European Forest Information and Communication System

(EFICS)

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European Forest Institute

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Foreword

Council Regulation (EEC) No 1615/89, extended by Council Regulation (EEC) No 400/94, established a European Forestry Information and Communication System (EFICS). The objective of EFICS was to collect comparable and objective information on the structure and operation of the forestry sector in the Community, and thus facilitate the implementation and monitoring of the Community forestry provisions in force. To that end, the system must collect, coordinate, standardise and process data concerning the forestry sector and its development. It must also make use of information available in the Member States, in particular, data contained in national forestry inventories, and of any database accessible at Community and international level.

Within this context, the Commission financed in 1996 a study of which the overall objective was to analyse in detail the statistical sources on forestry resources in the Member States of the European Union and to draw up proposals for obtaining data which would be mutually compatible and comparable, so as to be able to establish a reliable and consistent forestry statistics database at European level.

The European Forest Institute (EFI) was given the task of carrying out this study.

The consortium led by EFI consisted of: Federal Forest Research Institute (Austria), University of Gembloux (Belgium), Forest and Nature Agency (Denmark), Finnish Forest Research Institute (Finland), Agence MTDA and SCOT Conseil (France), University of Freiburg (Germany), NAGREF – Forest Research Institute of Thessaloniki (Greece), Coillte Teoranta (Ireland), Forest and Range Management Research Institute (Italy), EFOR (Luxembourg), Institute for Forest and Forest Products (the Netherlands), NIJOS – Norwegian Institute for Agricultural and Forest Mapping (Norway), Instituto Superior de Agronomia, Department of Forestry (Portugal), Escuela Tecnica Superior de Ingenieros de Montes (Spain), Swedish University of Agricultural Sciences (Sweden), Swiss Federal Institute of Forest, Snow and Landscape Research (Switzerland) and National Remote Sensing Centre Ltd. and Forestry Commission (UK).

In this report, the final conclusions of the EFICS-study are presented. We would like to thank especially the co-authors of the different parts of the study :Information Needs Assessment: Saija Miina, Simulation Study: Berthold Traub and Matti Maltamo, Analysis of Harmonisation Activities at Different Target Levels: Berthold Traub, Impact of New Technologies: Hervé Jeanjean, Marco Marchetti and Erkki Tomppo. In addition, the following members of the consortium contributed to this report: Jacqui Conway, Patric Farrington, Pierre Kalmes, Christoph Kleinn, Kullervo Kuusela, Isabelle Lagarde, Javier Martinez-Millan, Ioannis Meliadis, Tim Peck, Jacques Rondeaux, Ulf Söderberg, Margarida Tomé, Stein Tomter, Vittorio Tosi, Jari Varjo and Norbert Winkler.

In 1997, the Commission published country reports and the comparative study on the National forest inventory systems of the countries[1,2]. In addition, the EFICS-work has been partly reported in

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[1] European Commission. 1997. Study on European Forestry Information and Communication System – Reports on forestry inventory and survey systems. Volume 1 – Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Liechtenstein. 673 p.

[2] European Commission. 1997. Study on European Forestry Information and Communication System – Reports on forestry inventory and survey systems. Volume 2 – Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, Czech Republic, Hungary, Poland. Pp. 674-1328

Päivinen[3], du Breil de Pontbriand et al.[4] and Koehl et al.[5]. However, the full content of the final report has not been published.

The EFICS Regulation expired by the end of 2002 and the idea of European level forest information service is still waiting for materialisation. As it is obvious that there are still valid elements in the EFICS study carried out by EFI consortium in 1996–7, we wish to bring the results available to contribute to the development of forest information services at national, regional and global levels.

Joensuu and Hamburg, June 2005

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[3] Päivinen, R. 1999. European forest information and communication system – EFICS. In: Proceedings of the Farm Forestry Statistics Seminar, 8–11 July 1998, Helsinki and Joensuu, Finland. Information Centre of the Ministry of Agriculture and Forestry. Pp. 50–53.

[4] du Breil de Pontbriand, L., Flies, R., Folving, S., Kennedy, K. and Päivinen, R. 2000. EFICS (European Forest Communication and Information System) – Networked statistical and geo-referenced forest information? In: Salminen, H., Saarikko, J. and Virtanen, E. (eds.). Resource Technology ´98 Nordic, International symposium on advanced technology in environmental and natural resources. 8–12 June 1998, Rovaniemi, Finland. Proceedings. Finnish Forest Research Institute, Research Papers 791.

[5] Köhl, M., Traub, B. and Päivinen, R. 2000. Harmonisation and standardisation in multi-national environmental statistics – Mission impossible? Environmental Monitoring and Assessment 63(2):361–380.

Executive Summary

Objectives of EFICS and EFICS-study

The objective of the European Forest Information and Communication System (EFICS) is, according to Council Regulation (EEC) No. 1615/89 of 29 May 1989 which established it, to collect, co-ordinate, standardise and process data concerning the forestry sector and its development. It “should facilitate the implementation of decisions taken at national and regional level concerning the forestry sector, and thereby improve knowledge of that sector at all levels“ and “must be set up taking into account existing information systems“. In particular, information collected in National Forest Inventories and in any existing and accessible data bases should be utilised.

Thus, the European Union has the aim of collecting, through EFICS, the information that exists in Member States and of making it comparable. To reduce the heterogeneity, or even lack of reliability of the current data sources, an appropriate system is required to collect, process, analyse and disseminate the information.

The main objective of the EFICS-study, which the Commission contracted to the European Forest Institute, is “to analyse in detail the statistical sources of forest resources in the fifteen Member States of the European Union and the four EFTA Member States, Norway, Switzerland, Liechtenstein and Iceland, and to draw up proposals for obtaining data which are mutually compatible and comparable, so as to be able to establish a reliable and consistent statistical database at the European level”. This should include an assessment of the different options available to the decision-makers for the improvement of forest sector statistics and for developing EFICS. While EFICS is concerned with information relating to the forest sector as a whole, the EFICS-study is limited to the information concerning the forest resource.

The challenge

Today, a number of different forest resource inventory systems can be found in Europe, which were developed and optimised towards national objectives, but do not necessarily meet common, international requirements. The current situation is characterised by differences in inventory, sampling and assessment procedures, data sources utilised, nomenclature (e.g. measurement rules, definitions), models (e.g. volume estimation, estimation of growth components, forest structure), analysis techniques, inventory organisations and responsible bodies, and inventory cycles.

However, a system of international data collection, which makes use of national forest resource assessments, has some major advantages. They are often based on sound statistical techniques, they provide representative data on both wood and non-wood products and services for an entire region or nation, and the costs of the assessments have already been covered by the individual countries. A high degree of expertise exists in the national bodies. These advantages encourage to search for methods integrating differing techniques and to harmonise procedures and nomenclature, with the objective of compiling national forest resource information and establishing a reliable and consistent data base at the European level.

The following findings and recommendations are based on:

- thorough study of forest inventory methods in the countries
- assessment of information needs
- evaluation of alternative strategies for development of the EFICS

Main Findings

The EFICS-study found that there are clear needs for comparable information at the international level. This is due to the international initiatives originating from the Rio Global Convention, but also due to the needs of various private and public organisations in the member countries, as shown in the Information Needs Assessment, carried out as a part of the study.

The study showed that there are major knowledge gaps and unsatisfied information needs concerning the forest sector. Currently, information on the productive function of forests is available at the national level, but to meet the needs of comparability, existing data collection needs to be harmonised.
Information on the ecological attributes of forests and the non-wood goods and services is available infrequently. However, individual countries are developing their methods to assess these attributes. Therefore it is necessary to streamline the development internationally to meet the requirements of harmonised information in the future.

To fully utilise the possibilities of harmonised forestry and environmental information, an information service system should be established to serve the clients.
EFICS is urgently needed to close information gaps concerning European forests and the forestry sector. It has the potential to become a focal point of forestry in Europe and could have the capability to provide the information on forests, their sustainable management and their environment, which is needed by different categories of users.

Main recommendations

1. The existing national inventory and monitoring programmes form a sound basis for the development on EFICS, and the system should be based as much as possible on them.

2. Nomenclature, assessment methods and analysis methods differ between countries and the development of guidelines for harmonisation is necessary. This will involve the specification of the time frame, the level of harmonisation, technical aspects, analytical methods as well as the allocation of a budget and negotiations with the member states.

3. To guarantee reliable and comparable information at the European level the data assessment and nomenclature have to be harmonised. In the short run, conversion factors should be derived to convert country figures to make them comparable to the European definitions. In the long run, national forest inventories should apply the European definitions for certain attributes. They may apply their traditional definitions in addition.

4. In some cases, a special EFICS survey parallel to the national assessments could be a feasible solution. The utilisation of space-borne remote sensing methods, which provide harmonised data for all the countries, may require a Europe-wide approach.

5. The harmonised set of data at least should be made accessible through an EFICS data service. The means that data exchange and data update have to be provided.

6. As a first step, standard reports should be compiled and issued by EFICS. In the second phase analyses, should be made available in response to special requests. In the third phase interactive analysis should be offered to users.

7. The access to data requires the design and installation of an EFICS data service. The infrastructure of such a service centre must include, besides powerful hardware, software tools such as data bases, GIS or modelling and simulation systems.

8. EFICS should not become another institution that is limited to the periodic dissemination of key statistics about forestry. Thus the degree of access to the EFICS data base will be essential for its success. User interfaces, interactive information retrieval, and meta-information servers will allow to user to extract specific information and thus increase user satisfaction.

9. In particular, EFICS should find its proper role in the exchange of data with other information systems existing or under development. These systems include global ones, like the FAO/ECE Forest Resources Assessment 2000, and regional ones, especially various environmental information systems. EFICS has a potential to constitute the basis for deriving the criteria and indicators of sustainable forest management.

10. As found in the information needs assessment, not only forest resources information is interesting for potential clients. A study similar to this one should be undertaken regarding information on forest industry products, research and development projects, timber markets, forest policy, forest and environmental legislation. Regarding research projects, collaboration with COST-actions is recommended.

11. Regarding forest resources information, further work together with the countries involved is needed on the following topics:

- harmonisation of nomenclature
- design of an information system for EFICS
- design of a communication system and access to information held by EFICS
- statistical approach for the analysis of data provided by different countries
- possibilities for integration of environmental data into EFICS
- needs and possibilities to expand EFICS to non-EU and EFTA countries.

12. An EFICS working group should be established within the framework of the Standing Forestry Committee to steer the bringing into operation of EFICS, and to co-ordinate the work with the Inter-secretariat Working Group of Forest Statistics and other relevant bodies.

Alternative Strategies for developing EFICS

In the future development of EFICS we can distinguish three different working phases:

Data collection in the countries, and its organisation into comparable format

Data storage, including the preparations needed to make the data available for users

Data dissemination, including the preparation of publications and other tools to make the data and its analysis available for the users

1. Data collection

Four alternatives exist for the collection of data within the scope of EFICS:

a) rely on national forest resource assessments as they currently exists
b) in addition to the traditional national assessments, a set of harmonised attributes is assessed in national surveys
c) national assessments (including a set of harmonised attributes) plus a common assessment on the national level
d) conduct an independent EFICS survey.

Alternative (a), the restriction to national assessments as they are now, would render reliable information at the European level difficult. This alternative would not follow the EFICS-regulation either. An independent EFICS survey (alternative (d)) is not practicable due to the tremendous cost involved. Thus, it is recommended to concentrate the future considerations to alternative (b), the introduction of a set of harmonised attributes in national assessments or alternative (c), a harmonised assessment of some attributes at the national level parallel to the already existing national assessments.

2. Data storage and access

Two major alternatives exist for data storage:

a) all data are stored at the national forest inventory units only
b) part of the national data are stored twice: at a European data service unit and at the national inventory units.

Alternative (b) does not necessarily mean that the data would be physically stored in a 'European data centre', the essential thing is the access to the data. The public part of the data would be accessible to all users, the private part of the data only with the agreement of the data owner in the countries.

It seems reasonable to suppose that at least the harmonised part of the data would be public.

3. Data dissemination and analysis

Three alternatives exist for data analysis under the auspices of EFICS:

a) standard analysis with defined content, printed and electronic media publications
b) special analysis upon request, provided by qualified EFICS-staff or network
c) interactive analysis by users, with basic tools and advice for analysis provided by a qualified EFICS -staff or network.

Alternative c), interactive analyses would lead to the highest customer satisfaction, but would require most from the system. The qualified EFICS staff could be something like in the ICP-Forest Centres: a contractor hired for a certain period to carry out tasks defined by the Commission. However, more permanent alternatives should also be considered.

Tasks carried out within the EFICS-study

Analysis of the existing forest inventory and survey systems in the member states

The first phase of the project was mainly a compilation of existing systems at the national or regional (e.g. federal states) level. The analysis covers 15 EU and 4 EFTA countries. A modular approach was applied in the survey, the modules covering:

- data sources,
- nomenclature,
- assessment techniques,
- reliability of the data,
- data storage and analysis,
- models,
- inventory reports,
- forest statistics of the country,
- other forestry data,
- institutions and organisations involved in the assessments, including their tasks and resources, and the legal status of the assessment,
- the cost of the forest survey, separated in costs for assessment, administration, data analysis and infrastructure, financing bodies, the users of the information provided and the users needs,
- availability of data, and
- future developments.

A brief analysis of the situation in the Czech Republic, Hungary and Poland was also included.

Comparative Analysis of existing systems and the results obtained

The comparative analysis was carried out for each module presented in the previous section. This comparative analysis shows the basic problems in the compilation of national data at the international level.

According to the comparative analysis, the variables were grouped as follows:

- attributes that already have a comparable format or do not need any further modification,
- attributes that need to be harmonised and can hardly be utilised for aggregation at the moment,
- attributes that cannot be used in their current format but could be converted to meet the required standard,
- attributes that have to be collected in addition to the current set of available attributes.

Information Needs assessment

The information needs of actual and potential users of forest resources information have been investigated by means of a questionnaire, sent both to the national bodies in all 19 countries and to the international bodies collecting and using forestry information. Altogether 520 letters were sent. The replies to the questionnaire (altogether 222) were analysed by interest groups and by country groups.

Proposals for improvement

Proposals for the harmonisation of nationally assessed attributes to fulfil information needs at the European level were based on two major features:

1) the importance of the attributes (based on the information needs assessment) , and
2) the efforts needed to meet an appropriate standard of harmonisation.

For the main attributes, technical solutions were studied that would make it possible to modify, convert or transform the attributes into a form which allows comparative analyses at the European or regional level. The proposals were based as much as possible on existing definitions, assessment schemes and methods applied in the countries.

An investigation was carried out to estimate how much work would be required and what kind of costs would be involved, if different targets were set at the European level. Three hypothetical target levels were defined regarding the harmonisation efforts, namely:

- up to 5 most important attributes should be harmonised
- up to 10 most important attributes should be harmonised
- more than 10 attributes should be harmonised.

In the context of EFICS, the potential of remote sensing data was discussed as input for harmonising the existing nomenclatures, and also for contributing new harmonised information to the European forest information system. The anticipated development of various remote sensing methods in the coming 5-10 years was assessed, and their expected impact on the collection of harmonised forest information at the European level was evaluated.

A similar analysis was carried out on the possibilities of geographical information systems (GIS). Special attention was paid to the potentials to combine relevant data sources for analysis and to the presentation of the forestry statistics in an attractive and user-friendly way.

Modern information technologies will create new possibilities both for the collection of the information, and for its dissemination. The Internet is the most used ‘network of networks’, enabling computers in different locations to communicate with each other. Setting up the forest information systems in a decentralised way was compared to centralised ‘databanks’.

Summary of the results of the tasks

Task 1: Analysis of existing forest Inventory and Survey Systems in EU and EFTA countries, Their Methods, Procedures and Results

The forest resource assessments of the 15 EU and 4 EFTA countries (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Liechtenstein, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, UK) were compiled in 19 country reports. Summaries were provided for the Czech Republic, Hungary and Poland. The country reports cover the nomenclature, data sources, assessment techniques, data storage and analysis, reliability of data, models, inventory reports and future development and improvement plans.

The country reports will be published by the European Commission in 1997. They served as a basis for further analysis, and will also serve as a baseline document for forest inventory systems development in Europe or other parts of the world.

Task 2: Comparative Analysis of Existing Inventory Systems

Based on the country reports, the national forest resource assessments were compared.

The findings of the comparative study can be summarised as follows:

The main focus of the forest resource assessments up to now has been on the productive function of forests. However, the change towards multi-purpose inventories, including attributes describing biological variation etc. in the forests, is under way.

All countries are conducting sample based surveys, except for Denmark and Luxembourg, where standwise management inventories are used as a basis. The main data sources are field assessments, maps and aerial photographs. The period between two assessments varies from five to ten years in most countries. No updating of data is applied, i.e. no common point in time to which data are related is given.

In all countries except Greece, data assessed in national forest resource assessments are stored in digital format. In most countries data base systems are used, but software and hardware applied for data analysis varies considerably.

In most countries field checks are conducted to guarantee data quality.

For comparison, attributes were tentatively assessed by an expert team under 4 groups, regarding the expected effort needed to obtain harmonised information.

Comparability of the attributes.

	directly (in the field) assessed attributes (like breast height diameter, stand age)	*derived* (using models and field measurements) attributes (like stem volume, biomass)
sufficient level of comparability	16	1
not comparable, but could be harmonised	24	9
very difficult to harmonise	17	2
new attributes to be collected	1	4
TOTAL	58	16

A special study was carried out to describe the quantitative consequences of different definitions of a few key central variables.

The definitions for forest area vary considerably. Forest area is the most important forest attribute, and many other attributes are expressed per unit of forest area, (e.g. dry biomass per hectare). Two basic definitions for forest area are used:

- based on potential stem volume yield (1 m3/ha/a in the Nordic countries);
- based on potential crown cover (cover varying from 5 to 30%).

In both methods, forest area has a minimum size, varying from 0.05 to 0.5 hectares.

Width of the tree line. Especially in the method based on crown coverage, the delineation rule plays an important role. It determines the maximum acceptable distance from continuous forest to single tree or tree group outside the forest, for them to be defined as part of the forest.

A model forest, representing forest cover patterns in different parts of Europe, was used to simulate the impact of different forest cover definitions. The differences are highest in the areas where sparse forest exists. This is the case at high altitudes in the Nordic fells and the Alps, in peat- and wetlands or in dry areas in the Mediterranean region. In Central Europe, the forest/non-forest boundary area does not vary so much.

The results of the study on forest area definition show that applying definitions from different countries, the differences in forest area may be at maximum 7 % in the Nordic regions, 4% in Central Europe and 14% in the Mediterranean region.

No unique nomenclature exists for stem volume. Stem volume is of importance as such, but also because it is the best basis at present for estimating total biomass, carbon stock and other derived attributes.

The volume figures depend on three factors:

- how small trees are taken into account (minimum threshold value for the diameter at breast height),
- starting point of the stem volume included (ground or stump)
- end point of the stem volume included (minimum top diameter).

Switzerland used the highest threshold value (12 cm) and Finland, Sweden and UK the lowest (0 cm). Minimum top diameter varies from 0 (9 countries) to 7.5 cm (Spain). The starting point of the volume is at stump level in 7 countries, the others use ground level.

The volume of trees below 12 cm d.b.h. comprises 2-3 % of the total volume of the Swiss forests. If Swiss definitions would be applied for a typical Nordic forest, 13% of the total volume would be lost. This result shows that threshold values have more importance in those areas where relatively small trees cover high proportion of forest, like in the North and in the Mediterranean area. If UK definitions would be used in Finland and Sweden, they would show 5 % more volume in the forests.

Task 3: Information Needs Assessment

The information needs assessment was carried out in order to be able to prioritise the information needed for forest resources. It was made out for various interest groups at the national and international level. The questionnaires were sent to forestry and environment-related organisations, selected by the country partners. Forest education, the public, media and other potential information 'clients' were not covered by the questionnaire. The task of the recipients was to assess how important different information about the forest resource in other countries than their own was for their organisation.

To assess the information needs of users, 380 questionnaires were sent to different interest groups. 140 questionnaires were sent out to assess the information needs of international bodies. The following results are based on the 222 questionnaires received in time (43 % of the number sent). The rate of response can be regarded as satisfactory. In the table below, the number of replies from different interest groups and country groups are presented.

The distribution of replies by country- and interest groups.

	Country Group					
Interest Group	Northern Europe	Atlantic Europe	Central Europe	Southern Eur.	Inter-national	Others
Forestry and Agriculture / Government	8	9	15	15		2
Environment/ Government	3	5	3	1		
State forest organisation	3	5	5	3		2
Forest industry	5	10	1	2	9	
Private forest owners	4	2	1	2	1	
Nature conservation and environmental org.	3	5	6	2	6	1
Forest research	10	9	8	8	10	3
Other interest group	3	4	1	6	9	3
EU and related bodies					2	
FAO and related bodies					2	1
Helsinki Process					4	
Total	**39**	**49**	**40**	**39**	**43**	**12**

The recipients were asked to classify information as 'very important', 'important', 'interesting, but not important', and 'not important'. They also had the possibility to indicate if they had no opinion on the matter.

In the first question, recipients were asked to prioritise broad forestry information classes. The following were the 4 most important:

Wood resources; important or very important for	83 % of recipients
Forest policy (legislation, taxes, subsidies etc.)	71%
Research and development projects	70%
Forest industry production	64%

This result indicates that not only wood and forest resources, but also other information would be of interest for most potential clients of EFICS.

The other questions concerned forest resources. To summarise, the priority order of the forest resource attributes was the following:

Forest area (and its change), important or very important to	83% of recipients
Tree species composition	79%
Protective function and nature conservation	77%
Volume of annual increment and cut	75%
Biological richness and diversity	74%
Growing stock volume and its changes	71%
Health condition	69%

These attributes can be compiled from one or several variables, for example, 'Forest area change' consists of forest area 'increase', and 'decrease'. It should also be mentioned that the attributes found to be the most important ones in the Information Needs Assessment, are almost identical with the criteria and indicators of sustainable forest management of the Pan-European (Strasbourg-Helsinki-Lisbon) process. When the importance of information in map format was asked about, the priority order of the attributes was similar to the statistical information.

There are differences regarding information needs between the interest groups and also between the country groups. For instance, environmental organisations emphasise variables describing protective functions, biological richness, recreation and non-wood goods and services. Forest industry would like information on the volume of annual cut, timber quality and the volume of annual increment. Information needs between the country groups differ less than between the interest groups.

Based on the estimated time used in information collection in the 222 organisations replying the questionnaire, it can be concluded that an European Forest Information System would save probably tens of labour years annually compared to used for information collection in different organisations. In addition, an improved information basis would save resources indirectly.

Task 4: Proposals for Improvement

Harmonisation Activities

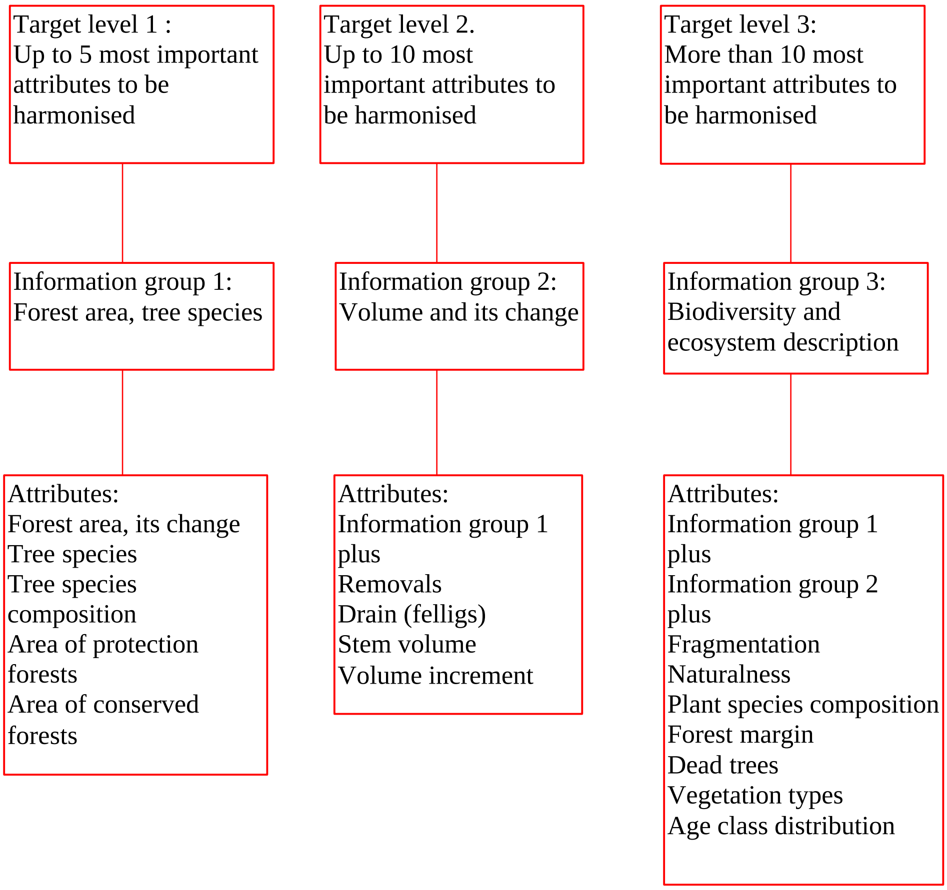
An analysis of the harmonisation activities at different target levels was carried out. Three target levels have been specified (up to 5, up to 10 and more than ten most important attributes to be harmonised) and attributes were assigned to the target levels according to the information needs assessment.

The 5 most important attributes that should be harmonised provide information on forest area, its change and tree species composition. The 10 most important attributes add attributes that provide information on volume and its change. The highest target level (more than ten most important attributes to be harmonised) add information related to the ecosystem description and biological diversity.

In the figure below, the most important attributes have been grouped into the 3 'target levels'.

The selected attributes and information groups are coherent with the criteria and indicators for sustainable management specified by the Helsinki process.

The workload in the countries in order for them to come up with a harmonised output regarding different variables was estimated. The most cost efficient alternative is to develop a definition that combines similarities within the countries in an optimal way and thus reduces the overall efforts to a minimum. In other words, the estimates here assume a certain definition, most often the most common in the countries. If some other definition should be applied, the total workload would be different and allocated differently between the countries.



Attributes grouped into target levels

For instance, the efforts needed to harmonise the forest area definition assume 20 % canopy cover to be the basic rule. Harmonisation of forest area would be carried out by different methods in the countries, depending on the data available. Those countries which measure plots also outside forest (Finland, Sweden), need some models to link canopy cover and variables measured in the field to estimate their forest area according to the harmonised definition. Spain, France and Greece need to estimate the difference in area between their definition (10 or 5 %) and the European one (20%), probably by re-sampling part of the plots from aerial photos or ground. In Austria, where 30% canopy cover has been used, new areas would be included, which would mean more work than in other countries, especially in the next inventory round when more plots should be measured..

Tree species and tree species composition are attributes that can be harmonised with small effort.

Information on protected and conserved areas would need a considerable effort in order to be comparable in the European countries. The problem is only partly depending on inventory practices; its roots lie in the legislation regarding forest protection and conservation.

Drain and removals are attributes that can easily be harmonised if national assessments would specify survivor trees, mortality, cut trees and trees which have became part of the inventory (ingrowth). Models have to be developed to quantify the amount of wood that is extracted from the forest. International comparisons require the application of a harmonised system of equations, which can be easily provided.

The attribute single tree volume would require the specification of harmonised threshold values, e.g. minimum d.b.h. and components that are included, e.g. stump. Individual countries have to adjust their volume equations according to the new definitions and report the differences between their national figures and the figures according to the harmonised nomenclature.

Assuming that a common approach for single tree volume and the assessment of the tree history (survivor, dead, cut, new trees/ingrowth) has been implemented in national forest resource assessments the attribute volume increment could be harmonised with minor effort. National procedures to calculate volume growth and volume of growth components could be maintained.

Nomenclatures for the biodiversity variables like 'naturalness', 'fragmentation', 'forest margins' , 'clearings' and 'dead trees' would have to be developed. This is the most demanding work in the harmonisation efforts. As no national nomenclatures exist yet, there is great potential for a harmonised approach. However, in many countries new variables are being developed, and international activities for harmonising these are well timed.

Health condition is the attribute which has been harmonised already in the context of the International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP-Forests of UN/ECE, Council Regulation 3528/86).

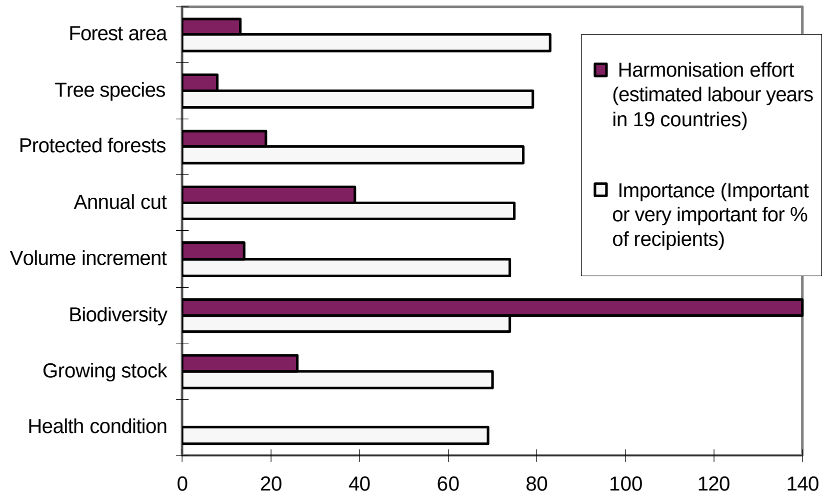
In the figure below, attributes are grouped to be fully comparable with the information needs assessment.

It can be seen that the first and second target levels would require - taking into account that the workload is divided between 19 countries - a modest harmonisation effort, but the third group would need a substantial investment in research and methodology development. However, it must be kept in mind that some development work is going on in the countries, so labour years presented here are not always entirely 'new' work.

The total costs necessary to meet the three target levels are:

up to 5 most important attributes:	40 person years
up to 10 most important attributes:	40 + 77 = 117 person years
more than 10 important attributes:	40 + 77 + 160 = 277 person years

If one person-year would cost 50 000 ECUs, the total cost of the lowest level harmonisation efforts (40 person-years) would be in the magnitude of 2 Mill. ECUs, and approximately 100 000 ECUs per country. The highest level would cost 7 times more.



Comparison of harmonisation efforts needed for certain attributes.

Impact of New Technologies

The impact of new technologies in the scope of EFICS has been analysed. For data collection, as far as remote sensing technologies are considered, optical satellite data should be the major source at the European level. In addition, data collected and incorporated into Geographical Information Systems will be essential in the future.

Remote sensing will provide mapped, geo-referenced data which is an important supplement to traditional statistics.

The feasibility of remote sensing data depends strongly on the spatial resolution, the spectral specifications, applied nomenclature and the mapping unit of reference. Remote sensing techniques are already now feasible for the assessment of the attributes 'forest area and its change', 'fragmentation' (describing structural biodiversity) and 'vegetation types'. Remote sensing techniques are possibly feasible for the assessment of the attributes like 'tree species composition', 'drain and removals', 'forest types', and ' other wooded land'.

Satellite remote sensing techniques cannot yet be applied for the direct assessment of the attributes such as 'forest function', 'single tree volume', 'volume increment', 'increment of volume components', 'naturalness', and 'dead trees and other woody material'. However, satellite technology is developing fast and the situation will be different in 5-10 years.

Satellite Remote Sensing will provide possibilities to harmonise existing information, but the main benefits are in assessing important traditional forest attributes, and in assessing new environmental attributes like landscape fragmentation.

Three different approaches can be applied for assessing forest area or other feasible attributes:

1. wall to wall coverage: coarse or medium resolution data (0.01-1 sq.km.)
2. sample of high resolution (0.01-1 ha) data
3. combination of these two sources.

The most relevant ongoing programmes in the European context are CORINE (land use classification by the European Environmental Agency), and FIRS (Forest Information from Remote Sensing by the Joint Research Centre at Ispra). The development of the FAO/ECE Forest Resources Assessment 2000 should also be kept under review.

Geographic Information Systems (GIS) are a very appropriate tool for storing, processing, compiling and disseminating forest data.

GIS are under rapid development in most European countries. While many GIS are operating at a regional level, very few countries have developed a nationwide geo-referenced forest database system.

GIS represents an indispensable element in any integrated forest information system and will definitively play an essential role in EFICS.

The establishment of a communication network between national inventory units, the EFICS data network and the end users will require the introduction of digital format data exchange, and the definition of a user friendly operating system.

Among the modern communication means, the development of the Internet services is the technology which is providing the most promising possibilities for data exchange and access to information.

Table of contents

1. Information Needs Assessment

1.1. Introduction

The objective of task 3 was to prioritise the information needed for forest resources regarding different users.

Task 3 consisted of two work packages: evaluation of information needs on the national and the international level. On the international level, the study concentrated on representatives of the international forestry and environmental organisations. On the national level, the study material was collected from various organisations representing local, rather than international, interests.

1.2. Materials

1.2.1. Questionnaires sent

The basic material was collected by a questionnaire, which was developed and tested by the partners of the consortium. The questionnaire was in English and it included a cover letter and an appendix, explaining the objectives of the EFICS study. The recipients were also informed about the other groups, which had received the questionnaire.

The questionnaire form is attached as Appendix 1, with the total number of replies for each question and alternative.

The sample used was decided on subjective grounds, based on the expertise of the partners in the countries. They were asked to provide at least three addresses in their own country from each group listed below. In Ireland, Italy, Portugal and the UK, the country partners wished to send the questionnaires directly. Regardless of who mailed the questionnaires, the partners or EFI, the country correspondents were responsible of contacting the recipients by phone.

The ‘interest groups’ in the countries were:

1. Ministry of Agriculture and Forestry (Ministry of Trade/Industry/Finances may also be included, if considered appropriate)
2. Ministry of Environment
3. State Forestry Organisations
4. Forest Industry Association or industry sector associations e.g. pulp and paper, sawmills, wood based panels
5. Associations of private forest owners
6. Nature Conservation/Environmental Organisation(s)
7. The main Forest Research Organisation(s) in the country
8. Members of the EU Standing Forestry Committee (if not included in 1.)

Altogether, 380 questionnaires were mailed to the representatives of these interest groups in 15 EU-countries and in Iceland, Liechtenstein, Norway and Switzerland.

It was discovered that in some countries the three first groups are more or less combined. In others some organisations do not exist, e.g. association of private forest owners.

On the international level, the following bodies were approached: European Commission (DGVI, DGIII), European Parliament/Committees, EUROSTAT, European Environment Agency, Joint Research Centre, European Centre for Nature, Conservation, FAO, FAO/ECE, ECE (Forestry Committee), IIASA, UN/ECE Team of Specialists (TBFRA2000, Non-wood goods and services, Public Relations in Forestry), Country correspondents/TBFRA2000, European Associations of Forest Owners, CEPI, CEI-Bois, OES, Forest Industry Organisations, WWF, WCMC, and Helsinki Process.

Because the UN/ECE team of specialists and country correspondents of TBFRA2000 were not approached by the EFI, the number of questionnaires sent on the international level is not exactly known, but it is estimated to be about 140. In a few cases, people have received two questionnaires, one as ‘national expert’ and another as ‘international expert’, but only one reply was sent. For example, this was often the case in France.

1.2.2. Questionnaires received

The total number of replies was 237. 15 of those were received too late, e.g. like some questionnaires from Greece, or were incomplete, and are thus not included in the present analysis. Analysis of replies and also non-replies have been made.

The choice of interest group was made by the person who filled the form. Often it was not the same than assumed when sending the questionnaire, and sometimes even different than could be expected from the name of the organisation, if filled in on the last page.

In Table 1, the number of recipients and replies in the countries and the interest groups are presented.

Table 1. Number of questionnaires sent and number of replies.

Country	Interest groups											
sent replies	gov/for	gov/env	state for org.	industry	priv. owners	nat. conserv.	Research	other interest g.	EU	FAO	Helsinki p.	Total	Reply rate
Austria	1 2	1 2	1 1	3 0	3	4 1	5 4	1				19 10	53
Belgium	4 1	⇦		4 2	1	1 1	3 1	1				14 5	36
Denmark	1 1	⇦ 1	⇦	2 1	1	2	2					8 3	38
Finland	3 6	2 1	4 2	5 2	4 3	3	6 5	5 2				32 21	66
France	4	3	4 1	3	3	3 1	3 1	1				24 3	13
Germany	1 10	1 1	16 3	3	3 1	4 1	11 2					39 18	46
Greece	3	1	 1				3					7 1	14
Iceland			1 1									1 1	100
Ireland	 2	 1	 3	 4	 1	 1	 3	 1				251) 16	
Italy	13 9	2 1	1	5 1	2 1	4	12 6	7 4				46 22	48
Liechtenstein		 1	1									1 1	100
Luxembourg	1	⇦	⇦ 1		1	2 1		1				5 2	40
Netherlands	3 2	1 1	1	4 1	2	2	5 1	 2				18 7	39
Norway	3 1	3	2 1	3	2	4 2	3 2	 1				20 7	35
Portugal	2 1	1	1	2	1	1 1	3 2	 2				112) 6	55
Spain	2 5	1	18 2	3 1	3 1	2 1	3					32 10	31
Sweden	2 1	1 2	3	3 3	2 1	4 1	3 3	2				20 11	55
Switzerland	11 2	⇦	⇦	7 1	1	5 3	2 1	 1				26 8	31
UK	3 3	2 2	3	5 2	1 1	5 2	13 4	 1				322) 15	47
International				16 9	1 1	4 6	2 10	1 9	8 2	6 2	4 4	1403) 43	
Others	 2		 2			 1	 3	 3		 1		 12	

1) estimation of the sent questionnaires
2) classification of sent questionnaires in each interest group is estimated
3) estimation of the number of questionnaires sent
⇦ included in previous group

The total number of questionnaires sent was about 520, of which 222 were completed and returned in time, and thus the reply rate was about 43%. On the national level, 380 questionnaires were sent, and 167 received. The reply rate is thus 44%.

If replies are analysed, the highest reply rate was in the group of government/agriculture and forestry, and second highest in government/environment. The lowest reply rate was in the groups of private forest owners and forest industry, where only every fourth questionnaire was filled and returned.

Originally few questionnaires were sent to representatives of the private forest owners associations, since they are not so numerous. Quite a low reply rate was also received from EU and related bodies (only 2 replies to 8 sent letters).

If we analyse how the receivers of the questionnaire were originally classified, we can see that the best reply rates are in the groups government/ agriculture and forestry and research. The lowest reply rates are in the groups private forest owners, industry and government/environment.

The reason to this is that in many cases the persons who replied have classified their organisation into a different class than originally thought. For example, government/forestry and agriculture includes the replies from the original state forest organisation group. For example, in Germany 10 replies were received from the group government/ forestry and agriculture, even though only one questionnaire were sent to the representative of this group. Representatives of the original group state forest organisations and research have chosen the first mentioned group. In some cases, the questionnaire could have been copied and forwarded to the other sections of the organisation. However, we think that this does not disturb the overall interpretation of the results.

The highest reply rates (100 %) were in Iceland and Liechtenstein (one sent and one received), the next highest were in Finland (66%), Sweden and Portugal (55%), and in Austria (53%). The reasons may have been the general interest in forest resources information and good personal contacts between the country partners and the recipients. The lowest reply rates were in France (13%) and Greece (14%).

In Table 2, the correlation between the total number of replies from geographical country groups and interest groups are shown. The country groups were the following (Figure 1):

- Northern Europe (Finland, Sweden and Norway),
- Atlantic Europe (Belgium, Denmark, Iceland, Ireland, Luxembourg, the Netherlands and the United Kingdom),
- Central Europe (Austria, France, Germany, Liechtenstein and Switzerland),
- Southern Europe (Greece, Italy, Portugal and Spain),
- International organisations and
- Others (countries other than EU and EFTA countries).

Table 2. Replies from different country groups.

	Government/ Forestry and Agriculture	Government/ Environment	State forest organisation	Industry	Private forest owners	Nature conservation/ environmental. org.	Research	Other interest group	EU and related bodies	FAO and related bodies	Helsinki Process	No group	Total
Northern Europe	8	3	3	5	4	3	10	3					39
Atlantic Europe	9	5	5	10	2	5	9	3				1	49
Central Europe	15	3	5	1	1	6	8	1					40
Southern Europe	15	1	3	2	2	2	8	6					39
International				9	1	6	10	9	2	2	4		43
Others	2		2			1	3	3		1			12
Total	49	12	18	27	10	23	48	25	2	3	4	1	222

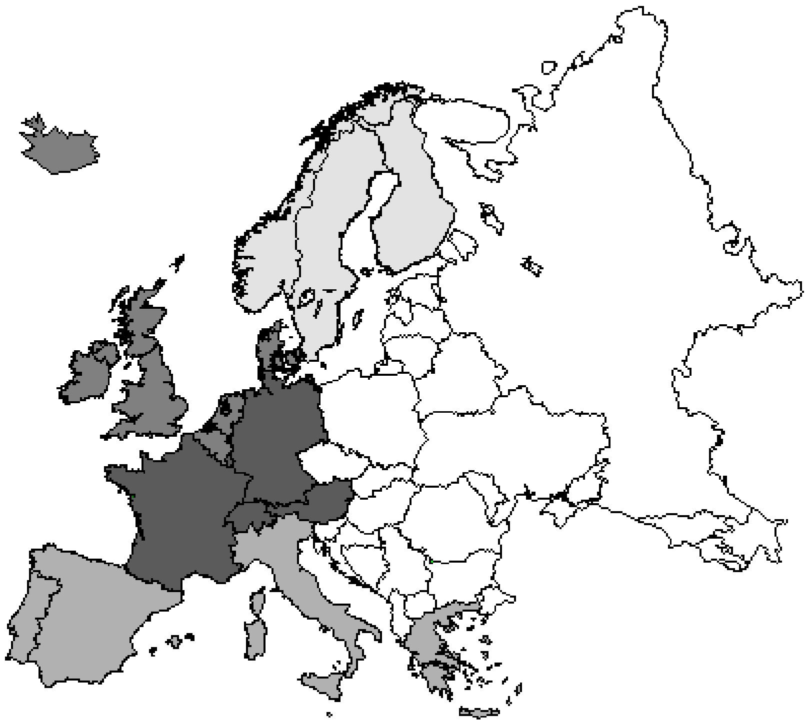


Figure 1. Country groups.

We can find some combinations of region and interest group, like:

- Atlantic region and international - many replies from forest industry
- Central Europe and Southern Europe- few replies from forest industry
- Southern Europe - few replies from environmental organisations
- Northern Europe - 40 % of private forest owners' replies

The regional distribution of the total number of replies is good.

1.3. Results

The results are presented as

- total results
- results by the interest groups and
- results by regional country groups, where international organisations form one of the groups.

1.3.1. Total results

The following results are based on all replies:

Forestry information areas in order of importance:

1. Wood production
2. Forest condition
3. Biodiversity
4. Land use (changes, efficient allocation, etc.)
5. Supply of non-wood goods and services
6. Climate changes

The principal unit of reference for use of information:

- Country (156 replies)
- Subcountry (59)
- Region (27)

The first question, regarding the issues, was not always properly understood. Thus the results to this question include a higher degree of uncertainty than the other results. However, the importance of wood production, forest condition and biodiversity are also reflected in the other replies.

The country as the main unit of reference is a very clear result, and endorsed by the replies to the other questions as well. The interest in the subcountry level information is highest in Central and Southern Europe. The interest groups that were most interested in the information on subcountry level, were government/ forestry and agriculture and government/ environment. However, the interest in the subcountry level information increases when the information is needed from neighbouring countries or large countries with big variations in growth regions.

Question 1. Importance of different information groups about European countries.

The replies confirm the importance of the wood resources information. However, it should be kept in mind - in the interpretation of this and other replies - that the conclusions depend on 1) to whom the questionnaire was sent, and 2) who replied.

Order of importance by the columns 1 and 2:

1. Wood resources
2. Forest policy
3. Research and development projects
4. Forest industry production, etc.
5. Trade/ quantities
6. Trade/ legislation and procedures
7. Non-wood goods and services
8. Forest industry capacity
9. Trade/ prices

The other information groups listed under this title were certification (4 times), biodiversity (3), environmental issues (2), nature conservation (2). Some other issues were mentioned only once.

Question 2.

Information about trade and research projects should be updated most often, in average every second year. New information about forest resources is needed in average only in every fourth year.

Questions 3-7.

The list of the 15 most important attributes was formed on the basis of ‘very important’ and ‘important’ replies. Their sum was used as an indicator. From 42 listed attributes (questions 3-7) the 15 most important ones are:

1. Decrease of forest land (183 replies to ‘very important’ and ‘important’)
2. Forest land (182)
3. Increase of forest land (180)
4. Tree species composition (175)
5. Protective function and natural conservation (172)
6. Volume of annual cut (167)
7. Volume of annual increment (165)
8. Biological richness and diversity (163)
9. Changes in growing stock volume (157)
10. Protection function (155)
11. Health condition / vitality of standing trees (154)
12. Growing stock/ stem volume (154)
13. Transfer of exploitable forest to other use (149)
14. Exploitable forest (147)
15. Age class distribution (146)

The four least interesting attributes were:

- Hunting (87)
- Other production than wood (cork, chestnut, pine kernel, resin, berries, mushrooms etc.) (82)
- Topography (78)
- Grazing area of domestic animals (70)

Question 8.

In the map format, forest area was often preferred in the scale of 1:100 000, instead of the scale of 1:500 000. There is no significant difference on the preference of map scales of other attributes. The other attributes which should be available in map format were conservation/ protection (mentioned 44 times), tree species composition (27), forest condition/ damages (25), vegetation type (18) and growing stock (17). The group nature conservation was the most interested in getting information map format and the group private forest owners the less interested.

Question 9.

Most of these organisations (71%) spend less than 4 weeks annually on the collection of forestry information concerning <u>other</u> European countries. Exception is interest group ‘Research’: 55 % of the organisations spend more than 1 month annually on the collection of forestry information. If we assume that ‘more than 6 months’ is 9 months, 1-6 months is 3 months, 1-4 weeks is 0.5 month and less than one week is 0.1 months, these 222 organisations spend about 25-30 person-years annually on forestry information collection.

Question 10.

The most popular format to receive forestry information is still paper hard copy (171 replies, 77%), but only in 17 % of replies it was the only form of preference. Other format, that is diskette, CD-ROM, e-mail or the Internet suit 40 % of the organisations.

1.3.2. Results by interest groups

The ranking of the attributes by the interest groups are presented in Table 3. The following observations can be made based on the table.

- The four most important attributes in total results are included in the top 15 in all interest groups.
- The interest groups differing from the mainstream are environmental organisations and industry.
- In the groups government/environment and nature conservation/environmental organisations, 7 and 6 attributes (respectively) of the top 15 attribute list, are not included in the overall top 15 list. Their new attributes are: protective function and natural conservation (rank: 1 and 1), biological richness and diversity (3 and 2), recreation/non-wood goods and services (4 and 12), wildlife habitat (8 and 3), etc. Many of these attributes do not belong to any other top 15 list. These replace attributes describing growing stock and its change in the other interest groups.
- Forest industry would like to have information on volume of annual cut, timber quality/assortments and volume of annual increment. That is only interest group including ‘mortality’ in their top 15 list.
- Forest owners share the views of forest industry in omitting protective function/nature conservation, biological richness and health condition from their top 15 list.
- The international organisations follow the general opinion. The only attribute, which is characteristic in their top 15, is ‘forest ownership’, which is more important for this group than to any other group.

From the members of Helsinki process was received 4 replies. The results were close to the total results. Differences were that they stressed the importance of biomass and attributes like ‘grazing’ and ‘other production than wood’ were high in their list of importance.

Table 3. 15 most important attributes in the different interest groups. Rank of attributes is based on replies under “important” and “very important”.

Attribute	Total	Government/ Forestry and Agriculture	Government/ Environment	State forest organisation	Industry	Private forest owners	Nature conservation/ environmental. org.	Research
n	222	49	12	18	27	10	23	48
Decrease of forest land	1	2	1	3	8	4	5	2
Forest land	2	4	5	1	11	4	8	1
Increase of forest land	3	4	5	1	8	4	8	3
Tree species composition	4	6	5	9	5	1	5	6
Protective function and natural conservation	5	1	1	3			1	3
Volume of annual cut	6	8		3	1	1		3
Volume of annual increment	7	10		3	2	1		6
Biological richness and diversity	8	6	1	3			1	10
Changes in growing stock volume	9			9	5	4		6
Protection function	10	2		9			5	
Healt condition/ vitality of standing trees	11	10	11				11	10
Growing stock/ stem volume	11	8			5	9		13
Transfer of 'exploitable forest' to other use	13	13	11		14	9		
Exploitable forest	14				4	9		
Age class distribution	15	13	11	9	13	4		
Plantations	16				8			
Silvicultural treatment	17			9		9		
Ownership	18	12				9		
Timber quality/ assortments	19			3	2			
Forest damage (excl. fire)	19						11	
Woody biomass	21							10
Productivity/ site quality	22			9				6
Recreation/ nwgs	23		1				11	
Wildlife habitat	24		5				1	
Potential land for afforestation	25							
Vegetation type	26		5					13
Other wooded land	27		11					
Volume of mortality (natural losses)	28				12			
"Naturalness"	29		5				4	
Changes in above-ground biomass	30							
Total biomass	31							
Recreation/ forest area	32		11					
Landscape/ scenic beauty	33		11				8	
Stand structure (density, layers)	33							
Accessibility	35							
Forest damage by fire	36						11	
Soil	36							

1.3.3. The results by country groups

The countries were grouped to 6 different regional groups (not based on any statistical analysis), the number of replies is in bold:

1. Northern Europe (Finland, Sweden, Norway) **39**
2. Atlantic Europe (Belgium, Denmark, Iceland, Ireland, Luxembourg, the Netherlands and the United Kingdom) **49**
3. Central Europe (Austria, France, Germany, Liechtenstein and Switzerland) **40**
4. Southern Europe (Greece, Italy, Portugal and Spain) **39**
5. International organisations **43**
6. Others (outside EU and EFTA countries, not international organisations) **12**

Table 4. 15 Most important attributes of the country groups. Rank of attributes is based on replies under "important" and "very important".

Attribute	Total	International organisations	Northern Europe	Atlantic Europe	Central Europe	Southern Europe
n	222	43	39	49	40	39
Decrease of forest land	1	1	7	3	1	4
Forest land	2	1	3	4	5	1
Increase of forest land	3	3	13	1	3	6
Tree species composition	4	6	7	2	6	1
Protective function and natural conservation	5	4	9	5	3	8
Volume of annual cut	6	10	1	7	7	12
Volume of annual increment	7	10	2	9	9	8
Biological richness and diversity	8	10	3	11	7	8
Changes in growing stock volume	9	5	3	12		14
Protection function	10		13		1	4
Healt condition/ vitality of standing trees	11	9	3		13	14
Growing stock/ stem volume	11	6	9	14	11	
Transfer of 'exploitable forest' to other use	13	10	13	14	11	
Exploitable forest	14	10	13	8		
Age class distribution	15		9	12		
Plantations	16			5		12
Silvicultural treatment	17				9	1
Ownership	18	6				
Timber quality/ assortments	19		9			
Forest damage (excl. fire)	19					8
Woody biomass	21				13	
Productivity/ site quality	22					
Recreation/ nwgs	23				13	
Wildlife habitat	24					14
Potential land for afforestation	25			9		
Vegetation type	26					6

The observations from Table 4 are as follows:

- Results do not differ as much between country groups as they do between interest groups.
- Each country group has some attributes in the top 15 list that the others do not have:
- Northern Europe: timber quality/ assortments (9)
- Atlantic Europe: potential land for afforestation (9)
- Central Europe: woody biomass (13), recreation/nwgs (13)
- Southern Europe: forest damage (excluding fire) (8), wildlife habitat (14), vegetation type (6)

International organisations have ‘ownership’, which was already mentioned earlier.

- In Northern Europe, there is more interest in volume of the annual cut and increment than in the other parts of Europe
- A small but probably characterising difference can be seen in the replies of Central and Atlantic Europe: In the former, the most interesting attribute is ‘decrease of forest land’, in the latter it is ‘increase of forest land’. In Central Europe, ‘protection function’ has shared the first place (not in top 15 in Atlantic) and in Atlantic Europe the area of ‘plantations’ is 5th in the rank, and not mentioned in Central Europe.

1.4. Conclusions

The results of the study reflect the views of “traditional” users of forestry information. The potential interest groups outside the forestry community and nature conservation groups are not covered by the assessment.

The working package ‘information needs assessment’ was originally divided in two parts: information needs inside the countries and in the international organisations. Based on the results of this questionnaire, there is actually very little difference between the average results obtained from the countries, and those obtained from international institutions.

The information needs between the regions within Europe and between the interest groups differ to some extent. However, the main interest is in two attributes

- Forest area (including its increase and decrease)
- Tree species composition

The next groups are

- Protective function and nature conservation area
- Volume of annual increment and cut
- Biological richness and diversity

In this, however, differences occur. Forest industry and private owners are very interested in the change of the volume, while environmental organisations have little interest in it. Regarding protection, conservation and biodiversity, the case is just the opposite.

The ‘willingness to pay’ is difficult to assess through this kind of questionnaire sent by mail only. The question was studied through the question ‘how much time is used in data collection regarding other

European countries?'. Based on these replies, it was estimated that 222 organisations use altogether 25-30 labour years to it.

The remaining questions are:

how many organisations there are altogether which would use the information about the European forests?
how much they would save time if EFICS will be materialised ?

The rate of reply was 43 %, so we know that there are more than 500 organisations, but most probably at least twice as much. These 1000 organisations would then use 100-150 labour years for data collection about other European countries. If they can save 25 % of their efforts, the number of saved labour years is 25-35.

However, based on these rough estimates, we can only speculate that EFICS might save tens of labour years. In addition, it may save more, if the quality of the available information is better than at present.

Appendix 1. Questionnaire on Forestry Information Needs Required for Europe

What do we mean by Forestry Information required for Europe?

1. Information describing the status of forests or forestry, measured in a similar way or otherwise comparable between countries.

2. Information which is generally available from publications, databases or computer networks.

In the first phase of the project, the European countries involved are the member countries of the European Union, and Norway, Switzerland, Iceland and Liechtenstein.

Please note that there are two possible levels on which to provide harmonised information: **Country level** and **subcountry** (regional, provincial) **level**. In the latter case one country is divided into two or more sub-areas and all information is provided for these areas.

In providing your answers, please keep in mind that what we need to know is *what information would be useful* ***for your organisation*** *about forests and forestry* ***not only in your own country but also in other countries*** *than your own.*

Please answer the following questions as an expert representing the viewpoint of your organisation. If you feel that the question is not applicable in your organisation's case, you can leave it open or tick the box with the question mark.

I represent: [1]

49	Government/Forestry and Agriculture
12	Government/Environment
18	State forest organisation
27	Forest Industry
10	Private forest owners
23	Nature conservation/environmental organisation
48	Research
2	Bodies of the European Union
3	FAO and related bodies
4	Helsinki Process
26	Other: ______

Country: ______

[1] Number of replies in each group

A number of major forestry issues have been discussed at national and international meetings in recent years and have been receiving the attention of policy-makers and managers. Please show the order of importance, from 1 upwards, for your organisation to receive international forestry information relevant to the issues listed below:[2]

3.	Biodiversity
6.	Climate change
2.	Forest condition
1.	Wood production
5.	Supply of non-wood goods and services
4.	Land use (changes, efficient allocation, etc.)
	Other (specify)
	Other (specify)

Note: Sustainability might have been included in the list as a major issue, but it was considered that it is already covered under the others, notably biodiversity, climate change, forest condition, etc.

What is the principal unit of reference for your use of information

27	Region (like Mediterranean, Nordic, etc.)
156	Country
59	Subcountry

Please return this questionnaire by **30 June, 1996** to

European Forest Institute
Torikatu 34, FIN-80100 Joensuu
Finland

Fax +358 73 124 393

[2] Importance based on the mean replies, 1. = most important

1. How important is the following information <u>about European countries</u> to your organisation? (Tick)

Information group		at country level 1	2	3	4	?	at subcountry level 1	2	3	4	?
Forest resources	Wood resources	117	69	19	6	11	48	30	34	20	90
	Non-wood goods and services	50	68	48	27	29	29	19	38	31	105
Forest products	Forest industry production, etc.	82	61	42	19	18	21	35	40	27	99
	Forest industry capacity.	58	52	61	26	25	18	32	39	30	103
Trade	Quantities (from-to)	68	56	47	22	29	15	19	47	33	108
	Prices	62	48	64	20	28	19	27	38	34	104
	Legislation and procedures	47	72	58	15	30	10	25	45	33	109
Forest policy	Legislation, taxes, subsidies, etc.	90	68	31	11	22	26	34	32	25	105
Research and development projects		84	72	41	7	18	29	30	36	23	104
Other (specify): [3]		23 6	2 1			197 215	8 2	2 1	1 1		211 218

1: very important 2: important 3: interesting, but not necessary 4: not important ?: no opinion

2. How often should the information be updated?

Information group	at country level Number of years	at subcountry level Number of years
Forest resources	4.37	4.3
Forest products	2.3	2.7
Trade	1.5	2.0
Forest policy	3.0	3.0
Research projects	1.8	2.0
Other (specify)[4]		

[3] e.g. Certification, Biodiversity
[4] e.g. Conservation

Since the main emphasis of the present EFICS-study is on forest resources, the following questions are concentrated on these.

3. How important is the following information of forest area in European countries to your organisation?

	at country level					at subcountry level				
	1	**2**	**3**	**4**	**?**	**1**	**2**	**3**	**4**	**?**
Forest land	12 0	62	24	5	11	43	41	24	17	97
Other wooded land (low productive, bushland)	53	69	60	21	19	21	33	35	31	102
Recreation	38	70	72	20	22	14	35	42	29	102
Ownership	62	78	51	11	20	23	33	36	22	108
Exploitable forest	79	68	44	10	21	32	31	34	22	103
Plantations	72	70	47	13	20	27	34	36	23	102
Protective function and natural conservation	10 0	72	26	9	15	46	31	31	18	96
Potential land area for afforestation	64	61	62	16	19	24	31	40	25	102
Other (specify): [5)5]	8 2	2	1		21 1 22 0	5 1	1			216 221

1: very important 2: important 3: interesting, but not necessary 4: not important ?: no opinion

4. How important is the following information of forest site in European countries to your organisation?

	at country level					at subcountry level				
	1	**2**	**3**	**4**	**?**	**1**	**2**	**3**	**4**	**?**
Vegetation type	59	64	60	22	17	38	28	28	25	103
Soil	37	62	73	29	21	19	38	29	30	106
Productivity/site quality	52	80	58	16	16	28	30	41	22	100
Topography	22	56	94	30	20	16	33	41	27	105
Accessibility	31	69	76	28	18	19	29	35	31	108
Other (specify): [6)6]	7 3	3	1		211 219	6 2	4			212 220

1: very important 2: important 3: interesting, but not necessary 4: not important ?: no opinion

[5] e.g. Protected areas
[6] e.g. Climate, species

5. How important is the following information about <u>growing stock</u> in European countries to your organisation?

	at country level					at subcountry level				
	1	**2**	**3**	**4**	**?**	**1**	**2**	**3**	**4**	**?**
Timber quality/ assortments	69	69	51	17	16	31	41	21	23	106
Woody biomass	51	82	53	21	15	19	38	33	24	108
Total biomass	44	65	64	34	15	14	33	35	32	108
Age class distribution	65	81	42	19	15	26	36	36	19	105
Growing stock/stem volume	84	70	32	19	17	32	33	27	23	107
Volume of annual cut	114	53	27	13	15	40	31	26	19	106
Volume of annual increment	101	64	26	14	17	34	34	28	19	107
Volume of mortality (natural losses)	48	72	63	23	16	16	34	37	26	109
Tree species composition	86	89	25	10	12	39	34	29	16	104
Stand structure (density, layers)	34	72	69	33	14	21	26	32	34	109
Mean diameter or mean height	29	64	72	40	17	10	32	36	35	109
Health condition/vitality of standing trees	67	87	38	16	14	33	35	26	22	106
Forest damage (excluding fire)	63	75	51	18	15	29	36	26	24	107
Forest damage by fire	42	57	74	30	19	19	31	28	32	112
“Naturalness”	57	62	60	21	22	30	23	31	28	110
Silvicultural treatment	53	88	45	15	21	32	23	36	23	108
Other (specify): [7]	2				220 222	1				221 222

1: very important 2: important 3: interesting, but not necessary 4: not important ?: no opinion

[7] e.g. Volume of annual thinnings, concervation

6. How important is the following information about <u>forest non-wood goods and services</u> in European countries to your organisation?

	at country level					at subcountry level				
	1	**2**	**3**	**4**	**?**	**1**	**2**	**3**	**4**	**?**
Protection function	80	75	35	11	21	47	23	28	22	102
Biological richness and diversity	85	78	30	13	16	44	34	27	19	98
Landscape/scenic beauty	44	62	65	30	21	26	26	36	30	104
Other production than wood (cork, chestnut, pine kernel, resin, berries, mushrooms, etc.)	36	46	72	41	27	21	20	34	43	104
Wildlife habitat	55	75	56	19	17	36	24	31	29	102
Hunting	31	56	80	33	22	18	33	31	35	105
Grazing of domestic animals	26	44	74	53	25	22	17	31	47	105
Recreation	45	86	50	25	16	27	29	34	28	104
Other (specify): [8]	5	1			216 222	3	1			218 222

1: very important 2: important 3: interesting, but not necessary 4: not important ?: no opinion

7. How important is the following information about <u>forest changes</u> in European countries to your organisation?

	at country level					at subcountry level				
	1	**2**	**3**	**4**	**?**	**1**	**2**	**3**	**4**	**?**
Increase of forest land	105	75	25	4	13	42	32	32	18	98
Decrease of forest land	108	75	21	5	13	46	31	29	18	98
Transfer of 'exploitable forest' to other use	72	77	37	14	22	28	31	34	26	103
Changes in growing stock volume	73	84	39	6	20	26	31	38	23	104
Changes in above-ground biomass	42	69	71	20	20	15	27	44	33	103
Other changes?)[9]	71	4			211 221	2	3			217 222

1: very important 2: important 3: interesting, but not necessary 4: not important ?: no opinion

[8] e.g. Forests used by public, Protection of water resources
[9] e.g. Changes in biodiversity

8. How important is it to have information available in map? In addition to forest area, please mention other important attributes which you would like to have in map format.

	1: 100 000				**1:500 000**			
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Forest area	57	45	28	25	60	39	23	22
Conservation/ protection (44)[10]								
Tree species composition (27)								
Forest condition/ damages (25)								
Vegetation type (18)								
Growing stock (17)[11]								

1: very important 2: important 3: interesting, but not necessary 4: not important

9. How much time does your organisation spend annually on the collection of forestry information about other European countries? Please include time used by your own staff and consultants.

12	More than 6 person-months/year
49	1-6 months/year
81	1-4 weeks/year
72	Less than one week/year

10 Number of replies where mentioned

11 Next ones: species (13), productivity (12), biodiversity (12), ownership (12), forest types (10), annual cut (9), soil (9), land use (8)

10. In what form(s) would you prefer to receive forestry information about European countries?

171	On paper (publications, reports, etc.)
95	On diskette
92	On CD-Rom
89	By e-mail/internet
0	Other (specify) ___________________________

11. Additional comments on this questionnaire:

Comments on 46 forms

____

____

____

____

12. Please send me the summary of the results of this questionnaire 181 ☐

Name: ____
Organisation: ____

Address: ____

____

Appendix: General information on European Forestry Information and Communication System - EFICS

The European Union aims to collect and make comparable the forestry information existing in its Member States. According to the Council regulation (EEC N° 1615/89 and N° 400/94 *), the objective of the European Forestry Information and Communication System - EFICS - is to collect, co-ordinate, standardise and process data concerning the forestry sector and its development. EFICS should also facilitate the implementation of decisions taken at national and regional levels, and improve knowledge at all levels.

EFICS will employ the existing national and international forest information systems. These systems, however, are based on different traditions of forest utilisation and information collection, and therefore harmonisation is needed. Harmonised forest information is essential, for instance, for the evaluation of sustainable forest management.

The European Forest Institute (EFI) has launched the first phase of the system in January 1996. The objectives of the one-year project, funded by the Directorate General VI (Agriculture, Forestry and Fisheries), are to analyse the differences in the national systems and to study the needs and possibilities to harmonise the existing information systems. Forest inventory experts from all Member States and from Switzerland and Norway are included in the consortium of EFI.

*OJ N°L 165, 15.6.1989, p. 12 and OJ N°L 54, 25.2.1994, p. 5

List of national and international organisations to be included in the information needs assessment

In each country the following organisations are approached with the questionnaire:

- Ministry of Agriculture and Forestry (Ministry of Trade/Industry/Finances may also be included, if considered appropriate)
- Ministry of Environment
- State Forestry Organisation
- Forest Industry Association or industry sector associations e.g. pulp and paper, sawmills, wood-based panels
- Association of private forest owners
- Nature Conservation/Environmental Organisation(s)
- The main Forest Research Organisation(s) in the country
- Members of Standing Forestry Committee (if not included in 1.)

International bodies to be approached, include:

- European Commission
    - DGVI
    - DGIII
- European Parliament/Committees
- EUROSTAT
- European Environmental Agency
- Joint Research Centre
- European Centre for Nature Conservation
- FAO
- FAO/ECE
- ECE (Forestry Committee)
- IIASA
- UN/ECE Team of Specialists
    - TBFRA2000
    - Non-wood goods and services
    - Public Relations in Forestry
    - Country correspondents/TBFRA2000
- European Associations of Forest Owners
- CEPI
- CEI-Bois
- OES
- Forest Industry Organisations
- WWF
- WCMC
- Helsinki Process

2. Simulation study

2.1 Introduction

The main topic of the simulation study carried out in the framework of the EFICS project is to quantify the impact of the differences of definitions of forest key attributes. The main objective was to simulate the assessments of these attributes as close to national definitions as possible, in order to facilitate a comparison between the different systems applied in the European countries. The study should support the judgement of the efficiency of harmonisation efforts with respect to costs and benefits by providing quantitative and qualitative figures about the differences caused by the heterogeneity of national differences.

The following key attributes were included in the simulation study:

- forest area
- single tree volume/upper stem diameter threshold values
- stand volume/d.b.h. threshold values for tally trees
- growth measures

The definition of forest area was the major attribute concerned, as most of the results presented in forest inventories are ratio estimators. The decision whether land covered by trees is assigned to forest land, other wooded land or assigned to other land use categories, depends on measures like crown coverage, width, area, and potential productivity of the forest land, and is not yet harmonised in the European countries.

Stand volume and volume increment are still important key attributes which characterise e.g. long-term changes in environmental conditions and site fertility. The impact of different threshold values for the upper stem diameter used to calculate statistics concerning merchantable timber, will be evaluated as well as the impact of different d.b.h threshold values on the stand volume.

The fourth topic of the simulation study is concerned with the comparability of the measurements of growth and growth components. The common system introduced by Beers (1962) will be compared to the so-called system of forest balance applied in the Scandinavian countries (Norway, Sweden, Finland).

2.2 Key attribute “forest area“

In European countries, several forest area definitions exist. The main criteria which are included in forest area definitions are:

- width of forest,
- crown coverage,
- forest area and
- production

of the forest, which relate attributes, such as total volume or total number of stems to unit area, i.e. to the forest area of the country. Kleinn (1992) already stated the impact of different definitions on the forest area measurement and showed the relationship of reference area, differences in minimum crown cover definitions and the spatial structure of forests.

Forest area structure varies widely in Europe from the Mediterranean types to types occurring in hilly areas and lowlands of central and western Europe to the forests in the northern regions. Changes and differences in the spatial structure are due to different climates, soil etc. and also due to altitude (natural timberlines in mountainous or alpine regions) and geographical location (coniferous limit in the northern countries).

2.2.1 Method

1) simulation of forest maps with different spatial structure

Computer generated forest/nonforest maps were used for the simulation study on the impact of different forest area definitions. Four main types of different spatial pattern types of forest structure were investigated:

basic types	(1)	sparsely/scattered distribution of forest patches
	(2)	dense and clustered forest types
merged types	(3)	close to basic type (1)
	(4)	close to basic type (2)

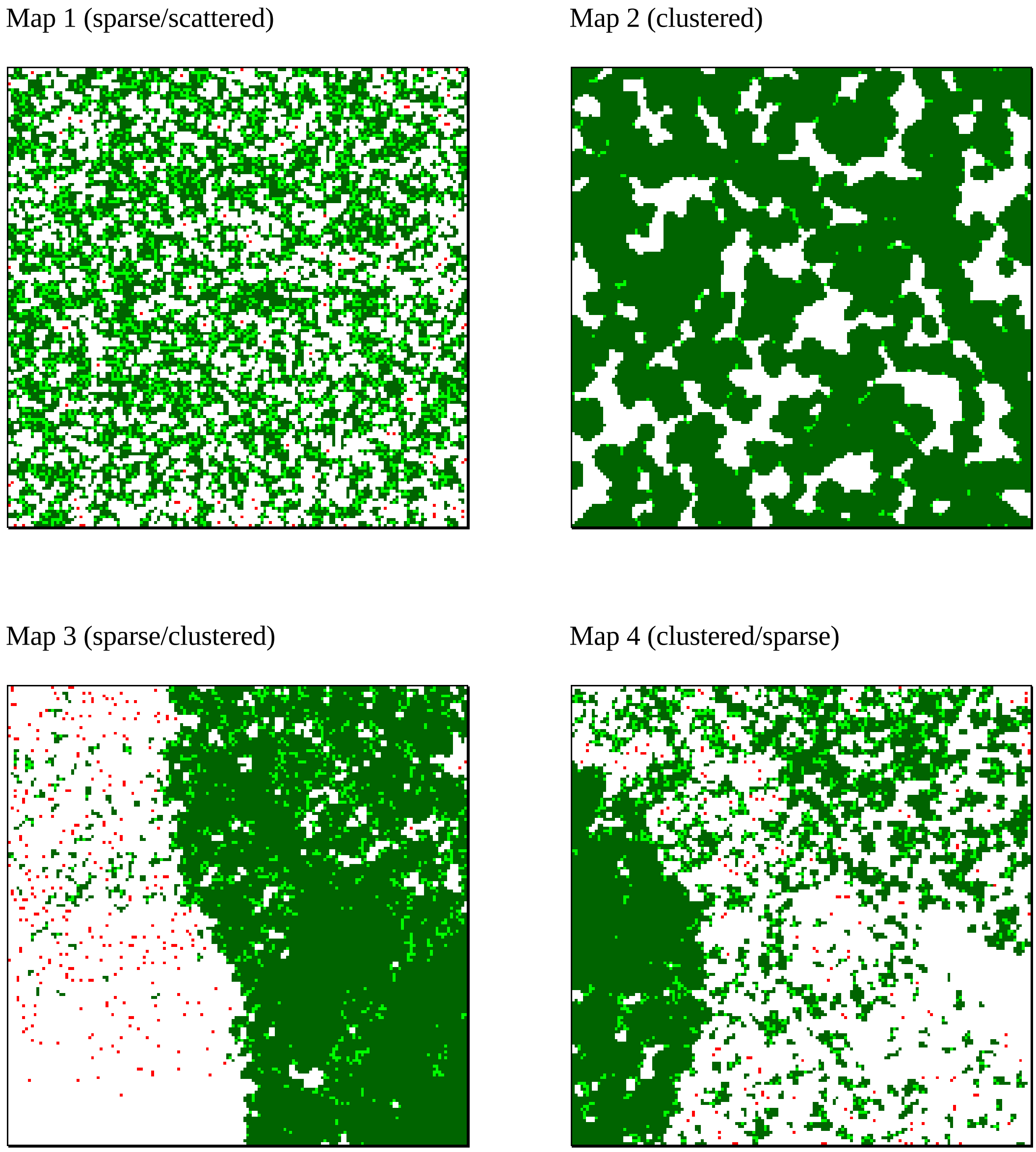


Figure 2. Four forest cover structure types, each pixel represents a tree crown. Green area covered by tree crowns (vertical projection), light green: potential forest area, not covered by tree crown, red: single trees, white: other land (maps kindly provided by Kleinn et al. 1995).

2) *forest cover* assessment procedure

In national forest inventories forest area can be assessed by a sample of aerial photo plots distributed systematically over the entire area of interest. This procedure is applied in most European countries however the rules for are quite different in the individual countries (Table 5). Each photo plot must be interpreted, deciding whether the area covered by the plot is to be concerned as forest or not. Main criteria for the forest/nonforest decision are: crown cover, size of forest area and width of forest area.

To simulate the photo plot interpretation, the procedure was subdivided into two parts:

step1 delineation phase: To measure the forest/nonforest criteria crown cover, size and width of forest area the potential forest area, subsequently called forest land, has to be delineated. To decide whether trees are to be concerned as a part of forest land even if there is a gap to the next closed forest patch, or as single trees located in other land a distance threshold for those trees has to be defined. In this study delineation distances of 25, 35 and 50 m were used. After this step the 4 maps of single trees change to maps consisting of two land categories: forest land (potential forest area) and other land. In this study 3 different maps for each of the 4 spatial structure types exist due to the 3 different delineation distances applied for each structure type. Thus the photo plot simulation was applied in a total of 12 maps.

step 2 photo plot simulation: After the delineation procedure the forest cover calculation can be done by systematic sampling, where for each sample a forest/non-forest decision has to be made according to the different definitions of the individual countries. About 6000 square samples of 50x50m were drawn. The size of 50x50m is applied in the 2nd Swiss NFI. One has to keep in mind, that the size of the photo plots also can influences the results of the forest/nonforest decision process as Kleinn (1992) stated.

Rules for *forest cover* calculation:

Forest cover is the relationship of plots assigned as forest to the total number of plots drawn from the map times 100 to give the results in percent. If the plot centre is located in forest land area, the forest/non-forest decision is made according to the threshold values for crown cover width and forest area. If the plot centre is located in other land area close to the forest borderline, the length of the shortest virtual line intersecting the plot centre and two borderlines are measured instead of the width of forest area. If the length of this line exceeded 25m the plot was assigned to non-forest.

The result of the photo plot procedure is an estimation of the forest cover derived from a systematic sample where the share of plots assigned to forest is given in percent of the total number of plots drawn.

Table 5. Ranges of threshold values for crown cover, size and width of forest area of the countries. The abbreviations of the countries are explained in Footnote 7.

value	min width [m]		min crown cover [%][6]		min area [ha]	
lowest	9	(B, Walloon)	10	(several countries)	0.05	(Austria, France)
highest	50	(FL/CH)	100	(FL/CH)	2	(GB)

In addition to the individual country definitions, a wide and restrictive definition given in Table 6 was applied to smooth the extreme differences between the individual countries.

Table 6. Threshold values for crown cover, size and width of forest area of the wide and restricted definition used in this study.

definition	min width [m]	min crown cover [%]	min area [ha]
W	10	10	0.05
R	40	30	0.5

step 3 relating the 4 forest structure types to European regions: To come up with results which are related to the northern, central and southern European regions, the shares of the 4 forest types to which these types occur in the according region were derived from the questionnaires in countries located in these regions. The results are given in Table 7.

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[6] In Spain also a forest category „very open forest“ exists where crown cover is between 5% and 10%, the crown cover threshold value for Spain however is assumed to be 10%.

Table 7. Shares (in %) of the 4 forest structure types related to the European regions.

European regions	map1 sparse/scattered	map2 clustered	map3 scattered/clustered	map4 clustered/scattered
northern	10	60	20	10
central	5	80	5	10
southern	30	20	20	30

In the northern countries, there are wide areas covered by closed coniferous forest a forest structure which is represented by map 2 in Figure 2. However, in peatlands or in forests near the coniferous timberline, the crown closure decreases and forest structure represented by the maps 1, 3 and 4 occur.

Also in the central and western parts of Europe, mainly closed forests exist. Typical properties are sharp and well-defined boundaries with other land categories. Moreover the spatial structure of the forests is more patchy than in northern forests, because more than 50% of the area in central Europe is covered by agricultural land. Those structures are represented by the structure given in map 2. Near the forest timberline open forest types are dominant with gradual transitions from forest land to other land, represented by maps 1, 3 and 4 in Figure 2.

In southern locations gradual transitions from forest to shrub lands are very frequent, which renders a clear definition of forest and shrub area difficult. The phenotypes of forest trees occur both as tree and as shrub. The wide variety of forest structure types leads to a more or less even representation by the 4 maps in Figure 2.

2.2.2. Results

1) comparison of the forest area definitions based on the basic structure types (map 1-4 in Figure 2)

For each of the 12 maps, forest area, respectively forest cover, was estimated based on the systematic photo plot sampling simulation procedure. These results refer to the principal structure types of forest pattern represented by map1-4.

As a primary result a country grouping referring to the level of estimated forest cover values can be detected, which is more or less independent of the forest structure type. Three groups of countries can be formed:

group 1, **high** level of forest cover estimation: A, B1, D, FIN, IC, N, S, W[7]

group 2, **medium** level of forest cover estimation: B2, CH, DK, F, FL, I, P, SP

group 3, **low** level of forest cover estimation: GB, GR, IRL, NL, R

This result means e.g. that due to the different forest area definitions, the forest cover estimated by means of the Austrian definition is always higher than the estimation derived from the Irish forest area definition.

[7] A=Austria, B1=Belgium(Walloon region), B2=Belgium(Flemish region), CH=Switzerland, D=Germany, DK=Denmark, F=France, FL=Liechtenstein, FIN=Finland, GB=The United Kingdom, GR=Greece, I=Italy, IC=Iceland, IRL=Ireland, N=Norway, NL=Netherlands, P=Portugal, R=Restricted definition, S=Sweden, SP=Spain, W=wide definition.

These principal results are also independent from the delineation distance. Subsequently only the results for a delineation distance of 35m are given to place the focus on the differences of the country definitions. On the effect of the delineation distance will be interpreted later.

Table 8. Ranges (difference between highest and lowest forest cover estimation) of forest cover [%] for the 4 forest structure types, derived from the country definitions as well as from the wide and restrictive definition (delineation distance=35m).

Definition\image	1	2	3	4
countries	29.26	1.48	8.29	11.75
wide/restricted	16.97	0.94	5.03	6.20

The highest range between forest cover estimation was found for the map type 1 (sparse/scattered). The difference of 29.26% was derived from the forest cover estimation according the Norwegian definition and the definition of the United Kingdom. However, the difference of 16.79% between the wide and restricted definition, seems to be more realistic since the forest area definitions of Iceland, Norway, Sweden and Finland do neither apply a minimum crown cover nor a minimum width of forest but a potential increment figure (except Iceland) which could not be implemented in this type of simulation study. Since the simulation of the forest area estimation for these countries is based on incomplete definitions, the results have to be interpreted carefully.

The lowest range between forest cover estimations was found for the map type 2 (clustered) The difference of forest cover estimation according to the Finnish definition and the definition of the United Kingdom is 1.48%. The difference between the wide and restricted definition is 0.94%.

2) Comparison between European regions

To get an idea of the impact of different forest area definitions for the 3 European regions the differences in forest cover estimation originating from different definitions were related to the shares of forest structure types in the corresponding regions. This approach is more realistic than the more theoretical results derived from the basic structure types (map 1-4).

The mean of the ranges shown in Table 8 weighted with the shares of the 4 spatial structure types related to European regions, given in Table 7 was calculated. The results are calculated for a delineation distance of 35m.

Table 9. Mean value of the ranges of forest cover estimation (Table 10) weighted with the shares of structure type 1-4 related to the European regions (Table 9). The results are given for the ranges derived from the country definitions as well as for the range between the wide and restrictive definition.

Definition\ region	north	central	south
countries	6.65	4.24	14.26
wide/restricted	3.89	2.46	8.14

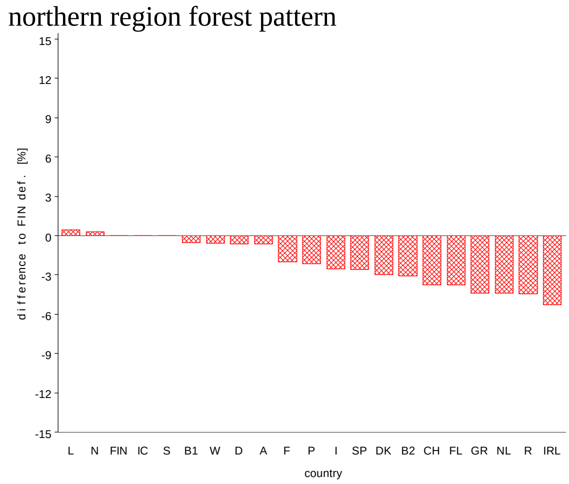
Highest ranges occur in the southern region because of the high partition of scattered forest types, while lowest ranges occur in the central region where clustered types are dominant.

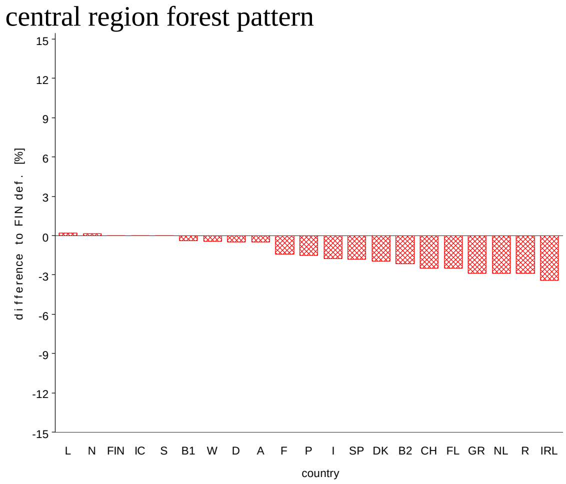
The impact of different delineation distances is shown in Table 10. As already derived from Table 9, highest ranges principally occur in the southern regions, lowest ranges in central regions. From this table it can be seen that the ranges are negatively correlated with the delineation distance. The direction of the impact of the delineation distance is independent from the forest structure, however, the magnitude of decrease is highest in southern regions and lowest in central regions..

Table 10. Mean values of the ranges of forest cover estimation weighted with the shares related to the European regions as a function of the delineation distance. Right: country definition / left: wide and restrictive definition. The bold values correspond to the values given in Table 9.

European region \ delineation distance	25m	35m	50m
northern	8.05 / 5.10	**6.65 / 3.89**	5.70 / 4.41
central	4.42 / 3.10	**4.24 / 2.46**	3.59 / 2.72
southern	18.12 / 11.22	**14.26 / 8.14**	11.98 / 9.81

In Figure 3 the impact of the country definitions for the northern, central and southern regions is shown in more detail. The differences of forest cover are referred to the forest cover assessment according to the Finnish forest area definition. Positive differences mean that the forest cover definition of the country under concern leads to a higher forest cover compared to the Finnish assessment. Negative differences accordingly mean that the assessed forest cover is lower than the Finnish forest cover.





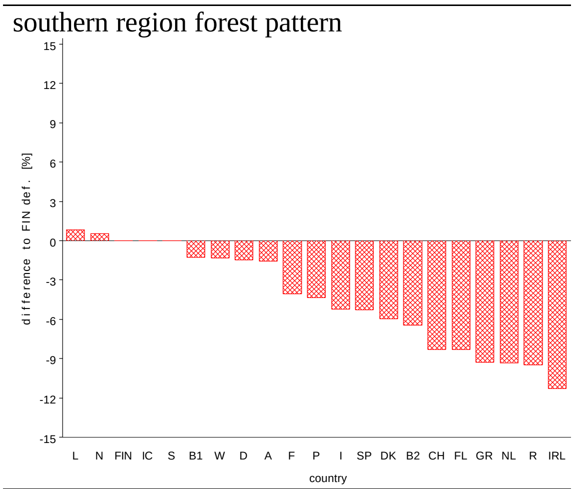


Figure 3. Differences of the individual country definitions of forest area to the Finnish definition for the Northern, Central and Southern European regions (delineation distance 35m).
Referring to the results of Iceland Norway, Sweden and Finland one has to keep in mind that the simulation of forest cover estimation is based on incomplete definitions and has therefore to be interpreted carefully[8].

2.2.3 Conclusions

- the importance of the three criteria defining forest area (width, area and crown cover) depends on the forest structure type
- the most important criteria is the width criteria, the crown cover criteria plays an important role in open forest types. Forest area size plays a subordinate role.
- not only the forest area definition but also the delineation rule is decisive for the estimation of forest area.

The highest range between country forest cover estimations is 29.26%, found for the map type1 (sparse/scattered) between Norway and the United Kingdom. The difference of 16.79% between the wide and restricted definition is more realistic.

The lowest range between country forest cover estimations is 1.48 found for map type2 (clustered) between Finland and the United Kingdom. The difference between the wide and restrictive definition is 0.94. These results refer to a delineation distance of 35m.

[8] In addition to Footnote 7, the abbreviation „L“ in the figures means „lowest definition“ (the threshold value for crown cover, width and area is 0).

As already presented in Table 8 the differences between the country definitions are correlated to forest structure. As can be seen in Figure 3, the biggest differences occur for forest types structured similar to map 1, hence in southern regions and in regions with natural timberlines, as is the case in mountainous (alpine) or northern regions.

When combining the theoretical map types to more ‘realistic’ forest patterns occurring in the Northern, Central, and Southern region, the maximum differences due to the different forest area definitions are 6.7, 4.2 and 14.2 %, respectively.

Highest ranges (biggest differences between country definitions) in the European regions occur in the southern regions because of the high partition of scattered forest types. Lowest ranges occur in the central region where clustered types are dominant.

This leads to the conclusion that harmonisation efforts are most important in southern European and in alpine and Northern regions.

As a very important result from this study, it can be stated that wide or ‘tolerant’ delineation definitions, i.e. big delineation distances, lead to high forest cover estimations, but to small differences of forest cover estimation between distinct definitions. The absolute estimation of a forest area is positively correlated to the delineation distance, the ranges between the forest cover estimates according to distinct definitions however decrease with increasing delineation distance.

As can be seen from Table 10, these principal rules do not depend on forest structure but the magnitude of the differences are highest in southern European countries.

This leads to the conclusion that the delineation procedure of potential forest area should be treated with high attention in harmonisation efforts of the forest area definition.

2.3 Key attribute “Volume of single trees“

The estimation of stand volume in forest inventories is based on the volume of tally trees The calculation of the stem volume of these tally trees is commonly based on volume functions or on tariffs which can be considered as a special local volume function. In several countries the single tree volume is calculated from stump or ground level up to a top diameter threshold to calculate the volume of merchantable timber. Belgium, France, Germany and Ireland use a threshold value of 7cm, i.e. stem parts above a diameter of 7cm are not considered for volume calculation. Other countries apply lower threshold values (e.g. Greece: 5cm) or do not apply any top threshold diameter at all. To compare volume figures of the individual European countries it is of major interest to get an idea on the volume of the stem part which is neglected due to the application of upper stem threshold values for volume calculation. The harmonisation needs for volume calculation definitions mainly depend on the impact of the differences in the definitions. The volume of 1000 trees randomly drawn from the Second Swiss Forest Inventory database was calculated. An upper stem threshold value of 7cm was applied to calculate the partition of the corresponding upper volume.

The volume was calculated by spline interpolation technique realised by means of the software tool ‘SITCA’ (Kleinn 1989). Some descriptive statistics on the 1000 trees are given in Table 11.

Table 11. Statistics of 1000 trees chosen from the Swiss NFI database to calculate upper stem volume shares for a top diameter threshold value of 7cm. Tree species composition: spruce: 48.3%, fir: 26.7%, beech: 25.0%.

variable	mean	coeff. of var. [%]
d.b.h [m]	0.290	45.17
height [m]	24.670	27.12
height/diameter ratio	92.900	23.96
volume [m3]	1.062	113.28
upper height [m]	3.430	32.36
upper volume [m3]	0.004	32.27
share of upper volume [%]	1.450	128.28

Figure 4 shows that the partition of the stem volume above a diameter of 7cm is up to 11% for trees with a d.b.h. of about 0.12m to 0.15m. The volume partitions of the upper stem parts are highly negative correlated with the d.b.h. and the height of the trees. The upper volume partition is lower than 1% if the diameter exceeds the value of about 0.25m respectively if the height exceeds a value of 30m.

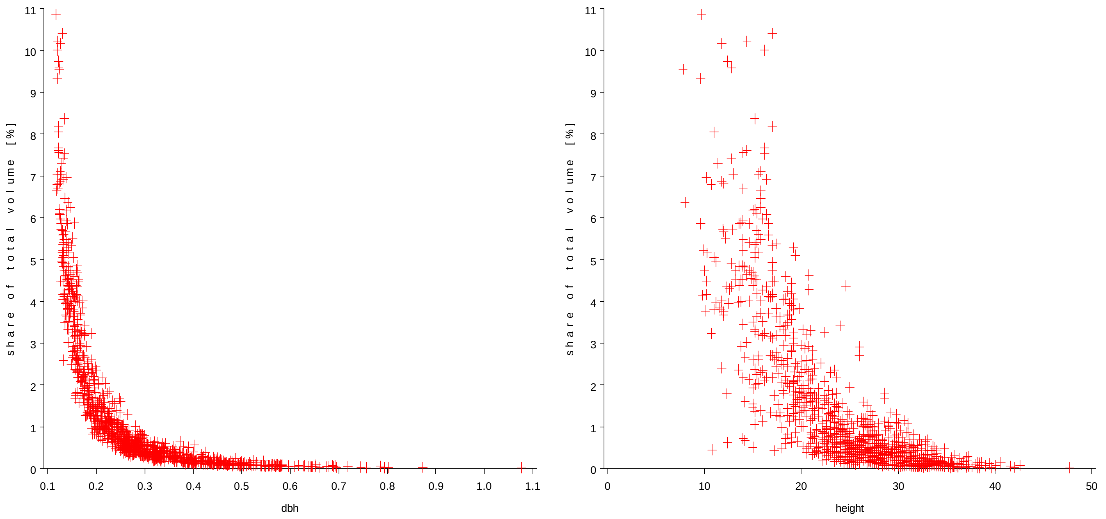


Figure 4. Results for the volume calculation of the stem part above a diameter of 7cm. The figures give the shares of upper volume as a function of the d.b.h and as a function of the height of the tree.

2.4 Key attribute “Stand volume“

The objective of this part of the simulation study is to derive figures on the impact of different d.b.h threshold values to divide tally trees from other trees on a sample plot. This division is applied in the most national forest inventory systems in Europe. The threshold values utilised are listed in Table 11 of the Comparative study, ranging from 0cm in Finland and Sweden to 12cm in Switzerland and Liechtenstein. Mainly efficiency consideration in field work led to the utilisation of a d.b.h threshold value. Due to these threshold values, volume figures from the individual countries do not contain the volume partition of stands made up by smaller trees. The extent of this partition will be investigated by means of several data sets in this part of the simulation study.

To study the impact of different d.b.h thresholds combined with rules for single tree volume calculation, inventory data of the Finnish National Forest Inventory were investigated. Also data from

Swiss growth and yield plots and additional data from growth and yield tables developed for managed forest stands were examined.

1) Data from the Finnish NFI

Particularly the loss respectively the gain in volume due to

- volume calculation from ground level/stump level,
- different d.b.h. threshold values and
- different top height diameter threshold values was calculated

The study area includes the forestry districts of Central Finland and North Karelia located in the central part of Finland. The study material consists of the forest measurements made on the 8600 Bitterlich sample plots of the 8th National Forest Inventory of Finland (NFI).

The results are presented in relative volumes so that the countries where there are no limits in diameter at the breast height and top stem diameter, and where volume calculation starts from the stump level, represent 100 % volume (Table 12).

Results show that differences in mean volumes are at the maximum almost 20%. If Swiss measurement rules would be applied in Finland, the volume reduction would be 13%. If the d.b.h. and top diameter are the same as in Switzerland, but volume is calculated from the stump level, the difference to volume, by the threshold values of Finland and Sweden, is 18%. The proportion of the stumps from the total volume is about 6% (Figure 5). From the results of Switzerland and Liechtenstein, where only the top stem diameter differs, it can be derived that the volume difference due to an upper stem diameter threshold of 7 cm is 1.7%. This result derived from Finnish stands confirms the results found in chapter 2.2.3.

Table 12. Relative mean volumes according to different diameter limits and different starting points of volume used in European countries (Data source: Finnish National Forest Inventory).

	Minimum d.b.h., cm	Minimum top stem diameter, cm	Starting point of volume	Whole Inventory area %
Finland, Sweden	0	0	stump	100
the United Kingdom, Iceland	0 (1)	0	ground	105.8
Austria, Netherlands, Portugal	5	0	ground	103.4
Italy	3	0/3	stump	98.9
Norway	5	0	stump	97.6
Germany, Ireland	7	7	ground	96.2
France	7.5	7	ground	95.3
Belgium	7	7	stump	90.6
Greece	10	0	stump	89.1
Liechtenstein	12	0	ground	88.9
Spain	7.5	7.5	stump	88.8
Switzerland	12	7	ground	87.3

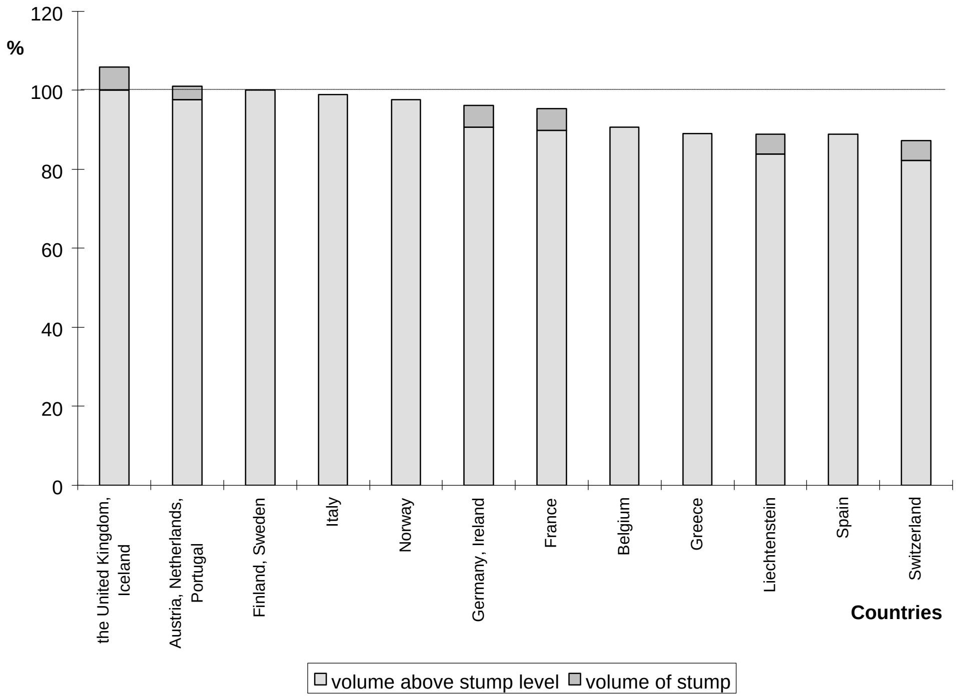


Figure 5. Relative mean volumes for a large forest area in Finland according to different diameter limits, different starting points and top diameters of volume used in European countries.

However, the differences in the volumes in different countries are based on the Finnish forest situation and can be transferred directly only to those countries which have a comparable forest structure. The differences would not be the same if the same measurement rules are applied in Switzerland, because the stem frequency distribution series are different. Separate stem diameter distribution models have to be developed For each country to calculate the amount of volume made up by trees below the d.b.h. threshold value.

2) Data from Swiss growth and yield plots

The partition of stand volume made up by small trees with a d.b.h between 8cm and 12cm was investigated for

- even aged, as well as for
- uneven aged stands.

For uneven aged forests the results concerning the volume share of small trees which have the diameter between 8 and 12 cm, are rather homogenous. The total mean volume/ha is about 500m^3 and varies between 335m^3 and 640m^3. The mean share of the stand volume made up by small trees is about 1% with a maximum of 2.18% of the stand volume. The volume of the single trees was calculated by local tariffs. The mean volume partition of small trees is 0.93 % the standard deviation is 0.39%. An overview on the results is given in Table 12.

Table 13. Statistics derived from the uneven aged growth and yield plots of Switzerland.

volume of	mean [m³/ha]	coeff. of var. [%]
small trees	4.62	42.21
all trees	500.50	12.26

The results derived from the even aged growth and yield plots are more heterogeneous than the results for the uneven aged stands, as uneven aged stands comprise of many age classes occurring close together on a very small area, thus showing mean figures for volume and stem number statistics.

In Figure 6 one can see that the volume partition of small trees with a d.b.h. between 8cm and 12cm decrease from about 10% in stands of the age class 5 (50-60 years, mean volume 300m^3/ha) to values lower than 1% if the stand age is older than 70 years (ageclass 7, mean volume 372m^3/ha). From Figure 6 also the decreasing variance of small tree volume as a function of the age class can be drawn. A significant step of decrease occurs in age class 6, where the volume partition of small trees tends to be lower than 10%. It can also be derived from this figure that the small tree stand volume partition increase again when the age class is higher than 13. This is due the increasing amount of regeneration trees in the understorey of these stands.

Summary of the results from the Swiss growth and yield plots:

In *uneven aged* stands, the proportion of trees with a d.b.h between 8cm and 12cm is about 1% for even aged stands, this proportion is about

- 30% in stands of the age between 30 and 40 years
- 10% in stands of the age between 50 and 60 years
- 3% in stands of the age between 60 and 70 years
- lower than 1% in older stand.

As the results from the growth and yield plot analysis, the stand volume of small trees (8cm-12cm) of the Swiss forests is about 2.57%. This amount refers to even aged and uneven aged stands which cover roughly 90% of the forest area of Switzerland.

The results from the growth and yield tables plots are close to the results found from the Swiss growth and yield plots.

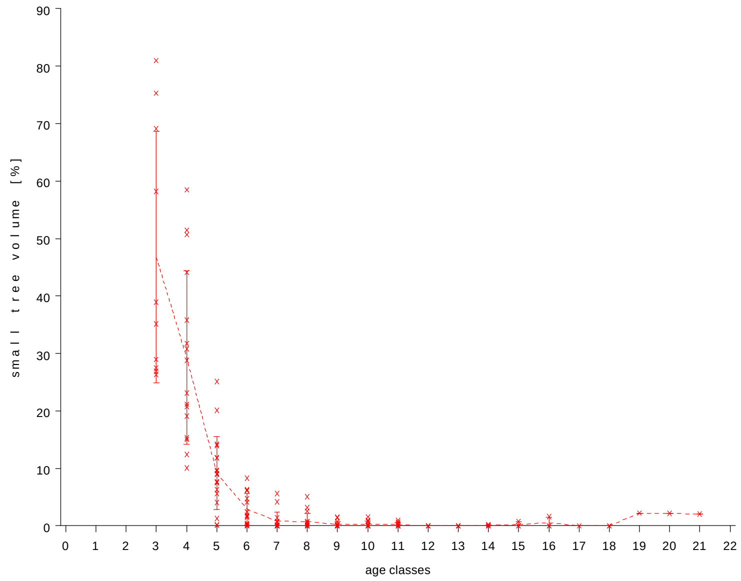


Figure 6. Shares of the stand volume made up by trees with a diameter between 8cm and 12cm as a function of the age classes. The width of the age classes is 10 years.
The vertical lines mark the standard deviation of the corresponding share, the dashed line connects the mean values of the corresponding shares.

2.5 Key attribute "Volume of increment components"

The objective of this chapter is to compare two systems which were developed to calculate the volume increment and the volume of increment components. Commonly the growth component system introduced by Beers (1962) is used in the central and southern European countries and in Northern America to determine volume increment and its components.

In the northern European countries, the system of forest balance (Kuusela 1994) is applied which uses different terms and measures to quantify volume increment components. The definitions of the forest balance system are given in Chapter 3, where the terms „Drain" and „Removals" are discussed. Subsequently, terms used in the forest balance system will be given in italics to separate them from the terms of the growth components system.

Both system are based on a tree history code originating from two or more inventory occasions and describe the growth of the forest by means of growth components, the forest balance approach additionally describes actually utilised wood, i.e. the timber extracted from the stands is recorded. The flowchart (Figure 7) and Table 14 give an overview on the interrelations of the terms of the two systems.

Ingrowth is not important if no calliper threshold is applied in a forest inventory system, as is the case e.g. in Finland and Sweden. Moreover since the forest balance system is widely used in northern European countries, where predominantly even aged stands exist, ingrowth is a subordinate figure in volume increment calculation.

The example in Table 14 (derived from Beers 1962) builds upon a sample of ten trees measured at two occasions. To show the gain in information by separating the measure fellings in the measures removals under bark on the one hand and bark and logging residues on the other hand, some additional figures were calculated. The loss due to bark and logging residues was assumed to be 20% from the the total volume of the fellings. As an alternative situation a partition of 40% of bark and logging residues was assumed. Whereas the figure 20% seems to be very realistic in European countries (Kuusela 1994, Table 2.10, page 26), the results for a loss of 40% cover an extreme situation which may occur under exploitation conditions or after certain diseases or storm damages. If the partition of losses due to bark and logging residues is assumed to be 40%, the total amount of these losses is about one third of the total drain or the deductions from the growing stock and exceeds the natural losses significantly. The relationship of the bark and logging losses to the gross growth (V2-V1+M+C) is also about one third since the gross increment figure is almost equal to the drain figure due to a 'balanced' relationship of increment and drain (V2-V1 -> 0m^3).

Table 14. Conversion of increment components calculation formula between the system of forest balance (Kuusela 1994) and the system of growth components (Beers 1962). V1=1.754, V2=1.768 (GI: gross increment, RGS1: growing stock at occasion 1, RGS2: growing stock at occasion 2, D: drain, Ni: net increment, NL: natural losses, B: balance, F: fellings, V1: stand volume at occasion 1 (RGS1), V2: stand volume at occasion 2 (RGS2), M: mortality, C: cut)

forest balance system		***growth component system***			
balance	*B = GI-D = NI-F*	= V2-V1	= net increase =	1.768-1.754 =	0.014
drain	*D = NL+F*	= M+C=		0.146+0.569 =	0.715
gross increment	*GI = RGS2-RGS1+D*	= V2-V1+M+C	= gross growth=	0.014+0.715 =	0.729
net increment	*NI = GI-NL*	= V2-V1+C	= net growth =	0.014+0.569 =	0.583

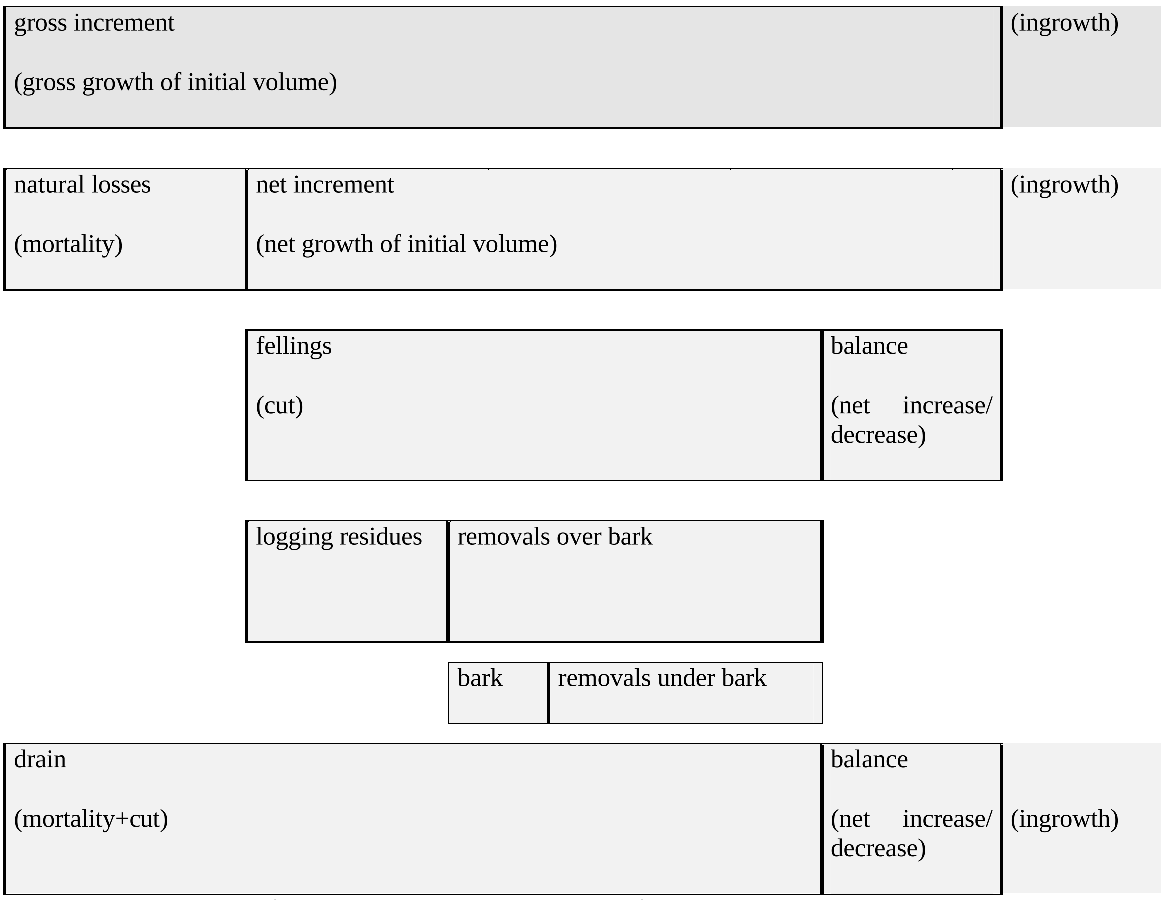


Figure 7. Components of gross increment according to the forest balance system (italics) and according to the growth component approach (terms in brackets). Please note that ingrowth is principally considered in both systems but has no practical meaning in the northern countries where the forest balance system is applied.

2.6 Conclusions

The system of forest balance does not necessarily regard ingrowth trees in all cases but it is more differentiated concerning the measure fellings or 'cut'. Fellings are separated in the components removals and logging residues, the removals are additionally divided in removals over bark and removals under bark.

The system of forest balance and the system of growth components are comparable but not totally harmonised in the countries concerned. The harmonisation of these systems is possible by using reduction factors to calculate the volume of logging residues and bark. Particularly for the share of bark, conversion tables and regression equations already exist for a large amount of tree species. The shares of logging residues can be derived from timber trade reports or tables given e.g. in Kuusela (1994). A share of 20% of logging residues and bark seems to be realistic in central Europe and is commonly used e.g. in Germany to calculate the volume of merchantable timber without bark from the cut trees.

A complete harmonisation of both systems requires an enlarged tree history code where additional components are to be recorded. For countries using the definitions and terms of the growth components system, it would mean setting up a system to determine the amount of removals and logging residues etc. For the northern countries, an enlarged history code would mean to recording ingrowth trees in the cases of their occurrence.

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Appendix 2: Simulation Study

Summary

Key attribute „forest area“

Method	Computer- generated forest/nonforest maps were used for the simulation study on the impact of different definitions of ”forest area” Four different spatial patterns of forest patches were investigated: basic types (1) sparsely distribution of patches, (2) dense and clustered forest types. merged types (3) close to basic type (1), (4) close to basic type (2). After the delineation of potential forest land, approximately 6000 samples were drawn in order to calculate the forest cover according to the different definitions of the individual countries. Main criteria were crown cover, size of forest area and width of forest area.
Results	1. General results not only the forest area definition but also the delineation rule is decisive for the estimation of forest area. From the 3 criteria determining forest area, ”width” is most important. However, the importance of the different criteria also depends on the delineation rule. 2. Comparison of individual definitions Three groups of countries can be formed: group1, high level of forest cover estimation: A, B1, D, FIN, IC, N, S, W group2, medium level of forest cover estimation: B2, CH, DK, F, FL, I, P, SP group3, low level of forest cover estimation: GB, GR, IRL, NL, R The differences found in the forest area estimates were maximal at about 40% for the sparsely distributed type (1) between Norway and the United Kingdom. The forest cover estimates depend highly on the spatial structure of the forest area, on the delineation rule and on the national definitions. The differences of forest cover estimates are lowest for the clustered and dense forest types (2) which are typically found in central and northern Europe in combination with a wide delineation rule. The maximal difference for this combination is between the Finnish definition and the definition of the United Kingdom (1.35%). The differences of forest cover estimates are highest for sparsely distributed forest types (1) typically occurring in the southern European regions and near the timberline in combination with a restrictive delineation rule. Maximal difference for this combination exists between the forest area definition of Norway and the definition of the United Kingdom (40.19%)

Key attribute „single tree volume/top diameter threshold value“

Method	One thousand trees with known volumes and tree attributes were randomly chosen from the Swiss NFI database. The volume proportion of the stem segment above a threshold value of 7cm was calculated and related to the total volume.
Results	The upper volume is highly correlated to the d.b.h.. The upper stem diameter impact on single tree volume depends on the dimension of the tree. For small trees the impact is high (up to 11% for d.b.h values of about 0.12m). The volume proportion decreases rapidly with increasing dimension. Above a d.b.h of 0.25m the impact is lower than 1%.

Key attribute „stand volume/d.b.h threshold value“

Method	Data from the Finnish NFI were evaluated. The loss in stand volume was calculated assuming that definitions from different countries would be applied to the Finnish forests. Data from Swiss growth and yield plots were examined. Even aged stands as well as Uneven aged stands were considered. The volume proportion of trees with a d.b.h. from 8cm to 12cm of the total stand volume was calculated. Data from growth and yield tables developed for managed forest stands in Germany were investigated. The proportion of trees with a d.b.h. from 6cm to 12cm in the total stand volume was estimated for different assumptions of stem number proportions for those tree dimensions.
Results	If the Swiss measurement rules are applied in Finnish forests, the loss in stand volume for Finland is about 13%. If the measurement rules of the United Kingdom or Iceland are applied, the gain in stand volume is about 5%. Swiss growth and yield plots: in uneven aged stands, the proportion of trees with a d.b.h. between 8cm and 12cm is about 1%. for even aged stands, this proportion is about 30% in age class 40-50 years, about 10% in age class 50-60 and about 3% in age class 60-70 and lower than 1% in older stands The results derived from the growth and yield tables are close to the results from the Swiss growth and yield plots.

Key attribute „volume increment“

Method	Two different approaches to calculate volume increment were compared. the forest balance system applied in the Nordic countries (Kuusela 1994) the estimation of growth components applied in central and southern Europe and in North America (Beers 1962). Both concepts describe the growth of forest by means of growth components, the forest balance approach additionally describes really utilised wood i.e. timber extracted is recorded.
Results	The growth of volume depends highly on the increment approach., i.e. the growth components considered in the calculation of total volume change. The growth component ingrowth is not considered in the countries which apply the forest balance system due to the forest structure and the measurement rule for stand volume. The growth components system does not differentiate removals from the forest stand.

Introduction

The main topic of the simulation study carried out in the framework of the EFICS project is to quantify the impact of the differences of definitions of forest key attributes. The main objective was not to apply the calculation procedures of each country, but to simulate the assessments as close to national definitions as possible, in order to facilitate a comparison between the different systems applied in the European countries. The study should support the judgement of the efficiency of harmonisation efforts with respect to costs and benefits by providing quantitative and qualitative figures about the differences caused by the heterogeneity of national differences. For this reason, the simulation approaches used in this study are simplified in some cases in comparison to real applications, which reveals at least qualitative differences caused by the different systems and definitions applied.

The following key attributes were included in the simulation study:

- forest area
- single tree volume/upper stem diameter threshold
- stand volume/d.b.h. threshold for tally trees
- growth measures

Forest area definition was the major attribute concerned, as most of the results presented in forest inventories are ratio estimators. The decision whether land covered by trees is assigned to forest land, other wooded land or assigned to other land use categories, depends on measures like crown coverage, width, area, and annual productivity of the forest land, and is not yet harmonised in the European countries.

Despite all discussions about non-timber functions of forests, stand volume and volume increment are still important key attributes which characterise long-term changes in environmental conditions, site fertility, as well as the success of the performance of different management systems. As total volume is compiled based on the volume of single trees, it is decisive the impact of different d.b.h threshold values on the volume of stands as a function of age and silvicultural systems. The impact of different threshold values for the upper stem diameter used to calculate statistics concerning merchantable timber, will also be evaluated in a separate chapter.

The fourth topic of the simulation study is concerned with the comparability of the measurements of growth and growth components. The common system introduced by Beers (1962) will be compared to the so-called system of forest balance applied in the Scandinavian countries (Norway, Sweden, Finland).

Key attribute „forest area“

In European countries, several forest area definitions exist, as was be seen in the comparative study. The main criteria which are included in forest area definition are:

- minimum width,
- minimum crown cover,
- minimum area and
- minimum production
- of the forest area, which relate attributes, such as total volume or total number of stems to unit area, i.e. to the forest area of the country.

Since various forest structure types exist in Europe, numerous types of forest area structure types have to be considered in the simulation study. Kleinn 1992 already stated the impact of different definitions on the forest area measurement and showed the relationship of reference area, differences in minimum crown cover definitions and the spatial structure of forests.

In the northern countries, there are wide areas covered by closed coniferous forest. However, in peatlands or in forests near the coniferous timberline, the crown closure decreases. In the central and western parts of Europe, as well, mainly closed forests exist. Typical properties are sharp and well-defined boundaries with other land categories. The spatial structures are more patchy than in northern forests, because more than 50% of the area in central Europe is covered by agricultural land. In southern locations gradual transitions from forest to shrub land occur often, which renders a clear definition of forest and shrub area difficult. The phenotypes of forest trees occur as both tree and shrub. Forest area structure varies widely in Europe from the Mediterranean types to types occurring in hilly areas and lowlands of central and western Europe, and to the forests in the northern regions. Changes in the spatial structure are also due to natural timberlines (altitude/geographical location) in mountains and to the coniferous limit in the northern countries. The main types of spatial structure of forest cover were simulated by means of computer generated binary raster images.

Forest area can be assessed by a sample of photo plots distributed systematically over the entire area of interest. This procedure is applied in most European countries. Individual interpretations must be made for each photo plot, deciding whether the area covered by the plot is to be concerned as forest or not. The rules for this process are quite different in individual countries. To simulate this assessment procedure, the simulation study is subdivided into two parts:

- simulation of different types of forest structure, production of artificial images
- simulation of the forest area assessment based on the artificial images

Simulation of forest maps

Basis of this study were artificial images, which represent the distribution of individual trees. Raster images were generated, with a simple random distribution of pixels. Clustered distribution was used as well. Each pixel represents a tree crown of 100 square meters (a square of 10m x 10m). The extent of each simulated image is 800 by 800 pixels which corresponds to an area of 8,000 by 8,000 m or 6,400 ha. The images represent a certain number of single trees, more or less aggregated or sparsely distributed. The type of the images is binary, black pixels (value=1) are assigned to tree pixels, white pixels (value=0) are assigned to non- tree pixels. The images are given in Figure A1. Image 1 shows a sparsely distributed type of forest with parts of low crown cover density. The transition between forest and nonforest is not clear. Image 2, in contrast to image 1, shows patches of dense forest land with clear transitions to nonforest areas. Images 3 and 4 can be interpreted as combinations of the basic types 1 and 2. Image 3 is closer to structure type 1, image 4 closer to structure type 2.

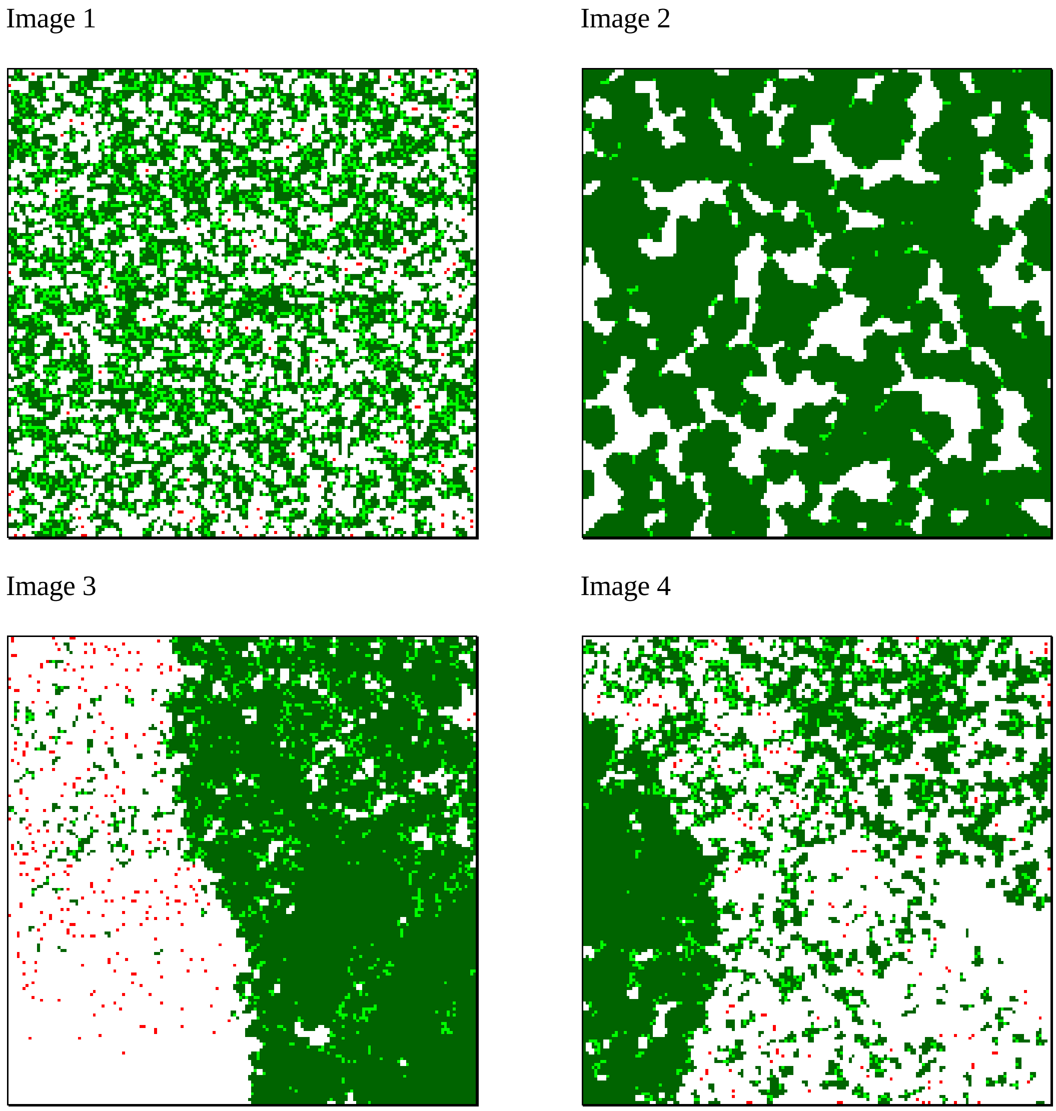


Figure A1. Forest cover structure types, each pixel represents a tree crown. Dark green: area covered by tree crowns (vertical projection), light green: potential forest area, not covered by tree crown, red: single trees, white: other land (maps kindly provided by Kleinn et al. 1995).

A questionnaire was circulated among all European countries to evaluate the relevance of the 4 structure types. The participants were asked to estimate the shares of the 4 crown cover types and also to estimate the shares of transition types from forest to other land according the forests in their country. The analyse of the questionnaire is given in Figure A2, the results are based on the response of 7 out of 19 countries.

In the northern and central European regions, the crown cover and transition type 2 is dominant. In the southern regions, all cover types are more or less equally frequent, the most frequent transition type is type 4, followed by type 2. This means that in the northern and central European regions, dense forests with sharp and clearly defined transition zones are widely distributed. In southern European countries a more heterogeneous situation can be stated concerning the structure and transition types of forest land.

The values for the standard deviation of the crown coverage (cc) and the transition types (tt) allow the comparison of the variations of the estimates between the individual countries.

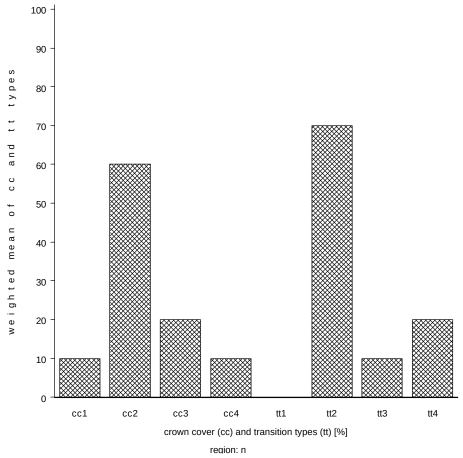
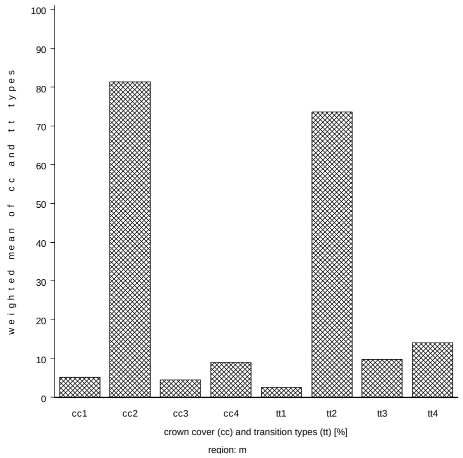
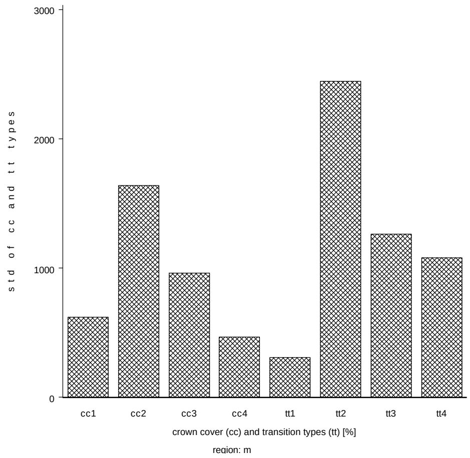
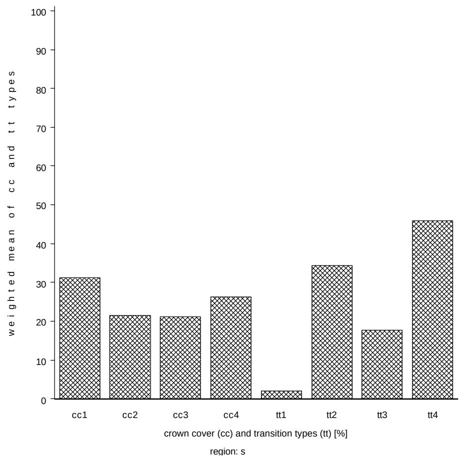


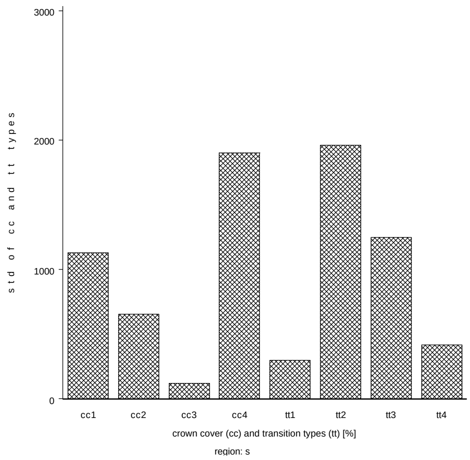
Figure A2. Left charts: Mean shares of crown cover and transition types in northern, middle and southern European countries. The mean shares of the single countries are weighted with the corresponding absolute forest area. Right charts: standard deviation of the shares

n=northern European countries
m= middle European countries
s=southern European countries
Analyse based on the responses of: D, I, L, GR, NL, A, N









Delineation of forest land on the artificial images

In most countries forest area is defined by law. Since these definitions are often not applicable in forest inventories, operational definitions are applied in most cases.

To develop a forest land map from single trees requires the delineation of a boundary between forest land and other land. The area covered by forest land can be subdivided into areas covered by tree crowns (area of vertical tree crown projection) and other areas not covered by tree crowns. This delineation is essential for the decision whether a photo sample plot is located within forest land or not, or whether a tree is a part of a forest stand.

Delineation is the first step in the forest/nonforest decision procedure, where potential forest area (forest land) is separated from other land use categories (other land). The forest cover or forest cover percentage is assessed by the photo plot samples. Whether a plot which is located in forest land is assigned as a forest plot, depends on the minimum threshold values for crown cover percentage, width, area, and productivity.

The delineation rule used in this simulation to divide forest land from other land is derived from the procedure applied in the Second Swiss National Forest Inventory. This procedure defines unambiguously whether a tree which is located at the forest margin is part of a forest stand or not. According to the Swiss definition, a tree pixel on the computer generated images was defined as a single tree pixel, if its distance to any other tree pixel exceeded the distance D=25m, in other cases it was considered to be part of the forest land. To investigate the impact of the delineation rule, particularly of the threshold value for D on the different forest area definitions used in Europe, three levels of D were examined: 25m, 35m and 50m.

Technical description of the computer driven delineation process

(Programming was done by Olaf Kuegler, University of Freiburg)

The distances between all pixels on the images were calculated. If the distance from a certain pixel to another pixel was less than 25m (centre to centre distance), these two pixels were connected by a virtual line. At the end of this process, a network of virtual lines between forest pixels was created . The smallest area unit is a triangle, therefore, the total forest land area consists of the sum of all triangle patches. Another possibility for forest land delineation as compared to A3 is to assign only trees with a distance greater than D as single trees.

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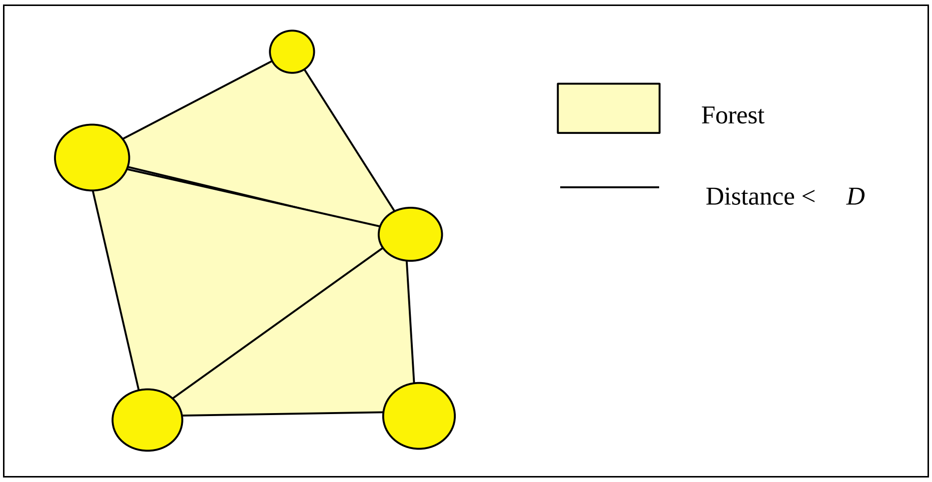


Figure A3. Procedure of forest land area delineation(1), the forest land area is composed of single triangles of forest area (figures kindly provided by Olaf Kuegler, University of Freiburg).

An important aspect of the delineation rule in defining the potential forest land area is the anticipation of the maximum value for forest cover. Forest cover cannot exceed the size of potential forest land area. Additionally, the delineation process anticipates the minimum threshold value for crown cover. If the delineation distance D tends to 0, each tree pixel would be assigned as single tree. Small values of D generally lead to a small amount of forest land patches with high values for crown coverage. If the values for D increase to the linear dimension of the image (8000m), the whole image will be assigned to forest land if at least one tree pixel exists.

Assuming that all tree pixels are systematically distributed in an equally distanced triangle grid, the crown cover percent is directly related to:

(a) the width of the grid which is the delineation distance D

(b) the area (resolution) of 1 pixel ($100m^2$) and

(c) the surrounding area, of 1 pixel (2 triangle areas).

In Table A1 some examples of crown cover percentage as a function of the grid width D are given.

Table A1. Crown cover percentage as a function of grid width. The area of pixel is assumed to represent a crown cover of 100 m^2.

grid width/ threshold dist. [m]	triangle area [m^3]	crown cover percent [%]
25	270,63	18,48
30	389,71	12,83
35	530,44	9,43
50	1082,53	4,62
75	2435,70	2,05

For those spatial structures, where trees are more or less systematically distributed with a distance between 25m and 50m, the delineation rule restricts the threshold value for minimum crown coverage. If e.g. a minimum distance of 25m is applied, it is not possible to get crown cover percentage values less than 18% because areas less densely covered with trees are defined as other land. If a minimum distance of 25m was applied in those countries where the minimum crown cover thresholds lower than

20% (as it is the case in Greece, Portugal and Spain), forest land would be restricted to areas covered by tree crowns to a share of at least 18%. For this reason threshold distances up to 50m were investigated.

After the delineation procedure, the images contain four different types of pixels:

- tree pixel inside forest area
- forest area pixel
- tree pixel outside forest area (single tree pixel)
- other land pixel

Definitions and terms used for the forest area simulation study

forest cover: result of photo plot sampling, the ratio of plots assigned to the class “forest” to the total number of plots.

forest land: potential forest area, comprised of all polygons made up by tree pixels with distance < D and forest land pixels inside the tree pixel polygons.

forest boundary: separates forest land from other land, made up by the edges of forest land polygons adjacent to other land category pixel.

other land: area outside the forest land boundary, composed of single tree pixels and other land pixels

Simulation of the of forest cover estimation

A systematic grid sampling procedure of aerial photo plots was simulated because aerial photos are commonly used for forest area assessments. Different algorithms were applied to simulate the work of the photo interpreter. Grid width is set at 50m and squared plots of 50x50 m were sampled on each grid point. One has to keep in mind, that the size of the photo plots can influences the results of the forest/nonforest decision process as Kleinn, 1992 stated.

The plot assessment works as follows:

For each sample plot a forest/nonforest decision was made. Three attributes were assessed in cases where the centre of the plot was located inside the forest area: crown cover percentage, size and width of forest area. If the centre of the plot was located outside the forest area, the shortest distance between two forest borderline points intersecting the plot centre was measured (Figure A5). If the distance was lower than a threshold value of 25m, the variables crown cover percent and size of forest area were measured.

Definitions

width (wi): shortest distance between two points of forest borderline intersecting the sample plot centre (Figure A4).

forest area (ar): number of pixels inside the forest borderline of a forest patch. If a plot covers two or more different, unconnected forest areas, the sum of those areas was calculated.

crown coverage (cc): share of the area of the vertical tree crown projection (tree pixels) in relation to the forest area.

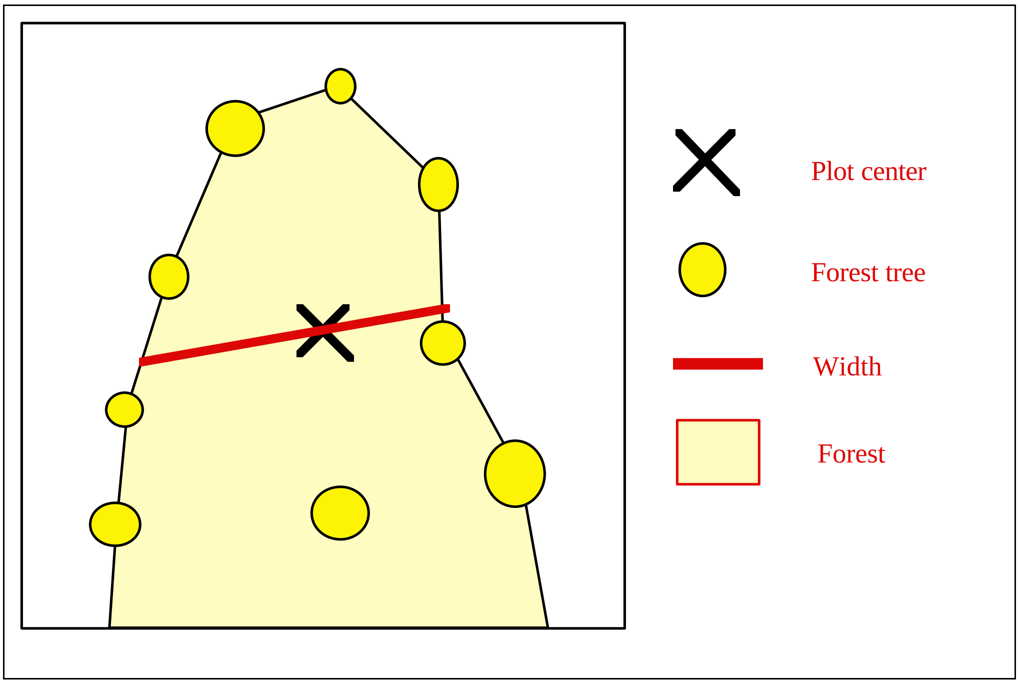


Figure A4. Description of width measurement (figures kindly provided by Olaf Kuegler, University of Freiburg).

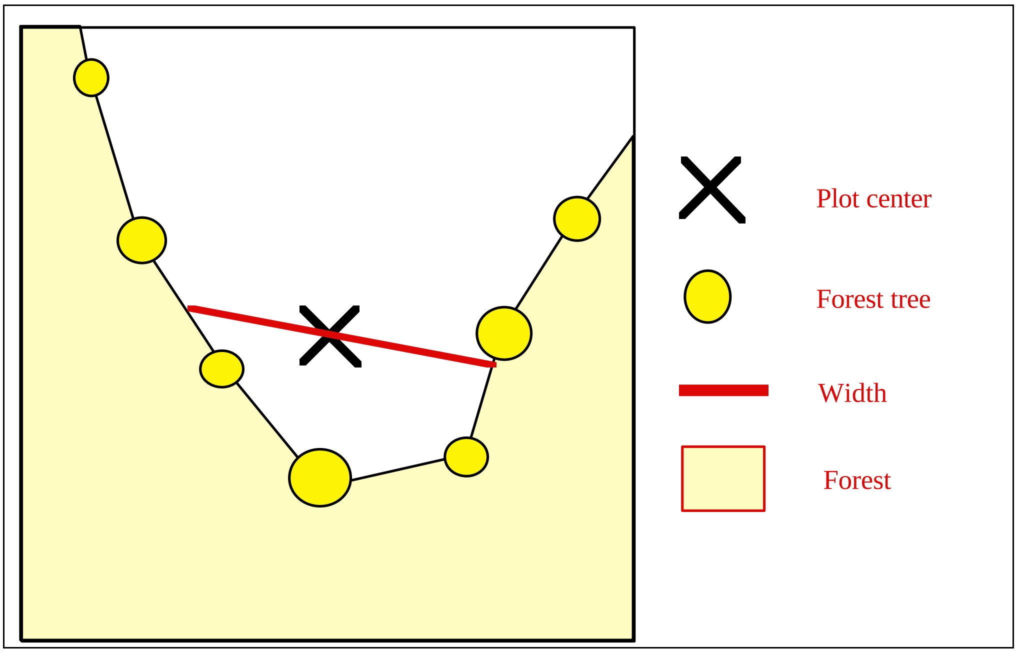


Figure A5. Description of distance measurement (figures kindly provided by Olaf Kuegler, University of Freiburg).

According to these rules, an unambiguous forest/nonforest decision can be made for each plot. The sample size results from the number of grid points which is 6084 for each image. Forest cover percent is the ratio of plots assigned to the class "forest" to the total number of plots multiplied by 100. The results of this study contain the forest cover percent according to the forest area definitions in different countries and the distribution of nonforest areas according to the different sets of criteria.

Results

As a primary result the shares of land categories of the 12 images are presented in Figure A6. The images show different shares of plots located on the classes "forest land", "other land" and plots located close to forest borderlines depending on spatial structure and the delineation rule. From Figure 16 it can be derived that the share of plots located on forest land is positively correlated with the delineation distance. The number of plots located outside or near the forest borderline decrease with increasing delineation distance. This observation is most significant for image 1, and less significant for image 2. The images 3 and 4 are intermediate. This result is due to the closing of gaps and due to the increase of forest land area size. The effect of the closing of gaps between the forest land patches in image 2 is minor compared to images 1, 3 and 4.

The frequency distributions for the variables crown coverage, width and area of forest land are given in Figure A7-A8. These attributes are mainly used to define forest area. However, Finland, Sweden, Norway and Iceland do not use crown cover and width of forest land. Here the potential production is an important measure to distinguish between forest area and other wooded land. This attribute does not fit in this simulation study since it has no geometrical character. The threshold values for crown cover range from 10% in Spain, France, Greece and Portugal to 30% in Austria and Denmark. In Switzerland and Liechtenstein the threshold values for crown coverage depend on the width of the forest patch and range from 20% to 100%. The value for crown cover percent on a photo plot is defined as the number of tree pixels divided by the number of pixels assigned as forest land on this plot. Consequently, if a plot is located at the forest borderline, the value depends both on the density of crowns and the delineation rule for forest land. The spatial structure of forest land and the share of forest borderlines, respectively, determine the impact of the delineation rule on forest area estimation. The threshold values for width range from 9m in the Wallon region of Belgium to 50m in the UK, minimum area threshold ranges from 0.25 ha in Finland and Iceland to 2 ha in the UK. Also these attributes are affected by the delineation rule since a forest borderline surrounds a forest area and width is measured between 2 borderline points.

To interpret the results of the simulation of forest area definition for the different countries, it is important to analyse the properties of the 12 images which are the basis for this simulation in detail.

The spatial structure of the images can be characterised by the structural indices “edge density”, as well as by the number, mean size and size variation of the forest patches. The values given in Table A2 are measured from the entire image in order to characterise the spatial structure of the image independently from any forest/nonforest decision procedure. The measures “mean of forest area” and “mean of crown coverage” and the corresponding values for the standard deviations are results from the photo plot simulation.

As a rule for all structure types, the variable share of forest area, as well as the indices “maximum patch size”, “mean patch size” and the standard deviation of mean patch size, are positively correlated with the delineation distance. This is due the gradual closing of forest gaps respectively the inclusion of single trees and the corresponding gaps of other land to the class forest area. This process leads to a ‘fusion’ of many small single patches, the number of patches decreases and the mean size of patches increases. The values of mean crown coverage and the indices edge density, as well as the number of patches, are negative correlated, due to the ‘gap-filling process’.

Table A2: Descriptive statistics for the 4 different types of spatial structure and the 3 different delineation distances. Total area=6400 ha

		area and crown cover figures, derived from simulated photo plot samples				Indices calculated from entire image					
Image	del. dist. [m]	mean of area size[%]	mean of crown coverage [%]	standard deviation of area [ha]	standard deviation crown coverage [%]	share of category forest land [%]	max. patch size [ha]	mean patch size [ha] (artihm. mean)	std of patch size [ha]	number of patches	edge density [m/ha]
1	25	130.76	80.74	190.21	12.65	43.10	511.42	0.62	8.78	2775	405.31
1	35	3594.22	59.78	472.92	14.56	58.28	3656.45	4.21	122.77	547	298.69
1	50	5248.38	42.18	101.38	16.74	82.10	5250.37	17.93	306.20	15	122.88
2	25	3402.05	99.84	1272.02	1.28	70.69	3897.73	323.14	993.42	14	41.14
2	35	3982.98	99.60	971.87	2.45	70.86	4227.52	412.28	1207.52	11	39.76
2	50	4034.46	98.90	962.54	5.52	71.38	4271.55	507.59	1331.86	9	37.28
3	25	2573.15	96.71	896.63	7.70	49.21	2885.57	1.88	70.38	1680	109.82
3	35	2706.20	92.15	920.16	13.54	51.45	3019.07	2.84	88.60	1160	95.93
3	50	2839.42	84.41	1044.00	22.50	55.74	3223.49	4.66	116.46	765	77.15
4	25	447.85	96.57	514.67	7.10	36.29	1058.88	1.30	25.28	1781	130.50
4	35	496.60	91.10	514.04	13.22	38.37	1100.16	2.26	34.65	1089	117.84
4	50	1349.28	79.88	894.31	23.60	43.35	1946.94	4.57	78.99	607	98.70

The results of the crown cover, width and area measures, recorded from the simulated photo plots were the basis for the forest/nonforest decision, derived separately according the definitions of the 19 European countries. In addition, the frequency distribution figures show in more detail (Table A2) whether these measures are correlated to image structure and delineation distance or not. The Figure A7, 1-4 show that the frequency distribution of crown coverage classes is a function of the spatial structure of the images and a function of the delineation rule as well. The values for the crown cover percent are measured from plots located near or within forest land. For a given image and thus for a certain type of spatial structure, the peak of the distribution or the mode value for image 1 moves from class 80-90% to the class 40-50%, if the delineation distances change from 25m to 50m. The standard deviation is about 15%. More details are given in Table A2. It is obvious that the estimation of the mean crown cover percent depends strongly on the delineation distance. The situation is different for the structure type of images 2, 3 and 4. The level of changes in the mean crown cover estimates are significantly lower and the peaks or mode values do not change when delineation distance changes. The peak is always with 100% crown coverage, the ‘flattening’ of the distribution is positively correlated with the delineation distance. The share of forest land which is not covered by tree crowns, raises with increasing delineation distance. In image 2 only a few plots have crown cover shares lower than 100%. For the images 3 and 4 the situation is comparable but not as significantly as in image 2.

To analyse the forest land size distribution derived from the photo plot simulation, the area classes are divided in 5 classes with the width of 0.1 ha. Values for area greater than 0.5 ha were combined to class 6. In Figure 18 the shares of the 6 classes are given. Area measures lower than 0.5ha do not occur on image 2. On the images 1, 3 and 4, they categories 1-5 play a subordinate role. The sum of area size from patches covered by the simulated plots is always highest with a delineation distance of 25m, 9.7% of the plots of image 1 cover patches summing up to a size lower than 0.5 ha, the corresponding figure for image 3 is 7,9% and for image 4 it is 8.9%. This results are correlated to the figures from the fragmentation index mean patch size given in Table A2.

The third attribute to be analysed is the width of forest land which was only measured from plots located inside the forest land. The width was also divided in 5 classes of 10m width, the sixth class includes all values greater than 50 m. A certain similarity with the shares of the crown cover classes can be stated. Due to the uneven definition of the class “width”, the peak is with the class 6 for all images and delineation distances. If the analysis is restricted to the 5 evenly spaced classes, a slight movement of the peak towards higher classes is visible with increasing delineation distance. The values of the shares of class 6 are positively correlated to the delineation distance and raise in image 1 from

14.4% for a distance of 25m to 92.2% for a distance of 50m. The corresponding figures for the images 3 and 4 behave not as significantly as it was stated for the image 1. On image 3, the shares of class 6 increase from 84% to 89.6% and the shares of this class on image 4 increase from 72.1% to 83.1%. For image 2 the share of class 6 is about 98% and does not depend on the delineation distance.

image 1

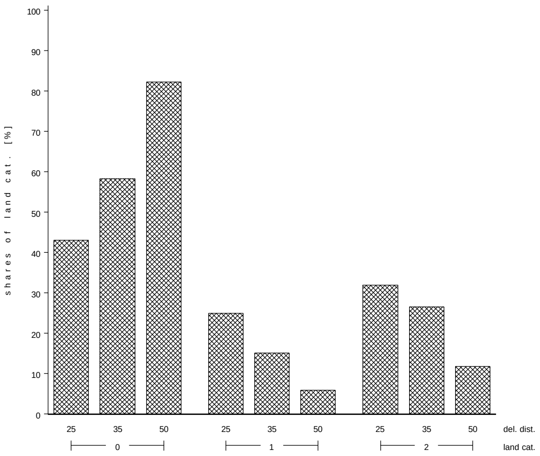


image 2

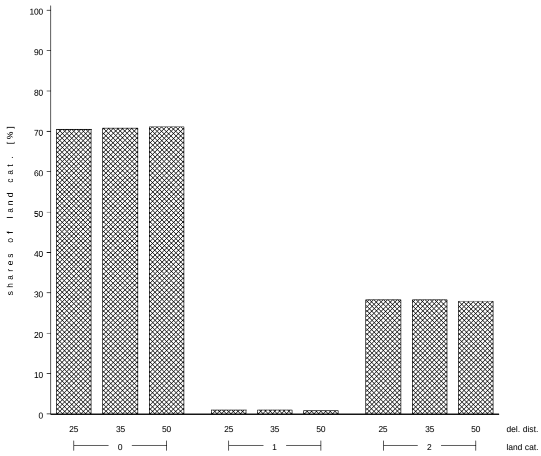


image 3

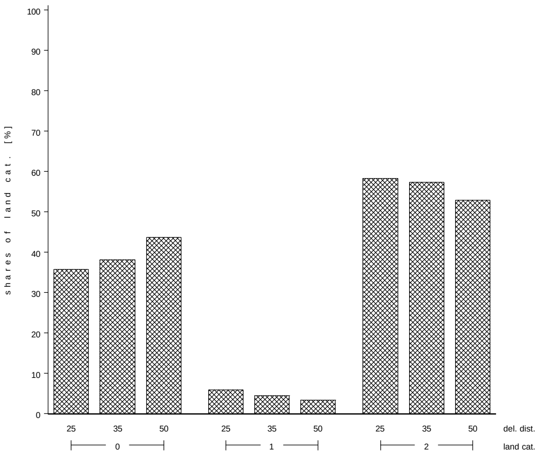
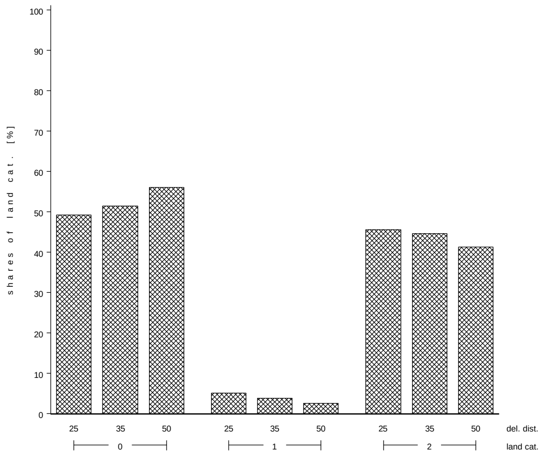


image 4



legend: land. cat.= land use category:, del. dist.= delineation distance

0: plot is located inside forest land

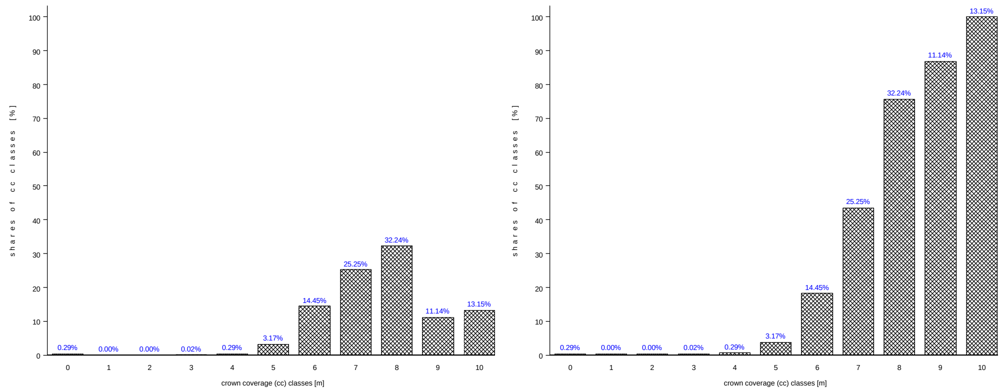
1: plot is located close to forest land

2: plot is located outside forest land

Figure A6. Frequency distributions of plot locations as a result of the simulated photo plot sampling procedure.

del. dist.

25



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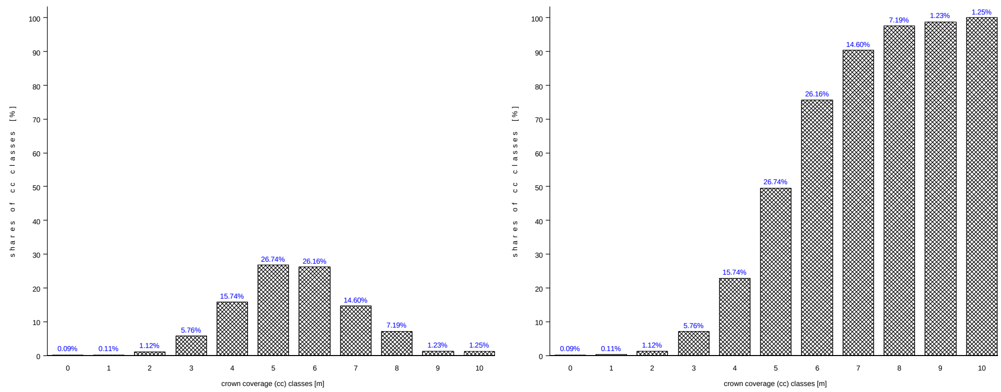

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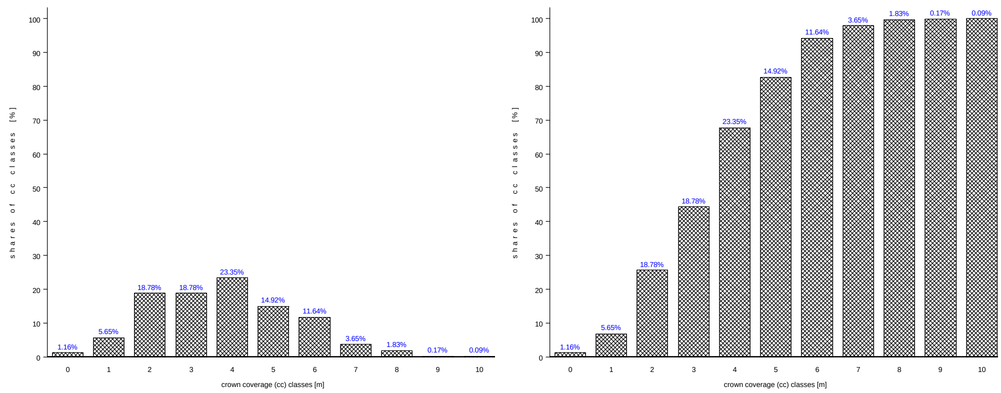
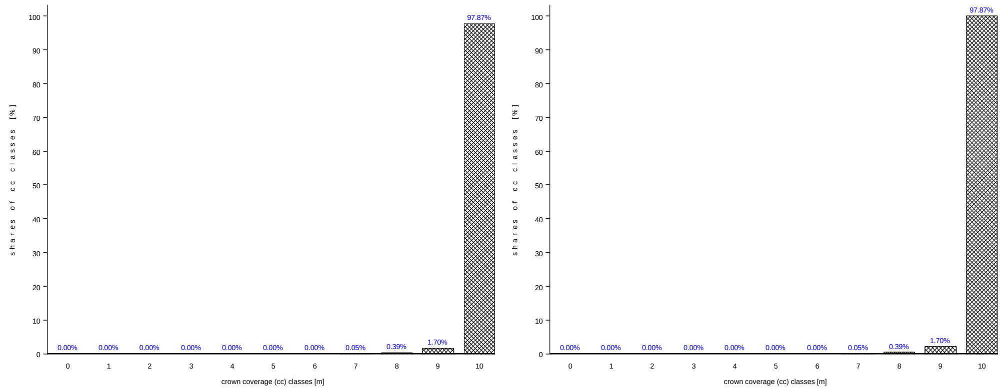


width of crown coverage classes=10%, class 0=0-9.99%

Figure A7. Image 1, shares of crown coverage classes (measured from plots with distance < 25m or inside the forest area). Left: frequency of crown cover classes [%], right: cumulative frequency of crown cover classes [%] (cont.)

del. dist.

25



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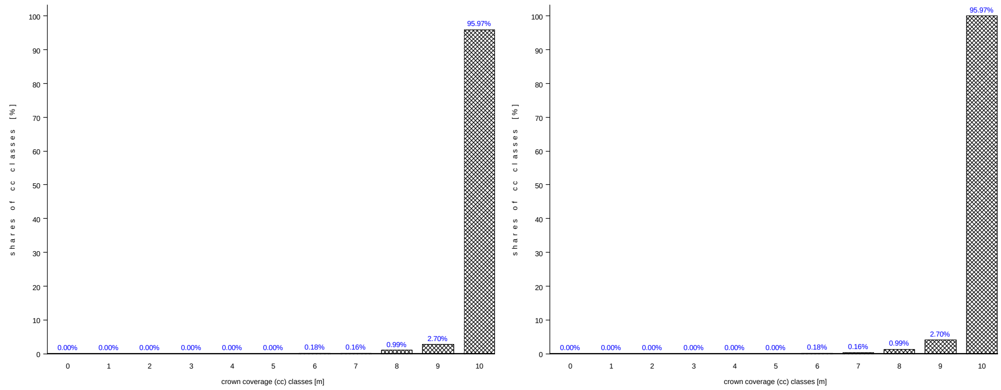

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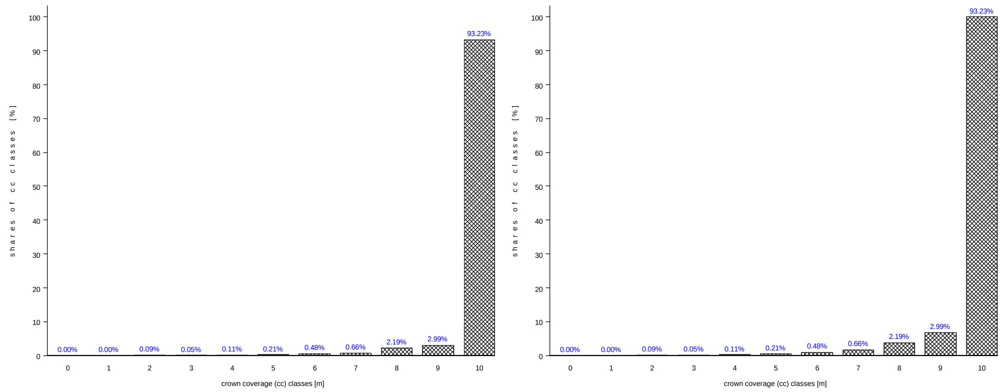

width of crown coverage classes=10%, class 0=0-9.99%

Figure A7 : Image 2 (cont.)

del. dist.

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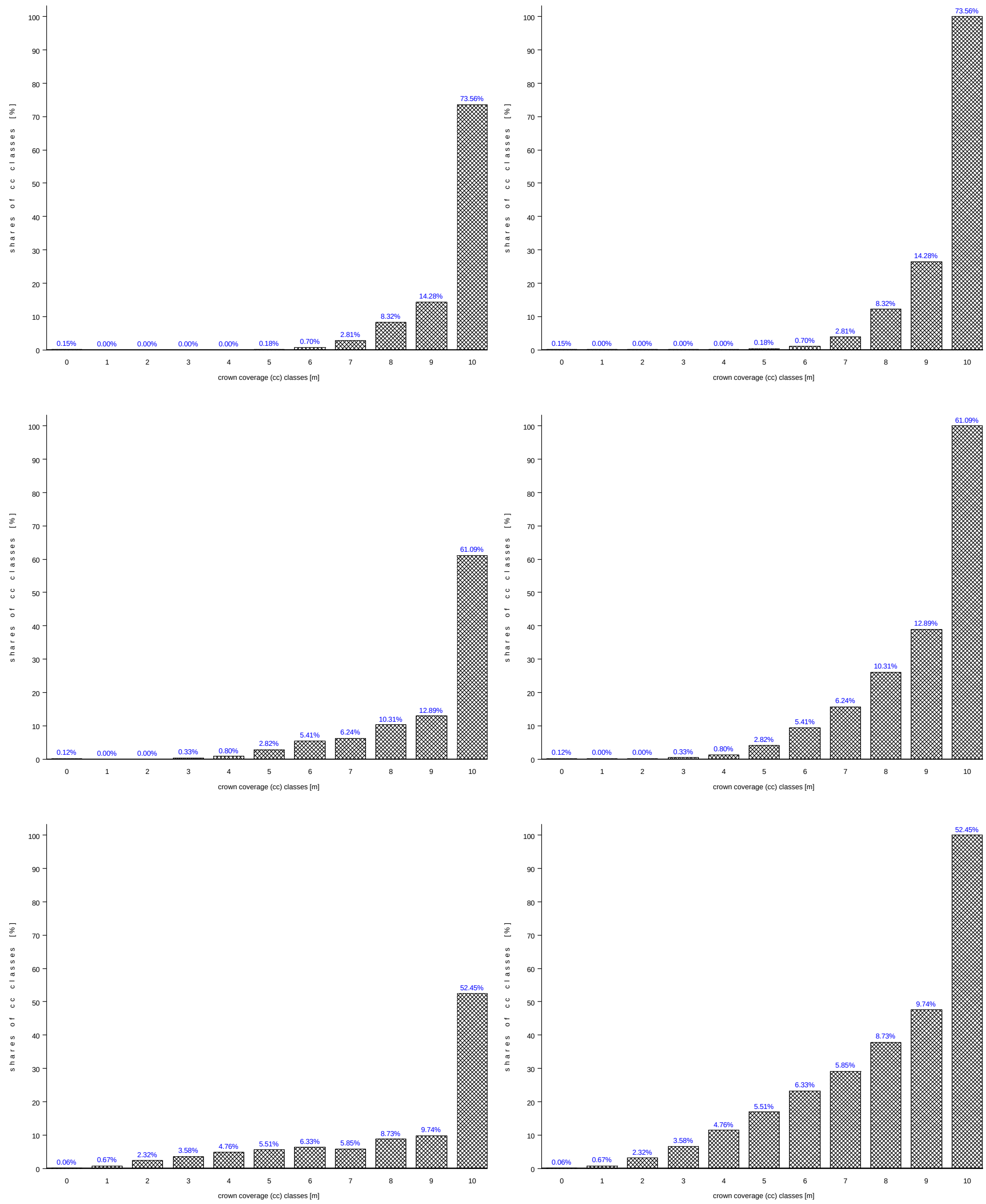

width of crown coverage classes=10%, class 10=0-9.99%

Figure A7 Image 3 (cont.).

del. dist.

25

35

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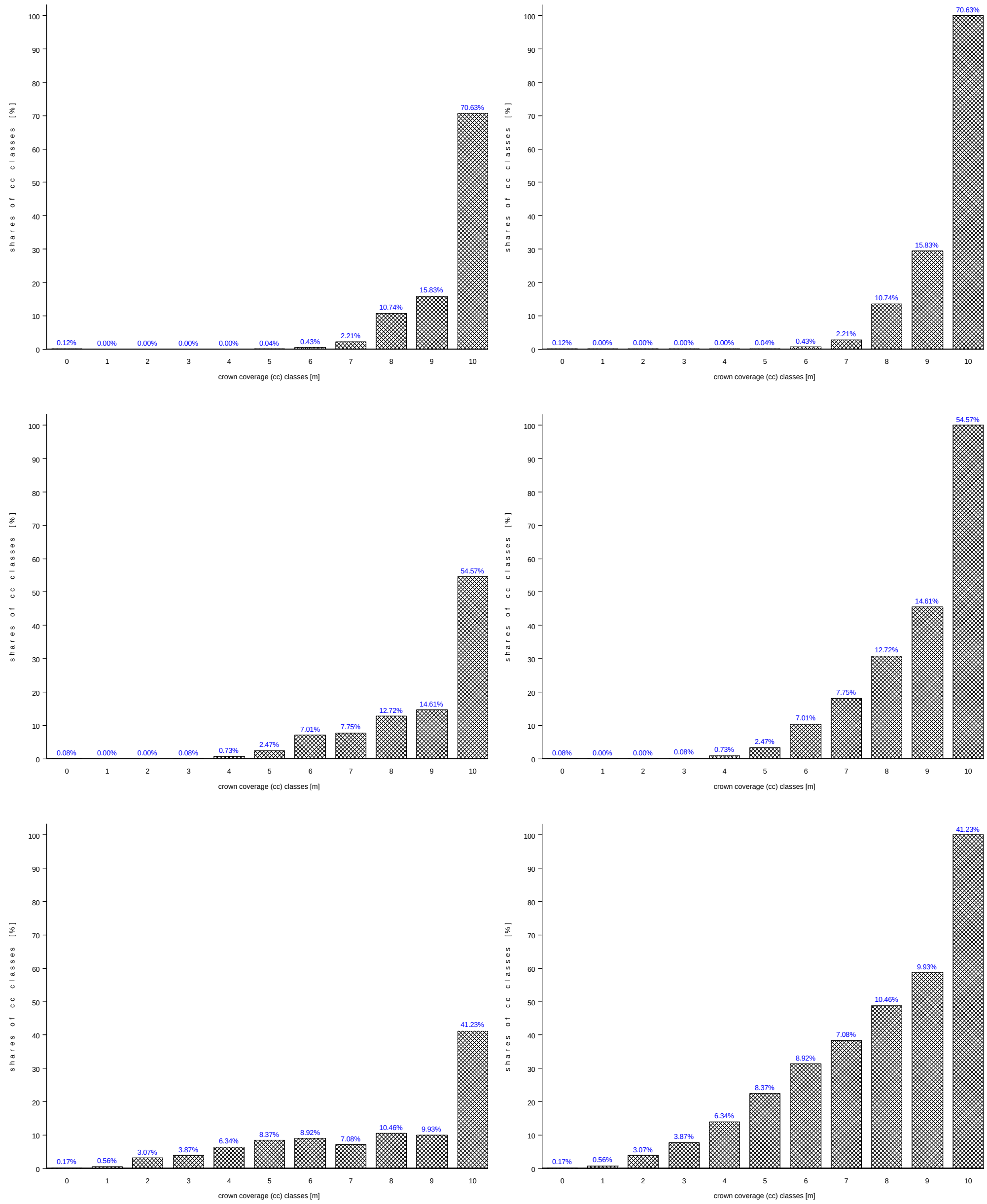
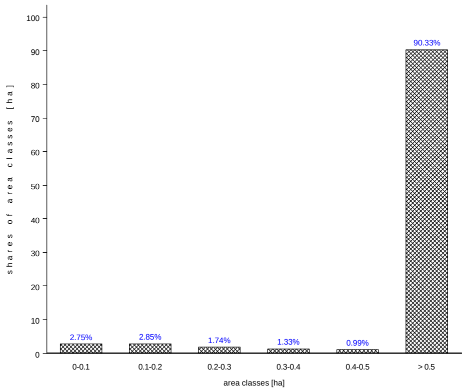


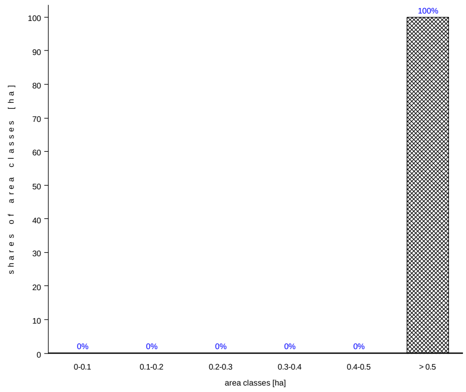
width of crown coverage classes=10%, class 10=0-9.99%, ...

Figure A7. Image 4.

del. dist. image 1 image 2

25





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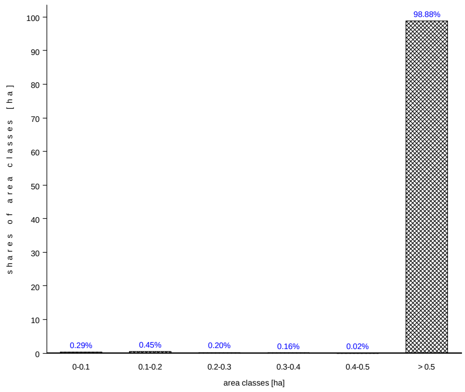

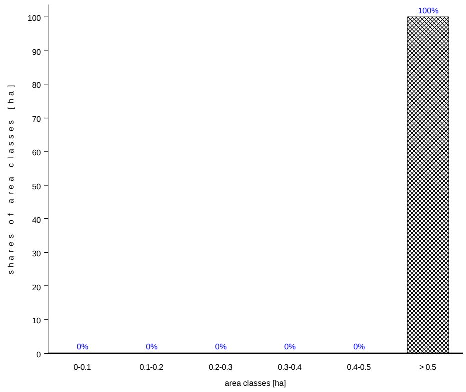

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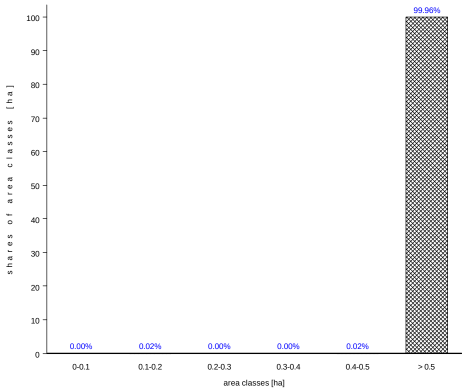

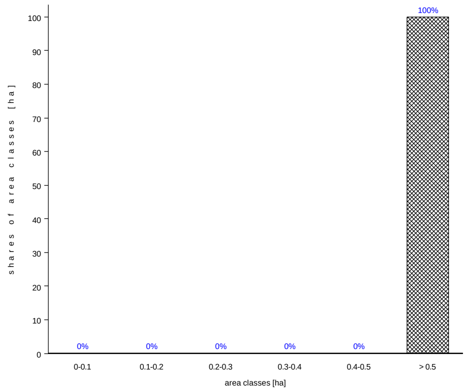

Figure A8. Area classes distribution, (measured from plots with distance < 25m or inside forest area) left: image 1, right: image 2 (cont.)

del. dist. image 3 image 4

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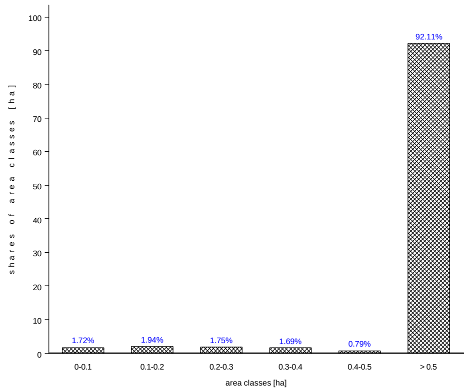

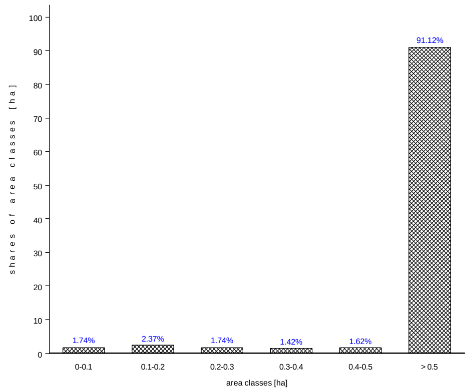

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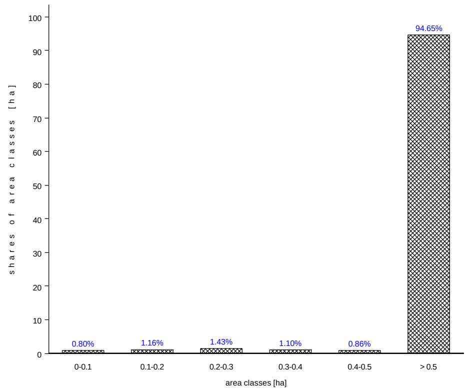

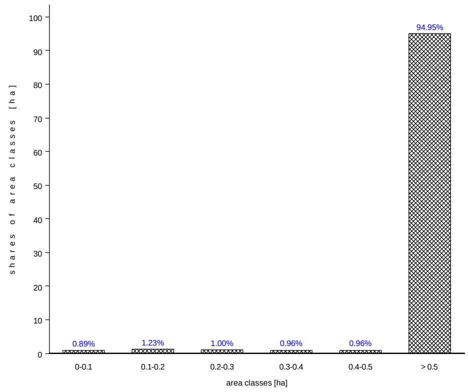

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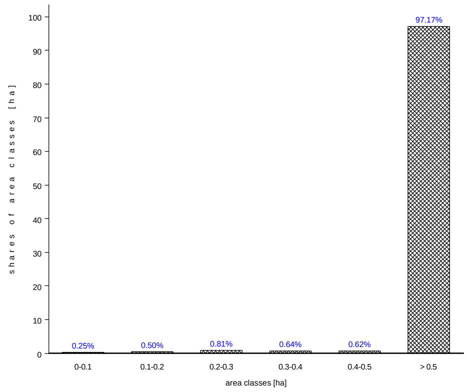

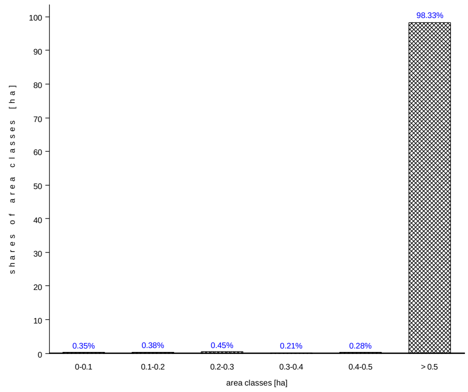

Figure A8 Left: image 3, right: image 4.

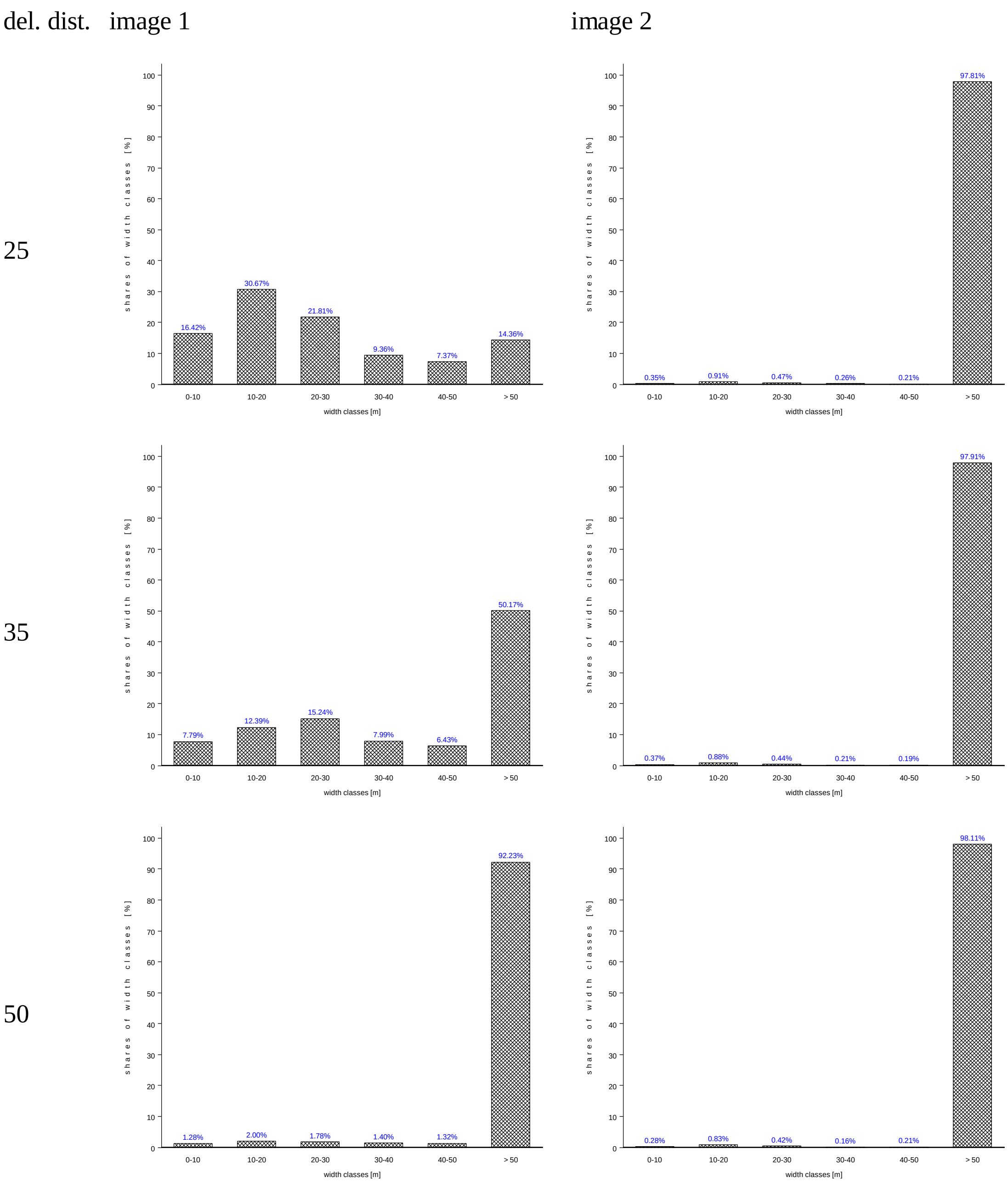

Figure A9. width classes distribution (measured for plots inside forest land). Left: image 1, right: image 2 (cont.)

del. dist. image 3 image 4

25

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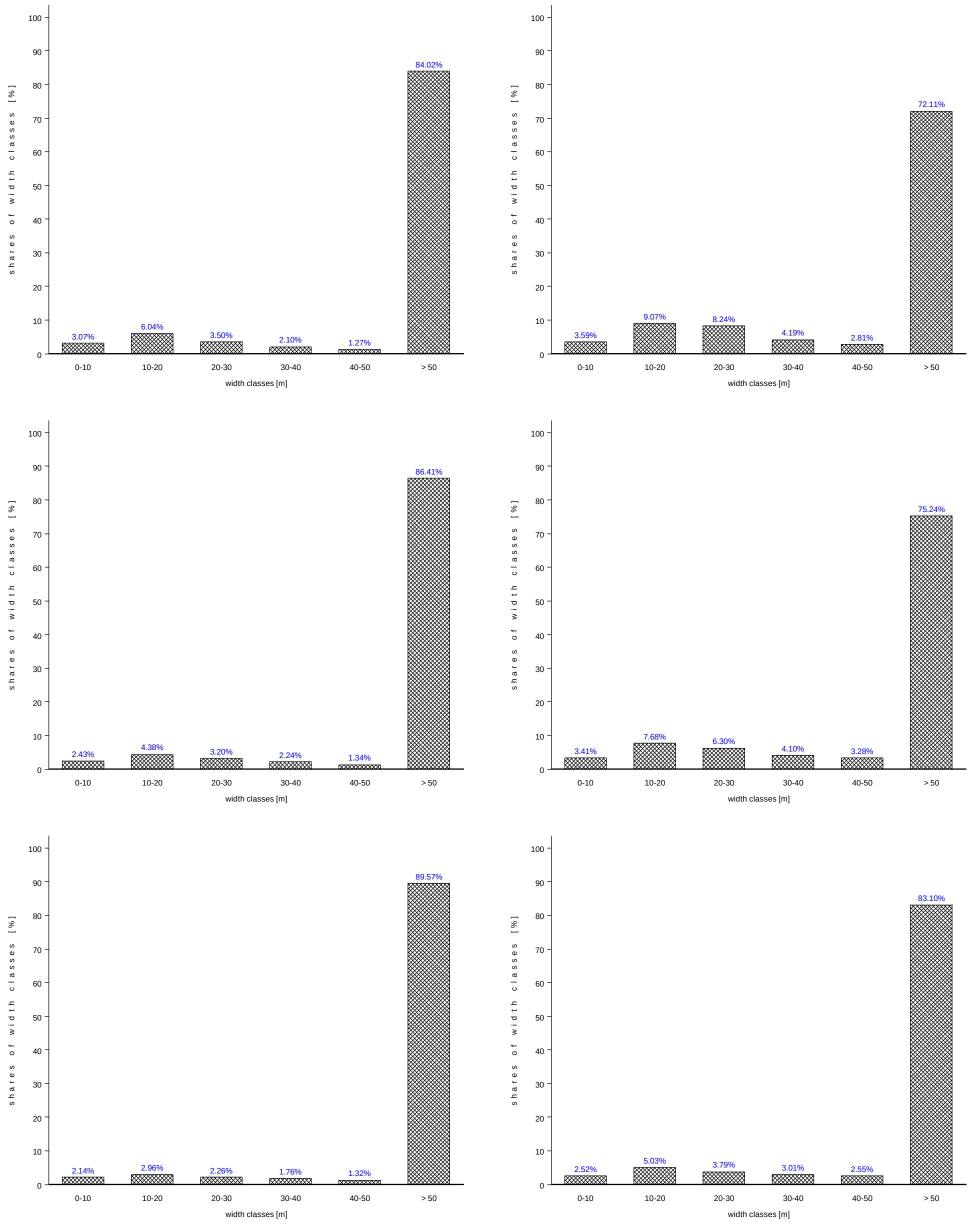


Figure A9. Left: image 3, right: image 4

Interpretation of the results for the forest area estimation by the different definitions of individual countries

In the charts listed in the Appendix of the simulation study, the results of the forest/nonforest decision for the individual countries are given. The estimated forest area size, as well as the impact of criteria responsible for the forest/nonforest decision, are represented by the bars. In addition to the countries represented, 3 further definition types are given. These are a wide, a restrictive and a 'lowest' definition. The threshold values for area, width and crown cover of the 'lowest' definition are 0. The wide definition uses the following threshold values: 10% for minimum crown cover, 10m for minimum width and 0.05ha for minimum area. The corresponding figures for the restrictive definition are: 30% for crown cover, 40m for width and 0.5 ha for area. The threshold values are listed below in Table A3.

Table A3: Threshold values for the forest/nonforest decision for 3 special definitions.

	crown cover [%]	area [ha]	width [m]
lowest	0	0	0
wide	10	0.05	10
restrictive	30	0.5	40

In Figure A1 the results of forest area estimation from all 6084 plots are given. The analysis of image 1 yields the biggest differences due to different forest area definitions. Forest area ranges from 66.14% (N) to 25.95% (GB) for a delineation distance of 25m, from 73.18% (N) to 43.92% (GB) for a distance of 35m and from 88.15% (N) to 62.74% (R). The differences between the maximum and minimum forest area values are 40.19%, 29.26% and 25.41% for the three distances. The estimates of forest area can be grouped. For a delineation distance of 25m the first group of forest area definitions estimate a forest area size greater than 60% (N, FIN, IC, S, B1, A, W, D). From a second group, F, P, I, SP, DK, B2, CH, FL, the national definitions lead to forest area estimates between 40% and 50%, and the third group (GR, NL, R, IRL, GB) yields estimated forest area sizes lower than 40%. This grouping is used with slight differences in ranking and a higher level of area estimates for the delineation distance of 35m. For a distance of 50m the second and third group merges but the first group (N, FIN, IC, S, B1, A, W, D) is still obvious.

On image 2, no significant differences between the different definitions and the three steps of delineation distances can be found. The estimated forest area is about 71.5% for all countries and images.

For images 3 and 4 three groups formed by definitions can also be observed. The first group consists of the same countries which form the first group for image 1, with some differences concerning the ranking within the group (N, B1, A, W, D, FIN, IC, S). Group 2 (F, P, I, SP, DK, B2, CH, FL) and group 3 (GR, NL, R, IRL, GB) can be separated for images 3 and 4 as well, the ranking of group 3 is the same as for image 1. The difference between image 3 and 4 is the range between the highest and lowest value for the forest cover estimates. For image 4 the range is 13.28%, 11.75%, 8.7% for the delineation steps 25m, 35m and 50m respectively, and for image 3 the corresponding figures are 8.84%, 8.29% and 7.4%. The level of change of forest area estimates for the individual countries with increasing delineation distances are similar for image 3 and image 4.

Table A4: Grouping of countries with a different level of forest area estimation

	group1, high level of forest cover estimates	**group2**, medium level of forest cover estimates	**group3**, low level of forest cover estimates
Countries/definitions	A, B1, D, FIN, IC, N, S, W	B2, CH, DK, F, FL, I, P, SP	GB, GR, IRL, NL, R
number of members	8	8	5

The reasons for this grouping is the share of criteria leading to the nonforest decision of a simulated photo plot. The upper left figure shows the absolute results derived from all 6084 plots, the lower left and lower right figures give relative shares of those plots located near or inside the forest borderline to allow a more detailed analysis.

From the upper right figures the proportion of plots where the centre was located outside forest area and exceeding the general distance threshold value of 25m can be evaluated. Due to the unified threshold value for the minimum distance, this share is equal for a given image and a given delineation distance for all countries. For image 1 the proportion of this type of plots decreases from about 32% for a delineation distance of 25m to about 12% for a delineation distance of 50m. In images 3 and 4 a minor decrease is found between the different delineation distances, the shares are between 40% and 50% on image 3 and between 50% and 60% on image 4. On image 2 the share is about 28% and does not change with the delineation distance. Since the nonforest cover is shown in this figures, the grouping of countries corresponds to the grouping found for the forest cover charts. However, the ranking is reversed.

Contrary to the unique criteria ‘distance to forest land’, the criteria ‘area of forest land’, ‘crown cover’ and ‘width of forest land’ for plots close or inside forest land differ between the individual countries. Subsequently, the plots assigned to nonforest, due to one or due to a combination of these criteria will be described.

For image 1, the countries having a unique level of forest cover estimate can additionally be subdivided. In the group of northern countries (FIN, IC, S, N) where the nonforest criteria are restricted to the minimum area threshold of 0.25 (0.1 for N), crown cover and width of forest land are not concerned. The proportion of nonforest plots decreases from roughly 10% to 0% with increasing delineation distances. The nonforest decision of A, B1, D(second part of group 1) and the wide definition (W) is mainly depending on the threshold value for width. For the other groups the assignment of the plots to the class nonforest is mainly due to the criteria width. In case of the delineation distance of 25m, the area criteria has an effect. For the delineation distance of 35m, only the width criteria is important, while in case of the 50m distance, the criteria crown cover is dominant. Crown cover has never been found decisive for the distances 25m and 35m. For countries of the groups 2 and 3, only width criteria leads to nonforest decisions.

On image 2 almost all plots close or inside the forest land are assigned to forest plots, the thresholds of the criteria crown cover and area are higher than the values found on the simulated plots. For the countries forming the group 2 and 3, the width criteria leads to about 1% to 1.5% of nonforest plots.

On image 3 and 4 a mixture of area width and combined criteria can be stated. The grouping is similar to image 1. The threshold values of crown coverage have no significant influence on the nonforest decision.

Table A5: Ranges between highest and lowest forest cover estimation separated by image type and delineation distance.

Delineation distance [m]	image 1 [%]	image 2 [%]	image 3 [%]	image 4 [%]
25	40.19 (N-GB)	1.55 (FIN-GB)	8.84 (N-GB)	13.28 (N-GB)
35	29.26 (N-GB)	1.48 (FIN-GB)	8.29 (N-GB)	11.75 (N-GB)
50	25.41 (N-GB)	1.35 (FIN-GB)	7.40 (N-GB)	8.70 (N-GB)

Conclusions

For sparsely structured forest areas, the differences between the country definitions are most significant, on image 2 the different definitions do not play an important role, which can be seen from Table A5. The differences are intermediate for structure types with showing dense and clustered parts of forest area in combination with sparsely structured types. The delineation distance plays an important role. On all images, the differences between the country definitions are highest with a delineation distance of 25m. The differences decrease with increasing delineation distance. The absolute level of forest area size estimations is positively correlated with the delineation distance. This is due to the increase in forest land. Whereas this increase leads to a lesser importance of the threshold values for the criteria area and width of forest land, an increase of forest land leads to lower values for crown cover as can be seen from Table A2. Obviously the extent of this decrease does not affect the threshold values of the single countries significantly. Only on image 1 and a delineation distance of 50m the crown cover leads to the assignment of plots to the nonforest class. Most important is width criteria followed by the area criteria. Combinations of single criteria play a subordinate role.

In northern and central European countries, the crown cover and transition type represented by image 2 is most frequent, however, the standard deviation for image type 2 is very high which is an expression of the different statements of the countries. In the southern countries, the 4 crown cover types are more equally distributed for the transition types, the images 2-4 are relevant in these region of Europe. It is important to keep in mind that the result of the questionnaires circulated gives only a rough idea of the distribution of the forest structure in Europe. A more detailed investigation would be necessary to judge more precisely the weight of different types of forest structure. But as a primary result, it can be stated that the significance of the forest cover definition is high if the proportion if the sparsely structured forest is high. With an increase of forest structure close to image 2, the importance of the forest cover definition tends to be low.

The implication due to a change in the forest cover definition for the countries is difficult to judge. A clear distinction must be made between the situation where new attributes would have to be set up, as would be the case for FIN, S, N and IC concerning the measures cover, width and area of forest land, and the situation where threshold values will be changed for attributes already used. In the first case e.g. field work procedure has to be changed. In the second situation forest cover probably changes, which leads to more or less field plots to be surveyed. The costs caused by these changes are correlated with the area of forest and other wooded land which is potential forest land.

In Chapter 3 the impacts for the countries are discussed if either the restrictive, or the wide forest cover definition would be applied

Key attribute „Volume of single trees"

The calculation of the stem volume of tally trees in forest inventories is commonly based on volume functions or on tariffs which can be considered as a special local volume function. In several countries the single tree volume is calculated from stump or ground level up to a top diameter threshold. Belgium, France, Germany and Ireland use a threshold value of 7cm, while other countries apply lower threshold values (e.g. Greece: 5cm) or do not apply any top threshold diameter at all. To compare the different definitions applied for single tree volume calculation, it is important to calculate the dimension of volume difference due to the application of a top diameter threshold value of 7cm. For this reason single tree data from the Second Swiss Forest Inventory were investigated.

For the volume calculation, 1000 trees from the Swiss NFI database were randomly chosen to calculate the proportion of volume above the minimum top diameter. The diameter of the trees chosen were measured in 2m sections. This enabled an exact volume calculation by spline interpolation technique realised by the means of the software tool 'SITCA' (Kleinn 1989). Some descriptive statistics on the 1000 trees are given in the Table A5. In Figure A10, the frequency distribution of the variables d.b.h., height, volume and height/diameter ratio is depicted. The minimum and maximum figures for these variables show that a wide variety of tree dimensions are represented in this data set.

Table A5: Statistics of 1000 trees chosen from the Swiss NFI database to calculate upper stem volume shares for a top diameter threshold value of 7cm.

variable	mean	std	maximum	minimum
d.b.h [m]	0.290	0.131	0.873	0.117
height [m]	24.67	6.69	42.6	7.80
volume [m^3]	1.062	1.203	9.731	0.046
upper height [m]	3.43	1.11	8.09	1.08
upper volume [m^3]	0.00440	0.00142	0.01037	0.00138
share of up. volume [%]	**1.45**	**1.86**	**10.85**	**0.02**
height/diameter ratio	92.90	22.26	165.43	38.47

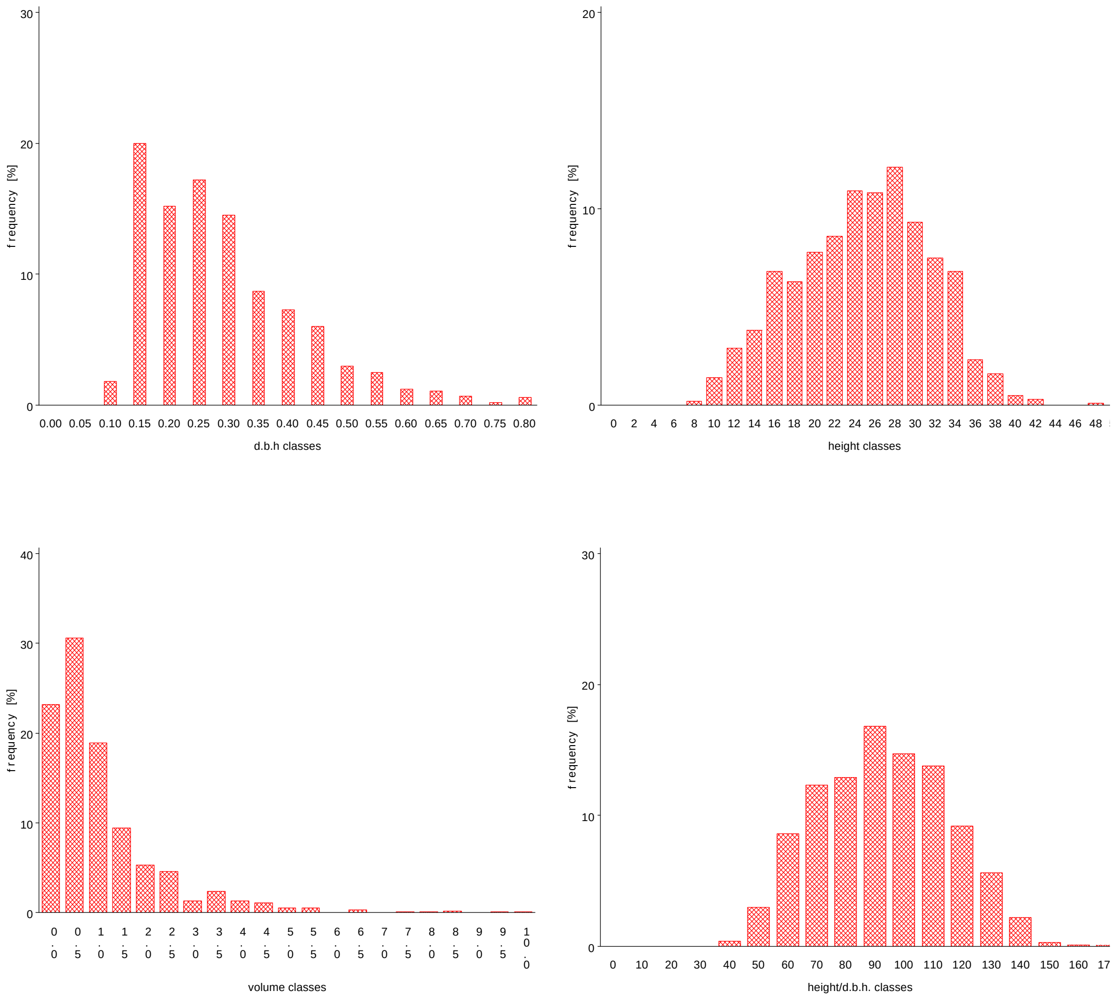
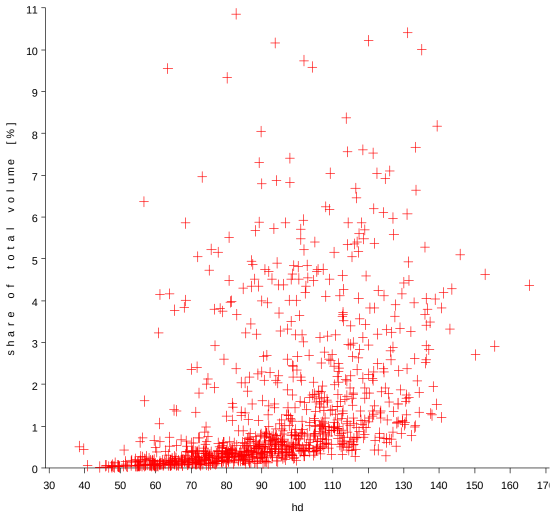
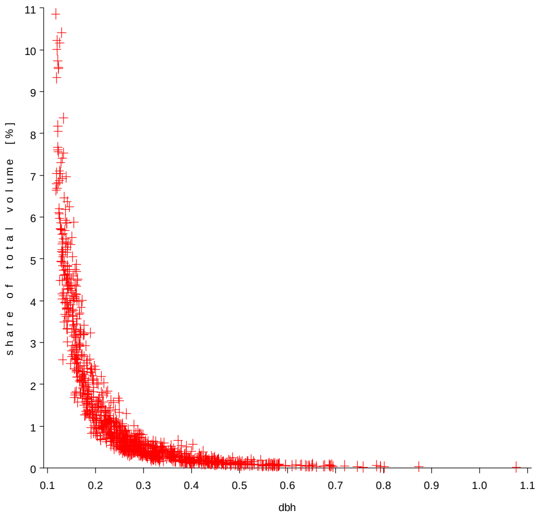


Figure A10. Frequency distribution of d.b.h (upper left), height (upper right), volume (lower left) and height/d.b.h. ratio (upper right) values.

The upper stem parts were treated as cones, the volume was, accordingly, calculated by the corresponding cone volume formulas. The results are given in Figure A11. This figure shows that the share of upper stem volume is never over 11%. The volume proportion of the upper stem parts are highly correlated with the d.b.h and with the height of a tree. This correlation is obvious as the diameter and the height of trees are correlated. The correlation of the volume proportions to the height/diameter ratio is weak.

Figure A11 shows the significant results that the upper volume shares are lower than 1% if the diameter exceeds the value of about 0.25m respectively if the height exceeds a value of 25m.





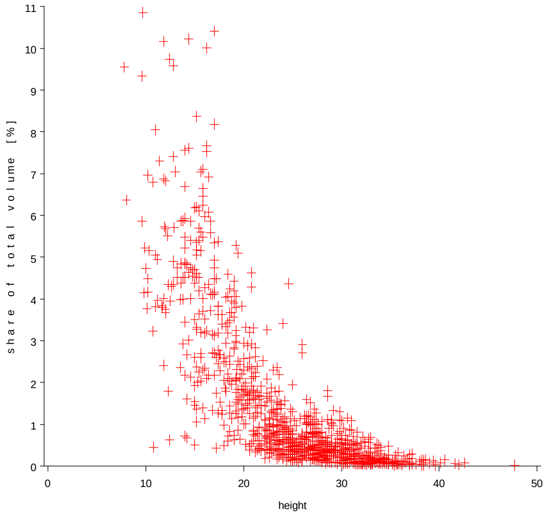


Figure A11. Results for the upper stem volume calculation. The figures give the shares of upper volume as a function of the height/diameter ratio (hd), as a function of the d.b.h and as a function of the height of the tree.

Key attribute „Stand volume“

The objective of this part of the simulation study is to derive figures on the impact of different d.b.h threshold values for the tally trees on the sample plots. The threshold values utilised in European countries range from 0cm in Finland and Sweden to 12cm in Switzerland and Liechtenstein. Also the impact of different top stem diameters and starting points of volume is studied.

Data from the Finnish National Forest Inventory were used to show the volume differences which would be obtained if different threshold values of European countries would be applied to calculate the stand volume of the Finnish forests.

To interpret the results of this simulation, two different kind of data were used:

Uneven-aged stand data, as well as even aged stand data, from growth and yield plots of the Swiss Institute for Forest Snow and Landscape Research (WSL) were investigated to determine the stand volume shares of trees with a d.b.h between 8cm and 12cm. These data allow to judge the potential amount of the shares for different stands based on long term monitoring plots.

Yield tables by Schober (1975) were evaluated.

Simulation study on the volume based on Finnish National Forest Inventory data

(The Study was made by Matti Maltamo, University of Joensuu)

Material and methods

The study area includes the forestry districts of Central Finland and North Karelia located in central part of Finland. The total land areas of these forestry districts are 1 531 000 hectares in Central Finland and 1 739 000 hectares in North Karelia (Finnish Forest Reseach Institute 1994). The study material consists of the forest measurements made on the 8600 Bitterlich sample plots of the 8th National Forest Inventory of Finland (NFI)..

The measurements of the forest stock on relascope sample plots used in this study consist of stand and tree measurements. The standwise measurements were the following: basal area, forest site fertility according to Cajanderian Forest types (Cajander 1926) and age of the stand (mean age of the trees). The applied treewise measurements were tree species and diameter at the breast height.

The calculation of stand volumes was done by using height models by Veltheim (1987) and taper curves by Laasasenaho (1982). Used height models are based on tree diameter at the breast height and on several stand characteristics. The taper curves by Laasasenaho use diameter at the breast height, and tree height and with these curves the volume of any part of the stem can be determined. Both models were applied separately to different tree species. After the calculation of treewise volumes the results were modified to per hectare using the principle of relascope (e.g. Bitterlich 1984). Different minimum diameters at the breast height, different minimum top stem diameter limits and two different starting points of volume were used in the calculations, according the rules used in the countries (Table A6). The relative mean volumes were calculated for both study areas separately and for the whole inventory area.

Results

The results are presented in relative volumes so that the countries where there are no limits in diameter at the breast height and top stem diameter, and where volume calculation starts from the stump level, represent 100 % volume (Table A6)

Results show that differences in mean volumes are at the maximum almost 20%. If Swiss measurement rules would be applied in Finland, the volume reduction would be 13%. If the d.b.h. and top diameter are the same as in Switzerland, but volume is calculated from the stump level, the difference to volume, by the threshold values of Finland and Sweden, is 18%. The proportion of the stumps from the total volume is about 6% (Figure A12). From the results of Switzerland and Liechtenstein, where only the top stem diameter differs, it can be derived that the volume difference due to an upper stem diameter threshold of 7 cm is 1.7%. This result derived from Finnish stands confirms the results found in chapter 2.2.4.

Table A6. Relative mean volumes according to different diameter limits and different starting points of volume used in European countries (Data source: Finnish National Forest Inventory).

	Minimum d.b.h., cm	Minimum top stem diameter, cm	Starting point volume	North of Karelia %	Central Finland %	Whole Inventory area %
Finland, Sweden	0	0	stump	100	100	100
the United Kingdom, Iceland	0 (1)	0	ground	105.6	106.1	105.8
Austria, Netherlands, Portugal	5	0	ground	103.1	103.6	103.4
Italy	3	0/3	stump	98.9	98.9	98.9
Norway	5	0	stump	97.6	97.7	97.6
Germany, Ireland	7	7	ground	95.6	96.9	96.2
France	7.5	7	ground	94.7	95.9	95.3
Belgium	7	7	stump	90.2	91	90.6
Greece	10	0	stump	88.6	89.6	89.1
Liechtenstein	12	0	ground	87.9	89.9	88.9
Spain	7.5	7.5	stump	88.4	89.2	88.8
Switzerland	12	7	ground	86.2	88.3	87.3

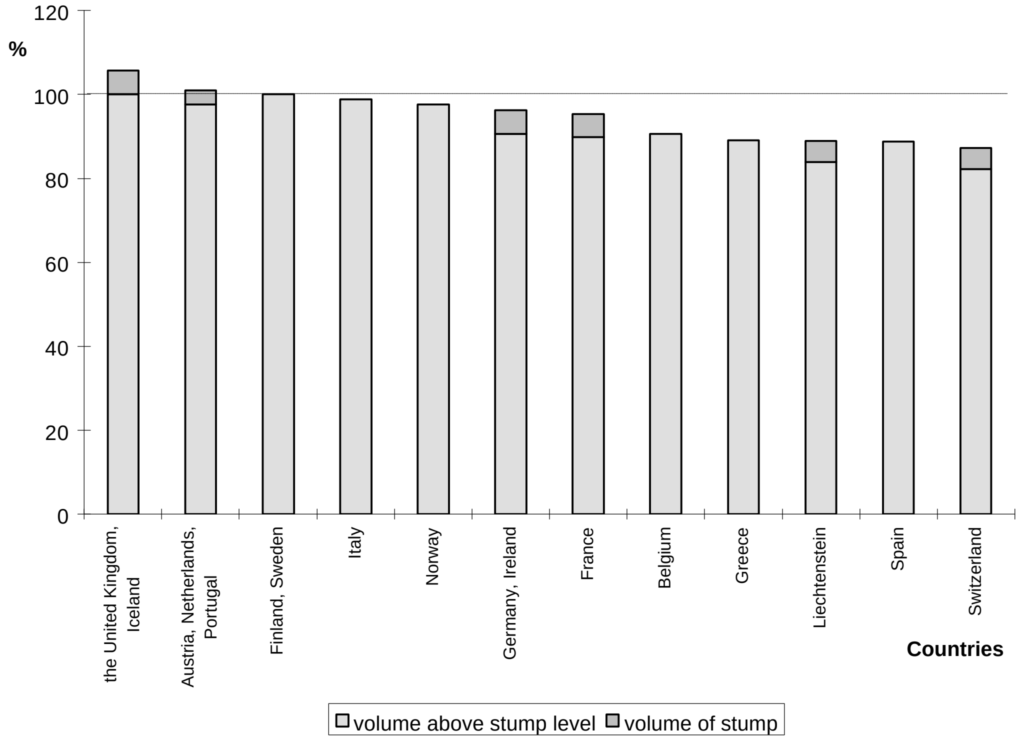


Figure A12. Relative mean volumes according to different diameter limits and different starting points of volume used in European countries.

However, the differences between the volumes in different countries are based on the Finnish forest situation and can be transferred directly to only those countries which have a comparable forest structure. The forests of Finland form a part of the boreal coniferous forest zone, and the mean volume of all stands in the study area is about 110 m^3 per hectare (Finnish Forest Research Institute 1994).

Therefore, the average size (d.b.h.) of trees in Finland is also smaller compared to, for example, the situation in Central Europe, and thus the effect of limits in tree dimensions is emphasised. The proportion of the plots with the mean d.b.h. under 12 cm, was 32.9 % within this study area. The differences would not be the same if the same measurement rules are applied in Switzerland, because the stem frequency distribution series are different. For each country separate stem diameter distribution models have to be developed to calculate the amount of volume made up by trees below the d.b.h. threshold value.

The stem diameter distribution and especially the amount of trees under 12 cm in Switzerland were described in following chapters.

Results derived from uneven aged growth and yield plots of Switzerland.

For uneven aged forests the results concerning the volume share of small trees which have diameter between 8 and 12 cm, are rather homogenous. The total mean volume/ha is about 500m^3 and varies between 335m^3 and 640m^3. The mean share of the stand volume made up by small trees is about 1% with a maximum of 2.18% of the stand volume. The total number of stems per ha varies between 360 and 770, and the share of small trees varies between 50 and 270, the relative share is between 10% and 42% with an mean value of 26%. The volume of the single trees were calculated by local tariffs. An overview is given in Table A7.

Table A7: Statistics derived from the uneven aged growth and yield plots of Switzerland.

	mean [%]	std [%]	min [%]	max [%]
share of small trees (volume)	0.93	0.39	0.32	2.18
share of small trees (number)	26.00	8.52	10.00	42.00
	mean [m³/ha]	std [m³/ha]	min [m³/ha]	max [m³/ha]
volume of small trees	4.62	1.95	1.62	10.20
volume of all trees	500.50	61.35	334.53	641.49
	mean	std	min	max
number of small trees	141.98	55.82	50	270
number of all trees	541.24	94.16	360	768

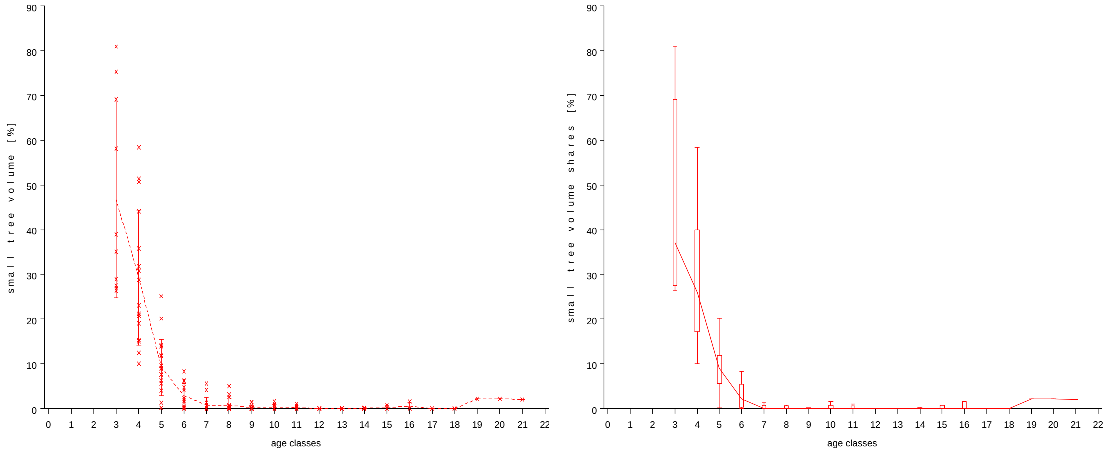
Results derived from even aged growth and yield plots:

The results for these plots are more heterogeneous than the results for the uneven aged stands, as uneven aged stand comprise of many age classes occurring close together on a very small area, thus showing mean figures for volume and stem number statistics.

Descriptive statistics derived from the 13 even aged growth and yield plots are given in Table 9 which comprise the general results. From this table as well as from the Figure A14 it was found that the volume shares of small trees decrease to values lower than 1% if the stand age is older than 70 years. The mean number of stems is about 715/ha in those stands which corresponds to a mean volume of about 372m^3/ha for all trees, and about 2.88 m^3/ha made up by the small trees between 8cm and 12cm d.b.h About 10% shares of mean volume for small trees occur in stands of the age class 5 (50-60 years), when the mean number of stems is about 1500 stems/ha and the total volume is 300m^3/ha. From Figure A14 the decrease of the heterogeneity of small tree volume and number as a function of the age class can be drawn. A significant step of decrease occurs in age class 6, where the volume shares and number of small trees tend to be lower than 10% of the values derived from all trees. It can also derived from this figure that the small tree shares increase when the age class is higher than 13. This is due the increasing amount of regeneration trees in the understorey of this stands.

Due to the data set available, the investigation was restricted to a d.b.h range from 8 cm to 12 cm. Trees with a d.b.h lower than 8 cm occur most frequently in stands younger than 30 years, regeneration stands, uneven aged stands or they form the understorey of a stand. Even if the number of the small trees is high, the volume proportion will not exceed the figures given for the trees between 8 cm and 12 cm.

volume shares



number of small stems

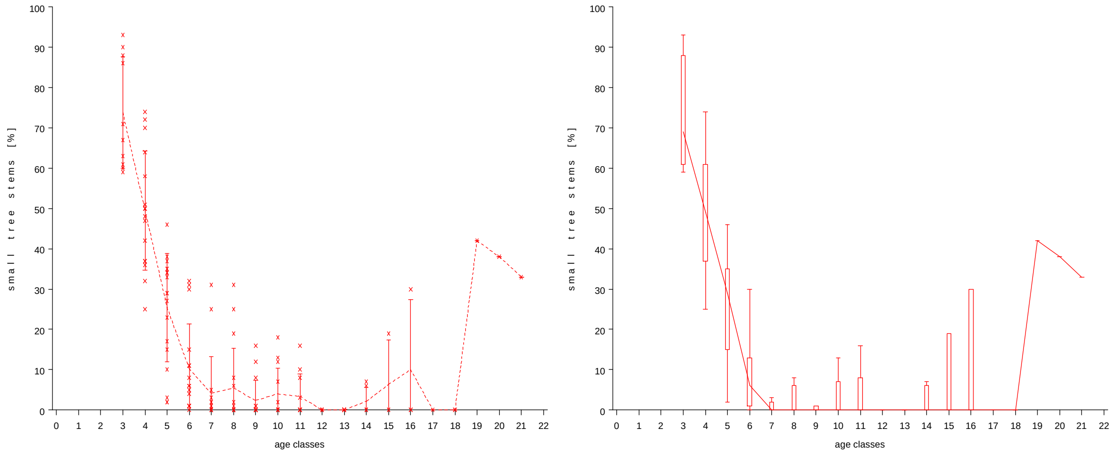


Figure A13. Volume (upper scatterplots) and stem number (lower scatterplots) share of trees with a diameter between 8cm and 12cm as a function of the age classes. The width of the age classes is 10 years. Left images: vertical lines mark the standard deviation of the corresponding share, the dashed line connects the mean values of the corresponding shares. Right images (Whisker-Box plots): the box bounds the 25 and the 75 percent t quartiles (interquartil range), the whiskers extent not more than 1.5 interquartil ranges.

Table A8: Statistics derived from the even aged growth and yield plots.

		mean						**standard deviation**					
age class	frequency	number of stems / ha	number of small stems /ha	percentage of small stems [%]	stand volume [m^3/ha]	volume of small trees [m^3/ha]	percentage of small tree volume [%]	number of stems /ha	number of small stems /ha	percentage of small stems [%]	stand volume [m^3/ha]	volume of small trees [m^3/ha]	percentage of small tree volume [%]
3	10	1345.50	959.70	73.8000	75.347	28.1564	46.7307	544.399	383.607	13.8468	50.734	15.3523	21.8895
4	16	1855.63	923.75	49.5625	195.472	49.2460	29.3009	231.768	317.040	14.7827	63.094	13.4659	15.0601
5	19	1452.63	402.16	25.4211	306.823	26.1926	9.1974	365.449	239.652	13.3928	59.774	15.4515	6.3145
6	16	1072.81	120.13	10.1875	353.102	10.0159	2.8985	228.941	132.674	11.1727	70.562	9.9342	2.6910
7	17	715.71	37.53	4.1176	372.450	2.8862	0.7985	198.717	86.187	9.1575	65.734	5.8487	1.6209
8	17	608.29	45.41	5.4118	452.246	4.1859	0.7511	207.945	88.405	9.8556	108.361	8.3897	1.4581
9	16	453.13	12.88	2.3750	515.284	1.2826	0.2468	116.705	26.673	5.0050	126.139	2.6228	0.5120
10	13	389.31	17.77	4.0000	530.369	1.8462	0.3345	122.291	26.963	6.3377	103.760	2.8558	0.5215
11	11	322.55	12.73	3.3636	579.479	1.2803	0.2182	84.465	19.764	5.5186	89.644	2.0259	0.3422
12	5	240.00	0.00	0.0000	599.167	0.0000	0.0000	55.227	0.000	0.0000	84.485	0.0000	0.0000
13	6	214.83	0.00	0.0000	493.002	0.0000	0.0000	151.698	0.000	0.0000	139.444	0.0000	0.0000
14	6	298.17	4.50	2.1667	723.328	0.5728	0.0750	128.534	7.314	3.3714	122.122	0.9270	0.1167
15	3	280.67	14.33	6.3333	632.693	2.0290	0.2590	42.147	24.826	10.9697	132.897	3.5143	0.4486
16	3	281.00	35.33	10.0000	670.016	4.7590	0.5407	64.211	61.199	17.3205	182.892	8.2428	0.9365
17	1	180.00	0.00	0.0000	490.256	0.0000	0.0000	.	.	.	.	.	.
18	2	152.00	0.00	0.0000	480.351	0.0000	0.0000	14.142	0.000	0.0000	21.238	0.0000	0.0000
19	1	826.00	351.00	42.0000	547.755	12.1760	2.2230	.	.	.	.	.	.
20	1	870.00	327.00	38.0000	530.382	11.6810	2.2020	.	.	.	.	.	.
21	1	880.00	289.00	33.0000	531.813	10.7500	2.0210	.	.	.	.	.	.

Results derived from growth and yield tables

The results drawn from the growth and yield tables are comparable to the findings from the even aged growth and yield plots. To simulate different stand structure types, the share of stems between 6cm and 12cm d.b.h. are assumed to range between 5% to 25% partitioned in 5% steps. The calculations for the volume shares corresponding to these partitions were carried out separately for the stand ages of 50, 80 and 110 years. For the stand age of 50 years a share of 25% of small stems seems to be a realistic figure which can be derived from the even aged growth and yield plots results. Thus the figures for the 25% share class of the age class of 50 years derived from the growth and yield table have to be taken into account. For the age class of 80 years, a small stem share of maximal 5% seems to be the most realistic figure. The corresponding mean of the small trees stand volume share of 25% for stand age of 50 years is 15.5% and the 5% share for the stand age of 80 years is 1.23% which is can roughly equal to the data derived from the growth and yield plots.

Key attribute „Volume of increment components“

The objective of this chapter is to compare two systems to define the volume increment and the volume of increment components. Commonly the growth component system of Beers (1962) is used in the central and southern European countries and in Northern America. In the northern European countries the system of forest balance (Kuusela 1994) is applied which uses different terms and measures to quantify volume increment components. The definitions of the forest balance system are given in Chapter 3 where the terms „Drain“ and „Removals“ are discussed. In Table A10 figures from an example drawn from Beers (1962) are given. From a sample plot measured in two occasions, the ‘history’ of 10 trees is depicted which forms the basis for the calculation of different growth components given in Table A11. The results of the different increment components calculations are given both on the basis of the total volume figures and on the basis of individual tree growth figures. The flowchart depicted in Figure A15 gives an overview on the interrelations of the terms of the two systems.

The system of forest balance and the system of growth components is comparable but not totally harmonised. The forest balance system as it is described in Kuusela, 1994 does not consider ingrowth as a component of the forest balance system which is an important difference between the two systems. However ingrowth principally is considered in other descriptions of the forest balance system. Ingrowth is not important if no calliper threshold is applied in a forest inventory system as it is the case e.g. in Finland and Sweden. Moreover since the forest balance system is widely used in northern European countries, where predominantly even aged stands exist, ingrowth is a subordinate figure in volume increment calculation. Due to these facts, the forest balance system applied in northern countries practically does not consider ingrowth trees.

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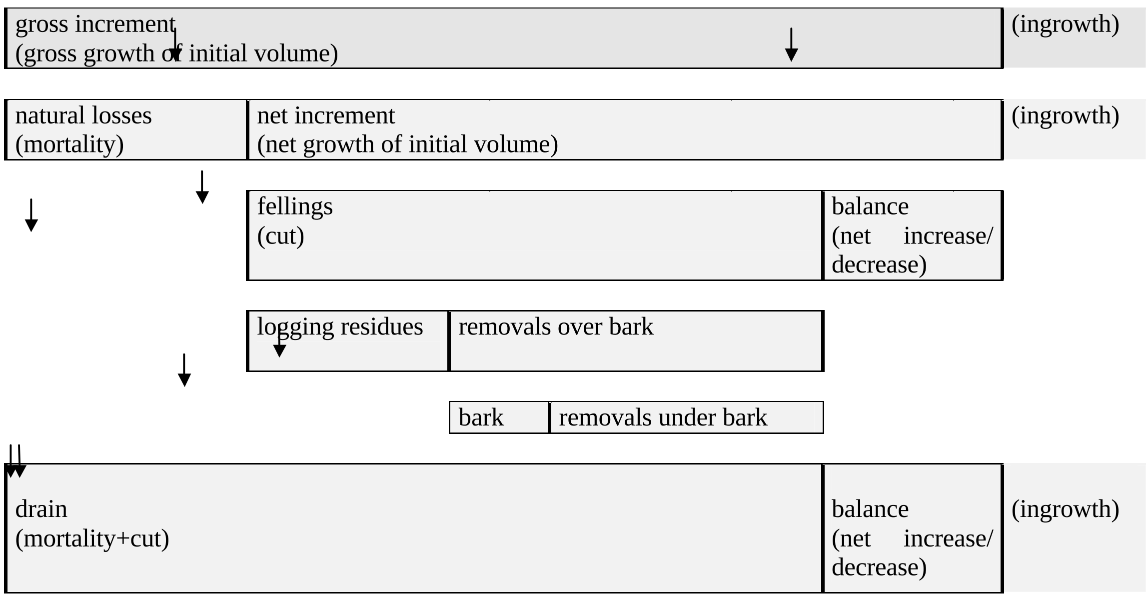

Figure A14. Components of gross increment according to the forest balance system (italics) and according to the growth component approach (terms in brackets).

For the calculation of the figures of the increment components, all trees presented in Table A10 were used, in order to get comparable results. The conversion formulas are given in Table A11, while the results are presented in Table A12. However, it has to be kept in mind that tree no. 7 would possibly not occur in even aged stands or inventory systems without a calliper threshold. It would either occur already in the first inventory cycle or it would not occur at all.

The term ‘drain’, used in the forest balance system, is easily comparable to the growth component system, since ‘drain’ is composed of ‘natural losses’ (NL) and ‘fellings’ (F) respectively ‘mortality’ (M) and ‘cut’ (C). The term ‘balance’ is analogous to the term ‘net increase’ of the growth components system. The total growth measures ‘gross growth’ and ‘net growth’ correspond to the measures ‘gross increment’ and ‘net increment’. The interrelations are given also in Figure A14.

Table A10: Figures of growth components partially derived from Beers 1962, the volume figures are given in m³ . Italic figures: measures of the forest balance system (Kuusela 1994)

tree no	first inventory / *recorded growing stock 1*	sec. inventory / *recorded growing stock 2*	survivor growth	mortality / *natural losses*	cut / *fellings*	ingrowth	net growth / *net increment*	*drain*	*bark + logging residues*[1]	*removals under bark*	*bark + logging residues*[2]	*removals under bark*
symbol→	V1/*RGS1*	V2/*RGS2*	GS	M	C	I	GN / *NI*	*D*	*LR*	*RUB*	*LR*	*RUB*
1	0.146	-	-	0.146	-		-0.146	*0.146*				
2	0.192	-	-	-	0.192			*0.192*	*0.038*	*0.154*	*0.077*	*0.115*
3	0.157	-	-	-	0.157			*0.157*	*0.031*	*0.126*	*0.063*	*0.094*
4	0.100	0.147	0.047	-	-		0.047					
5	0.149	0.289	0.140	-	-		0.140					
6	0.250	0.386	0.136	-	-		0.136					
7	-	0.082	-	-	-	0.082	0.082					
8	0.220	-	-	-	0.220			*0.220*	*0.044*	*0.176*	*0.088*	*0.132*
9	0.193	0.283	0.090	-	-		0.090					
10	0.347	0.581	0.234	-	-		0.234					
total	1.754	1.768	0.647	0.146	0.569	0.082	0.583	*0.715*	*0.113*	*0.456*	*0.228*	*0.341*

1: bark and logging residues are assumed to be ~20%, (based on Kuusela 1994, table 2.10, page 26)
2: bark and logging residues are assumed to be ~40%, (in case of extreme situation)

Table A11: Conversion of increment components calculation formula between the system of forest balance (Kuusela 1994) and the system of growth components (Beers 1962)

forest balance system		Beers 1962	
gross increment	GI = RGS2-RGS1+D	= V2-V1+M+C	= gross growth
net increment	NI = GI-NL	= V2-V1+C	= net growth
balance	B = GI-D = NI-F	= V2-V1	= net increase
drain	D = NL+F	= M+C	

GI: gross increment, RGS1: recorded growing stock at occasion 1, RGS2: recorded growing stock at occasion 2, D: drain, Ni: net increment, NL: natural losses, B: balance, F: fellings

V1: stand volume at occasion 1 (RGS1), V2: stand volume at occasion 2 (RGS2), M: mortality, C: cut

Table A12: Results for different types of increment derived from the total and from the individual tree growth volume figures.

increment component	total volume figures	individual tree growth figures
net increase *balance*	V2-V1 = 1.768-1.754 = **0.014**	GS+I-M-C = 0.647+0.082-0.146-0.569 = **0.014**
gross growth of initial volume	GD+M+C-I = 0.014+0.146+0.569-0.082 = **0.647**	GS = **0.647**
gross growth *gross increment*	GD+M+C = 0.014+0.164+0.569 = **0.729**	GS+I = 0.647+0.082 = **0.729**
net growth of initial volume	GD+C-I = 0.014+0.569-0.082 = **0.501**	GS-M = 0.647-0.146 = **0.501**
net growth *net increment*	GD+C = 0.014+0.569 = **0.583**	GS+I-M = 0.647+0.082-0.146 = **0.583**

The system of forest balance does not necessarily regard ingrowth trees but it is more differentiated concerning the measure fellings or ‘cut’. Fellings are separated in the components removals and logging residues, the removals are additionally divided in removals over bark and removals under bark. These distinctions are important in those countries where a large amount of bark and logging residues like branches or other parts of wood which cannot be utilised remain in the stand.

The system of forest balance and the system of growth components are comparable but not totally harmonised. The harmonisation of both systems is possible by using reduction factors to calculate the volume of logging residuals and bark. Particularly for the share of bark, conversion tables and regression equations are already existing for a large amount of tree species. The shares of logging residues can be derived from timber trade reports or tables given e.g. in Kuusela (1994). A share of

20% of logging residues and bark seems to be realistic in central Europe and is commonly used e.g. in Germany to calculate the volume of merchantable timber without bark from the cut trees.

A complete harmonisation of both systems requires an enlarged the tree history code. For countries using the definitions and terms of the growth components system, it would mean setting up a system to determine the amount of removals and logging residues etc. For the northern countries, an enlarged history code would mean recording ingrowth trees in the cases of their occurrence. An overview on differences and equally used measures and terms is given in Table A13.

Table A13: Different and equal used terms of the forest balance and the growth components system.

Terms and measures only used in the growth components system	Terms and measure used in both systems		Terms and measures only used in the forest balance system
ingrowth tree	stand volume(V)	recorded growing stock	*removals over bark*
gross growth of initial volume	net increase	*balance*	*removals under bark*
	gross growth	*gross increment*	*bark*
net growth of initial volume	net growth	*net increment*	*logging residues*
	cut	*fellings*	
	mortality	*natural losses*	
	cut+mortality	*drain*	

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3. Analysis of harmonisation activities at different target levels

The objective of Chapter 3 is to define the costs and benefits when either a small or large number of attributes are to be harmonised at a certain limit of comparability. The harmonisation efforts for individual countries are analysed on the basis of their national forest resource assessments. The first part of this chapter concentrates on the harmonisation of attributes, the second part describes updating methods that will allow to relate multinational inventories to one common point in time.

Three hypothetical target levels have been introduced to facilitate the analysis of the costs and benefits of the harmonisation process:

Target level 1: up to 5 most important attributes should be harmonised

Target level 2: up to 10 most important attributes should be harmonised

Target level 3: more than 10 important attributes should be harmonised

The attributes, which have to be assigned to the three target levels, were selected based on the Information Needs Assessment (see Chapter 1). The information topics mentioned most frequently as important or very important are listed in Table 15. 'Forest area' was assigned the highest rank, while 'plantations' was the information topic with the lowest rank included in the analysis of harmonisation activities. For each information topic, attributes that are used in national assessments were assigned to provide the desired information.

Table 15. Result of Information Needs Assessment and related attributes.

Information topics	Number of times mentioned under "important" and "very important" (222 replies)	Attributes assessed/ derived to provide information
Forest land	182	Forest area,
Decrease of forest land	183	Forest area
Increase of forest land	180	Forest area
Tree species composition	175	Tree species, tree species composition
Protective function	172/ 155	Area of forest fulfilling protective functions, area of forests fulfilling conservation function
Volume of annual cut	167	Drain, removals, single tree volume, volume increment, volume of increment components
Volume of annual increment	165	Drain, removals, single tree volume, volume increment, volume of increment components
Biological richness	163	Naturalness, fragmentation, biodiversity, plant species/ floristic composition, forest margin/ clearings, dead trees or other woody material, vegetation types
Changes of growing stock	157	Drain, removals, single tree volume, volume increment, volume of increment components
Growing stock/ stem volume	154	Drain, removals, single tree volume, volume increment, volume of increment components
Health condition/ vitality of standing trees	144	Already harmonised on European level

The three most important information topics (forest area, decrease of forest land and increase of forest land) can all be described by one attribute: forest area. Assessing forest area over time provides information on the current amount of forest land on each assessment occasion, as well as on the changes in forest land over time.

All attributes that provide information for the most important information topics are presented in table 16.

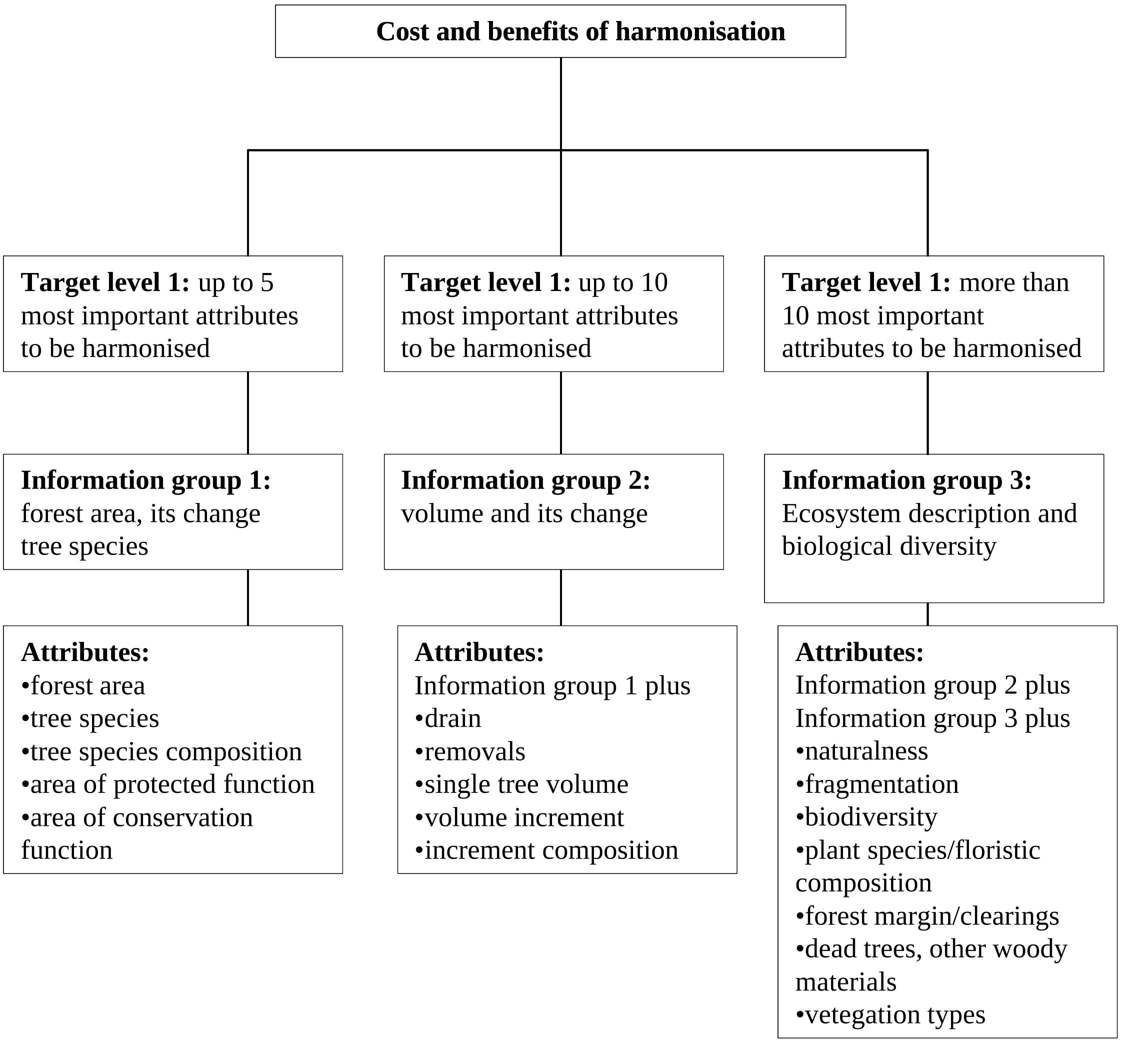
Table 16. Target levels for the harmonisation efforts.

Attribute	among up to 5 most important attributes	among up to 10 most important attributes	among more than 10 most important attributes
Forest area	*	*	*
Tree species	*	*	*
Tree species composition	*	*	*
Area of forests that fulfil protective functions	*	*	*
Area of forests that fulfil conservation function	*	*	*
Drain		*	*
Removals		*	*
Single tree volume		*	*
Volume increment		*	*
Volume of increment components		*	*
Naturalness			*
Fragmentation,			*
Biodiversity			*
Plant species/ floristic composition			*
Forest margin/ clearings			*
Dead trees or other woody material			*
Vegetation types			*

A listing of all attributes necessary in providing information on the most important information topics yields three general information groups, which reflect the three target levels. Target level 1 (5 most important attributes should be harmonised) includes attributes that provide information on forest area, its change, protection areas and tree species. Target level 2 (10 most important attributes should be harmonised) adds a group of attributes that provide information on volume and its change. The third group of attributes includes information on forest ecosystems and biological diversity and can be assigned to target level 3 (more than 10 important attributes should be harmonised).

As the three information groups correspond to the three target levels, the ranking of attributes within the information groups is of minor importance. The ranking can be changed without effecting the target levels.

3.1 Information groups and target levels



In the Helsinki resolutions and the follow-up resolutions of the Helsinki process, the criteria and indicators for sustainable forest management have been listed. The indicators are presented in Table 17.

Tables 15 and 17 show that there is a great amount of coincidence between information needs assessed by the EFICS study and the criteria and indicators identified in the Helsinki process. The only topic that is missing in the EFICS is the socio-economic functions and conditions mentioned in the Helsinki resolutions. Except for the indicator "forest with access", the other socio-economic indicators (share of forest sector, employment in forestry) cannot be derived from information assessed in forest resource surveys. Thus, the list of selected attributes represents the criteria and indicators of the Helsinki resolutions to a great extent.

Table 17. The Helsinki Resolutions: Criteria and Indicators for Sustainable Forest Management.

Forest Resources	Area of forests and other wooded land Changes in total volume, mean volume and age structure Carbon storage
Health and Vitality	Depositions Defoliation Damages by biotic and abiotic agents Nutrient balance
Productive Function	Balance between growth and removals Forest area managed according to management plan/ guidelines Non-wood forest products
Biological Diversity	Changes in area of natural forest types, forest reserves and protected forest Rare species Genetic resources Proportion of mixed stands Natural regeneration
Protective Functions in Managed Forests	Soil protection Water protection
Other Socio-economic functions and conditions	Share of forest sector Forest with access Employment in forestry

In the following, the 17 attributes selected from the Information Needs Assessment are analysed according to the necessary actions and costs for harmonisation on the European level. For some attributes, several alternatives are described. The analysis of harmonisation efforts will be based on the level of harmonisation that has already been reached. Actions and costs will be analysed according to the necessary methodology development and the additional training, assessment and analysis efforts.

The quantification of harmonisation costs for individual countries is rather critical. On one hand, the estimation of necessary actions is impossible without intensive studies in the countries; on the other hand, the level of salaries varies considerably within Europe. The cost figures in this analysis should be understood as very conservative estimates, i.e. they reflect the minimum of input to harmonise the attributes under consideration on the European level.

The discussion of benefits is not comprehensive. It is presented from the point of view of "classical" forest inventory objectives with a strong emphasis on the productive and protective functions. Users with different backgrounds, e.g. environmental protection agencies or wood processing industries, could probably add additional benefits. Thus the current evaluation has to be understood as a minimum set of benefits which could be reached by harmonisation. The most important benefit for all attributes, however, would be the possibility to provide standardised and comparable information for the decision-makers and would exclude the risk of faulty decisions because of "outliers", i.e. countries whose systems of nomenclature, and thus key statistics, diverge considerably from the average European nomenclatures.

3.1.1 Attribute "Forest Area"

Forest area has been considered to be the most important information to be provided by EFICS and it has been ranked highest by all different groups of potential users. Forest area provides information on forest land, forest cover percentage and changes in forest land. Forest area has to be considered as one of many classes or class combinations in land cover assessments. Thus the attribute forest area itself provides no information on land use, i.e. forest functions. Complementing the assessment of forest area by additional information on the use of forest, widens the scope of information that can be provided. If additional information of the primary forest functions is assessed, i.e. conservation function, protective function, recreation function, or additional information on the structure of forests, i.e. plantations or exploitable forest, the quantification of forest area can be split up for different types of the (potential) uses of forest land. As those splits have not ranked high in the Information Needs Assessment, they are not included in the three target levels and are not discussed in this analysis.

The assessment of forest area on successive points in time enables the quantification of the dynamics of forest area over time. Thus the single attribute ‘forest area’ provides information for the three information topics that ranked highest in the Information Needs Assessment.

The comparison of forest area definitions which are used in the national forest resource assessments showed a great variety of the nomenclature. In central and southern Europe the minimum area, the width and the crown cover of a forest patch are essential components of forest area definitions. The threshold values, however, are selected differently by individual countries. In northern Europe the minimum production of a forest plot is mainly utilised to separate forest from non-forest land. Thus the third level of harmonisation (attribute very difficult to be harmonised) was assigned to the attribute ‘forest area’.

Level of harmonisation:	3	attribute very difficult to be harmonised

What activities and costs are needed to harmonise the attribute?

The three approaches have been considered to evaluate the activities and costs needed to harmonised the attribute forest area.

Alternative 1: the "compromise" rule.
Alternative 2: individual countries should provide additional data according to a harmonised forest area definition.
Alternative 3: adjust existing forest land figures by conversion factors.

Alternative 1: The "compromise" rule.

The primary activity needed to promote this alternative is the definition of the European threshold values for minimum crown cover, minimum stand width and minimum area and the application of those threshold values in all national assessments. The data source used for the assessment (field plots or aerial photography) is not decisive for the definition. It is assumed that the current number of sample plots in each country is sufficient to meet the desired level of precision for forest area in each country. The definition of the three input parameters for the forest area definition requires a common delineation rule to assess the minimum width and the crown coverage of forest patches. This rule has to be developed and applied in all countries.

To keep the cost of harmonisation low, a mixed strategy could be considered:

To take the definition, which is most popular within the countries, and
If changes to that definition will be made, the move should be to a direction which causes less extra work in the countries

Wider forest area definition would mean additional sample plots or other studies in the countries which have strict definition, if the countries measure plots only on pre-defined forest area. Thus, the countries having a more strict definition than the harmonised one, will increase the cost of harmonisation more than the countries where the case is the opposite.

The following measures should be taken in various cases:

A. Countries with a more strict definition: A specific study to assess the forest area between the own, strict definition, and the European one, and/or new plots to be measured on this new lands in the next inventory

B. Countries having a wider definition: The plots which fall in the area between ‘national forest definition’ and ‘European forest definition’, should be assigned in the next inventory. Thus, these can be excluded when deriving the results for EFICS.

C. Countries having some other indicator: Like in A.

For example, if we have the following European forest area definition: Crown coverage 20%, line width 30 m, and stand size 0.25 ha, we have the following conclusions:

Crown coverage 20%

A. Austria (30%): In this country there are two possibilities: 1) to carry out a special study based on aerial photos to find the land area between 20 and 30 % crown coverage, and their forest characteristics, or 2) to measure more plots in the next inventory on that area. The cost of alternative 1) is estimated to be 2 labour years total. If the field crews should measure new plots, the amount of field work in alternative 2) is directly related to the new forest area.

B. France, Greece, Portugal, Spain (10 or and 5%) The area between their definition and 20 % should be studied by assessing on all plots in Spain for instance, if the canopy cover is between 5 and 20 %. These plots can then form their own stratum, which will be not included in the European forest area.

C. Finland, Sweden, Norway (1m3/ha/a), Denmark, Germany, Luxembourg, Iceland (not used) In these countries, to find the difference between their own definition and 20 % canopy cover, additional studies or new measurements (canopy cover estimate) in the next inventory cycle are needed in any case. The former will require 1- 2 labour years/country. The new measurements will require much less time, since these countries measure plots on all lands in any case.

Width 30 m

A. Switzerland, Liechtenstein, UK (50 m) An aerial-photo sample based study to estimate the amount of the land area in forests where the width is 30-50 m. The amount of these areas is not expected to be very high, and thus the study may take a few months, providing that the photos are already available.

B. Belgium, Austria, Denmark, France, Germany, Iceland, Ireland, Italy, Portugal, Spain In these countries in the next inventory, those plots or stands having the width between the national definition and 30 m should be assigned to a separate class. The cost is marginal.

C. Finland, Sweden, Luxembourg, Sweden, Norway (width not used) A small study or consultancy work if the European definition will change anything. Cost: 2 months.

Size 0.25 ha

A. Belgium (VL), Denmark, Greece, Ireland, Netherlands, UK A special study to find forest plots which are between 0.25 ha and 0.5 ha, cost may be 0.5 years per country.

B. Austria, Belgium (W), France, Italy, Norway, Portugal. Plots in the stands smaller than 0.25 ha, but larger than by their own definition, should be separated in the next inventory. Cost is marginal.

C. Switzerland, Germany, Liechtenstein, Luxembourg. A small study to find out if the application of European definition will change anything. Cost: 2 months.

Conclusion

The compromise rule is not applicable without additional assessments in most countries. A common forest area definition has to include minimum crown cover, minimum width and minimum area. As none of the countries will meet all three threshold values, all countries have to introduce the new threshold values and change their assessments accordingly.

This alternative has been considered in the final evaluation of cost of harmonisation.

Alternative 2: Individual countries should provide additional data according to a harmonised forest area definition

The primary activity would be to derive a common definition with threshold values for crown cover, stand width and minimum size of forested patches and clear delineation rules for the forest edge. The new definition could meet two extremes:

wide definition:	small threshold values are specified: 10% crown cover, 10m minimum width and minimum area of 0.05 ha.
restrictive definition:	large threshold values are specified: 30% crown cover, 40m minimum width and minimum area of 0.5 ha.

Table A2 presents the forest area definitions that are currently applied in national forest resource assessments. As no country meets either the wide, or the restrictive definition, new attributes have to be assessed or currently applied threshold values have to be adjusted. Actions are necessary for each country.

Table 18. Currently applied forest area definitions.

Country	Minimum width	Minimum crown cover	Minimum area	Minimum production	Comments
Austria	10 m	30 %	0.05 ha	-	
Belgium	9 m /25 m	-/20 %	0.1/ 0.5 ha	-	
Denmark	20m	-	0.5 ha		trees in the forest should be able to grow taller than 6 m
Finland	-	-	0.25 ha	1m^3/ha/a	
France	15 m	10% or 500 stems/ha with c.b.h < 24.5 cm	0.05 ha	-	
Germany	10 m	-	0.1 ha	-	
Greece	30 m	10 %	0.5 ha	-	
Iceland	-	-	0.25 ha		
Ireland	10 m	20%	0.5 ha	4 m^3/ha/a (coniferous) 2 m^3/ha/a (broadleaf)	
Italy	20 m	20 %	0.2 ha	-	
Liechtenstein	25 m to 50 m	100 % to 20 %	-	-	same definition as CH
Luxembourg	-	-	-	-	only local surveys
Netherlands	30 m	20 %	0.5 ha	-	
Norway	-	-	0.1 ha	1 m^3/ha/a	
Portugal*	15 m	10 %	0.2 ha	-	
Spain	20 m	5 %	0.25 ha	-	
Sweden	-	-	0.25 ha	1 m^3/ha/a	
Switzerland	25 m to 50 m	100 % to 20 %	-	-	functional relationship between minimum width and minimum crown cover
UK	50m	20%	2 ha		

* Refers to the last inventory period. In the current NFI the forest area definitions are 20m, 10% and 0.5 ha.

Table 19. Actions to meet wide forest area definition.

Country	Minimum width	Minimum crown cover	Minimum area
Austria	no change	reduce to 10%	no change
Belgium	reduce to 10 m	new attribute/ reduce to 10%	reduce to 0.05 ha
Denmark	reduce to 10 m	new attribute	reduce to 0.05 ha
Finland	new attribute	new attribute	reduce to 0.05 ha
France	reduce to 10 m	no change	no change
Germany	no change	new attribute	reduce to 0.05 ha
Greece	reduce to 10 m	no change	reduce to 0.05 ha
Iceland	new attribute	new attribute	reduce to 0.05 ha
Ireland	no change	reduce to 10%	reduce to 0.05 ha
Italy	reduce to 10 m	reduce to 10%	reduce to 0.05 ha
Liechtenstein	reduce to 10 m	reduce to 10%	new attribute
Luxembourg	new attribute	new attribute	new attribute
Netherlands	reduce to 10 m	reduce to 10%	reduce to 0.05 ha
Norway	new attribute	new attribute	reduce to 0.05 ha
Portugal	reduce to 10 m	no change	reduce to 0.05 ha
Spain	reduce to 10 m	increase to 10%	reduce to 0.05 ha
Sweden	new attribute	new attribute	reduce to 0.05 ha
Switzerland	reduce to 10 m	reduce to 10%	new attribute
UK	reduce to 10 m	reduce to 10%	reduce to 0.05 ha

Table 20. Actions to meet restrictive forest area definition.

Country	Minimum width	Minimum crown cover	Minimum area
Austria	increase to 40m	no change	increase to 0.5 ha
Belgium	increase to 40m	new attribute/ increase to 30%	increase to 0.5 ha/ no change
Denmark	increase to 40m	new attribute	no change
Finland	new attribute	new attribute	increase to 0.5 ha
France	increase to 40m	increase to 30%	increase to 0.5 ha
Germany	increase to 40m	new attribute	increase to 0.5 ha
Greece	increase to 40m	increase to 30%	no change
Iceland	new attribute	new attribute	increase to 0.5 ha
Ireland	increase to 40m	increase to 30%	no change
Italy	increase to 40m	increase to 30%	increase to 0.5 ha
Liechtenstein	fix at 40m	fix at 30%	new attribute
Luxembourg	new attribute	new attribute	new attribute
Netherlands	increase to 40m	increase to 30%	no change
Norway	new attribute	new attribute	increase to 0.5 ha
Portugal	increase to 40m	increase to 30%	increase to 0.5 ha
Spain	increase to 40m	increase to 30%	increase to 0.5 ha
Sweden	new attribute	new attribute	increase to 0.5 ha
Switzerland	fix at 40m	fix at 30%	new attribute
UK	decrease to 40m	increase to 30%	decrease to 0.5 ha

Tables 19 and 20 present the actions that are necessary on the national level to meet the harmonised restrictive and wide forest area definition. Irrespective of which forest area definition (threshold values) will finally be applied, each country has to adjust its forest area definition. The additional costs for each country are evaluated under two assumptions:

Assumption 1: The countries introduce new definitions in their next assessment season, but do not conduct special assessments between assessment seasons. Therefore, it takes more than a decade from now to get harmonised data on forest area in Europe.

Assumption 2: The countries record the values of minimum width, minimum crown cover and minimum area according to the new definition. This enables the countries to maintain forest area estimates according to their individual definitions.

The cost associated with the introduction of a new forest area definition is somewhere between the extremes presented below. In Finland, France, the Netherlands and Sweden, plots are assessed on forest and non-forest land, i.e. trees outside forests are included in the assessments. In those countries, no additional costs for tree measurements are necessary (see comparative study, sampling frame).

Costs for wide forest area definition

In all countries that assess trees only inside forest land, additional measurements are required. The number of forest plots increases especially in those areas where a natural timberline exists (alpine region, drylands or northern peatlands and fjells), i.e. in Finland, Norway, Sweden, Austria, Liechtenstein, Switzerland and Greece, due to the reduction of the threshold values for crown cover, width and area. In these countries, the costs necessary to meet the restrictive forest area definition are high. However, it cannot be quantified how many new plots are necessary as the number depends very much on the spatial and structural patterns of forests.

In most Central European countries the number of additional plots will be rather low and thus the cost implications are minor.

In Italy, the additional costs are relatively high, as all plots with width between 10 m and 20 m and crown cover between 10 and 20% and minimum areas between 0.05 and 0.2 ha have to be included as well. In Spain and Portugal, the costs would probably be low, as only very few additional plots have to be assessed. These two countries already apply low threshold values. In Greece, the costs will be relatively high, as all plots with a width between 10 m and 30 m and a minimum area between 0.05 and 0.5 ha have to be included.

In Austria, additional plots have to be assessed, especially in the Alpine region, as all plots with crown cover between 10% and 30% have to be included. In Liechtenstein and Switzerland, the assessment of additional plots is necessary, as the threshold values for minimum width and the minimum crown cover are lowered. In the Alpine region of France and Germany, an increase of the number of plots is very likely to occur. The assessment costs of plots are very high in the Alpine region due to poor accessibility and problematic terrain characteristics. Thus the increase of costs will not be proportional to the number of additional plots but will be approximately 150 % higher.

Denmark and Luxembourg have to introduce sample based approach, which results in high costs.

In Norway, Finland and Sweden, all plots are visited in the field irrespective of forest area definition. Thus only few additional efforts are necessary in these countries.

Costs for restrictive forest area definition

In all countries, especially in those with natural timberlines, the number of plots that have to be assessed will be reduced. Open forests with low crown coverage will be less often included in the assessment. This holds true especially in the Alpine region, in Spain and in Portugal. The assessment costs are lower than with the current national definitions. Even if additional attributes have to be assessed in some countries, the assessment costs will not be increased significantly.

Conclusion

The reliability of forest area figures would be high, if a harmonised forest area definition was applied in Europe. However, there would be some major drawbacks. The sampling frame of each individual country would be changed, as it is set by the forest area definition. On the additional (new) forested plots, all attributes assessed on forested plots have to conducted in addition. This would effect the cost of harmonisation tremendously. All area-related figures will change, e.g. volume per hectare or increment per hectare. No consistency over time will be obtained for individual countries, if the individual, old definitions are not maintained in addition to the new, harmonised definition. The characteristics of different forest ecosystems and eco-regions are not taken into account.

The costs for implementing the new definitions are high for many countries. Thus it is not very likely that the new definitions are accepted by individual countries, unless a share of costs is provided.

During the Kotka III meeting it was decided to introduce a minimum crown cover of 10 percent in the UN-FAO/ECE Forest Resource Assessment 2000 (FRA 2000). In the last global FRA which presents figures for 1990, a 10 percent threshold was used for the tropical and sub-tropical zone and a 20 percent threshold for the temperate and boreal zone (TBFRA 90). Introducing the 10 percent threshold value on the European level, would require major activities in all countries, except Greece, Spain and Portugal, as the wide forest area has to be applied. At the moment it is not clear how FRA 2000 and TBFRA 2000 will maintain their own time series and how European countries can provide data according to the new FAO-definition.

Alternative 3: Adjust existing land figures by conversion factors

The primary activity would be to develop a harmonised forest area definition. Based on the national definitions, conversion factors that transfer national figures into harmonised ones have to be derived. Besides the national forest area definitions, the forest structures and spatial patterns of forests have to be taken into account separately for each country. The effect of the conversion of national into harmonised figures would be significant in countries with natural timber lines and definitions, and where high minimum crown covers, minimum width and minimum areas are applied.

Costs

The derivation of conversion factors renders additional studies necessary. Those studies have to include revisits of field plots and additional assessments by aerial photographs. Satellite remote sensing images with an acceptable level of accuracy are not yet applicable for the entire Europe. The accuracy is not satisfactory, especially in areas with open forests or small, narrow forest patches. The studies have to be undertaken in all countries and result in approximately 1 to 3 person years per country.

Conclusions

The forest area in individual countries, and thus the area related attributes will change. The approach is likely to be accepted by the countries, as the national definitions and forest area estimates are maintained over time and - besides the studies for the construction of the conversion factors - no additional costs have to be covered by countries.

The accuracy will be low in countries with natural timberlines. Changes over time cannot be captured in those areas, as the inaccuracies of the assessments will be larger than the changes itself.

It is assumed that the studies undertaken to derive conversion factors are conducted in a degree of detail and to an extent where all forested areas of countries are covered. The reliability of the conversion factors depends on the forest structures and spatial patters of forests. The more open forests, and narrow small patches, the less reliable the conversion will be. The conversion factors have to be updated and checked over time.

3.1.2 Attribute "Tree species"

Tree species is an attribute that is assessed in all national forest inventories. The assessment is based on scientific names in all countries. However, there are differences in grouping the tree species. The attribute has already reached a sufficient level of comparability.

Level of harmonisation: 1, already sufficient level of comparability

Actions

There are no actions necessary to harmonise the attribute. The only problem occurs when rare species are grouped together (ssp.), which could be solved by two alternatives:

Alternative 1: Assessment of all species according to scientific key.
Alternative 2: Assessment or grouping of tree species to genus.

Alternative 1 requires an enlargement of the species keys for individual nations, which could easily be done by following standard classification keys. Alternative 2 could be implemented by grouping the species. However, some information on generally rare species, or on locally rare species would be lost. Alternative 2 is closely linked to the attribute tree species composition.

Costs

Except for additional training efforts for field crews, no major costs are necessary for the assessment. Each country has to either provide the tree species codes, or recode tree species according to a general code provided by EFICS. The efforts concerning data manipulation or data base modification (include a new attribute "EFICS-tree species code") are minor.

Conclusions

The harmonisation of this attribute does not affect national systems of nomenclature. The only actions to be introduced on the European level are to enlarge the list of tree species that are assessed in some countries (and to train the field crews accordingly), and to recode the national tree species codes.

3.1.3. Attribute "tree species composition"

In national forest inventories tree species is assessed for each tallied tree, i.e. trees that are selected on sample plots, and is available for all national assessments, except Denmark and Luxembourg. However, if only tallied trees are considered, regeneration or young plantations are not included. Under the assumption that a common minimum d.b.h. is introduced, the tree species composition can be provided either based on number of trees, or based on weighting factors, such as basal area or volume. Different groupings are possible, e.g. coniferous/deciduous trees, or more detailed tree species groups. The attribute has already reached a high level of compatibility.

As in national forest inventories tree species composition is derived from tallied trees, it is given for the unit (area) of reference, except for individual stands. Except for extremely large, homogenous stands, e.g. even-aged, single species stands in the boreal zone or large scale plantations, the number of sample plots applied in national forest inventories is generally too small to provide information on the stand level.

Level of harmonisation: 2 attribute not comparable but could be harmonised

Activities

The compilation of tree species composition can easily be done based on the national data already available. If tree species groups are required, the species assigned to the species groups have to be listed.

If young growth (regeneration and plantations) have to be included, all countries have to assess trees below the national threshold values for d.b.h. and tree height in addition.

If the area occupied by individual tree species is requested, it can be assessed based on the trees tallied on each plot. The proportion of individual tree species with relation to number of trees or basal area can be used to weight the plot area and to come up with an estimate for the area covered by individual tree species.

The countries have various definitions and classifications for tree species composition. However, since tree species are defined in a similar way in all countries, basic information for grouping tree species in necessary classes exists in all countries. In those countries, where trees are tallied by species, like in all sample based inventories, almost any groping can be carried out by using existing inventory materials. In the few countries where trees are not tallied, additional data should be collected.

Tree species composition is needed to estimate the state of the forest ecosystem, and for evaluating future possibilities for timber harvesting. In the latter, certain silvicultural rules should be assumed. If we take the state of the forest as baseline, the tree species composition could be defined as follows:

Share of 3 most common tree species in the stand/ plot, using 10 % classes of basal area or volume.

This kind of classes can be found in some countries, but in most countries it is easy to provide these classes by deriving their forest inventory results once more. Depending of the information systems in the countries, the labour cost for deriving these results can vary from 1 week to 2 months.

Costs

No additional costs are necessary for the assessment, if only tallied trees (trees of a minimum size) are included. The area of regeneration, recently afforested areas and young plantations are not included in this approach. The cost for introducing weighting factors are low, since only simple, additional analysis based on existing data is required. The cost of the preparation of tree species lists for grouping tree species can be neglected.

Conclusions

Based on harmonised tree species codes and the introduction of a common minimum threshold value for d.b.h., information on tree species composition can easily be obtained with minimum efforts.

3.1. 4 Attributes "Areas of forest that fulfil protective function" and "Areas of forests that fulfil conservation function"

The conservation function is assigned to forests, especially for areas which are protected or where land use restrictions are valid. The protective function includes protection from snow, rain, erosion, noise, air pollution, wind and floods. The assignment of either of the two functions to forest land does not regard land cover - which is assessed by the attribute forest area - but land use.

(Forest) areas of protective or conservation function are defined by national laws. It is the task of the EU to give a framework for the national laws to define the properties of those areas. The harmonisation efforts are more related to legislation than to the nomenclature used in forest inventories, and are thus beyond the scope of EFICS.

Level of harmonisation: 2 attribute not comparable but could be harmonised

Actions

The area of forests to which conservation and protective functions are assigned has to be included in the national assessments. The national procedures to assign these specific functions to a forest patch differ considerably.

Costs

The national definitions and procedures have to be compared. A comparative study to meet this goal is already launched (Cost Action E4: Research network of Nature Forest).

A further study could focus on the description of the indicators which are closely correlated to the potential protective or conservative functions of the forest area. These indicators and the measurement rules have to be defined clearly to get sufficient and comparable results from sample based forest inventories. Aerial photographs and thematic maps combined by a GIS would be the most promising solution to derive those indicators.

Conclusions

As long as no common rules exist in Europe to regulate the assignment of protective and conservation status to forests, the two attributes under consideration can only reflect the habits of individual countries to assign those functions. Comparisons between countries are difficult.

Indicators which quantify the potential protective and conservation function could be selected. However, the results of those assessments and analyses might easily be in contradiction with the national figures.

3.1.5 Attributes “Drain” and “Removals”

These two terms are closely associated and will thus be discussed together. The terms are widely used in northern European countries. Kuusela (1994) gives definitions for the terms drain and removals. Other countries apply a different terminology which follows Beers (1962). Instead of drain and removals the terms mortality and cut are used. Both approaches, however, describe the volume of woody material that is lost from the growing stock.

According to Kuusela (1994) drain is the “volume of those trees which are removed by forestry measures and natural causes from the growing stock“, natural losses is "volume of those trees which die of natural causes", and fellings are "drain minus natural losses, volume of those trees which are removed from the growing stock by forestry measures".

Fellings are not necessarily removed completely from the stand, and are thus subdivided in removals and logging residuals. Removals is the proportion or total volume of fellings (wood) extracted from the stand. Logging residuals are the proportion or total volume of fellings which remains in the stand. Logging residuals are typically made up by branches, parts of the stem below a threshold diameter and woody parts of the tree that show decay or other defects.

The term removals is not defined in a sound way and is used in various meanings. Some authors describe removals as all woody material that is removed from the growing stock, others use the expression to quantify the woody material that is removed from the stand. Here it is assumed that removals describe the latter, i.e. woody material removed from the stand.

Kuusela (1994) uses this terminology to describe a concept he calls "forest balance". However, it has to be mentioned that this terminology is not generally used nor understood in other than northern European countries. Even in the USA and Canada this approach is not widely accepted.

In most European countries, as well as in North America, the more simplistic definitions of Beers (1962) are used. He defines the terms mortality and cut to describe losses from growing stock. Beers gives the following definitions:

"Mortality is the number or volume of trees periodically dying from natural causes such as old age, competition, insects, diseases, wind and ice."

"Cut is the number or volume of trees periodically felled or salvaged, whether removed from the forest or not."

Merging the two definitions brings some clarification to both concepts and allows to derive a harmonised approach for the European level.

Separating fellings and natural losses into two classes, one quantifying the wood that is taken out of the stand, and other quantifying the wood that remains inside the stand, is essential especially in those regions, where a fairly small amount of wood can be utilised because of technical or natural defects. Thus the cut itself does not necessarily provide a sound figure on the amount of wood that can actually be utilised, or on the amount of biomass taken from stands.

Both concepts, forest balance, as well as the comparison of growth components as described by Beers (1962), make it possible to describe the dynamics of the wood resources in a defined area on the basis of successive forest inventories and enable to cross-check statistics of growing stock, increment, natural losses and fellings over time. At the moment, the concept of drain and removals is used mainly in Scandinavian countries. The attributes drain and removals are not comparable on the European level but could be harmonised.

Level of harmonisation: 2 attribute not comparable but could be harmonised

Actions

Growth components are typically derived from single tree volumes. A "tree history code" is showing to which class an individual tree has to be assigned: survivor tree, ingrowth* , cut (felled) or mortality (natural loss). In forest resource assessments it is not possible to assess removals directly. They have to be modelled according to data gathered in specific studies (exploitation surveys) and are of similar character as models for assortments of standing trees. The models can be, but do not necessarily have to be based on stump tallies. In national statistics removals are often calculated based on timber market surveys.

A key to harmonise the attributes drain and removals is the introduction of a harmonised tree history code. An enlarged tree history code has to be established in some countries to record the history of sample trees measured in successive occasions in more detail. At minimum, the tree history classes drain, fellings, ingrowth and survivor trees have to be assessed. For each class the amount of timber has to be recorded or analysed. The amount of the timber volume of fellings and natural losses that is removed from the forest stand has to be quantified by models. These models have to be developed for most European countries.

Particular problems to record single tree history exist in surveys where point sampling (Bitterlich sampling) is applied. Due to the tree selection with varying probability drain and ingrowth is difficult

* Ingrowth is the number or volume of trees periodically growing into measurable size.

to assess. Even if stumps are included in the point sampling process to assess fellings, great care has to be taken to avoid biased results. It is widely accepted that ingrowth (trees having a d.b.h. smaller than a d.b.h.-threshold value in the first and having a d.b.h. larger than a d.b.h.-threshold value in the second survey) can hardly be separated from ongrowth (a tree having a d.b.h. smaller than d.b.h. of a borderline tree in the first survey and having a larger d.b.h. than the d.b.h. of a borderline tree in the second survey, i.e. not being tallied in the first but in the second survey) in point sampling.

Volume of fellings, natural losses, removals, logging residuals and growth of survivor trees can be given either inside or outside bark. This problem will be dealt with, in detail, under the attribute "single tree volume". Conversion factors have to be developed that relate volume inside and outside bark. Kuusela (1994, page 26) provides tables where the conversion factor is presented as a ratio RUB/F (Removals under bark/Fellings) for different country groups. The ratio varies between 0.68 (Mediterranean East) and 0.92 (Central) with a mean value of 0.84 for the entire Europe.

In the simulation study, the relationships between different terms of growth components are presented in more detail.

Costs

The development of a nomenclature for a unique tree history code that enables the derivation of growth components such as cut, survivor trees, mortality or ingrowth is essential. Deriving a tree history code is possible with marginal cost if the definitions by Beers (1962) are followed. For surveys on successive occasions these definitions are straightforward and are applied in European countries, such as Austria, France or Switzerland.

In each country, models have to be developed to separate fellings into logging residuals and removals. These models have to be more sophisticated than the amount of natural agents that lower the value and quality of timber increases, i.e. the models for the Mediterranean, Alpine and Arctic regions need substantial efforts. Separate models have to be derived for individual tree species; influencing factors are stand age, stand structure and natural and environmental conditions. The minimum amount of work needed for each country is 3 person years, but the amount can be substantially higher especially for the Mediterranean region. These models are required if the concept of forest balance as described by Kuusela (1994) should be introduced on the European level and fellings have to be separated into logging residuals and removals.

An alternative for modelling removals would be to conduct an independent timber market survey, where the supply and demand of timber is compared to the volume assessed for fellings and mortality. This approach could be realised with less efforts but would result in less accurate results.

Conclusion

The quantification of drain and removals provides essential figures about the European timber market. At the moment the concept is applied only in the Scandinavian countries. Thus valuable information is not available on the European level.

3.1.6 Attribute “single tree volume”

Single tree volume is one of the most important attributes to describe the productive function of forests. However, it cannot be assessed directly, instead it has to be derived by volume functions or taper curves. Different types of volumes are utilised throughout Europe using d.b.h., upper stem diameters and tree height as input parameters. Those three input parameters are used to model the stem form of individual trees. The ability of a volume function to take into account varying stem forms is crucial for the prediction errors and the accuracy of the function.

As stem forms vary considerably for different tree species, genotypes and growth conditions, it is very difficult - if not impossible - to derive single volume functions for the entire Europe. Volume functions are a major topic in forest growth and yield research and it can, without any doubt, be assumed that the individual countries have derived sound and accurate volume functions which reflect stem forms in an appropriate way. However, different definitions of single tree volume are applied in Europe. Threshold value for top stem diameters and d.b.h. differ, volume inside and outside bark is reported, and branches can be either included (Greece, Spain and partially, Italy) or not (all other countries). Table 21 presents information on the concepts of single tree volume utilised in the EU and EFTA countries.

Table 21. Single tree volume.

Country	Minimum d.b.h., cm	Minimum top stem diameter, cm	Including branches? yes/no	Including bark? Yes/ no	Starting point of volume
Austria	5	0	no	yes	ground
Belgium	7	7	no	yes	stump
Denmark	does not apply				
Finland	0	0	no	yes	stump
France	24.5 (C.b.h.)	7	no	yes	ground
Germany	7	7	no	yes	ground
Greece	10	0	yes	yes	stump
Iceland	1	0	no	yes	ground
Ireland	7	7	no	yes	ground
Italy	3	0 = conifers 3 = deciduous	no = conifers yes = deciduous and pines with large crown	yes	stump
Liechtenstein	12	0	no	yes	ground
Luxembourg	0	0	no	yes	ground
Netherlands	5	0	no	yes	ground
Norway	5	0	no	yes/no	stump
Portugal	5	0	no	yes	ground
Spain	7.5	7.5	yes	yes	stump
Sweden	0	0	no	yes	stump
Switzerland	12	7	no	yes	ground
the United Kingdom	0	0	no	yes	ground

Currently the attribute single tree volume is not comparable on the European level but could be harmonised.

Level of harmonisation: 2 attribute not comparable but could be harmonised

Setting a threshold value for d.b.h. might be crucial for some countries that include trees with small d.b.h. values in their surveys. For example, Finland which has ‘0’ minimum d.b.h., would loose 18 percent of its total volume if the Swiss d.b.h. threshold value of 12 cm would be applied. It can, however, not be quantified how much countries with large d.b.h. threshold values (Belgium, France, Germany, Greece, Ireland, Liechtenstein, Spain, Switzerland) would gain in total volume if a lower minimum d.b.h. would be introduced, because there are no data on trees with small d.b.h. available on national scales.

Applying the "smallest common denominator rule" for d.b.h. would mean that all countries would report only the volume of trees with d.b.h. larger than 12 cm. This approach would not consider the structure of forests in some European regions, such as boreal forests or forests in the Mediterranean area, where the new definition would result in a significant loss of total volume. Thus this approach is not feasible.

If a d.b.h. threshold value of 0 cm is introduced, i.e. all trees standing on a plot are tallied independent of their size, the future potential and dynamics of forests could be described best. This is, however, the approach that maximises the amount of activities and costs on the European level. As it is very likely that a 0 cm threshold value will not be accepted on the European level, this approach was not considered.

Actions

Common threshold values have to be defined to harmonise the attribute single tree volume on the European level. The threshold value for the upper stem diameter has only low impact on the calculation of total volume (approximately 1-2% of total volume) which can be seen from the simulation study. Thus the only threshold value to be standardised is d.b.h. Minimum d.b.h is the most crucial measure for volume calculation. Minimum d.b.h values in the European countries range between 0 cm (Finland) and 12 cm (Switzerland, Liechtenstein). A minimum d.b.h. threshold below 5 cm should not be defined, as this would force the majority of countries to validate or modify their volume functions. Besides this, countries would have to assess too many small trees, which have only a minor contribution to total volume. A d.b.h. threshold of 5 cm would, however, be a compromise. Also standardising the starting point of volume should be considered, because the difference between the volume without the stump and with it is 3-5%.

Costs

Each country that has to lower its d.b.h. threshold, has to conduct special experiment with the objective to verify the accuracy of the volume functions below the threshold value to which they have been applied before. Those countries might have to extrapolate their functions beyond the range of data that were available when the volume functions were derived. This could lead to serious bias for small trees, even resulting in negative volume values for individual trees. These studies are essential for Switzerland, Liechtenstein and Greece, and require intensive, additional single tree measurements to verify old or develop new volume functions. In those countries at least 10 person years are necessary for intensive tree measurements and to develop or modify the existing functions. In Belgium, France, Germany, Ireland, and Spain, the verification of volume functions is probably the only activity that has to be performed. The efforts in each country are 1 person year. Denmark has to check available functions for their suitability in the scope of a sample based assessment. If new developments and additional intensive single tree measurement turn out to be necessary, at least 10 person years are needed. All other countries (Austria, Finland, Iceland, Italy, Luxembourg, Netherlands, Norway, Portugal, Sweden and the UK) do not have to undertake any efforts and validate their volume functions, if a minimum d.b.h. threshold of 5 cm is introduced.

Belgium, France, Germany, Greece, Ireland, Liechtenstein, Spain and Switzerland would have to assess additional trees in their national forest inventories, which would increase the assessment costs substantially. Depending on the average diameter distribution in the country and the forest structure (proportion of evenaged and unevenaged stands), the total field assessments costs could be increased by up to 5 percent.

Greece is the only country including branches in volume figures. Italy includes the volume of branches for deciduous trees and pines with large crowns only. Those countries have either to derive new volume functions that quantify volume without branches, or to develop conversion factors that transfer volume including branches into volume excluding branches. In Spain there are already equations for the estimation of volume of branches separately. The efforts for new volume functions would be approximately 10 person years, and for the development of conversion factors roughly 2 person years per country. Additional assessments for these studies might be necessary.

Conclusion

Single tree volume is an attribute that is crucial for information on the productive function of forests and for timber market issues. It is a major input to other attributes, such as volume increment. The volume functions in individual countries are reliable but have to be checked in those countries where threshold values are changed. Luxembourg and Denmark have to undertake major efforts to develop assessment methods that are comparable to other European countries. Spain, Greece, Italy and UK have to undertake efforts to adjust their volume functions to the common European nomenclature. In those countries where the d.b.h. threshold changes, the selection probability for small trees changes as well, and by this the sampling frame changes, requiring additional efforts in field assessments. The comparability of national results over time is not affected as the old approaches could be maintained by each country.

3.1.7 Attribute "Volume increment" and "Increment of volume components"

The two attributes, volume increment and increment of volume components, are directly related. Different approaches have been described to calculate both attributes. The most comprehensive summary of approaches is given by Beers (1962). According to Beers (1962), growth is made up of the components survivor growth, ingrowth, mortality and cut. Ingrowth is the number or volume of trees periodically growing into measurable size, mortality is the number or volume of trees periodically dying from natural causes, cut is the volume or number of trees felled between two occasions, and survivor growth is the growth related to trees observed at the first and ongoing occasions. On the basis of these definitions, Beers (1962) presented growth terms for continuous forest inventory (CFI) analyses for two different approaches. One approach deals with groups of volume data where tree volumes at each terminal of the growth period are totalled with no attempt made to pair successive volumes of each individual tree. In the second approach, successive tree volumes are paired to determine the growth contribution of each tree. This approach is called the tree level approach. The equations for both approaches differ but fortunately lead to the same results. Although Beers stressed volume growth, the terms are equally appropriate if another characteristic, such as basal area growth, is considered. In Table 22 the equations presented by Beers are given with the following components of growth.

The importance of the tree history code has been stressed under the attributes drain and removals. For the estimation of growth components the tree history code is essential as well. Mortality and cut must be recorded separately to calculate increment of volume components. The different models to calculate volume increment include the volume calculation of increment components.

V_1 = the volume of trees measured on the first occasion = V_{S1} + M + C
V_2 = the volume of trees measured on the second occasion = V_{S2} + I
V_{S1} = the initial volume of survivor trees
V_{S2} = the final volume of survivor trees
G_S = survivor growth
M = the initial volume of trees dying during the period between inventories
C = the initial volume of trees cut during the period between inventories
I = the volume of trees grown into measurable size between first and second occasion

Table 22. Equations for growth estimation (after Beers, 1962).

Formula if using		
Type of growth	**Volume totals**	**Individual tree growth figures**
Gross growth of initial volume	$=V_2+M+C-I-V_1$	$=V_{s2}+I+M+C-I-V_{s1}-M-C$
		$=V_{s2}-V_{s1}=G_s$
Gross growth	$=V_2+M+C-V_1$	$=V_{s2}+I+M+C-V_{s1}-M-C = G_s+I$
Net growth of initial volume	$=V_2+C-I-V_1$	$=V_{s2}+M+C-I-V_{s1}-M-C$
		$=G_s-M$
Net growth	$=V_2+C-V_1$	$=V_{s2}+M+C-V_{s1}-M-C$
		$=G_s+I-M$
Net increase	$=V_2-V_1$	$=V_{s2}+I-V_{s1}-M-C$
		$=G_s+I-M-C$

The analysis of activities and costs is based on the assumption that the attribute single tree volume is harmonised on the European level. Currently, the attributes volume increment and volume increment of growth components are not comparable on the European level but could be harmonised.

Level of harmonisation: 2 attribute not comparable but could be harmonised

The equations presented above do not take into account the growth of mortality and cut between two occasions. Ingrowth is assumed to be present on the plot for the entire time period between two occasions. Thus the equations underestimate growth and lead to biased results. The volume of the growth components of mortality, cut and ingrowth cannot be assessed but has to be modelled. It can be assumed that trees which were cut or which died between two occasions have half of the volume growth of a tree with the same d.b.h. on the first occasion, and that ingrowth has half of the volume growth of a tree with the same d.b.h. on the second occasion. These simplistic assumptions "average" growth and provide rather realistic figures (Köhl, 1994). This approach requires the construction of growth functions which utilise attributes such as d.b.h., altitude or tree species as independent parameters. In many practical applications, however, the growth of mortality, cut and ingrowth between two occasions is not considered.

Activities

The smallest common denominator is the calculation of volume increment by subtracting volume on the occasion 1 from volume measured on the occasion 2. This approach is called net increase by Beers (1962). Applying this approach, no tree history code is necessary. The forest balance or cut and mortality cannot be calculated and have to be estimated from other non-sampling based data sources like statistical yearbooks etc.

The calculation of the volume of growth components requires the assessment of the tree history code. The calculations are straightforward, but have to follow a common approach, i.e. one of the types of growth defined by Beers (1962) has to be applied in all countries.

If the growth mortality, cut and ingrowth between two occasions have to be quantified, growth models have to be derived for all countries.

Costs

Assuming that the tree history approach is assessed in all countries for each tallied tree, and that a common concept of single tree volume has been introduced, the necessary costs for harmonisation are marginal. Each country has to apply the standardised type of growth calculation, which requires minor national efforts. For each country, the efforts should not exceed 1 person month.

The cost for deriving growth functions are rather high for individual countries. Differences of tree growth caused by tree size, stand structure, site quality, climatic conditions, and management regimes have to be taken into account. For each tree species in a country several months are necessary to derive the growth functions, assuming that the data from successive surveys are available and cover all forest types.

Conclusion

Assuming that a common approach for single tree volume and the assessment of the tree history code has been implemented in national forest resource assessments, the attributes volume increment and volume increment of growth components can be harmonised with minor efforts. National procedures to calculate volume growth and volume of growth components could be maintained.

3.1.8 Attributes "Naturalness", "Fragmentation" and "Biodiversity"

Currently the attributes naturalness, fragmentation and biodiversity are not assessed in any national forest inventory. These attributes have to be collected in addition to the current ones. Definitions and assessment techniques could be developed on the European level. National solo attempts should be omitted.

Level of harmonisation: 4 attributes to be collected in addition to the current ones

Actions

Naturalness of forests has been expressed in the scope of the two types of forest; natural and cultural, the latter being maintained by man. However, no clear concept to assess naturalness exists, and the attribute is not considered in European forest resource assessments. Harmonisation efforts are needed, but do not have to take into account national nomenclatures or assessment methods - as they do not exist. A link may be envisaged with the Natura 2000 initiative and the new Special areas of Conservation identified as part of the EC Habitats Directive 1994.

The concept of naturalness is not clearly defined. It could be understood as the difference between the natural forest composition and the existing one. The way to derive the natural forest condition is not obvious. Models taking into account climate, soil, site, topography, eco-region and other factors have to be constructed to predict the natural forest vegetation. The modelling has to consider the temporal (succession) aspect, as well as the spatial aspect. For each sample plot, the location and the natural forest composition has to be derived and compared with the existing one. However, it is felt that the construction of a unique model and the agreement on a common index for naturalness needs major efforts. This could involve discussions with organisations associated with the EC habitats directive.

Biodiversity is a term that is nowadays widely used. However, the understanding and definition of the term varies considerably. The Helsinki process and Agenda 21 stress the conservation of biodiversity, but no practicable techniques have been developed to include biodiversity in sample based forest surveys so far. Diversity indices could easily be introduced in national assessments, but they are not free of problems (see for example Köhl and Zingg, 1996). In the scope of national forest resource assessments genetic diversity cannot be assessed. Species and habitat diversity could be assessed via indicators that define key habitats. The valuation and interpretation of forest biodiversity has to take into account the specific natural situation in the European eco-regions.

Fragmentation can be quantified via fragmentation indices. Recently, many attempts have been undertaken to derive fragmentation indices based on remotely sensed data. Fragmentation can hardly be assessed on field plots, except for the fragmentation of small parts of the forest edge. Fractal dimension uses perimeter-to-area calculations to provide a measure of complexity of patch shape. Fractal dimension is an indicator for the complexity of spatial patterns. This indicator can be used to select areas which are suitable for species inhabiting edges or require multiple habitats. On the other hand, it can be used to select areas which are suitable for species inhabiting large, contagious areas.

Basic studies would be necessary to develop approach for each of these attributes. Special emphasis has to be laid on clearly defined quantitative measures which can be assessed from remote sensing data, or on field sample plots, or in the neighbourhood of the sample plots, and which are reliable indicators for the basic attributes.

Aerial photographs or satellite images are appropriate data sources for landscape fragmentation measures. These data sources, particularly the latter one, have not been introduced in the majority of national forest resource assessments.

Costs

The development of assessment methods and systems of nomenclature should not be undertaken as national solo attempts, but have to be co-ordinated on the European level instead. A joint effort to develop assessment methods would decrease the development methods dramatically and result in a harmonised system and comparable data. However, regional and sub-regional aspects have to be considered in developing the methods. The cost for providing a sound, harmonised approach cannot be underestimated and will certainly be higher than 100 person years.

Conclusion

Changes in inventory objectives and information needs require the inclusion of biodiversity, naturalness and fragmentation in national forest resource assessments. As those attributes are not yet included in national assessments, there is a great chance to derive harmonised approaches from the very beginning. Information on these attributes, however, is not likely to be available in the very near future.

3.1.9 Attribute "Plant species/floristic composition"

Plant species are based on biological names, thus this attribute is already harmonised. Shrub, berry, herbal and other plant species are included. Subspecies are often combined to classes like oak ssp. In the case of subspecies grouping, a list of included subspecies and relative shares should be provided.

The attribute floristic composition is also determined by biological names. The shares are given in number per area unit, or in relative shares like area coverage. As different classification systems are applied in individual countries - sometimes even within countries - harmonisation is rather difficult. The major constraint in harmonisation activities are the differences in abundance of plant species. Floristic compositions of different eco-regions are not comparable.

Taking into account the biological meaning of plant species abundance and floristic composition, it is felt that those attributes should not be harmonised on the European level. The countries should rather provide information about eco-floristic regions or vegetation types.

3.1.10 Attribute "Forest margin/clearings"

Intensive assessments of forest margins and clearings are the exception in national forest surveys. Thus basic studies have to be undertaken to provide a sound knowledge on quantitative sample based measures to quantify the structural properties of forest margins.

Level of harmonisation: 2 attributes not comparable but could be harmonised

Actions

Forest margins and clearings are very difficult to assess. One of the most crucial problems is the grouping of forest margins, and the determination of the scale i.e. the grain and extent of the area where measurements have to be conducted.

The easiest approach to provide information on this attribute would be a binary assessment, i.e. two classes: forest margins/clearings present or not. This attribute could easily be included in national forest surveys.

This approach, however, provides no information on the structural diversity and spatial characteristics of forest margins/clearings. Here basic studies are unavoidable. Attributes such as the exposition, the structure (shelterbelt, shrub belt, herbal belt) density, shape (straight, intended, patchy, undulating), the limits (roads, water bodies, meadows etc.) and the surroundings (arable land, settlements etc.) of the forest margin have to be included in the assessment. Beside the development of sample based assessments, the valuation and interpretation of figures on forest margins has to be considered and take the specific characteristics of eco-regions into account.

Costs

Reporting the percentage of sample plots with and without forest margins can be implemented in forest resource assessments with minor costs. A more detailed assessment of forest margins - and only this would be suitable to provide sound and meaningful information - requires major efforts. As with the attributes of biodiversity, fragmentation and naturalness, these attempts should be co-ordinated to guarantee a harmonised approach for national forest inventories. For the Nordic, Mediterranean, Oceanic and Central regions of Europe more than 10 person years each would be necessary for the development of preliminary methods.

Conclusion

Changes in inventory objectives and information needs require the implementation of information on forest margins and clearings. Both are parts of biodiversity, naturalness and fragmentation. As those attributes are not yet included in national assessments, there is a great chance to derive harmonised approaches from the very beginning. As the efforts for method developments are relatively small, the harmonised methods could be implemented in national forest inventories rather soon.

3.1. 11 Attribute “Dead trees or other woody materials”

Dead trees or other woody materials are indicators for forest biodiversity. Currently the attributes, as they are assessed in national forest inventories, are not comparable at the European level.

Level of harmonisation: 2 attributes not comparable but could be harmonised

Actions

The primary action would be to define measures of dead trees, e.g. the number, the volume or the d.b.h. of dead trees ad other woody material. The definition of the term „dead tree“ has to be unified. It could be a standing dead trees (snag) or a lying dead tree. The Finnish rule could be applied, which considers material that can still be used to heat a sauna to be wood, not rotten material.

Minimum threshold values for d.b.h. of standing dead trees have to be defined. They should, however, be the same as those applied for standing living trees.

A common system of nomenclature has to be developed, which requires special studies. The studies have to emphasise the separation of dead and rotten trees.

Costs

The cost for special studies are approximately 3 person years, if the volume estimation for single (living) trees is applied and only tallied trees are considered. Countries, which do not assess dead trees at the moment, would have additional assessment costs. Those costs vary between and within countries. They will be higher in regions with extensive forest management and overmature stands. In central Europe the costs should be marginal as generally less than 1 percent of the trees tallied are dead.

Conclusion

Dead trees and other woody material could be harmonised with rather low cost. The attribute is an important indicator for biodiversity and naturalness.

3.1.12 Attribute "vegetation types"

There are different types of phyto-sociological vegetation classification systems. In the scope of national forest inventories, vegetation types are assessed either based on tree species and tree species composition or based on phyto-sociological classes. Vegetation types can be based on plant species as well. The keys to assign vegetation types or phyto-sociological classes vary between nations and are developed for the specific ecological situation of the country. In some countries, specific phyto-sociological surveys are conducted.

Level of harmonisation: 3 attribute very difficult to harmonise

Actions

Before initiating attempts to harmonise the attribute vegetation type, the ecological meaning of such a harmonisation should be investigated.

A rather simplistic approach would be to apply rules for the separation of forests in three classes: coniferous forests (low, e.g. lower than 15% share of deciduous trees), mixed forests (shares of deciduous trees between 15% and 85%) and deciduous/broad-leaved forests (more than 85% share of deciduous tree species). This rule could easily be implemented, as tree species are already assessed in a harmonised way.

A more sophisticated approach would be to undertake the calculation of main species for each of the three layers: ground, bush and tree layer. The classification could be done according to CEC and Council of Europe, 1987, and thus separate 140 classes. This approach would require the development of assessment rules and could be implemented in the next national inventory cycles.

Costs

The first approach (3 classes: coniferous, mixed and deciduous forests) can be implemented with marginal costs. The classification is based on the assessment of tree species, which is undertaken in all national forest surveys. Only simple calculations are necessary, which should be possible without any additional cost for the individual countries.

The second approach (tree species composition of three layers) requires more efforts. In some countries additional assessments are necessary. As tree species, as well as the social position of trees, are assessed in the majority of national surveys, no additional efforts would be necessary in most European countries. The analysis could be done in the scope of the standard inventory analysis.

Conclusions

The two approaches suggested may not satisfy all user's needs and should be understood as the absolute minimum to satisfy information needs. Approaches as undertaken by plant physiologists are much more complicated to be harmonised and require major efforts. It is, however, doubtful if phyto-sociological surveys are within the scope of EFICS.

3.2 Cost of harmonisation

This chapter presents figures for the cost of harmonisation on the European level. The figures reflect the dimension of work load and the share of individual attributes. They should not be understood as accurate figures that could be used for further detailed project planning. The figures have been discussed by the consortium and have been approved by the country experts.

There are three classes of work to be considered: Small (2-4 months), Medium, (5 months to 2 years) and large (2 years and more), which can be both special studies or additional assessments. The base for the cost estimation for individual attributes were the actions as described in the previous sections. In some cases different alternatives have been described. For the estimation of harmonisation cost, the most feasible alternative was chosen. In the case of forest area the compromise rule (alternative 1) was used.

In all or some countries additional assessments are necessary to provide harmonised data. This holds for forest area, tree species, single tree volume, as well as dead trees and other woody material. For some attributes special investigations and studies are necessary. A common tree history code has to be developed to assess drain and removals, models for removals giving the amount and/or share of removed material as a function of dead and cut trees have to be developed. Some countries with d.b.h. threshold values larger than 5 cm have to develop new volume function, which includes trees beyond the current threshold values, or to verify the consistency of the old functions applied to lower d.b.h. values, and additional assessments of trees with d.b.h. between the harmonised and the national threshold have to conducted. In eight countries growth models have to be developed to be able to assess the growth of volume components, eight countries have to extent the assessments and have to include dead trees and other woody material in addition.

For the harmonisation of some attributes special studies are required. A common assessment method has to be developed for forest margins/clearings, a tree history code has to be derived, and estimation methods for drain and removals have to be formulated. These studies could be co-ordinated by EFICS as they have to be carried out in some or all countries. Rather intensive and large studies are necessary for the assessment of biodiversity, naturalness and fragmentation. Some attributes (tree species composition, volume increment, dead trees, vegetation types) require rather extensive calculations by all countries, which are not very cost intensive.

It has to be emphasised that the cost components listed in the table below do not all have to be covered by EFICS. Many of the activities have to be covered by individual countries. This holds especially true for the largest cost components - the development of assessment methods for biodiversity, naturalness and fragmentation and the assessment of forest margins. EFICS could co-ordinate the research activities and help to avoid parallel studies and national solo attempts.

Attribute/definition	Size of the study	Number of studies needed	Total costs in 19 countries (labour years)	Grand total costs for attribute (labour years)
FOREST AREA 20% crown cover, 30 width, 0,25 ha size	S M L	18 7 1	4 7 2	13
TREE SPECIES	S M L	3	5[6]	5
TREE SPECIES COMPOSITION 3 main species	S M L	19	3	3
PROTECTED AND CONSERVATION AREAS	S M L	19	19	19
DRAIN AND REMOVALS tree history code	S M L	1 1[7]	0.5 4	4.5
DRAIN AND REMOVALS models for removals[8]	S M L	17	34	34
DRAIN AND REMOVALS estimation procedures	S M L	1	0.5	0.5
SINGLE TREE VOLUME threshold 5 cm new volume functions[9]	S M L	9	20	20
SINGLE TREE VOLUME threshold 5 cm additional field assessments	S M L	8	4	4

[6] additional assessments, e.g. Portugal
[7] for countries that use point sampling
[8] needed to calculate forest balance
[9] for countries with threshold > 5 cm

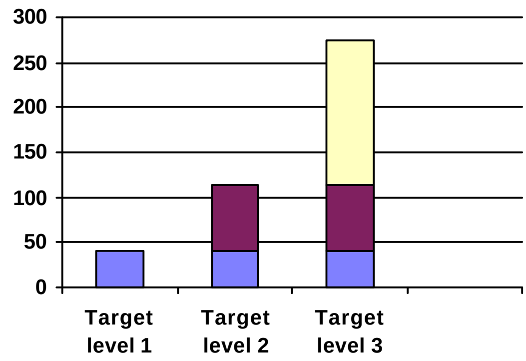
Attribute/definition	Size of the study	Number of studies needed	Total costs in 19 countries (labour years)	Grand total costs for attribute (labour years)
VOLUME INCREMENT	S M L	19	6	 6
VOLUME COMPONENTS growth models	S M L	 8	 8	 8
BIODIVERSITY, NATURALNESS, FRAGMENTATION	S M L	 20	 100	 100
FOREST MARGIN/ CLEARINGS calculation of binary variable	S M L	 11	 0.5	 0.5
FOREST MARGIN/ CLEARINGS development of assessment method	S M L	 4[10]	 40	 40
DEAD TREES/ OTHER WOODY MATERIAL special study	S M L	19	3	 3
DEAD TREES/ OTHER WOODY MATERIAL additional assessments	S M L	 10[11]	 10	 10
VEGETATION TYPES 3 classes (coniferous, deciduous, mixed)	S M L	19	0.5	 0.5
VEGETATION TYPES tree species composition in 3 layers	S M L	13 6	0.5 6	 6.5

Target level 1: up to 5 most important attributes to be harmonised
Target level 2: up to 10 most important attributes to be harmonised
Target level 3: more than 10 most important attributes to be harmonised

The total cost necessary to meet the three target levels are:

Target level 1:	up to 5 most important attributes:	40 person years
Target level 2:	up to 10 most important attributes:	40 + 77 = 117 person years
Target level 3:	more than 10 important attributes:	40 + 77 + 160.5 = 277.5 person years

[10] for Nordic, Central, Oceanic and Mediterranean region
[11] in countries that do not yet assess dead trees and other woody material



This shows that the first target level could be reached with rather low efforts. Only three countries would have to conduct additional assessments to cover the entire range of tree species. Most efforts would be necessary to come up with harmonised forest area estimates. The cost to individual countries is described in detail under the attribute forest area, alternative 1.

3.3 Updating Techniques

Needs for updating techniques

In the European national forest inventories (with the exception of Liechtenstein and Denmark), data assessment is conducted in a time span of several years. For example, in the first Swiss NFI, the assessment period lasted from 1983 to 1986, in the German NFI from 1985 to 1990. However, the need to relate the results to a single point in time has been expressed.

The time span of four years seems to generally accepted in NFIs and needs to relate results to a single point in time have rarely been stated by the users of the results. The necessity to update inventory data to get results for a single point in time depends on the length of the time period covered by data assessments. If a periodic survey with a ten year cycle is introduced, updating techniques could be required by customers. Several alternative updating techniques and methods applied in NFIs are described below.

Examples

In the German "Bundeswaldinventur", the data have been assessed over a time span of five years. On page 15 of the publication of the final results (Bundeswaldinventur 1986 - 1990,(D), Band 1) it is stated, that the results refer to a single point in time. However, no updating techniques were applied.

In Austria, inventory results were published for the period from 1971 to 1980 (Oesterreichische Forstinventur 1971-1980: Zehnjahresergebnis, FBVA, Wien, 1985). It is clearly stated that the results have been assessed over a ten year period and no updating has been applied. In the last decade, the inventory cycle in Austria has been shortened to five years. Still no updating techniques are applied or planned for. Even the ten year time span has widely been accepted by the users of the inventory results. As in Austria the entire country is covered each year by sample plots, it can be assumed than "average values" for the observation period are reported.

In the Swedish NFI, results are given for 5-year periods (1973-1977, 1978-1982, 1983-1987, 1988-1992). Since 1981 annual "updates" of the results have been published, which are based mainly on the data of the last five years. No updating techniques are applied. For forecasting of timber yield growth models for individual trees have been developed (U. Söderberg, 1986: Functions for forecasting of timber yield, SLU, Report 14). For regional estimates of long term potential cut, an updating technique called the "Hugin system" is applied. This is a basically a substitution of new data by trees with similar previous data.

For the Swiss NFI, single tree growth tariffs will be derived. Based on repeated measurements on selected trees, growth will be expressed as a function of d.b.h. These growth models could be used as an updating technique for individual trees. Ingrowth and changes in tree history (mortality, cut, survivor tree) have to be modelled.

Research needs

In most European NFIs no updating techniques are applied and data assessed at different years are used. Therefore, the needs for updating techniques have to be evaluated carefully, especially as they would require a specific amount of research efforts and increase the complexity of the analysis procedures.

Two alternatives for updating inventory data exist. One approach is based on the modelling of tree growth and requires a model to predict ingrowth and tree history (survivor, mortality and cut). In assessing the cut, remote sensing methods would be appropriate over large areas (Köhl and Päivinen 1996). A second approach utilises estimation methods that relate estimated values to a common point in time.

Four different approaches for modelling tree growth (alternative 1) can be applied:

a. growth and yield tables
b. inventory growth models
c. substitution of new data by trees with similar previous data (analogue to the Swedish Hugin-system)
d. tariff functions

In most European countries, growth and yield tables have been developed for pure, evenaged stands with high thinning. These can not be applied on the entire forested area of Europe. Growth and yield models are available for only a limited number of tree species (spruce, fir, beech, larch, and Douglas fir). Further development of more specific growth and yield models, especially those for mixed and/or uneven aged stands and further tree species, would be time consuming and expensive. Therefore, the growth and yield model approach is not always appropriate for updating NFI data.

The development of national inventory growth models, based on data from two measurement occasions would be time consuming, as many detailed models have to be derived. An approach similar to the Swedish Hugin-system would be the second choice. However, it is not clear how this technique would perform under the heterogeneous forest conditions of Central Europe. The most appropriate approach would use the tariff functions developed for the latest point in time. Those functions give the growth of the latest period as a function of d.b.h. Compared with the other three approaches, this model would require the smallest adjustments and research efforts.

The second alternative (relating estimated values to a common point in time) is not based on modelling growth of single tree data, instead it allows to relate inventory results independent of the year of the assessment to individual points in time. Many methods for developing estimates from a sample design exist. Simple means and variances are appropriate for most designs, if no updating to a common point in time is required. Updating requires the adjustment of data according to the length of the time between the assessment and the required reference time. In the scope of EFICS, this process would be complicated as the individual sampling designs of the countries require different approaches.

One method of improving the estimates in successive surveys is to use the Kalman filter. It was developed for time series data but adapted to forest surveys. They showed that is simplifies the Sampling with Partial Replacement (SPR) estimator, that links data from three types of plots: plots only measured on the first occasion, those only measured on the second occasions and plots that are measured on both occasions. It is a recursive estimator, in that the estimates at time t are developed by first estimating values at time 2 based on time 1, then time 3 based on time 2, etc.

A related method is the mixed estimator. The regression or generalised least squares (GLS) approach is used for the sample data. When prior information in the form of growth models is available, then using them can improve the sample-based estimates. The sample data and the model predictions are then set in a single estimation framework to provide more precise resource estimates.

One of the major difficulties with most estimators is the lack of additivity of tables. If the estimators are applied to each cell in a table and to the table margins, the rows and columns will not sum to the margins.

Recommendations

If updating techniques have to be applied, they should be kept simple. Current growth estimation methods should be explored and an evaluation of updating techniques has to de done. The expected feasibility of remote sensing in assessing the various types of cuttings in different ecological conditions should be confirmed. Further research on this topic is required.

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4. Impact of new technologies

4.1 Introduction

New technologies and their application within EFICS will have a substantial impact on the scope, the capability, the financial situation and - last, but not least - the success of EFICS. The short life cycles of technologies render an evaluation of their impact difficult. Future plans of launching new satellites are known to have been expressed, but forecasts rarely extent the next decade. Therefore, we will limit our discussion of the impact of new technologies for a time period of less than one decade - predictions for a longer period would be rather prophetic than a sound base for planning.

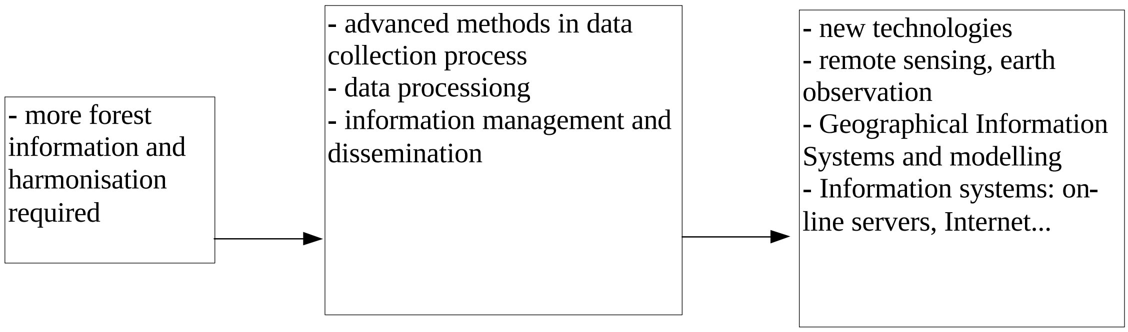


Figure 8. Introduction of new technologies to address new information needs.

The impact of new technologies is evaluated for three different topics:

1. Remote sensing and Geographic Information Systems
2. Data processing
3. Information management

The first topic (remote sensing) relates to data assessment. The working packages presented so far showed, on one hand, the need for harmonised information for traditional, i.e. production related attributes and new attributes, i.e. biological diversity and nature conservation. On the other hand, the potential of remote sensing to provide or supplement the assessment of harmonised data has been shown. In the field of data assessment there will not be many future developments of technology that could be applied in field assessments, except the more intensive application of Global Positioning Systems (GPS) and of handheld computers in the field work. The future development of remote sensing technologies offers a great potential for data assessment. Remote sensing can help to introduce new approaches for the harmonisation and assessment of additional attributes. It has often been stated that one of the great advantages of remote sensing is the possibility of implementation within a short period of time. Thus remote sensing can play a major role in the future of data assessment and is therefore treated rather intensively in this chapter.

The separation between the second and the third topic is motivated by the semantic difference between data and information. Data are generally seen as figures or numbers, which can be stored, processed and analysed. For this topic it is essential to discuss the means of data exchange, data storage, data processing and access to the data. Information can be seen as purposive knowledge. Data are generally chains of signs, which are built up according to specified rules, e.g. the syntax of a sentence in the English language. Data themselves do not possess any meaning. Only by processing data information can be obtained. Information is an increase of knowledge or it enables actions. Data become information either by interpretation or by the way they are processed by algorithms. Thus the third topic builds up on data processing and focuses on systems and tools for information management as well as the dissemination of information.

4.2. Remote sensing techniques

4.2.1. Characteristics of remote sensing data

Data sources

Remote sensing data are obtained either from air or space and they are characterised by:

- the spatial resolution of the sensor: it can vary from tens of centimetres (aerial photographs) to more than 1 kilometre (NOAA-AVHRR). Spaceborne sensors operate at different resolutions, with 5 meters to 10 meters resolution for the most advanced systems in panchromatic mode.
- the spectral resolution with the number of spectral bands (from 1 on several sensors to 15 on ENVISAT-1, and more than 200 bands on some airborne imaging spectrometers) and the wavelengths (visible to microwave). Spectral bands in the green, red, near-infrared and mid-infrared are particularly adapted for vegetation monitoring. Radar systems provide another type of information, penetrating through clouds and into the vegetation cover.
- the temporal resolution which is the revisiting capability of the sensor over the same point: it is ranging from less than one day (geostationary satellite) to more than 20 days (very high resolution satellites).

Remote sensing data can be provided by two sources: airborne sensors and spaceborne sensors.

Airborne sensors

Airborne sensors consist of traditional aerial photographic systems (analogic products) and optical scanners (digital products). Aerial photographs are commonly used in national forest inventory schemes. Two categories can be distinguished: the black and white photographs, and the colour photographs (visible and infra-red).

Digital data are derived from airborne imaging spectrometers. These systems are more dedicated for research as they provide unique opportunities to test the potential of narrow spectral bands at a certain resolution.

Radar airborne systems represent an interesting alternative and complementary source of data to optical systems. They are mainly designed for research studies, and generally offer multi-frequency, multi-polarisation and multi-incidence angles capabilities.

Spaceborne sensors

Earth observation satellites have been used for more than 20 years for vegetation studies. State-owned space agencies have been very active in developing new platforms with advanced sensors. Today, some private agencies are planning to launch their own satellites to cover specific markets.

In 1996, more than 20 sensors on board more than 15 satellite platforms are in operation and are dedicated to Earth observation. This great variety of space data offers promising possibilities in forest monitoring at local, regional and global scales. However, one of the major bottlenecks is the availability of high resolution data, which is sometimes problematic and often prevents operational use at the local level.

Regarding the resolution, the following can be summarised: In very high resolution satellite images (1 to 10 meters), a tree is covered by one or a few pixels, and this should enable canopy structure and texture to be extracted. In high resolution satellite images (10 to 100 meters), a pixel usually covers several trees. This resolution is particularly adapted for monitoring forest at the stand level. Satellite data at 100 to 500 meters resolution (medium resolution) are well adapted for regional forest surveys and monitoring. Pixels at this resolution cover one to several hectares, but research studies have shown that they are still containing relevant information on the forest cover.

Information content of optical remote sensing data

In Fig. 9 the spectral response from a Norway spruce canopy is presented as a function of wavelength, measured from a point of tens of square centimetres. The data from space- and airborne sensors is an aggregate of different wavelengths. The ‘channels’ or ‘bands’ can be wide or narrow, trying to catch essential parts of the curve presented in Fig 9. The spectral response of the recording unit on the ground is also an aggregate of spectral responses from tree canopies, soil, ground vegetation, all both in the sunlight and in the shadow. The bigger the size of the ‘pixel’ is, the more of different objects are included.

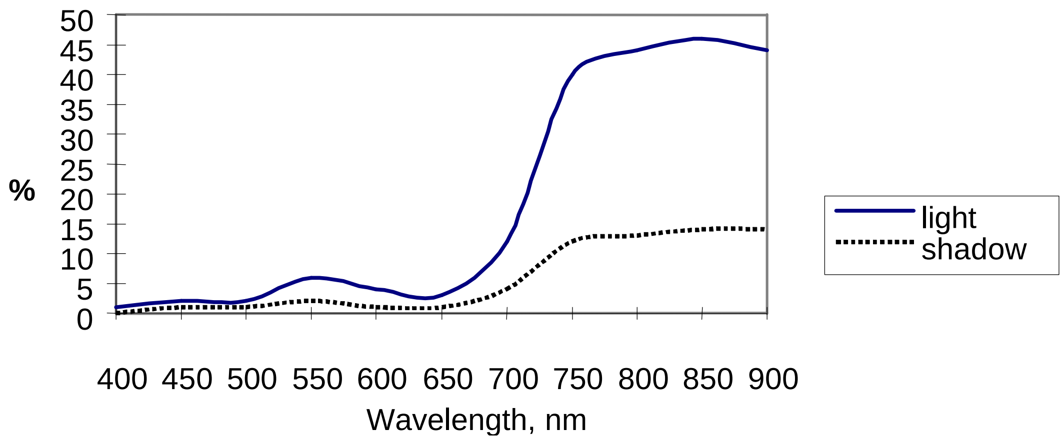


Figure 9. Spectral response of Norway Spruce

For technical reasons, the finer the spatial resolution is, the more difficult it is to develop sensors with narrow spectral bands. That is the reason why the finest sensors operate in panchromatic mode (large spectral range). This source of data is particularly adapted for detecting structural patterns or features of the forest stands: limits of different forest types, logging roads, clear cutting, canopy texture etc. The multi-spectral mode (several narrow spectral bands) is more adapted for characterising vegetation types: species composition, broadleaf and conifer stands, canopy density, photosynthesis activity (vegetation index), hydric stress, fire activity and so on.

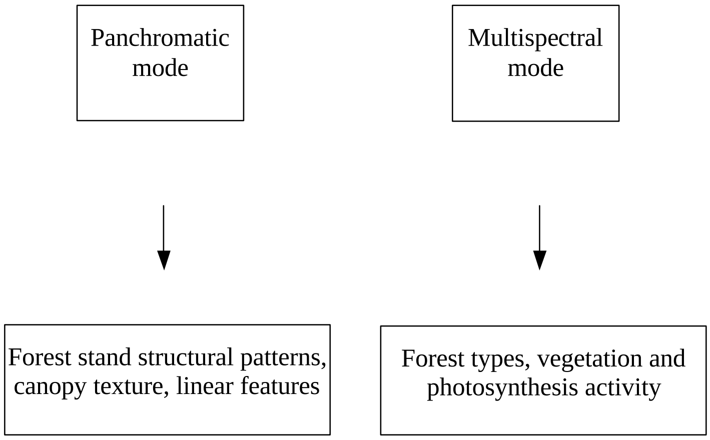


Figure 10. Advantages of panchromatic and multi-spectral modes of spaceborne optical sensors.

In forests some attributes are correlated to others, such as standing volume, age and tree height. They can be sometimes retrieved by remote sensing data since they are indirectly correlated to the parameters having a direct influence on the spectral signature.

In multi-spectral satellite images, rather strong correlation is generally observed between the visible bands, and between the medium-infrared bands. In forestry studies, the most important spectral bands are the visible bands, the near-infrared and medium-infrared bands.

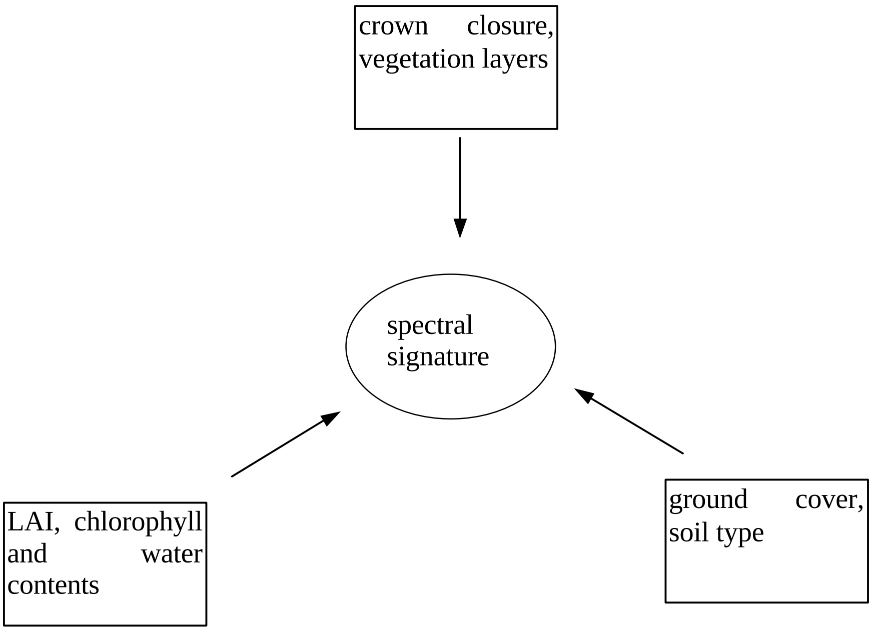


Figure 11. Key factors of the spectral signature in forest environment.

Information content of radar remote sensing data

Optical sensors record the reflected sun radiation from different ground surfaces. Radar systems send actively microwaves to the target and collect the characteristics of the backscattering waves. Radar systems are especially useful in the areas where clouds prevent obtaining the optical satellite data. Radar data cannot yet be recommended for operational monitoring, but by the use of advanced techniques, such as interferometry and coherence images, the radar technology might become useful in forest studies in the future. Presently, moist vegetation after rain fall causes problems in interpreting radar images.

Methods for extracting information

In forest type mapping, traditional methods, such as visual interpretation, are still considered reliable and efficient since they allow the integration of ancillary information during the interpretation phase (expert knowledge). However, the final result depends greatly on the experience of the photo-interpreter.

Digital processing methods are more adapted when a large amount of data are processed, since they provide a consistent and reproducible approach which can be repeated many times. In spectral classifications, spectral noise can affect the accuracy of the results. But significant advances have been made in classification schemes, e.g. neural networks concepts, utilisation of forest light interaction models.

Both methods require ground information. In the visual method, the interpreter compares the field information to the satellite data hardcopy or aerial photograph, and learns how different vegetation covers should look on the image. In digital methods, spectral classes are formed automatically, using different algorithms, or by using training areas.

Current use of RS in national forest inventory programmes

In most European countries, (except in Austria, Norway and Finland), aerial photos are used in the national forest inventories at a scale ranging from 1:10,000 to 1:25,000. In some cases, forest changes are detected and mapped.

The use of satellite imagery is most often limited to basic and to applied research. The only country in this study where satellite remote sensing data are used on an operational basis is Finland, where the interpretation of Landsat TM data is used for locating forest resources. In general, the feasibility of RS techniques for national forest inventory is more advanced in Northern European countries than in Southern European countries where the forest ecosystems are more complex and heterogeneous.

Austria

Aerial photos including infrared imagery are widely used at the local level for producing forest management maps at very large scales. The topography effects in such a mountainous country as Austria make the operational applications of satellite imagery in forest inventory and monitoring difficult. Information on forest area change can be obtained from the Austrian Forest Inventory at the regional to federal level, and as a by-product of the revision of the 1:50,000 base map, which is performed every ten years.

Belgium

In the Flemish region, small-scale colour infrared aerial photography at 1:30,000 is used to assess the forest cover and to up-date forest maps. Colour infrared orthophoto maps at 1:5,000 are the base documents for thematic mapping. Each orthophoto map covers exactly one quarter of NGI 1:10,000 map. Classified satellite images are considered as complementary documents in the field of ecological monitoring. Furthermore, satellite remote sensing has been evaluated for assessing forest classes and storm damage. Panchromatic SPOT imagery was preferred for its spatial resolution. Reliable information on storm damage was, however, restricted to stands where severe damages occurred.

In the Walloon region, remote sensing data are not systematically used in the forest inventory. However, information from aerial photos e.g. delineation of forest stands boundaries is now incorporated into a GIS database.

Denmark

In Denmark, aerial photos are used in combination with ground surveys for mapping purposes. Forest maps are digitised from corrected aerial photos at 1:5,000 based upon a field survey. Every stand is observed in the field. Satellite remote sensing data is considered to be unable to provide information with high accuracy and is consequently not used.

Finland

Finland is the only country in this study using satellite image data in the forest inventory on an operational basis. The Finnish Forest Research Institute began to utilise a new inventory system in 1989 in order to obtain geographically localised, up-to-date information for smaller areas than before. Estimates of all variables of the inventory are computed for each pixel. The system is now operative, and the inventory has been applied to an area of about 16 million hectares, producing theme maps and statistics for large and small areas. Some research projects are carried out for testing the utilisation of ERS-1 radar data.

France

In the whole country, forest stands are mapped at 1:25,000 from an aerial photograph survey at 1:17,000 or 1:20,000. All sample points in the inventory are photointerpreted and checked in the field. The points are distributed on a regular grid over each department, with one point for about 30 hectare, which leads to an average set of 18 000 points per department. Satellite imagery, e.g. SPOT data, has been tested for detecting forest changes and for up-dating forest maps between two inventory cycles (10 years).

Germany

Most of the data in forest inventories is obtained from the direct recording of measurements during field work. Forest maps are geometrically based on national topographic maps. The application of remote sensing is limited to the use of aerial photos or orthophoto maps for mapping forest stands, map up-dating, refining definition of forest stands in forest management. Satellite images are rarely used in the forestry sector.

Greece

Data sources for the National Forest Inventory, which started 30 years ago, are aerial photographs and field measurements. The aerial photos are B/W and at a 1:20,000 to 1:42,000 scale acquired in different years. In each aerial photograph, 25 plots were selected, measured and classified. Moreover, 1:50,000 scale forest mapping has been carried out by the laboratory of Orthophoto-mapping using aerial photographs from different years. Those maps were enlarged to 1:20,000 scale. A third mapping exercise started in 1979 during the Ecological Land Resource Survey. The objective was to quantify land suitability. Vegetation maps (1:20,000), geology maps (1:50,000) and topographic maps (1:50,000) have been analysed together with B/W aerial photographs at a 1:30,000 scale. The Army Geographical Service is the organisation responsible for acquiring aerial photographs. Different acquisitions over the country were made in 1945, 1960, 1963 and later on. Satellite imagery is not used at present.

Ireland

The State owned forests (80 % of total forests) are inventoried by Coillte's own staff specially trained in forest inventory methods and procedures. Attributes and map data are collected by visiting each stand. The most up-to-date complete stereoscopic aerial photography dates back to the 1970s and is thus of little use for forest inventory. Satellite imagery is not used at present, due to its too poor resolution. However, an exhaustive mapping of Irish forests is being launched with the intensive use of high resolution satellite data. All results and data are expected to be integrated into a national forest information system.

Italy

Forest maps at a 1:33,000 or 1:50,000 scale have been produced with aerial photographs, B/W and colour infrared. In some areas, larger scale mapping (1:5,000) has been performed for health monitoring. Satellite remote sensing, if not used on operational basis, is regarded as a potential source of valuable information, and many algorithms of classification are currently being tested by forest researchers.

Luxembourg

Aerial photographs have been used since 1963. They are still used and their acquisition is made at a 1:10,000 scale in B/W. Forest maps at the stand level are derived at a 1:10,000 scale. Experiments on satellite imagery started in 1986, with problems of calibration over forest stands between successive images. It was felt that the interpretation of satellite imagery prints requires high knowledge of tree physiology, and that any automatic classification procedure is still premature.

The Netherlands

Aerial photographs have been used for the National Forest Area Survey (1980-83), and the Other Wooded Land Survey. The scale is 1:18,000, and only black/white film is used. No orthophotos were made for the survey. A complete set of data was acquired in 1980 covering the entire country. No digital remote sensing methods were used in the latest NFAS, and in the Other Wooded Land Survey.

Norway

The National Forest Survey does not use aerial photography. The only uses of aerial photography are for mapping land cover type at 1:5,000, or for topographic mapping at a 1:50,000 scale. A couple of experimental studies have been executed at the Norwegian Institute of Land Inventory. SPOT multi-spectral data were used to map mountain birch forests. Another study was carried out with both TM and SPOT data for discriminating different stand classes (coniferous and deciduous stands).

Portugal

The National Forest Inventory started in 1968, with 1:15,000 scale infrared aerial photography. In 1974, new aerial photography data were gathered for northern and central Portugal, and the up-dating of the inventory lasted until 1980. The second NFI has also used aerial photography. The third NFI, which is now taking place, is based on full-coverage false colour infrared aerial photography at a 1:15,000 scale. Satellite imagery has been tested for mapping burned areas. After some experiments with the combination of SPOT and TM data on test sites, the methodology has been extended to the whole country using only TM data. Results are mapped at a scale of 1:100,000. In the future, there are plans to detect forest changes with satellite imagery and characterise them with a combination of aerial photography and field work. The up-dating frequency should be 5 years.

Spain

Aerial photographs have been used for the second National Forest Inventory. Non-orthophotos, panchromatic photographs were acquired during a national survey at a 1:30,000 scale in 1983-1986. In some regions, up-to-date aerial panchromatic photographs at a 1:18,000, or a 1:20,000 scale have been used. No satellite images have been reported to be used by the NFI.

Sweden

In the NFI, the field assessment, maps and area statistics are the only data sources. Black and white aerial photography is used for the assessment of plots in the high mountains. Spaceborne or airborne digital remote sensing is not in use at present, but tests are continued.

Switzerland

The Swiss NFI utilises black and white aerial photographs at a 1:30,000 scale which are provided by the Swiss Federal Office of Topography free of charge. Photos have been acquired from 1987 to 1993. No spaceborne or airborne digital remote sensing techniques have been applied in the NFI. However, comprehensive studies concerning the mapping of Swiss forests by digital remote sensing have been undertaken with NOAA-AVHRR, SPOT and Landsat TM data. The accuracy is very often rather low, and the resolution of 10 to 30 meters is considered as too coarse in Switzerland.

The United Kingdom

For the National Inventory of Woodland and Trees, the boundaries of all woodlands over 2 hectares are captured into a GIS from 1:25,000 scale aerial photography. The field survey data of the

Countryside Survey 1990 have been integrated with a land cover data-set obtained from satellite imagery to produce a digital database of land cover for Great Britain. The Land Cover of Scotland 1988 (LCS88) has utilised air photos for mapping land cover types. Comparisons between the satellite derived land cover map and LCS88 have shown poor agreements due to differences in nomenclature and errors of interpretation.

The Czech Republic

All data were, and still are, collected by the Forest Management Planning Institute, including aerial photography and forest maps.

No satellite data have been reported to be used for forest inventory in the Czech Republic.

Poland

No utilisation of airborne or spaceborne data has been reported for forest inventory. Based on field work, forest maps are produced in traditional analogue form. The application of new technologies such as GIS and remote sensing is under investigation.

Hungary

The national forest inventory is based on traditional methods with field measurements. No aerial or satellite based imagery is used at the moment. Maps are still made manually, but the development of a GIS integrating digitized maps and the national forest database (NFDB) is currently studied with several pilot projects.

Conclusion

The current utilisation of remote sensing in the European countries is summarised in Table 23.

In many countries, aerial photographs at a scale ranging from 1:5,000 to 1:50,000 are used in the forest assessment programmes. The main utilisation is for mapping forest types, but aerial photos are also sometimes used for locating sample plots, or for assessing plots where access is difficult.

Satellite imagery is very seldom used. The only example of the concrete integration of satellite data into the forest inventory procedure is in Finland, with the utilisation of Landsat TM and SPOT data. In Portugal, TM data are used to monitor fire risk. However, various experiments have been conducted, and are still in progress for using satellite imagery in forest inventory. Future plans indicate that in some countries satellite imagery is going to be used for specific applications. Great interest is generally shown in the monitoring of forest changes and of forest diversity, with pilot studies being carried out in test areas.

Table 23. Current utilisation of airborne and spaceborne remote sensing data in forest information systems in Europe.

Country	Use of aerial photographs	Use of digital airborne and spaceborne imagery	Database and GIS	Access to NFI database and data	Future plans
Austria	NFI : no utilisation in current assessment (used in previous exercise). Infrared air photos used for producing forest management maps.	NFI : no utilisation.	Data stored into ORACLE database. Maps are not under digital form.	Inquiries to be addressed to Federal Forest Research Centre.	Introduction of GIS at federal level is planned.
Belgium	NFI : utilisation when available. Infrared photos at 1:30,000 scale used in the Flemish region.	NFI : no utilisation. Experiments for assessing forest classes and storm damage.	Storage of data into ACCESS database.	Inquires to be addressed to the "Ministère de la Région Wallonne".	New forest inventory in Wallonia started in 1994.
Denmark	NFI : utilisation for mapping forest types.	NFI : no utilisation. Experiments by the Danish National Forest and Nature Agency and the Department of Land Data for up-dating forest maps with Spot XS data.	Digitisation of forest maps. Some forest maps are stored and managed under Intergraph		
Finland	NFI : no utilisation.	Since 1989, utilisation of Landsat TM data in the multi-source inventory system.	Data are stored into self-designed ASCII file system. Utilisation of SAS. DISIMP software is used for image processing.	Access to general information on WWW.	The 9th inventory will use remote sensing data (possibly airborne imaging spectrometer) and digital map data together with field measurements. Future utilisation of ARC-Info.
France	NFI : forest type mapping at 1:25,000 based on air photos, black and white and infrared. Each ground sample plot is photointerpreted.	NFI : no utilisation. Experiments in progress for change detection using SPOT imagery.	Forest types maps are digitised into Arc-Info (nearly completed).	Access to database by on-line server and Minitel. Access by WWW under development.	The main changes concern the development of GIS.
Germany	NFI: not systematically used. Some	NFI : no utilisation.	The complete data set of the first NFI is	Requests can be made to BML (Federal	Next NFI under discussion.

	utilisation for forest mapping and map up-dating.		managed under the data base system Informix on DEC station in BFH (Federal Research Centre for Forestry and Forest Products).	Government) who owns the data.	
Greece	NFI : utilisation of black and white aerial photographs for forest mapping at 1:20,000.	NFI : no utilisation.	Data are stored under different system : DBASE III, LOTUS, WP51.	Data available in paper or digital format.	Future of the NFI unknown.
Ireland	State owned forest : utilisation of air photos in isolated cases. Private woodland : utilisation of air photos.	No utilisation.	State owned forest : data are owned and stored by Coillte in Arc-Info. Private woodland : data are stored and managed by the Forest Service of the Department of Agriculture in EBCDIC file format.	Dissemination of data on request.	Increase use of air photos at 1:40,000 scale. Introduction of satellite imagery for mapping forest types.
Italy	Utilisation of black and white and infrared photos for forest mapping in some regions.	No utilisation. Research in progress for developing applications.	Data of the NFI are stored in a database system at the Ministry of Agriculture, Forest and Food (ORACLE). Various database systems are used in the different regions.	Access to data is usually possible on request.	Plans are made for integrating all data sources and results into a national GIS.
Luxembourg	Local forest inventories : black and white air photos have been used since 1963 for forest mapping at 1:10,000.	No utilisation. Methodological attempts have been made.	Data are stored in an own main frame database system Data of the national forest condition assessment are stored in MS Excel database.		GIS are under development.
The Netherlands	National Forest Area Survey and Other Wooded Land Survey : utilisation of air photos at 1:18,000. Full coverage in 1980.	No utilisation.	Data of the NFAS is stored in a self-created ASCII file system.	Requests to be made to the National Reference Centre for Nature, Forests and Landscape.	Discussions are on the way for a new NFAS. GIS and digitised topographical maps should be developed.
Norway	National Forest Survey : no	No systematic utilisation.	Data of the current cycle are	No direct access to the database.	For the next NFI cycle (1999-

	utilisation of aerial photographs	Experimental studies have been carried out with SPOT and TM data.	stored on ORACLE database. Land cover maps derived from air photos are being digitised into Arc-Info.		2003), experiments will be carried out to evaluate the possibility of combining satellite images and other geo-referenced information.
Portugal	NFI : utilisation of 1:15,000 scale air photos since the first cycle in 1968.	NFI : no utilisation. Tests for mapping burned areas. Extension the whole country with TM data.	Data are stored in a self-created ASCII file system.	Access to data is possible under specific requests. Agreement by the Portuguese Forest Service is needed.	There are plans for detecting forest changes with satellite imagery combined with air photo and field work.
Spain	NFI : utilisation of 1:30,000 aerial photographs for the location of field plots.	NFI : no utilisation.	Digital maps are stored and managed in Arc-Info. Inventory data are stored in a self created relational database under ADABASE system.	Raw and derived attributes from the database can be obtained on PC diskettes.	NFI 3 to be conducted between 1997 and 2006. Possibility of using satellite images for the detection of changes is being studied.
Sweden	NFI : utilisation of aerial photos only for assessment of plots in high mountains.	No utilisation on a routine basis. Tests are in progress.	Data are stored in a database under the responsibility of the Department of Forest Resource Management and Geomatics, Swedish University of Agricultural Sciences.	Data are available with some restrictions.	Next NFI cycle will start in 2003. Satellite imagery should be introduced in the inventory design.
Switzerland	NFI : black and white aerial photos at 1:30,000 are used.	NFI : no utilisation.	Data of the first and second NFI are stored in ORACLE database. SAS is used for analysis.	Data are available with restrictions.	Third cycle should start in 2003. GIS-based analyses will gain importance. Satellite imagery might be used.
United Kingdom	Utilisation for the National Inventory of Woodlands and Trees (NIWT) and for the mapping of Scotland.	Data of the Countryside Survey 1990 have been integrated with satellite images.	Data of NIWT to be integrated into a GIS. ORACLE database is used for storing and managing data.	Data are not available.	

Operational applications of satellite remote sensing

Main advantages and benefits of remote sensing

Satellite remote sensing systems represent a valuable source of data with the following advantages:

- **possibility to produce maps with relatively high spatial accuracy**: In field inventories, sample plots represent very low percentage of the target area, and thus the minimum area to derive results with sufficient accuracy is large (10 000-100 000 hectares). Satellite images can be geometrically corrected in order to provide accurate location of the pixel in geographic co-ordinates. Thus, the remote sensing data provides possibilities to derive the results for smaller areas than in inventories based on pure field sampling.

- **harmonised data over large areas**: a full coverage of the study area is generally feasible, which leads to a unique set of homogeneous data acquired in a rather short period of time. As a result, the estimates of forest attributes and the stratification of forest areas can be more effective since the extraction of information relies on the same source of data.

- **multi-temporal data available**: due to their revisiting capability, spaceborne sensors can provide data on the same area at different dates, which is particularly adapted for change detection and monitoring applications, and for vegetation classification and mapping.

- **multi-scale approach**: the wide variety of spaceborne sensors offers great possibilities to assess and monitor forest resources at different scales at the same time. By combining data at different resolutions, it is possible to retrieve forest attributes with reasonable accuracy over large areas (see multiphase sampling aspects, section 4226).

- **free access to the data**: with several operational sensors operating around the Earth, tremendous amount of data are recorded every day and are easy to acquire. Moreover, information from more than 20 years has been archived by previous sensors, which provides further opportunities to analyse changes in forest conditions. Only cloud cover would is prevent the availability of data for a desired time period.

- **combination possibility with ancillary data**: other sources of data, both mapped data and point data, like field plots, can be linked and integrated with remote sensing data with the use of GIS techniques.

- **cost-effectiveness**: satellite imagery has proved to be less expensive than aerial photographs, although it cannot yet lead to results with the same level of statistical precision. For certain tasks, requiring properties mentioned above, satellite data has proved to be cost-effective.

Feasibility of remote sensing for forestry applications

Taking into consideration the most recent advances of remote sensing in retrieving forest attributes (for further information see Köhl and Päivinen, 1996), it is possible to evaluate the current state-of-the-art and the technical feasibility of this technology (see also Feasibility study on…, 1993) (table 24).

The applications of satellite remote sensing can be divided into three main domains:

1. forest resources assessment (statistic and cartographic attributes regarding timber production)
2. forest resources monitoring (change estimates)
3. forest environment monitoring (attributes describing forest ecosystem)

The technical feasibility of remote sensing is described with three levels:

1. yes (i.e. feasible),
2. to be confirmed (possibly feasible but requires more research), and
3. limited (with current knowledge and existing sensors).

The application can be considered as

- operational (i.e. the methods can be applied an a routine basis),
- developed (i.e. research has led to promising results and pilot projects are still to demonstrate the feasibility), and
- research. (still in research phase)

Table 24. Feasibility of spatial remote sensing for forestry applications.

Application group	Specific application	Technical feasibility	Level of operationality	Comments
Forest resources assessment (statistic and / or cartographic)	forest/ non forest mapping	yes	operational	accuracy up to 85% to 95%. Depending on the forest area definition (mapping unit and crown closure)
	forest type mapping (broad-leaf's/ conifers/ mixed)	yes	operational	accuracy depending on the mapping unit and the resolution of the sensor
	Species discrimination	limited	research and development	some investigation in unmixing pixel modelling
	Stand age	limited	research	not applicable in uneven aged stands
	Stand structure	to be confirmed	research	require forest light interaction modelling
	Standing volume	to be confirmed	research	better results with homogeneous stands (like most attributes).
	Biomass	to be confirmed	developed	good correlation between vegetation index and biomass, especially in Nordic countries
Forest resources monitoring	variation of forest area	yes	developed	change matrix can be derived
	forest map up-dating	yes	developed	can utilise GIS techniques
	afforestation	to be confirmed	developed	require long time series of satellite data, limitations in detecting young plantations, better results with high resolution panchromatic images
	clear-cutting	yes	operational	more accurate results with high resolution panchromatic images
	thinning cutting	to be confirmed	research	require advanced change detection techniques and radiometric calibration between images
	natural regeneration	to be confirmed	research	difficult to monitor with the diffuse aspect of regeneration
Forest environment monitoring	forest decline/ defoliation	to be confirmed	research	forest decline is difficult to monitor as it affects scattered trees
	pest damage	to be confirmed	research	possible only when high damage is affecting large areas
	fire risk mapping	yes	operational	possible with hydric stress assessment; requires GIS techniques
	fire damage assessment	yes	operational	the level of damage requires ground checking
	stand structural diversity and fragmentation of the forest cover	yes	developed	applications in forest edge assessment, habitat, corridors...
	indicators for sustainable forest management	to be confirmed	research	depending on the indicators : some possible applications for biological diversity and health of forests.

Forest resources assessment and forest area mapping

Using satellite remote sensing data, four different approaches can be taken on a regional basis:

- analysis of a large area, or "wall to wall" coverage of coarse or medium resolution satellite data;
- analysis of a sample of high resolution satellite data;
- analysis of a set of coarse and high resolution satellite data;
- analysis of a full coverage of high resolution satellite data.

The first approach is consisting in analysing a large area coverage of coarse resolution satellite data, e.g. AVHRR data, or medium resolution satellite data. However, the estimation of forest proportion is presenting a systematic bias due to aggregation effects, the coarse resolution data tend to overestimate the dominating class, especially if the landscape is scattered.

The second method is aimed at estimating forest proportion from a sample of high resolution images: this method has been tested and implemented by FAO in the Forest Resources Assessment 1990. FAO is planning to use this methodology globally in the Forest Resources Assessment 2000.

An alternative between these two options is feasible by combining coarse or medium resolution satellite data with high resolution satellite data. A correction function can be derived from a double sampling design with regression estimator. The regression is performed between the auxiliary variable, measured from the AVHRR data set, and the target variable, measured on a sample of high resolution satellite data sites.

The last option consists of applying a full coverage of high resolution satellite data. This method is feasible when the region of interest is not too large. CORINE land-cover is using this approach. When the study area is very large i.e. the scale is from continental to global, the first three options are recommended.

The delineation of forest types or forest area classes can be used for stratification. In statistics, stratification is a widely used method to decrease the overall variance of the estimator by delineating homogeneous strata in which the variance of the population is reduced significantly. Stratification is usually leading to more accurate estimates, and can be applied to optimise the sampling scheme.

A **multiphase sampling for stratification** is applicable with remote sensing data. Remote sensing data can be used to delineate homogeneous strata in terms of forest cover or forest types composition. A full coverage of Europe would be needed with coarse or medium resolution satellite data. A sample of high resolution satellite data can be then applied to derive more attributes, with a sample of ground plots within each image.

The **forest structure** can be characterised and measured by:

- the forest composition which refers to features associated with the presence and amount of forest types or tree species.
- the forest pattern which refers to spatial characteristics of forest units/patches or forest types/species within defined spatial boundaries.

The main forest types (broad-leaved, conifers, mixed stands) can be delineated by remote sensing means on operational basis with reasonable accuracy. But the discrimination of species remains difficult and needs more research with the development of unmixing pixel modelling. The forest pattern with spatial characteristics of forest patches can be measured by remote sensing techniques. This question is addressed in the forest environment monitoring section.

Forest resources monitoring and change detection

Forest ecosystems are in continuous evolution. The intensity of change can be abrupt (clear cutting, deforestation, and forest fires) or diffuse and gradual (stands growth, natural regeneration).

Today, the most feasible application of remote sensing is the detection of clear-cutting with panchromatic high resolution images. The variation of forest area is feasible, and pilot projects are in progress at different levels (local to global). By using satellite data over the same area at different dates, a change matrix can be derived with valuable information on the nature and magnitude of change between different land-cover classes.

Forest map up-dating is considered as a possible application of remote sensing. With GIS techniques, historical boundaries or classifications can be superimposed with new sets of data, and changes can be integrated into the map.

Forest environment and diversity indicators monitoring

Due to its nature, pixel by pixel recording, remote sensing is especially good in the measurement of spatial fragmentation of vegetation patches. Fragmentation has its importance in assessing the biological diversity as it breaks up the continuous vegetation cover which can hinder the species migration and decrease diversity. On the other hand, fragmented forest has more edges, preferred by many other flora and fauna species. Landscape indicators such as forest patches sizes, perimeter-to-area ratio, fractal dimension and habitat proportions, have to be measured at a scale larger than field plots. Hence, remote sensing and cartographic methods can be applied.

Fire damage assessment and fire risk mapping are the most operational fields of application. Forest decline assessment can benefit from the use of remote sensing when the decline is so strong that there is significant change in spectral response.

Conclusions

Due to its frequent availability and harmonised recording of information, satellite remote sensing is potential especially in the tasks where information is needed about

- large areas
- relatively small geographical units (mapping possibility) and
- changes (monitoring of some key attributes)

For tasks, for which stand mapping by field survey, or sampling of field plots is a too slow and expensive method, remote sensing can be a cost-effective tool.

These kinds of tasks are: deriving change matrix (land use changes), and assessing some changes and activities which occurred on the forest cover, e.g. clear-cutting, fire damages. If old map information is available, up-dating maps (clear-cuttings, forest fires). Some indicators for sustainable forest management could benefit from remote sensing, e.g. health and vitality, and biological diversity criteria. Forests with difficult access are especially relevant for the use of remote sensing.

For most remote sensing applications, ground checking and plot measurements are needed for validating and calibrating the results. Only few forest attributes can be directly derived from the spectral response in satellite data.

On the other hand, classifying the forest area on the basis of the spectral response, the forests can be effectively stratified for assessing the field plots. Multiphase sampling for stratification and for regression estimators can rely on a complete set of low or medium resolution satellite data as a first phase, while high resolution satellite data can constitute the second phase. Aerial photographs and ground plots can be used then as other stages.

Some examples of operational applications

In the National Forest Inventory of Finland, TM and Spot imagery is used in addition to ground measurements. Image analysis methods have been chosen so that estimates of all variables of the inventory can be computed for each pixel. The results have been compared with the estimates based on field sample plots of the NFI. The system is more applicable for estimating some attributes in smaller areas than the use of field sample only. The system is now operative and applied to the area of whole country.

In Europe, several forest mapping projects have been carried out with success. The Rhenish forest in France was mapped in 1990 with Spot data when it was decided to convert this fragile ecosystem into a protection forest. In order to assess the forest conditions of all forest owners, more than 2000 parcels covering 5000 hectares were analysed. Spot data were classified into 5 main categories, with 13 classes within the forest class. In Sweden, one of the biggest forest companies is up-dating its forest maps with the use of Spot images. The overall cost of the method is found to be twice as cheap as traditional methods (aerial photographs and ground checking).

In Canada, private forests firms are using Spot panchromatic imagery for detecting clear-cutting activities and up-dating the infrastructure (logging roads). Acting under the authority of Canada Natural Resources, the Canadian Centre for Geomatics (CCG), in charge of the country's topographic information programme, is responsible for acquiring data and up-dating the national topographic database (NTDB). Since 1994, Spot imagery is used on routine basis.

In USA, old growth forests in Oregon and Washington States have been mapped with TM data by USFS. Twelve scenes have been processed, and more than 5 millions hectares have been mapped with different criteria characterising the forest structure. With more than 2600 test sites, the overall accuracy was found to be 80 %. In Minnesota, the Department of Natural Resources has tested and implemented a continuous forest inventory based on a two-stage sampling design. Six TM scenes were acquired over five counties for a total study area of 3 millions hectares. Six forest classes and five non-forest classes were identified. The resulting area estimate for total forest land in the five counties was within 3 % of the USDA estimate. By using multi-date TM imagery, forest canopy depletion, canopy increment, and no change could be identified with greater than 90 % accuracy.

The US Forest Service has implemented the FOCIS (FOrest Classification and Inventory System) which is based on TM data and ground sample plots for estimating forest variables. The TM imagery is analysed for delineating forest strata and designing the sampling scheme of ground plots. This method is applied for the National Forests which size is ranging from 2500 to 6000 km².

Expected developments

Many research projects are currently in progress in Europe addressing the increasing demand in forest information. Results and perspectives are actively discussed during international workshops and conferences (see Designing a system…, and Application of remote…) and fast develoment is expected in the near future. The European Union is investigating the utilisation of remote sensing for forestry applications through its Fourth Framework Programme, Environment and Climate, which includes:

- MARIE-F project (Monitoring and Assessment of Resources in Europe - Forest), aimed at developing an original inversible model of forest reflectance and testing it for various applications.
- EUFORA project (EUropean Forest Observations by Radar), aimed at evaluating the value of the most advanced radar remote sensing research results with respect to information required in environment and climate studies, as well as in forest management issues. The project will validate methods and results at different European sites, and define methods applicable in European conditions.
- MEGAFIRES project is a research project based on the use of satellite remote sensing for operational management of large wildland fires in the European Mediterranean Basin. This project is organised around three axes: pre-fire with fire prevention and risk mapping, during fire with fire detection and fire growth monitoring, and post-fire with mapping of large forest fires. Many projects on forest fire have been carried out during the Environment RTD Programme 1991-94.

The European Commission, DGVI, has launched in 1996 a study on the use of satellite remote sensing for forest change detection and structural diversity monitoring. Its main objective is to define, develop and test a system for detecting and identifying significant changes in forest cover, and for monitoring structural diversity of the forested areas over some representative pilot sites in Europe.

The European Space Agency is also investigating the possibility to launch a specific forest resources satellite system. In 1992, under the auspices of the International Space Year, ESA has mapped the entire Europe with respect to forest / non-forest cover (Remote sensing forest map…, 1992).

All these dedicated projects are showing the increasing attention paid to space technology for addressing emerging needs in forest resources assessment and monitoring at the European level.

Current relevant programmes

Technical and institutional links with other programmes in charge of regional to global assessment of forest resources may benefit to EFICS and create a synergy. Two of the described programmes are carried out by Commission funding, the third is a program by United Nations.

The FIRS project (Forest Information from Remote Sensing) was launched by the Joint Research Centre of European Commission in 1994. Implemented by the Environmental Mapping and Modelling Unit of the Space Applications Institute, the project aims at contributing to the establishment of a European forest information system. Methods for deriving statistical and cartographic information about forest production and environmental issues are developed. Satellite data are used as far as possible, and GIS techniques are worked out to integrate them with ancillary information, and to facilitate the distribution of results and information. In the three Foundation Actions of FIRS, a regionalisation and stratification of European ecosystems has been carried out on the basis of forest cover, species composition and volume.

In 1985 the CORINE programme (Co-ordinating Information on the Environment) by the European Union was initiated. Now taken over by the European Environment Agency, the CORINE programme is producing land-cover maps at a 1:100,000 scale, with 44 classes in a 3-level hierarchy. Forest is divided into three classes. The methodology consists of computer assisted photo-interpretation of satellite images with simultaneous consultation of ancillary data. The minimum unit to be recorded is 25 hectares. The main objective is to provide information on the biophysical cover of the EU territory and changes. The integrated database is now operational for about 3.5 million km², and is managed by GIS-CO, the European Commission GIS. Six countries are completed, and in other nine countries significant parts are already inventoried.

The UN-ECE/FAO TBFRA project is also working on the compilation of forest statistics at the global scale. It should be pointed out that in the strategic plan for the next exercise (FRA 2000), the assessment of the state and change of forest resources, and the measurement of parameters related to environmental issues such as biomass, biodiversity, and land degradation represent the major objectives of FAO. In tropical regions, a sample of high resolution satellite images has been used for the FRA 1990 which produced estimates of forest area and area changes. A major improvement, but involving also major effort and cost, is the recommendation to extend the remote sensing method presently used in the tropical context to the rest of the world.

Possible role of remote sensing for EFICS

Feasibility of remote sensing for retrieving EFICS attributes

One solution might be to use satellite data for improving the compatibility among NFI and the efficiency of existing systems. The information needs assessment and the comparative study have led to the classification of EFICS most important attributes into four categories, according to the level of compatibility.

Among the attributes which are difficult to harmonise, some biodiversity indicators such as **fragmentation** can be assessed by means of remote sensing using fragmentation indices.

A second group of attributes ranked as incomparable but which could be harmonised, and which could benefit from remote sensing techniques are: **drain and removals, clearings and forest margin**.

Main tree species groups (broadleaf, conifer and mixed stands) can be assessed by satellite remote sensing with reasonable accuracy.

Forest biomass is an attribute which is derived from other measurements or by destructive methods. In global change studies and carbon cycle investigation, this attribute is of particular interest. Remote sensing has proved to be feasible in some type of European forests for assessing biomass or stem volume, which is closely correlated with total biomass.

Forest area plays an essential role since it is used for extrapolating the other attributes on the entire study area. Harmonisation is strongly needed at European level. Remote sensing can help in this task by providing an independent source of data. The estimate of forest area changes is also a possible application of remote sensing since it can improve the up-dating frequency in national forest inventories which is usually 10 years.

Benefits expected from calibration and multiphase sampling

Two satellite-based approaches can be envisaged for harmonising EFICS attributes, and the effectiveness of them will depend on the current level of compatibility, and on their availability in the NFI:

the calibration approach, which consists of estimating the forest attribute with remote sensing data independently from the NFI estimates but on a harmonised manner at the European level, and of deriving a calibration factor to weight national figures. High resolution satellite data are recommended for this method, and ancillary data or ground measurements should be linked into the high resolution data. The calibration approach can help in understanding and correcting the differences in nomenclature. It allows statistical estimates, but not cartographic harmonisation.

the multiphase sampling approach with satellite data in the first phase, for estimating the auxiliary variable, and ground segments in the last phase for field assessments (target variables estimates). In multiphase sampling for stratification and for regression estimators, the first phase can be based on a wall-to-wall coverage with coarse or medium resolution satellite data. The auxiliary variables can be assessed and a stratification of forest cover proportion and forest types can be proposed by crossing the satellite data-sets with ancillary information into a GIS. The estimation of the strata size can be used to weight national figures. For the second phase, high resolution satellite data can be used on a sample basis, such as Spot or Landsat imagery, and the auxiliary variable can be estimated. Then, a multistage approach could be proposed, with utilisation of aerial photographs, and ground sample plots within the high resolution satellite scenes. This method can help to overcome the differences in the sampling designs between Member States, but not the differences in nomenclature. It allows both statistical and cartographic harmonisation.

Table 25. Improvements in the harmonisation effort provided by the calibration and multiphase sampling methods.

	satellite data	**statistical and cartographic benefits**	**overcome differences in nomenclature**	**overcome differences in sampling designs**	**impact on existing or new attributes**
calibration method	sample of high resolution satellite data	only statistical	yes	no	recommended for existing attributes difficult to harmonise
multi-phase sampling method	wall to wall coverage of coarse or medium resolution satellite data, with sample of high resolution satellite data	both statistical and cartographic	no	yes	recommended for existing attributes that can be harmonised, and for new attributes

Conclusions

By combining the two methods, it should be possible to overcome both differences and discrepancies in sampling designs and nomenclature. New field plots can be required, but the existing ones in the current NFI could be used as well.

An overall scheme based on remote sensing data would greatly benefit from the FIRS project activities and especially from its regionalisation and stratification results. Moreover, it is recommended to use other sources of information such as the CORINE land-cover maps where forest boundaries can be superimposed with FIRS strata and other data (national boundaries).

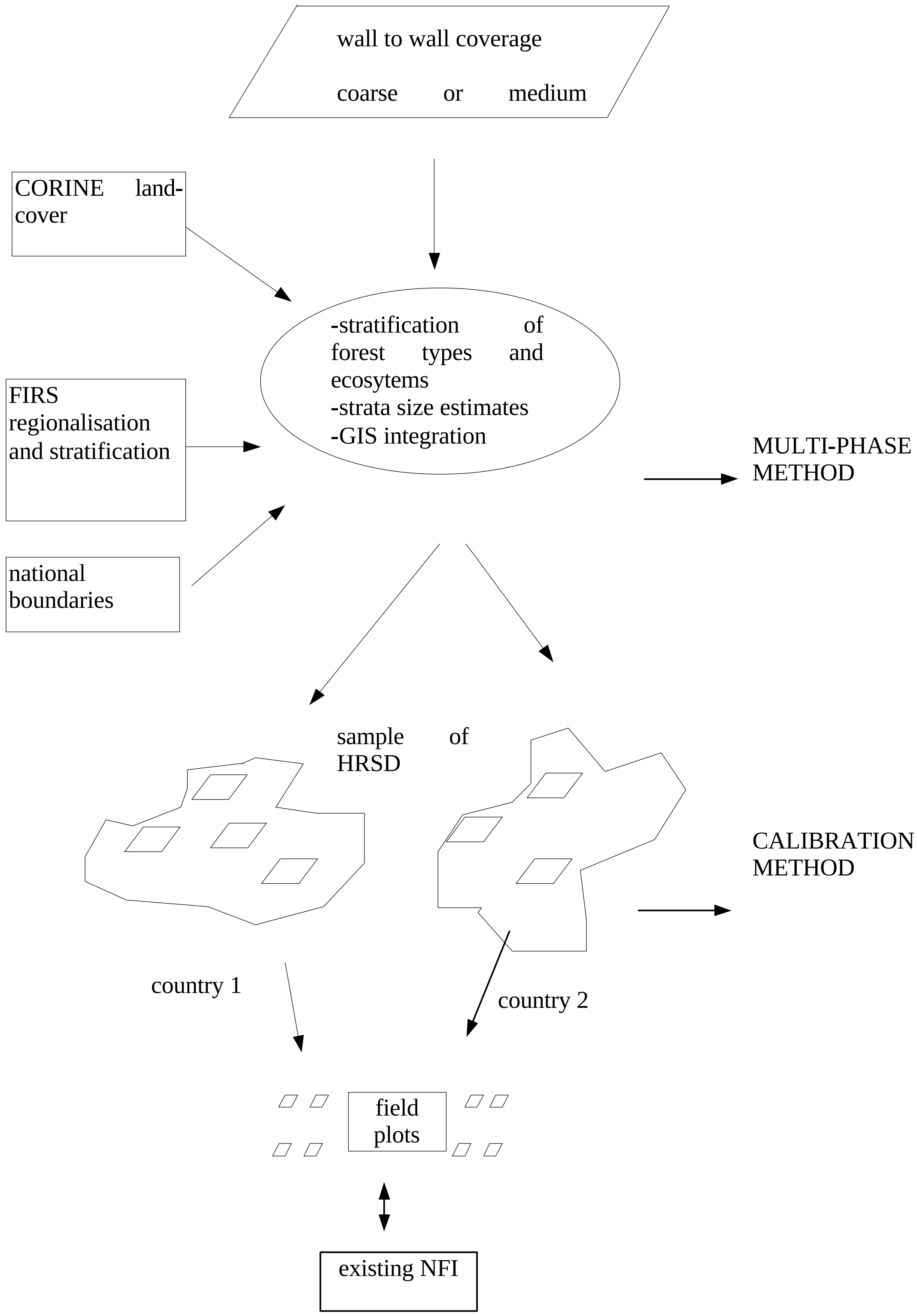


Figure 12. Overall scheme for facilitating the harmonisation of EFICS attributes with the introduction of remote sensing and GIS techniques.

Future possibilities of satellite sensors

Significant advances are likely to be achieved in the estimate accuracy with the new generation of very high resolution sensors. However, the gain in spatial resolution is obtained with a loss of spectral resolution, which is a drawback for assessing forest attributes. More attention is now paid to the combination of different types of sensors having different spatial and spectral resolution. Satellite systems offering multi-resolution capabilities should be of considerable advantage, such as SPOT 4 and 5 (see appendix).

It should be pointed out that the ideal satellite system for monitoring European forests does not yet exist. It would have the following specifications:

- very high resolution for assessing forest attributes at the level a tree or a group of trees;
- multi-resolution capacities for extrapolating large scale assessment to a broad scale;
- high spectral resolution (from visible bands to medium infrared) to allow accurate discrimination of tree species composition and vegetation types;
- high revisiting capability for overcoming the cloud cover problem in some regions;
- large swath width for covering large areas.

The only possibility is to find a good compromise which can meet most of requirements. This can be achieved by combining different bands or images from different sources. In the next five years, significant advances will be made with the launch of very high resolution satellites with 1 to 5 meters resolution in Panchromatic mode (EARLYBIRD, Orbview, Space Imaging). In such images, a tree will be covered by several pixels, and this will enable new information, e.g. about image texture to be obtained. In multi-spectral mode, the new generation of satellites will provide data at 4 to 10 meters. Medium resolution sensors are also providing a new source of data which needs to be fully investigated. The VEGETATION instrument on board Spot 4 (1000 meters resolution) will provide significant improvements in the radiometric and geometric aspects compared with AVHRR, and multi-resolution capabilities will be made possible with the combination of low and high resolution data recorded at the same time on board Spot 4.

Final conclusions concerning Remote Sensing

1. Using satellite Remote Sensing, it is possible to produce forest maps. Such maps can only present a limited number of attributes, like forest area, tree species groups, and fragmentation. Biomass, stem volume and vegetation types may be mapped with less accuracy.

2. These maps can be updated relatively quickly using multi-temporal images.

3. The map information is useful in:

providing results for both small and large scale maps (regional and local maps)
making environmental or other analysis by combining forest map to other information sources, like rainfall, road network, sulphur deposition, protected areas, etc.

4. In forest research, new attributes answering the emerging information needs should be developed together with field survey methods (especially those describing ecosystem). In the near future, more attributes and indicators are likely to be added to the list of applications.

5. Remote sensing can also increase the cost-efficiency of the field sampling by providing basis for stratification. Multi-phase sampling utilising field plots and various remote sensing data, has proven to be cost-efficient method.

6. In principle, remote sensing can be utilised in harmonising the results from neighbouring countries. This, however, needs to be studied more.

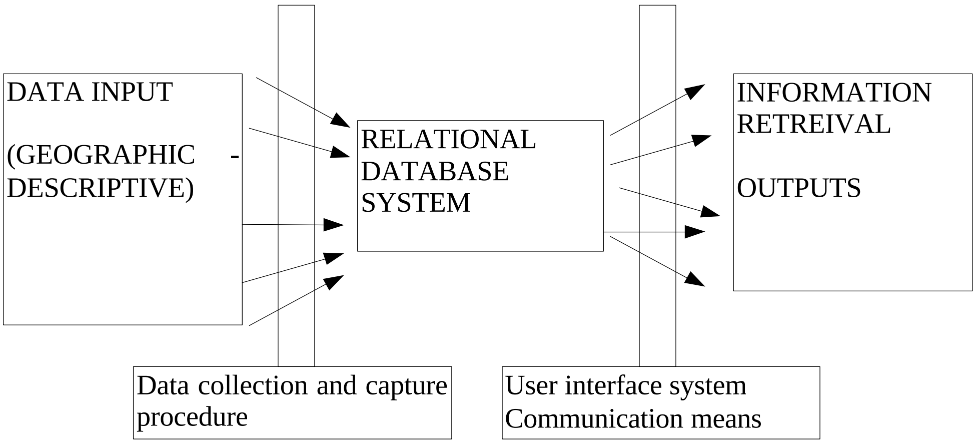
4.3 Geographic Information System

4.3.1. Structure of a GIS

A GIS (Geographic Information System) is an information system where data can be geo-referenced with geographic co-ordinates.

The three main components of a GIS are:

1. data collection procedure;
2. data storage and management;
3. information retrieval.



Basic structure of a GIS

The data sources are twofold:

1. geographic data: they are consist of spatial geo-referenced elementary units which should lead to the entire domain of investigation when aggregated. These data are generally provided by maps and can contain administrative boundaries (borders, districts limits) or thematic boundaries (forest stands boundaries etc.).
2. descriptive data: they are quantitative in nature and characterise the spatial elementary units. They can be forest attributes collected on the field.

Data collection is, in many cases, the most time consuming part of building up a GIS. But it is also the most important, since the usability of the GIS will depend on the quality and reliability of the data input.

The data storage and management is usually carried out by software enabling data capture, data storage, data analysis and data retrieval. Those functions are provided by relational database systems. Specific functions are devoted to the management of geographic data. The database system should be able to operate in both raster and vector format.

Normally, a common client will interact with the database through the user interface system. The user interface system should have the following functions :

- user identification: normal user, privileged user etc.
- request management: all requests can be treated by a customer service which can decide on the authorisation level of data exchange;
- security aspects and controls;
- user-friendly navigation tool for quick data access;

Finally, the information exchange has to be performed with adequate communication means and media which will depend on the amount and format of data, and on the delivery delay requested by the client (see 4.4: communication means).

The most significant advantages of a GIS are:

- integration of different layers of information;
- advanced capabilities for data analysis;
- management of digital data;
- map up-dating facilities;
- modelling and simulation studies;

4.3.2. Utilisation of GIS for NFI in Europe

It can be noted that there is a general trend of increasing the use of GIS techniques for storing, processing and compiling forest data. However, although many forestry GIS are already operational at a sub-national level, very few countries have developed a national geo-referenced forest information system (see table 38).

In most countries, the utilisation of GIS for integrating data collected from field measurements and digitised maps is under investigation or being developed. If map up-dating is expected to be one of the major objectives, other issues are to be addressed such as data management, modelling studies, and data dissemination.

4.3.3. Conclusions

Geographic Information System structure represents the core element in any integrated forest information system. It should play an essential role in EFICS by providing easy and quick access to geo-referenced data. It offers adequate facilities for storing, processing and compiling forest data, with further possibilities in displaying and illustrating information on a didactic manner.

GIS can be used for wood resources and accessibility analysis, but also for non-wood goods and benefits studies, like protective forests (avalanche and erosion risk mapping), landscape planning, and for climate change or pollution risk studies.

4.4 Communication means

Under the assumption that the currently available databases need to be accessed from the external world and need to be made available to a larger community, the means of communication between the user and the information provider need to be identified, specified and checked against the currently available technology.

In the following, the emphasis will be put on the technology to provide access to a database.

Additionally, the key elements required for the inter-connection of the databases will be identified and the user/provider interface of the CEO-ES system (Centre for Earth Observation - Enabling System) will be briefly introduced.

4.4.1. Remote access to Databases

Two different layers need to be taken into account:

1. the **access layer**: (Language to be used in a query formulation) and the
2. the **transport layer**: (Protocol between client and provider for the query and information transportation).

Access Layer

Any system aimed at communicating must provide a structured language. For the commonly utilised relational database management systems, access is enabled via the Simple Query language (SQL) which allows users to query a database if they know its structure.

Since SQL requires the knowledge of the query language and of the database structure, it can be cumbersome if a wide community needs access. Consequently, an additional abstraction layer is needed to allow users to query a database without knowing its structure. This could be realised by the following systems:

- The first possibility is to use a customised user interface which hides the database structure from the user. Most query systems are based on this technology.

Drawbacks: The client package has to be installed at all user sites, which is expensive and probably hard to maintain because of heterogeneous computer platforms running under different operating systems.

- A second possibility is to use a standard user interface which is e.g. realised in the WWW (World Wide Web). Information can be provided on web-pages. To get access to the information, the address and possibly a password must be known. For a more structured database query via the WWW, databases can be implemented on web-pages. The user has to fill a form to submit a query and gets the retrieval results in real time. This database query is independent from specific hardware and operating systems.

Transport Layer

In the following the focus is put on the WWW and the Internet as they are powerful tools with respect to a standard database and information access.

Data transfer techniques via the Internet:

Telnet (Internet Standard Protocol for remote login). It allows a remote login to a computer which provides the access to the database of interest. The use of this technology in the current context of querying and information retrieval has the following drawbacks:

The query interface must be kept simple, no fancy windows and functionality can be utilised.
There is a security breach that any computer hacker can use to perform destructive actions.

Electronic Mail (e-mail). It allows a user to send and receive letters via the Internet. The use of this technology in the current context of querying and information retrieval has the following drawbacks:

The message structure is not unique, queries are defined in a letter style which can lead to communication problems between the user and provider.
There is no real time interaction with the user, no possibility to check the current activity of the provider and no on-line help.
The compatibility between e-mail software packages is not always guaranteed.

Advantages:

Large data files can be sent as attached files in addition to providers comments given in the reply to the query.

FTP (File Transfer Protocol). FTP allows interactive communication with a remote server, files can be sent and received. Currently it is the common means to transfer large files. Since communication works via file transfer, in the context of information query this tool is not very satisfying and must be seen as a tool utilised in addition to other communication means

HTTP (HyperText transfer Protocol). HTTP is the client-server protocol i.e. a language used in the WWW system. Without using the widely available extensions (plug-ins, Java application) the HTTP protocol has the following drawbacks in the current context of querying and information retrieval:

There is no means to retrieve binary data, only HTML (Hypertext Mark-up Language) text data can be retrieved.
There is no means to send other data than the query.

4.4.2. Databases and Communication

In this chapter the basic concepts required to make several remotely located databases accessible to a single user and the communication between these databases are introduced.

Also the distributed database concept (i.e. the remotely located databases are considered from the database Management System (DBMS) as one database) will be considered.

The communication and access to the different components which is handled directly by the DBMS is not discussed because it is not widely used and requires a strong homogeneity between the databases. Moreover, it is equivalent to the system where users have access to one database.

Consequently, the databases discussed are considered as independently developed databases running with different DBMS. The considerations are based on the Single Access Point system which means that the user specifies a query from one particular location. Once specified, the query is sent to the databases and the results will be sent back to the user.

Query Communication and Retrieval of Results

The query specified by the user can not be understood directly by the DBMS, consequently a translation mechanism must be implemented. There are two different options and also an intermediate solution - the CEO-ES system - described in chapter 4.2.4.3.

Option 1: The query is sent in its original form submitted from the user access point server to the DBMS. Therefore a translation system is needed which transforms the incoming query, specified in generic terms, into a query which can be processed by the DBMS. This so called "gateway" is to be installed at the database location. It has the following characteristics; (i) the knowledge about the database structure is only important for the particular database location, (ii) the server has to send the query to all databases even if not relevant, (iii) the translation system is complex and may have to be customised to each database location.

Option 2: The query is translated by the user access point server and sent directly to the databases. It has the following characteristics: (i) the user access point server must know the database structure, (ii) the information about the database structure must be kept up to date at the user access point server site, (iii) no translation mechanism are required at the databases site, (iv) the user access point server may choose the relevant databases for each query.

For the retrieval of the results two options are applicable:

the server displays the results as received and a unique layout is performed at the databases site or
the layout is performed at the user access point server site.

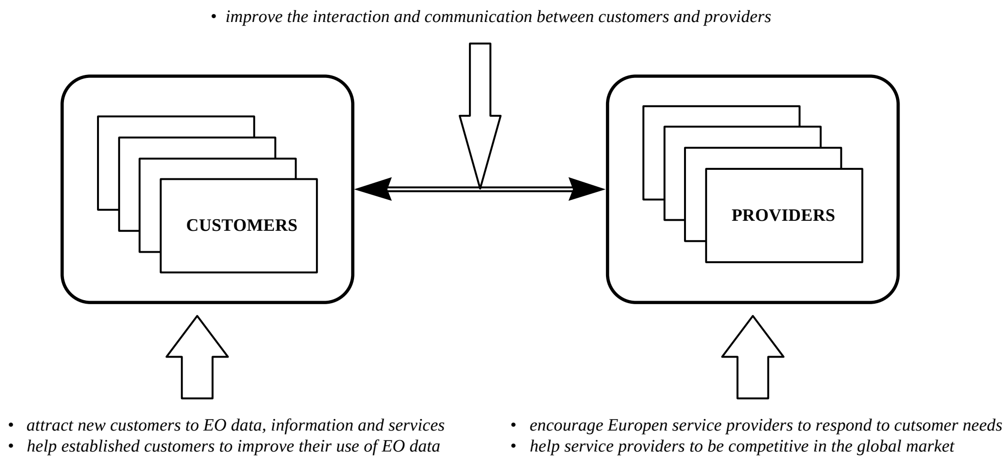
4.4.3 The CEO-ES System - a brief introduction

As stated above, the CEO system is to be regarded as an intermediate system for query communication and the retrieval of results.

The CEO-ES system forms one part of the CEO programme. The three major objectives of the CEO programme are [RD-11]:

to attract new customers to use Earth observation data, information and services, and to help established customers to improve their use of Earth observation data;
to encourage European service providers to respond better to the needs of the customers and to help these providers to become competitive in the global market;
to improve the interaction and communication between customers and service providers.

These aims are summarised in the following figure.



The concept:

Within the Earth observation (EO), remote sensing and associated communities, there is a wealth of EO data, information and services which are of interest to potential users. However, in many cases the potential users are often unaware of the potential of this database since there is no information system which is capable to allow access to these services and which could retrieve the results for the interested user.

The purpose of the CEO-ES is to facilitate the interface between all potential users of the CEO services and the corresponding providers. To achieve this goal, the CEO ES will be developed as ‘middleware’, a software tool which does not substitute the existing communication system between customers and providers. The CEO-ES will provide a single access point whereby a potential user can explore all provider services registered within the CEO-ES in an efficient way. The required step towards satisfaction of user requests will be to allow service providers to advertise their services and to provide on-line distributed search services. Hence, in addition to the user satisfaction the CEO-ES system guarantees a potential market in the CEO-ES user base for the service providers.

4.5 Future Developments of Information Processing

EFICS will be a system that collects and processes information. The future development of information processing will be characterised by a shift from providing statistical figures to information that illuminates the (causal) relationships of complex systems and the support of the decision process. This chapter outlines the potential impact of future developments of information processing on EFICS. The consortium tried not to limit itself on the - by whatever means specified - feasible alternatives, but tried to show the entire range of information processing approaches.

4.5.1 Information processing systems

Several categories or systems can be selected for information processing, which are

- Monitoring system
- Conventional information system
- Compilation and analysis system
- Decision support system
- Integrated forest information system

Monitoring system

These systems are concerned with "measurements and control". They are used for environmental monitoring and the control of environmental impact on ecosystems.

Conventional information system

This class comprises systems that are used for data storage, integration and output of data with different origin and structure:

- raw data from assessments
- formatted data on facts such as critical loads, emission factors, timber flow etc.
- unformatted documents such as national laws, literature etc.

The requirements concerning temporal and spatial relations of the data have to be considered. The extraction of information does not typically go further than selecting and putting together data from different sources.

Compilation and analysis system

Compilation and analysis systems support the processing of data by means of complex mathematical and/or statistical methods and models, e.g. prognosis methods, image analysis systems or simulation systems. An example of these systems are simulation models that are used for causal inference in forest decline studies.

Decision support system

They offer direct support to decision-makers by providing methods for the valuation of alternatives or by offering reasons for decisions. The difference to the systems mentioned above is that decision support systems offer components that go beyond the analysis of the status-quo and assist the selection of alternatives. Here inference models with logical components and expert systems are requested.

Integrated information system

Integrated (forest) information systems combine different aspects of the systems mentioned above. Designing these systems requires the combination of different concepts such as data base systems, GIS, simulation models and expert systems.

4.5.2. Information processing tools

In addition to the information processing systems, different methods and tools of information processing exist and have to be evaluated in the scope of EFICS:

- Data base systems and GIS
- Modelling and simulation techniques
- Artificial intelligence
- User interfaces and software ergonomy
- Computer graphics and visualisation
- Neural networks
- Integration

Data base systems and GIS

Data base systems are among the most important tools for information systems related to the environment. Problems, however, occur when the complex structures of environmental data have to transferred in data models of standard data base systems. At the moment, different aspects of processing environmental information are supported by different data base systems. The currently available systems support one-sided special user groups but do not offer solutions that are flexible enough to satisfy all needs of environmental information processing.

Relational data base systems lack practicability if complex information sources such as assessed data, text (e.g. laws, regulations) or area related data have to be combined. The structure of such information makes the set-up of normalised relationships difficult. Integrated information systems require new database concepts, such as object oriented database systems, which enable the sound and unique processing of information.

Geographic information systems (GIS) are designed to work with data referenced in geographic co-ordinates. GIS is a database system with special capabilities for spatial referenced data. The set-up of large GIS-based systems renders the combination of different data structures with various spatial resolution essential. Special techniques for the analysis of spatial data such as geo-statistical (Journel and Huijbregts, 1978, Köhl and Gernter, 1992, Mandallaz, 1994) have to be an integrated component of an information system.

Modelling and simulation techniques

Modelling and simulations techniques are valuable tools for the analysis of complex systems. They allow causation by integrating different layers and different sources of information and should thus be an essential part of any information system.

Artificial intelligence

The usability of artificial intelligence, especially expert systems, with respect to environmental information systems has been widely discussed. However, the proportion of solutions that can be used in reality is currently rather limited. Approaches based on artificial intelligence could be developed for information retrieval, monitoring and causal inference. The implementation of expert systems will, however, be limited as techniques for information acquisition and related tools for inter- and multi-disciplinary fields are hardly developed and lack real-time features.

User interfaces and software ergonomy

A prerequisite for the wide use of EFICS will be the user-friendly and easy access to information. Thus, such user interfaces have to be developed which do not only support frequent users but enable potential users with periodic access to retrieve information. The simple and comfortable access to EFICS will only be guaranteed by powerful user interfaces that are designed according to the principles of software ergonomy. The interfaces have to incorporate components that guide the users to the information required.

Computer graphics and visualisation

Applications of computer graphics and visualisation are essential for the political decision process, reports and research. As visualisation can support the presentation and analysis of complex structures, they have to be integrated in analysis systems. The importance of visualisation for explorative analysis is obvious (Denzer et al., 1994).

Neural networks

Neural networks are a special application of artificial intelligence. An integrated component of neural networks are algorithms that can process information in the sense of learning processes. Neural networks can be helpful tools for screening large data sets and for the exploration of "hidden" structures and relationships (Köhl and Jensen, 1993)

Integration

Environmental issues are among those where most integration tasks have to be fulfilled. Not only system dependent integration has to be undertaken, but different actors (international organisations, national and federal administration, communities, enterprises, citizens, environmental protections agencies etc.) and different levels of knowledge have to be co-ordinated.

In the scope of environmental information systems, the concept of meta-information has been proved useful, i.e. the information about information, which is analysed by the user or the system itself. Within complex information systems, such interactive user interfaces have to be developed that guide users to the information required. Data stored with different structures in different locations can be connected by meta-information servers.

Meta-information is required to navigate through complex information systems and it provides knowledge about the semantic of the stored data, which is necessary to utilise the data beyond the context where they have been assessed. However, major research is required to present, standardise, automatically generate and analyse meta-information.

4.5.3. Combination of information processing tools and systems in the decision process

The systems for information processing require the implementation of different information processing tools to various extent. According to Page and Hilty (1995), modelling and simulation, for example, is extremely relevant for compilation and analysis systems but not relevant for a conventional information system. In the following, an example of the relevance of various processing tools for different type of systems is given:

Information Processing Systems

Information Processing Tools	Monitoring system	Conventional information system	Compilation and analysis system	Decision support system	Integrated forest information system
Data base systems, GIS	xx	xxx	xxx	xx	xxx
Modelling and simulation Qualitative and fuzzy models	xx	x	xxx	xxx	xx
Artificial intelligence (expert systems)	xxx	x	xx	xxx	xx
Computer graphics visualisation	xxx	xx	xxx	xx	xx
User interfaces software ergonomy	xxx	xxx	xx	xxx	xxx
Neural networks	xx	x	xxx	x	xx
Integration and Meta-information	xxx	xxx	xx	xx	xxx

not relevant	x
relevant	xx
extremely relevant	xxx

The degree to which the concepts and categories described above will be utilised in the scope of EFICS depends on the level and intensity with which raw data have to be transformed to forest information and how EFICS should facilitate decision-making processes. The decision-making process can be divided in five steps, each of which could be supported by EFICS (Kast and Rosenzweig, J. 1974, Päivinen and Solberg, 1995).

1. The first task in the process of providing information is to define for whom the information should be produced. The decision-maker is not always a forest manager or otherwise easily identified person or body, but more often an anonymous group of people creating public opinion. Another task is to define the target system, and what elements of the target system the decisions concern.

2. In the next phase, the goals of the decision-maker must be analysed. The quantitative and qualitative variables which affect the utility of the decision-maker are to be stated first.

3. Description of the target system is the next phase. Forest inventory is a typical task. It can as well include inventory of the human resources, infrastructure or other facilities. In forest inventory, there is a set of alternatives to be evaluated when deciding the information flow from raw data to value added information.

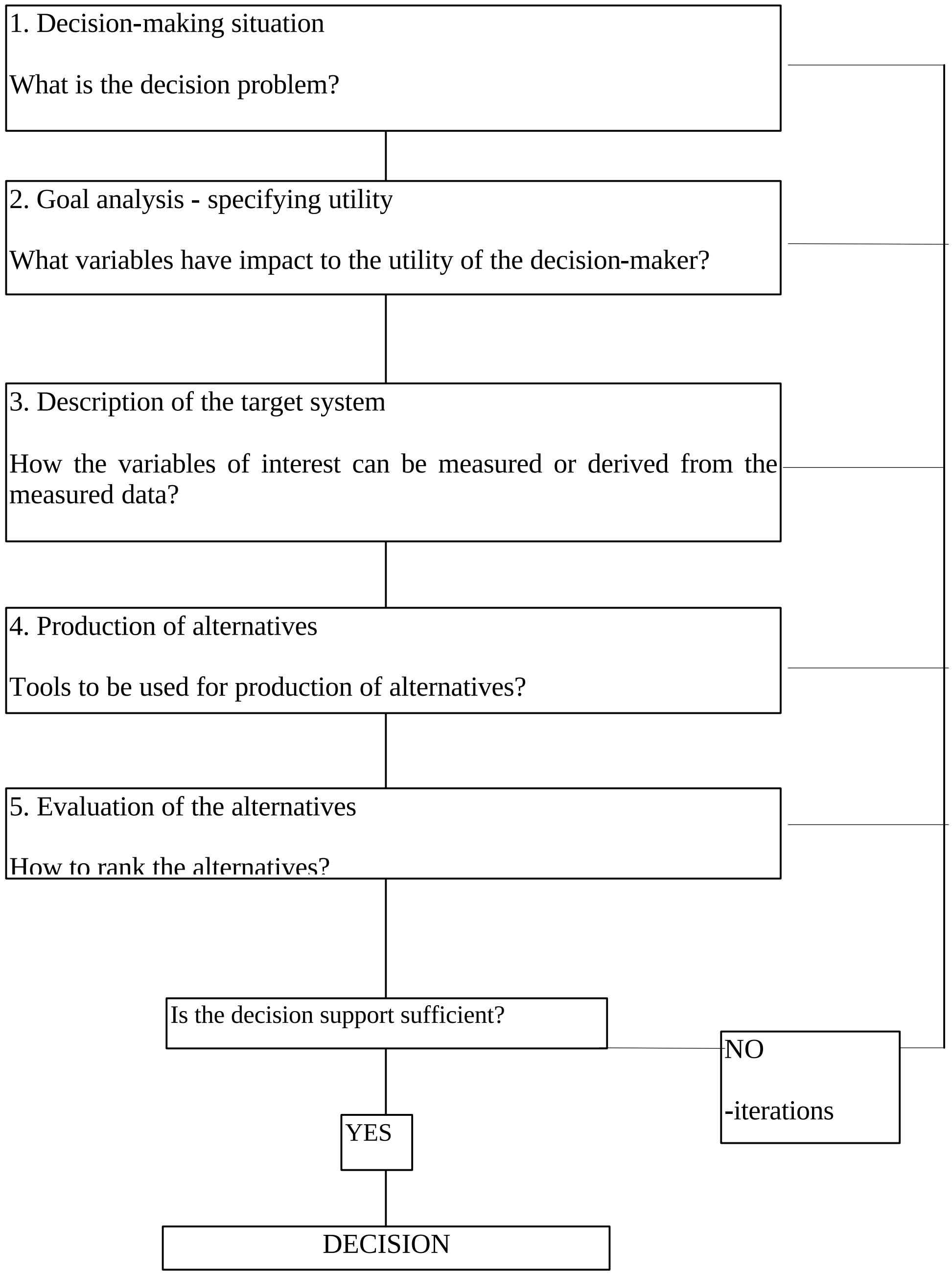
4. The decision can be made only if there are more than one alternative actions. The central task in decision-making process is to define the consequences of the alternative ways of action. In forest management planning and in a number of other tasks, this is most often carried out by computer simulation.

5. After having defined the alternatives, they must be evaluated in the light of the analysis of goals. How the interesting variables are to be weighted, will be set when forming the utility function.

Research will have an impact on all phases of the decision-making process; it will bring up new decision problems and emphasise new variables which may affect to the utility of the decision-maker. These variables must be measured, and their dynamics described in order to create alternatives, and finally rank the decision alternatives.

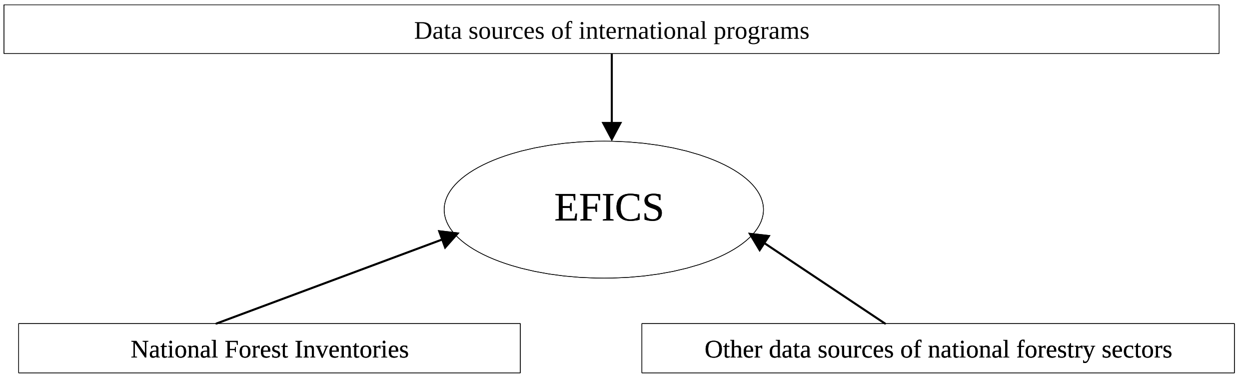
This process is often iterative. The first trials may show that the decision support is not sufficient, and one must go back and include more variables, measure variables more accurately, or create more alternatives for decision-making. The concepts and categories of data processing can be utilised to a varying degree to support the five steps of the decision-making process. It has, however, to be realised that conventional information systems fail to be helpful in the entire decision process. They do not provide means to derive alternatives and evaluate them and thus are of limited use decision making.

The phases of the decision-making process.



4.5.4. Integrating EFICS and other information and communication systems

The present study has shown that the retrieval of information necessary for decisions concerning forestry and the environment requires data that origin from various sources. It is obvious that the information support provided by EFICS will be limited, if only data from national forest inventories are utilised. Thus EFICS has, on one hand, to collect data and information from other sources and, on the other hand, provide its own data stock to outside information systems. New technologies, especially those concerning data processing and information management, will facilitate data integration and data exchange. EFICS could be the institution to gather data and information from the forestry sector. This information has to be made available for other users or information systems and information from these systems has to be integrated into EFICS to render comprehensive analysis of forests and the environmental impact possible. Potential partners for EFICS could be scientific programs in ecology, hydrology, geology, soil sciences and others as well as with international organisations such as UNESCO, United Nations Environmental Programme (UNEP), World Meteorological Organization (WMO), World Conservation Monitoring Center (WCMC), Man and Biosphere Programme (MAB), International Hydrology Programme (IHP), NASA, ESA, United Nations Food and Agriculture Organisation (FAO) or United Nations Economic Commission for Europe (ECE), and many others.



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Remote sensing map of Europe at 1:6,000,000 scale. 1992. GAF, SSC, Scot Conseil, National land survey of Finland. ESA contract.

Appendix 3: Characteristic at satellite sensors

Very high and high resolution satellite sensors, in service.

Mission (Agency)	Sensor	Pixel size	No of bands	Wave-lengths	Swath width	Stereo capability	Launch date	Status	Access to data
Landsat 5 (NOAA)	TM MSS	30 m 120 m 80 m	6 1 1	Vis-SWIR Thermal Vis-NIR	185 Km 185 Km 185 Km	No No	1984	In service	Easy
IRS-1B (ISRO)	LISS 2 LISS 1	36 m 72.5 m	4 4	Vis-NIR Vis-NIR	2-74 Km	No	1991	In service	Difficult
SPOT 1-3 (CNES)	HRV HRV	10 m 20 m	1 3	Pan Vis-NIR	2-60 km 2-60 km	Yes Yes	1986, 1990, 1993	SPOT 3 lost in Nov. '96	Easy
JERS-1 (NASDA)	OPS	18-24 m	4	Vis-SWIR	75 Km	No	1992	In service	Difficult
Resurs-O1-3 (Russia)	MSU-E	45 m	3	Vis-NIR	2-45 Km	No	1994	In service	Medium
IRS-1C (ISRO)	Pan LISS3	5.8 m 23.5 m 70.5 m	1 3 1	Pan Vis-NIR SWIR	71 km 148 Km 148 Km	No No	1995	In service	Should start early 1997
ADEOS 1 (NASDA)	AVNIR AVNIR	8 m 16 m	1 4	Pan Vis-NIR	80 Km 80 Km	No No	1996	In service	Difficult

Medium and low resolution satellite sensors, in service.

Mission (Agency)	Sensor	Pixel size	No of bands	Wave-lengths	Swath width	Launch date	Status	Access to data
Resurs-O1-3 (Russia)	MSU-SK	170 m	4	Vis-NIR	600 Km	1994	In service	Medium
NOAA 12, NOAA 14 (NOAA)	AVHRR2	1000 m	3 2	Vis-SWIR Thermal	2400 Km	1991, 1994	In service	Easy
IRS-1C (ISRO)	WiFS	188 m	2	NIR	770 Km	1995	In service	in 1997

Very high and high resolution satellite sensors, planned.

Mission (Agency)	Sensor	Pixel size	No of bands	Wave-lengths	Swath width	Stereo capability	Launch date	Status
Early Bird (Earth Watch Inc)		3 m	1	Pan	6 km	Yes	1997	Firm, approved
SPOT 4 (CNES)	HRVIR HRVIR	10 m 20 m	1 4	Pan Vis-SWIR	2 - 60 km 2 - 60 km	Yes Yes	1997	Firm, approved
Space Imaging (Lockheed)		1 m 4 m	1 4	Pan Vis-NIR	15 km 15 Km	Yes	1998	Firm, approved
Orbview (Orbital Science Corp)		2 m 4 m	1 4	Pan Vis-NIR	15 Km 15 Km	Yes	1998	Planned
Landsat 7 (NASA)	ETM ETM ETM	1 6 1	15 m 30 m 120 m	Pan Vis-SWIR Thermal	185 Km	No	1999	Firm, approved
SPOT 5 (CNES)	HRG HRG	10 m 20 m	3 1	Vis-NIR SWIR	2 - 60 km 2 - 60 km	Yes Yes	2002	Firm, approved

Medium and low resolution satellite sensors, planned.

Mission (Agency)	Sensor	Pixel size	No of bands	Wave-lengths	Swath width	Launch date	Status
SPOT 4 (CNES)	VEGETA TION	1000 m	4	Vis-SWIR	2200 Km	1998	Firm, approved
EOS (NASA)	MODIS AM-1	250 m 500 m	2 5	NIR Vis-SWIR	2300 Km 2300 Km	1998	Firm, approved
ENVISAT (ESA)	MERIS	300-1200 m	15	Vis-SWIR	1450 Km	1999	Firm, approved
NOAA K-N (NOAA)	AVHRR3	1000 m	4	Vis-SWIR	2400 Km	1996-97-98, 2000, 2003	In service and approved
METOP-1 (Eumetsat)	AVHRR3	1000 m	4	Vis-SWIR	2400 Km	2000+	Firm, approved

Radar satellite sensors, in service or planned.

Mission (Agency)	Sensor	Pixel size	No of bands	Wave-lengths	Image size	Launch date	Status	Access to data
ERS 1-2 (ESA)	SAR	30 m	1	C	102 Km	1991, 1995	In service	Easy
JERS-1 (NASDA)	SAR	18 m	1	L	75 Km	1992	In service	Difficult
Radarsat (Canadian Space Agency)	SAR	10-100 m	1	C	50-500 Km	1995	In service	Medium
ENVISAT-1 (ESA)	ASAR	30-100 m	1	C	100-400 m	1999	Firm, approved	
ALOS (NASDA)	VSAR	10 m	1	L	70 Km	2002	Firm, approved	

5. Final conclusions

The objective of the final conclusions is to outline the actions and next steps towards a European Forest Information and Communication System. The work packages (WP) described so far form the base for the analysis of the final conclusion of the study. The following working packages had special impact on the final conclusions:

Country analysis and reports:

- state-of-the-art inventory methods and procedures applied in EU and EFTA countries

- definition and measurement rules for directly assessed and derived attributes

- analysis methods

Comparative Study

- needs for improvement and harmonisation

Simulation study

- impact of different definitions and measurement on results

Information needs on national and international level

- key information required from EFICS

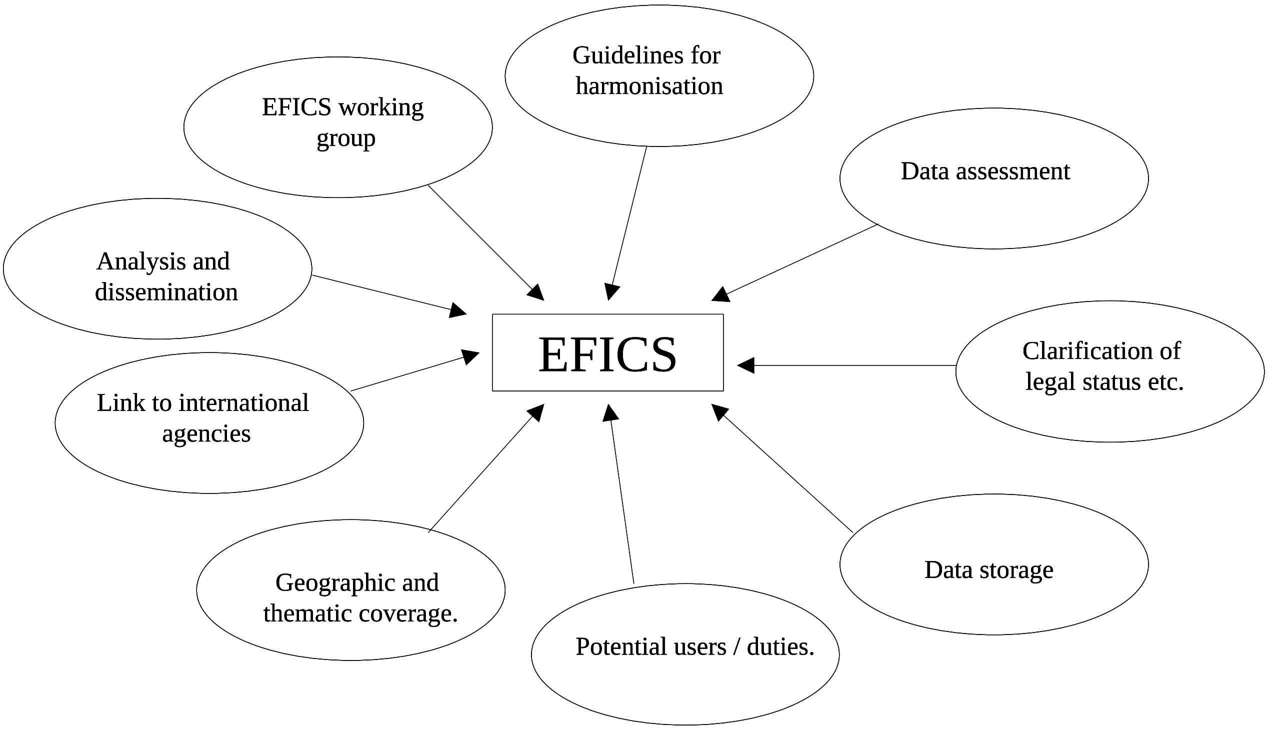
Analysis of improvements and harmonisation activities needed and respective costs

- outline of necessary activities to harmonise three target levels of attributes

Development of new technologies and its impact on the harmonisation

- feasibility study on the application of new technologies in the near future

The final conclusions do not summarise the results of the other Wps but present the potential future development of EFICS. The discussion will be done separately for nine different groups of actions:



Most of the groups of actions will be presented in modular form. This enables to build up an action plan for EFICS based on different assumptions and goals, but does not provide a one-sided view of the consortium. The solution of the most suitable set of actions requires the possibility to select the most appropriate set of actions among a variety of approaches by weighting each approach according to the required needs and funds. The consortium did restrict itself to the presentation of different actions and the description of their advantages and disadvantages.

5.1. Data assessment

EFICS has to have access to data assessed in forest resource assessments. The problems concerning the comparability of data on the national level and the reliability of international statistics compiled on the base of national data have been presented and discussed in Task 1 and Task 2.

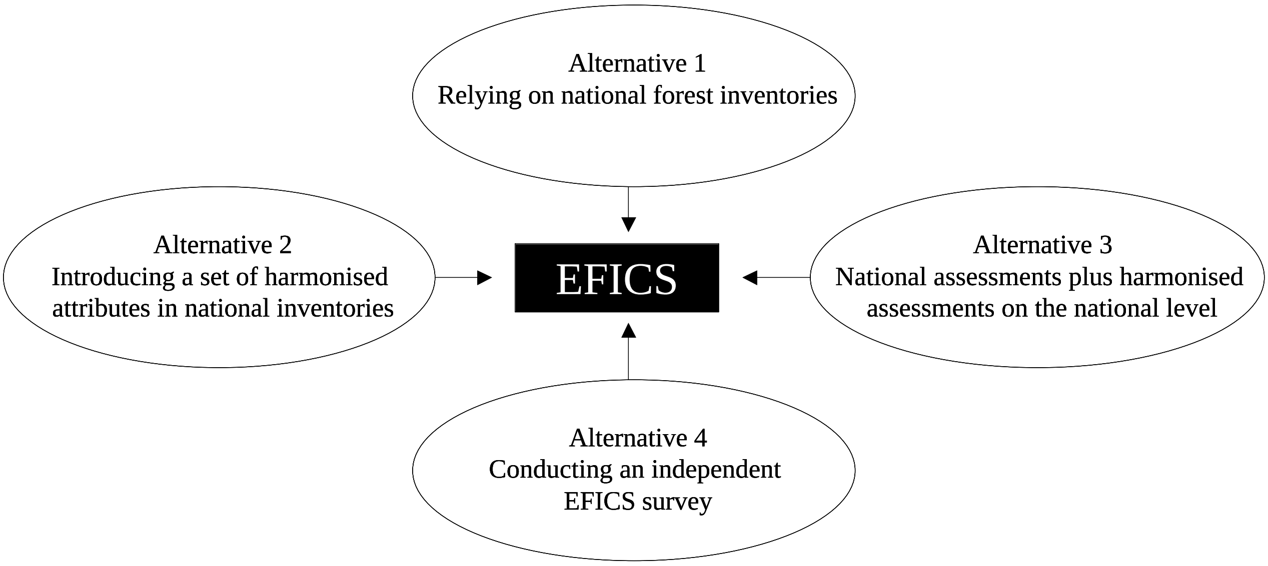
There are four major approaches existing which EFICS could follow in the near future:

Alternative 1. Relying on national forest inventories

Alternative 2. Introducing a set of harmonised attributes in national forest inventories

Alternative 3. Using data from national assessments plus harmonised assessments on the national level

Alternative 4. Conducting an independent EFICS survey



Between these four approaches transitions are possible, which increase the number of potential solutions for data assessment in the scope of EFICS. The discussion, however, will concentrate on the four approaches presented above, as each of them is a nucleus and indicates specific advantages and disadvantages.

Each approach is described briefly, the advantages and disadvantages are listed and the likelihood of the approach to be realised is discussed. The list of advantages and disadvantages is based on the Information Needs Assessment conducted by the Consortium. It could be widened if additional potential users of EFICS - mainly outside forestry - would be included. Some advantages could be considered to be a disadvantage from a different perspective. The comparisons listed below allow, however, to judge the potential of realisation and the improvement in making reliable information available on the European level.

Alternative 1. Rely on national forest inventories

This alternative describes the current state of data acquisition on the European level. Different data sources are utilised by individual nations to assess data to satisfy national information needs. As a side product the national data are compiled on the multi-national level. The advantages (+) and disadvantages (-) are briefly listed below:

+ no additional costs for data assessment have to be allocated

+ the survey methods are adapted to national information needs

+ for many countries long time series are available

+ the infrastructure for conducting surveys is available

+ already implemented on the European level (except Luxembourg and Denmark)

- not all of the data and assessment methods are yet harmonised on the European level

- national data compiled on the multi-national level lack comparability
- sampling fraction, precision and sampling frame differ substantially between nations
- manifold survey and analysis methods lead to results which are not comparable
- the different statistical approaches are difficult to compare on the multi-national level
- there are differences in the sets of data assessed in different countries, i.e. not all information required on the European level can be obtained from each country
- analyses are restricted to national boundaries; the analysis of regions which overlap more than one country is not possible
- the information required cannot be obtained in a short period of time as the individual inventory cycles determine the data disposal
- problems with periodicity exist, i.e. the data are assessed over a long period of time (> 10 years) and cannot be referred to a common reference point or a suitable reference period

The comparison of advantages and disadvantages shows that there are many reasons not to rely on national forest inventories alone. The information needs specified for EFICS can hardly be met and will leave some doubt about the necessity of EFICS in the future. Following this approach EFICS will not be a tool for comprehensive and timely retrieval of information. On the other hand, no costs for data assessment have to be covered by EFICS and countries can stick to their inventory traditions, which can be regarded to be an advantage of this approach. This approach is definitively not suitable to meet the specific tasks of EFICS.

Alternative 2. Introduce in national forest inventories a set of harmonised attributes

A moderate approach to obtain harmonised data on the European level would be the combination of national inventories and assessments following some standardised European guidelines. In the short run, conversion factors should be derived to convert country figures to make them comparable to the European definitions. As a second step, in realising the assessment of a set of attributes according to a standardised nomenclature would be to include "EFICS-assessments" in national surveys. EFICS could submit the nomenclature for a limited set of attributes to national inventory bodies and request the assessment of those attributes according to the nomenclature provided.

This approach would concentrate on the assessment of a fixed set of attributes. The selection rules, the sampling frame, the survey methods and the sampling fraction would not be affected and would still follow national regulations. On each sample plot (field or aerial photography) and each selected tree, respectively, the standardised attributes would be assessed in addition to the attributes assessed according to the national nomenclature. To give an example, Finland, Norway and Sweden would have to include measurements of stand width, crown cover and minimum area for the assessment of forest area, but simultaneously maintain their traditional forest area definition that is based on minimum production per hectare and year.

The advantages and disadvantages of this approach are as follows:

+ only small additional costs for data assessment have to be allocated
+ the survey methods adapted to national information needs will be maintained
+ long time series on the national level will be maintained

+ the infrastructure for conducting surveys is available

+ harmonised information for key attributes will be available

+ data assessed according to two nomenclature (EFICS and national) can form the data base for the calculation of conversion factors and thus facilitate harmonised information for the past

+ national harmonised data compiled on the multi-national level will have high reliability

+ new attributes can be harmonised in advance and introduced easily

- not all of the assessment methods are yet harmonised on the European level

- sampling fraction, precision and sampling frame differ substantially between nations

- manifold survey and analysis methods

- different statistical approaches lead to difficulties to compile harmonised attributes on the European level and to provide results for regions which overlap more than one country

- the information required cannot be obtained in a short period of time as the individual inventory cycles determine the data disposal

- problems with periodicity, i.e. the data are assessed over a long period of time (> 10 years) and cannot be referred to a common reference point or a suitable reference period

The gain in reliability of European statistics will be considerable. However, the approach is still a compromise, as the statistical design and the assessment methods applied by individual countries will not be influenced.

The share of cost of such additional, harmonised attributes will be decisive for the realisation of this approach. If the additional costs have to be covered by individual nations, the likelihood of getting this process accepted will be by far less than if EFICS would provide financial support (subsidies) for the additional efforts. This alternative might be the most feasible and realistic one at the moment.

Alternative 3. National assessments plus harmonised assessments on the national level

Alternative 2 relies very intensively on the national assessment methods and statistical designs. An extension of this approach would be to conduct an "EFICS-assessment" parallel to the national assessments. This would lead to a situation where two independent surveys would be conducted in each country: (1) the traditional national forest inventory and (2) a forest inventory designed for the European level. The second survey will be called "EFICS-survey" in the following.

The EFICS-survey could utilise both field assessments and remote sensing as primary data sources. As field surveys are time and cost consumptive and require a well developed infrastructure, the utilisation of remote sensing techniques is the more straightforward and realistic approach. GIS techniques could be used in addition to facilitate the calculation and modelling of derived attributes. Work Package 4.2. gives a summary of the present and future potential uses of remote sensing.

The remote sensing phase could be the central part of the EFICS survey. From a statistical point of view, this would be the first phase of a multi-phase sampling design. All national data could be considered to be the second - and further - phases and estimators combining stratified sampling, and multi-phase sampling could be used for data analysis. The remote sensing phase could be a "calibration" phase as well and be used to derive and apply conversion factors for the national level.

Multi-phase sampling designs include information from different assessment levels. The data collected from the n-1 phases serve as auxiliary variables, while the variables of interest are derived from data from the lowest (n_{th}) level. Remote-sensing techniques are the ideal solution for data assessment of the n-1 phases as they reduce the assessment cost for auxiliary variables considerably compared to the assessment cost of the variable of interest. The sample size is highest in the first phase and decreases from phase to phase. There are two types of multi-phase sampling designs which can be applied to combined forest surveys: multi-phase sampling with regression estimators (MSR) and multi-phase sampling for stratification (MSS). As MSR can be applied only for a very limited set of key attributes (attributes on an absolute or interval scale), while MSS will offer much more flexibility and power in the scope of EFICS.

Both inventory systems, national and the EFICS surveys, can but do not necessarily have to be linked. Methodological problems, however, would still be present as the two data sets are not harmonised. Sophisticated statistical methods have to be developed that allow to "compare apples and pears".

The advantages and disadvantages of this approach are as follows:

+ the survey methods adapted to national information needs will be maintained

+ long time series on the national level will be maintained

+ the infrastructure for conducting national surveys is available and could be used for the EFICS-survey as well

+ harmonised information will be available due to harmonised methods on the European level

+ data assessed according to two nomenclature (EFICS and national) can form the data base for the calculation of conversion factors and thus facilitate harmonised information for the past

+ nationally harmonised data compiled on the multi-national level will have high reliability

+ the national assessments could be used to increase the reliability and precision of the EFICS survey

+ sampling fraction, precision and sampling frame do not differ between nations

+ results for regions which overlap more than one country can easily be compiled

+ the information required can be obtained in a short period of time as the individual inventory cycles do not determine the disposal of data

+ new attributes can be introduced rapidly and thus new information needs can be met in a short period of time

+ problems with periodicity, i.e. the data are assessed over a long period of time (> 10 years) and cannot be referred to a common reference point or a suitable reference period will be solved

+ discussions on the "best solutions" will be minimised

- high additional costs

- two sets of results are available: one according to the traditional assessments and one according to the EFICS-survey. Differences are likely to occur and will lead to substantial discussions

- the national acceptance of the EFICS-survey could be low due to political and personal reasons

- the legal base for an EFICS survey has to be formed before the survey can be conducted

This survey would combine the national needs and the necessity for sound information on the European level. The cost would be very high, as two independent surveys have to be conducted.

Costs and national considerations conflict with the availability of harmonised and reliable information on the European level. The potential of realisation will be highly depending on the political process that has to be initiated to introduce the EFICS survey.

Alternative 4. Conduct an independent EFICS survey

The fourth alternative is strictly related to information on the European level. Under the auspices of EFICS a survey covering the entire area of EU member states (and EFTA countries) will be designed and conducted. The design of the survey can be focused on multi-national user needs and thus lead to the most cost-efficient survey design to obtain information on the European level. Information on the national level has subordinate importance, but can be considered in the optimisation process. The traditions and specific long term information in individual countries will not be maintained, the comparability with former national figures will be weakened. Information on the national level can, however, be provided with a specified level of precision, but not all attributes and information will necessarily be provided for individual nations.

The advantages and disadvantages of this approach are as follows:

\+ harmonised and reliable information will be available on the European level

\+ the assessment methods are harmonised on the European level

\+ national harmonised data compiled on the multi-national level will have high reliability

\+ the national assessments could be used to increase the reliability and precision of the EFICS survey

\+ sampling fraction, precision and sampling frame do not differ between nations

\+ unique survey and analysis methods

\+ results for regions which overlap more than one country can easily be compiled

\+ the information required can be obtained in a short period of time as the individual inventory cycles have not to be followed

\+ new attributes can be introduced rapidly and thus new information needs can be met in a short period of time

\+ no problems with periodicity; a common reference point or a suitable reference period can be realised

\+ reduction of costs as method development, assessment and analysis are "in one hand" and costly national solo attempts are avoided

\+ only one set of unambiguous results is available (EFICS-survey)

\+ individual nations can extend the set of attributes on the national level to be able to provide specific, national information

\+ new technologies could be introduced on the European level

\- the survey methods adapted to national information needs will not be maintained

\- long time series on the national level are likely to be lost

\- the infrastructure for conducting national surveys has to be replaced

\- the national acceptance of the EFICS-survey could be low due to political/ personal reasons

\- the legal base for an EFICS survey may have to be formed before the survey can be conducted

\- the solution bears a high risk for conflicts and polarisation of national and Commission interests

\- national forest surveys have to be reorganised

This alternative is the one going furthest in obtaining harmonised information on the European level. The alternative would be the most suitable one to reach objectives formulated for EFICS. It would, however, be the alternative taking away most of the responsibilities from the countries. The budgets for forest inventories would have to be allocated with EFICS, the countries would conduct the inventories according to instructions. Thus, this alternative has a very low potential to be carried out within a short period of time and would highlight the conflict of interests. It is completely unrealistic in the present budgetary situation.

A modification of this alternative, which is not discussed here, would be to assess additional attributes or to increase the sampling intensity on the national level within the EFICS survey. This would increase the potential of realisation of alternative 4.

5.2. Data Storage

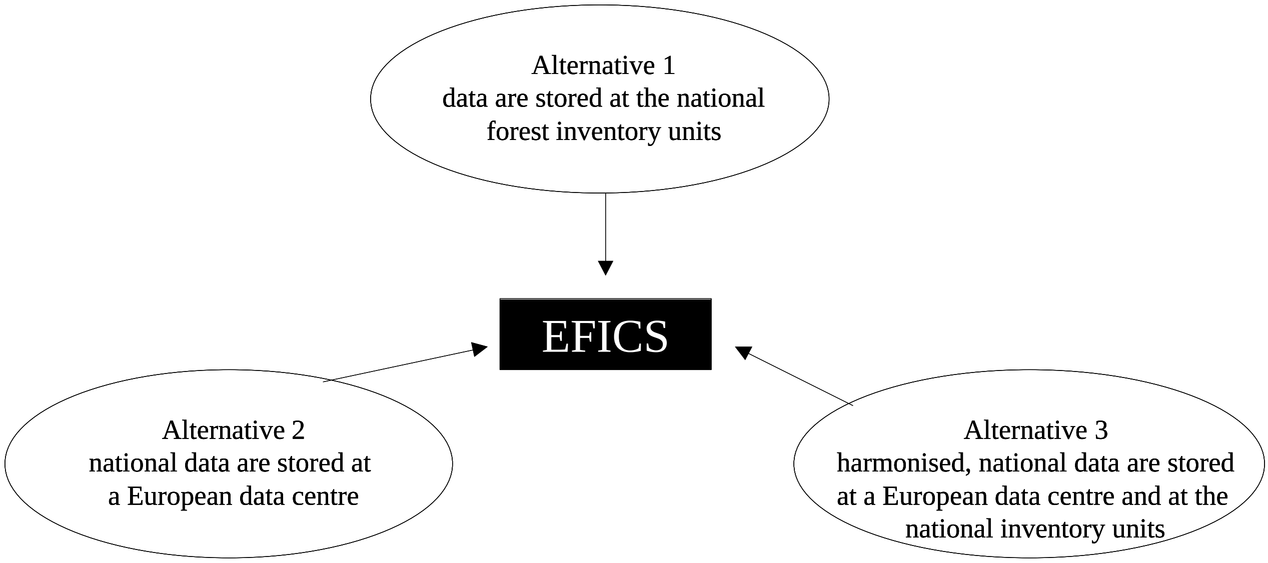
Three major alternatives exists for data storage:

Alternative 1: data are stored at the national forest inventory units

Alternative 2: national data are stored at a European data centre to be assigned or established by EFICS[12]

Alternative 3: harmonised, national data are stored twice: at a European data centre and at the national inventory units

[12] This alternative is added only to be comprehensive. It is practically unfeasible.



The selection of an alternative depends on the approaches selected for data assessment and data analysis. The analysis of the three alternatives does not take into account legal restrictions on the national and Commission level. Alternative 1 is a theoretical option, but practically unfeasible.

Alternative 1: Data are stored at the national forest inventory units

This alternative reflects the current status. Each of the member states is responsible for storage, reliability and safety of data. The national data would not be stored in one common place. The advantages and disadvantages of this approach are as follows:

+ countries can control the use of their data

+ the data bases and file systems are established and available

+ low costs

+ no redundancy

- the structure of data bases (entity relationships) are different

- access to national data bases by EFICS problematic

- high costs for unique data structure

- different levels of data reliability and plausibility

- data base structure optimised according to national but not to EFICS needs

- each country has to change data base structure if new attributes are introduced by EFICS

- national data base structures will vary over time which renders the development of standardised access and analysis procedures difficult

If this alternative is followed EFICS would either have to have access to the national data bases or the nations would have to do the data retrieval and provide EFICS with a data extract. This is the alternative with lowest costs but the one that most hinders a unique data structure and thus harmonisation efforts. It is, however, the alternative that is already realised.

Alternative 2: National data are stored at a European data centre to be assigned or established by EFICS

This alternative is just the opposite of the first alternative. The data would not be stored in national data bases but at one central centre to be established or assigned by EFICS. The advantages and disadvantages of this approach are as follows:

\+ the structure of data bases (entity relationships) will be unique

\+ access to EFICS data base by individual nations is possible

\+ low cost for unique data structure

\+ unique level of data reliability and plausibility

\+ data base structure optimised according to EFICS needs

\+ data base structure can easily be changed if new attributes are introduced by EFICS

\+ data base structures will vary over time but standardised access and analysis procedures can easily be adjusted

\+ one unique different data base system facilitates data retrieval and analysis

\+ no redundancy

- the data base structures have to be developed

- countries have no direct control over their data and thus probably block sensitive data

The second alternative would be the most suitable one in the sense of harmonisation on the European level. It would, however, render the access of countries to their data sets more difficult. The ownership and the power of disposition of data would be assigned to EFICS which bears major conflicts with individual countries. This alternative is not very likely to be introduced in the near future. A rather restrictive set of regulations would have to be set up in advance to force the countries to submit all their relevant data. National attempts to store their own data cannot be avoided.

Alternative 3: Harmonised national data are stored twice: at a European data centre and at the national inventory units

The third alternative suggests to store the set of harmonised data twice. This alternative bears the problem that in the course of time adjustments of data are necessary due to plausibility checks and additionally derived attributes and thus two data sets with different status would exist. It is difficult to say which of the two is the appropriate and valid one.

Countries could submit a less detailed but harmonised set of data to the EFICS data base. The more detailed data which are assessed according to national systems of nomenclature could be made available to EFICS as well.

Advantages:

+ the structure of data bases (entity relationships) will be unique

+ access to EFICS data base by individual nations problematic

+ unique level of data reliability and plausibility

+ data base structure optimised according to EFICS needs

+ data base structure can easily be changed if new attributes are introduced by EFICS

+ data base structures will vary over time but standardised access and analysis procedures can easily be adjusted

+ one unique different data base system facilitates data retrieval and analysis

+ the data bases and file systems are established and available for the national data bases

Disadvantages:

- redundant data storage

- the data base structures have to be developed for the EFICS data base

- countries have no direct control over their data stored in EFICS data base

- the exchange and update of data has to be regulated

- in the course of time, two data bases with different data status will be available

This alternative requires a high degree of collaboration between countries and the EFICS data centre. The countries as well as EFICS have fast and unrestricted access to the data. Legal regulations have to be formulated to enable the data transmission from the national level to EFICS. This solution will satisfy most user needs. The only argument against this alternative might be the desire of countries to regulate and control the access to "their" data. EFICS has to set up clear and transparent user regulations that enable the countries to take influence on the submission of data to outside bodies and to control analyses and publication of results. If this is realised, there should be no rational reason for countries to refuse to this alternative.

Alternative 1 refers to decentralised system, and alternatives 2 and 3 to centralised or semi-centralised one. These are illustrated in the Appendix.

5. 3. Analysis and dissemination

Data analysis and dissemination of results are closely linked tasks and will be discussed together. There are three possibilities for

Data analysis:

Alternative 1: Standard analysis with defined content

Alternative 2: Special analysis upon request

Alternative 3: Interactive analysis by users

The first alternative is the only one that could be realised if either individual countries provide national results or the data are analysed in a central place. Alternatives 2 and 3 require an EFICS data centre with the possibility of centralised data access and analysis.

Alternative 1: Standard analysis with defined content

Alternative 1 is the approach chosen by many national forest inventories, by the UN/ ECE-FAO Temperate and Boreal Forest Resources Assessment (TBFRA) and EUROSTAT. The standard analysis focuses on pre-specified information needs and is carried out periodically. As the data provided by individual nations are due to the inventory cycles updated every 5 to 10 years, there is no need to conduct a standardised analysis more often than every 5 years.

The major drawback of the first analysis is the poor flexibility. Once the data have been analysed, there is no way to react on additional user needs. Unfortunately those needs often come up if users have a first look at the standardised results. Special investigations can hardly be realised. Due to the periodicity, there is the risk that the knowledge and expertise of staff cannot be maintained. This alternative hinders the set-up of a permanent analysis group, as there are no permanent but only periodic tasks.

The user satisfaction will be poor, as special needs cannot be considered. The costs are relatively high due to the lack of permanence and the need of new developments each time a new standardised analysis has to be conducted. The results will be outdated soon and cannot provide a sound base for flexible decision-making. If EFICS follows this approach, there is a great risk that EFICS will be one among the many institutions that provide data every once in a while. The potential power of EFICS, i.e. providing up-to-date, satisfactory and flexible information cannot be developed.

The analyses themselves could be done in two ways:

(1) EFICS conducts the analyses itself and compiles the results, or

(2) the individual nations provide key statistics, EFICS collects and puts them together and publishes the results.

EFICS will be highly dependent on individual nations if the latter approach is chosen. Each new request has to be submitted to each country and providing results has to be postponed until all countries submit intermediate statistics. It will be difficult to check the quality of data and analyses for each country, i.e. this approach has the characteristics of a black box.

Alternative 2: Special analysis upon request

Alternative 2 renders direct access to national data essential. Permanent staff would be necessary to satisfy users on the long run. Providing special analyses could be done in addition to alternative 1 (standardised analyses).

This alternative will result in high user satisfaction. As the analyses are retrieved by qualified staff, EFICS has some control on the quality and suitability of the results. EFICS could become an expert centre providing assistance for a multitude of users with different requests and technical skills. The cost for fulfilling this task would be considerably higher than providing just a standardised analysis. However, it would be essential to make EFICS a useful, reliable and satisfactory tool for users and decision-makers.

Alternative 3: Interactive analysis by users

This alternative goes beyond alternative 2. Irrespectively of the fact that standardised reports are published this approach is the most flexible for individual users. Potential users would have interactive access to the EFICS data base and analysis software for example via the Internet. This does, however, not mean that no trained experts have to be available at EFICS. EFICS would have to concentrate on developing a user friendly interface and maintenance of the data base and analysis software.

The quality of analyses could be poor if users overcharge the potential of analyses. Some potential users might not be skilled enough to conduct the analyses themselves. For those cases EFICS has to provide staff that conducts the analyses upon users' requests. Users familiar with the analyses interface will be motivated to conduct analyses and thus make EFICS a helpful tool. In any case, users should be responsible on the conclusions made.

The costs necessary to realise this alternative are slightly higher than for alternative 2. The balance of costs will, however, be more related to the development of software and analysis tools and will not be wasted with routine analyses. The interaction between users and EFICS will be very high. As the users have some identification with their results, EFICS could become a widely used tool and enable decision-makers to obtain exactly those results they need.

Statistical Analysis Procedures

Besides the extraction and pre-processing of data the development of sound statistical approaches for statistical data analysis is a key issue to make EFICS a flexible and reliable tool. Several analysis approaches can be implemented in EFICS. Those approaches comprise stratified sampling, multi-phase and multi-stage sampling techniques, Bayes estimators and others. A leading principle in selecting the optimal alternative for EFICS should be the criterion of cost-effectiveness, i.e. that approach should be chosen, that results in the smaller sampling error for the given budget. However, the users of information should not be forgotten in selecting the appropriate analysis procedures. The procedures have to be transparent so that not only persons holding a PhD-degree in statistics can understand and interpret the results.

A suitable statistical approach that does not involve complex estimation procedures is stratified sampling. In stratified sampling the population is divided into sub-populations, which are non-overlapping and together comprise the whole of the population. The sub-populations are called strata. To obtain the full benefit from stratified sampling the size of the individual strata has to be known. As strata can be assigned after the samples have been selected, the combination of remote sensing and national data is possible. In a strong statistical sense the strata are formed in a way that the variance within the strata is as small as possible and the variance between strata is large. If the strata are not formed in a way that optimises the separation of variance the results are not biased but become less precise compared to optimal stratification. This advantage of stratified sampling as well as the fact that samples have to be selected independently within the strata renders the application possible for EFICS. Three alternatives for the formation of strata could be thought of in the scope of EFICS:

1. strata according to the political boundaries

2. strata obtained by remote sensing

3. a combination of both remote sensing stratification and national borders.

The first alternative could be realised easily. The countries could provide total values, mean values, ratios and their variances for selected attributes. The key statistics could be linked by applying the standard equations of stratified sampling (see Cochran, W.G.,1977: Sampling Techniques, John Wiley & Sons) for further details).

Mean values:

$$\bar{y}_{st} = \frac{\sum_{h=1}^{L} N_h \bar{y}_h}{N}$$

where

N = population size

N_h= number of units in stratum h

L = total number of strata

$\bar{y}_h$= sample mean in stratum h

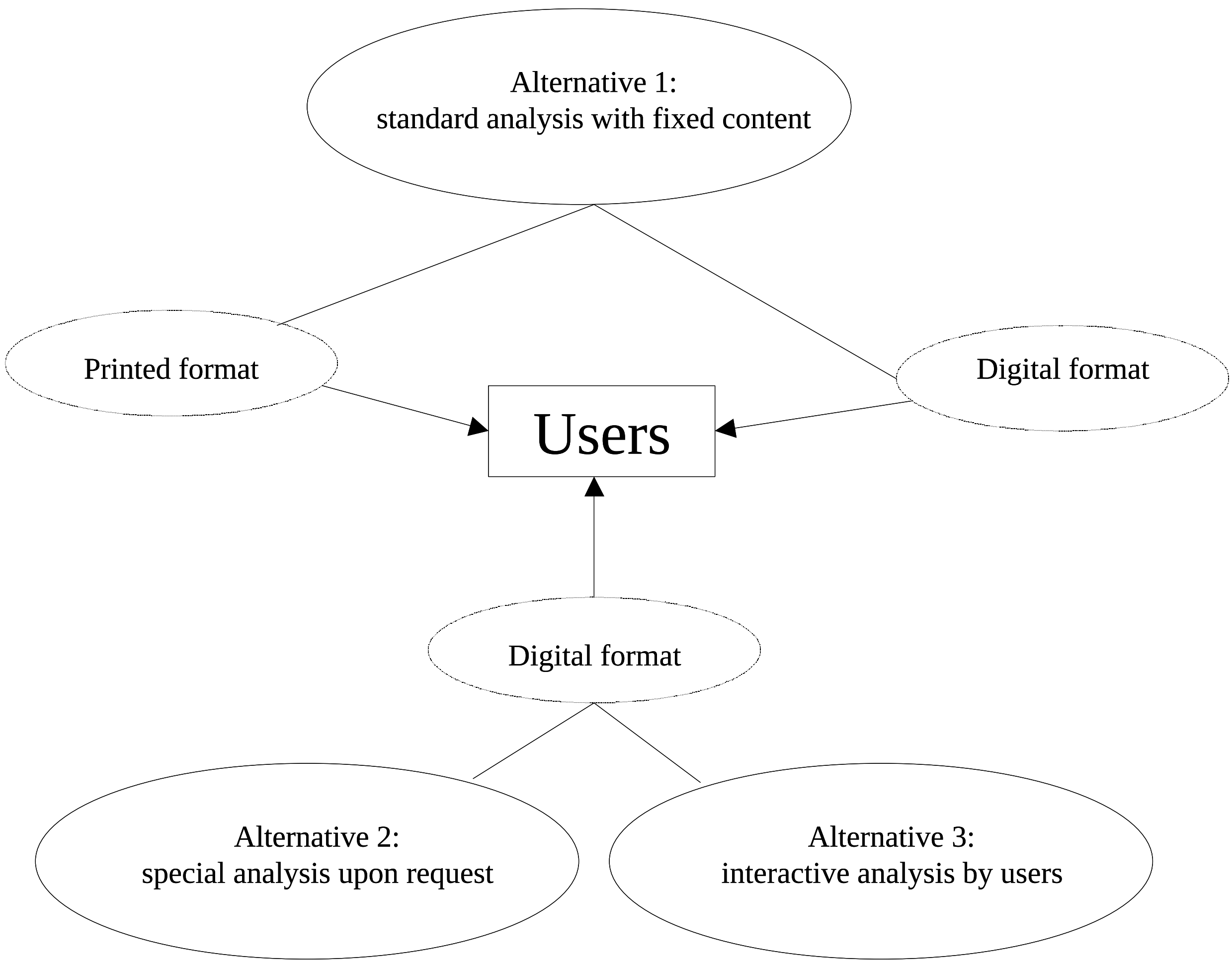
total values:

$$\hat{Y}_{st} = N\bar{y}_{st}$$

Instead of N, the total number of elements in the population, and N_h, the number of elements in stratum h, the area of the population and the strata respectively could be used to estimate the strata means. Doing this enables the application of remote sensing techniques, which could be used to assign strata according to difference in the structure of forests. The stratification by remote sensing has to be linked with political boundaries, as the countries apply different sampling designs. If a stratification according to political boundaries is omitted, the sampling designs would vary within the strata. Therefore alternative 2 - the stratification according to remote sensing alone, is theoretical. A stratification according to political boundaries is arbitrary form a statistical point of view and does not take into account differences in the forest structure, growth condition or ecological situation, i.e. it is no optimal concerning the separation of variances. The efficiency of estimates could be increased by adding the stratification according to remote sensing, i.e. including the aspect of forest structure, as this would reduce the variances within the strata.

Dissemination

The results of EFICS could be published (1) as books or other paper copies or (2) in digital format. The way of dissemination depends very much on the approach chosen for the analysis of data. Standard reports are to be published in printed format or a fixed report has to be put on a CD-ROM or disc. The results of special analyses are ideally transferred (published) to individual users electronically, i.e. in digital format. More detail can be found in the report in WP 4.2.



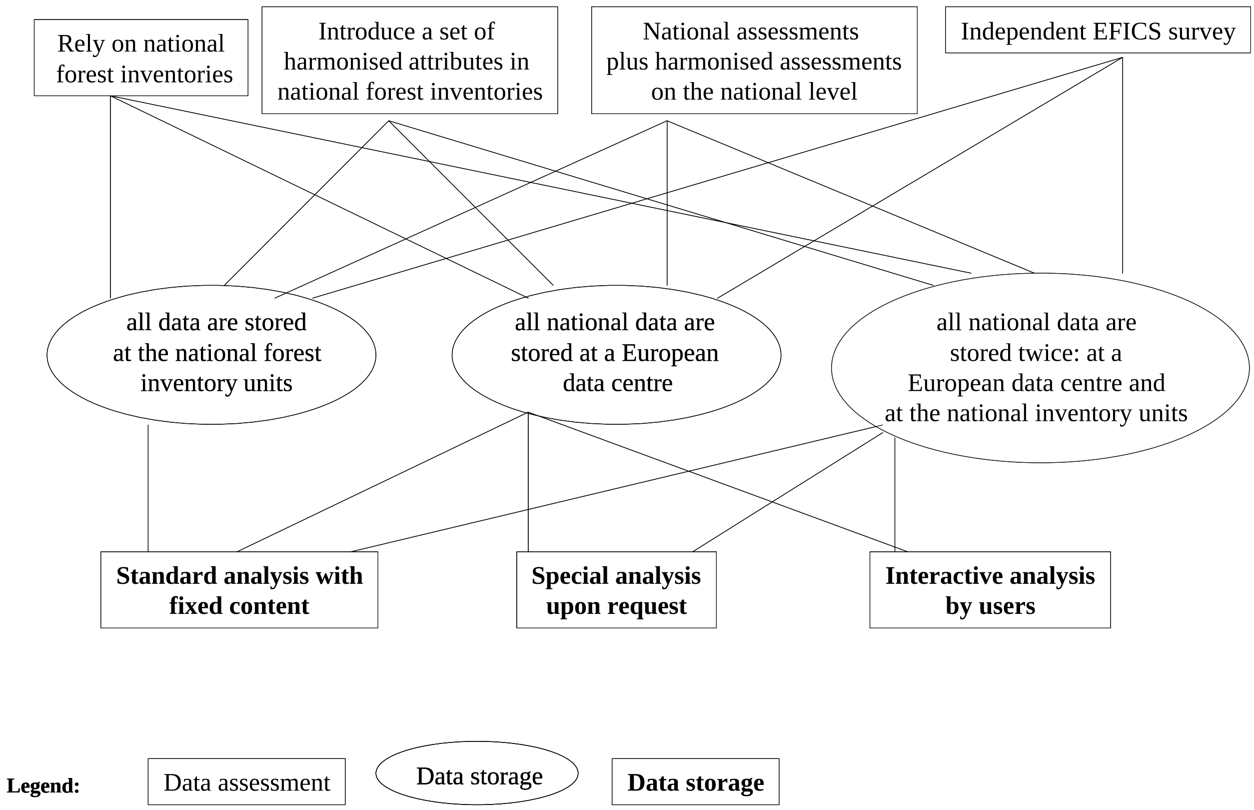
Analysis of the combination of assessment techniques, data storage and analysis procedures

The modules assessment techniques, data storage and analysis procedures could be combined in different ways resulting in 19 potential alternatives. Not all alternatives are suitable and the optimal alternative could be selected according to different decision rules. The alternatives, which are graphically presented below, will be analysed according to different comparison factors. No final or optimal solution will be presented.

The alternatives listed are not all appropriate on the same level. For some alternatives it is obvious that they will probably never be realised. It would, for example, be not very appropriate to rely on the national forest inventories for data assessments, store all data at a European data centre and provide tools for interactive analysis by users.

All potential alternatives which can be formed on the three modules data assessment, data storage and analysis procedures have been listed to illuminate the variety of potential solutions for EFICS. The figure presented below gives all possible combinations of the three modules, indicated by lines. However, some of the combinations are mentioned only to be comprehensive, but are not feasible for practical applications.

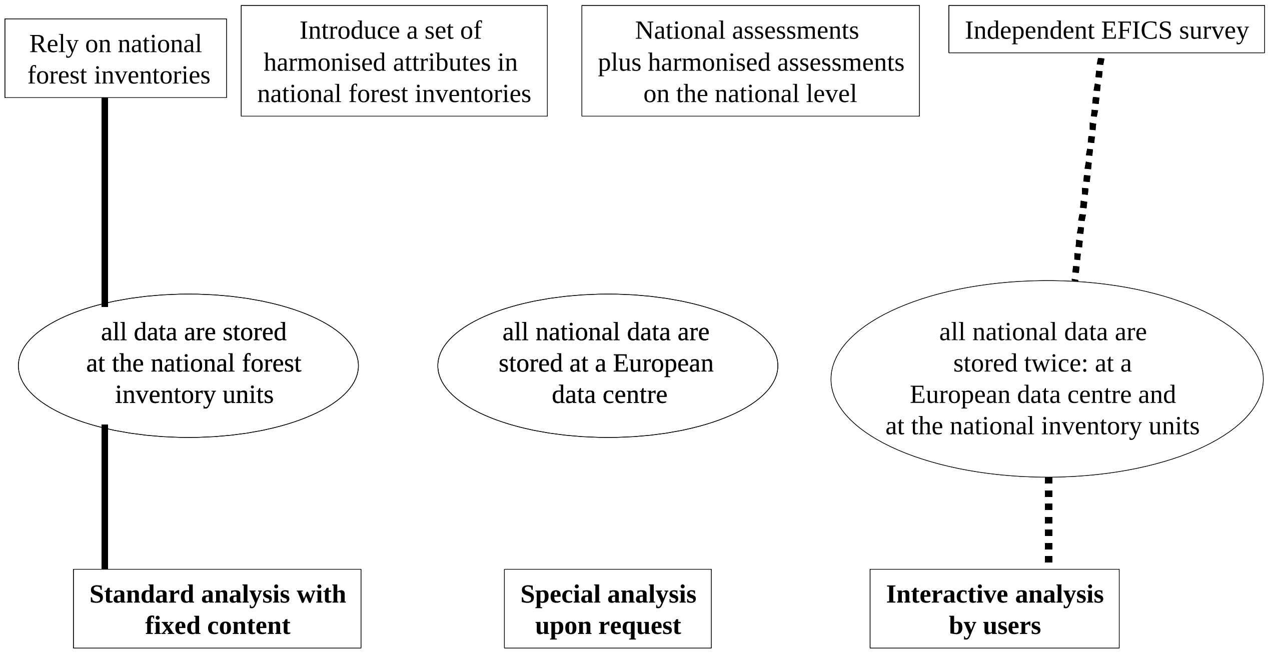
Alternatives for EFICS based on the combinations of assessment methods, data storage and analysis procedures



The final solution selected from these 19 alternatives can be found by various decision rules. Here the selection and weighting of a decision is proposed to facilitate the selection of the most suitable alternative for EFICS. The list of comparison factors can be extended. The weight of different comparison factors such as costs, users' satisfaction or potential of realisation can be assigned in different ways and can be influenced by the perspectives and preferences. Thus, instead of weighting all alternatives for different comparison factors, only the most suitable and less suitable solution for each comparison factor has been assigned. The individual factors do not necessarily have equal weights in the decision process. The weighting of individual comparison factors can lead to the final selection. The assignment of weights for individual factors as well as the final selection of the most appropriate alternative for EFICS is, however, beyond the responsibility of the consortium. The consortium would like to limit itself on presenting an approach for selecting an optimal EFICS strategy.

The comparison factors considered are (1) costs, (2) users satisfaction, (3) reliability of results, (4) willingness of countries to accept the alternative and (5) the temporal aspect, i.e. the shortest period in time needed to obtain harmonised results on the European leve

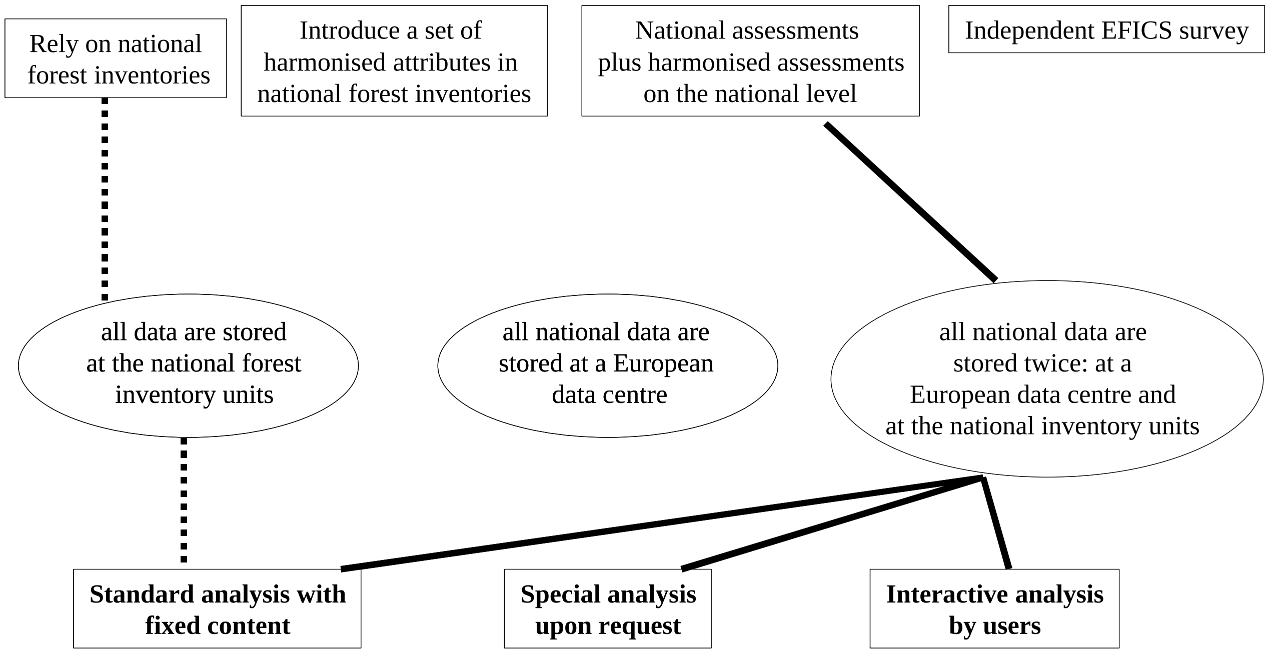
The cheapest (bold) and most expensive (dashed) alternatives for EFICS concerning



The cheapest alternative would be to follow the current state-of-the-art.

The most expensive alternative would be to introduce an EFICS survey, to store data twice, and to provide tools for interactive analyses by users. This alternative would require a maximum of activities.

The most suitable (bold) and least suitable (dashed) alternatives for EFICS concerning USER SATISFACTION

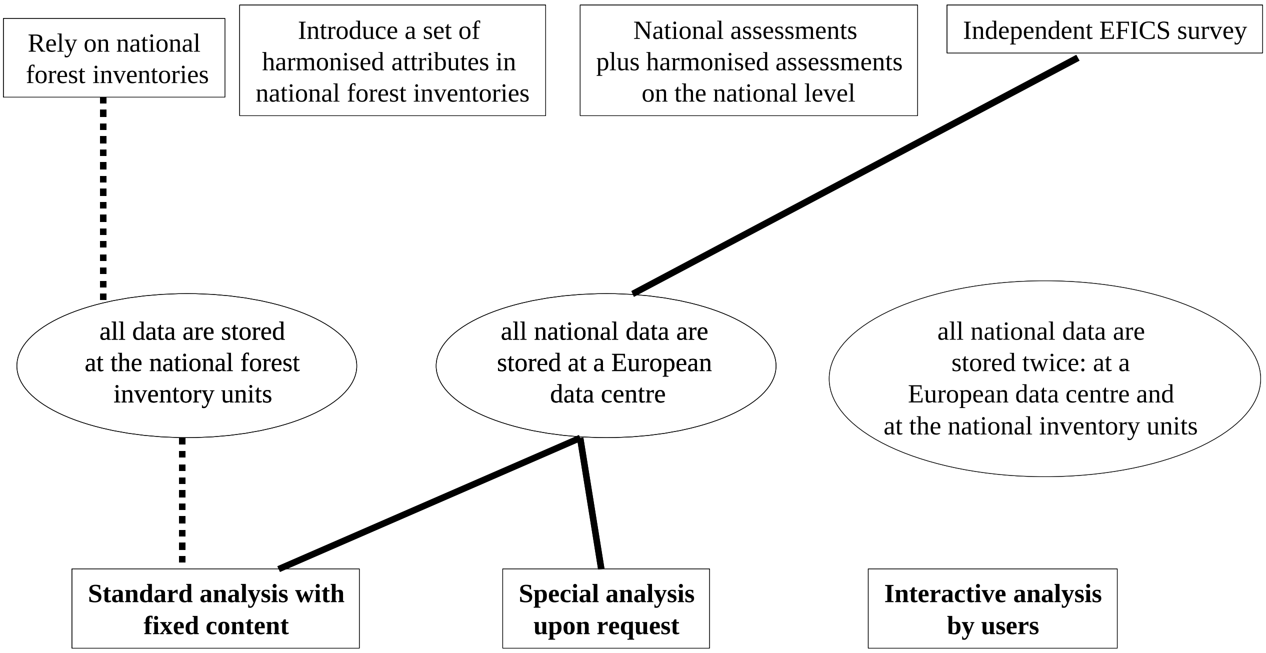


User satisfaction is very much dependent on the user’s professional background and the information that has to be provided by EFICS. Here we assume to satisfy a variety of potential users with different backgrounds. Selecting a specific user profile, e.g. a decision-maker who is dealing with forest policy on the national level, would lead to a different selection of the most suitable combination of modules.

Carrying out both national surveys and a harmonised assessment on the European level, storing the data as well in national data bases as in an EFICS data base and providing all tools for analyses (standard analysis, analysis upon special request and interactive analysis) would satisfy a wide range of potential users best. This selection shows that EFICS has to be very strong on the side of data analysis.

The least suitable alternative would be to stick to the current situation, i.e. national assessments, national data bases and a standardised analysis.

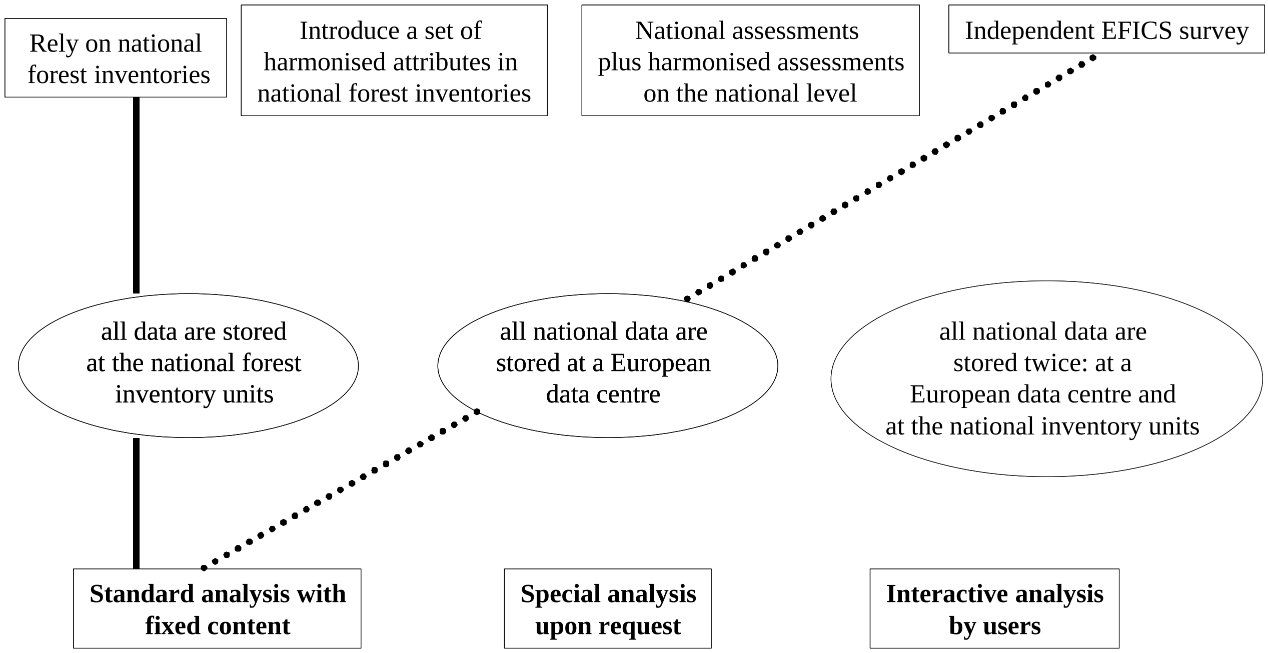
The most suitable (bold) and least suitable (dashed) alternatives for EFICS concerning RELIABILITY OF RESULTS



The most reliable results would be obtained by independent EFICS-surveys, an EFICS data base and standard analysis as well as analysis upon special requests. The interactive analysis by users could lead to fuzzy or misleading results.

The least suitable reliability of results on the European level would be obtained if the current system would be maintained.

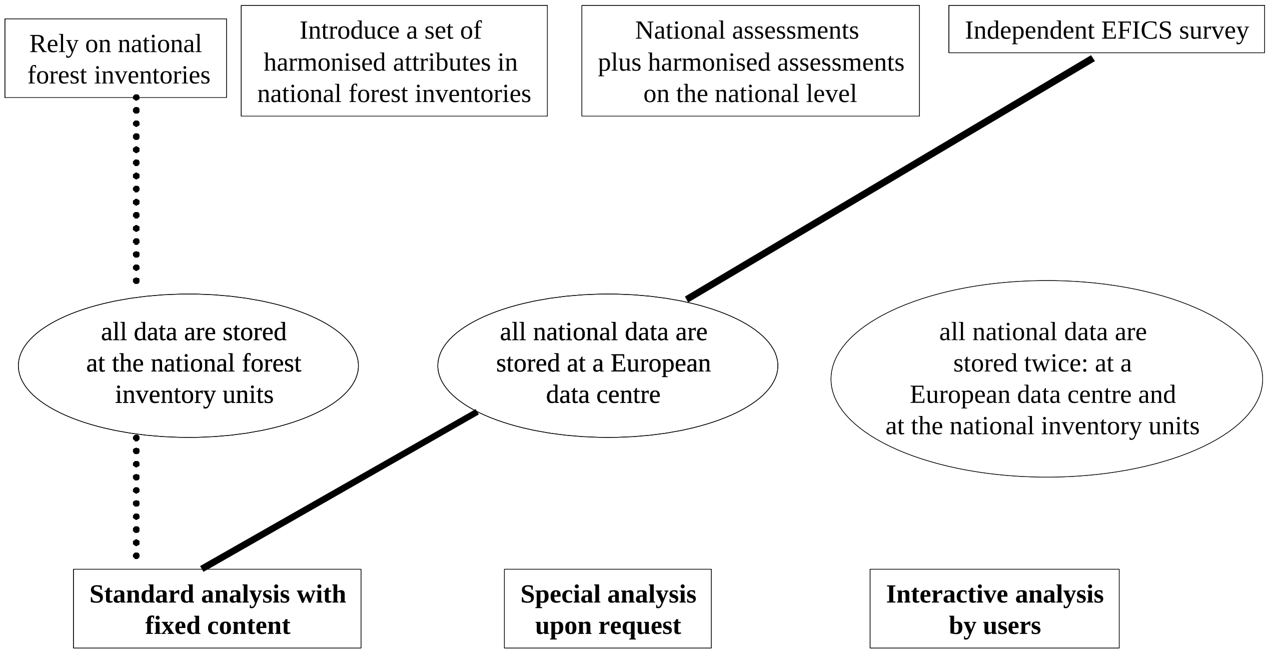
The most suitable (bold) and least suitable (dashed) alternatives for EFICS concerning WILLINGNESS OF COUNTRIES TO ACCEPT THE ALTERNATIVE



Here not the users of information, but those who provide is one considered. The individual countries might wish to stick to their inventory systems because of many reasons, e.g. the fear of "uncontrolled" use of their data, the unpredictable efforts necessary to change the current set-up and the indolence of national experts.

For the same reasons the greatest hesitation could be observed if data assessment, data storage and data analysis were centralised. If countries have the opportunity to obtain analyses according to their own requests, the willingness to accept EFICS would increase.

The most suitable (bold) and least suitable (dashed) alternatives for EFICS concerning TEMPORAL ASPECT



The shortest period in time needed to obtain harmonised results on the European level would be realised with an independent EFICS survey, a European data centre and standard analysis with fixed content. The current set-up will never allow harmonised information on the European level and thus it is the least suitable one.

Conclusion:

The current set-up has been chosen as the "best" solution for the comparison factors "cost" and willingness of countries to accept the alternative. It has, however, been selected as the least suitable alternative if user satisfaction, reliability of results and temporal aspects are considered. The independent EFICS survey has been mentioned twice as the least suitable solution.

This preliminary analysis of different comparison factors shows that neither the current system with national assessments and data bases nor an independent EFICS system have a great potential to be selected as the optimal alternative that satisfies most comparison factors. The alternative with best chances to be realised has to combine national assessments and harmonised assessments on the European level. The optimal solution for data storage and analysis is very much driven by the fact that countries want to have control to their own data. Thus storing raw data in the countries and in a European data base and providing appropriate tools for data retrieval and analysis will facilitate the implementation of EFICS.

Alternatives for EFICS: the most suitable compromise

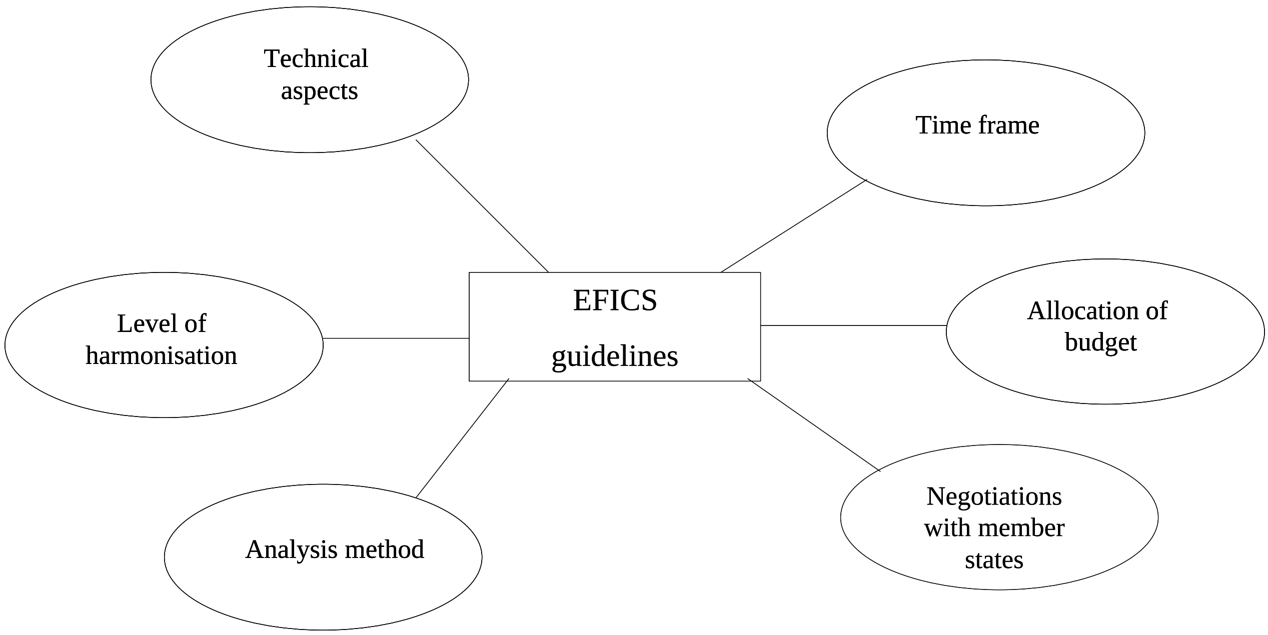
Taking into account the findings of the analyses of the comparison factors there are two alternative designs which are most likely to guarantee the timely set-up of EFICS.

Alternative 1: introduce a set of harmonised attributes in national surveys, all national data are stored twice and standard analysis and special analyses upon request will be conducted

Alternative 2: introduce harmonised assessments on the national level in addition to the national forest resource surveys, all national data are stored twice and standard analysis and special analyses upon request will be conducted. Tools for interactive analysis by the users will be developed.

5.4. Guidelines for harmonisation

Irrespectively of the final decision on the alternative selected for data assessment, data storage and analysis guidelines for harmonisation should be developed, applied in the member states. In the future, EFICS could constitute the basis of deriving data on criteria and indicators of sustainable forest management. Different tasks have to be fulfilled to establish guidelines for harmonisation in the member states.



Technical aspects

Before the design of harmonised guidelines can be specified, a couple of decisions have to be made in advance. These decisions include an agreement on the attributes to be assessed, the data sources utilised and the assessment techniques. The system of nomenclature has to be derived and could be based on the results of this study (comparative study, simulation study, analysis of harmonisation activities) and the EC-JRC study "Designing a system of nomenclature for a pan- European forest map" conducted under the auspices of the FIRS-project.

The procedures for data transmission to the EFICS data base or the access of EFICS staff to the national data bases has to be regulated.

Check assessments have to be planned to ensure high data quality. It is extremely important to avoid national differences in assessing attributes on nominal or ordinal scale, i.e. attributes that are assessed according to definitions. Workshops and training courses, which are attended by field crews from each member states, are crucial to avoid differences in national standards.

New information needs have arisen recently, as national inventories have to shift from the classical assessment of the productive functions of forests to the assessment of non-timber goods and services. The Helsinki process requires the development of new monitoring techniques. EFICS could provide a network of experts and co-ordinate research on methods that have to be developed to satisfy the new information needs.

Time frame

The time needed to obtain a total coverage of all EU and EFTA countries will depend on the periodicity of national assessments. The countries should be given a minimum of time to prepare for the additional attributes and to train their staff. If additional attributes are introduced in the national surveys, harmonised data will not be available before the end of the next decade.

Level of harmonisation

Different levels of harmonisation can be introduced. The three target levels specified in Chapter 3 can be considered as the first steps towards harmonisation. A further level could be reached by introducing a common sampling frame, i.e. a common forest area definition, which is decisive for the selection probability of sample plots and a minimum d.b.h. threshold, which sets the selection probability for single trees. Introducing standardised sampling fractions, assessment methods and models would lead to a high level of harmonisation and would be a stepwise introduction of the leading role of EFICS.

Allocation of budget

The implementation of harmonised attributes and assessment methods depends greatly on the share of costs individual countries have to contribute. Subsidising the assessments on the national level would facilitate harmonisation activities.

New approaches in forest inventories have to be developed to satisfy information needs that go beyond the assessment of the productive function of forests. EFICS could initiate a harmonised approach to develop methods which are applicable for all member states. Research funds have to be allocated to promote this process and ensure EFICS leading role.

Analysis methods

Analysis methods have to be developed that enable the compilation of information on the European level. This task requires the development and implementation of data bases, data base access, statistical procedures and analysis software.

Negotiations with member states

Decisions on the technical level have to be made in co-operation and agreement with the member states. The selection of optimal technical solutions among alternatives has to be done together with experts of the member states. To maximise the input of national expertise in decision processes, EFICS has to set up a network of experts and provide the platform for the exchange of experience and professional skills. The team of specialists has the task to assist EFICS in technical and methodological decisions.

5.5. Foundation of EFICS working group

The success of EFICS will highly depend on the co-operation of the member states. They should at a very early phase participate in the decision processes and be tied up in responsibilities. The foundation of a EFICS working group, in the framework of Standing Forestry Committee, would facilitate the acceptance and national support of EFICS.

The following groups should be included in the EFICS group:

- country representatives, which are mainly associated with the responsible authorities. This group should be made up of decision-makers and forest politicians.

- technical experts, which are either members of the national forest inventory units or scientist working at research institutions and represent special expertise in forest surveys, data processing, remote sensing, applied statistics and assessment techniques.

- representatives from international organisations, such as FAO, ECE, WCMC, EUROSTAT, UNEP etc.

The main objective of the EFICS group would be to assist DG VI in the decision process and to provide "outside knowledge".

5.6. Clarification of legal status, willingness to co-operate

Besides the preparation of the technical background of EFICS, the legal status and the willingness of countries to support and contribute to EFICS has to be studied. After Austria, Finland and Sweden joined the European Union, major forest facts have changed. The forest area, the annual increment and the annual cut of the EU have been doubled, which might affect the classical role and balance of old member states.

The development of methods and the implementation of new techniques and guidelines on the European level has to respect specific constraints. The most important constraint are the national and EU regulations and laws. To specify those constraints and provide the frame for EFICS, the legal status in the member states and on EU level has to be analysed in detail.

The legal situation is one of the milestones that are decisive for the realisation of EFICS. Besides this the willingness of countries is essential for the success of EFICS. Often personal considerations can be extremely important and hinder an objective decision process. The analysis of the willingness of countries, i.e. the willingness of decision-makers within the countries to contribute to EFICS, should be assessed.

A decisive criterion will be the legal status and the willingness to provide and exchange data and to implement harmonised methods and guidelines that go beyond the traditional national practices.

5.7. Geographic and thematic coverage of EFICS

The objectives of EFICS are, according to the Council Regulation (EEC) No. 1615/89, to collect, co-ordinate, standardise and process data concerning the forestry sector and its development. At the moment EFICS is intended to cover the EU member states.

These objectives can be met in different ways and with different intensities. Information concerning the forestry sector comprises of many different topics. Besides the timber market and key statistics on the productive function of forests new information topics gain importance. This process was accelerated in the beginning of the 1980s when the with concern the health and condition of European forests became a major concern of the public. The political changes in the former eastern European countries had decisive influence on the forest sector, not only by opening new timber markets and changing timber flows.

The intention that led to the Council Regulation concerning EFICS has to be reconsidered. After the initiation of the Rio-, Montreal- and Helsinki-processes the importance of information needs has changed and renders the inclusion of new information necessary. The thematic coverage of EFICS probably has to be widened towards information concerning topics such as forest ecosystems, forest condition, nature protection, biodiversity or sustainability of the multiple functions of forests, and recreation.

As many dynamics and problems of the forest sector can only be analysed and understood if neighbouring regions of the Commission are considered as well it should be analysed if EFICS should not be extended to EFTA countries and countries in transition.

5.8. Potential use/ duties of EFICS

The Council Regulation gives the objectives for EFICS, but they have to be transformed into working - guidelines to establish EFICS in the Commission. A profile of potential users and the information requested by them has to be set up. The specific duties of EFICS have to be derived. These duties could comprise different levels. EFICS could be - similar to EUROSTAT - an institution that provides periodically information on the European level. EFICS could, also be an institution that collects, compiles and analyses data on the forests of the Community and provides a centre of experts in forest monitoring. EFICS could initiate research on forest inventories and be a focal point for the development of new methods that are needed to provide sound information for various topics. As there is a lack of methods to assess and quantify the non-wood goods and services, EFICS could initiate research co-operatives and provide harmonised approaches to satisfy new information needs.

In addition, the possible role of EFICS in providing information about other topics than forest resources, like forest industry, its products, forest research, forest policies, etc. should be studied.

5.9. International activities

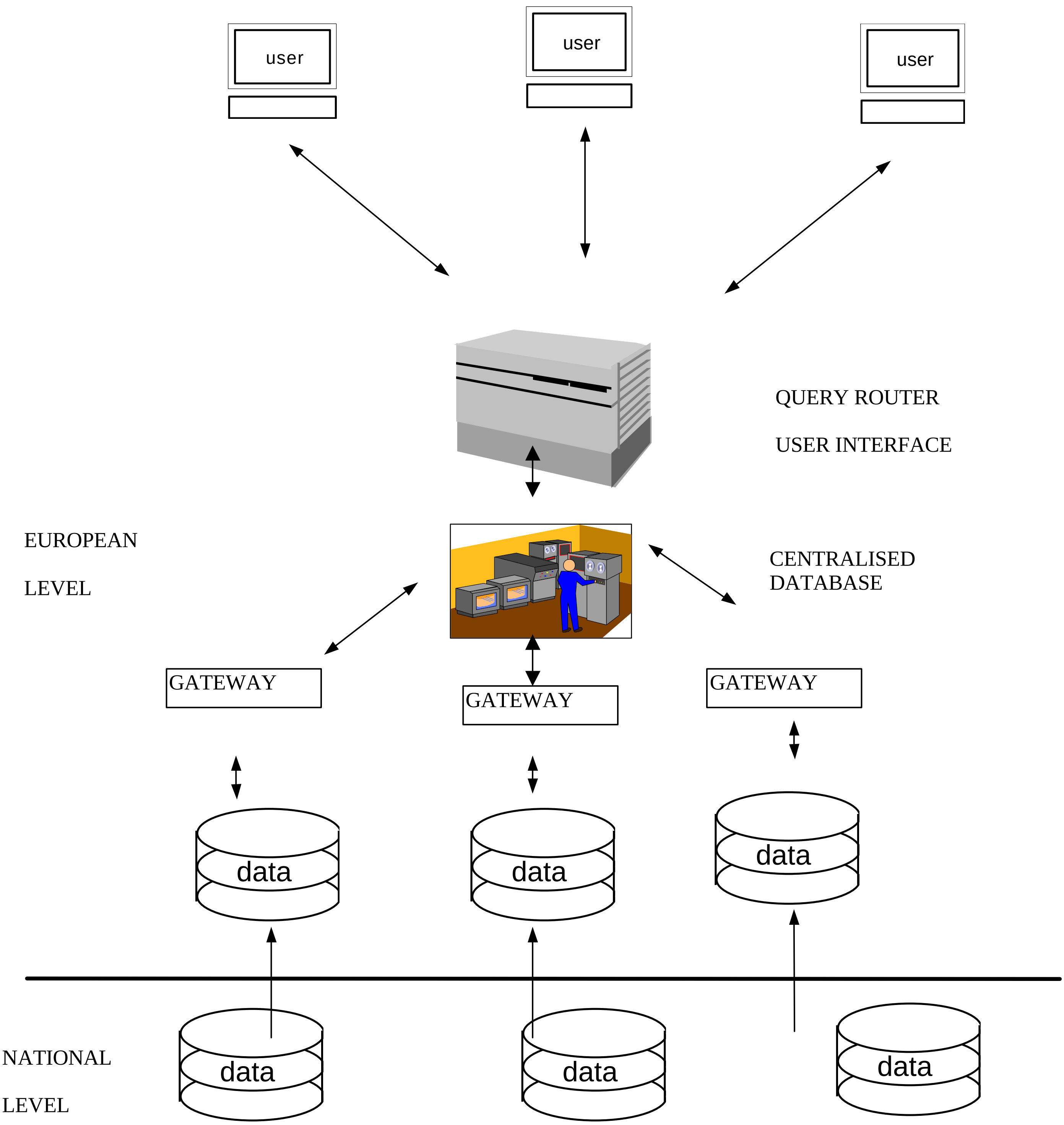
Many international organisations and institutions are concerned with the forest sector. The emphasis of these institutions varies. EFICS should co-operate with institutions within the

Commission (EUROSTAT, EEA etc.) and outside (UNEP, ECE, FAO, WCMC, GTOS, MAB, ILO, WTO, Helsinki-process, etc.). The role of EFICS within the Intersecretariat Working Group of Forest Statistics (FAO, ECE, EC/DGVI, Eurostat, ITTO, OECD) has to be specified. Potential links have to be described, routines for data and information exchange be laid down and the co-operation of EFICS with established institutions has to be initiated. This requires a survey of international activities and a detection of knowledge and information gaps. EFICS could fill these gaps and become a powerful institution inside and outside the Commission.

The link between international institutions and nations could be realised via EFICS. As EFICS will hold harmonised information it could become the information pool for international organisations and provide the link between international institutions and individual countries. This would guarantee a high level of quality of the information that is provided to international institutions and statistics.

Appendix 4: Centralised and decentralised information data systems

Centralised system



Decentralised system