

Contribution of forests and forestry in Finland to mitigate greenhouse effect

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This paper gives an overview of activities in Finland related to contribution of forests and forestry to mitigate greenhouse effect. Ministry of the Environment is coordinating matters related to the UN's Framework Convention on Climate Change. National reporting of greenhouse gas inventories for land-use change and forestry category utilises forest inventory results with appropriate studies on biomass allocation and wood properties as well as national wood consumption statistics allowing to use country-specific values instead of overall default values provided in the IPCC guidelines. Several studies assessing carbon pools and fluxes, as well as impacts of forest management on carbon stocks and fluxes have been carried out in several research organisations. Further studies, especially experimental work, on the impacts of different forest management practices on forest carbon stocks and fluxes are needed. This paper provides also some views of the possible Finnish contribution to COST E21 action as well as expectations from the action.

Keywords. Carbon, forest inventory, forest management, national communication, Finland.

1. INTRODUCTION

In Finland, the Ministry of the Environment is in charge of matters related to the UN's Framework Convention on Climate Change (UNFCCC) and international negotiations under the Convention. Several national expert teams have been nominated to facilitate the negotiation and reporting process. The Finnish statements to the climate negotiations are prepared under the "Climate work group", and the "Gas work group", nominated by the Ministry of Environment, is responsible for the Finland's Annual Inventory Report on Greenhouse Gases submitted to the UNFCCC. In addition to these annual reports, two larger country reports have been submitted, in 1995 and in 1997 (Finland's... 1995, 1997), and the third National Communication (NC) is under preparation. The Ministry of Agriculture and Forestry has nominated a "Sink work group", which deals with implementation of the sink articles of the Kyoto Protocol.

Total national carbon dioxide (CO₂) emissions were 64.9 Mt in 1990, 66.0 Mt in 1995, and 67.7 Mt in 1998 according to the Finland's Inventory Reports on Greenhouse Gases under the framework convention on climate change (**Table 1**). According to the latest inventory, the national CO₂ emissions were 67.4 Mt in 1999.

Table 1. Summary of the updated CO₂ emissions (Mt) in Finland by main categories as reported to the UNFCCC (Finland's ...1999).

CO ₂ emissions (Mt)	1990	1995	1998	1999
1. Energy	57.43	59.43	60.93	60.36
2. Industrial Processes	1.13	0.81	0.92	1.11
3. Solvent and Other Product Use				
4. Agriculture	5.67	5.06	5.14	5.14
5. Land-use Change and Forestry (LUCF)	-23.80	-14.69	-9.71	-10.82
6. Waste				
7. Other	0.64	0.70	0.72	0.75
Total Emissions without CO ₂ from LUCF	64.87	66.00	67.71	67.36
Total Emissions (with net CO ₂ removals)	41.07	51.32	58.00	56.54

2. WORKING GROUP 1 RELATED ACTIVITIES (Inventory of carbon sinks and sources)

Assessment and calculation of carbon sinks of the land-use change and forestry category for the first national communication have been described in Karjalainen, Kellomäki (1996). Forest inventory results with appropriate studies on biomass allocation and wood properties as well as national wood consumption statistics allow the use of accurate country-specific values instead of overall default values provided in the IPCC guidelines. Forest inventory results and harvest statistics in Finland, as in most countries, are provided for the commercial portion of the biomass (m³ of roundwood). Therefore the volume of stemwood expressed in m³ must be converted to total biomass (dry matter) and total carbon content of trees. The calculation of carbon uptake and emission in managed forests is calculated as:

$$\begin{aligned} \text{Carbon uptake} &= \text{Ha of land in a particular category} \\ &\times \text{Average annual net growth per ha in biomass} \\ &\times \text{Carbon content} \end{aligned}$$

$$\begin{aligned} \text{Carbon emission} &= \text{Total harvest by category} \\ &\times \text{Expansion factor to treat slash} \times \text{Carbon content} \end{aligned}$$

$$\begin{aligned} \text{Net annual biomass change} &= \text{Total Carbon uptake} - \\ &\text{Total Carbon emission} \end{aligned}$$

The Finnish National Forest Inventory (NFI) results and wood consumption statistics allow the calculation to be done by tree species for the whole tree biomass and directly for the whole country:

$$\begin{aligned} \text{Total carbon content of tree biomass}_i &= \text{Stemwood} \\ &\text{volume}_i \times dw_i \times ef_i \times cc_i \end{aligned}$$

where

i is tree species,
stemwood volume is growth, harvest or stock of stemwood (m³),

dw is conversion factor to dry matter (Mg·m⁻³),

ef is expansion factor to expand stemwood to total tree biomass,

cc is carbon content (**Table 2**).

Dry weight densities, expansion factors and carbon contents vary within species, between regions and between age classes. Values in **table 2** are average values, but more precise than the default values provided in the IPCC guidelines.

Results of the GHG inventory for land-use change and forestry (LUCF) in Finland for 1990 are shown in **table 3**. It should be noted that in the first National Communication (NC1), only the annual growth (28.0 Mt C·y⁻¹),

Table 2. Conversion factors to convert stemwood volume to total tree biomass in terms of carbon (Karjalainen, Kellomäki, 1996).

Tree species	<i>dw</i> (Mg·m ⁻³)	<i>ef</i> (fraction)	<i>cc</i> (fraction)
Pine	0.390	1.527	0.519
Spruce	0.385	1.859	0.519
Non-coniferous	0.490	1.678	0.505

dw is conversion factor to dry matter (Kellomäki *et al.*, 1992), *ef* is expansion factor to expand stemwood to total tree biomass (*ibidem*), and *cc* is carbon content (Karjalainen, Kellomäki, 1993)

Table 3. Summary of the carbon emissions and removals for the year 1990 when also highly uncertain^a figures or figures that are otherwise excluded^b from the first National Communication (NC1) are considered (Karjalainen, Kellomäki, 1996). Possible accumulation of carbon in the soil is excluded.

Subcategory	Emissions (+)/ Removals (-), Mt C·y ⁻¹ in 1990
Forest clearing ^a	0.179 to 0.279
Grassland conversion	-
Abandonment of managed lands ^a	-0.014
Managed forests	
Annual growth	-27.968
Village and farm trees ^a	-0.087
Biomass harvest	19.619
Additional matters	
Forest drainage ^a	6.600
Soil preparation ^a	0.385 to 0.426
Building of permanent forest roads ^a	0.007 to 0.008
Wood products ^b	-0.500 to -2.600
Wood import ^b	-1.200
Land-use change and forestry, total	-2.979 to -4.937

biomass harvest (19.7 Mt C·y⁻¹) and net stock change (8.3 Mt C·y⁻¹) have been reported, as shown in **table 4**.

In Finland, several studies assessing carbon pools and fluxes have been carried out, e.g. Kauppi *et al.* (1997) have estimated that the carbon stock of living trees is 618 Mt and the amount of carbon in forest soils and peat is 5,840 Mt. Liski has estimated also pool changes of 5.1 Mt C·y⁻¹ for tree biomass and of 2.0 Mt C·y⁻¹ for soil (personal communication). Pingoud *et al.* (1996) have estimated for 1990 that the carbon stock in forest products in Finland was 15 Mt and net change 0.6 Mt C·y⁻¹. There are also other studies related to estimation of carbon stocks and stock changes in forest biomass (Karjalainen, Kellomäki, 1993) and forest soils (Liski, 1995; Liski, Westman, 1995, 1997a, b).

Table 4. Carbon uptake by growth, emission as a result of harvest, net change and stock as reported in the Finland's second National Communication (NC2) to the UNFCCC (Finland... 1997).

	1970	1980	1990	1995
Uptake, Mt C.y ⁻¹	20.6	24.8	28 ^a	26.6
Emission, Mt C.y ⁻¹	-20	-17.6	-19.7	-22.7
Net change, Mt C.y ⁻¹	0.5	7.2	8.3 ^a	3.9
Stock, Mt C	529	584	660	695

^a uptake in 1990 was based on the computational updating and the real increment (26Mt C) turned out to be smaller when the measurements were ready, therefore the updated figure for land-use change and forestry in **table 1** is smaller than here (6.5 Mt C.y⁻¹).

The Finnish Forest Research Institute carries out National Forest Inventory (NFI). Some information about the NFI is given in Laitat *et al.*, (2000, this issue) see table 1. More information can be found from <<http://www.metla.fi/tutkimus/vmi/nfi.htm>>. Statistical yearbook of forestry is available in the internet at <<http://www.metla.fi/hanke/3006/eng/public.htm#ybook>> providing exhaustive statistical overview of forestry and the forest industries in Finland. Currently, the Finnish Forest Research Institute is also responsible for the reporting of land-use change and forestry category as a part of the annual report on GHG inventory to the UNFCCC and more precise calculation methods are under development (Tomppo, 2000, this issue).

3. WORKING GROUP 2 RELATED ACTIVITIES (Analysis of forest management practices)

Silvicultural and forest improvement works aim to safeguard high and economically valuable timber production, as well as versatile and healthy forests. Forests are managed during the rotation period in many ways, including regeneration felling, clearing of regeneration areas, soil preparation, natural regeneration, seeding or planting, tending of seedling stands, pruning, fertilization, and thinning. Forest law is guiding forest management and aims to encourage use of forests taking into account economical, ecological and social aspects, and that forests should provide sustainable and good yield, maintaining at the same time biological diversity.

The Forestry Development Centre (FDC) Tapio develops products that are used by the Ministry of Agriculture and Forestry, The Forestry Centres and other parties active within forestry in their daily operations. FDC Tapio monitors the development of the forests and launches initiatives in issues relating to them. FDC Tapio provides guidelines/handbooks for

forest management. More about the FDC Tapio is on <http://www.tapio.net/tapionet_eng.html>.

A forest certification system suitable for local conditions has been established in Finland. It is known as the Finnish Forest Certification System (FFCS). The FFCS system comprises all the sub-factors required for forest certification: the requirements for forest management, chain of custody certification, and the accreditation and quality of external auditing. The FFCS requirements and rules have been incorporated in eight standards. A total of 37 forestry criteria have been laid down for sustainable forest management, an impartial third party, i.e. a certification body, evaluating adherence to these criteria. Additionally, the system includes standards that have to be met before the wood chain of custody can be certified. The FFCS thus incorporates two certificates, a forest certificate and a chain of custody certificate. Around 200,000 Finnish forest owners have already committed themselves to certification. More details about FFCS on <<http://www.smy.fi/certification/eng/index.htm>>.

In Finland, several studies on the impact of forest management on carbon stocks and fluxes are conducted, e.g.:

- sequestration capacity of wood products in carbon sequestration (Karjalainen *et al.*, 1994);
- effect of nitrogen input on carbon accumulation of boreal forest soils and ground vegetation based on long-term fertilization experiments (Mäkipää, 1995);
- greenhouse gas emissions from the use of primary energy in forest operations and long-distance transportation of timber (Karjalainen, Asikainen 1996);
- impact of intensity and timing of harvesting on forest and wood product carbon stocks and fluxes under current and changing climatic conditions in Finland on stand level (Karjalainen, 1996a, b);
- impacts of forest management and climate change on the forest sector carbon stocks and fluxes (Karjalainen *et al.*, 1995; Pusssinen *et al.*, 1997; Karjalainen *et al.*, 1998; Karjalainen *et al.*, 1999);
- model analysis of the effects of soil age, fires and harvesting on the carbon storage of boreal forest soils (Liski *et al.*, 1998);
- model computations on the impact of nitrogen fertilization on carbon accumulation in boreal forests (Mäkipää *et al.*, 1998a-b);
- long-term effects of forest drainage on peat carbon stocks on pine mires (Minkkinen, Laine, 1998);
- effects of climate change and nitrogen deposition on the carbon sequestration of a forest ecosystem in the boreal zone (Mäkipää *et al.*, 1999);
- impacts of climate change on soil carbon (Liski *et al.*, 1999)

- implications of Article 3.3 for Finland based on the IPCC and FAO definitions for afforestation, reforestation and deforestation, and statistical data (Mäkipää, Tomppo, 1998);
- economical impacts of CO₂ emission reduction (Pohjola, 1999);
- magnitude of the sink and source capacity of tree biomass in the Nordic countries and EU based on the latest forest inventory data, sink and source capacity under Article 3.3 when applying IPCC and FAO definitions for afforestation, reforestation and deforestation (Karjalainen *et al.*, 2000, Liski *et al.*, 2000).

However, further studies especially experimental work on the impacts of different forest management practices on forest carbon stocks and fluxes are needed.

4. PERSPECTIVES AND RESEARCH NEEDS

When COST E21 started, people who have been active on the area were asked about their expectations and desired outcomes from the action. Expectations included:

- bringing together experts from the area of the Action, enhancing collaboration, also between disciplines;
- look into the outcome of the IPCC-SR, reflections from countries;
- to learn in greater detail what is going on in different countries;
- cooperation in developing tools for analyzing impacts of forest management.

Desired outcomes included:

- applicability of different inventory methods in different countries, what kind of “national systems” (as mentioned in the Kyoto Protocol) are/will be (working group 1);
- potential of different forest management measures in different countries (Art. 3.3, 3.4, 6, and 12 if applicable) (working group 2);
- seminars/workshops and proceedings;
- comparison of forest management options in different countries;
- easy dissemination of activities through the web.

Relevant research in Finland is carried out in several places, including the University of Helsinki, Finnish Forest Research Institute, University of Joensuu, European Forest Institute (in European scale), University of Kuopio, Finnish Environment Institute, Geological Survey of Finland, VTT Energy.

Following strengths and specialities have been listed:

- strong and long tradition in forest inventories;

- forests regularly managed, forestry and forest industry serious business;
- early 1990’s climate change research programme SILMU, several groups have continued carbon-related work, new global change programme FIGARE;
- some researchers have been involved in the IPCC reports (SAR, TAR, SR);
- expertise in forest management;
- expertise in forest economics;
- role of bioenergy (mainly wood) high in energy production, more than 15% of the energy supply, which is the highest proportion among the industrialized countries. Expertise in this field may be relevant for working group 2;
- large peat resources, long experience from utilization, also from research and GHG point of view;
- impact assessments, also modelling in different spatial and temporal scales;
- many groups have participated / are participating in EU projects;
- many dissertations from the area of E21;
- EFI also looking into issues on pan European scale;
- Involvement in the development of European Forestry Information and Communication System (EFICS) and Global Forest Information Service (GFIS).

Regarding the work programme of the action, following remarks were made:

- the scope of COST E21 should be enlarged to all signatories of the Action and not restricted to the EU as it stands in the memorandum of understanding;
- careful examination of the IPCC-SR is strongly needed as how to be implemented in E21 work;
- possible inclusion of “national system” as requested in the Kyoto protocol, and reporting.

4.1. National programmes/projects

Projects that are relevant to COST E21 include at least following:

- Pools and fluxes of carbon in Finnish forests and their economic and social implications. Duration 2000–2005. Project leader Risto Sievänen.
- Forest carbon sink and economic costs of Kyoto Protocol. Duration 2000–2003. Project leader Raisa Mäkipää.
- Carbon balance implications from wood production chain, manufacturing and use of wood products. Duration 1998–2000. Project leader Timo Karjalainen. URL: <http://www.efi.fi/projects/carbon_balance/>.
- Modelling energy-, carbon-, and nutrient budgets for forestry; Duration 1998–2000. Project leader

Seppo Kellomäki. URL: <<http://www.efi.fi/projects/project.phtml?id=1649C>>.

- Long-term Regional Effects Climate Change on European Forests: Impact Assessment and Consequences for Carbon Budgets (LTEEF-II). Duration 1998-2000. Project leader at EFI Timo Karjalainen. URL: <<http://www.efi.fi/projects/project.phtml?id=15501C>>.

4.2. Coordination of EU programmes/projects

- Response Strategies to climatic change in management of European forests.

Acronym: SilviStrat.

Coordinator: Seppo Kellomäki

Network: University of Joensuu (Finland); Potsdam Institute for Climate Impact Research (Germany); Wageningen University (the Netherlands); University of Agricultural Sciences, Vienna (Austria); Centre de Recerca Ecològica i Aplicacions Forestals (Spain); European Forest Institute (Finland); Swedish University of Agricultural Sciences (Sweden).

Period: 2001–2003.

The aim of the SilviStrat is to develop adaptive forest management strategies in order to increase the sequestration and storage of carbon and to mitigate adverse impacts of climate change in the European forests.

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