Comparison and evaluation of methods for Monitoring biodiversity in European forests

A Forest Focus project

Elmar Hauk
Austrian Forest inventory
Contributions:

Deadwood: Jacques Rondeux
Christine Sanchez

Epiphytic lichens: Anna Lena Axelsson

Ground vegetation: Iciar Alberdi Asensio

Forest structure: Elmar Hauk
Large scale monitoring systems in Europe

National Forest Inventories (NFIs)

Long time observation of Forests on national level
In some countries since 1920

ICP forest-monitoring scheme on EU level

Air pollution effects on forests
In some countries cooperation with NFIs
New variables needed for new reporting issues

Kyoto Climate change,

MCPFE sustainability of forest management

CBD Biodiversity

Harmonisation of European forest inventories
ENFIN- European National Forest Inventory Network

Network of European Inventories,
Harmonisation of assessment methods and indicators,
Establishing a core set of variables for common reporting
Launching scientific projects like ComMon
COST E43 (2004-2008)
harmonisation of National Forest Inventories
in Europe: techniques for common reporting
27 countries

One part of the COST Action is to define common
variables for biodiversity reporting

Only travel expenses are funded by EU
• Methods applicable for large scale NFI

• End of program 8th of May 2007

• Budget for each country 44 000 EURO
  – 75 percent from EC (Forest Focus)
  – 25 percent national funding
Country reports considering the 4 subjects
http://www.resgeom.slu.se/resana/projekt/common/Default.htm

Literature review of existing indicators

Link to the COST E43 Action

Suggested indicators for NFIs

Literature database

Papers for publication

Final report
Dead Wood - biodiversity

Dead Wood is ..... 
- an important component of forest ecosystems
- a key factor in the nutrient cycle
- a habitat for numerous plants, animals and fungi
- an important substrate for the regeneration of some tree species

Dead Wood generates ..... 
- high habitat diversity
- storage and cycling of nutrients and water

Dead wood can be measured
Dead Wood Definition and Components

Harmon, 1996: Different categories due to different aims of studies

**Above ground**
- coarse woody detritus
diameter ≥ 10 cm
length ≥ 1,5 m

Snags : standing dead from natural processes
Stumps: short standing pieces from cutting
logs : dead and downed

**fine woody detritus**
downed
suspended on living or dead trees

**Below ground:**
buried wood and roots
Dead Wood Definition and Components

One of definitions gathered in COST E27 (protected forests):

**material over a certain size (limit = 10cm diameter) that is no longer living and that is left in the forest.**

ICP-Forests monitoring programme, Chirici et al.(2003):

**Dead down trees, lying coarse wood pieces, lying fine wood pieces, stumps and accumulated cutting debris**
Dead Wood Definition and NFIs

NFI s need simple harmonised definitions and clear thresholds like

material over a certain size (limit = 10cm diameter) that is no longer living and that is left in the forest.

The dead wood below ground and on living trees is excluded from NFIs because such data are too difficult to collect and to quantify
Dead Wood - Different Sampling Methods

Snags:
• often same methodology as living trees
  - fixed or variable sample plot size

Lying dead wood
• Main sampling methods:
  (1) Fixed- or non-fixed- area sample plot
  (2) Line intersect method (LIS)
  (3) Visual estimation
Dead Wood - different thresholds

Standing dead trees and snags:

**DBH threshold**

<table>
<thead>
<tr>
<th>Country</th>
<th>DBH threshold</th>
<th>Height threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>AT</td>
<td>5 cm</td>
<td>-</td>
</tr>
<tr>
<td>BE</td>
<td>6.4 cm</td>
<td>-</td>
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<tr>
<td>CZ</td>
<td>7 cm</td>
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<td>-</td>
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<tr>
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<td>-</td>
<td>-</td>
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<tr>
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<td>SK</td>
<td>15 cm</td>
<td>-</td>
</tr>
<tr>
<td>ES</td>
<td>7.5 cm</td>
<td>-</td>
</tr>
<tr>
<td>SE</td>
<td>4 cm</td>
<td>1.3 m</td>
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<tr>
<td>CH</td>
<td>12 cm</td>
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<tr>
<td>UK</td>
<td>5 cm</td>
<td>-</td>
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</table>

**NFI mean value**

= 9.4 cm
**EXISTING DEFINITIONS AT THE INTERNATIONAL LEVEL**

<table>
<thead>
<tr>
<th>Country</th>
<th>Diameter</th>
<th>Length</th>
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</thead>
<tbody>
<tr>
<td>TBFRA2005 (FAO)</td>
<td>10 cm (diameter thicker end)</td>
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<tr>
<td>ForestBIOTA</td>
<td>10 cm (minimum diameter)</td>
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<tr>
<td>Biosoil</td>
<td>10 cm (mean diameter)</td>
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<tr>
<td>MCPFE (2002)</td>
<td>10 cm (mean diameter)</td>
<td>1 m</td>
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**NFI definitions**

<table>
<thead>
<tr>
<th>Country</th>
<th>Diameter</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposition (biodiversity)</td>
<td>10 cm (minimum diameter)</td>
<td>1.3 m</td>
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<tr>
<td>AT</td>
<td>20 cm</td>
<td>-</td>
</tr>
<tr>
<td>BE</td>
<td>6.4 cm small diameter</td>
<td>1 m</td>
</tr>
<tr>
<td>CZ</td>
<td>7 cm median diameter</td>
<td>0.1 m</td>
</tr>
<tr>
<td>EE</td>
<td>15 cm</td>
<td>1 m</td>
</tr>
<tr>
<td>FR</td>
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<td>-</td>
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<tr>
<td>FI</td>
<td>10 cm</td>
<td>1.3 m</td>
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<tr>
<td>DE</td>
<td>20 cm thicker end</td>
<td>0.1 m</td>
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<tr>
<td>GR</td>
<td>4 cm</td>
<td>2 m</td>
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<tr>
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<tr>
<td>IT</td>
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<td>-</td>
</tr>
<tr>
<td>LV</td>
<td>6.1 cm</td>
<td>0.5 m</td>
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<tr>
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<tr>
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<td>0.6 m</td>
</tr>
<tr>
<td>RO</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>SK</td>
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<td>1 m</td>
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<tr>
<td>ES</td>
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<td>0.3 m</td>
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<tr>
<td>SE</td>
<td>4 cm</td>
<td>1.3 m</td>
</tr>
<tr>
<td>CH</td>
<td>5 cm</td>
<td>1 m</td>
</tr>
<tr>
<td>UK</td>
<td>5 cm mid-diameter</td>
<td>0.5 m mid-length</td>
</tr>
</tbody>
</table>

**NFI values**

Lying coarse dead wood:

- **Minimum diameter threshold**
- **Minimum length**

**EU NFI**

<table>
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<tr>
<th>Country</th>
<th>Diameter</th>
<th>Length</th>
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<tbody>
<tr>
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<td>-</td>
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<tr>
<td>FI</td>
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<td>1.3 m</td>
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<tr>
<td>DE</td>
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<tr>
<td>GR</td>
<td>4 cm</td>
<td>2 m</td>
</tr>
<tr>
<td>HU</td>
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<td>-</td>
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<tr>
<td>IT</td>
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<td>-</td>
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<td>LV</td>
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<td>0.5 m</td>
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<tr>
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<td>-</td>
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<td>NO</td>
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<td>0.6 m</td>
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<tr>
<td>RO</td>
<td>-</td>
<td>-</td>
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<tr>
<td>UK</td>
<td>5 cm mid-diameter</td>
<td>0.5 m mid-length</td>
</tr>
</tbody>
</table>
Proposal for deadwood thresholds as a result of analyzing the deadwood questionnaires of the NFIs participating in the COST E43 Action

Snags and stumps 10 cm dbh
Logs 10 cm diameter

Minimum length: 1,3m
Suggested Deadwood Indicators for NFIs

• presence / absence of coarse dead wood

• **TADW = Total Amount of Dead Wood** \((m^3 \text{ or } m^3/\text{ha})\)

• surface of forests containing at least 40 \(m^3\) of dead wood per ha-
  
  conservation of diversified communities of saproxylic organisms (Coleoptera)

• **Surface of forests containing at least 20 \(m^3/\text{ha}\) of dead wood with a diameter > 40 cm**
  
  invertebrate red list species, fungi, birds
Forest Structure

Spatial arrangement of the various components of the ecosystem

Spacing and shape of trees

Horizontal mosaic: dense areas and clearings

Vertical construction: different layers
Forest Structure, biodiversity and forest management

Forest structure depends on
  forest type (biogeographical region)
  human influence

Noss (1999): Temperate zone forests are not threatened by deforestation, they are endangered by simplification to secondary stands and fragmentation.

Intense forest management increases the number of ubiquitous Species and decrease the number of specialists.
There are trends in forest management (central Europe) towards „naturalness“. (combination of economic yield and rich forest structure)
Structural attributes

Stand and site attributes

Stand category by the number of layers
Woody species- abundance/dominance per layer
Stand density, ground coverage of the layers
Opening areas (gaps, patches)
Edge effects (gradient of radiation)
Roughness of the ground

Tree data:

• Stem diameter
• Tree height
• Tree coordinates
• Crown length, crown radius, foliage distribution
Structure- possible indicators

Percentage on the forest area of a forest type:

• One, two, multi layered stands

• Stands where current tree composition corresponds with the potential tree species composition

• Stands with short lived pioneer species

• Development phases

• Size classes of openings
Frequency distributions of standard error classes:

- DBH, tree height, crown length, crown radius

Indices based on the spatial tree distribution:

- Distances between neighbouring trees
- Comparison of attributes of nearest neighbouring trees
- Uniform angle index (Gadow)
Assessed Structural attributes -NFIs (20 European NFIs)
• Neumann + Starlinger found correlation between DBH-variation and many structural indices
Suggested Structural Indicators for NFIs

- Distribution of standard deviation classes of DBH (now possible)
- Area ratio of one layered, two layered, multi layered stands (no common definition of layer, at the moment not possible)
- Frequency distribution of gap size (GS Values) classes (assessed in only few countries, at the moment not possible)
- Number of uprooted trees per hectare (assessed in only few countries, at the moment not possible)

Stratification by Forest type
Frequency distributions of standard error classes of sample plots: BDH (cm): example from Austrian NFI
Epiphytic lichens and biodiversity

Several studies show increasing diversity with increasing lichen diversity, e.g.:
Spiders in boreal forests
Birds

Many lichens are habitat specific thus a heterogeneity of lichens at a site indicates habitat heterogeneity.

Lichens provide food for animals habitat for invertebrates

Lichens are sensitive to air quality and climate change
Epiphytic lichens and biodiversity

Diversity of lichens is closely related to
Climate
Forest type
Forest age
Tree density
Spatial arrangement of trees

Lichen diversity enhanced by:
• Late successional status
• Open structure with high light level
• Lack of dominance by bryophytes
• High moisture level

Lichen diversity decreases by:
• Early successional status
• Dense stands with poor light
• Dominance by bryophytes (due to extremely wet climate)
• Very dry climate
Epiphytic lichens- Variables

Variables which can be observed in the field

BIOMASS

ABUNDANCE or ABSENCE/ PRESENCE of
SPECIES/
SPECIES GROUPS/
FUNCTIONAL GROUPS

LENGTH OF THALLI
Epiphytic lichens - NFIs

- Subsets
  - Selected individual species/indicator species
  - Morphological groups (most countries)

- All species
  - All epiphytic lichens (group)
  - Counting species (Spain, ForestBiota)
  - All macrolichens (USA)
Epiphytic lichens- Different sampling methods

Use of subsets decreases time and costs

<table>
<thead>
<tr>
<th>Abundance of morphological groups</th>
<th>fruticose</th>
<th>foliose</th>
<th>crustose</th>
</tr>
</thead>
</table>

Abundance of selected guilds:

pendulous lichens: Alectoria, Bryoria, Usnea (Sweden, Finland)
(indicate species rich, old grown forests)

Presence/absence of Indicator species

Lobaria ssp. (lobaria pulmonaria, L. scrobiculata)
forests with long continuity/ good air quality
(Swedish NILS Inventory)
(19 indicator species in Swiss inventory)
Epiphytic lichens NFIs

• Less than 50 % of the countries include lichens in NFI

• Knowledge and time consumption
  – Basic to Intermediate
    • Around 5 min per plot
  – Advanced
    • 0.5-2 hours per plot
Inventory of epiphytic lichens is currently used in only few European countries.

It should - at the moment – not be included in a reporting system for Biodiversity.

High workload, expert level

Different species, different variables, different methods

Still has to be tested
GROUND VEGETATION
Biodiversity Indicators in National Forest Inventories
GROUND VEGETATION: CORE VARIABLE IN NFIs

• Ground vegetation-biodiversity:
  - Wildlife forage and shelter,
  - Nutrient cycle
  - Indicator site degradation,
  - Pollution indicator,
  - Assess ecosystem health…

• COST E43: NFIs FB questionnaire
  OBJECTIVE: Select core bio-variables
  RESULT: 16/41 selected
There are different classifications depending on the plant ecology needs and the objectives of each inventory.

It is quite difficult to achieve a common definition for ground vegetation.

Two points of view are usually chosen, the botanical definition or the aggregation of different life-forms into layers.
SOME USED METHODS

• Points: point frames
• Line: Line intercept (LIS)
• Areas: Plot- visual estimation, mapping and charting methods, photographic methods...

NFIs:

Areas are commonly used to estimate species richness, frequency, density and cover

For long term monitoring of plant species diversity circular, quadrangular or rectangular plots of given areas are the most used and recommended areas.
SOME GV INDICATORS

COMPOSITION:
- Floristic composition
- Endemic species.
- Introduced species.
- Key species.
- Threatened species
- Species richness
- Ecological succession

STRUCTURE:
- Number of layers
- Sociability of each group of species or each species
- Cover of each group of species or each species
- Biomass of each group of species or each species
### GROUND VEGETATION

<table>
<thead>
<tr>
<th></th>
<th>Bushes, shrubs</th>
<th>Herbs, graminoids, forbs</th>
<th>Ferns</th>
<th>Lichens</th>
<th>Liverworts</th>
<th>Mosses</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abundance</strong></td>
<td>66.7%</td>
<td>54.5%</td>
<td>40.0%</td>
<td>37.5%</td>
<td>66.7%</td>
<td>44.4%</td>
</tr>
<tr>
<td><strong>Coverage</strong></td>
<td>77.8%</td>
<td>81.8%</td>
<td>80.0%</td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
</tr>
<tr>
<td><strong>Occurrence</strong></td>
<td>66.7%</td>
<td>63.6%</td>
<td>60.0%</td>
<td>87.5%</td>
<td>100.0%</td>
<td>77.8%</td>
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<tr>
<td><strong>Species richness</strong></td>
<td>44.4%</td>
<td>27.3%</td>
<td>30.0%</td>
<td>25.0%</td>
<td>0.0%</td>
<td>22.2%</td>
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</tbody>
</table>

NFI: GROUND VEGETATION SAMPLED ATTRIBUTES

COST E43 QUESTIONNAIRE RESULT

C-STUDIES CONFERENCE; Brussels; October 2007
DIFFICULTIES- COMPARATIONS BETWEEN NFIs:

- **Inventory cycles**
  vary from annual inventories to 10 years cycle

- **Sampling year season**
  50% countries do not have a fixed period for the visits while 40% do

- **Monitoring area**

- **No experts in field teams; trained personnel**
<table>
<thead>
<tr>
<th>Country</th>
<th>Inventory Cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>every 5-10 years</td>
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<tr>
<td>Belgium</td>
<td>10 years</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>Not fixed yet</td>
</tr>
<tr>
<td>Estonia</td>
<td>Every year (lichens and herbs)</td>
</tr>
<tr>
<td>France</td>
<td>12 years before Nov 2004 and annual since then</td>
</tr>
<tr>
<td>Germany</td>
<td>Not defined</td>
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<tr>
<td>Italy</td>
<td>5 to 10 years</td>
</tr>
<tr>
<td>Lithuania</td>
<td>Every year</td>
</tr>
<tr>
<td>Norway</td>
<td>5 years</td>
</tr>
<tr>
<td>Romania</td>
<td>5 years</td>
</tr>
<tr>
<td>Slovak Republic</td>
<td>10 years</td>
</tr>
<tr>
<td>Spain</td>
<td>10 years</td>
</tr>
<tr>
<td>Sweden</td>
<td>Continuous, annual</td>
</tr>
<tr>
<td>Switzerland</td>
<td>Every 10 years</td>
</tr>
<tr>
<td>UK</td>
<td>Not available</td>
</tr>
</tbody>
</table>

**Ground Vegetation**

**Sampling season**

- Not fixed: 13.33%
- Fixed: 46.67%
- Not available: 40.00%
<table>
<thead>
<tr>
<th>Country</th>
<th>Area (m²) SHRB</th>
<th>Area (m²) HERBS</th>
<th>Area (m²) FERNS</th>
<th>Area (m²) LICHENS</th>
<th>Area (m²) LIVERWORTS</th>
<th>Area (m²) MOSSES</th>
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PROPOSED INDICATORS

FOR EUROPEAN WIDE NFI CALCULATIONS (COST E43)

1. Shrubs, climbers and palms shrubs composition (ICP codes)

2. Ground vegetation layers coverage (definition COST E43: layers classification)

3. Shrub species cover (definition COST E43: harmonization –NFIs cover ranges)
PROPOSAL OF FUTURE BIODIVERSITY INDICATORS (COST E43)

- Shrubs layer indicator species –FTs;
- unreal nowadays-
- Herb layer indicator species –FTs;
- unreal nowadays-
- Moss layer indicator species –FTs;
- unreal nowadays-
- Sociability –FTs; unreal nowadays-
- Shrubs genus/species average height (Cover-Biomass) –unreal nowadays-
Conclusions and Recommendations for large scale biodiversity monitoring

Large scale forest inventories should provide statistically significant data on change.

Reported data should be comparable between at least European countries.

The methods should give good estimates in various forest types should be as simple and cost efficient as possible should be robust enough to be used by non-specialists should be repeatable.
Conclusions and Recommendations for large scale biodiversity monitoring

Focus of monitoring biodiversity by large scale forest inventories should be put on

indirect indicators if possible, derived from measured attributes

like forest structure or deadwood amount instead on species
Conclusions and Recommendations for large scale biodiversity monitoring

For comparable results in Europe;

Stratification is important by

FOREST TYPE

Conclusions and Recommendations for large scale biodiversity monitoring

**DEAD WOOD**

**Thresholds**

Deadwood diameter threshold for snags and CWD: 10cm
Deadwood length threshold for snags and CWD: 1.3m

Deadwood below ground excluded

**Biodiversity relevant indicators**

- **TADW = Total Amount of Dead Wood** (m$^3$ or m$^3$/ha)

- Surface of forests containing at least 40 m$^3$ of dead wood per ha

- Surface of forests containing at least 20 m$^3$/ha of dead wood with a diameter > 40 cm
Conclusions and Recommendations for large scale biodiversity monitoring

FOREST STRUCTURE

At the moment possible DBH threshold : 120 mm

- Distribution of (1cm) standard deviation classes of DBH
Conclusions and Recommendations for large scale biodiversity monitoring

GROUND VEGETATION

- Shrubs, climbers and palms shrubs composition (ICP codes)

- Ground vegetation layers coverage (definition COST E43: layers classification)

- 3 Shrub species cover (definition COST E43: harmonization –NFIs cover ranges)
Thank You for Your Attention

Elmar Hauk
Austrian Forest inventory