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COST E21 Worshop

Contribution of forests and forestry to mitigate greenhouse effects

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Introduction: Towards an integrated scientific approach for carbon accounting in forestry

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In the COST E21-Action "Contribution of Forests and Forestry to Mitigate Greenhouse Effects", emphasis is put on the quantification of carbon storage in the forest ecosystems and on the understanding of linkages between human activities and climate change, particularly the role of forests and forestry. COST E21 integrates natural, socio-economic as well as methodological aspects relevant for reporting under the United Nations Framework Convention on Climate Change and the Kyoto Protocol, as well as decision-making at the European level in the context of carbon mitigation in forest ecosystems. This Action is a pioneering attempt to co-ordinate research; to exchange experience and knowledge towards standardised greenhouse gas inventory accounting for forests over Europe. It will match, within four years (1999–2003), both scientific and political agendas. This paper gives a background presentation of the COST E21-Action, its work plan and its clearing house. It finally gives the outline of country specific information to the COST E21 as presented in this issue in a standard format.
Keywords. Carbon, clearing house, COSTE21, forest inventory, forest management, forestry, greenhouse gas inventory, land use, land-use change, work plan, region, Europe.

1. INTRODUCTION

The area of forest and other wooded land in Europe is 215 Mha, accounting for about 37% of its total land area (FAO, 2000). Some 149 Mha are considered available for wood supply (forest where legal, economic, or specific environmental restrictions do not have a significant impact on the supply of wood), 27 Mha are considered not available for wood supply (forest where legal, economic or specific environmental restrictions prevent any significant supply of wood) and 40 Mha are classified as other wooded land. In comparison with the vast boreal and tropical forests of other regions of the world, forest resources in the Europe may seem unimportant at the first glance. Nevertheless, Europe produces approximately one third of the coniferous sawn goods, half of the particle board and one third of the printing and writing paper (FAOSTAT Database on line at: <http://apps.fao.org/>).

Forestry is also important in economic terms, since for example in the EU, the wood chain involves 82,000 enterprises representing a cumulated budget of 400 billion €, 3 million employees and 1/8 of the added value of all the EU industries (CEC, 1999). Traditionally, the foremost function of forests in Europe is considered to be their use as a regenerative source of timber and other products, such as resin, cork, mushrooms and berries – known as the raw-material function of forests. Besides their economic role, forests in Europe also offer many other benefits, which could be regarded useful to the society. Increasing leisure time, for instance, has made the recreational use of forests socially important. Environmental aspects associated with forests protective functions, like biodiversity or water and soil protection, are highly valued, too.

Over the last decade, the role of forests in the global carbon (C) cycle has grown in importance. This has been emphasised for example in the report from the Third Ministerial Conference on the Protection of Forest in Europe, which includes the "maintenance and appropriate enhancement of forest resources and their contribution to global C-cycles" in its list of European criteria and indicators for sustainable forest management (Ministerial Conference, 1998). According to the recent Special Report on Land Use, Land-Use Change and Forestry (LULUCF-SR) of the Inter-governmental Panel on Climate Change (IPCC), in the 1990s approximately 20% of the global C-emissions were from land-use change, namely from deforestation in the tropics. That report also suggests that terrestrial uptake corresponded approximately to 30% of the emissions, which means that, in the last decade, the terrestrial biosphere was a net C-sink. Forests cover approximately one third of the land surface of the Earth and account for approximately 80% of the plant and approximately 40% of the soil C (Watson *et al.*, 2000). Based on above, we can argue that forests play an important role in the global C-balance.

The net flux of carbon between the atmosphere and a terrestrial ecosystem consists of two large C-flux terms: gross uptake by photosynthesis and respiratory losses by plants (autotrophic) and decomposition of soil organic matter (heterotrophic). Human activities, like forest management and (regular) harvests, affect not only on these physiological processes but on the net carbon sequestration. In some forest ecosystems photosynthesis and autotrophic and heterotrophic respiration can be in balance (e.g. Lindroth *et al.*, 1998). Therefore, a small change in either of the two fluxes will have a large effect on the annual C-balance (Valentini *et al.*, 2000). Land use, changes in land-use, CO_2 fertilisation, nutrient deposition, changes in climate and disturbances influence the net uptake of C in terrestrial ecosystems. Some of these factors are directly human induced, some indirectly, some are natural. It is presently not possible to determine the relative importance of these different processes (Watson *et al.*, 2000). Moreover, some underlying processes, especially regarding the dynamics of the below-ground C-pools under increasing atmospheric CO_2 and changing climatic conditions are not yet well understood. There is an increasing concern that the large C-pools stored in the soils, mostly in the boreal forest ecosystems, may turn into C-sources as an effect of global warming, thus accelerating the induced climatic change (e.g. Houghton *et al.*, 1998), although carbon in deeper soil layers may not be that sensitive to changes in temperature (Liski *et al.*, 1999). Because forests are long-lived communities, rapidly rising CO_2 concentration, together with the predicted rise in temperature and other associated changes in climate — including natural catastrophes: storms and fire —, will also affect not only the forests of the future but also on forests that currently are growing (e.g. Jarvis, 1989; Kirschbaum, Fischlin, 1996).

The United Nations Framework Convention on Climate Change (UNFCCC), which was signed in Rio de Janeiro in 1992, was the first global attempt to fight against climate change (UNFCCC, 1992). Ultimate objective of the convention is stabilising "greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic (human-induced) interference with the climate system". The Convention also calls to promote sustainable management, and to promote and to cooperate in the conservation and enhancement, as appropriate, of sinks and reservoirs of all greenhouse gases (GHG) not controlled by the Montreal Protocol, including biomass and forests. Parties to the climate convention have to report their national greenhouse gas inventories, including land use and forestry, to the UNFCCC. Quantified emission limitation and reduction commitments were agreed five years later in Kyoto (Kyoto Protocol, 1997). Industrialised countries should reduce their overall emissions of six gases listed in the Protocol by at least 5 percent below 1990 levels in the commitment period 2008 to 2012. The Protocol also includes some mechanisms, so called "Kyoto mechanisms", that would help industrialised countries in meeting their commitments, including emission trading, joint implementation and clean development mechanism. Also some forestry activities are considered.

The Subsidiary Body for Scientific and Technological Advice (SBSTA) to the UNFCCC requested the IPCC to prepare a special report on land use, land-use change and forestry (Watson *et al.*, 2000) to examine the scientific and technical implications of C-sequestration strategies related to Land Use, Land-Use Change and Forestry (LULUCF) activities. Some of the issues of this special report have been mentioned already earlier. The report examines several key questions relating to the exchange of C between the atmosphere and the terrestrial pools of above ground biomass, below ground biomass and soils. It analyses also the broad scale opportunities and implications of afforestation, reforestation and deforestation and additional human-induced activities now and in the future. The report also identifies questions that Parties of the Protocol may wish to consider regarding definitions and accounting rules, it also provides information about measurement and monitoring techniques for assessing changes in C-stocks. These need to be discussed and agreed before the implementation of the Protocol can take place.

The potential role of forests in meeting the reduction targets for GHG emissions is still not clear in long-term perspective. European forests contain about 9 Pg C in vegetation and 25 Pg C in the soil (Dixon *et al.*, 1994). Recent estimate in the TBFRA 2000 report (UN-ECE/FAO, 2000) gives a rate of change in the C stock of woody biomass of 0.11 $Pg{\cdot}y^{-1}$ (Liski, Kauppi, 2000), which equals approximately 10% of the anthropogenic CO_2 emissions in Europe. It is of vital importance to study all relevant processes in the forest ecosystems to establish the "net ecosystem exchange" of C (Steffen *et al.*, 1998). Particular attention should be paid to how C-stocks and stock changes should be monitored, which is the focus in working group 1 of the COST Action E21 and how various forest management strategies influence C-stocks and stock changes, as focused in working group 2. Further details of the COST E21 and its working groups are provided in the next section.

2. WHAT IS COST E21?

COST is an intergovernmental framework for European Co-operation in the field of Scientific and Technical research, allowing the coordination of nationally funded research on a European level. The member countries participate on a "à la carte" principle and activities are launched following a "bottom-up" approach, where scientists define the topics and contexts of the research. COST has a geographical scope beyond the 15 members of the EU and most of the Central and Eastern European countries are members. COST also welcomes the participation of interested institutions from non-COST-member states without any geographical restriction. COST-Actions fit into 12 distinct research domains: agriculture, food and biotechnology, chemistry, forest and forestry products, health and medicine, materials, meteorology and nanoscience, physics, social sciences, telecommunications, transport, urban civil engineering and environment (see on line at: <http://www.belspo.be/cost/>).

Among the "forest and forestry products" domain, the COST-Action entitled "Contribution of forest and forestry to the mitigation of greenhouse effects" was acknowledged under the label COST E21. The Committee of Senior Officials (CSO), the decision-making and highest body in COST, approved the COST E21-Action on May 27th 1999. The Action entered into force on December 16th 1999 after five countries had signed the Memorandum of Understanding (MoU). The Action is to last until December 15th 2003. In November 2000, 18 countries have signed the MoU involving more than 140 scientists. In this context "Europe" should be understood beyond the EU 15.

There is considerable public concern about the future quality of the European environment. Measures for reducing CO_2 emissions have been emphasised (Berlin Mandate in March 1995, UNGASS in June 1997, Kyoto Protocol in December 1997) and have been strongly supported by the EU. The leading role of the EU in promoting the International Panel on Forests (IPF) and in launching an Intergovernmental Forum on Forests (IFF) in the United Nations (UN-ECOSOC, 2000) gives another sound basis to this Action. Previous resolutions of European Ministerial Conferences (Strasbourg, Helsinki and Lisbon) already acknowledged the protection of C-sinks, especially in forests.

The "political rationale" is based on the UNFCCC (1992) and on the Kyoto Protocol (1997). To fulfil the commitments of the Protocol, Parties must "establish its level of carbon stocks in 1990 and to enable an estimate to be made of its changes in carbon stocks in subsequent years". Moreover, the signatories will have to report the net changes in emissions from sources and removals by sinks in "a transparent and verifiable manner". All these matters have a high priority in diplomatic, political and administrative agendas (CEC, 1999; UNFCCC, 2000) as well as in the scientific agenda (Watson *et al.*, 2000). It is also of utmost importance to ensure that Europe increases its competence, at the highest international level, within the field of forest ecosystem research and "C-management".

The "scientific rationale" is the need to bring together scientists of common interest to consider and clarify the contribution of forests and forestry to the mitigation of greenhouse effects. COST E21 addresses the complex issue of C-accounting with the objective of contributing to the development of an agreed C-accounting strategy for European forests within the framework of the Kyoto Protocol. The Action will further seek to define and quantify the influence of forest management on the C-balance of forests, investigating both the biogeochemical and socio-economic impacts of management practices and exploring the potential for enhancing the role of forests in the mitigation of greenhouse effects.

2.1. Objectives

The main objective of COST E21 is to contribute to the debate towards a commonly agreed C-accounting system for the land use and forestry sector that would serve the needs for the UNFCCC reporting and the reporting under the Kyoto Protocol. A commonly agreed C-accounting system would allow estimating the contribution of European forests to the mitigation of climate change and achieving the commitments taken in the Kyoto Protocol. The LULUCF-SR of the IPCC and possible decisions of the Conference of the Parties (COP) — further to be replaced by the Meeting of the Parties (MOP) when the Protocol will enter into force — need to be taken into account in the work.

The secondary objectives of the action are:

- To promote interaction within the community of scientists engaged in research on the C-cycle in forests. It will create a forum for the interchange of results, the sharing of scientific experience and will provide the foundation for the development of potentially valuable, multi-institutional, multi-disciplinary research projects.
- To evaluate inventory/accounting systems available and under development, their strengths and weaknesses (including for e.g. accuracy, cost, applicability).
- To assess the respective impacts of climate change, land use/cover changes, management and disturbance impacts on changes in C-pools between 1990 and 2008–2012.
- To inform the public about likely changes in forest ecosystems as a consequence of climate change and their consequences in the socio-economic context for various European forest regions.

2.2. Outline of COST E21

The scope of COST E21 is focused on European forests and some of the GHG included in the Kyoto Protocol: namely CO_2, N_2O and CH_4. In order to meet the objectives, the COST E21-Action is organised into two Working groups:

- Working group 1: Inventory of sinks and sources in the perspective of net C-emission reporting;
- Working group 2: Analysis of forest management practices.

Outline of Working Group 1

Aim

To evaluate and improve inventory/accounting systems with a view to refine existing estimates of C-pools and fluxes in forests.

Scope

The scope of this working group is to coordinate the national efforts of the participating countries devoted to the inventory of C-pools and changes in C-pools in forests. The relevant C-pools are in the tree biomass, ground vegetation, litter and woody debris, soil and wood products. This inventory comprises the assessment of land area occupied by the different forest types considered, estimates of the amount of the C-stored per unit area in each C-pool together with their turn-over time and monitoring the changes occurring over periods of years.

The LULUCF-SR of the IPCC (Watson *et al.*, 2000) has examined the methods existing for inventorying C-pools in the forest sector. Such data also exists in the TBFRA report 2000 (UN-ECE/FAO, 2000). A practical and simple method is based on the data in National Forest Inventories (NFI). It takes benefit from the detailed information available on the standing volume of forest. However, there are large discrepancies between countries in the inventory protocols regarding the periodicity, definitions and measurements methods, and capability to detect changes in land-use. Conversion from standing volume to C-stocks in biomass and soil pools is also not trivial since conversion factors are not available for the whole range of forest encompassed, for example little information is available for the Mediterranean forests. In addition, the adequacy of this approach for monitoring changes in national C-stocks over 5 to 10-year long periods may be questioned. All these aspects presented in **table 1**, will be discussed in the conclusion under §4. Coupling the national inventories of soil and forest is another critical point to be considered. Other methods, such as flux measurements or inverse modelling may also provide useful data at a larger scale and shorter time resolution. Finally, the relevance of the accounting strategies needs to be evaluated rigorously from the point of view of the mass balance of CO_2 and other GHGs in the atmosphere, which is indeed the ultimate target of the Kyoto Protocol.

Objectives

- To assess the existing methodologies in terms of accuracy, feasibility, uncertainty, verifiability for:
  - the estimation of C-stocks in forests,
  - the calculation of turn-over times for different C-pools,
  - the monitoring of changes in the C-stocks for different pools.
- To examine existing databases and identify research necessary to improve and refine existing estimates.
- To identify measurements, verification, uncertainties and reporting needs of C-stock changes plus CO_2, CH_4 and N_2O exchange between atmosphere and forests at national level. This requirement arises from LULUCF activities and should be framed in response to the Kyoto Protocol and any subsequent decisions to be taken at COP-or COP/MOP meetings. Existing technologies serving these needs will be evaluated and improved. New harmonised, efficient and more accurate techniques are being

Table 1. Synoptic table for National Forest Inventories following contributors*.

Country	AT	BE	CH	DE	DK	ES	FI	FR	GB	GR	HU	IR	IS	NL	NO	SE
Start	1961	1980 1994[1]	1983	1986	1981	1964	1921	1960	1924	1963	1950's	1998	1972	1940	1919	1923
Periodicity (year)	5	10	10	15	10	20–10	<10	10–12	15–20	30	Cont.[2]		15	5	5	1(5)[3]
Forest surface area (in 1,000 ha)[4]	3,924	682[5]	1,234	10,740	538	25,984	22,768	16,989	2,489	6,513	1,811	621	131	339	12,000	30,259
Grid (in km)	4x4	1x0.5	1.4x1.4 0.5x0.5	4x4	—	1x1	6x6	various	various	1x0.5	Comp.[6]		—		3x3	3x3 (30x30)[7]
Plots	11,000	10,600	6,500	12,580	—	84,203	70,000	133,500		2,744	—		—	3,400	10,500	18,000
Level	N	SN	N	N	N	N	N	N	SN	N	N	N		N	N	N
Inventory	F	F	A, F, S	F	Q	F,A	F, A, S	F,A	A,F	F,A	F,A	F,A	F,A	F, Q	F	F,A
Percentage standard error (in area)	1.2	0,42	0.30	1,10	N.A.	N.A.	0.48	0.71	3-15	0.2	N.A.	1.0	N.A.	N.A.	0.96	0.50
Percentage standard error (in volume)	1.6	5,1	1.0	0.80	N.A.	0.85 1.13[8]	0.57	0.54	1-15	2.6	N.A.		N.A.	5	1.36	0.60
Percentage standard error (in volume growth)	N.A.	N.A.	0.90	N.A.	N.A.	N.A.	0.80	0.59	N.A.	N.A.	N.A.		N.A.	N.A.	1.40	0.40
Wood volume	MS	MS	MS	Other[9]	M	MS	MS	MS	MS	MS	Other[10]		MS	MS	MS	MS
Above ground	B		B	B, C		N.A.	N.A	N.A.	N.A.	N.A.	B, C		C	N.A.	N.A.	B, C
Below ground	SC	N.A.	N.A.	RM, SC	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	SC		RM, SC	N.A.	SC	RM, SC
Expansion factors	D2, N	D1, D2	N	N[11]	D1, N	N	N	D2, N	N.A.	D1	D1, N		N	D1, N	N[12]	N

Forest inventories are conducted at the national- (N), or sub-national- (SN) level, implying eventually different methodologies. Inventories are conducted by sampling forest plots using field surveys (F), aerial photographs (A), satellite imagery (S) or questionnaire (Q). Wood volume: MS= marketable stemwood or total bole volume overbark and/or underbark. Assessment of above ground biomass (B) or carbon (C). Assessment of below ground biomass for root biomass (RM), mostly coarse roots, and soil carbon (SC). Expansion/conversion factors are default values from IPCC (D1), default values from other European countries (D2) or derived from National data (N). N.A. = Non Assessed; (—) = Not relevant; ( )= Not communicated.

Following country-codes are used according ISO 3166-1 Alpha-2 code elements in alphabetic order: AT= Austria, BE= Belgium, CH= Switzerland, DE= Germany, DK = Denmark, ES= Spain, FI= Finland, FR= France, GB= United Kingdom, GR= Greece, IR= Ireland, IS= Iceland, NL = The Netherlands, NO= Norway, SE= Sweden .

[1]Respectively for the Walloon and Flemish regions.

[2]Continuous inventory, in which approximately one-tenth of the forest is surveyed.

[3]Annual inventory on 9,750 random plots, plus inventory every fifth year on 3,764 permanent plots.

[4]From TBFRA-2000 (UN-ECE/FAO, 2000) or modified according to contributors.

[5]For details by Regions, see Perrin *et al.*, this issue.

[6]The unit of the survey is the forest compartment (administrative blocks).

[7]Grid is 3x3 to 15x15 km on random plots and 7x7 to 30x30 km on permanent plots. The density of the grid decreases from the South towards North.

[8]Respectively for conifers and for deciduous.

[9]Wood > 7 cm diameter (including coarse branches).

[10]Total aboveground volume including fine branches and leaves.

[11]Derived from in-depths studies. Not from the NFI.

[12]Soil samples carried out on a sub-sample of the NFI plots.

*Peter Weiss (AT); Christian Laurent (BE); Peter Brassel and Jürg Bucher (CH); Rainer Baritz and Sigrid Strich (DE); Lars Vesterdal (DK); Maria-José Sanz (ES); Raisa Mäkipää (FI); Gérôme Pignard (FR); Kalliopi Radoglou (GR); Ronnie Milne (GB), Zoltan Somogyi (HU); Karl Coggins (IR); Arnór Snorrason (IS); Gert-Jan Nabuurs (NL); Harald Aalde (NO); Thomas Thuresson (SE). The number of sample plots were calculted according EFFICS by Risto Païvinen (FI). Some contributors modified these figures.

developed and suggested for implementation to better serve future reporting needs.

– To facilitate a scientific forum to improve understanding of the C-sequestration mechanisms of forest ecosystems and to promote discussion between scientists involved in the preparation of national GHG inventories, arising from LULUCF.

Outline of Working Group 2

Aim

Forest management plays an important role in the C-balance of forests. This working group aims to investigate the influence of management practices and forest product use on current sinks and sources of C and to assess the potential of forest management in C-mitigation in Europe.

Scope

The focus of this group is on the state of knowledge and the assessment of potentials regarding management practices and mitigation strategies at stand, landscape and national levels.

Forest management practices considered are, e.g.:

- Afforestation, reforestation, deforestation;
  see Watson *et al.*, 2000 for a detailed discussion on definitions of terms and their importance in the C-balance.
- Stand treatments;
  both the timing and the intensity of harvesting (thinning and final felling) are directly influencing productivity and C-storage of forest stands.
- Harvesting techniques;
  certain harvesting techniques may reduce C-mineralization from the forest soil; reduced impact logging increases the remaining C-stocks in the forest; the amount of slash left in the forest is influencing the C-storage in coarse woody debris.
- Rotation length;
  longer rotation will increase C-storage, however, it may also reduce productivity and hence C-sequestration in the forest.
- Stand replacement;
  the species composition and the selected genotypes will affect stand productivity, C-storage and utilization of forest products.
- Site manipulations;
  fertilisation and drainage may increase forest productivity, but they may also lead to a reduced C-storage in the soils.
- Disturbance control;
  natural disturbances generally lead to a release of C from the forest and therefore controlling disturbances will increase C-storage. However, excessive C-accumulation in forest ecosystems may ultimately lead to catastrophic disturbance events with a great instant C-release, for example in fire-controlled ecosystems.

It should be emphasised that the listed management practices can increase some of the C-stocks, while other C-stocks may decrease or vice versa and also short and long term impacts can differ.

Mitigation strategies in forest management are defined following the IPCC classification (Brown *et al.*, 1996):

- Conservation management;
  measures to prevent emissions: for example, controlling deforestation, protection and conservation of forests currently under thread of unsustainable exploitation.
- Storage management;
  short-term measures (over the next 50 years or so) to increase the sequestration and storage of C in the forest or in wood products: including measures to increase the productivity of forest stands as well as measures which increase the average C-storage in the forest or wood products, for example by means of extended rotation length or extended life time of wood products.
- Substitution management;
  measures to substitute C-emission from fossil fuels, for example through utilization of wood as building-material instead of other materials which use more energy in the production process.

Objectives

- To assess existing knowledge of forest management practices on ecosystem C-storage, including C in vegetation, soils, coarse woody debris, and wood products.
  While there has been a lot of research on the effects of forest management on forest production, much less information is available about the consequences of management practices on ecosystem C-storage, including C in soils and coarse woody debris.
- To assess the potential of mitigation strategies at stand, landscape and national levels.
  Mitigation strategies can be applied at different hierarchical scales. Additional to forest management practices which increase C-sequestration of individual forest stands there are also potentials for C mitigation at the landscape level, e.g. through set aside policies on parts of the forest area.
- To assess the interactions between forest management and C aspects related to forest product utilization.
  Forest management activities affect wood quality and may therefore lead to different forest products with variable life spans.
- To compare mitigation potentials between countries and bio-geographical regions.
- To assess the implications of alternative C-accounting rules.
  Depending on the C-accounting rules (as described in Watson *et al.*, 2000) there may be large differences between reportable and actual C-mitigation effect of forest management activities (see also figure 1 in Nabuurs *et al.*, this issue, 2000).
- To assess permanence, leakage and spill-over effects of forest based C-mitigation.
  Permanence effects address the duration of C-mitigation measures, e.g. will afforested sites stay under forest, how big is the risk that they will be cleared again for another type of land-use ? Leakage addresses possible secondary effects outside the area of a particular C-mitigation project, e.g. will the protection of one forest-area lead to increasing deforestation in other areas ? Spill-over effects may

occur if good practices in forest management (e.g. reduced impact logging) are adopted outside of the area of particular C-mitigation projects.
– To consider ecological, economic and social implications of mitigation strategies.
  C-mitigation as a new management objective may have significant effects on other forest functions, for example converting mixed-deciduous forest into fast growing coniferous monocultures has effects on amenity values, biodiversity, ground water recharge, etc. Manifold social or economic implications may occur if for example forest conservation areas are installed in areas with intensive forest utilization.
– To analyze existing projects and practices and to develop recommendations and guidelines.

2.3. Means of implementing the Action

The work plan will be implemented by means of:
– compilation of existing research results;
– questionnaires among participating countries;
– topical meetings;
– assigned working tasks between meetings;
– short term scientific missions and other longer-term scientific exchange.

Key background documents to establish the contribution of forests and forestry to the mitigation of greenhouse effects include following:
– The IPCC Special Report on Land Use, Land-Use Change and Forestry;
  Summary for policy makers on line at: <http://www.ipcc.ch/pub/SPM_SRLULUCF.pdf> (Watson *et al.*, 2000).
– The IPCC best management practices;
  Report on line at: <http://www.ipcc-nggip.iges.or.jp/public/gp/gpgaum.htm>.
– The IPCC revised guidelines for national greenhouse gas inventories 1996, especially Chapter 5 in each of the tree volumes;
  Report on line at: <http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.htm>.
– Study on European Forestry Information and Communication System, EFICS (EC, 1997).

2.4. Dissemination of the results

Almost all the information generated by COST falls in the public domain. Moreover, COST Action outputs are generally unrestricted for the diffusion. We have identified the following target groups for the results of COST E21:
– European policy and decision-makers dealing with LUCF in the perspective of the UNFCCC and the Kyoto Protocol reporting duties;
– Ministries responsible for UNFCCC related activities;
– Ministries for environment, agriculture and forests;
– Stakeholders of the processes on greenhouse gas emission reductions; European organisations of stakeholders around forest owners, forest industry, environment, non-governmental organisations;
– The Liaison Unit of the Ministerial Conference on the Protection of Forests in Europe;
– DG Research of the European Commission and other research funding agencies;
– Forestry scientists and academics; forest management authorities;
– Companies and Industry associations;
– The public interested in global climate change.

COST E21 results will be provided to policy-and decision-makers as well as other stakeholders through: COST E21-clearing house, seminars and seminar proceedings and working group reports.

3. COST E21 CLEARING HOUSE

COST E21 launched a clearing house in August 2000. This web site is more than a web page presenting the COST E21-Action (**Figure 1**). It aims at searching through the available information, literature and contacts, hosting discussion lists around the activities of the Action.

The welcome page (on line at: <http://www.bib.fsagx.ac.be/coste21/>) contains 3 active zones:
– "Administration" containing a description of the Action, its structure, the agenda, the ongoing call for short-term scientific missions, business displaying the minutes of the meetings and the progress reports and lastly the work plan, as adopted at the second management committee meeting in Joensuu.
– "Databases" for Users, Literature, Research projects and Electronic resources.
– "Online help": Howto, Abbreviation, Glossary and Site Map.

"Administration" is under the responsibility of the COST E21-Action chairperson and of the steering committee, while the web master makes the maintenance of the clearing house. Because of the enormous amount of relevant information, coming from a wide range of sources, the management of these databases was meant as a collective task for COST E21-users.

More than 400 scientific papers relevant to COST E21 were published in the year 2000 and the number of search engine and web pages related to the scope of the Action is increasing exponentially. This plethora in information gives scientists no chance to be "fully" aware of all progress around the estimates of C-sequestration in forest ecosystems and this motivated

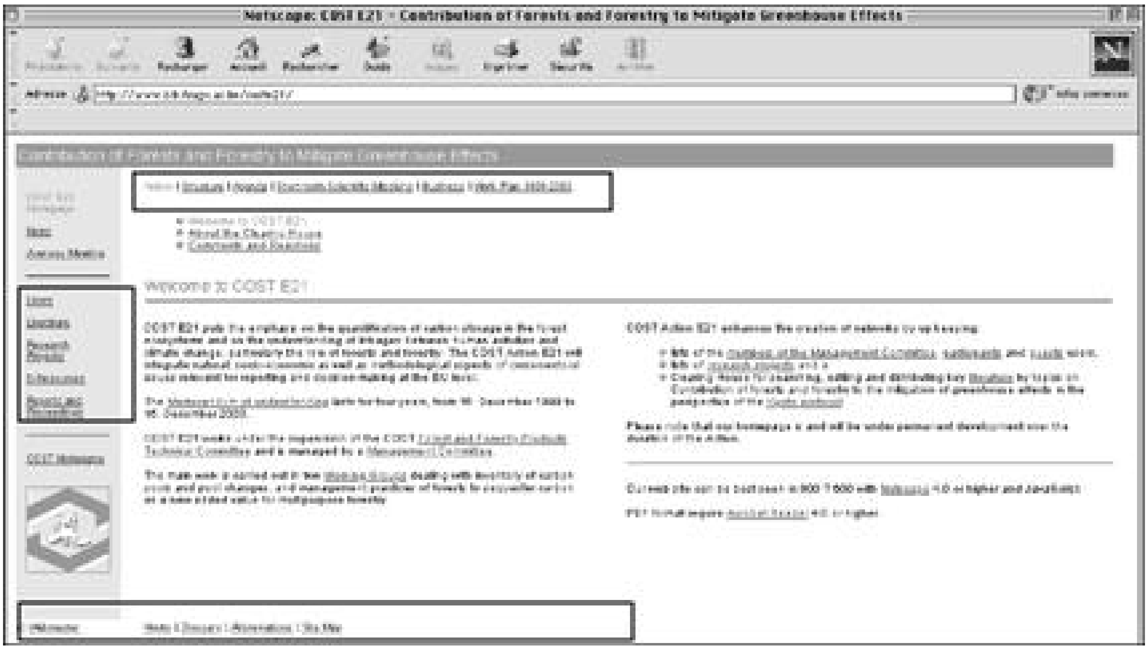

Figure 1. COST E21 home page showing the three active zones for COSTE21 administrative business, databases and Online help.

the design of the clearing house. This COST E21 platform, maintaining four databases for users, literature, research projects and electronic resources, helps finding scientists by countries or by field of expertise and retrieving information whether in progress in the frame of ongoing research projects or published in various kinds of literature (**Figure 2**).

There are three types of "users" of COST E21.

– Members: national authorities, at the initiative of their CSO, an administrative body of European Commission COST-administration, nominate the delegates to the management committee. There is a maximum of two delegates per signatory country.
– Guests: all interested persons. This category of user can access all the information of the clearing house but can not give inputs. Users have to register and update their personal information when needed.
– Participants: all interested scientists contributing to the action. To contribute to the action and be registered as "Participant", users have to contact the member of the management committee in his country (for COST E21 citizens) or the chairperson.

"Key literature" included in the database consists of papers in scientific journals, reports and papers in electronic formats. Participants to COST E21 are invited to encode the references (authors, date, article, pages…) and index the reference (key words, subject, level, language and country). There is also an opportunity to include an English summary or an electronic version

Figure 2. User's database displaying the signatories of COST E21 and some features for searching users in the database (by Guest, Participants, Members of the management committee and by Country, Working group and Meeting).

of the full text. To allow an easy search by all users, descriptors were limited to the following categories:

SUBJECT
Afforestation, Biodiversity, C-flux, C-pool, C-sequestration, Climate, Disturbance, Emission inventory, Forest inventory, Forest management, Forestation, Impact study, Model, Reforestation, Soil productivity, Structure.

LEVEL
Country, Ecosystem, Global, Landscape, Region, Stand, Tree.

LANGUAGE
Bulgarian, Croatian, Czech, Danish, Dutch, English, Estonian, Finnish, French, German, Greek, Hungarian, Icelandic, Irish, Italian, Latvian, Lithuanian, Maltese, Norwegian, Polish, Portuguese, Romanian, Spanish, Swedish, Turkish.

COUNTRY
Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Rumania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom.

There is no restriction to English literature, because some "grey literature" in the official languages of the European countries may also contain valuable information. Provided the entry contains an English title, key words, abstract, etc., the scientific contribution can be retrieved in the advanced search procedure. Indeed, advanced search is done in full text for all entries to the database, using all the information available.

There is an alternative for downloading the information from the clearing house: the complete databases from the main page or extracts after having completed an advanced search procedure. All search outputs and all information contained in the databases are downloadable in TAB delimited or REFER formats.

4. FIRST WHOLE ACTION MEETING

The first whole action meeting was held 28–30 September 2000 in Joensuu (Finland). The European Forest Institute (URL at: <www.efi.fi>) and the University of Joensuu (URL at: <www.joensuu.fi>) hosted the meeting. The purpose of this meeting was threefold:

– To provide a discussion forum for issues concerning the LULUCF-SR prepared by the IPCC to the request of the SBSTA under the UNFCCC, as the theme of the first day;
– To report on country specific activities relevant to COST E21 using a standard format, as theme of the second day, and;
– To elaborate a work plan for the duration of the whole COST E21 Action, as the theme of the third day.

The meeting was split into two workshops. The first workshop was entitled "Land use, land-use change and forestry: the road to COP-6" and was organised by IEA Bioenergy Task 25 (URL at: <www.joanneum.ac.at/iea-bioenergy-task25>) and co-organised by COST E21, Joanneum Research, European Forest Institute and University of Joensuu. It was divided in four sessions:

– A chapter by chapter overview of the LULUCF-SR, with detailed information on the implications of different definitions and generic issues (Chapter 2); afforestation, reforestation and deforestation (Chapter 3); additional human-induced activities under Art. 3.4 (Chapter 4); project based activities (Chapter 5) and; the implications of the Kyoto Protocol for the reporting guidelines (Chapter 6).
– C-accounting methodologies, with particular emphasis on the ton year index and alternative methodologies in supporting climate-conscious policy measures.
– Activities under Art. 3.3 and 3.4 addressing issues around trees as C-sinks and sources in the EU, accumulation of C in agricultural soils and measurement and marketing of C-sequestration in Australian forests.
– The current state of the negotiations highlighted the present status of the negotiations and some perspectives including aspects on the "clean development mechanism".

The proceedings of this workshop were edited by Robertson, Schlamadinger (2000), and they are available at: <http://www.joanneum.ac.at/iea-bioenergy-task25/workshop/fwrkshp.htm>.

The second workshop focused on "COST E21-country specific activities". It was designed for fine-tuning the work plan for the whole action and providing country reports on reference values for national GHG inventories, working group 1 related activities, working group 2 related activities, perspectives and research needs as well as comments and improvement on the work plan. A study tour demonstrated how forest inventory is carried out in Finland and how the results from the forest inventory are utilised in the national GHG inventory reporting (see Tomppo, this issue, 2000).

The next 16 articles of BASE include contributions from the second workshop. They give a series of background information, sometimes widely scattered for (in alphabetic order): Austria, Belgium, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Norway, the Netherlands, Spain, Sweden, Switzerland and the United Kingdom. Though not engaging the Joint Research Centre as an EU body, the paper from Löwe *et al.* (this issue, 2000) gives some conclusions enlarging the issues around C in forests, from national- to some EU perspectives. All these articles are the first significant contribution "towards an integrated scientific approach for C-accounting in forest ecosystem". Contributors to this second workshop were asked to report on:

- The process in their country providing the UNFCCC with data for GHG-inventory, the National Communications (NC), further referred to NC1, NC2, …, reference values for GHG inventories from 1990-till last communication;
- Country-information on the National Forest Inventory (NFI), context and hypothesis, date of the first inventory, periodicity, sampling intensity, data, accuracy, the sinks capacities;
- Working group I related activities (Inventory of sinks and sources);
- Working group 2 related activities (Analysis of forest management practices);
- Perspectives and research needs.

As concluded by Löwe *et al.* (this issue, 2000) "there is a lack of transparency, consistency and completeness for the reporting on chapter 5 of the National GHG Inventories for UNFCCC". Moreover, the "shopping list" given in Nabuurs *et al.* (this issue, 2000) shows that "many datasets are available through different organisations. However, these possible sources of information are very scattered and have never been linked before". According to a preliminary comparison of the latest forest inventories provided by some European countries (**Table 1**), the state of the art of forest inventorying and C-sinks/ emission reporting is highly variable between different European countries. Some countries have a long-term forestry tradition and assess their forest resources since 1919 (NO). Others assess sampling errors for the total timber volume as low as 0.3% (CH). Others never performed a forest inventory but sent questionnaires to forest owners (DK). Others made once an inventory some decades ago or lasting for some decades (GR). Even within a country, highly different procedures may have been applied at sub-national level (BE). "Independent of the quality of the underlying NFIs, there remains the key problem that NFIs are performed for assessing marketable stemwood and not for C-sinks/ emission reporting. Therefore, harmonisation is needed with regard to the different expansion and conversion factors applied for transforming timber volume into overall CO_2-emissions and sinks" (*ibidem*).

Finally, in terms of monitoring techniques and reporting C-sequestration for land use change and forestry, it becomes evident from Nabuurs *et al.* (this issue), see particularly **figure 1**, that EU countries are in the position to report a much bigger C-sink. Reported data might be multiplied by a factor around 10, illustrating that the current ways of reporting of C-sink strength are simply inadequate. Considering that previous reporting of C-sinks and sources from LUCF, as based on NCs, is not sufficient to fulfil future requirements regarding the Kyoto Protocol.

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