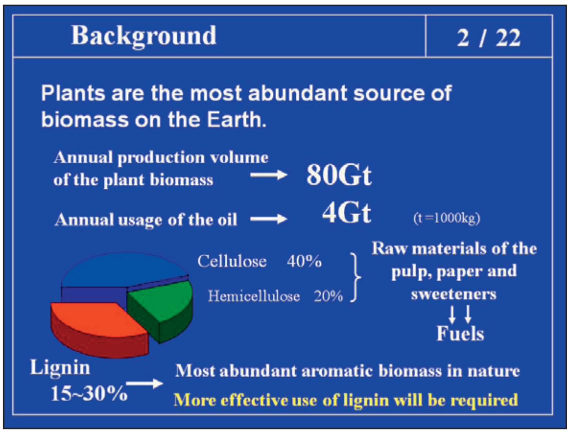
Otsuka, Y., Nakamura, M., Shigehara, K., Sugimura, K., Masai, E., Ohara, S., Katayama, Y. (2006). "Efficient production of 2-pyrone 4,6-dicarboxylic acid as a novel polymer-based material from protocatechuate by microbial function", Applied Microbiology and Biotechnology, 71, 608–614

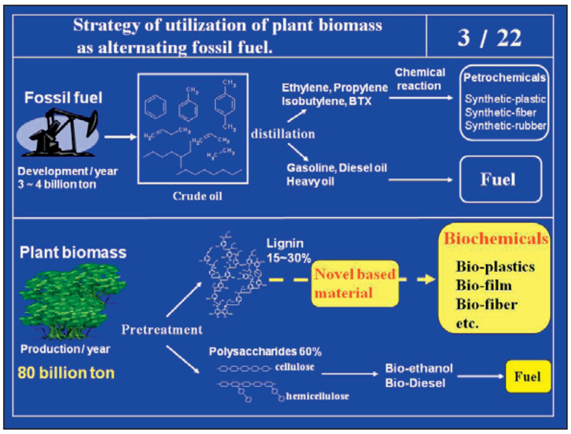
Appendix

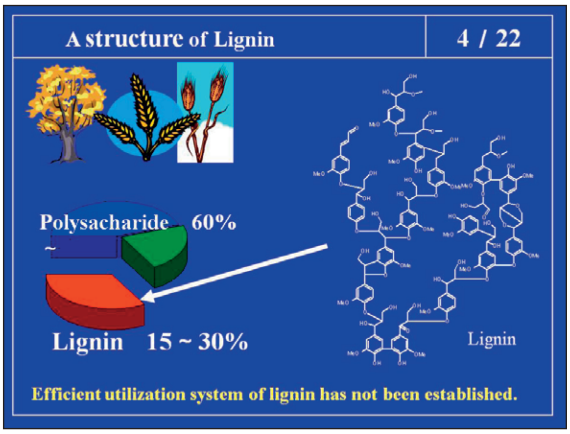
Presentation: Production of 2-pyrone-4,6-dicarboxylic acid as a novel polymer-based material from lignin by metabolic engineering of microbial functions

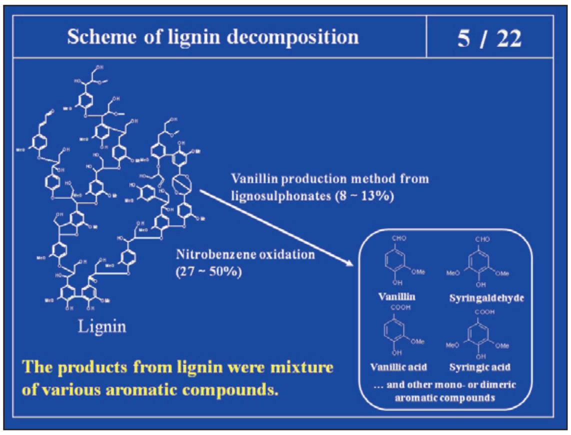












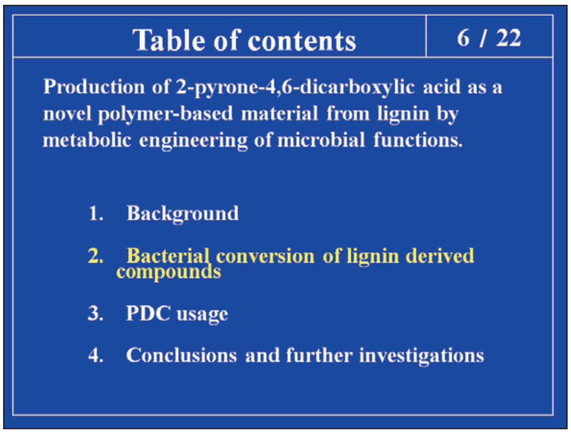


Table of contents
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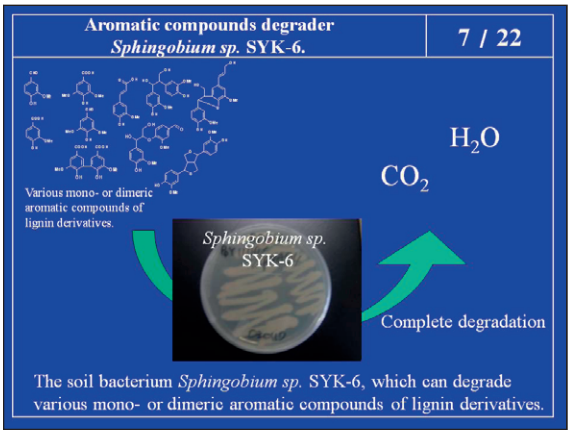
Production of 2-pyrone-4,6-dicarboxylic acid as a novel polymer-based material from lignin by metabolic engineering of microbial functions.
1. Background
2. Bacterial conversion of lignin derived compounds
3. PDC usage
4. Conclusions and further investigations


Aromatic compounds degrader
Sphingobium sp. SYK-6.
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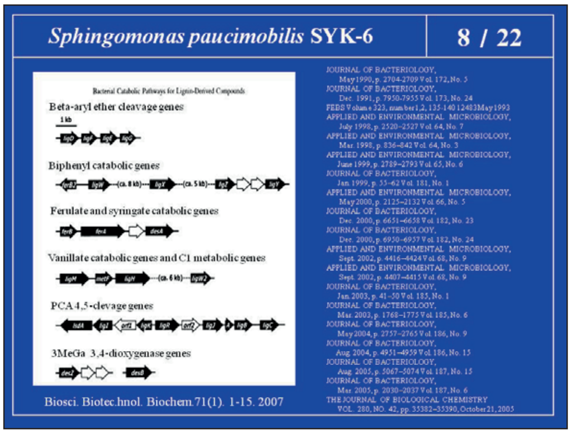
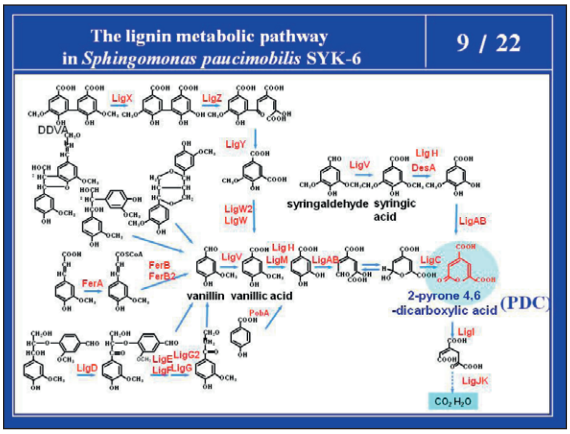
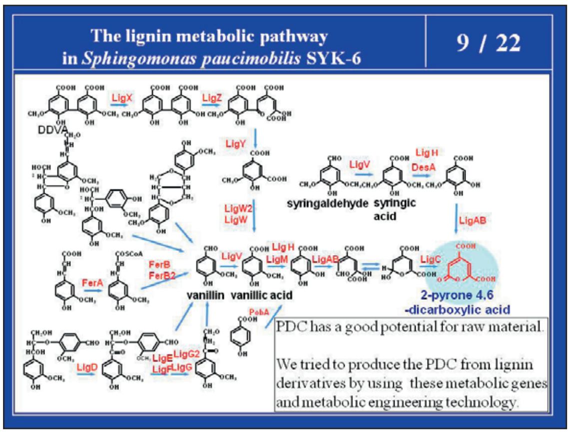
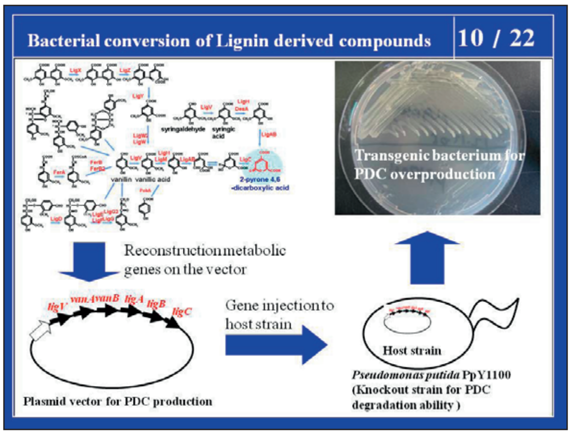
Various mono- or dimeric aromatic compounds of lignin derivatives.
Sphingobium sp. SYK-6
H2O
CO2
Complete degradation
The soil bacterium Sphingobium sp. SYK-6, which can degrade various mono- or dimeric aromatic compounds of lignin derivatives.


Sphingomonas paucimobilis SYK-6
8 / 22
Beta-aryl ether cleavage genes
Biphenyl catabolic genes
Ferulate and syringate catabolic genes
Vanillate catabolic genes and C1 metabolic genes
PCA 4,5-clevage genes
3MeGa 3,4-dioxygenase genes
Biosci. Biotechnol. Biochem.71(1). 1-15. 2007


The lignin metabolic pathway
in Sphingomonas paucimobilis SYK-6
9 / 22
DDVA
LigX
LigZ
LigY
LigV
LigH
DesA
syringaldehyde
syringic acid
LigW2
LigW
LigAB
FerA
FerB
FerB2
vanillin
vanillic acid
LigC
2-pyrone 4,6 -dicarboxylic acid
(PDC)
LigI
LigJK
LigD
LigE
LigG2
LigF
LigG
CO2 H2O


The lignin metabolic pathway
in Sphingomonas paucimobilis SYK-6
9 / 22
DDVA
syringaldehyde
syringic acid
vanillin
vanillic acid
2-pyrone 4,6 -dicarboxylic acid
PDC has a good potential for raw material.
We tried to produce the PDC from lignin derivatives by using these metabolic genes and metabolic engineering technology.


Bacterial conversion of Lignin derived compounds
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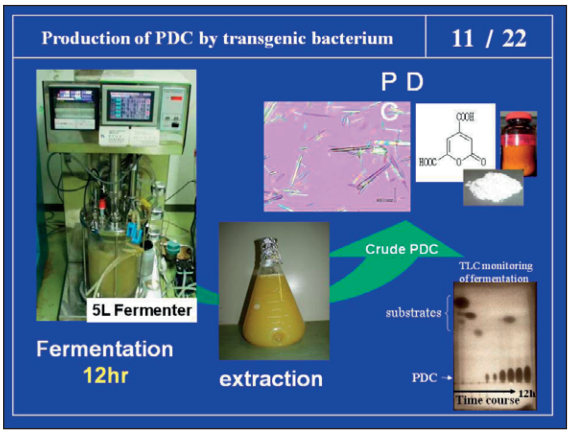
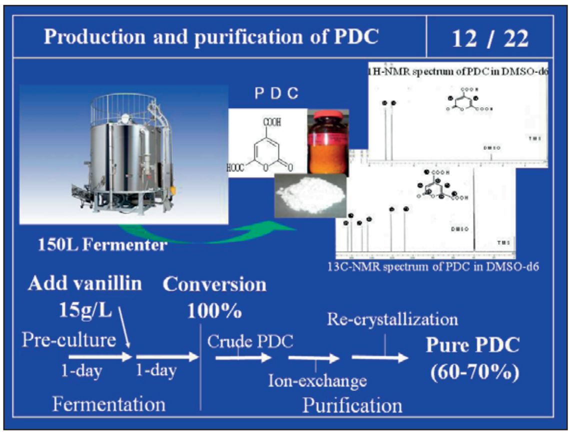
Transgenic bacterium for PDC overproduction
Reconstruction metabolic genes on the vector
Gene injection to host strain
Host strain
Plasmid vector for PDC production
Pseudomonas putida PpY1100
(Knockout strain for PDC degradation ability)


Production of PDC by transgenic bacterium
11 / 22
PDC
5L Fermenter
Fermentation
12hr
extraction
Crude PDC
TLC monitoring of fermentation
substrates
PDC
Time course
12h


Production and purification of PDC
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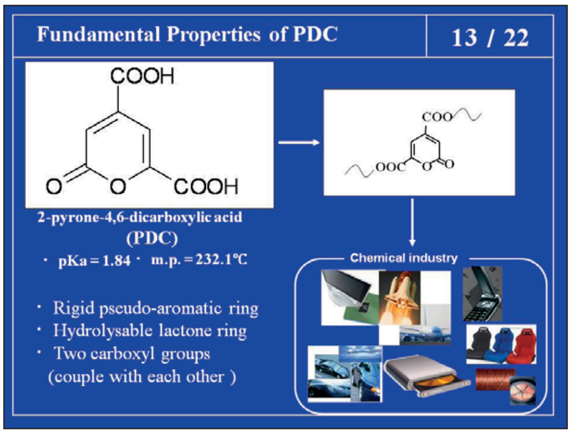
PDC
1H-NMR spectrum of PDC in DMSO-d6
13C-NMR spectrum of PDC in DMSO-d6
150L Fermenter
Add vanillin
15g/L
Conversion
100%
Pre-culture
1-day
1-day
Fermentation
Crude PDC
Ion-exchange
Re-crystallization
Purification
Pure PDC
(60-70%)


Fundamental Properties of PDC
13 / 22
COOH
O
O
COOH
2-pyrone-4,6-dicarboxylic acid
(PDC)
・ pKa = 1.84 ・ m.p. = 232.1℃
・ Rigid pseudo-aromatic ring
・ Hydrolysable lactone ring
・ Two carboxyl groups
(couple with each other)
Chemical industry

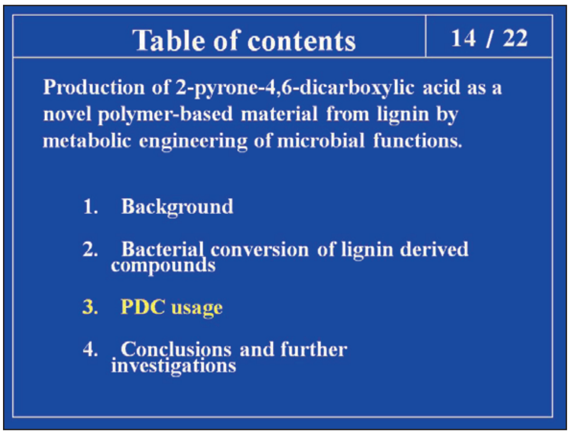


Table of contents
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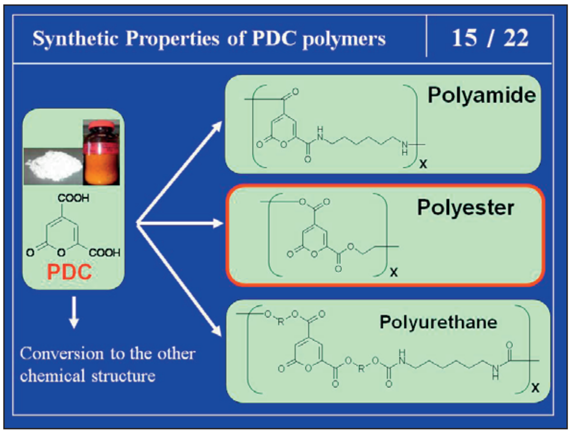
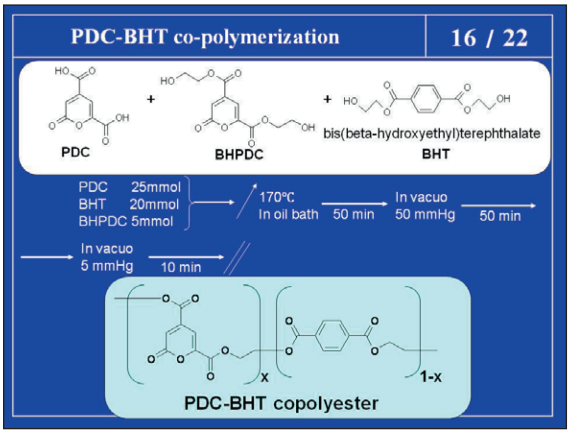
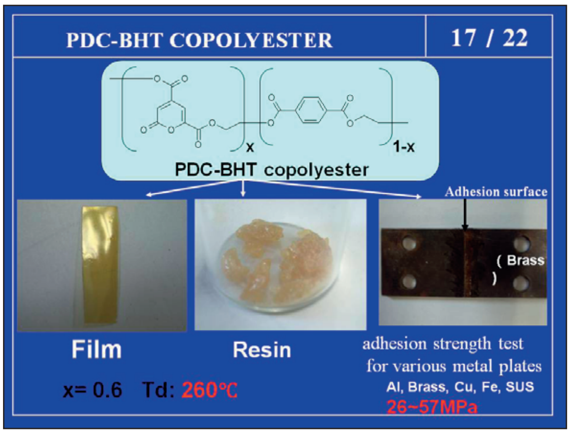
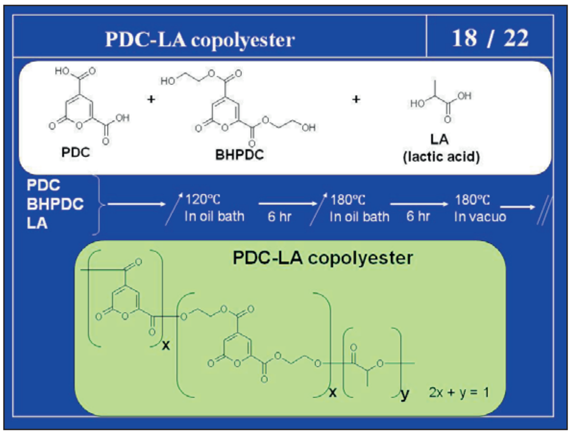
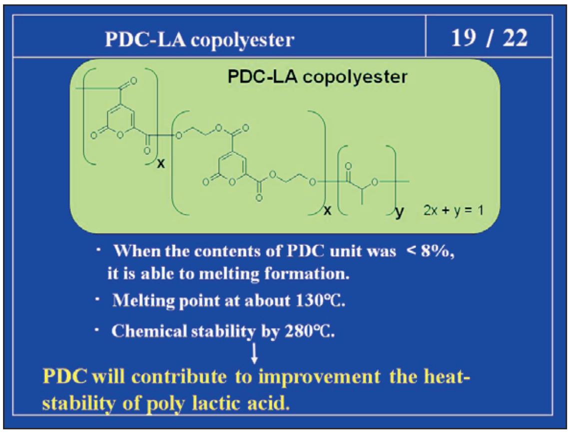
Production of 2-pyrone-4,6-dicarboxylic acid as a novel polymer-based material from lignin by metabolic engineering of microbial functions.
1. Background
2. Bacterial conversion of lignin derived compounds
3. PDC usage
4. Conclusions and further investigations

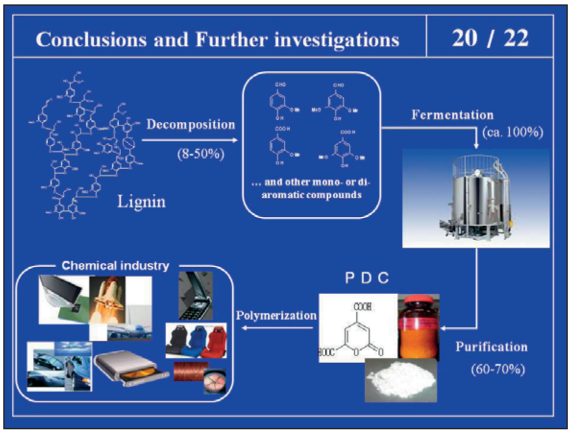

Synthetic Properties of PDC polymers
15 / 22
Polyamide
Polyester
Polyurethane
PDC
Conversion to the other chemical structure

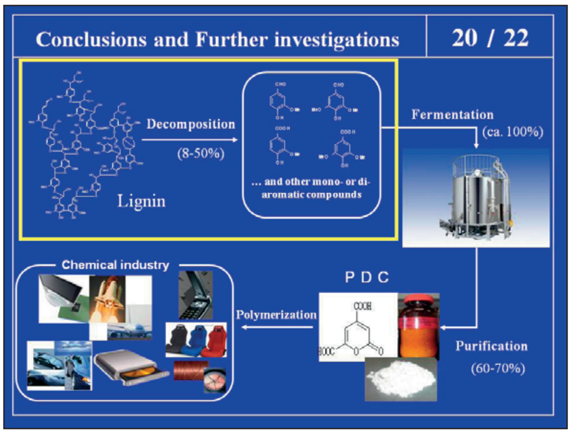

PDC-BHT co-polymerization
16 / 22
PDC
BHPDC
bis(beta-hydroxyethyl)terephthalate
BHT
PDC 25mmol
BHT 20mmol
BHPDC 5mmol
170℃
In oil bath
50 min
In vacuo
50 mmHg
50 min
In vacuo
5 mmHg
10 min
PDC-BHT copolyester

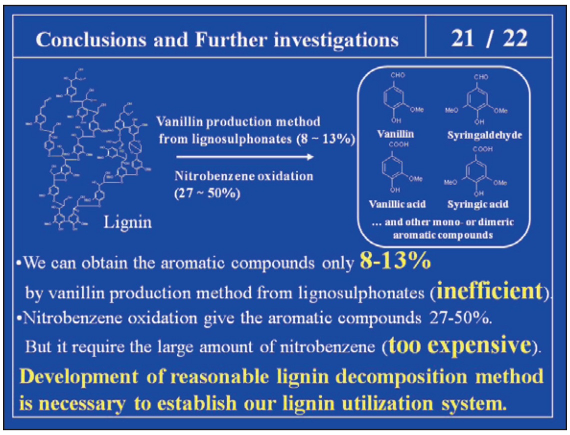

PDC-BHT COPOLYESTER
17 / 22
PDC-BHT copolyester
Adhesion surface
(Brass)
Film
Resin
adhesion strength test
for various metal plates
Al, Brass, Cu, Fe, SUS
26~57MPa
x= 0.6 Td: 260℃

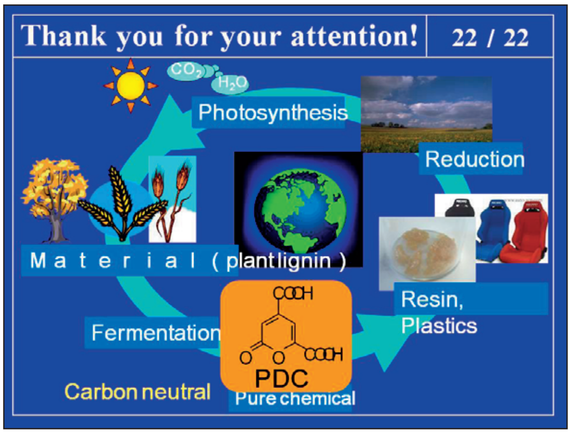

PDC-LA copolyester
18 / 22
PDC
BHPDC
LA
(lactic acid)
120℃
In oil bath
6 hr
180℃
In oil bath
6 hr
180℃
In vacuo
PDC-LA copolyester
2x + y = 1


PDC-LA copolyester
19 / 22
PDC-LA copolyester
2x + y = 1
・ When the contents of PDC unit was < 8%, it is able to melting formation.
・ Melting point at about 130℃.
・ Chemical stability by 280℃.
PDC will contribute to improvement the heat-stability of poly lactic acid.


Conclusions and Further investigations
20 / 22
Decomposition
(8-50%)
Lignin
… and other mono- or di-aromatic compounds
Fermentation
(ca. 100%)
Chemical industry
Polymerization
PDC
Purification
(60-70%)


Conclusions and Further investigations
20 / 22
Decomposition
(8-50%)
Lignin
… and other mono- or di-aromatic compounds
Fermentation
(ca. 100%)
Chemical industry
PDC
Polymerization
Purification
(60-70%)


Conclusions and Further investigations
21 / 22
Vanillin production method
from lignosulphonates (8 ~ 13%)
Nitrobenzene oxidation
(27 ~ 50%)
Lignin
Vanillin
Syringaldehyde
Vanillic acid
Syringic acid
… and other mono- or dimeric aromatic compounds
•We can obtain the aromatic compounds only 8-13%
by vanillin production method from lignosulphonates (inefficient).
•Nitrobenzene oxidation give the aromatic compounds 27-50%.
But it require the large amount of nitrobenzene (too expensive).
Development of reasonable lignin decomposition method
is necessary to establish our lignin utilization system.


Thank you for your attention!
22 / 22
CO_2
H_2O
Photosynthesis
Reduction
M a t e r i a l (plant lignin)
Resin,
Plastics
Fermentation
PDC
Carbon neutral
Pure chemical

Improving maturing process of compost using ozonated Japanese cedar as auxiliary feedstock

Tomoko Sugimoto

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The odor is one of a problem with composting process. The ammonia release from manure is one of the causes of such odor. The composting process sometimes takes a long time. When keeping cows, Japanese cedar (*Cryptomeria japonica*) sawdust is spread on the floor of the cow shed to absorb some of the odor. This sawdust can be used as a feedstock of compost, however making compost from Japanese cedar is not easy because of slow decomposition due to its high lignin content. The sawdust of this species is used because of its abundant availability.

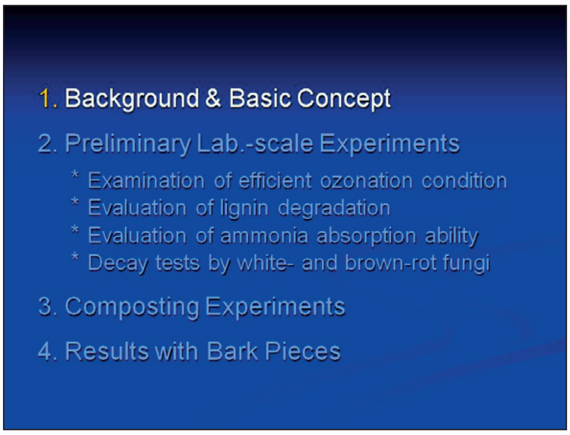
When wood meal is treated with ozone, carbon-carbon double bonds in lignin are attacked by ozone . When these double bonds in lignin aromatics are attacked, ring cleavage takes place. From our laboratory-scale experiments, it was shown that the resultant muconic acid-type structures can absorb ammonia in aqueous solution. It was also shown that oxidation of lignin by ozone accelerated the white-rotting of wood chips by Coriolus versicolor.

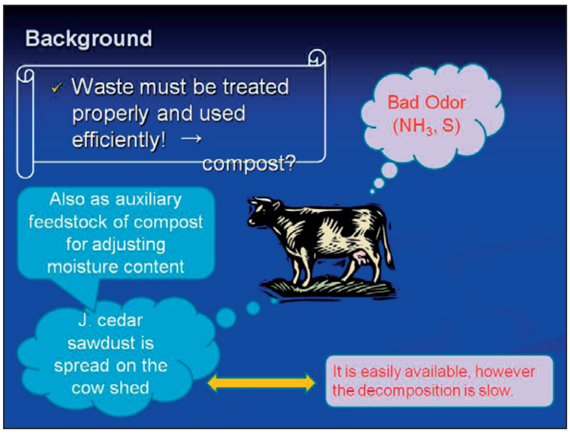
Based on the above results, we have 50 kg batches of ozonated Japanese cedar wood meal and Japanese cedar bark pieces. In the case of ozonated wood meal as ozonation progressed, the Klason lignin content and the reaction products obtained by nitrobenzene oxidation of ozonated wood meal decreased, while the ammonia absorbing ability from aqueous solution increased. In the case of the ozonated bark pieces the changes associated with ozonation were smaller.

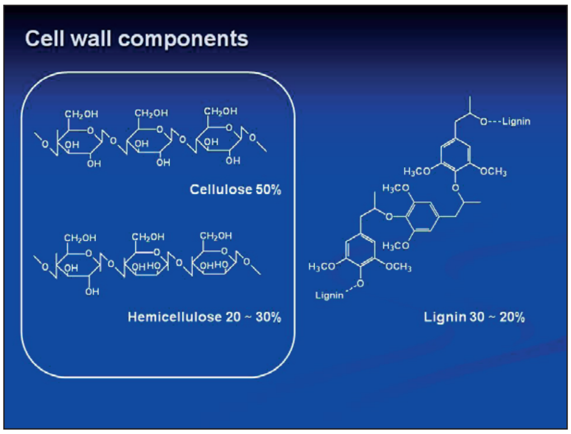
Using these ozonated feedstocks as auxiliary feedstocks, we have tried to make cow manure using 1.8 m^3 scale batch composting reactors. Although we could not completely stop the release of ammonia, addition of ozonated wood meals reduced ammonia release from the composting reactor by up to 70%. Also, decomposition of organics was faster in the reactor with ozonated wood meal. Ammonia absorption ability of untreated bark pieces was 1.6 times higher than that of untreated wood meal, and was the highest among of the ozonated wood meals used in our experiments. On the other hand, the decomposition rate of organics in untreated and ozonated bark pieces were less than in untreated wood meals, although ozonation accelerated decomposition of organics. These results suggests that ozonation of wood meal would shorten the period required to complete composting of both Japanese cedar wood meal and bark pieces, however the efficiency of ozonation itself is low in the case of bark pieces.

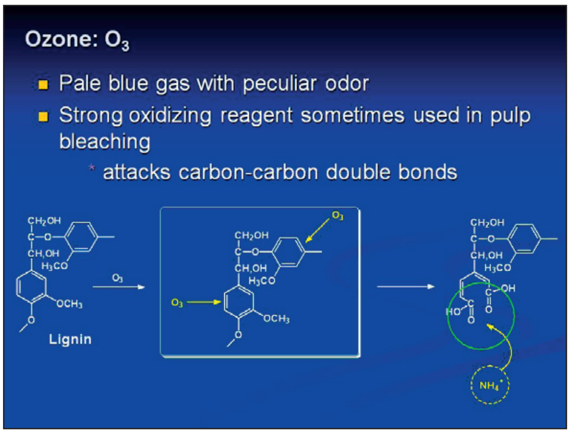
Appendix

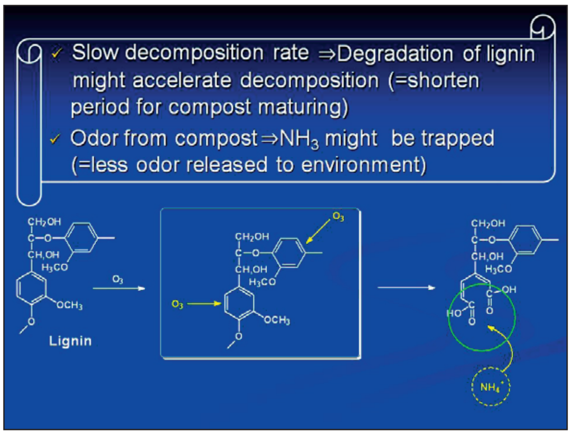
Presentation: Improving maturing process of compost using ozonated Japanese cedar as auxiliary feedstock











1. Background & Basic Concept
2. Preliminary Lab.-scale Experiments
   - Examination of efficient ozonation condition
   - Evaluation of lignin degradation
   - Evaluation of ammonia absorption ability
   - Decay tests by white- and brown-rot fungi
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Examination of efficient ozonation condition

- Moisture content of the sample is very important for the reactivity (=consumption) of O_3. When the moisture content of the sample is around 40%, almost 100% of O_3 is consumed by the sample

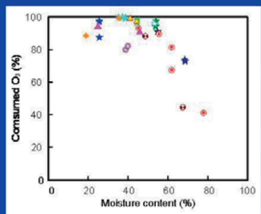

Fig. The relationship between moisture content and O_3 consumption by various samples during the first 1hr of ozonation

Ozonation conditions of wood meal

- **Starting material**
  Japanese cedar (*Cryptomeria japonica*) wood meal
- **Ozone treatment**
  Wood meal (c.a. 25kg o.d.) was treated with 150L/min of O_2 flow containing 2.9% of O_3 in a rotating reactor.

⇒moisture content was adjusted to c.a. 50%

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Degradation of lignin

Degradation of lignin

- The yield of nitrobenzene oxidation products and Klason lignin content determined **decreased** on ozonation (*only the result of nitrobenzene oxidation is shown)*

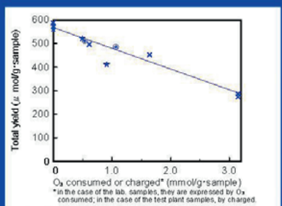


Fig. Yield of nitrobenzen oxidation products of ozonated J. cedar wood meal (×: lab.-scale, ●: plant-treated (1), ★: plant-treated (2))

Degradation of lignin vs NH_3 absorption ability

- The NH_3 absorbing ability of ozonated Japanese cedar **increased** with the progress of ozone treatment (⇒*Red line in the Figure)*

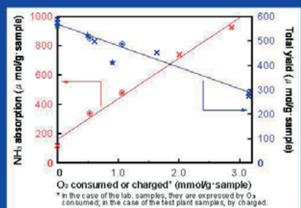
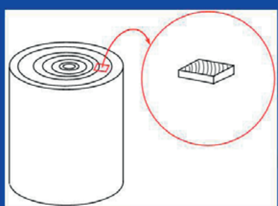


Fig. Ammonium absorption (—) and yield of nitro-benzene oxidation products (—) of ozonated *sugi* wood meals (×: lab.-scale, ●: plant-treated (1), ★: plant-treated (2))

Decay tests by fungi (*c.f.* JIS Z 2101-1994)

- **Sample specimen**
  Japanese cedar (*Cryptomeria japonica*) chip
  size: 20mm×20mm with thickness of 2mm
  Specimen were taken from heartwood, sapwood and intermediate wood
- **Ozonation**
  Non-treated, 1.5 ~ 1.6% treated and 3.5% ~ 4.3% treated

  ⇒after the ozonation the specimen was left in a desiccator with NH_3 aq. sol.



Decay test by brown-rot

- No clear relation was observed between ozonation and weight loss of the specimen

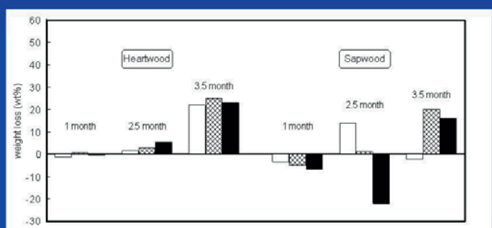


Fig. Weight loss of the ozonated Japanese cedar specimen by *Tyromyces palustris* decay test (without treatment, 1.5~1.6% O_3 treatment, 3.5~4.3% O_3 treatment)

Decay test by white-rot

- Weight loss was accelerated by ozonation, especially with heartwood specimen

Fig. Weight loss of the ozonated Japanese cedar specimen by *Coriolus versicolor* decay test (without treatment, 1.5~1.6% O_3 treatment, 3.5~4.3% O_3 treatment)

Summary of the preliminary experiments

1. By adjusting the moisture content of sample 40 ~ 50%, O_3 reacts efficiently with the sample and lignin can be degraded
2. Ammonia absorption ability increased with the progress of lignin degradation
3. Decay of wood by white fungus was accelerated, especially with heartwood specimen

⇒These results were obtained in lab.-scale experiment. How about in practical composting process?

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Composting experiments - Experimental

- Compost production
  - cow manure: ozonated J. cedar = 4:1 (w/w)
  - 1.8m^3 forced aeration composting reactors were used
  - NH_3 release and degradation of organics were determined for 4 weeks

National Agricultural Res. Center for Kyushu Okinawa Region

	Reactor-0	Reactor-0.5	Reactor-2
Varieties of ozonated wood meals added	Non-treated	Mixture of Non-treated: 1hr-treated=1:1	2hrs-treated

Composting experiments - Result 1

- The NH_3 release from the reactors with ozonated J. cedar wood meal was reduced compared with that with non-treated, especially at the beginning.

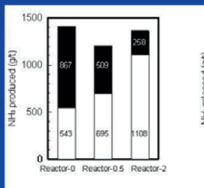

Fig. The amount of NH_3 produced during composting process (absorbed, released)

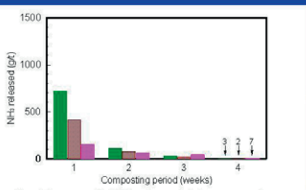

Fig. The amount of NH_3 released during composting process of cow manure and ozonated J. cedar (: Reactor-0, : Reactor-0.5, : Reactor-2)

Composting experiments - Result 2

- Decomposition of organics was faster with the reactors with ozonated J. cedar wood meal.

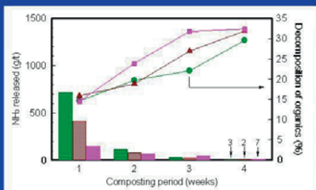

Fig. The amount of NH_3 released (left) and decompotion of organics (right) during composting process of cow manure and ozonated J.cedar wood meals (■ ● : Reactor-0, ■ ▲ : Reactor-0.5, ■ ■ : Reactor-2)

Summary of the composting experiments

1. Addition of ozonated J. cedar wood meal reduced at the maximum 70% of NH_3 release from composting reactor
2. Decomposition rate of organics was also faster with ozonated wood meal
3. However, ozonated wood meal cannot stop odor caused by sulfer compounds (i.e. H_2S, CH_4S, DMS, DMDS)

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Results with J. cedar bark pieces

- NH_3 absorption ability of bark pieces was higher from the beginning, and the increase by ozonation was smaller compared with wood meal

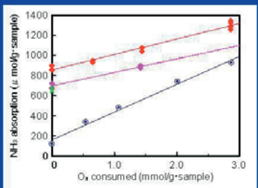

Fig. 1 Ammonium absorption by O_3 treated *sugi* samples
(: bark-A, : bark-B, : wood)
(: bark-B as received)

⇒O_3 was consumed not only with degrading lignin but also polyphenols (tannnins) in bark.

Results with J. cedar bark pieces

- The NH_3 release from the reactors with bark pieces was very small and effect of ozonation was hardly seen.
- Acceleration of organic decomposition by ozonation was also small.

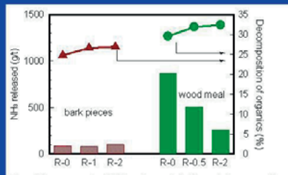

Fig. The amount of NH_3 released (left) and decompotion of organics (right) during composting process of cow manure and ozonated wood meals
(: bark, : wood meal)

This research was conducted under the following project funded by the Ministry of Agriculture, Forestry and Fisheries of Japan

"Study on biorecycling of wastes from agriculture, forestry and fisheries sector : Development of technology for sustainable utilization of livestock wastes"

Tomoko Sugimoto[1) 2)], Shuji Hosoya[1)], Satoshi Oosawa[3)], Akihiro Tanaka[4)], Kenichi Yakushido[4)]

1) Forestry and Forest Products Research Institute, Japan
2) Japan International Research Center for Agricultural Sciences
3) Daitofujitec Co., Ltd
4) National Agricultural Research Center for Kyushu Okinawa Region

Research topics for expanding the use of logging residues in FFPRI

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Since 2000, several waste-related laws have been enforced or drastically amended to make the supply of construction derived wood residues (CDWR) more apparent and stable. On the other hand, several laws and policies related to renewable energy have also been launched. Additionally, the rising prices of fossil fuels have led to the greater use of biomass for energy.

As a result, the fuel chip demand rose rapidly from 1.5 million tons in 2004 to 6.0 million tons in 2008, mainly because low-priced fuel chips from CDWR are highly cost competitive with fossil fuels: whereas the thermal cost of coal was 1.5 yen/kWh, it was 0.7 yen/kWh for CDWR. According to the Ministry for Agriculture Forestry and Fisheries (MAFF), the total amounts of CDWR, sawmill residues and logging residues were 4.7, 5.0 and 3.7 million dry tons per year, respectively. Furthermore, sawmill residues have begun to be used for energy production because their thermal cost is around 1.4 yen/kWh. However, logging residues have not yet been used because at over 3 yen/kWh, they cannot compete with coal (although they can compete with fuel oil).

Although thermal power plants which use fuel chips are still being constructed, some existing plants have stopped or scaled down their operations because of the shortage of cheap fuel chips. Therefore, there is growing demand for research on reducing the supply cost and establishing a supply chain for logging residues. At the Forestry and Forest Products Research Institute (FFPRI), we have set up the following four study topics: (1) To identify regions with high potential for supplying wood biomass; (2) To assess the efficiency of the system for supplying logging residues; (3) To assess the profitability of energy utilization styles; and (4) To develop demonstration models of using wood biomass in several regions.

Regarding topic (1), we developed a model for estimating the wood biomass supply for each municipality by using GIS and statistical analyses. Through this model, we found that Kyushu Island is very promising for wood biomass utilization (Fig. 1). On Kyushu Island, two areas, Hita City and Kobayashi City, were identified as the most promising locations for large-scale biomass utilization, such as bio-refinery plants. Below the cost of 52€/t-wet (1€=135 yen), the potential supply of wood biomass was estimated to be over 100 000 t-wet in Kobayashi City.

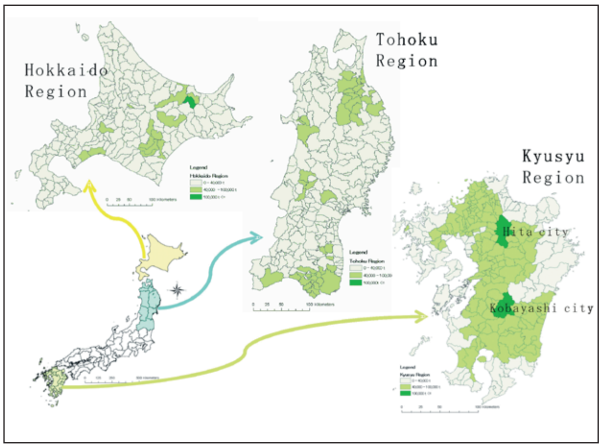


Figure 1: Promising area for wood biomass utilization in Japan. Map: FFPRI

In Japan, about one-third of logging systems use forwarders. A typical Japanese forwarder can carry only 1.4 t-wet of logging residues even though its maximum load is 3.5 t. To reduce the cost of supplying logging residues, it is important to modify the forwarder to handle both commercial logs and logging residues. One solution is to compress logging residues on the carrier of the forwarder. Researchers in the Wood Engineering Department are working on developing a new forwarder which can carry double the load of logging residues (Fig. 2).

Figure 2: Improved forwarder, Japen. Photo: FFPRI.

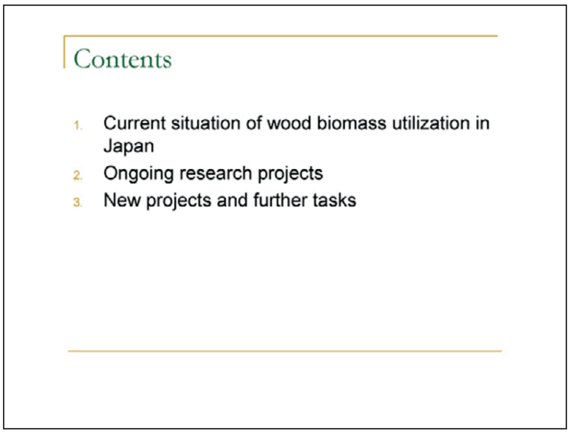
We developed a simulation model to assess the profitability of biomass energy by using pay back time analysis. As shown in Table 1, four actual wood biomass utilization styles were assessed in this study: (1) heat supply by chip boiler; (2) small-scale gasification in a combined heat and power (CHP) plant; (3) medium-scale gasification in a CHP plant; and (4) power plant with large-scale boiler and steam turbine. We found that the heat supply by chip boiler was most profitable.

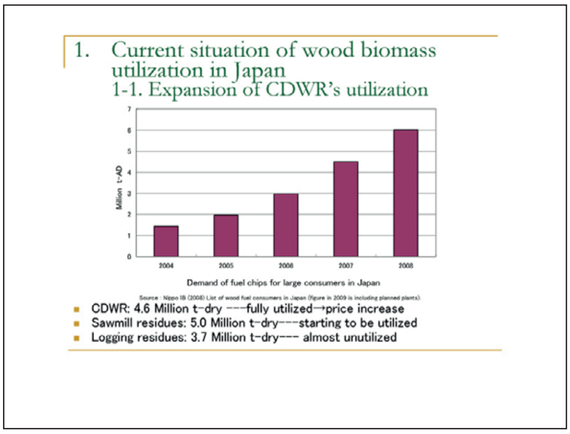
Table 1: Pay back period for each biomass energy plants.

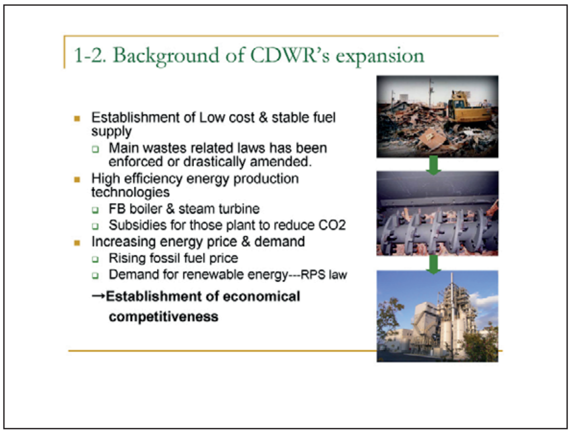
chip price (€/t-100% d.b.)	Chip boiler 1400kW$_{th}$	Small gasifying & gas-engine system 140kWe & 140kW$_{th}$	Medium gasifying & gas-engine svstem 2000kWe & 6800kW$_{th}$	Steam turbine power plant 10MWe
7	1	9	3	13
22	2	43	4	-20
37	3	-17	6	-6
52	10	-7	16	-3

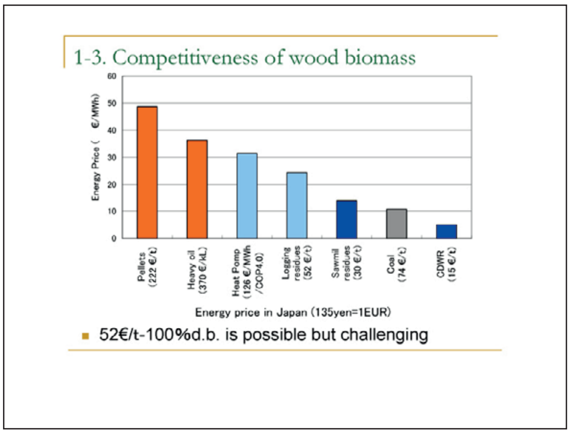
Appendix

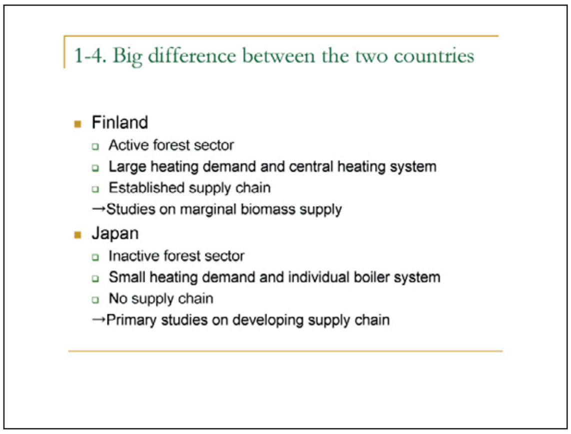
Presentation: Research topics for expanding the use of logging residues in FFPRI







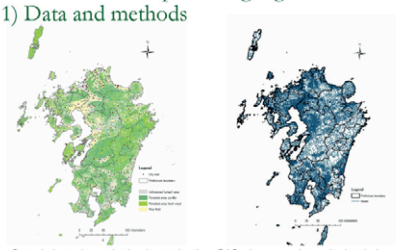




2. Ongoing research projects to expand wood biomass utilization

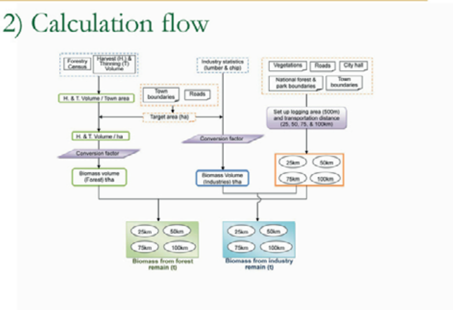
1. To distinguish regions with high supply potential of wood biomass
2. To establish low cost supply system of logging residues
3. To assess profitability of energy utilizations
4. To develop regional models

2-1. Estimation of promising regions
1) Data and methods

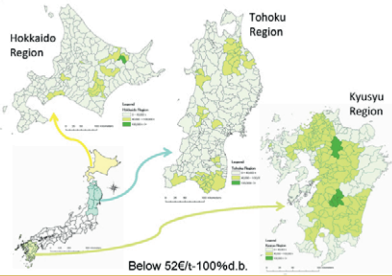


- Spatial and statistical analysis: GIS data and statistical data at municipal scale

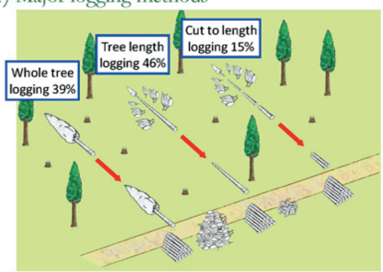
2) Calculation flow



3) Results



2-2. Study about efficient supply systems
1) Major logging methods



2) Typical log forwarder

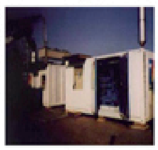
- Small crawler type: narrow, steep and muddy skid road
→Small capacity: biomass 1.4t/ log 3.5t

3) Improved forwarder

- To make load weight double: 1.4t → 2.8t

2-3. Profitable energy utilizations
1) Transformation technologies

- Chip boiler
  - Heat: 40 €/MWh$_{th}$
  - Plant cost : 520 €/kW$_{th}$
- Small gasifying & gas-engine system
  - Power: 119 €/kW$_{e}$
  - Plant cost : 7400 €/kW$_{e}$



continued

- Medium gasifying & gas-engine system
  - Plant cost : 5600 €/kW$_e$
  - 3 personnel
- Steam turbine power plant
  - Power: 57 €/kW$_e$
  - Plant cost : 2200 €/kW$_e$
    ↓ 24h, 330days

Assessing profitability by pay back period

2) Results of the analysis

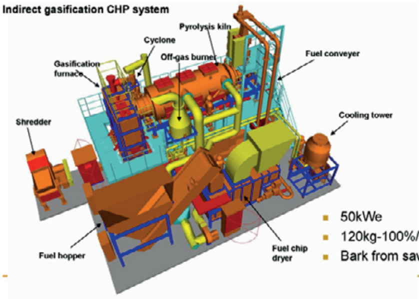
Table 1. Pay back period for each biomass energy plants

chip price (€/t−100% d.b.)	Chip boiler 1400kW$_{th}$	Small gasifying & gas−engine system 140kWe & 140kW$_{th}$	Medium gasifying & gas−engine svstem 2000kWe & 6800kW$_{th}$	Steam turbine power plant 10MWe
7	1	9	3	13
22	2	43	4	−20
37	3	−17	6	−6
52	10	−7	16	−3

- Heat production by chip boiler was most profitable.

2-4. Regional demonstration project

Indirect gasification CHP system



- 50kWe
- 120kg-100%/h
- Bark from sawmill

3. New projects and further tasks

3-1. New projects

- Study on adaptability of business models of advanced forestry countries
  - Forest owner support systems served by forest owners' cooperatives or regional foresters
  - Transfer of land property rights e.g. REIT, TIMO
- Study on effects of biomass harvest on timber growth
  - Nutrients' reduction from soil

3-2. Further tasks

- Reduction of comminution cost
- Utilization of natural hardwood forest
- Find heat demand for biomass

Thank you for your attention!

Independent Administrative Institution
Forestry and Forest Products Research Institute

FFPRI

Utilization of woody biomass: future feedstock for biorefining

Antti Asikainen

Finnish Forest Research Institute (Metla), Joensuu Research Unit, antti.asikainen(at)metla.fi

All biomass components of trees can, in principle, be used as the feedstock for biorefining processes. Three main strategies in feedstock supply can be identified: (1) reallocation of current biomass flows (mainly from pulping to biorefining); (2) mobilization of the surplus forest growth; and (3) boosting the biomass production by intensifying wood production on the existing forest area or by establishing new plantations.

Forests form a vast source of biomass globally. Forests cover 3.9 billion hectares representing about 30% of the total landmass (FAOSTAT 2009). Although the total forest area has decreased by 50 million hectares since the year 2000, different trends can be found between the continents: in Europe, North America and Asia, forest area is increasing; and in Africa, South America and Oceania decreasing. Global growing stock totals 434 billion m^3 stemwood measured over bark.

Current global use of wood is 3.7 billion m^3 per year over bark. More than half (1.9 billion m^3) is used directly for fuel mainly in developing countries (FAOSTAT 2009). The other 1.8 billion $m^3$of the material is used by forest industries, but 40% of this ends up in energy use via by-product and residues. Thus already now about 70% of utilized wood goes to energy production.

The justifiable volume of reallocation of current flow of industrial roundwood to biorefining purposes has not been estimated before. If 10% of global industrial roundwood utilization would be redirected to biorefining, the annual volume would be 170 million m^3 (71 million dry tonnes). This is roughly 25% of the wood consumption in chemical and mechanical pulping today.

Assuming that 25% of the surplus forest growth could be mobilized for biorefining, there would be 340 million m^3 (143 million dry tonnes) available globally. This would still leave 75% of the surplus forest growth unutilized or as a potential raw material for the traditional energy generation and forest industry (Anttila et al. 2009).

Boosting of biomass production on plantations allows a future resource for feedstock. By 2020 all industrial woody biomass could in principle be produced on plantation forests. If one-third of the wood coming from plantations was directed into biorefining, it would add 270 million m^3 per year to the potential feedstock.

The total biomass potential for biorefining is 780 million m^3 per year (330 dry tonnes per year). This is close to the figures that have been estimated to be available for the traditional heat and power production (1 billion m^3 per year). Together these resources would represent about 2% of the global energy consumption.

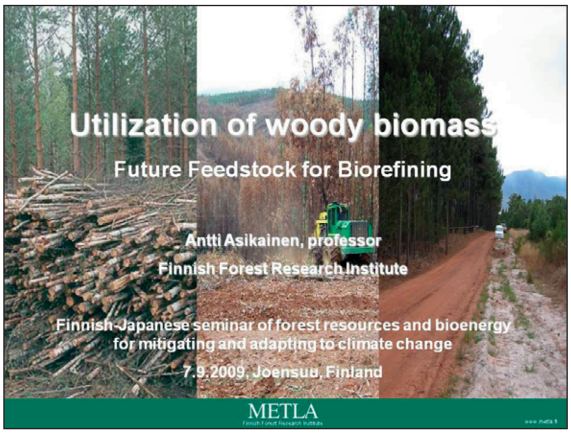
References

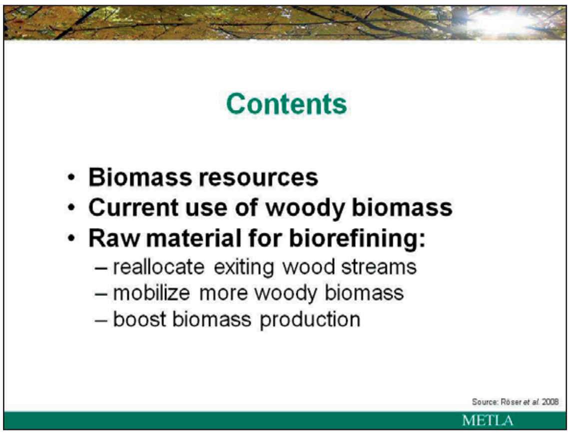
FAOSTAT data (2009). Available at http://faostat.fao.org/. Last accessed on 30 March 2009.

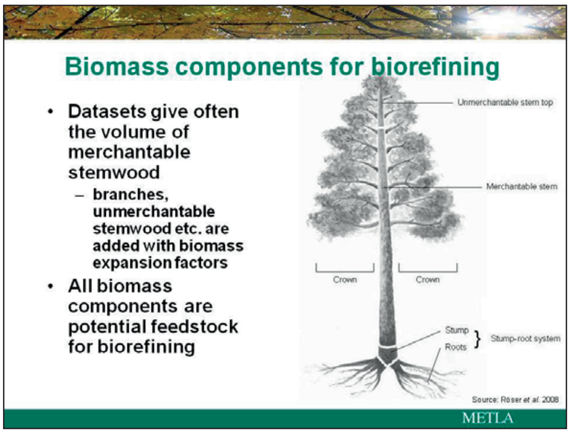
Anttila P., Karjalainen T. & A. Asikainen (2009). Global potential of modern fuelwood. Working Papers of the Finnish Forest Research Institute 118. 29 p.

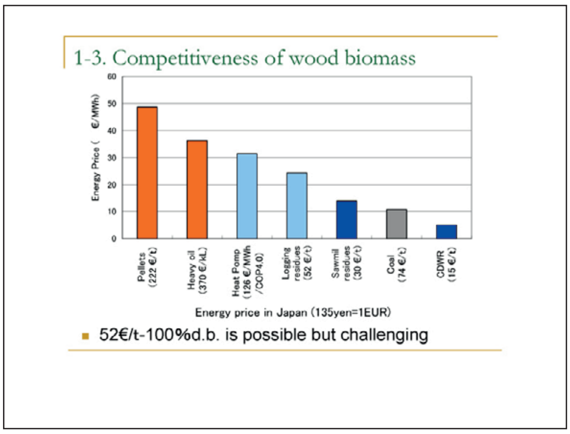
Appendix

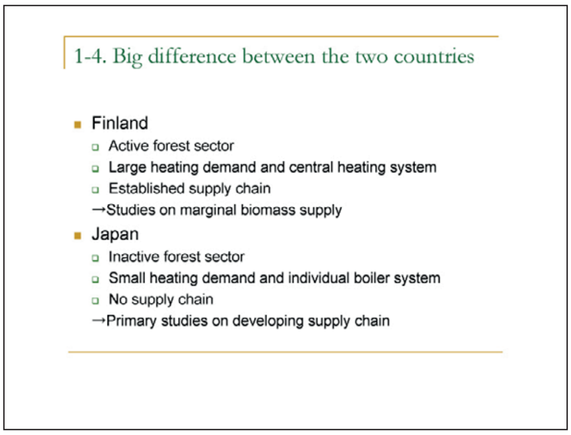
Presentation: Utilization of woody biomass: future feedstock for biorefining











Stumps

METLA

Fuelwood plantations

METLA

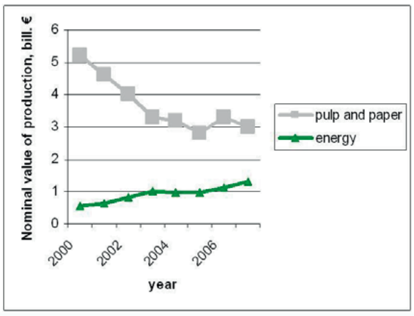
Reallocate

- **Global** material and energy use of wood 3.7 bill. m³/a
  - 1.8 bill. m³/a for material use
  - 1.9 bill. m³/a for direct energy generation
- **EU27** 467 mill. m³/a
  - 379 mill. m³/a for material use
  - 88 mill. m³/a for direct energy production

Source: Röser *et al.* 2008

METLA

Reallocate: Case Finland



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Potential of reallocation

- If 10% of the current **industrial** use of roundwood would be refined to new energy and material products
  - **Global** potential: 180 mill. m³ (75 mill. ODT/a)
  - **EU 27's** potential: 47 mill. m³ (20 mill. ODT/a)

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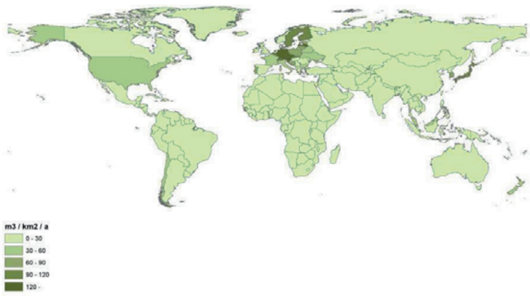
Mobilize

- **Net annual increment** exceeds the annual cut especially in the northern hemisphere
- In many cases only the **stemwood and bark** are extracted from the forest
- **Surplus forest growth** and **logging residues and stumps** could be used for biorefining
- Logging residues and stumps have greater quality variation than that of stemwood
  - Reasonable to use logging residues and stumps in the traditional heat and power generation
  - Surplus forest growth consisting mainly of stemwood to biorefining

Source: Röser *et al.* 2008

METLA

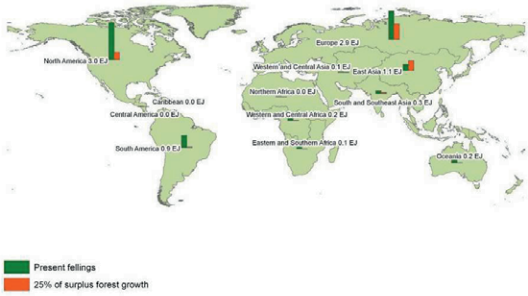
Total forest energy potential per land area



Borders: ESRI Data & Maps

METLA

Regional potentials



Borders: ESRI Data & Maps

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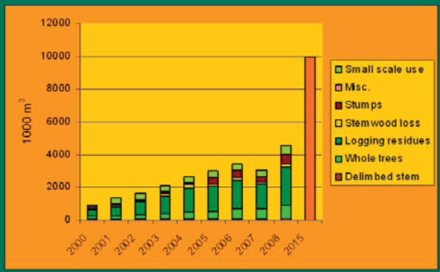
Wood fuel mobilization

in Finland 2000-2008



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Potential when 25% of the surplus forest biomass growth is mobilized

- **Globally** 340 mill. m^3/a (143 mill. ODT/a)
- **EU27** 103 mill. m^3/a (43 mill. ODT/a)

Source: Röser *et al.* 2008

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Boost

- In the northern hemisphere the growth of forest has been increasing
- Area of plantation forests increases globally
- Boosting of forest growth
  - more landmass for wood production
  - intensive management of existing forest land

Source: Röser *et al.* 2008

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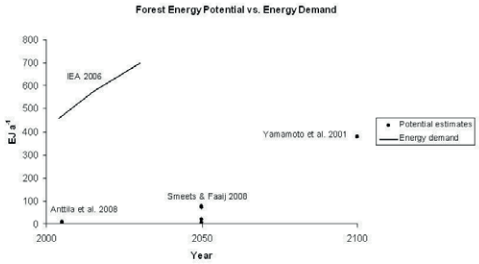
World energy consumption and forest energy resources



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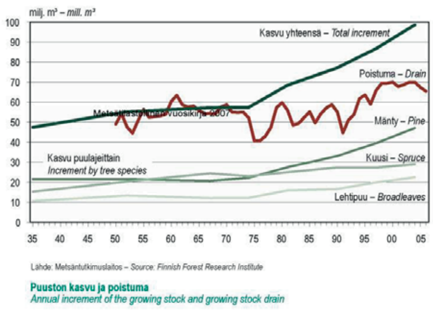
Case Finland: Annual increment



Metsätilastollinen vuosikirja 2007

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Potential of boosting woody biomass production by 2050

- **Globally** 150 mill. m^3/a (63 mill. ODT/a)
- **EU27** 50 mill. m^3/a (21 mill. ODT/a)

Source: Röser *et al.* 2008

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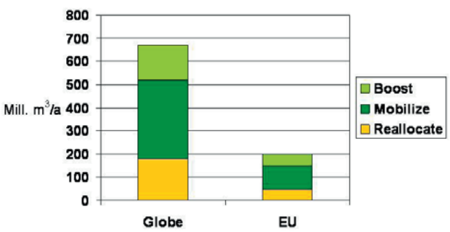
Total potential for biorefining



Source: Röser *et al.* 2008

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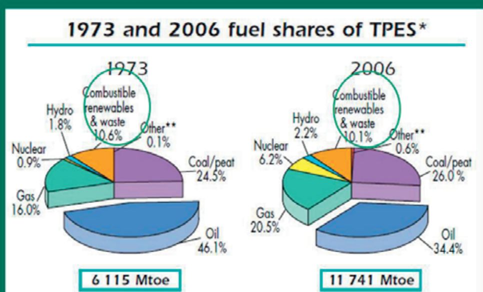
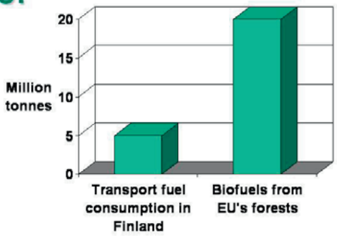
Woody biomass for biorefining: c.a. 1% of the world TPES



World Total Primary Energy Supply (TPES), IEA 2008

METLA

Woody biomass for biorefining in the EU:



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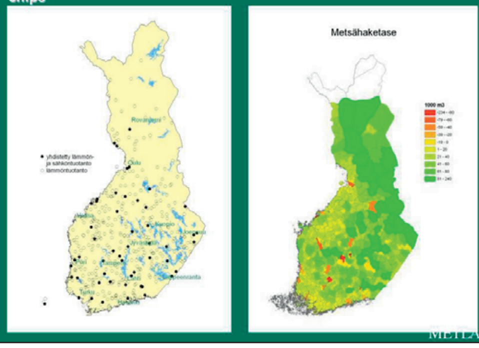
Competition for Biomass

Plants using forest chips

Resources – current use of forest chips



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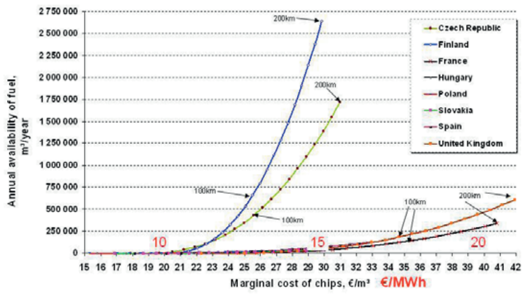
Regional differences in supply cost

Cost of chips at plant



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Conclusions

- **Reallocation** of current raw material flows probably the most realistic and quickest source
- **Mobilization** of existing surplus forest growth has been done successfully to serve traditional energy production
- **Boosting** of biomass production possible only in the long run in Europe
  - if decisions and actions are made now, the harvest could start after several decades
  - in the Russian Federation introduction of thinnings would double the net annual increment

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Conclusions

- **Great regional differences** in supply potentials and costs between regions in Europe
- **Need to combine raw material sources**
- **Pulpwood** may be the most important source for biorefining
- **Competition** on woody biomass increases due to ambitious targets to increase renewable material and energy production

METLA

Process estimation of liquid fuel production process from woody biomass

Shinji Fujimoto

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Biomass is a carbon neutral and renewable resource that has become an attractive alternative in Japan since the Biomass-Nippon Strategy was decided upon in 2002. A process to produce transportation liquid fuel from biomass is also attractive. In this study, the Biomass to Liquids (BTL) process was considered from economic and environmental viewpoints. The BTL process comprises a number of phases:

1. conversion of biomass into syngas (gasification) (syngas is a mixture of carbon monoxide (CO) and hydrogen (H_2));
2. cleaning and compression of the syngas;
3. synthesis of hydrocarbons from the syngas; and
4. distillation of FT diesel.

An economic and environmental evaluation was made based on process simulation and process analysis. In this presentation, the effect of the utility of the process on CO_2 emission and the effect of syngas composition on product yield are considered.

The BTL process requires thermal energy in gasification and distillation phases, and electricity in the compression phase. In this study, the effect on CO_2 mitigation when the requirements were fulfilled by fossil fuel or biomass was considered. Consequently, the combustion of a part of a biomass as a heat source decreased the total CO_2 emission though the partial combustion decreased the feedstock biomass and the yield of FT diesel. Further, the power generation using biomass was not useful if the efficiency was low. In other words, a process that does not depend on a fossil fuel is not necessarily effective.

In the process, a lot of off-gas was discharged after FT synthesis. The off-gas had approximately half the heating value of feedstock biomass. Therefore, the combustion of the off-gas and the recycling of the off-gas for effective utilization of the off-gas were examined. Consequently, it was found that the combustion of the off-gas as a heat source was effective for CO_2 mitigation. On the other hand, the recycling of the off-gas to the gasifier where hydrocarbons were reformed into CO and H_2 notably increased the yield of FT diesel. However, it increased the amount of power needed to compress the syngas and the consumption of electricity because of the increase of syngas flow rate. Accordingly, CO_2 mitigation decreased in this case. The compression capacity strongly affected CO_2 mitigation.

In the process, the H_2:CO ratio, is limited by the following reaction:

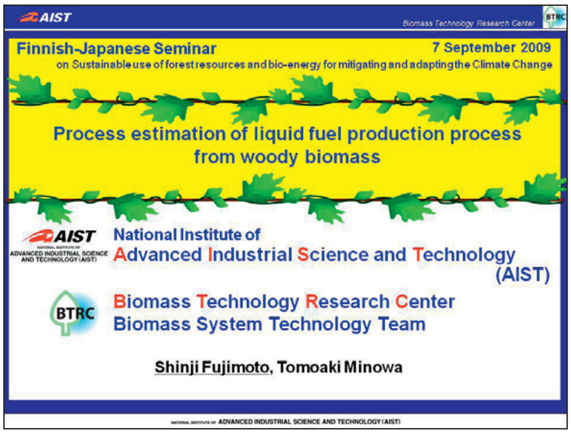
$$CO + H_2O = CO_2 + H_2$$

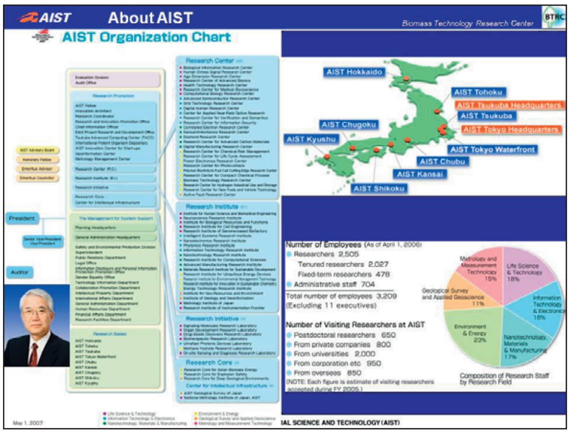
Therefore, the CO that is the feedstock of FT synthesis decreases to increase the H_2:CO ratio. The H_2:CO ratio can be adjusted by controlling the amount of supplied H_2O. When the carbon conversion to syngas in the gasification was 95% and the CO conversion to hydrocarbon in FT synthesis was 80%, the yield of FT oil was maximized at an H_2:CO ratio of 1.78. That is, the increase of H_2:CO ratio decreases the yield of FT oil because CO is consumed to increase H_2:CO ratio when the H_2:CO ratio is more than 1.78. On the other hand, when the carbon conversion to syngas decreased, the yield of FT oil also decreased. The yield of FT oil that was calculated in the condition of the carbon conversion to syngas of 80% and the H_2:CO ratio of 1.78 became equal to the yield calculated in the condition of the carbon conversion to syngas of 95% and the H_2:CO ratio of 2.25.

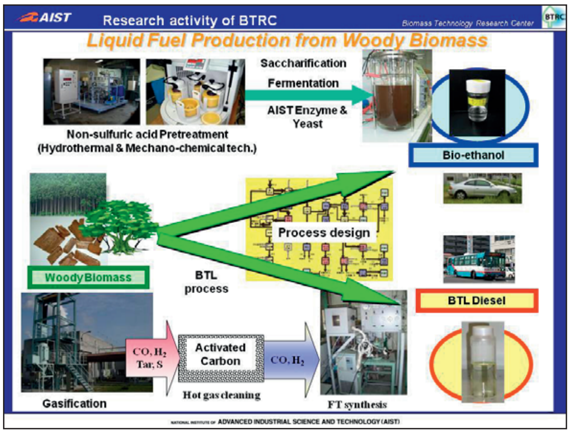
In the BTL process, it is not only the increase of the carbon conversion to syngas, but also syngas composition that is important.

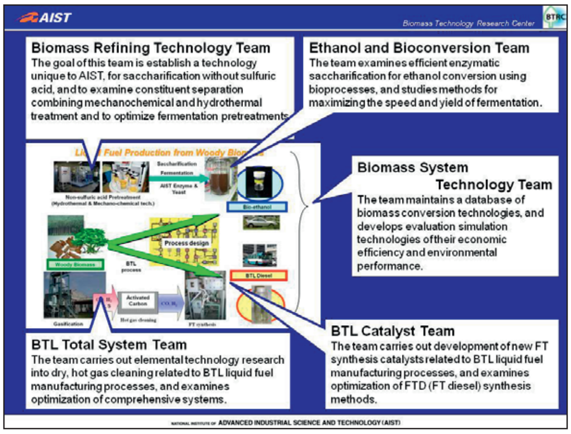
Appendix

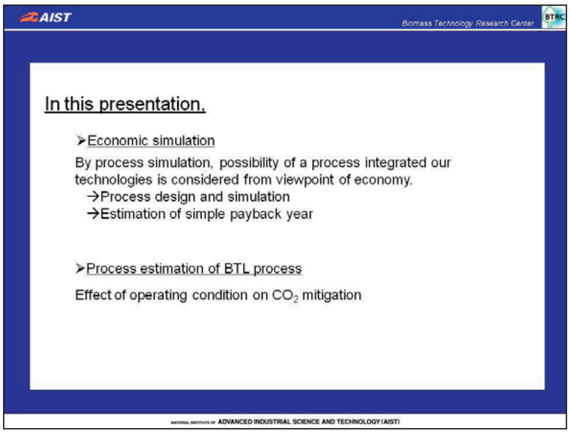
Presentation: Process estimation of liquid fuel production process from woody biomass

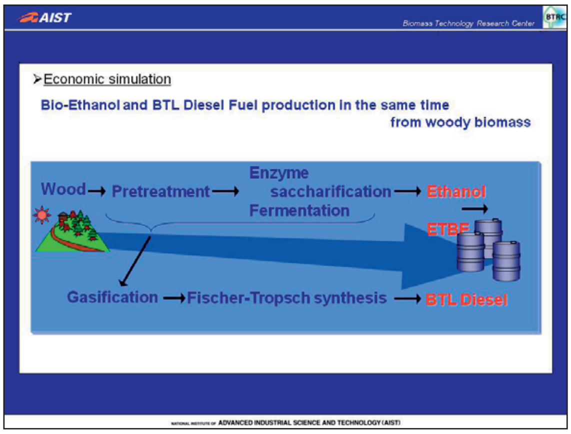


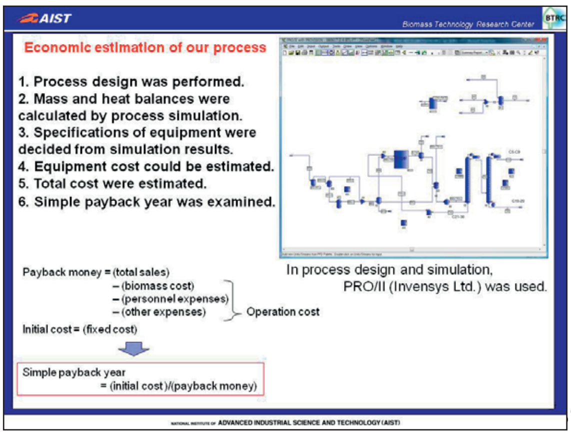


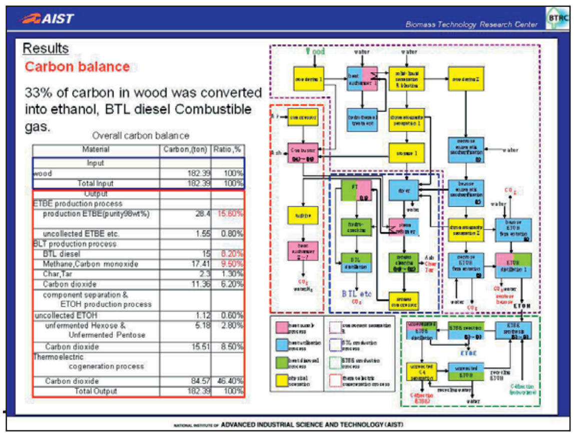


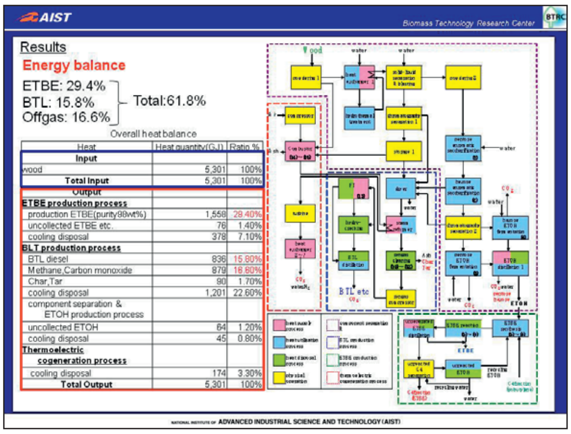








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Biomass Technology Research Center
Results
Energy balance
ETBE: 29.4%
BTL: 15.8%
Offgas: 16.6%
Total:61.8%
Overall heat balance

Heat	Heat quantity(GJ)	Ratio %
Input		
wood	5,301	100%
Total Input	5,301	100%
Output		
ETBE production process		
production ETBE(purity98wt%)	1,558	29.40%
uncollected ETBE etc.	76	1.40%
cooling disposal	378	7.10%
BLT production process		
BTL diesel	836	15.80%
Methane,Carbon monoxide	879	16.60%
Char,Tar	90	1.70%
cooling disposal	1,201	22.60%
component separation & ETOH production process		
uncollected ETOH	64	1.20%
cooling disposal	45	0.80%
Thermoelectric cogeneration process		
cooling disposal	174	3.30%
Total Output	5,301	100%

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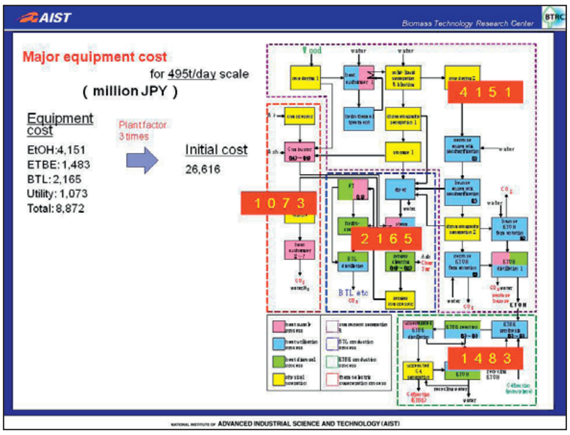
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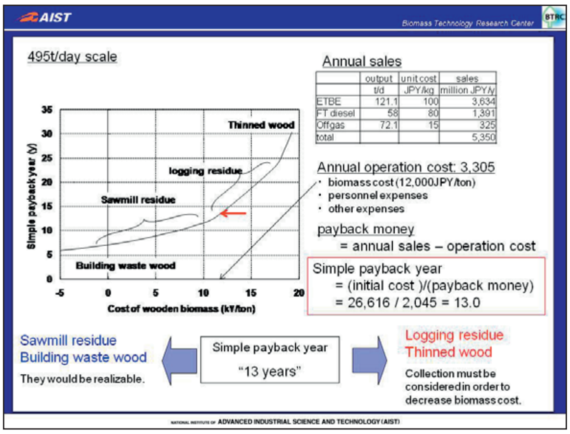
Major equipment cost
for 495t/day scale
(million JPY)
Equipment cost
Plant factor 3 times
EtOH:4,151
ETBE:1,483
BTL:2,165
Utility:1,073
Total:8,872
Initial cost
26,616
4151
1073
2165
1483
ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY (AIST)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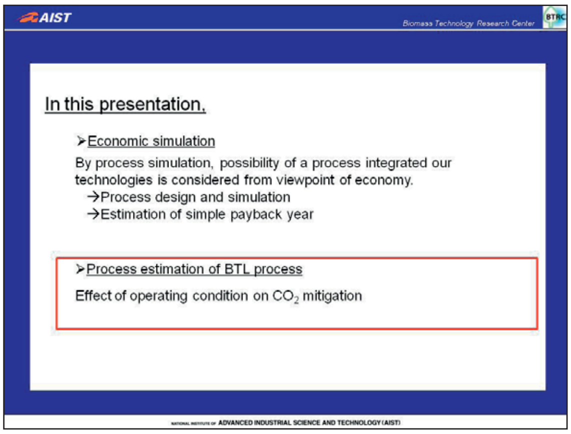
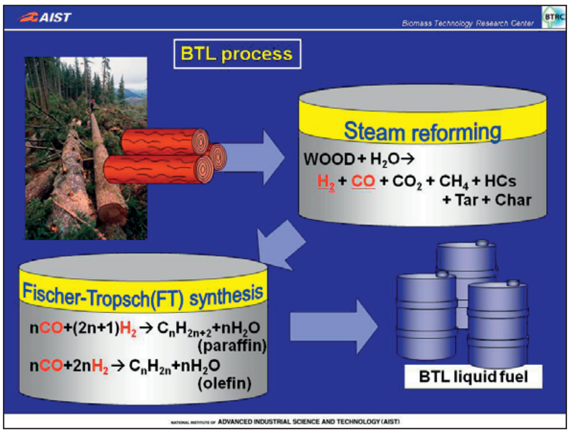
495t/day scale
Simple payback year (y)
Thinned wood
logging residue
Sawmill residue
Building waste wood
Cost of wooden biomass (kY/ton)
Annual sales

	output	unit cost	sales
	t/d	JPY/kg	million JPY/y
ETBE	121.1	100	3,634
FT diesel	58	80	1,391
Offgas	72.1	15	325
total			5,350

Annual operation cost: 3,305
・ biomass cost (12,000JPY/ton)
・ personnel expenses
・ other expenses
payback money
= annual sales – operation cost
Simple payback year
= (initial cost)/(payback money)
= 26,616 / 2,045 = 13.0
Sawmill residue
Building waste wood
They would be realizable.
Simple payback year
"13 years"
Logging residue
Thinned wood
Collection must be considered in order to decrease biomass cost.
ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY (AIST)


AIST
Biomass Technology Research Center
In this presentation,
➢Economic simulation
By process simulation, possibility of a process integrated our technologies is considered from viewpoint of economy.
→Process design and simulation
→Estimation of simple payback year
➢Process estimation of BTL process
Effect of operating condition on CO_2 mitigation
ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY (AIST)


AIST
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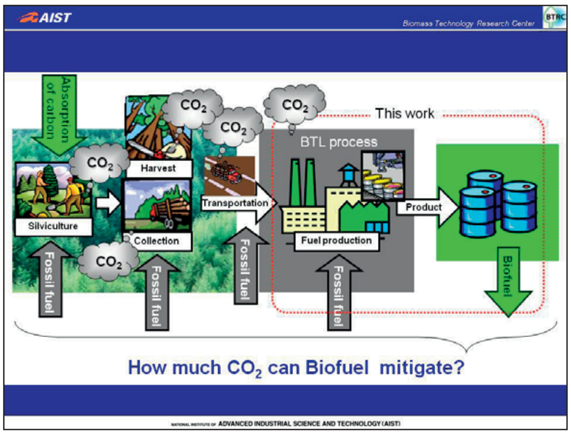
BTL process
Steam reforming
$WOOD + H_2O \rightarrow$
$H_2 + CO + CO_2 + CH_4 + HCs + Tar + Char$
Fischer-Tropsch(FT) synthesis
$nCO + (2n+1)H_2 \rightarrow C_nH_{2n+2} + nH_2O$ (paraffin)
$nCO + 2nH_2 \rightarrow C_nH_{2n} + nH_2O$ (olefin)
BTL liquid fuel
ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY (AIST)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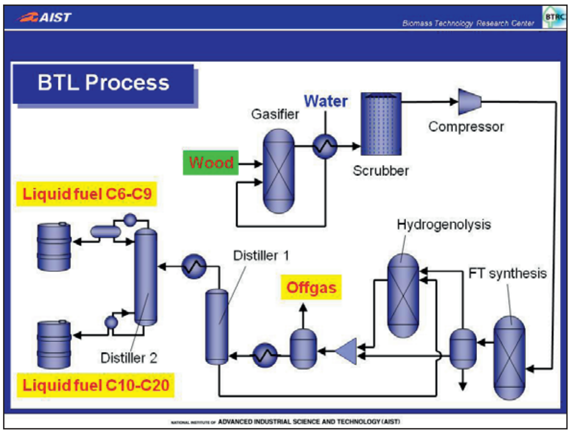
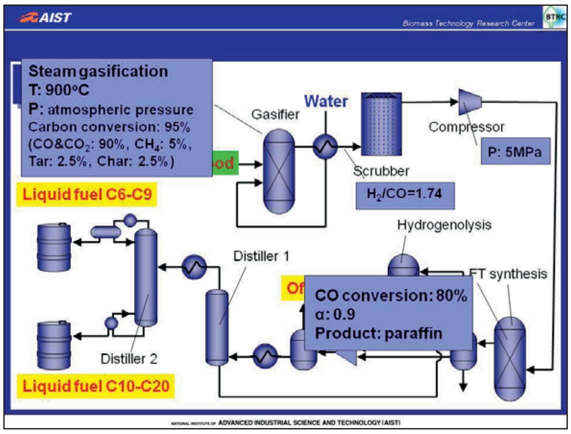
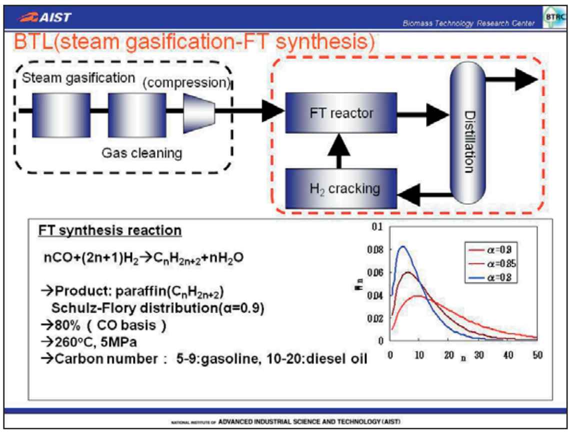
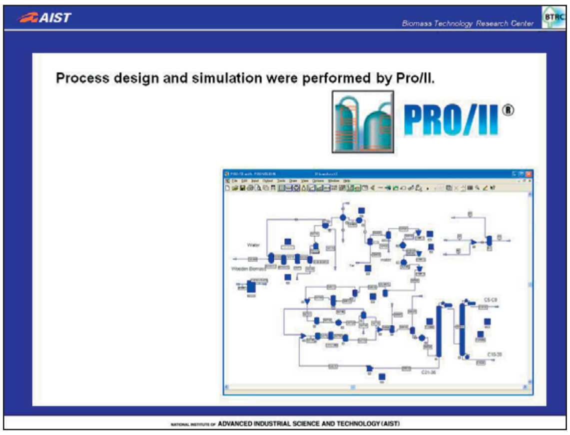
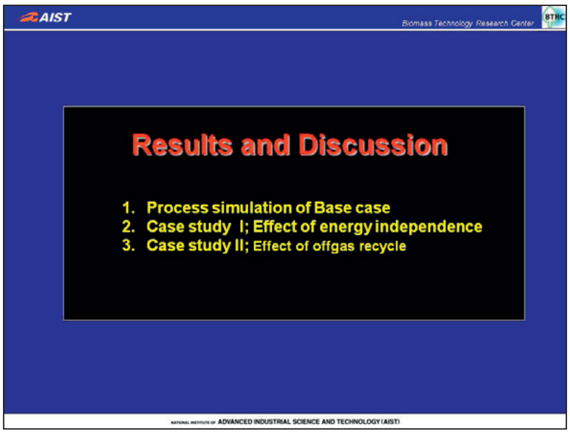
Biomass Technology Research Center
Absorption of carbon
CO_2
This work
BTL process
Silviculture
Harvest
Collection
Transportation
Fuel production
Product
Fossil fuel
Biofuel
How much CO_2 can Biofuel mitigate?
ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY (AIST)

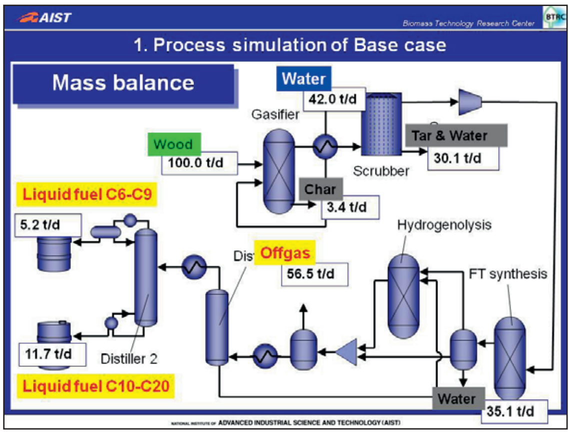

AIST
Biomass Technology Research Center
BTL Process
Gasifier
Water
Compressor
Wood
Scrubber
Liquid fuel C6-C9
Hydrogenolysis
Distiller 1
Offgas
FT synthesis
Distiller 2
Liquid fuel C10-C20
ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY (AIST)

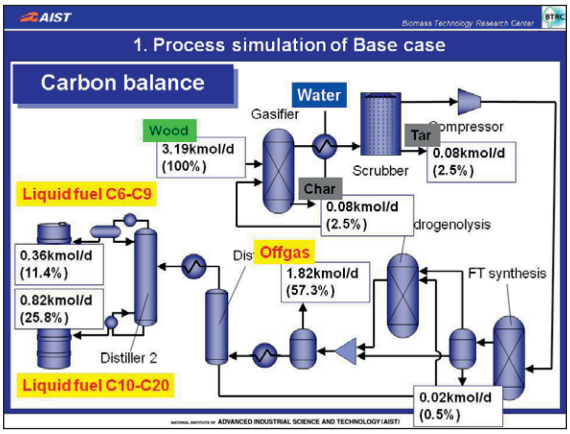

AIST
Biomass Technology Research Center
Steam gasification
T: 900°C
P: atmospheric pressure
Carbon conversion: 95%
($CO \& CO_2$: 90%, CH_4: 5%, Tar: 2.5%, Char: 2.5%)
Gasifier
Water
Compressor
P: 5MPa
Scrubber
H_2/CO=1.74
Liquid fuel C6-C9
Hydrogenolysis
Distiller 1
FT synthesis
CO conversion: 80%
α: 0.9
Product: paraffin
Distiller 2
Liquid fuel C10-C20
ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY (AIST)

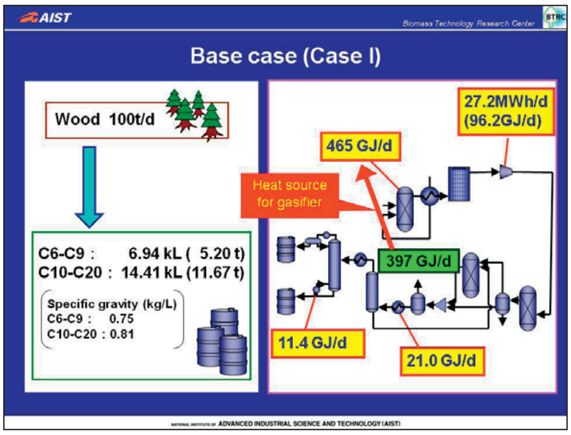

AIST
Biomass Technology Research Center
BTL(steam gasification-FT synthesis)
Steam gasification (compression)
Gas cleaning
FT reactor
Distillation
H_2 cracking
FT synthesis reaction
$nCO+(2n+1)H_2 \rightarrow C_nH_{2n+2}+nH_2O$
→Product: paraffin(C_nH_{2n+2})
Schulz-Flory distribution(α=0.9)
→80% (CO basis)
→260°C, 5MPa
→Carbon number : 5-9:gasoline, 10-20:diesel oil
α=0.9
α=0.85
α=0.8
NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY (AIST)

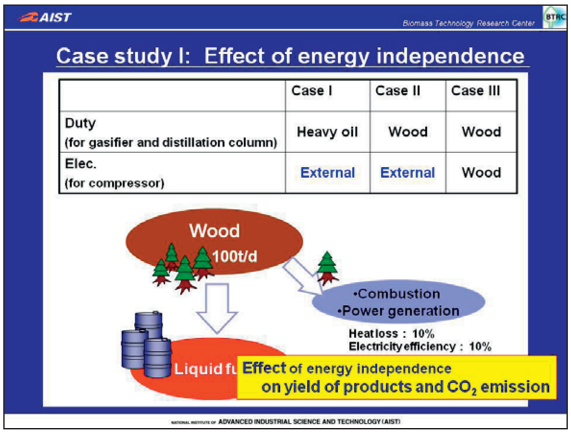

AIST
Biomass Technology Research Center
Process design and simulation were performed by Pro/II.
PRO/II®
NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY (AIST)

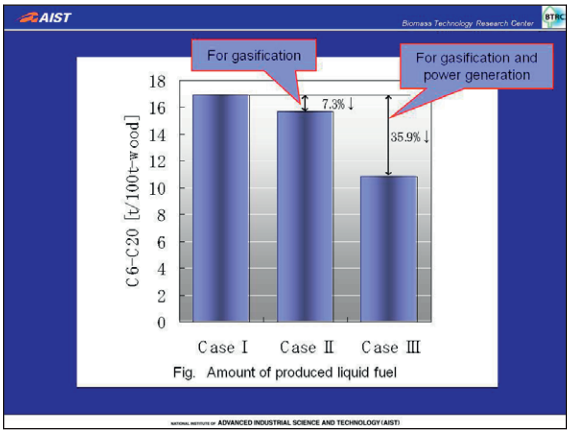

AIST
Biomass Technology Research Center
Results and Discussion
1. Process simulation of Base case
2. Case study I; Effect of energy independence
3. Case study II; Effect of offgas recycle
NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY (AIST)


AIST
Biomass Technology Research Center
1. Process simulation of Base case
Mass balance
Water
42.0 t/d
Gasifier
Wood
100.0 t/d
Tar & Water
30.1 t/d
Scrubber
Char
3.4 t/d
Liquid fuel C6-C9
5.2 t/d
Hydrogenolysis
Offgas
56.5 t/d
FT synthesis
11.7 t/d
Distiller 2
Liquid fuel C10-C20
Water
35.1 t/d
NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY (AIST)


AIST
Biomass Technology Research Center
1. Process simulation of Base case
Carbon balance
Water
Gasifier
Wood
3.19kmol/d
(100%)
Tar
0.08kmol/d
(2.5%)
Scrubber
Char
0.08kmol/d
(2.5%)
Liquid fuel C6-C9
0.36kmol/d
(11.4%)
0.82kmol/d
(25.8%)
Offgas
1.82kmol/d
(57.3%)
FT synthesis
Distiller 2
Liquid fuel C10-C20
0.02kmol/d
(0.5%)
NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY (AIST)


AIST
Biomass Technology Research Center
Base case (Case I)
Wood 100t/d
C6-C9 : 6.94 kL (5.20 t)
C10-C20 : 14.41 kL (11.67 t)
Specific gravity (kg/L)
C6-C9 : 0.75
C10-C20 : 0.81
27.2MWh/d
(96.2GJ/d)
465 GJ/d
Heat source
for gasifier
397 GJ/d
11.4 GJ/d
21.0 GJ/d
NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY (AIST)


AIST
Biomass Technology Research Center
Case study I: Effect of energy independence
Case I | Case II | Case III
Duty (for gasifier and distillation column) | Heavy oil | Wood | Wood
Elec. (for compressor) | External | External | Wood
Wood
100t/d
•Combustion
•Power generation
Heat loss : 10%
Electricity efficiency : 10%
Effect of energy independence
on yield of products and CO_2 emission
NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY (AIST)


AIST
Biomass Technology Research Center
For gasification
For gasification and power generation
7.3%↓
35.9%↓
C6-C20 [t/100t-wood]
Case I
Case II
Case III
Fig. Amount of produced liquid fuel
NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY (AIST)

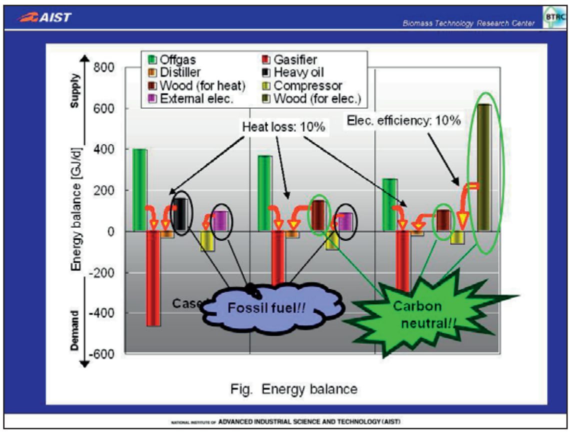


Fig. Energy balance

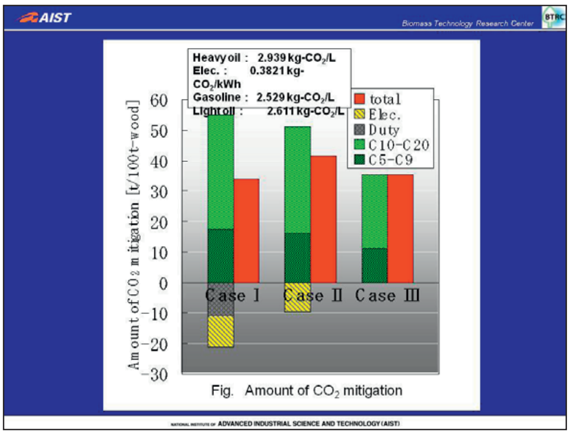
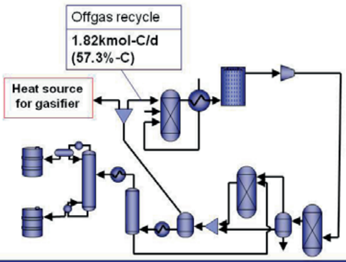


Fig. Amount of CO_2 mitigation

Case study II: Effect of offgas recycle

	Case IV	Case V	Case VI
Duty	Heavy oil	Wood	Wood
Elec	External	External	Wood



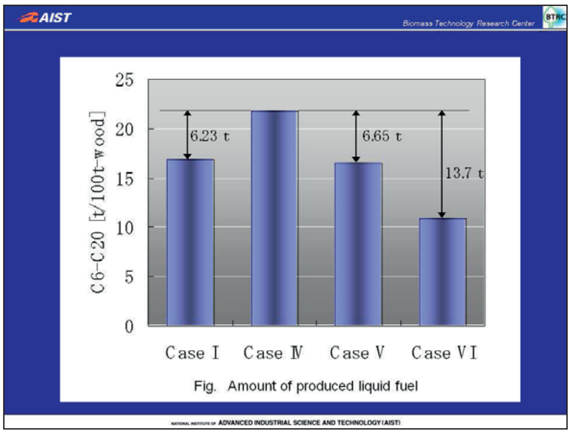


Fig. Amount of produced liquid fuel

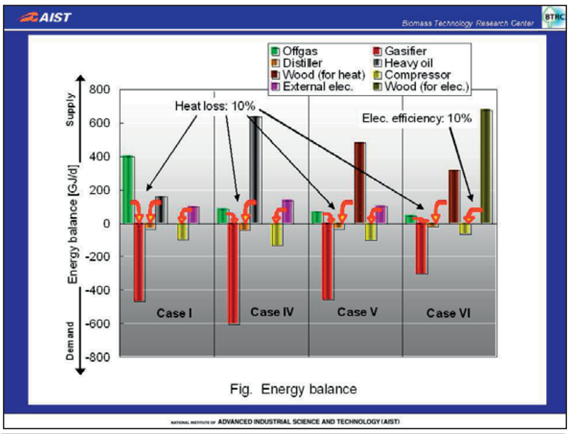
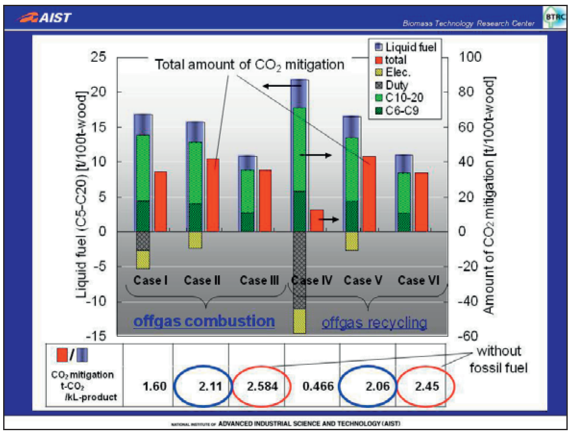


Fig. Energy balance



Summary

BTRC(Biomass Technology Research Center)
We are studying production process of Bio-ethanol and BTL oil.
Biomass System Technology Team
Economic and environmental estimation are considered by process simulation.

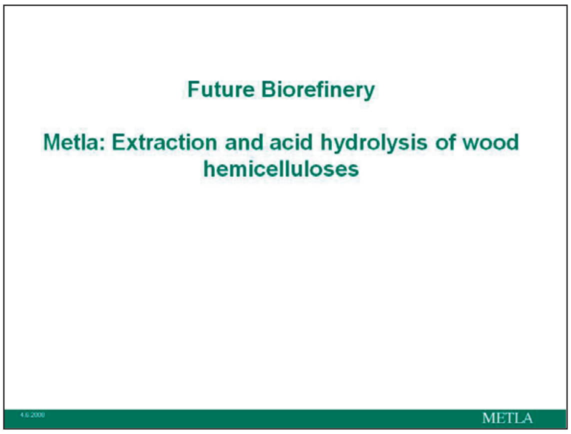
Development of economic estimation for biomass process:
Cost of each equipment is estimated and total cost can be obtained. Production cost and payback year can be calculated from the cost.
In this presentation, the simple payback year was estimated approximately 13 for biomass cost of 12,000 JPY in ETBE/BTL process.

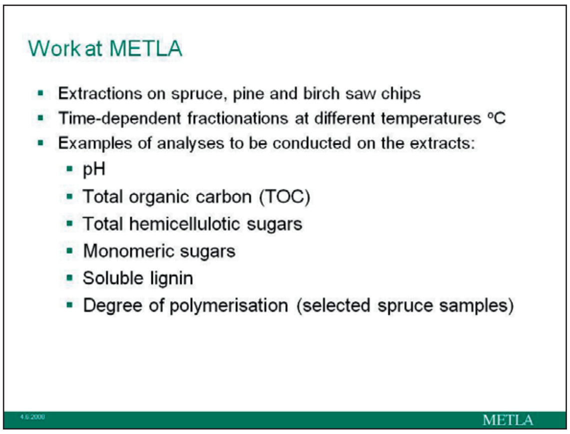
Process estimation of BTL process:
CO_2 mitigation changes with operating condition. If CO_2 emission factor of external electricity is small, onsite power generation decreases CO_2 mitigation.
Offgas recycle is not good for CO_2 mitigation.

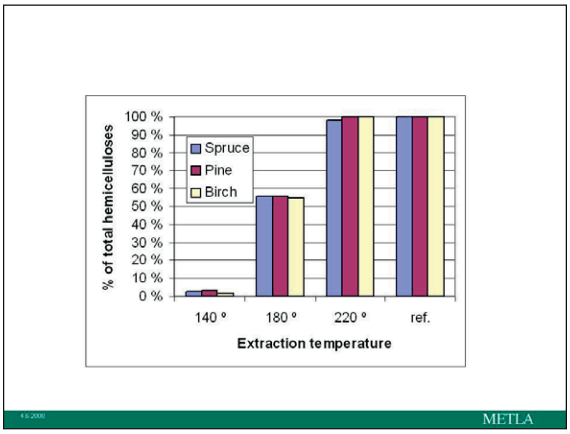
Future biorefinery

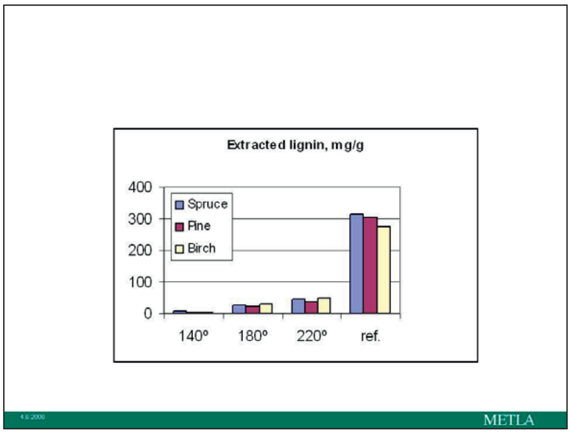
Hannu Ilvesniemi

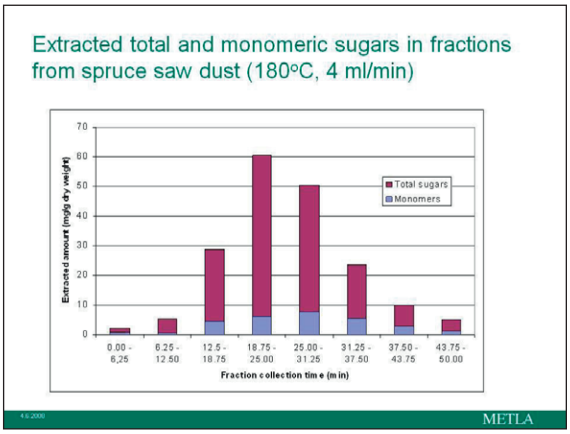
Finnish Forest Research Institute (Metla), Vantaa Research Unit, hannu.ilvesniemi(at)metla.fi

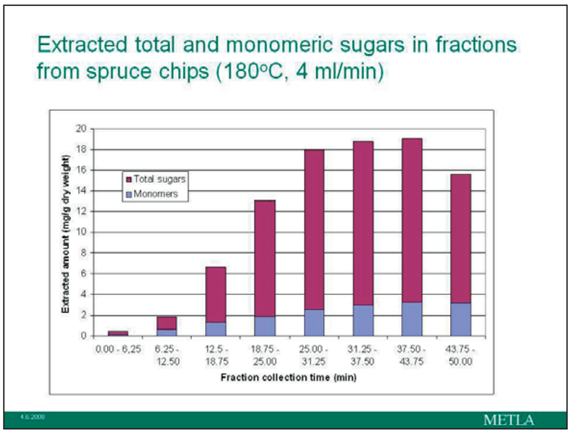




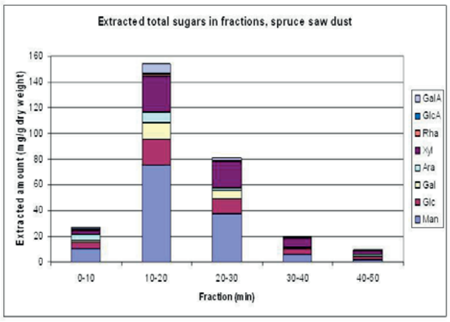




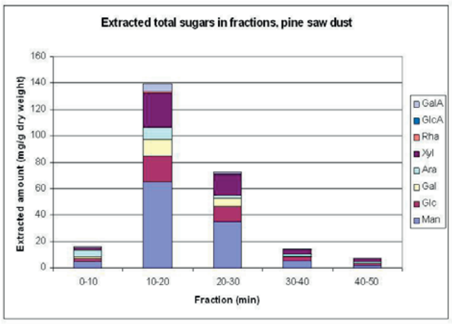




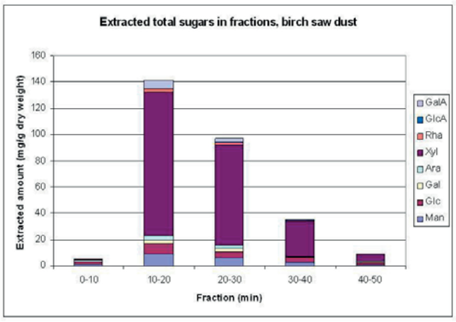
Fractionations (total sugars, spruce)



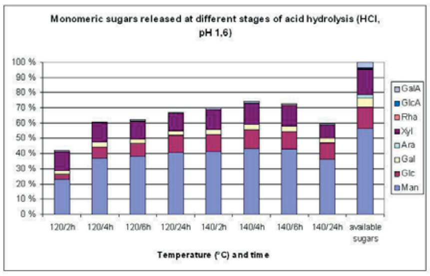
Fractionations (total sugars, pine)



Fractionations (total sugars, birch)

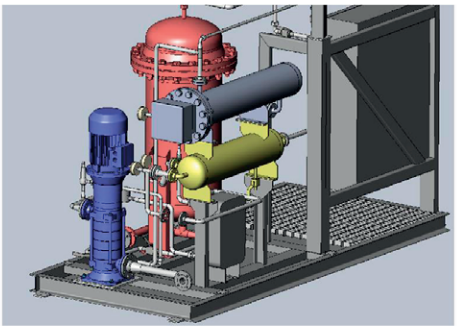


Hydrolysis of extracts (pH 1,6)



Sample	Total sugars left (%)
120/2h	99,9
120/4h	99,4
120/6h	98,9
120/24h	90,1
140/2h	99,3
140/4h	88,5
140/8h	88,4
140/24h	73,4

Pilot-scale extraction unit



Session 3 Evaluating forest value under changing climate conditions for sustaining forest health

A stated preference approach to value ecosystem services of forests

Kentaro Yoshida

Faculty of Environmental Studies, Nagasaki University, ykentaro(at)nagasaki-u.ac.jp

A forestry conservation tax was implemented by the prefecture of Kochi in 2003. It was implemented in order to conserve headwater forests. The prefecture imposes a tax of 500 yen annually on each taxpayer to raise a fund to conserve forests. In 2004, the prefecture of Okayama introduced a similar local tax to conserve forests. Since then more than 20 local governments have introduced similar local environmental taxes; an effective method for evaluation of these instruments is called for.

In order to value non-market goods, stated preference approaches are often employed. Yoshida (2004) used stated preference approaches to evaluate headwater forestry conservation program and suggested that the choice experiment method was more reliable than contingent valuation method (CVM) in terms of a scope test. One of the advantages of the choice experiment is that it allows researchers to evaluate and compare a number of different attributes using one question. Because of this, the choice experiment method has recently drawn attention in environmental economics. However, since local environmental taxes are conducted in a number of local governments, the constraint of budget and expertise may make it difficult to apply a social cost–benefit analysis to the measures. Therefore, it appears to be important to assess the reliability of benefit transfer using choice experiment as well as CVM although it may present formidable challenges.

In this study, by conducting CVM and choice experiment in almost identical forms in three locations, Kochi Prefecture, Okayama Prefecture, and Tottori Prefecture, the results of the experiments are examined to see the transferability of benefit estimates. In the field of environmental and natural resource economics, research on benefit transfer and stated preference approaches has increased recently.

Benefit transfer is the process to predict a benefit estimate of a new policy site by using benefit estimates or functions of existing studies. If existing studies for a similar environmental good can be applicable to cost–benefit analysis of a new policy site, government agencies will be able to avoid wasting time and money for tedious work. It is often required by the government agencies for practical reasons to obtain benefit estimates at a new policy site. Benefit transfer can be divided into three major types: (1) fixed value transfer; (2) expert judgment; and (3) value estimator models. A number of empirical studies have been conducted to assess the transferability of benefit estimates. However, they have mostly focused on the CVM and the travel cost method. Benefit transfer of choice experiments is a relatively new field, which should be explored by intensive empirical studies.

Since choice experiment has the advantage of producing per-unit benefit valuation of policy effects, it makes the connection with cost–benefit analyses easy and is efficient in terms of cost and time. If a benefit transfer approach of choice experiment is established, it will further enhance the efficiency of cost–benefit analyses. In order to test the reliability of choice experiment, comparison with CVM results would be useful to interpret the results. Therefore, both CVM and choice experiment were employed.

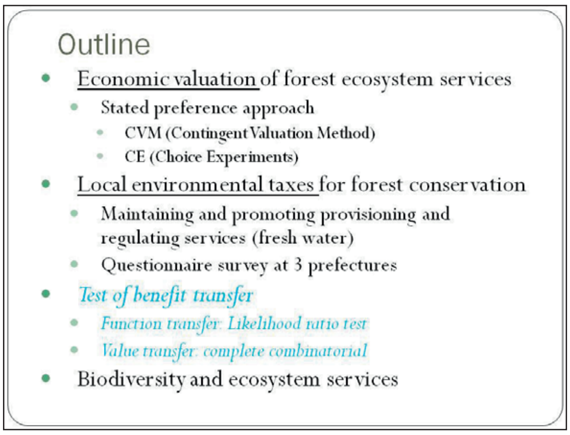
By conducting both likelihood ratio test and direct transfer test by a complete combinatorial approach, both tests were likely to generate a different result. As Downing and Ozuna (1996) indicated, nonlinearity may cause such a result.

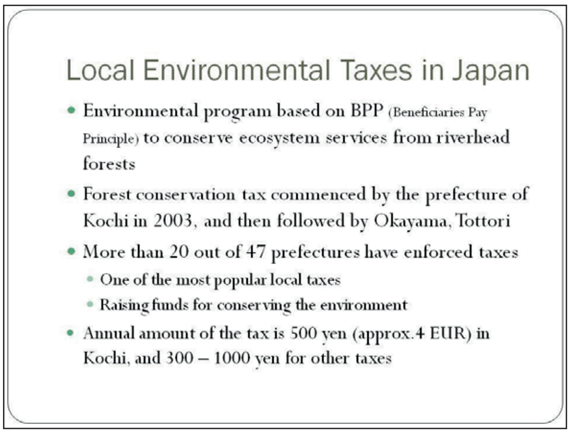
Reference

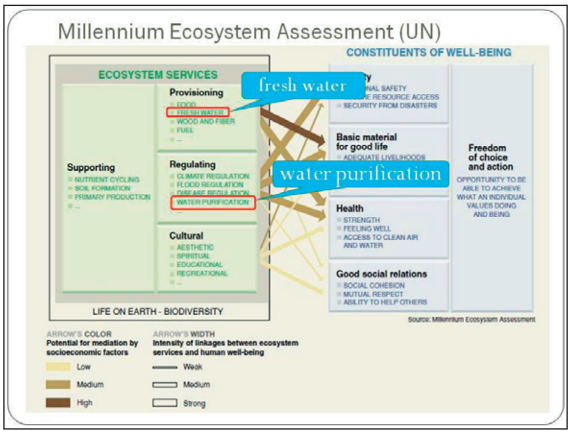
Yoshida K. (2004) "Testing the Transferability of Environmental Benefits for the Local Environmental Tax." Journal of the City Planning Institute of Japan, 39 (3), pp.571–576.

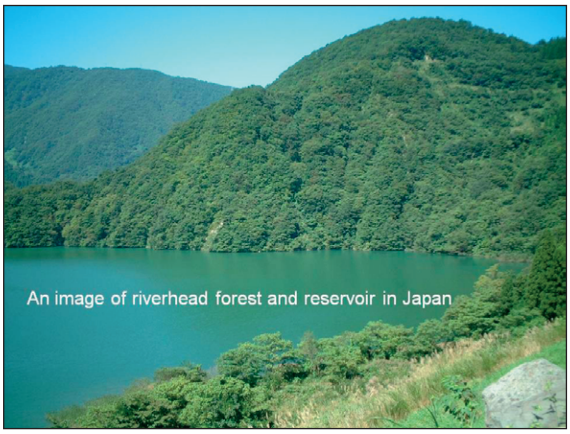
Appendix

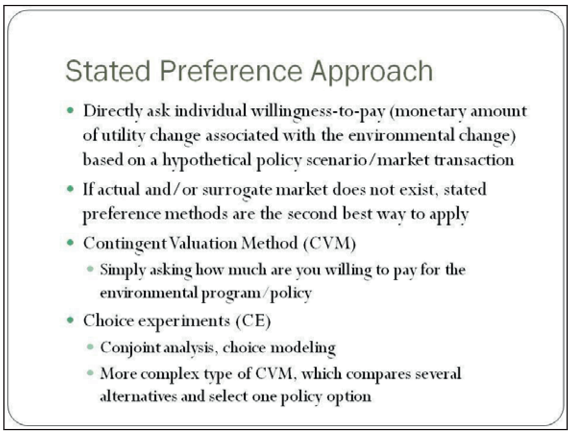
Presentation: A stated preference approach to value ecosystem services of forests







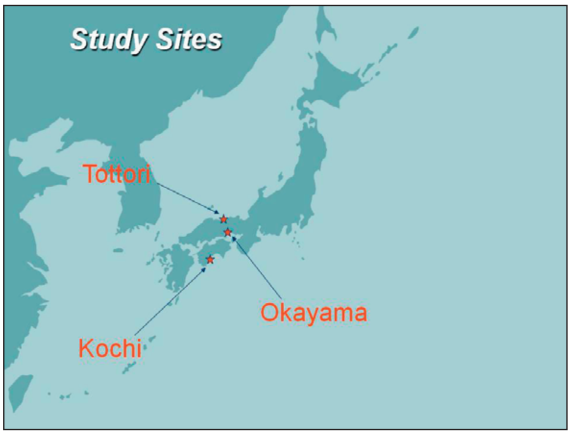




Questionnaire Survey

- Mail survey with a single reminder
- The survey was conducted in December 2004
- Random sampling from voters list
- Two municipalities, representing urban and rural, in each prefecture were chosen

	Return / Deliver	Response rate
Kochi	173/359	48.1 %
Okayama	152/366	41.5 %
Tottori	161/362	44.5 %



WTP Question of CVM

- The following hypothetical scenario was presented to elicit individual WTP (monetary value)
  - "The present forest conservation program covers only 0.1% of a total area of artificial forests.
  - Now suppose that we will expand a targeted area of forests and cover the whole forests in the prefecture.
  - If the government raises the amount of a new tax up to *1,000 yen (randomly assigned value)*, are you going to vote for the proposal?" (YES/NO)
- If a respondent answer "YES," a higher amount of value is asked. If "NO," lower.
  - Repeated referendum: double-bounded dichotomous

Estimated Coefficients of CVM

Variable	Kochi	Okayama	Tottori
Constant	11.1**	11.9**	6.47**
Log. of threshold value	-1.70**	-1.71**	-1.39**
Region (1=urban, 0=rural)	-0.461	-0.00708	-0.434
Forest concern (no interest)	1.56**	0.546	-2.06*
Forest thinning (disapproval)	-1.98**	-0.918	-
Public relations (disapproval)	-0.931**	0.00982	-0.993*
Job opportunity (disapproval)	-	-0.753	-
Env. education (disapproval)	-	-	-0.471
Forest tax (expand)	1.26**	1.55**	1.37**
Use of bottled water	1.73	-0.425	-1.33
Number of household	-0.163	0.0384	-0.153
Log. of income	0.521*	0.194	0.879**
# of observations	159	129	147
Log likelihood	-208.6	-162.3	-170.9

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Log likelihood	-208.6	-162.3	-170.9

Results of CVM

- "Region" (dummy variable of urban/rural) was not statistically significant
  - WTP of urban residents is not different from WTP of rural residents
- Most of the forest conservation taxes impose the same amount of money to all taxpayers in the prefecture. These results suggest that the differentiated tax amount in urban/rural municipalities is not necessary
- However, "Income" was significantly positive in the results of two prefectures
- It suggests that individual amount of tax may be progressive

Annual WTP/household (CVM)

	Kochi	Okayama	Tottori
WTP	2,817 yen (=20 EUR)	2,211 yen	2,209 yen
[90% C.I.]	[2370 - 3403]	[1781 – 2671]	[1775 - 2826]

Choice Experiments
(An example of choice set; combination of profiles)

Attribute	Measure 1	Measure 2	Measure 3 Current	
Forest conservation	900ha	450ha	300ha	Choose none of these
Urban green space preservation	120ha	80ha	40ha	
River water quality improvement	B	AA	Status quo	
Environmental tax	5,000 yen	2,000 yen	500 yen	
Circle one	1	2	3	

Estimated Coefficients of CE (conditional logit model)

Variable	Kochi	Okayama	Tottori
ASC (const.)	-0.476**	-1.10**	-0.673**
Forest conservation	0.00480**	0.00296**	0.00262**
Urban green space	0.000446	-0.00135	0.00000121
River water quality	0.197*	0.223*	0.418**
Environmental tax	-0.000197**	-0.000247**	0.0000248**
# of observations	608	496	540
Log-likelihood	-720.1	-589.4	-630.5

Estimated Coefficients of CE (conditional logit model)

Variable	Kochi	Okayama	Tottori
ASC (const.)	-0.476**	-1.10**	-0.673**
Forest conservation	0.00480**	0.00296**	0.00262**
Urban green space	0.000446	-0.00135	0.00000121
River water quality	0.197*	0.223*	0.418**
Environmental tax	-0.000197**	-0.000247**	0.0000248**
# of observations	608	496	540
Log-likelihood	-720.1	-589.4	-630.5

Results and Interpretation of Choice Experiments

- "Urban Green Space" was not significant for all models
- People value riverhead forest conservation and river water improvements for policy target

Annual marginal willingness-to-pay per household

Choice Experiments	Kochi	Okayama	Tottori
Forest conservation [90% C.I.]	24 yen/ha [17 – 33]	12 yen/ha [4.6 – 20]	11 yen/ha [4.0 – 18]
River water quality [90% C.I.]	999 yen/% [190 - 1814]	901 yen/% [279 - 1650]	1681 yen/% [1017 - 2409]

Benefit Transfer

- "Benefit transfer" is the process to predict benefit estimates (and/or functions) by using existing environmental valuation studies
  - Greater needs of practitioners for "cheaper but reliable" benefit-cost analysis
  - Fixed value transfer, expert opinions and value estimator models (Bergstrom and De Civita, 1999), Meta-analytical approach (Morrison, 2002)
- Equality of functions and WTPs to be tested

Transferability (Equality) Tests

- Likelihood ratio (LR) test
  - Test of equality of models between two sites
    - LL_A is log-likelihood obtained at site A
    - LL_B is log-likelihood obtained at site B
    - LL_{A+B} is log-likelihood obtained by pooling the data of A and B
  - $\lambda = -2\,[LL_{A+B} - (LL_A + LL_B)] \sim \chi^2$
- Value transfer (complete combinatorial)
  - Test of equality of marginal willingness-to-pay based on simulated distribution of each coefficients (1million trial)
  - H_0: $MWTP_A - MWTP_B = 0$

WTP of CVM and Marginal WTP of CE

CVM	Kochi	Okayama	Tottori
Median WTP [90% C.I.]	2817 yen [2370 - 3403]	2211 yen [1781 – 2671]	2209 yen [1775 - 2826]

Choice Experiments	Kochi	Okayama	Tottori
Forestry conservation [90% C.I.]	24 yen/ha [17 – 33]	12 yen/ha [4.6 – 20]	11 yen/ha [4.0 – 18]
River water quality [90% C.I.]	999 yen/% [190 - 1814]	901 yen/% [279 - 1650]	1681 yen/% [1017 - 2409]

WTP of CVM and Marginal WTP of CE

CVM	Kochi	Okayama	Tottori
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Results of Transferability (Equality) Test

	CVM		Choice experiment		
	LR-test	Direct transfer	LR-test	Direct transfer	
				Forest	River
Kochi－Okayama	-	*	**	**	-
Kochi－Tottori	-	*	**	**	-
Okayama－Tottori	-	-	**	-	-

Note: *, ** show rejection at a significant level of 5% & 1%, respectively.

"-" means that WTPs of two populations are not different.

"*/ **"means that WTPs of two populations are different.

Results of Transferability (Equality) Test

- Function transfer (LR test)
  - *CVM*: none of the null hypotheses on the combinations were rejected
  - *CE*: all of the null hypotheses on the combinations were rejected
- Value/WTP transfer (complete combinatorial)
  - Only a WTP of Kochi is statistically different from other prefectures

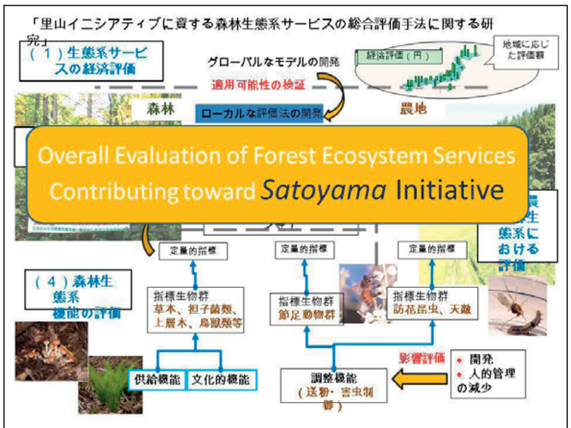
Discussion and Conclusion

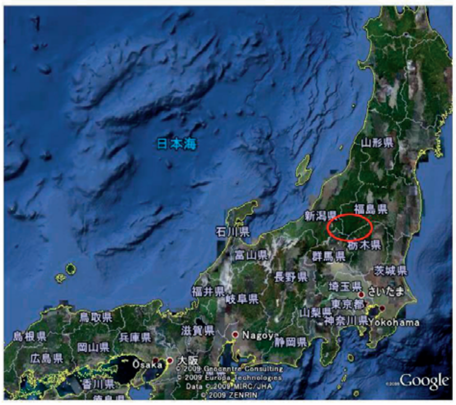
- Individual WTP for forest conservation obtained by CVM and CE surpassed a current tax amount of each prefecture
- Function transfer test revealed the different characteristics of estimated models between CVM and CE
- WTP for forestry conservation of Okayama and Tottori were transferable each other. On the other hand, WTP estimated by the data of Kochi prefecture was not.
  - Kochi prefecture started forestry conservation tax two years ago. The prefecture of Okayama has just introduced the new tax and the prefecture of Tottori had not implemented it at the time of survey
  - The results of the analyses may indicate that evaluation reflects the time elapsed after implementation of the tax at the time of survey

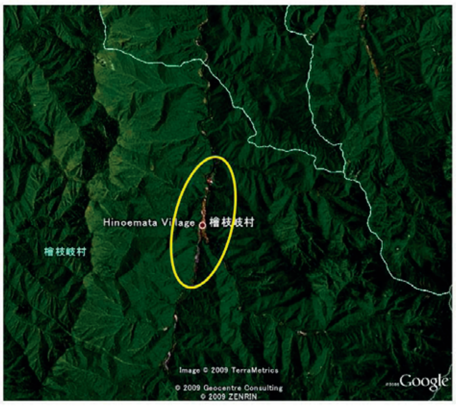
Forest Ecosystem Services: Replacement Cost Method

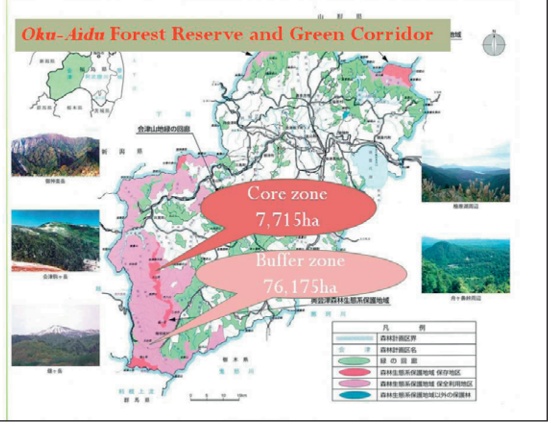
Ecosystem Services	Value (billion yen)
Absorbing CO_2	1,239 (=10 billion EUR)
Substituting fossil fuels	226
Preventing erosion	28,256
Preventing landslide	8,442
Mitigating flood risk	6,468
Fostering water resources	8,740
Purifying water	14,636
Recreation and relaxation	2,254
Biodiversity	*N/A*

Source: MRI(2001)





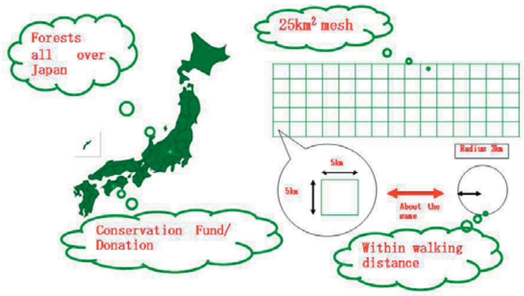




Passive Use Value of Forest Ecosystems

- Internet survey
- January 2009
- Respondents: 1,234 registered persons
- Method: Conjoint analysis (stated preference)
- Conducted by the University of Tsukuba and FFPRI
- Source
  - Ohdoko and Yoshida (2009), "Challenging the valuation of biodiversity and ecosystem services," presented at annual meeting of Ecological Society of Japan

Hypothetical Policy Scenario



An example of a question to elicit individual willingness-to-pay

回答例(計画案1のほうが望ましいとき)

	計画案 1		計画案 2
普通にいる動物の保護	20 種	<	35 種
普通にある植物の保護	250 種	<	400 種
希少な動物の保護	32 種	>	8 種
希少な植物の保護	55 種	>	10 種
負担金（世帯当たり）	1500 円	>	500 円

どちらの数値が大きいかを表します.
<:右が大きい >:左が大きい =:等しい

(1) 計画案1	(2) 計画案2
◉	○

Estimated Marginal Willingness-to-pay Using Conjoint Analysis

	MWTP/household
Common animal species protection	0 (JPY /species)
Common plant species protection	3
Endangered animal species protection	72
Endangered plant species protection	32

Nature-based recreation research in Finland

Tuija Sievänen

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Nature-based recreation research has been going on in the Finnish Forest Research Institute (Metla) since the mid-1970s, and the National Outdoor Recreation Demand Inventory (LVVI) -study was established in the late-1990s. The LVVI-study collects statistics and data on a continuous basis in order to monitor changes in outdoor recreation behaviour patterns. The main issues for the study were to produce data concerning participation in outdoor activities and recreational use of different forest areas (state land, community land, private land). The study also focuses on different special themes such as human wellbeing and health impacts of nature and environmental changes such as climate change and nature-based recreation and tourism. The LVVI study provides national and regional outdoor recreation statistics and research reports and scientific articles on different topics based on the LVVI-data. The second national recreation survey is on-going in 2009-2010. The outdoor recreation statistics are widely used in forest policy and environment policy documents (e.g. National Forestry Program and VILMAT program), by the tourism sector, and by municipal, regional and state agencies which manage recreation resources and services in Finland. The project description and publications can be found at http://www.metla.fi/metinfo/monikaytto/lvvi.

A special study topic based on LVVI-data is participation in different outdoor activities such as mushroom picking. The study revealed that the majority of Finnish people participate in picking mushrooms, and two out of every five Finnish people participate in an average year. Both participation rates and numbers of picking occasions vary depending on whether the mushroom crop is good or poor in a particular year. The most important socio-economic factors affecting the participation and the number of picking occasions are gender, age, place of residence (size of municipality and location of region). Interestingly mushroom picking frequency was not related to the income of picker. It seems that mushrooms are not a necessity in a Finnish household, but rather they are luxury of more highly educated Finns. The same conclusion can also be drawn from the decrease in picking frequencies in poor crop years. This gives an impression that Finns do not have an annual mental quota or goal for amount of mushrooms picked and conserved. Rather they take advantage of the plentiful crops of mushrooms on those years when they appear.

Another research topic has concerned outdoor recreation and adaptation to climate change. The focus was in recreation activities which are dependent on natural snow cover (cross-country skiing, downhill skiing and snowmobiling), and also summer activities which are related to warm temperature and sunny conditions (swimming in natural waters). The study produced recreation participation models based on the data of the national inventory of outdoor recreation (LVVI). Based on scenarios for near term (2005–2020), mid-term (2021–2050) and long term (2070–2099) according to participation models, the study concludes that (1) decrease in participation rates and days occur in winter activities, particularly in cross-country skiing and snowmobiling; (2) participation in downhill skiing is less sensitive to changes in climate conditions compared to cross-country skiing; (3) participation rate increases in swimming in natural waters. The recreation participation scenarios provide a vision of how current patterns of recreation behaviour follow the changes in climate, demography and socio-economic development. People adapt their participation in recreational activities in various ways: (a) shifting to activities which are less sensitive to weather conditions; (b) by travelling to more distant locations; and (c) by investing in new types of recreation equipments with high-tech solutions in changed climate conditions.

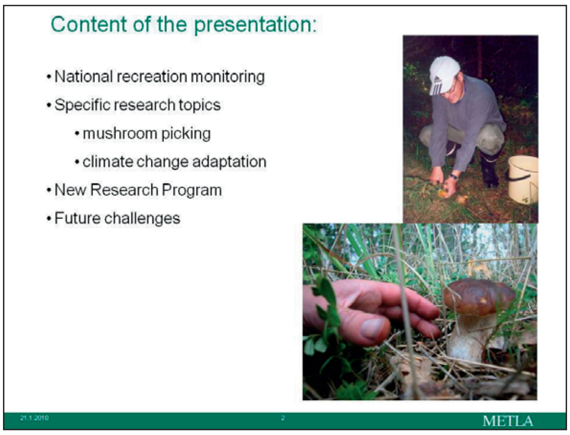
In Metla, a 5-year research program 'Wellbeing of Forests' (HYV) was established in 2008 (http://www.metla.fi/tutkimus). It includes seven main projects and several sub-projects. The aim of the program is to produce new information on the following topics: (1) integration of different forest uses; (2) benefits and economic values of forest recreation and tourism; (3) demand and trends of nature-based recreation and tourism; (4) cultural and social values of forests; and (5) entrepreneurship and new products and services. The main projects are:

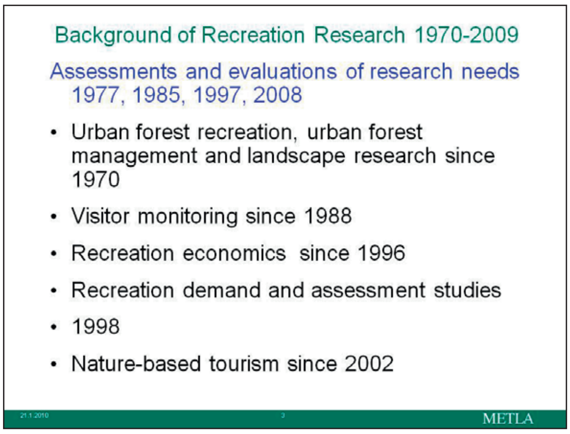
- The meaning of tourism and recreation in rural development and landscape;
- Environmental and recreation services of forests: economic impacts, valuation, and business opportunities;
- Impacts of forest management practises on landscape and recreational values;
- Integrating ecological and social information in urban planning;
- Land-use planning for sustainable tourism destinations;
- Nature-based recreation monitoring and assessment (including LVVI study);
- Developing services for efficient utilization of forest resources for the welfare of forest owners and society.

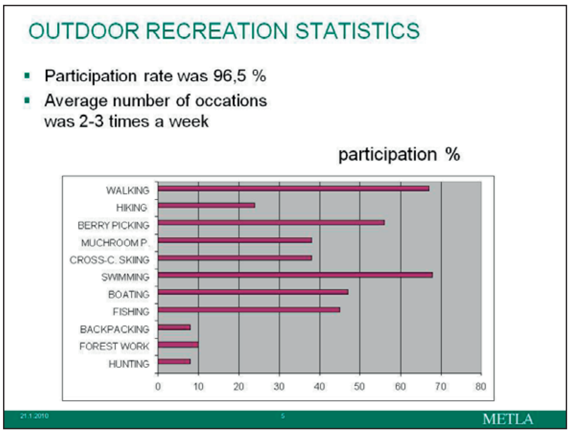
The HYV program is the strongest unit in this field of research in Finland. HYV -program researchers have contacts and co-operation with international research networks in Europe (e.g. COST Actions E33, E39 and E45) and also worldwide (International Union of Forest Research Organisations (IUFRO), International Symposium of Society and Resource Management (ISSRM). Co-operation with Japanese research units are an interesting opportunity. Common issues could be forest impacts on human health and wellbeing, and interest in wild mushrooms as a source of food and recreation among other possible up-coming issues.

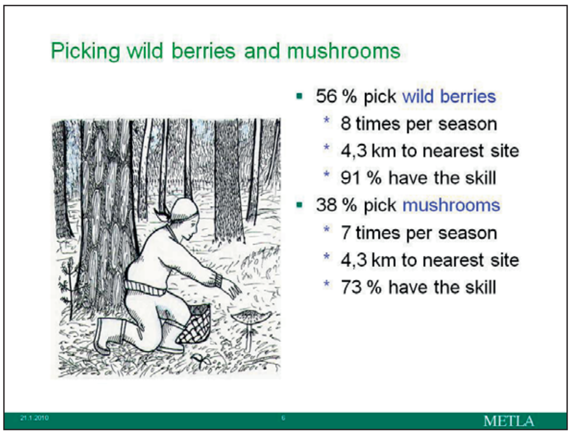
Appendix

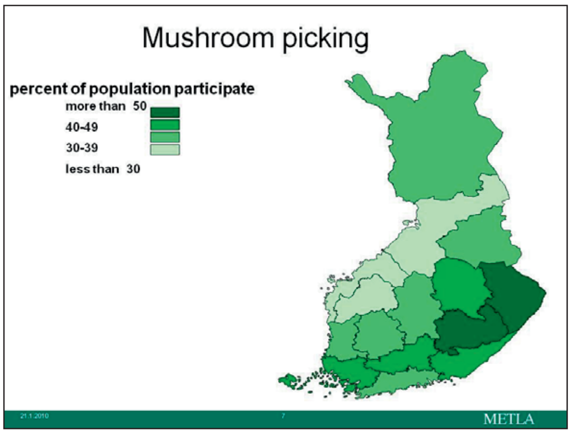
Presentation: Nature-based recreation research in Finland

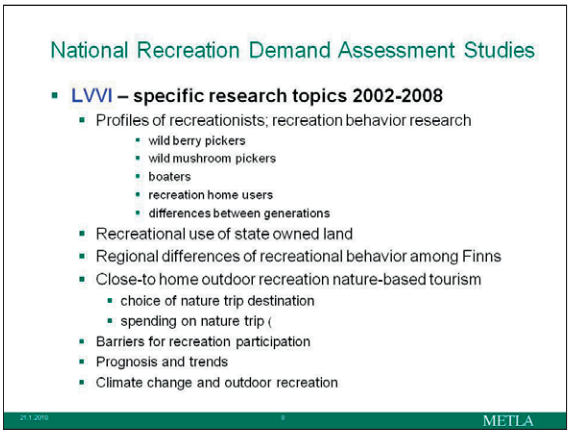


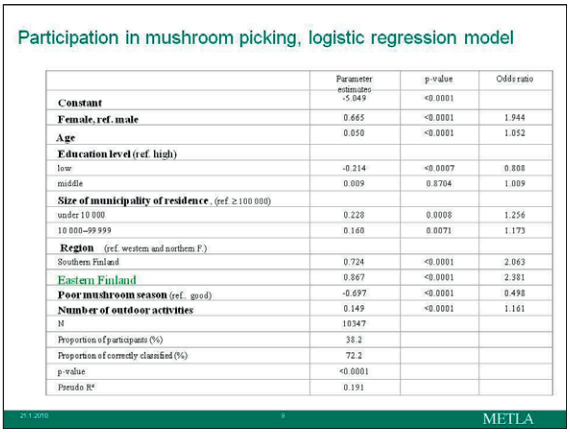




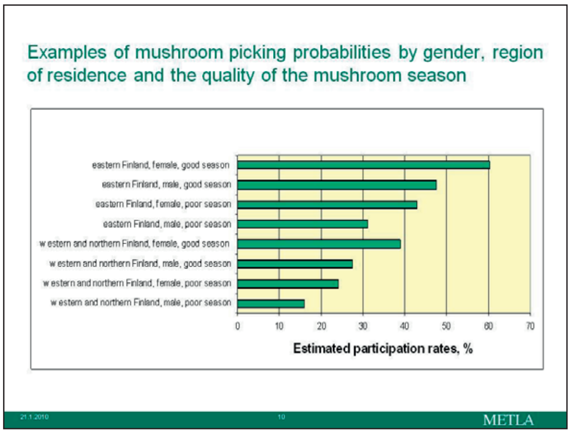


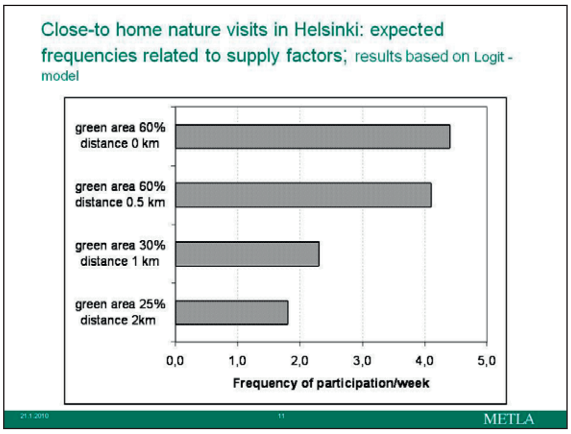


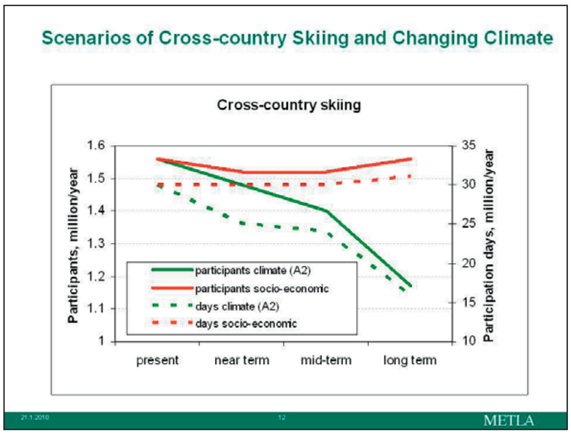


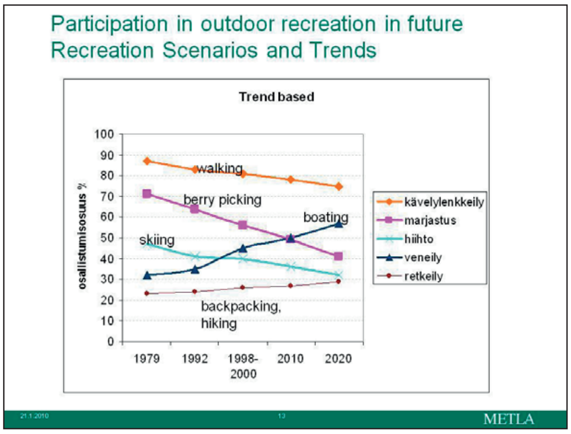

Participation in mushroom picking, logistic regression model

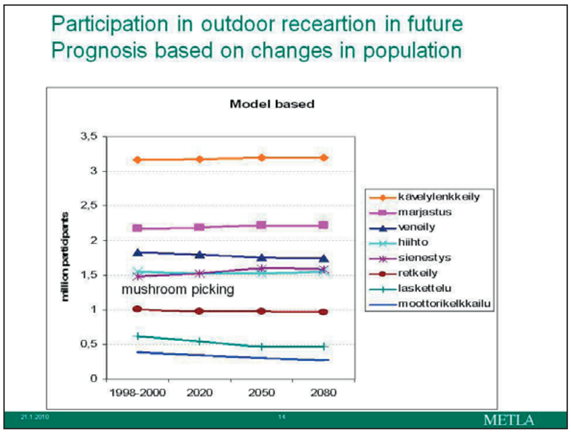
	Parameter estimates	p-value	Odds ratio
Constant	-5.049	<0.0001	
Female, ref. male	0.665	<0.0001	1.944
Age	0.050	<0.0001	1.052
Education level (ref. high)			
low	-0.214	<0.0007	0.808
middle	0.009	0.8704	1.009
Size of municipality of residence, (ref. ≥ 100 000)			
under 10 000	0.228	0.0008	1.256
10 000–99 999	0.160	0.0071	1.173
Region (ref. western and northern F.)			
Southern Finland	0.724	<0.0001	2.063
Eastern Finland	0.867	<0.0001	2.381
Poor mushroom season (ref. good)	-0.697	<0.0001	0.498
Number of outdoor activities	0.149	<0.0001	1.161
N	10347		
Proportion of participants (%)	38.2		
Proportion of correctly classified (%)	72.2		
p-value	<0.0001		
Pseudo R²	0.191		











Wellbeing of Forests – Research Program (2008-2012) http://www.metla.fi/tutkimus/

Major research fields of 'Wellbeing of forests' – research program

- Forest recreation
- Nature tourism
- New products and services
- Integrating different forest uses

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National Outdoor Recreation Demand Inventory (LVVI 2) in 2008-2011

- Updated outdoor recreation statistics
- Theme study issues concern changes in society and environment
  - **Outdoor recreation and human health and wellbeing**
  - Adaptation for climate change and other environmental issues
  - Use of private forests for recreation; rural development, nature-based tourism, recreation homes
  - Recreational use of coastal areas (Baltic sea)

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Other recreation and nature tourism projects (7) in 2008-2012 in Metla

- **Environmental and recreation services of forests: economic impacts, valuation, and business opportunities**
- **Impacts of forest management practices on landscape and recreational values**
- **Integrating ecological and social information in urban planning**
- **Land-use planning for sustainable tourism destinations**
- **Sustainable multiple use of forests in northern Lapland**
- **The meaning of tourism and recreation in rural development and landscape**

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Co-operation with Japan?

Thank You

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Research projects for cultivating *Tricholoma matsutake* in FFPRI

Takashi Yamanaka

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Tricholoma matsutake (S. Ito & Imai) Sing. is one of the most economically important edible ectomycorrhizal mushrooms in the world. However, in spite of many attempts to cultivate *T. matsutake*, none has succeeded. Therefore, commercial demand is met by harvesting fruit bodies that grow spontaneously in coniferous ectomycorrhizal forests, mainly under *Pinus densiflora* trees. In the early 1940s about 12 000 tons of *T. matsutake* were harvested each year in Japan; production has since drastically decreased to less than 100 tons per year. Possible causes are pine wilt disease and modern forestry management practices, which might have damaged the symbiotic association between *T. matsutake* and pine trees.

This fungus develops mycelial aggregations in association with mycorrhizal roots and soil particles, which are called "shiros", in well-drained and nutrient-poor forest soil. Fruit bodies of *T. matsutake* develop on these shiros, and so research on the mechanisms of development of shiros and the mycorrhizal association between *T. matsutake* and pine trees (Fig. 1) is necessary to improve the production of matsutake in pine forests and to establish an artificial cultivation system.

Figure 1: Ectomycorrhizae of Pinus densiflora formed by Trihcoloma matsutake. Photo: FFPRI

For shiros to develop in nutrient-poor soils, carbon is translocated from pine trees into *T. matsutake*, and nitrogen might be obtained from soil microbes in or near shiros in soil. At FFPRI, we started a research project on the nutrient acquisition of *T. matsutake* by estimating the physiological and morphological reactions of pine roots against infection by *T. matsutake* and by clarifying the changes in gene expression by colonization of *T. matsutake*. We also examined the nitrogen-fixing activity in shiros, as well as soils outside and inside the shiros for clarifying the nitrogen acquisition of shiro.

In Japan, two Tricholoma species (*T. bakamatsutake* and *T. fulvocastaneum*) closely related to *T. matsutake* have been reported from oak trees (*Quercus* spp.). Among these two species, *T. bakamatsutake* has a strong fragrance similar to that of *T. matsutake*, whereas *T. fulvocastaneum* has a faint fragrance. These two species are expected to be valuable edible mushrooms which can be cultivated. We have started another project to cultivate these two *Tricholoma* species. Initially, the relationship of *T. bakamatsutake* and *T. fulvocastaneum* with *T. matsutake* will be investigated genetically. By developing a technique to synthesize ectomycorrhiza between these two *Tricholomas* and oak seedling *in vitro*, the host range of these fungi will be clarified for selecting an adequate combination of fungus and its host tree.

Appendix

Presentation: Research projects for cultivating *Tricholoma matsutake* in FFPRI

Research projects for cultivation of *Tricholoma matsutake* in FFPRI

Takashi Yamanaka
Forest Microbiology Division
Forestry and Forest Products Research Institute
JAPAN

Research projects for cultivation of *Tricholoma matsutake* in FFPRI

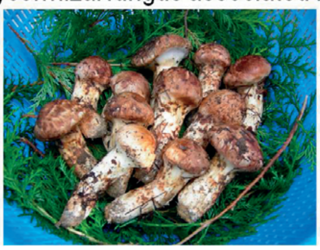
Content

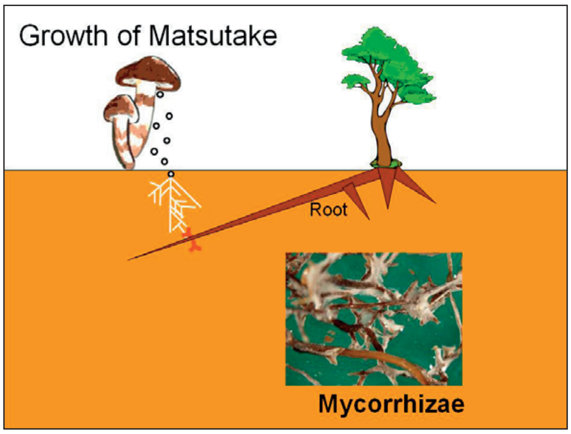
- What is Matsutake?
- Research on nutrient acquisition of *T. matsutake*
- Research on cultivation of oak-forest *Matsutake*

What is Matsutake?

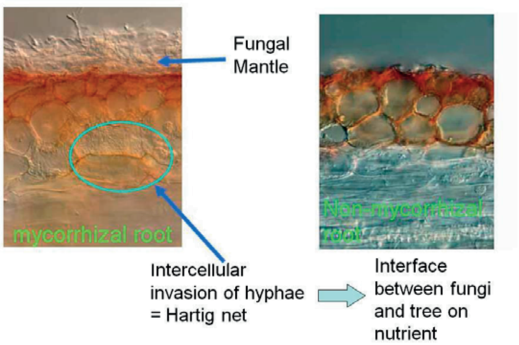
Matsutake (*Tricholoma matsutake*) is

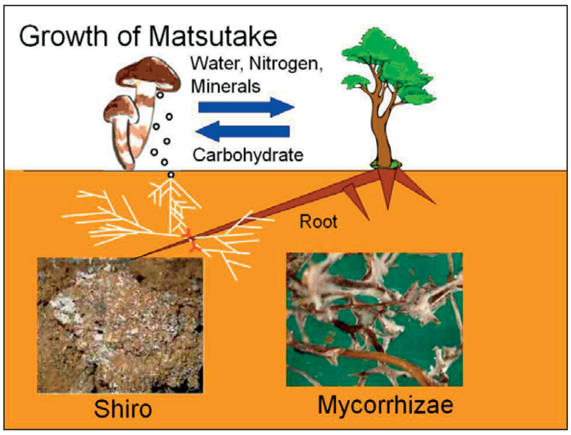
- Edible mushroom
- Ectomycorrhizal fungus associated with pine



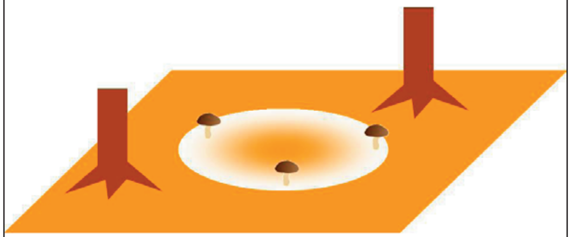


Ectomycorrhiza formed by *Pinus densiflopra* and *Trhicholoma matsutake*





Development of a Mastutake shiro



Matsutake appear on the periphery of the shiro in the soil. It called as a fairy ring.

Green building materials

- *Green building materials* are environmentally responsible even though impacts are considered over the life of the product
- Factors that make these materials desirable for use in sustainable building are:
  - resource efficiency: low use of non-renewable resources
  - energy efficiency: production time, life time (insulation, etc.), end-of-life
  - affordability: no matter the rate of marketing and promotion, price matters!
- Wood-based building materials meet these requirements because they are:
  - natural, plentiful and renewable
  - produced using resource-efficient manufacturing processes
  - locally available
  - reusable and recyclable
  - durable
  - highly functional

METLA

Matsutake related species

•*T. matsutake* Asia
•*T. nauseosum* Europe and N. Africa (=*T. matsutake*)
•*T. caligatum* Europe (Matsushita et al. 2005)
•*T. magnivelare* N. America (Wang et al. 1997)

T. matsutake (Nagano, Japan)

T. magnivelare (Oregon USA)

To improve matsutake production in pine forests
To establish an artificial cultivation system

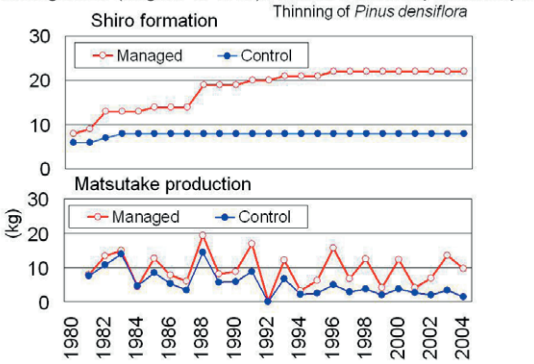
Forest management

Mechanisms of development of shiro
Mycorrhizal association between matsutake and pine

We started a research project on nutrient acquisition of *T. matsutake*
•reaction of pine root against infection by *T. matsutake*
•changes in gene expression by colonization of *T. matsutake*
•nitrogen-fixing activity in shiro

Forest management and Matsutake production

Management (Nagano in 1980): Removal of understory and litter layer
Thinning of *Pinus densiflora*



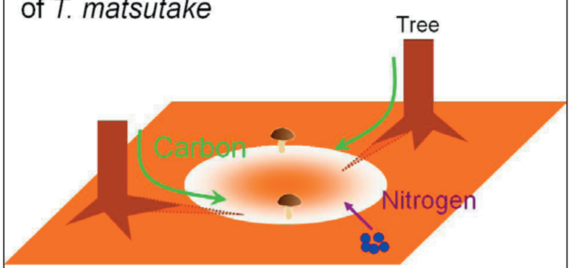
To improve matsutake production in pine forests
To establish an artificial cultivation system

Forest management

Mechanisms of development of shiro
Mycorrhizal association between matsutake and pine

We started a research project on nutrient acquisition of *T. matsutake* in mycorrhizal association
•reaction of pine root against infection by *T. matsutake*
•changes in gene expression by colonization of *T. matsutake*
•nitrogen-fixing activity in shiro

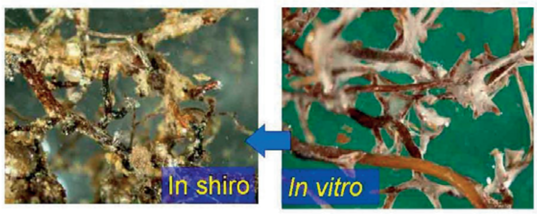
1.Research on nutrient acquisition of *T. matsutake*



Nutrient poor soil
(granite, sandstone etc)

N_2-fixing microorganisms

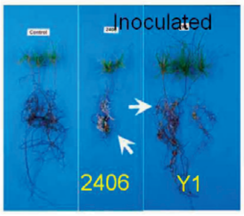
Reaction of pine root against infection by *T. matsutake*



Mycorrhizal pine roots in shiro
•winding, blackened
(roots in shiro were squeezed by matsutake?)

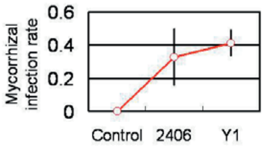
Growth of pine seedlings after Matsutake inoculation

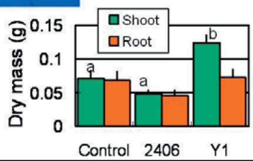
Uninocu-lated (control)



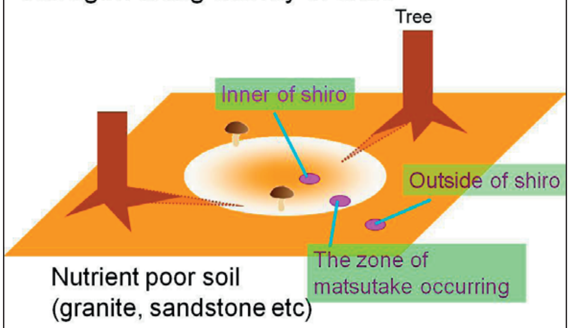
Ectomycorrhizae (arrows)

Pine growth was affected differently by matsutake strains

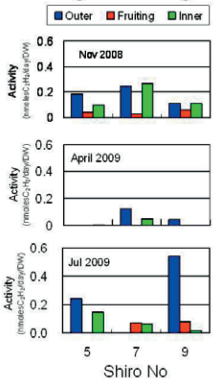




Nitrogen-fixing activity in shiro



Nitrogen-fixing activity in shiro



- Lower activities of N_2 fixation were observed at the zone of Matsutake occurring.
- This is matched with antibacterial activity in this zone of shiro

Clear zone formed by antibacterial activity of the fruiting zone.

- Developing Matsutake shiro is considered to acquire N sources from soil microbes (N_2 fixers) growing outside of the shiro after killing them by antibacterial activity

By this project

- Responses of pine to Matsutake infection will be clarified.

This could be used for selection of adequate combination of matsutake and pine.

- N dynamics along with shiro development will be clarified

This result could be applied for forest management to improve matsutake production.

2. Research on cultivation of oak-forest *Matsutake*

T. bakamatsutake

T. fulvocastaneum

Cultivation of oak-forest *Matsutake*

- Matsutake-related species in Japan will be examined genetically and morphologically.
- Host range of these Matsutakes will be studied.
- Conditions for fruit-body formation of oak-forest Matsutake will be determined (Shiga Prefectural Forest Research Center)

Acknowledgements

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Ectomycorrhization of *Tricholoma matsutake* and two major conifers, and a field investigation in Finland

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Tricholoma matsutake (S. Ito et Imai) Sing. is an ectomycorrhizal fungus, which produces commercially valuable mushrooms. *T. matsutake* resources are endangered in Japan and more than 2000 tons of *T. matsutake* or closely related species are imported to Japan annually (having a total annual value of more than €120 million). This mushroom was selected as the mushroom of 2007 in Finland. There have been many studies concerning matsutake and *Pinus densiflora* (in Japan); however, there is not much information about matsutake in northern Europe both with European host tree species and shiro in field (‘shiro’ refers to the dense mat of fungal filaments that Matsutake forms in soil in association with pine roots and soil particles).

One of main aims of the project is to test the ability of *T. matsutake* isolates to form mycorrhizas with two major conifers in northern Europe: Scots pine (*Pinus sylvestris* L.) and Norway spruce (*Picea abies* (L.) Karst.). Germinated seedlings of Scots pine and Norway spruce were separately inoculated with either Finnish or Japanese isolates (kindly provided by Prof. K. Suzuki). Eight months after inoculation, the Finnish isolate had formed a sheath and Hartig net on both pine and spruce. Inoculation with the Japanese isolate resulted in an initial Hartig net-like structure in pine but not in spruce. This study documents and describes the *in vitro* ectomycorrhization between *T. matsutake* and Scots pine or Norway spruce and the variable mycorrhizal structures that matsutake isolates can form.

The second aim of our study is to provide information on fruitbody formation of *T. matsutake* and other fungi species within the matsutake growing area during the matsutake producing season. Furthermore, we wanted to compare matsutake DNA contents within shiro soil in early summer with matsutake fruitbody numbers in each fairy ring. This study was conducted at one experimental site (1.5ha) in a mixed conifer and birch forest near Helsinki, Finland. During July to October 2009, the site was visited every other day to ensure comprehensive sampling of sporocarps including *T. matsutake* and other mushrooms. Shiro soil samples were collected at the beginning of June, 2009. Crude genomic DNA was extracted from soil and was analyzed by matsutake ITS specific primers (Kikuchi et al. 2000) and RT-PCR. The results showed that *T. matsutake* was not the only mushroom within the matsutake shiro area since *Russula* sp. *Cortinarius* sp. were also frequently found in the matsutake growing area. However, the fruiting time of matsutake was a little bit different from the other mushrooms. Furthermore, the results showed that matsutake DNA contents of shiro soil in early summer are correlated well with later emerging fruitbody numbers.

The third aim of this study is to provide information on the dynamics of mycorrhiza formation and development in natural forest by microscope observation. The root tips of *T. matsutake* mycorrhizas were collected and observed from spring to autumn. The roots colonized by *T. matsutake* were alive and white in color in the spring season. However, the mycorrhizas sampled during the summer and autumn were becoming brown and dying even when they were still fully colonized by *T. matsutake* hyphae (Vaario et al. 2009). This morphological phenomenon raises a question: does *T. matsutake* have multiple trophic statuses depending on the time of year.

In conclusion, our studies have demonstrated that *T. matsutake* can develop typical ectomycorrhizas with Scots pine and Norway spruce, two major European conifers. Our in vitro system provides an experimental platform for further investigation of the relationship between matsutake fungi and these two conifers. The native isolate had higher infectivity compared to the Japanese isolate, which raises the interesting question of whether the host tree species/genotype has an established relationship with the local *T. matsutake* that cannot be co-opted by strains from elsewhere. The results of a field investigation showed the dynamics of shiro formation and development of *T. matsutake* which will give hints for evaluating the role of shiro formation in our further studies.

This research was supported by the Foundation for Research of Natural Resources in Finland.

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Wood construction in Finland – a natural way of mitigating climate change

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Owing to the global economic recession striking especially hard against the pulp and paper industries, we expect to face fundamental changes in the structure of the forest industries in Finland. We expect that wood product manufacturing, and subsequently, wood-based construction will have a more profound role in the society and business. Based on indisputable facts, we do have political and ecological support for wooden construction, and even more importantly, consumers appear to be willing to purchase wooden houses. However, there are still some technical, economic and regulatory obstacles that slow down the process of moving towards a more sustainable course of construction. One crucial point is the gap between wood product manufacturers and builders. The wood product manufacturers cannot, currently, provide the builders with solutions based on integrated product systems. It means that the current wood products, i.e., sawn timber, gluelam beams, plywood, etc., have not been developed to be smoothly applicable to the modern product systems used in the construction business. Instead, today's wood products are still mainly equal to the ones traditionally used in private building processes of single houses, resulting in lots of carpentry work and lots of waste during the various phases of construction work. Hence, there is a lack of component and system manufacturers that could act between the primary industries and modern industrial building contractors. This problem is pronounced in the value chain of business customers in the construction field, where in many cases the current wood product solutions are not cost competitive enough in comparison to the concrete- and steel-based alternatives, for instance. Radical innovations are, therefore, necessary both from the product and business points of view.

Another challenge is related to the education of structural engineers and architects. Based on several decades of domination of concrete and steel in large-scale construction, Finland has almost completely lost the expertise of wood construction at the university level. The graduating building contractors, designers and architects are thus mostly not competent to make structural calculations and plans for timber structures.

Construction in general, is responsible for approximately 50% of the consumption of natural resources and 40% of the waste production. The majority of the resources consumed are non-renewable. It is expected that volumes of construction will increase globally due to the growth in population, urbanisation and general welfare. At the same time, the availability of non-renewable resources is expected to decrease.

Wood is the only construction material that is renewable and certified. Wood-based construction consumes far less energy and natural resources compared to any other industrial construction material. Energy consumed in wood product manufacturing processes is almost entirely renewable, originating from burning the waste wood. All other construction materials use mostly non-renewable energy. Production of aluminium, for instance, consumes almost 50 times more energy than production of the same volume of plywood. In addition, wood products, when disposed by burning, produce more energy than their production has consumed. Wood products also store carbon over their life cycle, and replace fossil fuels at the end of their life cycle.

In Finland, approximately 88% of single family houses are currently made with timber frames, and 12% are based on concrete, steel or stone. However, public buildings and multi-storey houses are still almost entirely based on concrete and steel structures. In the case of public building and multi-storey houses, the general figure at the European scale is about the same as in Finland. The Finnish Forest Industries Federation has calculated that if the dwellings in Europe would be built using wood instead of concrete and steel, the total consumption of natural resources (expressed as kg/m2), would drop by 70% from its current level. Furthermore, the consumption of energy during the production of building materials, and overall CO2 emissions would drop more than 40% and more than 60%, respectively. Using wood in all residential construction is, of course, impossible. However, the figures presented above illustrate the possibilities related to wood-based construction from the viewpoint of sustainability.

Appendix

Presentation: Wood construction in Finland – a natural way of mitigating climate change

Wood construction in Finland – natural way of mitigating climate change

Henrik Heräjärvi

Seminar on Sustainable use of forest resources and bio-energy for mitigating and adapting the climate change

Joensuu, 7.-9.9. 2009

METLA

What have we done?

- Since the 1850's, people have released some 300 000 000 000 tons of CO_2 in the atmosphere, thus increasing its CO_2 content by 30%
  - This is mainly caused by burning fossil fuels
- The increment in atmosphere's CO_2 content is expected to have an influence to the climate
- We still release CO_2 more than 3 billion tons per year

21.1.2010 2 METLA

More Facts

- One cubic metre of wood stores 0.8 tons of CO_2
- The longer the life span of wood product (instead of non-carbohydrate based materials), the longer store of carbon molecule
- Average Finnish single family house contains 15-20 m^3 of wood, which corresponds to a CO_2 storage of 13-15 tons
  - This storage has grown and is expected to grow, thus making up a carbon sink
- Every Finn consumes approximately 1.1 m^3 of timber per annum
- 70% of domestic consumption of wood products end up to construction

=> Growth in wood construction efficiently increase wood use and, therefore, carbon storage!

21.1.2010 3 METLA

Policy programmes to promote wood construction

- Wood construction has a special attention in Finnish policy-making
- Decision to support, promote and facilitate wood construction
- Why?
  - Added value and use for domestic raw material
  - Demand for reasonably priced wooden houses
  - Export of wooden houses is expected to rise

21.1.2010 4 METLA

In Finland:

- More than 50% of the *number* of houses have wooden load carrying frame
- 40-45% of the *volume* of new houses are wooden
- Still, examples of larger, public wooden houses are few

Joensuu Areena: 1.46 ha, free height 24 m *Metla house: 0.77 ha, office for 220 people*

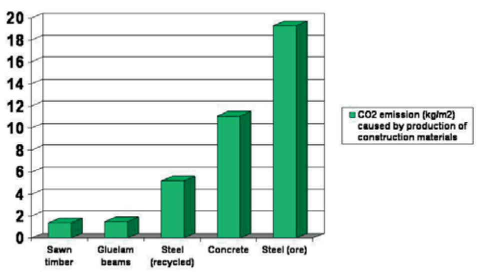
21.1.2010 5 METLA

Wood as a construction material

- The only renewing, industrially utilised construction material
- Properties
  - Load carrying
  - Aesthetic
  - Insulating but still heat reserving
  - High moisture capacity => hygroscopic material
  - Easy to handle, machine, recycle and dispose
  - ...

21.1.2010 6 METLA

Energy consumption of construction materials?



Source: Swedish Forest Industries Federation, 2003

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Green building materials

- *Green building materials* are environmentally responsible even though impacts are considered over the life of the product
- Factors that make these materials desirable for use in sustainable building are:
  - resource efficiency: low use of non-renewable resources
  - energy efficiency: production time, life time (insulation, etc.), end-of-life
  - affordability: no matter the rate of marketing and promotion, price matters!
- Wood-based building materials meet these requirements because they are:
  - natural, plentiful and renewable
  - produced using resource-efficient manufacturing processes
  - locally available
  - reusable and recyclable
  - durable
  - highly functional

21.1.2010 8 METLA

Conclusions and outlook to the future

The basic idea of forest research cooperation between FFPRI and Metla grow from the similarities and the importance of forests in both countries. The forest area is about the same, as well as the volume of forest industry. Total wood volume and growth is larger in Japan because of more advantageous conditions. On the other hand domestic wood is utilized more in Finland. Both countries have a well developed society and infrastructure, but on the other hand they also have an ageing population.

Forest research has over a hundred-year long traditions and it is well organized in both countries. Preventing climate warming and mitigating its consequences raises many important research tasks. Maintaining a vibrant forest-based economy and the health effects of forests are significant for the well-being of society. Renewable versatile forest resources offer a good base to tackle potential future problems with help of efficient forest research. Combining the strengths of two different cultures and traditions offer new research perspectives. Combining resources and dividing research tasks wisely generates effective research with lower costs.

Single researchers of both research institutes had visited each others on many topics. Some, mostly international seminar articles were written together. These showed the possibilities which could be gained with broader cooperation. Thus the visit of Metla director general Hannu Raitio to FFPRI headquarters in Tsukuba in 2007 offered the occasion to sign the treaty on mutual research interests between Metla and FFPRI.

Then FFPRI president Kazuo Suzuki visited Metla in 2008 to plan forms of cooperation. The first cooperation was a seminar on the mitigation of climate change. Others forms of cooperation will include enabling researcher to visit other facilities, and later also the planning of common research programs.

Now we had the first researcher forest seminar between Metla and FFPRI in Joensuu 7–9 September 2009. There was a Matsutake excursion before and a wood bioenergy harvesting and utilization excursion after the seminar. Altogether 12 Japanese researchers under the leadership of vice-president Isamu Okochi from FFPRI and some other Japanese research organizations took part in the seminar. Metla director general Hannu Raitio and director of Joensuu Research Unit Jari Parviainen were leaders of the Finnish researchers.

There were vivid discussions after each presentation. According to the questionnaire after the seminar, most participants found that the seminar fulfilled their expectations. The interesting program was the most often mentioned reason to join the seminar. Networking with other researchers and exchanging information between each other were also mentioned as important benefits of this seminar. Some participants considered that the program was too broad. Since the seminar the Finnish and Japanese researchers have continued to be in contact about the seminar topics.

After the seminar it was proposed that another seminar should be held in Japan. FFPRI promised to be the host for seminar, which would be located in both Tsukuba and in Sapporo. The date was set as the week after the IUFRO WORLD CONGRESS 2010 in Seoul.

The main target of the Metla–FFPRI Forest Seminar is to find mutually beneficial cooperative research projects which offer wider and deeper views on each topic. Resources can thus be more efficiently utilized and solutions may have wider application. Both institutes may also invite members of other research institutions to join the seminars.

Themes for the next seminar were agreed:
- General theme
    - Climate change
- Sub themes
    - Ecosystem services and public goods (ncluding also forest tree breeding, entomology and pathology)
    - Physical and chemical properties of wood
    - Promoting private forestry

Both parties apply cooperatively funding for seminar arrangements and participation from the Japan Society for the Promoting of Science and the Finnish Academy. Other possible sources can also be used.

This first Finnish–Japanese Forest Seminar has shown the usefulness of face-to-face discussions in finding new knowledge and especially in finding ways to develop research projects and to start cooperative studies between our two organizations.

Arto Rummukainen
Finnish Forest Research Institute (Metla)

1 Finnish–Japanese Forest Seminar group picture in front of Metla House in Joensuu, Finland (Photo: Metla/Markus Lier). 2 First seminar day. 3 Demonstration of Metla's root laboratory in Joensuu, Finland. (Photos: Metla/Arto Rummukainen)

4 Second seminar day (Photo: Metla/Arto Rummukainen). 5 Excurssion: harvesting forest biomass in Eno, Finland. 6 Excurssion: Matsutake growing site near Kontiolahti, Finland. (Photos: Metla/Markus Lier)