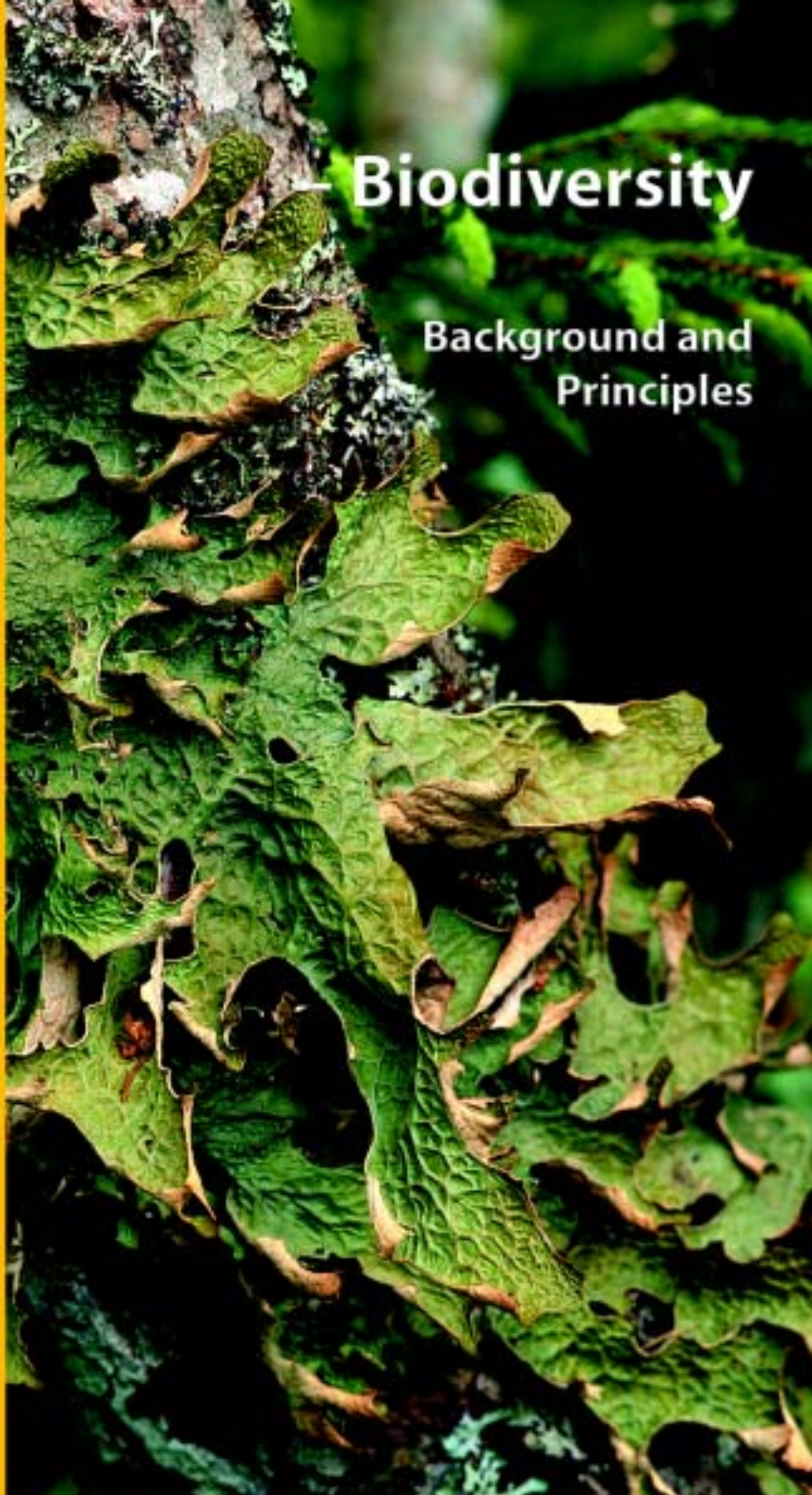
Environmental Inventories in Forests



– Biodiversity

Background and Principles

Environmental Inventories in Forests – Biodiversity

A manual for conducting inventories of forest habitats

Part 1:
Background and Principles

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by: Karl Kerner, Agro Lingua

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Editors:
Camilla Baumann, Ivar Gjerde,
Hans H. Blom and Magne Sætersdal, Skogforsk,
Jan-Erik Nilsen, NIJOS,
Beate Løken and Ivar Ekanger, Ministry of Agriculture

The entire booklet can be accessed via the Skogforsk website, please check for updates: www.skogforsk.no.
For further information, please contact:
Camilla Baumann (camilla.baumann@skogforsk.no)
or Jan-Erik Nilsen (jen@nijos.no)

Design: Svein Grønvold
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Contents

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Cystostereum murraii

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Environmental Inventories in Forests – An Important Basis for Environmental Planning in Forestry

Background

This manual is a result of the «Environmental Inventories in Forests» project (in Norwegian referred to as *Miljøregistrering i Skog* – MiS). In 1996, the Norwegian Ministry of Agriculture (Landbruksdepartementet) appointed the Norwegian Forest Research Institute (Skogforsk) to manage and conduct the project. The project's main objective was to develop and test a scientifically based method for recording environmental features which can be applied in forest management planning.

Skogforsk managed the project in cooperation with more than 100 other participants, including universities, forest inventory institutes and biologists. For example, field recordings were carried out in cooperation with forest inventory institutes in nine municipalities. So far, the project's budget framework has amounted to more than NOK 30 million (about EUR 4 million).

The environmental inventory project has collected extensive environmental data, such as species inventories, forest structures, etc., and has processed the data with the aim of clarifying connections of importance for the further development of the inventory's methodology.

The project has generated extensive knowledge which will have an effect on future environmental efforts within the forestry sector. For example, it has been shown that environmental features associated with biodiversity are spread throughout the forested areas. Thus, the attempts of preserving a large share of important environmental features on relatively small areas by defining so-called key habitats have a rather limited effect.

Methodology of the Environmental Inventory

The environmental inventory in forests is based on the following steps:

– Inventory – using a method based on scientific expertise and practical experience from environmental and forest inventories. The inventory shall also document all recorded habitats and features.
– Ranking and selection of the recorded environmental features.

The manual describes interrelationships in forest ecosystems. It also contains a description of the method's basic elements, and finally, it also includes specific guidelines for the implementation of the inventory. The Ministry assumes that these guidelines are used for environmental inventories conducted with public support given in connection with forest management planning.

Data Collection

Based on scientific results of the «Environmental Inventories in Forests» project, a specific data collection methodology has been developed, which can be linked to forest planning. The method was developed in cooperation between the environmental inventory project, which was responsible for the scientific profile, and the Norwegian Institute of Land Inventory (NIJOS). NIJOS is a centre of expertise for forest management planning and the development of forest inventory methodology. Four regional inventories were conducted as a test in 2000, and the experience from these was used in finalizing the selected methodology.

The objective of the environmental inventories is to obtain extensive information on important environmental qualities in forests. The method is based on recording specific data in those areas with active forest operations and in old forests. This enables an efficient inventory, while it at the same time

represents a precautionary approach, until such inventories have been conducted throughout most of the country's forested area. The method is based on an extensive inventory and the subsequent ranking of the registered environmental features by various parameters. The effects of protecting the registered environmental features on forestry operations and forest economy are not recorded. It is therefore assumed that these aspects are taken into consideration when deciding upon which environmental features to protect.

Ranking and Selection

According to the guidelines, the inventory shall record habitats and sites, and data on these in order to enable their ranking according to their environmental value. Such a ranking is necessary, since a large number of environmental features are recorded, many of which are interchangeable. Efficient ranking is enabled by specifically designed software. Due to the recording of additional data as well, it would be appropriate to secure the quality of the ranking by using forestry and environmental experts. These would make sure that the data are prepared in such a manner as to ensure the best possible result of the final selection. The guidelines and the necessary software for the ranking of registered data were completed in spring 2002.

There are always many alternatives when it comes to choosing between forestry operations and environmental considerations. The environmental inventory will not limit these choices, rather quite the opposite. If the registered elements cannot be protected on the basis of existing laws or regulations, the affected forest owner becomes the decision maker in each specific case. In cooperation with his/her advisers in the forest owner associations and forest inventory institutions, the individual forest owner must decide on how to deal with the registered environmental features. Important considerations in this process include the assessment of which elements do not result in additional costs or inconveniences for the forest owner,

and which elements actually have such significant consequences and are such a heavy burden for the forest owner that he / she cannot deal with them. As a basis for such considerations, the forest owner must evaluate how to follow up rules and regulations, the standards of «*Levende Skog*[1]» and own priorities. In connection with the development of software and guidelines for such a ranking, scientific advice for the selection process will also be presented.

Future Activities

There are still many activities being carried out within the «Environmental Inventories in Forests» project:

– Publication of project results in peer-reviewed, scientific journals.
– Extensive data have been collected, which for example can be used to give sound advice on specific silvicultural measures related to the environmental features that have been recorded.

As a result of the project, we can expect the generation of knowledge which will have an effect on future inventory methods, as well as on the environmental adaptations in forestry in accordance with official forest policy and the «Levende Skog» standards.

In 2000, four regional environmental inventories were carried out as part of methodology development. The data are still being processed, and this work will presumably give useful impulses in the future. 2001 was the first year with extensive inventory, ranking and selection of environmental features important for biodiversity in accordance with the inventory's methodology. Experience from the inventories in 2001 and the publication of the project's results will lead to the development and

[1] Levende Skog (*the «Living Forests Project»*): a broadly based project working for sustainable forest management in Norway, primarily aimed at the development of a set of performance level standards.

improvement of the methodology prior to the 2002 season, regarding such parameters as quality, efficiency and costs.

In spring 2001, the Forest Extension Service Institute conducted a series of courses in cooperation with the «Environmental Inventories in Forests» project and NIJOS.

In spring 2001, the Ministry of Agriculture initiated a consultative round on a support scheme for especially important environmental measures in forestry. To begin with, special emphasis will be placed on biodiversity. It has been decided that such a scheme will be established. When the forest owners begin to specifically follow up the environmental inventories, there will thus be a public support scheme to facilitate the implementation of measures which could not have been shouldered by the individual forest owners themselves.

In 2001, the Ministry of Agriculture initiated a process aimed at the implementation of the same type of environmental inventories in the remaining forest areas, including those which are not worth harvesting. Eventually, the aim is to have as complete an overview as possible as a basis for the selection of environmental measures.

This project was commissioned by the Ministry of Agriculture. It had several objectives, such as contributing to the knowledge base regarding forestry's environmental efforts and facilitating the follow up of the «Levende Skog» project. A large number of participants have contributed to the project's results, and the Ministry of Agriculture would like to thank everyone for their efforts. The ministry is certain that this manual, and the expertise on which it is based, will contribute to the improvement of forestry's environmental efforts.

Ministry of Agriculture, Forestry Department, May 2001

Ivar Ekanger, Deputy Director General

Biodiversity in Norwegian Forests

Biodiversity is a broad term, and is often used as a collective term for the natural variation in ecosystems, biotopes, species and genes. The conservation of biodiversity thus implies the conservation of this variation. When it comes to the practical management of biodiversity, focus is usually directed at species and their habitats. The genetic variation within a species will however be indirectly secured by maintaining sufficiently large populations in various parts of the geographic range of a species.

Biodiversity is natural variation in ecosystems, biotopes, species and genes.

Biodiversity within a given geographical area is determined by important environmental factors such as climate, geology, natural (forest fires, storm damage, insect attacks) and man-made (logging, pollution, etc.) changes, as well as the total temporal and spatial variation of these factors. In a global perspective, the number of species found in Norwegian forests is relatively modest, but this is part of the general decrease in diversity as one moves from the equator towards the poles. Another side of the same picture is that species in general are distributed over a greater area in northern latitudes than further south. This can be seen by the fact that there are few endemic species, i.e., species that only occur in Norway. However, there are several species for which Norway represents the main geographic range.

Even though Norway is stretched out across many degrees of latitude, most of its forest areas lie within the Eurasian Boreal Zone, the northern coniferous forest belt that spans the entire Eurasian continent from the Pacific to the Norwegian Sea (Fig. 1).

The coniferous forest belt is relatively sparsely populated, and has not been significantly developed. On satellite images, it thus appears as a more or less continuous forest area. One

Norwegian forests exhibit significant variations in climate, topography and geology.

reason for this is that the natural conditions severely limit the possibility for farming. The coniferous forest belt has a unique flora and fauna, adapted to the varying natural conditions. Compared to large parts of the coniferous forest belt, Norwegian forests are subject to large variations in climate, topography and geology, both at macro and micro scale. For example, Norway has unique coastal forests, alpine forests and northern birch forests. The diversity of species includes a very rich flora of mosses and lichens.

A northern outskirt of the European Deciduous Forest Zone can be found at the southernmost tip of Norway (Fig. 1). Southern Norway and parts of eastern Norway are characterized by a significantly higher species diversity than the boreal zone, and with many times more Red List species, in spite of the considerably smaller area. The European Deciduous Forest Zone is one of the regions in the world most affected by human activity. A large share of the indigenous deciduous forest on the European continent was removed long ago, and has been replaced by farmland and built-up areas. The presently existing forests consist to large degree of either conifer plantations, narrow forest corridors or highly cultivated deciduous forests. The Norwegian forests within this zone are somewhat different, as they have less farmland and a larger share of natural tree regeneration. Thus, the

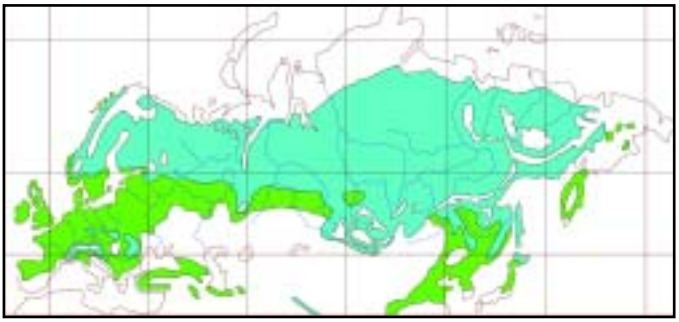

Fig. 1. The coniferous forest (blue) and the deciduous forest (green) zones.

broad-leaved forests of southern Norway represent a valuable contribution to the maintenance of biodiversity, even though they do not cover a large area.

In Norway, approximately 30,000 terrestrial species have been recorded (excluding microorganisms), of which about 18,000 are associated with forests. Nobody knows for sure how many species actually live in Norwegian forests, but 25,000 species must be considered a minimum. A few species occur nearly everywhere, whereas most species have a more limited or scattered distribution. In addition, there is an unknown number of extremely rare species. Each year, species are discovered that have not been previously recorded in Norway, some of which are completely unknown to science.

Forestry affects species diversity by altering forest structure and composition.

Even though forestry does not reduce the total forest area in Norway, it does affect species diversity because the structure and composition of forests are altered. Natural disturbances and successions following forest fires, insect attacks and storm fellings are changed when forest operations affect these processes. Forest fires are extinguished, burned and storm-felled areas are cleared and planted. Young, planted spruce forests grow in areas where deciduous forests would grow under natural conditions. Clearcutting and planting monocultures also result in a mosaic of stands in various age classes, which deviate from natural landscape patterns. The trees' life expectancy is reduced due to logging, and the timber is removed from the forest. This, in connection with natural tree deaths, results in only very few trees remaining to become really old. Compared to the forests in which today's species have developed, present forests have fewer old trees, less deadwood, less area of untouched burned forest and late successions of deciduous trees. During the past 100 years, several of these factors have shown a positive trend, e.g., there is more deadwood in many places today than in the early 1900s. Nevertheless, these elements still represent a small share of what they otherwise would if the forests could

develop completely untouched by humans. The occurrence and composition of such elements in «virgin forest» landscapes has been documented, e.g., in Russia.

Species react differently to anthropogenic changes of forest composition. Certain species are even favoured by the large percentage of clear-cut areas and young stands. With regard to the conservation of biodiversity in forestry, it is therefore important to primarily focus on those species associated with structures and conditions that are becoming scarce as a result of forestry operations.

Important environments that are becoming scarce in areas with intensive forestry include:

- Deadwood
- Old trees
- Late successions of deciduous trees
- Burned forest

Species with small populations are often vulnerable to environmental changes.

Species with small populations are often vulnerable to environmental changes, and under extreme circumstances they could be threatened by extinction. This applies to species that have been gradually decreasing over a longer period of time and to species that have recently re-established themselves in Norway. Regarding species that only recently have been discovered, it is difficult to determine if they are stable, increasing or decreasing species. Species that are common today, but with a continuous decreasing trend, will eventually be reduced to small, threatened populations.

A «Red List» is an overview of the species threatened by extinction or which are in danger of becoming threatened.

A «Red List» is an overview of species considered to be threatened by extinction or exposed to a significant reduction of its population. The Norwegian Red Lists are issued by the Directorate for Nature Management, in cooperation with experts for different groups of species. The lists are updated regularly in accordance with new knowledge, and to include

additional groups of species that have been assessed. The Red List does not only include species that presently are decreasing, but also stable or increasing species whose populations are so small that they still cannot be considered as viable. The species are assessed and assigned to one of several specifically designated categories of threat. These categories include everything from already extinct species or species threatened by extinction to those that should be monitored due to an assumed negative population trend. National Red Lists are published in order to increase the focus on threatened species, thus preventing their extinction. The Red List shall thus play a concrete role in environmental planning. The latest version of the Norwegian Red List contains 3,062 species.

The Norwegian Red List contains 3,062 species.

A study of the approximately 1,500 Red List species that have forests as their habitat, shows that many of these are associated with deadwood, old trees and old-growth forest. However, knowledge about individual Red List species is limited, and for most species, there are presently no data showing population size or trends. Even though the Red Lists are updated (species are removed from and added to the list) in accordance with new knowledge on individual species, the lists will at any given time be dominated by species associated with habitats which are considered rare or decreasing. Thus, if measures to maintain habitats threatened by forest operations are implemented, the protection of forest-dwelling Red List species would also be supported.

The protection of habitats threatened by forest operations also promotes the conservation of forest-dwelling Red List species.

Species Inventories as a Basis for the Conservation of Biodiversity

There may be many reasons for conducting species inventories and designing classification systems for natural environments. In the past decade, there has been increasing focus on inventories to be used as a basis for the conservation of biodiversity.

There is a need for simple methods for the determination of habitats important for the conservation of biodiversity.

For many years, the recording of species and their distribution has been an important task at universities and other research institutes. In recent years, databases of species distribution have become readily accessible, and today it is possible to download geographically specific data on an increasing number of species directly from the Internet. This information is valuable for research and public administration alike. However, it is not appropriate to base the management of biodiversity only on known observations of species, e.g., Red List species, since these only represent a small part of the species' actual occurrence. There is thus a need for indirect, relatively simple methods for the determination of habitats important for the conservation of biodiversity.

In the 1990s, a group of field biologists (who call themselves *Siste Sjanse*, the «Last Chance») developed a method aimed at localizing a small section of a forest which can be considered to have specific importance for biodiversity. These areas were called «key biotopes». The method, which originated in Sweden, has mainly been applied to forests in eastern Norway. Areas are classified as key biotopes on the basis of field observations. Assessment categories include the frequency of a certain biotope in the landscape, vegetation, forest structures, landscape forms and the observation of species that indicate especially valuable areas for biodiversity (indicator species). A book describing key biotopes and indicator species was published by *Siste Sjanse* in 1996. Their concept was to conserve the key biotopes by either completely protecting the areas or subjecting them to specific management practices in order to ensure the conservation of the environmental features of value for biodiversity.

In 1999, the Directorate for Nature Management published a manual for the mapping of nature types (DN handbook 13), which also included an overview of nature types considered to be especially important for biodiversity. For forests, 12 important nature types are listed, with emphasis on nutrient-

rich vegetation types, old-growth forest and moist habitats. The selection of nature types was conducted according to a set of criteria, among which the possible occurrence of Red List species was one. Other criteria included species diversity, and to what degree the biotopes are threatened or rare. For some of the nature types, only specific variants are registered. For each nature type, areas considered to be important or very important are to be recorded. The manual is mainly intended to be used in municipal inventories of nature types, and is adapted to the legal requirements of municipal general planning and administration. In some municipalities, the work consists of processing already available data, whereas in others, it also includes field inventories. The determination of nature types is mainly conducted as field registrations by external biological experts. Most of the other data (e.g., occurrence of Red List species, game and freshwater) have already been collected and thus only need to be systematized and in part validated. Many municipalities combine the revision of wildlife maps with the nature type inventories. The Directorate for Nature Management grants NOK 50,000 to each municipality that wishes to conduct such an inventory, under the condition that the municipality matches the grant with an equivalent sum.

The «Environmental Inventories in Forests» project was assigned to develop an inventory design which is compatible with forest management planning. A forest management plan shall result in a proposal for measures within each stand, and the inventories are thus linked to the area units represented by forest stands. The inventory design shall also enable the localization of parts of stands with specific qualities and those elements that should be protected if or when the stand is harvested. Strategically, the environmental inventories are distinguished from the municipal nature type inventories by their greater level of accuracy and by being directly associated with forest planning processes. On the other hand, the environmental inventories also differ from the key biotope

The environmental inventories are directly adapted to forest planning procedures.

inventories, since they gather data from a larger forest area for use in the planning process, which can serve as a basis for several kinds of management measures. Data collected via the different methods can thus not be directly compared, and any transfer of information from one type of inventory to another requires sound knowledge of both methods.

Basic Principles of the Environmental Inventories

The design of the inventory as described in this manual is a result of the «Environmental Inventories in Forests» project. The most important underlying principles of the inventory design are briefly presented in the following. The biological principles of the inventory's methodology are based on the project's own and other research.

Biological Principles

Spatial distribution of species

The distribution of species in forests is determined by their habitat requirements, the distribution and history of the habitats and the species' own reproductive and distributional history. Presently, about one half of the Norwegian forests consists of younger forest (maturity class 1-3), resulting from logging, natural regrowth and afforestation since the 1950s. The other half is older forest (maturity class 4-5), mainly originating from the period before the transition to clear-cutting and planting monocultures. In the older forests, there are occasionally trees older than 150 years. This does not mean that the forest has remained untouched, but that certain trees have been left standing in spite of logging activities. Young forests established on clearcuts or cultivated land usually lack the habitats necessary for many Red List species, such as

Young forest stands usually lack the habitats necessary for many Red List species.

sufficient amounts of deadwood and old trees. Studies of the spatial distribution of Red List plants and fungi show that most of these are nowadays found in forests with a maturity class of 4-5.

In the older forests, elements that are vital for Red List species occur in varying densities, on a small and larger scale. Assuming that 90 % of these habitat elements occurred within 1 % of the forest land, a localization of these stands would thus result in an almost complete inventory of Red List species habitats. The actual distribution of such elements as deadwood and old trees shows that high-density areas do exist, but that most of the habitat elements nevertheless occur outside of these. Thus, less than 1 % of the old forest stands have concentrations of logs of 50 m^3 per hectare or more. The mean amount of deadwood is about 7 m^3 per hectare according to data from the National Forest Inventory. In reality, this means that most deadwood is to be found outside of the mentioned high-density areas. There is very little virgin forest in Norway, but relatively large areas of old forest with a certain amount of old trees and deadwood. In addition, the different habitats are found in different parts of the forest, thus adding to the dispersed distribution of the valuable environmental features.

Scattered environmental features are important for maintaining biodiversity.

Studies show that Red List plants and fungi can also be found in high-density areas at the stand level, but most of them occur spread throughout old forest stands. The species are often found associated with scattered habitat elements of the appropriate quality, which shows that such habitat elements in sum contribute to a significant share of the Red List populations. Furthermore, the highest density of Red List species is found in specific types of habitats. Thus, Red List species that mainly occur in *other* environments than these, will thus be poorly represented if there is too much focus on those areas with a high Red List species diversity.

The environmental inventories are designed to register both high-density areas and scattered environmental features.

Environmental inventories and the incorporation of biodiversity issues in forest management planning must thus be based on the distributional aspects mentioned above. The environmental inventories are therefore designed to register both concentrated and more scattered valuable environmental features at the stand level. Such valuable features can then be protected through various forestry-related measures. If the valuable environmental features shall be protected by setting aside certain forest stands for natural development, the per-area efficiency of the measure will be greatest in areas with a high density of such features, and as such, are incompatible with intensive logging activities. If the valuable environmental features shall be protected by setting aside individual habitat elements or small groups of trees when the area is harvested (applies to environments that tolerate or are favoured by clearing the surrounding forest), this is best done by implementing the measures in those stands where a certain type of habitat element has been documented and mapped in the inventory.

Environmental gradients

All species have different habitat requirements. Imagine a simple experiment in which a row of flower pots is given increasing amounts of water from left to right. Somewhere along the line, any given flower species will show the best response (growth). However, this point will vary for different species. Such a visible moisture *gradient* can be found in forests, e.g., in the transition from mineral soil to bogs. Along such gradients, a gradual succession of species can easily be observed. However, the same variation applies to areas in which dry and moist zones form a complex pattern on the forest floor. In natural ecosystems, there are many, partially interwoven environmental gradients. Two such gradients that are very important for the spatial distribution of species in forests are *nutrient content* and *moisture*. Species composition will more or less change completely when moving from a dry, nutrient-poor pine forest to a moist, nutrient-rich hardwood forest.

One of the main principles of the environmental inventories is the distribution of species in relation to the nutrient and moisture gradients. The recorded habitats are classified according to these two main gradients. There is an almost unlimited biotope diversity in forests. Not all of this can be registered, but it is nevertheless important that the inventory can distinguish between biotopes with significantly different characteristics. For practical use, we divided each of the two gradients into two parts, thus resulting in the four combinations shown in Fig. 2. This enables the inventory to cover vital environmental variation.

The nutrient and moisture status of a habitat greatly influence species composition.

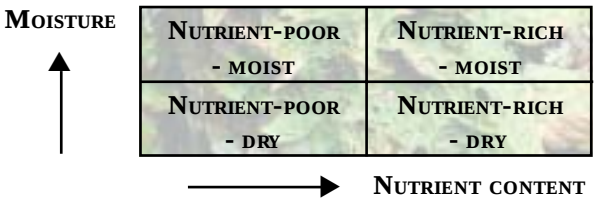

Fig. 2. Classification of forest habitats by the two main gradients nutrient content and moisture.

Complementary habitats

Different types of biotopes must be represented in order to significantly preserve biodiversity.

The species in a forest are distributed according to their habitat requirements. Thus, different environments have different species compositions. Environments rich in nutrients have more species than low-nutrient ones, but at the same time, there are species that only can be found in oligotrophic habitats. For example, noble hardwood forests contain more species than spruce forests, but the latter nevertheless are home to species which do not occur in the hardwood forests. This implies that not all species can be sufficiently protected by merely preserving those environments with the highest species diversity. One has to take different habitats into consideration in order to significantly preserve biodiversity. This principle is referred to by biologists as the complementarity principle. In the environmental inventories, forests are categorized into four main groups of habitat elements: deadwood, living trees, ground and rocks / cliffs. Each of these groups can in turn be further classified according to nutrient content and moisture. For example, nutrient-rich rock walls consist of calcareous rock, deciduous trees are defined as nutrient-rich and conifers as nutrient-poor tree species. All combinations of habitat elements and environmental features make up what we have called complementary habitats. These are the basic building blocks of the environmental inventories. Clay ravines and stream gorges are unique habitat elements with high moisture, and are therefore classified as separate habitat elements.

This manual describes 12 habitat elements to be recorded in the inventory. Most of these are sub-divided according to variations in nutrient content and moisture, so that a total of 29 different *habitats* are defined, see Table 1.

Table 1. An overview of the 12 habitat elements and the 29 habitats which are recorded in the environmental inventories.

	Habitat element	Habitat
1.	Snags	hardwoods – moist hardwoods – dry conifers – moist conifers – dry
2.	Logs	hardwoods – moist hardwoods – dry conifers – moist conifers – dry
3.	Trees with nutrient-rich bark	– moist – dry
4.	Trees with pendant lichens	– moist – dry
5.	Late successions of deciduous trees	– moist – dry
6.	Old trees	old hardwoods – moist old hardwoods – dry old conifers – moist old conifers – dry
7.	Hollow deciduous trees	
8.	Burned forest	
9.	Rich ground vegetation	– moist – dry
10.	Rock walls	nutrient-rich – moist nutrient-rich – dry nutrient-poor – moist nutrient-poor – dry
11.	Clay ravines	
12.	Stream gorges	nutrient-rich nutrient-poor

Indicators and ranking

The indicators are used to identify, delimit and assess the quality and amount of the different habitats. Each habitat is defined by a set of criteria. The applied indicators are mainly based on forest structures. However, for some habitats, indicator species are used in addition to forest structures in order to increase the indicators' accuracy. For example, for species associated with trees with nutrient-rich bark, it is not sufficient to use vegetation type, tree species or tree age. Thus, it is also necessary to record the occurrence of lungwort lichens (*Lobaria* spp.), which indicate that the ecological requirements for species associated with nutrient-rich bark are met.

Following the inventory, registered objects within each type of habitat can be ranked. The ranking of the data by specific criteria is meant to be an important tool for making priorities in the planning process, and not as the definite answer. The ranking criteria are based on simple relationships between forest structures and the occurrence of specific species. There is a clear correlation between the extent of a habitat and the number of species occurring there (including rare species). For example, there will be a greater number of species and a greater population density of species associated with deadwood in areas with lots of deadwood than in areas with little deadwood. If protective measures are only to be implemented in some forest areas, this is done most efficiently in areas with a high density of environmental features. Furthermore, the quality of a habitat determines the number of rare species and the total number of species occurring. For example, the higher the pH of the bark is, the more species associated with nutrient-rich bark will be found. The ranking of recorded objects within one type of habitat is thus based on the parameters density (number per area unit) and quality. For logs, one also takes small-scale variations of quality into consideration. Thus, areas with a high density of many different deadwood qualities are ranked highest.

The ranking of recorded features assists in making priorities for future forest management.

Strategic Principles

What should the inventories detect?

The inventories focus on habitats in Norwegian forests with unique biodiversity, and which are considered vulnerable to impact from forest operations. The inventories should be able to identify the relatively small scale occurrence of habitat elements which are vital for the dominant part of biodiversity: invertebrates, plants and fungi. Registered occurrences of such habitat elements as deadwood, old trees, hollow trees, trees with pendant lichens and rock walls are also important for specialized species with greater spatial requirements, such as certain bird and bat species. The spatial distribution of habitat elements and forest types in a planning area become visible when the recorded data have been mapped and digitized. Such general maps can then be used to plan environmental measures at a larger scale.

Integration with forest management planning

After conducting a forest inventory, forest management plans are made, containing, among others, a stand overview with suggested measures for the individual stands. Stand boundaries are defined on the basis of maturity class, site quality class, tree species and property boundaries. In sum, this enables the long-term management of timber resources. In the same way, an inventory of habitats can be compiled, based on the environmental inventory. The latter is designed so that it can be conducted simultaneously with the field work necessary for making forest management plans. However, the environmental inventory can also be separately conducted.

The inventories result in an overview of important environmental features in a forest management area.

The inventories cover the same area for which the management plans are made, but in principle, the method can be applied to any forest area. Within the area covered by the management plan, habitats are recorded in mature forest (maturity class 5) and forest that will be mature in the course of the planning period. In maturity classes 1-3, usually only

clay ravines, stream gorges and burned areas are recorded. In areas lacking certain habitats, a combination of usual stand data (age, tree species, site quality class, vegetation) and map data (e.g., topography, aspect) can be used to choose a young forest stand which in the long run shall develop the desired features.

Distinguishing between environmental inventory and management

The actual inventories are purely descriptive, and administrative decisions are first taken afterwards.

The environmental inventory clearly distinguishes between data collection and forest management. The actual inventory is a purely descriptive task, whereas the use of the collected data in the conservation of biodiversity requires an assessment of values in connection with determining the scope of different measures. Distinguishing these two aspects implies that management decisions are not made in the course of the inventory, but are rather implemented as an integrated assessment after the data collection phase is completed. The extent of biodiversity-related considerations in the forest management plans is determined by the forest owners' ambitions, scientific criteria, political guidelines and the standards for sustainable forestry. When applying the inventory in forest management planning, it is recommended to assure the quality of the environmental feature assessments by using forest biologists or environmental experts, thus making sure that the data have been optimally prepared for the final selection process.

Inventory threshold

The inventories are designed to map relatively detailed information about environmental features within a large portion of the area to be covered by the management plan. This area is divided into three categories: (1) Areas with a high density of environmental features, (2) areas in which the features are more scattered, and (3) areas with few or no environmental features. Areas with a high density of certain habitat elements (e.g., trees with nutrient-rich bark) and

habitats with natural limitations (e.g., stream gorges) are marked on the map. The occurrence or absence of the various types of habitats is also recorded. This enables the integration of environmental considerations and land use planning in a completely different manner than before: priorities can now be made on the basis of a more comprehensive resource inventory. This makes it easier to take landscape ecology into consideration and to find solutions that balance forestry and environmental issues.

This inventory threshold is the minimum requirement for the recording of a habitat, and is based on qualitative and quantitative aspects. The thresholds for various habitats presented in the manual are based on experience from test inventories. However, there will be significant variations of environmental feature density in different areas, which may necessitate local adaptations of the threshold values. For example, in regions with large areas fulfilling the given threshold values, it may be necessary to raise the threshold in order to reduce the scope of the inventory to remain within the available time and financial limits. Environment features that are omitted from the map in such cases will nevertheless be identified by the stand-level inventory. Accordingly, it may be necessary to lower the threshold values in areas with very scattered occurrences of a habitat in order to secure a sufficient amount of data for the planning process.

The inventory threshold is the minimum requirement for the recording of a habitat.

Occurrence of endangered and vulnerable species

The environmental inventories are based on the identification of important forest habitats. The inventories form the basis for implementing measures aimed at the conservation of biodiversity. Many Red List species will be identified by the inventories, as well as by the subsequent measures. However, the most seldom species will easily be overlooked in the process. The fewer specimens of a species exist, the greater the possibility of it being overlooked in the inventory of the chosen area. Equally, the smaller the area being managed with

regard to the conservation of biodiversity, the greater the probability of rare species being overlooked.

Forest management plans can take known populations of endangered or vulnerable species into consideration.

In order to detect the most seldom species in Norwegian forests, and to take them into consideration when designating areas and measures for biodiversity protection, one should make use of known populations of directly endangered or vulnerable Red List species. Of these, about 450 are forest-dwelling species. One could thus protect these populations, even if there are no highly ranked habitat at the site. This would include known nesting places of vulnerable bird species, such as the goshawk (*Accipiter gentilis*).

It is possible to incorporate all documented occurrences of directly endangered or vulnerable Red List species in the forest management plans via the environmental inventories. However, plant and fungi sites are most suitable. Data on such sites are available via databases on the internet, various publications, county environmental departments, municipalities and direct contact with research institutes and local experts. Occurrences which are not identified accurately enough to be pinpointed within a stand, cannot be included.

The Phlegmacium species Cortinarius rufoolivaceus *is classified as directly threatened by extinction on the Red List.*

If there is doubt, the site can be controlled by an expert in order to assess whether or not the species or its required habitat is still present. Known sites in the area should be transferred to the forest stand map before field work commences. For each identified site, the field inventory will note the type of habitat in which the species are found in order to enable coordination with the environmental inventories and the implementation of relevant measures.

Local adaptations

The application of a general inventory design to varying, local conditions can lead to certain challenges. These include: (1) insufficient emphasis on unique local conditions and (2) collection of unnecessary data. Norway is divided into detailed geographical regions based on climate and vegetation. In addition, national atlases specifically showing variations in climate, geology and vegetation are also useful in evaluating local adaptations of the environmental inventory design. This manual presents another regional division, based on the distribution of Red List species in Norway, see Fig. 3. According to this classification, Norway is divided into four main regions, which in turn are subdivided into a total of eight sub-regions. The regions are based on defining large geographical units in which Red List species are found that to a great extent are unique to this region.

The importance of the various habitats for biodiversity varies between the different parts of Norway.

Species that only or mainly occur in a given region, are often associated with specific habitats. In order to focus on major environmental features, we have for each region selected certain habitats which are to receive highest priority with regard to the incorporation of environmental considerations in the forest management plans. These are listed as «important habitats» under each region described on pages 27-29. In each region, there will also be habitats that do not represent any unusually high degree of biodiversity. Such habitats should not be given the same priority. Examples include moist habitats with pendant lichens in western and northern Norway,

hollow trees in northern Norway and nutrient-poor rock walls in coastal spruce forests. These lists are only to be regarded as recommendations based on present insights. It must be underlined that local knowledge is essential for the final priorities to be made within each area.

Fig. 3. Regional division based on the occurrence of Red List species.

The various regions presented in Fig. 3 are briefly presented below. Based on the occurrence of Red List species, the most important habitats in each region are also shown.

1a Boreal Main Region

Dominated by coniferous forests and a relatively continental climate. Species only occurring in Region 1a are often predominantly eastern Eurasian species.

Important habitats:
Deadwood (conifers), old conifers, trees with pendant lichens, late successions of deciduous trees, rich ground vegetation (coniferous forests, bog forests, alluvial forests) burned forest.

1b Gudbrandsdalen

This valley is classified as a separate sub-region of the boreal region due to the occurrence of unique species associated with the area's many stream gorges. In these, the climate is characterized by high summer temperatures and a high humidity. The occurring species are often predominantly eastern Eurasian species.

Important habitats:
Trees with pendant lichens, stream gorges, moist and rich ground vegetation (tall-herb woodland, alluvial forests), rock walls.

1c Coastal Spruce Forests

The region is dominated by spruce forests and many days of precipitation per year. Many hydrophilic and typically northern species. The region is especially known for its diverse lichen populations, with species otherwise only to be found in North-American coastal regions.

Important habitats:
Logs (conifers), trees with nutrient-rich bark, trees with pendant lichens, clay ravines.

2a Southeastern Norway

Northern fringe of the European Deciduous Forest Zone, characterized by high summer temperatures. Species unique to this region are usually found south of Scandinavia.

Important habitats:
Deadwood (deciduous trees), trees with nutrient-rich bark, late successions of deciduous trees, old and hollow deciduous trees, rich ground vegetation (calcareous low-herb woodland), oak, beech and other broad-leaved deciduous forests, nutrient-rich bog forests), calcareous rock walls.

2b Western Norway – Fjords

The climate in this region resembles that of Region 2a, but with cooler summers and less species diversity. Widespread occurrence of deciduous forests.

Important habitats:
Trees with nutrient-rich bark, old and hollow deciduous trees, rich ground vegetation (broad-leaved deciduous trees).

3 Western Norway – Coastal Region

Pine and deciduous forests in an oceanic climate with mild winter temperatures and high rainfall. Species unique to this region are predominantly found in western Europe.

Important habitats:
Trees with nutrient-rich bark, rich ground vegetation (broad-leaved deciduous forests, calcareous low-herb woodland and nutrient-rich bog forests), moist and nutrient-poor rock walls, stream gorges.

4a Northern Norway

Birch forests in a coastal climate, extending further north than the natural geographic range of spruce. Species with a northern Scandinavian distribution.

Important habitats:
Rich ground vegetation (calcareous low-herb woodland, low-herb and tall-herb woodland), rock walls, stream gorges.

4b Northern Norway - Valleys

River valleys with a northern continental climate. Birch, pine and alder forests with species unique to northeastern Europe.

Important habitats:
Trees with nutrient-rich bark, old conifers, rich ground vegetation (moist deciduous forests, calcareous low-herb woodland), rock walls, stream gorges.

A coastal spruce forest (1c) in Namsos.

Glossary of Terms

Additional information: Information on recorded objects which is not directly used in ranking, but which can be used to select and prioritize measures aimed at protecting biodiversity.

Complementary habitats: Habitats containing different 'sets' of species.

Deadwood profile: Deadwood volume (logs), specified according to tree size class and degree of decay.

Environment gradient: An ordered change, for example from dry to moist, in an environmental factor or a complex of factors that occurs along a spatial transect from one place to another.

Habitat element: General unit representing a habitat or other resource for a species. The term includes structural components in forests, such as deadwood, living trees and rock wall, as well as larger units, such as stream gorges, burned areas and late successions of deciduous trees. Habitat elements are subdivided into habitats according to tree species, nutrient status and moisture.

Habitat: Basic unit of the environmental inventory, defined as a sub-unit of a habitat element with specific characteristics with regard to tree species, nutrient status and moisture.

Indicator: Indirect measure used to localize a habitat and its associated species.

Inventory threshold: Minimum requirement for the recording of a habitat or environmental feature, based on qualitative and quantitative aspects.

Mycorrhizal fungi: Fungal species living in symbiosis with plant roots.

Object: Recorded point features or polygons (on maps), with associated environmental data, showing the occurrence of habitats in the environmental inventory.

Ranking variable: A parameter used to rank recorded objects within an individual habitat.

Red List: List of species that are classified as threatened by extinction, or which are in danger of becoming threatened.

Red List species: Species included in the (Norwegian) Red List.

Region: In this context: a general division of Norwegian forests into eight areas according to the known distribution of Red List species.

Succession: Natural development of a forest stand following a natural or man-made disturbance.

Vegetation type: In accordance with the classification used by the National Forest Inventory.

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Landbruksdepartementet = Norwegian Ministry of Agriculture
Skogforsk = Norwegian Forest Research Institute
NIJOS = Norwegian Institute of Land Inventory

The manual for environmental inventories of forest habitats consists of four parts:

Part 1: Background and Principles
Part 2: Forest Habitats
Part 3: Inventory Guidelines 2001 (Norwegian only)
Part 4: Guidelines for Ranking and Selection 2002

SKOG FORSK

NIJOS
Norsk institutt for jord- og skogkartlegging

LANDBRUKSDEPARTEMENTET