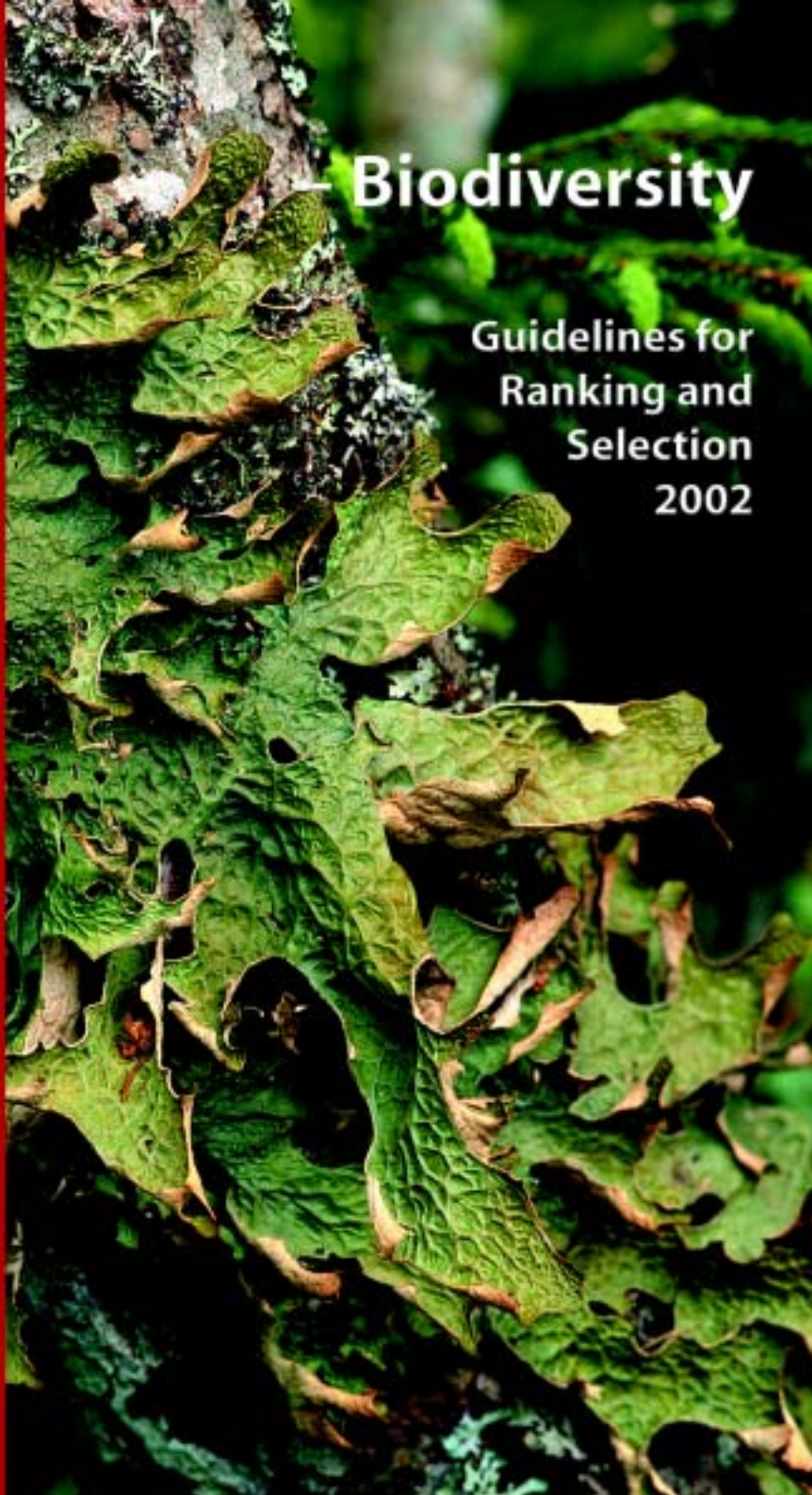
Environmental Inventories in Forests



– Biodiversity

Guidelines for Ranking and Selection 2002

Environmental Inventories in Forests – Biodiversity

A manual for conducting inventories of forest habitats

Part 4:
Guidelines for Ranking and Selection 2002

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Introduction

According to the guidelines for the inventory of environmental features important for biodiversity in forests, habitats and habitat data shall be surveyed. Based on this data, the environmental features can be ranked according to specified environmental parameters. Ranking is necessary because the inventory generally surveys more habitats and a greater area of environmental features than can be expected to be protected by specific environmental measures. The inventory's methodology is designed to enable the ranking of habitats according to certain criteria using specially developed software. The ranking routines shall enable the systematization of the recorded features within each habitat, thus forming the basis for the selection of areas which are to be managed in certain ways, or which are to be totally protected in the near future.

The ranking routines shall enable the systematization of the recorded features within each habitat, thus forming the basis for the selection and management of habitat areas.

The selection process must consider the specific interests of both forestry and the environment. The environmental inventory does not limit the options presented by the selection process, and may perhaps even give rise to additional choices. Thus, each forest owner must make decisions, in cooperation with advisers of the forest owner associations, regarding the management of the surveyed environmental features. Important considerations include the distinction between those features that do not imply any significant obstructions to forest operations or lead to additional costs, and those that result in a substantial practical and financial burden. The forest owner's decisions and priorities must be based on the assessment of public regulations and the standards of Levende Skog[1] .

According to the Levende Skog standards for landscape planning, environmental considerations must be taken and implemented across property boundaries. This landscape

[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.

ecological approach implies that each forest owner not only must consider the environmental issues within the framework of his or her own land, but also, as much as possible, in a broader context. Whereas this approach is necessary in order to take the general development of a landscape area into consideration, it is also useful for stating priorities in the conflict between environmental and business interests. When evaluating measures that cross property boundaries, it is also appropriate that the forest owners discuss these issues with forest advisers.

Inventory Phases

The implementation of the environmental inventories carried out in connection with regular forest management planning can be divided into the following four phases:

Phase 1 - Preparations

- Land assessment and evaluation of the scope of the inventory, level of accuracy and methods. This phase should also include the assessment / determination of the inventory's threshold values.
- Collecting relevant environmental data.
- Interpretation of aerial photos.

Phase 2 – Data collection in field

- Environmental survey based on the environmental inventory project guidelines.
- Quality assurance.

Phase 3 – Follow-up

- Data processing, digitizing.
- Ranking and sorting habitats.
- Selection of habitats for specific management or total protection.

Phase 4 - Forest management plan

- Establish forest management plans that include proposals for environmental consideration of habitats in need of protection, as well as suggestions for the management of scattered environmental features.

This manual describes phases 3 and 4, and includes the following steps from the ranking of habitats to the implementation of the inventory in forest management plans:

1 Habitat elements registered in the stand database (SPREL) are transferred together with necessary stand data to a separate database (MSAccess 2000), in which the elements are divided between habitats (see Table 1, page 7). The database distinguishes between habitats associated with designated high-density areas and those based on scattered occurrences of the observed features.

2 The ranking database calculates, ranks and sorts the observed data within each habitat. The results are presented as separate reports for each habitat. These reports are to be used together with a map in the selection phase.

Selection is a manual process, which uses the ranking reports and maps to select those habitat areas which are potentially in need of specific silvicultural measures or considerations.

3 Selection is a manual process, which uses the ranking reports and maps to select those habitat areas which are potentially in need of specific silvicultural measures or considerations. The selection process must be based on the individual forest owner's priorities as well as a broader, cross-boundary biological approach. Thus, the process should involve external expertise in order to assess the environmental features in a landscape ecological context.

4 When the selections have been made, these are recorded in the ranking database, and the data is transferred back to the stand database (SPREL), thus becoming available for use in the forest management planning process.

Ranking

The description of the ranking principles in this manual corresponds with the ranking and sorting functions in the database software.

Scientific basis for the ranking of habitat areas (high-density areas)

The ***ranking*** of habitats is based on the connection between forest structures and species diversity. There is also a connection between the extent of a certain type of habitat and the number of species (including Red List and other rare species) occurring in that habitat. For example, areas with a high density of deadwood will generally have a greater number of species per hectare than areas with a lower deadwood frequency. In addition, the number of (rare) species occurring in an area is also dependent on the characteristics of the habitat. For example, there will be a greater number and different types of xylophagous species on partially and totally decayed logs than on newly fallen wood.

The ranking of surveyed objects within a specific habitat is thus based on two major principles: *quantity* and *quality*. The former is expressed as the number of objects within a certain area, whereas the latter is recorded as tree species, diameter class, degree of decay, vegetation type and aspect.

The surveyed elements form the basis for the establishment of complementary habitats.

The surveyed elements form the basis for the establishment of complementary habitats – different sets of environmental features which are separately ranked since they have environmental qualities which are difficult to compare. Based on inventory data, numerical indexes shall be determined, which are to be used for the ranking of the polygons within each habitat. These indexes are specific for the individual habitat, and cannot be used to make comparisons between different types of habitats.

As a tool in the ranking process, specially designed software generates reports and lists. These reports contain infor-

mation about the different habitats, ranked according to quality and quantity. The software ensures that the habitat element with the highest index value is placed on the top of the ranking list for the respective habitat.

Habitats with the same index value are then sorted on the basis of other variables.

Those habitats with the same ranking (equal index values) are then sorted on the basis of other variables. The objective of the sorting is to systematically present the information associated with each individual habitat. For example, habitats associated with «logs» will be ranked by tree diameter and degree of decay. Objects with the same ranking index will be sorted according to their moisture status.

Each habitat area can consist of different habitats (see Table 1, page 7) for which a specified area cannot be given. For example, a habitat area of logs could consist of both coniferous and deciduous trees, and thus contain two habitats, representing nutrient-poor and rich environments, respectively. However, we cannot distinguish between the exact percentage of the area covered by coniferous or deciduous logs.

For each polygon, some parameters determine the ranking, whereas others are used to sort the elements within each habitat. This information also supports the selection of those areas / habitats which require specific management or total protection.

The habitat areas are surveyed in accordance with the 12 habitat elements. These can be divided into a total of 29 different habitats, according to the environmental gradients dry / moist (based on vegetation type and topography) and nutrient-poor / nutrient-rich (based on the occurrence of coniferous or deciduous trees).

An overview of the different habitat elements and habitats is presented in Table 1.

Table 1. Habitats

	Habitat element	Habitat
1.1	Snags	hardwoods – moist
1.2		hardwoods – dry
1.3		conifers – moist
1.4		conifers – dry
2.1	Logs	hardwoods – moist
2.2		hardwoods – dry
2.3		conifers – moist
2.4		conifers – dry
3.1	Trees with nutrient-rich bark	– moist
		– dry
4.1	Trees with pendant lichens	– moist
4.2		– dry
5.1	Late successions of	– moist
5.2	deciduous trees	– dry
6.1	Old trees	old hardwoods – moist
6.2		old hardwoods – dry
6.3		old conifers – moist
6.4		old conifers – dry
7.1	Hollow deciduous trees	
8.1	Burned forest	
9.1	Rich ground vegetation	– moist
9.2		– dry
10.1	Rock walls	nutrient-rich – moist
10.2		nutrient-rich – dry
10.3		nutrient-poor – moist
10.4		nutrient-poor – dry
11.1	Clay ravines	
12.1	Stream gorges	nutrient-rich
12.2		nutrient-poor

Scientific basis for the sorting of stands and sub-stands with scattered environmental features

Among other things, the environmental inventory project conducted field studies of the distribution of Red List species in forests. The studies show that Red List species usually occur relatively scattered in older forests. Even though there are definite high-density areas of Red List species, these areas only account for a small share of the total occurrence of these species. The environmental features with which the Red List species are associated show a similar distribution.

The conclusions regarding the distribution of environmental features and species imply that it wouldn't be appropriate to base any environmental measures solely on setting aside areas for complete protection. A suitable balance between completely protected areas and areas with environmentally adapted forest operations would result in a more efficient approach to environmental forest management. The inventory's methodology thus accounts for the survey of environmental features of such densities which would require complete protection for a certain period, and of habitat elements that can be taken into consideration in regular forest operations.

Scattered environmental features are also surveyed, since they are ecologically significant when it comes to taking vulnerable habitats into consideration.

The main focus is directed at the survey of high density environmental features in order to secure the protection of specified areas. It is thus also natural to expect that most of the resulting environmental considerations will be concentrated within such areas. The most productive forest areas and mature forests will also receive high priority.

When ranking and selecting areas for consequent environmental measures, focus and resources will primarily be directed at areas with high densities of environmental features.

Nevertheless, scattered environmental features are also surveyed, since they are ecologically significant when it comes to taking vulnerable habitats into consideration. Such information can also be useful when attempting to balance environmental and business considerations. It may often be more efficient and profitable to choose the implementation of

scattered environmental measures or measures associated with non-profitable areas instead of having to set aside economically vital parts of a mature forest. The newly established environmental subsidy scheme is thus based on such an approach. The subsidy scheme is designed to render support to the maintenance of scattered environmental features as well as of areas with a high density of features.

Ranking and Sorting Principles for Habitat Areas (High-density)

1. Snags

Polygons with snags are divided into four habitats, depending on the vegetation / topography (moisture) and observed tree species (nutrient status). Each polygon can consist of up to two habitats, i.e., coniferous (nutrient-poor) and deciduous (nutrient-rich) trees in either a moist or dry environment. Vegetation type and topography (which in turn determines the site's moisture status) are uniform within a single polygon. The inventory guidelines for snags do not include the recording of polygons for dry habitats. Nevertheless, the ranking model does allow the ranking of such habitats.

Snags are ranked / sorted according to different priorities for moist and dry habitats (see Figure 1 – ranking principles).

Habitat no.	Habitat
1.1	Snags, deciduous trees, moist
1.2	Snags, deciduous trees, dry
1.3	Snags, coniferous trees, moist
1.4	Snags, coniferous trees, dry

Ranking according to the occurrence of large trees (> 30 cm diameter)

In order to give preference to habitats containing large snags, all habitats with snags are first sorted by whether or not trees with a diameter of more than 30 cm occur.

As a result, habitats with high densities of small trees cannot rank above areas with a broad range of tree size classes, even if snag density is lower in the latter.

Ranking according to density index

Ranking according to density is done by grouping habitats by their density index. Habitats with the same index, are sorted according to moisture (applies to habitats 1.1 and 1.3).

The density index (Kv) for a habitat is determined by first determining the polygon density for each tree size class (more or less than 30 cm diameter), and finding the corresponding density index in Table 2. The two density indexes are then summed.

Table 2. Density indexes

Density indexes (Kv)

	Number of trees per hectare	
Kv	Diam < 30 cm	Diam > 30 cm
1	1-29	1-9
2	30-49	10-19
3	50-99	20-39
4	>99	>39

Equation:

Kv<30 + Kv>30 = habitat's density index

Sorting by moisture

Habitats with the same ranking according to density index, are sorted by moisture in the following order:

1. habitats with a moist vegetation type and moist topographic location

2. habitats with only a moist topographic location
3. habitats with only a moist vegetation type

Sorting by moisture is only done for *moist habitats (1.1 and 1.3).*

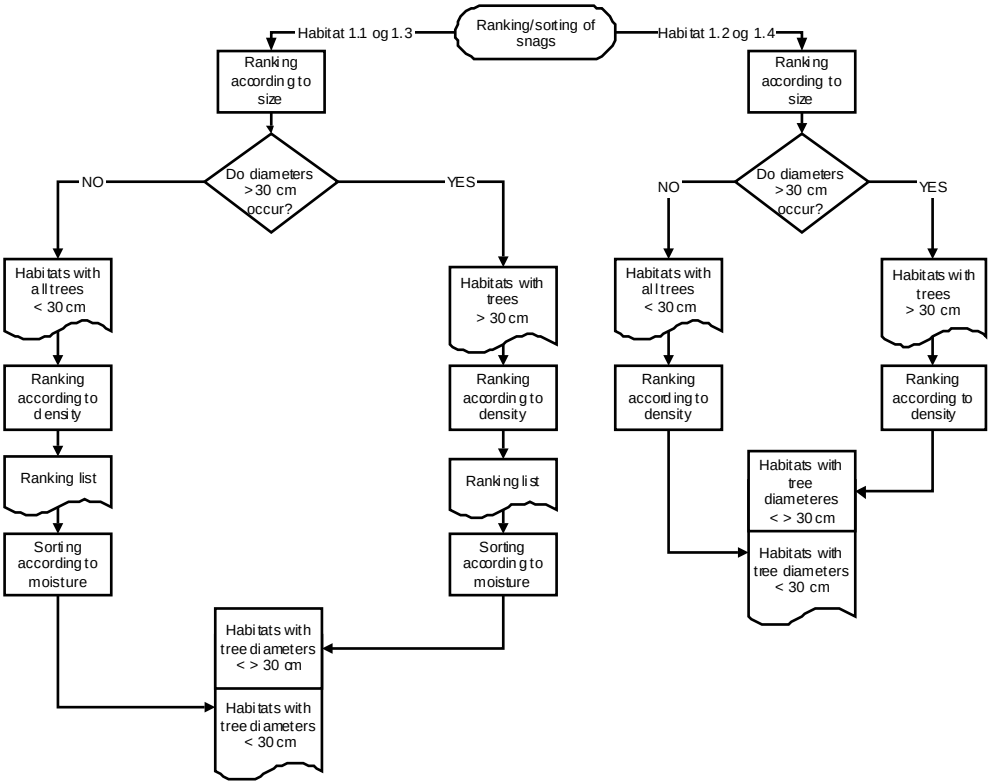

Figure 1. Ranking/sorting principles for snags.

2. Logs

Polygons with logs are divided into four habitats, depending on the vegetation / topography (moisture) and observed tree species (nutrient status). Each polygon can consist of up to two habitats, i.e., coniferous (nutrient-poor) and deciduous (nutrient-rich) trees in either a moist or dry environment. Vegetation type and topography (which in turn determines the site's moisture status) are uniform within a single polygon.

Habitat no.	Habitat
2.1	Logs, deciduous trees, moist
2.2	Logs, deciduous trees, dry
2.3	Logs, coniferous trees, moist
2.4	Logs, coniferous trees, dry

Logs are ranked / sorted according to different priorities for moist and dry habitats (see Figure 2 – ranking principles).

Ranking according to density index

Ranking according to density is done by grouping habitats by their density index. Habitats with the same index, are ranked according to moisture (applies to habitats 2.1 and 2.3).

In addition to size, logs are also sorted by degree of decay, which is weighted as shown in Table 3 (*weighted index for degree of decay)*. This implies that logs with a degree of decay 2 (advanced decay) are given a higher ranking index within each density class.

Table 3. Weighted index for degree of decay

Degree of decay 1	1
Degree of decay 2	2

The density index (Kv) for logs is determined by dividing the total number of the habitat's trees by the polygon's area, and allocating a density index by referring to Table *2 – Density indexes* (see 1. Snags), for each diameter and decay class. The

density indexes are then multiplied with the weighted index for degree of decay, and these figures summed.

Equation:
$Kv<30_{deg.\ dec.1}$ * weighted $index_{deg.\ dec.1}$ + $Kv<30_{deg.\ dec.2}$ * weighted $index_{deg.\ dec.2}$ + $Kv>30_{deg.\ dec.1}$ * weighted $index_{deg.\ dec.1}$ + $Kv>30_{deg.\ dec.2}$ * weighted $index_{deg.\ dec.2}$ = habitat's density index

Sorting by moisture
Habitats with the same ranking according to density index, are sorted by moisture in the following order:

1. habitats with a moist vegetation type and moist topographic location
2. habitats with only a moist vegetation type
3. habitats with only a moist topographic location

Sorting by moisture is only done for *moist habitats (2.1 and 2.3).*

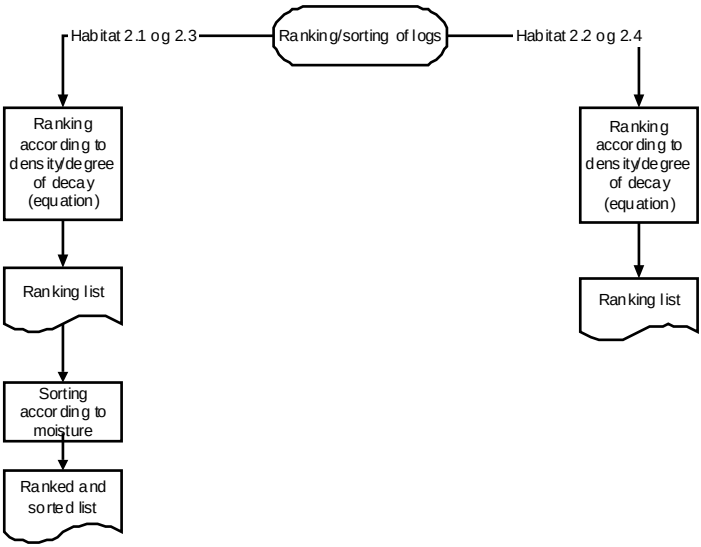

Figure 2. Ranking/sorting principles for logs.

3. Trees with nutrient-rich bark

Ranking parameters for trees with nutrient-rich bark include the occurrence of trees with Lobaria lichens and Norway maple.

Habitat areas with trees with nutrient-rich bark are divided into two habitats, according to the areas vegetation type / topography (moisture).

Ranking parameters for trees with nutrient-rich bark include the occurrence of trees with Lobaria lichens and Norway maple (*Acer platanoides*). Since these can occur separately or together within the same habitat area, there are several orders of priority to consider when ranking within this habitat.

Habitat no.	Habitat
3.1	Trees with nutrient-rich bark, moist
3.2	Trees with nutrient-rich bark, dry

The habitats are ranked according to different principles, see Figure 3 – Ranking principles for trees with nutrient-rich bark.

Ranking according to density index

Habitat areas containing trees with Lobaria lichens shall be ranked before those that only contain Norway maple. Habitat areas with Lobaria lichens are therefore ranked before those without Lobaria lichens. Ranking is done according to density, based on the sum of all trees with Lobaria lichens and Norway maples.

Equation:

(number of trees with Lobarion lichens + number of Norway maples)/area = habitat's density index

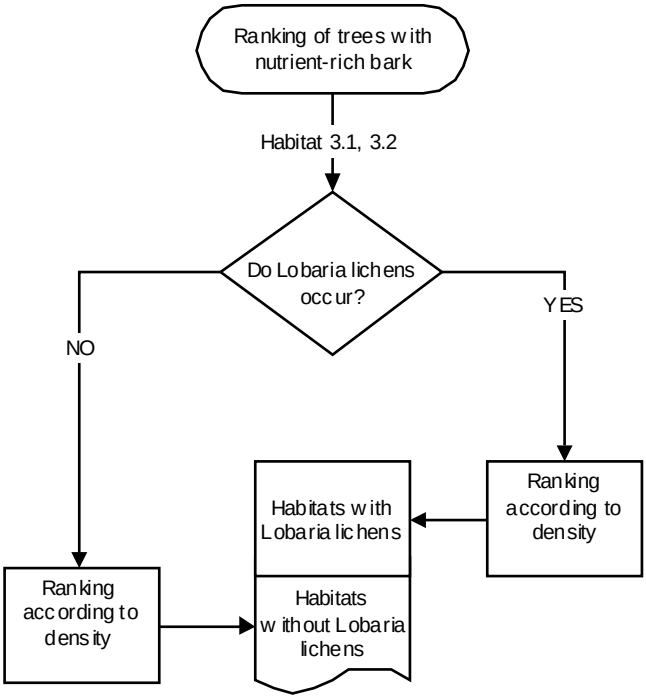

Figure 3. Ranking/sorting principles for trees with nutrient-rich bark.

4.Trees with pendant lichens

Habitat areas with pendant lichens are categorized according to vegetation type / topography (moisture).

Habitat no.	Habitat
4.1	Trees with pendant lichens, moist
4.2	Trees with pendant lichens, dry

The habitats are ranked / sorted according to different principles, see Figure 4 – Ranking / sorting principles for trees with pendant lichens.

Ranking according to density index

The ranking is based on the total number of trees with significant amounts of pendant lichens. Habitats with Red List pendant lichen species (*Usnea longissima* and *Evernia divaricata*) are classified as a separate group, disregarding the habitat's density index.

Equation:

Number of trees with pendant lichens/area = habitat's density index

Sorting by moisture

Habitats with the same ranking according to density index, are sorted by moisture in the following order:

1. habitats with a moist vegetation type and moist topographic location
2. habitats with only a moist topographic location
3. habitats with only a moist vegetation type

Sorting by moisture is only done for *moist habitat (4.1)*.

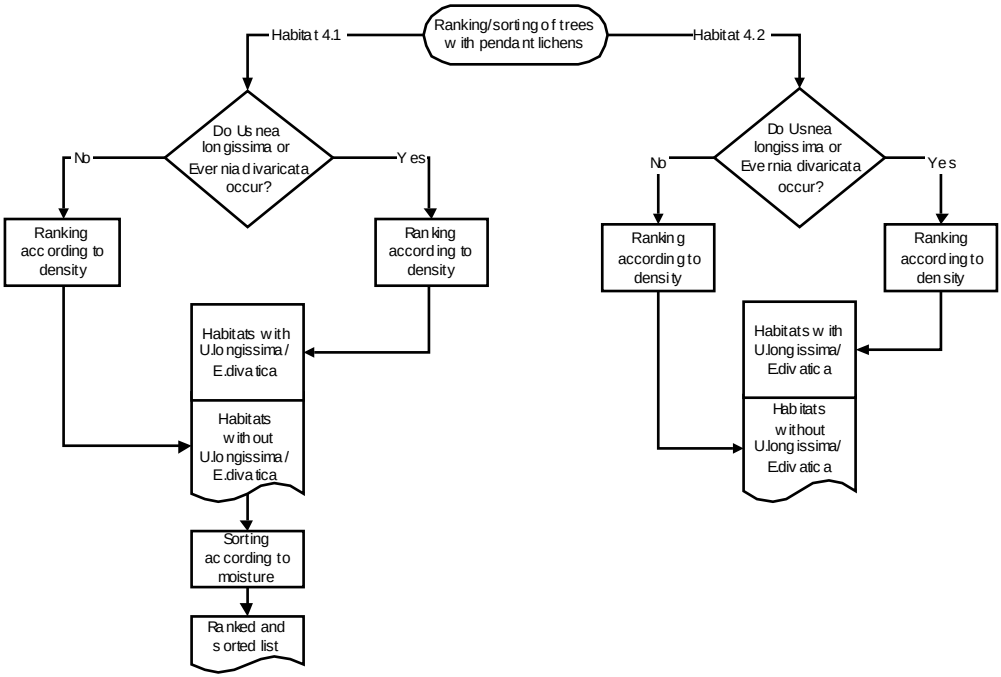

Figure 4. Ranking/sorting principles for trees with pendant lichens.

5. Late successions of deciduous trees

Late successions of deciduous trees are categorized according to vegetation type / topography (moisture).

Habitat no.	Habitat
5.1	Late successions of deciduous trees, moist
5.2	Late successions of deciduous trees, dry

The habitats are ranked according to different principles, see Figure 5 – Ranking principles for late successions of deciduous trees.

Ranking according to density index

The ranking of late successions of deciduous trees is based on the number of trees and the dominant diameter class for each tree species (tsp). Ranking is done according to the dominating average diameter class (Equation 1).

Habitats with the same diameter index are then ranked according to their density index (Equation 2).

Equation 1:

$$(number\ of\ trees_{tsp1} * diam.class_{tsp1} + number\ of\ trees_{tsp2} * diam.class_{tsp2} + number\ of\ trees_{tsp3} * diam.class_{tsp3}) / total\ number\ of\ trees = habitat's\ diameter\ index$$

Equation 2:

$$(number\ of\ trees_{tsp1} + number\ of\ trees_{tsp2} + number\ of\ trees_{tsp3}) / area = habitat's\ density\ index$$

Sorting by moisture

Habitats with the same ranking according to density index, are sorted by moisture in the following order:

1. habitats with a moist vegetation type and moist topographic location
2. habitats with only a moist vegetation type
3. habitats with only a moist topographic location

Sorting by moisture is only done for *moist habitat (5.1).*

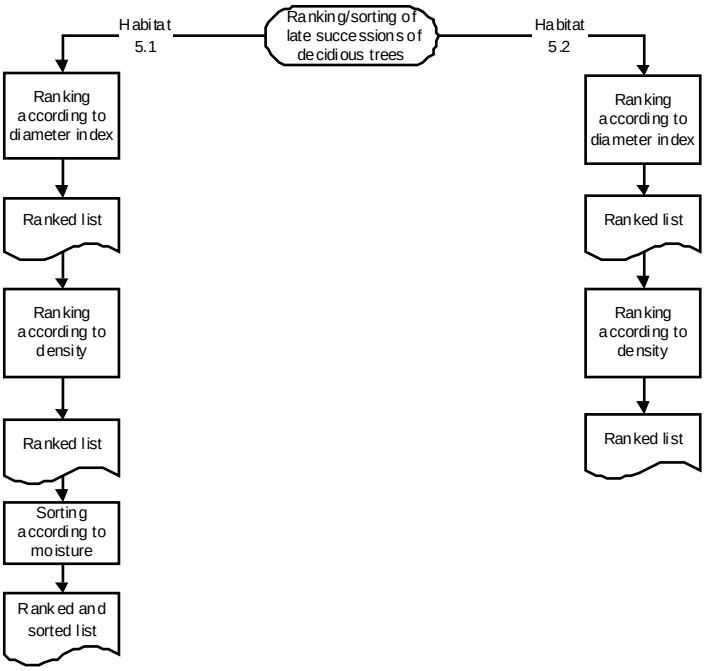

Figure 5. Ranking/sorting principles for late successions of deciduous trees.

6. Old trees

Habitat areas with old trees are divided into four habitats, depending on the vegetation / topography (moisture) and observed tree species (nutrient status). Each polygon can consist of up to two habitats, i.e., coniferous (nutrient-poor) and deciduous (nutrient-rich) trees in either a moist or dry environment. Vegetation type and topography (which in turn determines the site's moisture status) are uniform within a single polygon.

Habitat no.	Habitat
6.1	Old deciduous trees, moist
6.2	Old deciduous trees, dry
6.3	Old coniferous trees, moist
6.4	Old coniferous trees, dry

Old trees are only ranked according to density (of individual tree species) and diameter classes (see Figure 6 – Ranking principles for old trees).

A ranking list is generated for each habitat.

Ranking according to density index

Ranking according to density is done by determining the number of trees per ha for each tree species within each diameter class.

Ranking of old trees is based on the number of trees and the dominating diameter class for each tree species. First, the old tree habitats are ranked according to the dominating average diameter class (Equation 1). Habitats with the same diameter index are then ranked according to their density index (Equation 2).

Equation 1:

$$(number\ of\ trees_{tsp1} * diam.class_{tsp1} + number\ of\ trees_{tsp2} * diam.class_{tsp2} + number\ of\ trees_{tsp3} * diam.class_{tsp3}) / total\ number\ of\ trees = habitat's\ diameter\ index\ (rounded\ to\ the\ nearest\ 0.5)$$

Equation 2:

(number of trees$_{tsp1}$ + number of trees$_{tsp2}$ + number of trees$_{tsp3}$)/area = habitat's density index

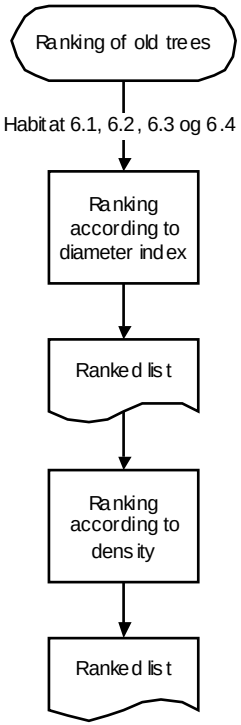

Figure 6. Ranking/sorting principles for old trees.

7. Hollow deciduous trees

Hollow deciduous trees are not recorded as separate polygons, but are rather associated with stands / sub-stands.

Habitat no.	Habitat
7.1	Hollow deciduous trees

The ranking is recorded on a separate list for stands.
The ranking index is determined by the number of hollow deciduous trees.

8. Burned forest

Burned forest areas are specified as polygons, and are shown on a separate list without any further ranking.

Habitat no.	Habitat
8.1	Burned forest

9. Rich ground vegetation

Habitat no.	Habitat
9.1	Rich ground vegetation, moist
9.2	Rich ground vegetation, dry

Ranking according to ranking index

A ranking index is assigned to habitats with rich ground vegetation, in accordance with Table 4 (Highest number represents highest ranking order).

The ranking indexes should be adapted to regional and local conditions.

Table 4. Ranking indexes for rich ground vegetation

Moist vegetation types

Ranking index	**Vegetation type**	**Code** (National Forest Inventory)
1	Grey alder-bird cherry woodland	310
2	Tall-herb woodland	242, 244
3	Wooded pasture	263
3	Alder-ash woodland	460
4	Willow bogs	510
4	Spruce and birch bog forests	524
5	Deciduous and willow bog forests	540

Dry vegetation types

Ranking index	**Vegetation type**	**Code**
1	Low-herb woodland	222, 224
2	Elm-lime forest	450
3	Wooded pasture	262
3	Low-herb oak forest	420
3	Low-herb beech forest	440
3	Calcareous low-herb woodland	210

10. Rock walls

Rock walls are divided into four habitats. However, no specific parameters are recorded that allow a distinct classification. Rock walls are categorized according to their moisture regime, based on vegetation type and their topographical location. They can be classified as separate habitat areas or within a stand / sub-stand. Initially, nutrient-rich rock walls can be found by using bedrock maps, etc.

Rock walls associated with other habitats or stands/sub-stands are shown on the ranking lists together with these.

Habitat no.	Habitat
10.1	Nutrient-rich – moist rock walls
10.2	Nutrient-rich – dry rock walls
10.3	Nutrient-poor – moist rock walls
10.4	Nutrient-poor – dry rock walls

Recorded rock walls that are associated with other habitats or stands / sub-stands are shown on the ranking lists together with these.

11. Clay ravines

Clay ravines are shown as separate polygons, which can include other habitats or stands / sub-stands, or can occur within such objects.

Habitat no.	Habitat
11.1	Clay ravines

Clay ravines are ranked according to the occurrence of other habitats or stands / sub-stands in which environmental features have been recorded.

Ranking order:

1. Clay ravines containing habitat areas (high-density areas) are separately ranked for each occurring environmental feature.

2. Clay ravines containing stands / sub-stands in which environmental features occur.
3. Clay ravines without any other recorded environmental features.

Clay ravines within each of the categories 1 and 2 are ranked according to the percentage of the area covered by other habitat areas (Equation 1) or stands / sub-stands in which environmental features have been recorded (Equation 2).

Equation 1:
*(area of the environmental feature$_n$ / total area of the clay ravine)*100 = percentage of the environmental feature's area (rounded to nearest 25 %)*

Equation 2:
*(area of stand/sub-stand$_n$ / total area of the clay ravine)*100 = percentage of the environmental feature's area (rounded to nearest 25 %)*

Clay ravines with the same percentage of the environmental feature's area are sorted according to their direction, in accordance with the codes in the inventory guidelines. Sorting order: 4 (north), 3 (east), 2 (west) and 1 (south).

12. Stream gorges

Stream gorges can be extensive, and include other habitats or stands / sub-stands, or they can be small and themselves part of such objects. Stream gorges containing one or several types of rich ground vegetation are defined as rich, those without any kind of rich ground vegetation are classified as poor.

Stream gorges containing one or several types of rich ground vegetation are defined as nutrient-rich.

Stream gorges consist of two habitats, and are shown as separate polygons.

Habitat no.	Habitat
12.1	Nutrient-rich stream gorges
12.2	Nutrient-poor stream gorges

Stream gorges are ranked according to the occurrence of other habitats or stands / sub-stands in which environmental features have been recorded.

Ranking order:

1. Stream gorges containing habitat areas (high-density areas) are separately ranked for each occurring environmental feature.
2. Stream gorges containing stands / sub-stands in which environmental features occur.
3. Stream gorges without any other recorded environmental features.

Stream gorges within each of the categories 1 and 2 are ranked according to the percentage of the area covered by other habitat areas (Equation 1) or stands / sub-stands in which environmental features have been recorded (Equation 2).

Equation 1:
*(area of the environmental feature$_n$ / total area of the gorge)*100 = percentage of the environmental feature's area (rounded to nearest 25 %)*

Equation 2:
*(area of stand/sub-stand$_n$ / total area of the gorge)*100 = percentage of the environmental feature's area (rounded to nearest 25 %)*

Stream gorges with the same percentage of the environmental feature's area are sorted according to their direction, in accordance with the codes in the inventory guidelines. Sorting order: 2 (west), 3 (east), 4 (north) and 1 (south).

Sorting Principles for Stands /Sub-stands with Scattered Environmental Features

Scattered environmental features in stands / sub-stands are recorded without being quantified, and for that reason, no ranking indexes are determined. In order to enable the incorporation of data associated with stands / sub-stands in the overall selection of areas requiring environmental consideration, the stands / sub-stands are sorted and categorized according to specified criteria.

1. Snags

Stands / sub-stands containing snags are divided into four groups (see description below), depending on the stand's vegetation type (moisture) and distribution of coniferous and deciduous tree species. The stand / sub-stand habitats are defined as nutrient-rich when the percentage of deciduous trees (by volume) exceeds 60 %. Stands / sub-stands with less deciduous tree species are defined as nutrient-poor.

1. Stands / sub-stands with snags, nutrient-rich, moist habitat
2. Stands / sub-stands with snags, nutrient-rich, dry habitat
3. Stands / sub-stands with snags, nutrient-poor, moist habitat
4. Stands / sub-stands with snags, nutrient-poor, dry habitat

Following this classification, the individual groups are sorted according to the distribution of tree size classes within the stand:

1. <> 30 cm
2. > 30 cm
3. < 30 cm

Each group is additionally sorted by stand area (descending order).

2. Logs

Stands / sub-stands containing logs are divided into four groups (see description below), depending on the stand's vegetation type (moisture) and distribution of coniferous and deciduous tree species. The stand / sub-stand habitats are defined as nutrient-rich when the percentage of deciduous trees (by volume) exceeds 60 %. Stands / sub-stands with less deciduous tree species are defined as nutrient-poor.

1. Stands / sub-stands with logs, nutrient-rich, moist habitat
2. Stands / sub-stands with logs, nutrient-rich, dry habitat
3. Stands / sub-stands with logs, nutrient-poor, moist habitat
4. Stands / sub-stands with logs, nutrient-poor, dry habitat

Following this classification, the individual groups are sorted according to the distribution of tree size classes within the stand:

1. <> 30 cm
2. > 30 cm
3. < 30 cm

Each group is sorted by the degree of decay, i.e., stands / sub-stands containing logs with a decree of decay index 2 rank above those containing logs with a degree of decay index 1. Each group is additionally sorted by stand area (descending order).

3. Trees with nutrient-rich bark

Stands / sub-stands containing trees with nutrient-rich bark are divided into two groups (see description below), depending on the stand's vegetation type (moisture).

1. Trees with nutrient-rich bark, moist
2. Trees with nutrient-rich bark, dry

Within each group, the stands are sorted according to the occurrence of Lobaria lichens and Norway maple:

1. Lobaria lichens *and* Norway maple occur
2. Only Lobaria lichens
3. Only Norway maple

4.Trees with pendant lichens

Stands / sub-stands containing trees with pendant lichens are divided into two groups (see description below), depending on the stand's vegetation type (moisture).

1. Trees with pendant lichens, moist
2. Trees with pendant lichens, dry

Each group is then sorted by stand area (descending order).

6.Old trees

Stands / sub-stands containing old trees are divided into four groups (see description below), depending on the stand's vegetation type (moisture) and distribution of coniferous and deciduous tree species. The stand / sub-stand habitats are defined as nutrient-rich when old deciduous trees occur, otherwise, they are defined as nutrient-poor.

1. Stands / sub-stands with old trees, nutrient-rich, moist habitat
2. Stands / sub-stands with old trees, nutrient-rich, dry habitat
3. Stands / sub-stands with old trees, nutrient-poor, moist habitat
4. Stands / sub-stands with old trees, nutrient-poor, dry habitat

Each group is then sorted by stand area (descending order).

Rock walls, clay ravines and stream gorges are treated in accordance with the guidelines for the ranking / sorting of high-density areas.

Ranking and Selecting Habitat Areas

Each habitat is associated with a stand / sub-stand, either as one or several habitat areas or point features, or as scattered features within a stand. Rational use of the software requires that the observed features are digitized together with available forest data. The recorded environmental features can be presented on a map by using different colours / symbols for each type of habitat. Together with a ranking list, the data can be used to conduct the assessments necessary for the selection of habitat areas and possible entire stands in need of specific protection measures.

Ranking Software

In connection with these guidelines, a programme was developed (in MsAccess 2000), which automatically ranks and sorts the recorded habitats. The programme consists of five parts:

1. *Import* of data from the stand data base SPREL. When importing data, the recorded features are categorized according to moisture and nutrient status.

2. *Ranking and sorting* of each individual habitat. Ranking and sorting are done automatically in accordance with the principles presented in these guidelines. The results are presented as tables.

3. *Export* of the ranked and sorted tables to MsExcel. This routine enables the user to further process the data. The tables can be printed and used together with maps in the selection process.

4. *Registration* of selected habitat areas and scattered occurrences. The results of the selection process can be registered in the Access database. In order to facilitate the presentation of the chosen units (categorized by forest owner), they can also be exported to MsExcel.

5. *Export* of the selected units to SPREL. The results of the selection process shall be implemented in the individual forest owner's forest management plan. The export procedures to SPREL include the transfer of data on the affected area and suggested measures.

Selection

When the processing of data from the environmental inventory is completed, the results are available as lists of high-density habitat areas and stands/sub-stands with scattered environmental features. The lists contain ranked habitats and additional sorting of habitats for which supplementary data has been recorded. The lists of scattered environmental features are also sorted and grouped, so that this information can efficiently contribute to the selection of environmental considerations (scope, localization and type of measures) to be implemented. Based on this information, habitat areas are to be selected in which specific measures are to be implemented, regardless of whether the environmental features occur as high-density areas or as scattered occurrences.

The selection process differs significantly from the survey and ranking of the environmental data. Survey and ranking are mainly done according to clearly defined principles, based on the best of current knowledge. Selection, however, is additionally based on choices between different alternatives in a situation with no 'correct' solution. Different solutions are possible, depending on the chosen approach to the environmental features and varying emphasis on economic, political and personal issues.

The survey is conducted according to documented procedures and shall result in verifiable information. Ranking of the data is to be done in accordance with current expertise about the environmental value of the various recorded features. The selection process will have to take both the protection of important environmental features and the actual effects of the protection measures into consideration.

In the end, selection is the forest owner's responsibility, and cannot be reduced to merely a scientific issue. Selection is rather an issue of priorities based on scientific, economic, policy and personal aspects.

The survey agency should effectively prepare the selection process and enable interested forest owners to participate in the process (perhaps with necessary help from the forest owners' association).

Practical Implementation

Involved parties and their roles

Several stakeholders may be involved in the selection process. It is therefore important to clarify the responsibilities of the various participants.

Forest owner

The individual forest owner is responsible for land and resource management on his / her own property, in accordance with rules and regulations, public priorities and various environmental standards. The selection process must thus take this into consideration, and allow interested forest owners to participate in the process, and have real influence thereupon.

The forest owner makes the final decisions with regard to the scope of environmental considerations in his / her forest. For example, this can be done by presenting an overview of the environmental features found on the property and the selection procedures to the forest owner.

In the actual selection process, the forest owner association / representative, perhaps in cooperation with necessary

scientific expertise, can propose a selection of features / measures, which the forest owner then can confirm or approve for his / her property.

Experience shows that it sometimes may be appropriate to supply expert advice and scientific comments on relevant ecological / biological issues.

Survey agency
The agency that has conducted the survey should also be responsible for data processing, so that those formulating proposals for selection and measures have access to all necessary information (maps and ranking lists). The agency can also give advice regarding the implementation of the survey's results in the forest management plans.

Forest owner association
The forest owner associations act as consultants with regard to the requirements of *Levende Skog* and various certification schemes. In addition, they can often supply expert advice and help forest owners to become involved in the process.

Steering committee
It is now common to involve a local steering committee in forest inventories (as coordinator and decision-maker). It is thus natural that this committee also is involved in the selection process, in order to ensure that it is carried out in accordance with its intentions, and that all parties are given the possibility to voice their interests.

Useful information for the selection process
In addition to the forest and environmental data generated by the project, other information may be a useful supplement in the selection process. Such information may include:
- Regional information from the national forest inventory
- Geological maps
- Nature type maps from municipal inventories (Directorate for Nature Management guidelines)

- Overview of forest reserves
- Species inventories (Red List species)

Planning the selection process

A simple plan for the selection process should be made; this helps to avoid procedural discussions while work is in progress. Based on experience, we recommend the following procedure:

- Agree upon the order of dealing with habitat elements. We recommend to begin with those elements with the highest local priority, starting with habitats which are not to be felled and additionally require a buffer zone. This usually applies to moist habitats.

- The level of ambition for each environmental feature should be discussed and clarified with each individual forest owner, so that he/she can assess the proposed measures on the basis of sufficient information about the effects. This process should be based on all relevant landscape information, and may involve expert advice on which measures are most appropriate in relation to the forest owner's objectives.

- The evaluation of habitat elements should include both high-density areas and stands with scattered occurrences of environmental features.

- For overlapping or adjacent habitats, those with a high ranking that are to be excluded from felling and require a buffer zone should be assessed first.

Selection criteria

Regional conditions

Coastal areas with significant altitudinal variations often cover two or more vegetation regions, which may result in different priorities in the selection process.

Local conditions
Local vegetational or geological conditions may also affect the selection process. When delimiting an area for a survey, large areas may be left out because harvesting is not economically viable. If relevant data on environmental features in such areas are available, the extent of the selected areas can be evaluated in relation to this.

Landscape conditions
The selection process should also assess the spatial distribution of environmental features, e.g., if they are evenly dispersed or occur as «clusters». This assessment should also include the distribution of selected features among the forest owners. Under consideration of the limits presented by the landscape as well as the inventory itself, one should thus aim at an even distribution of selected features.

Documentation
The selection process and its results shall be documented and verifiable. This implies that a detailed journal of all meetings should be kept, in which all decisions and resolutions are explained and documented.

Necessary assessments

The environmental inventories are based on regional habitat assessments. This can be achieved by adapting the inventory's threshold values to the region's characteristics, and by the consequent priorities in the selection process.

In this process, it may be necessary to consider the allocation of areas in need of biodiversity management between individual properties and larger landscape units. Following this assessment, such areas shall be divided among different habitat types. The size of the management areas should be based on such factors as habitat diversity, the extent of the different habitats, as well as their spatial distribution. If an area is small and must be divided among many different types

of habitats, the area of each habitat could become too small to ensure the survival of certain species.

Selecting many small-sized plots instead of fewer larger ones results in a larger buffer zone area, even if the total habitat area is the same. For example, a 0.1 ha habitat surrounded by a 25 m buffer zone results in a total management area of 0.6 ha. The buffer zone thus represents 83 % of the total area. However, a 1 ha habitat surrounded by a buffer zone of 25 m results in a total management area of 2.1 ha. In this case, the buffer zone only represents 52 % of the total area.

The methodology of the environmental inventory project includes the survey of high-density areas and scattered occurrences in stands / sub-stands. The project has shown that both types of environmental features are important for the protection of biodiversity. The following aspects should be considered when choosing between measures aimed at habitat areas or at stands / sub-stands.

A forest owner may have an area considered relevant for biodiversity protection measures, which is classified as a scattered occurrence of environmental features in a stand or sub-stand. In order to make a comparison with a high-density habitat area, the total extent of the environmental feature in question can be compared with the extent of the feature within the habitat area.

Upon deciding whether to implement measures in scattered occurrences instead of in separate habitat areas, one needs to consider that the latter may represent certain qualities which are not found in scattered occurrences.

Upon deciding whether to implement measures in scattered occurrences instead of in separate habitat areas, one needs to consider that the latter may represent certain qualities which are not found in scattered occurrences. For examples, this seems to be the case for trees with nutrient-rich bark.

It may also be necessary to implement measures for a habitat in a certain part of the management area in order to ensure proximity between the objects in focus. This can either be done by allocating a large, continuous area, or a collection of many, smaller objects. In case of the former, this area can consist of high-density habitat areas with stands containing scattered habitats in between.

Many habitats occur in clusters. When the areas for each

habitat are to be designated, landscape ecological considerations may promote the selection of areas with such habitat clusters. Other sections of an inventory area may in turn be chosen to protect clusters of other kinds of habitats.

Implementation in Forest Management Plans

Quality assurance

Before the selected areas, including both high-density areas and scattered occurrences of environmental features, are incorporated into the forest management plans, they must be quality assured. One way of doing this is to check if the data on habitat characteristics are in agreement with forest stand data such as maturity class, site quality, tree species, vegetation type, etc.

Suggesting forest management measures

The aim of selecting certain habitat areas is the conservation of their environmental qualities. A long-term approach must be applied, even if forest management policies are often determined for shorter periods at a time.

The environmental inventory project did not study silvicultural measures, and has therefore not generated new knowledge on silvicultural or other specific environmental considerations.

The suggested measures presented in these guidelines are thus based on general knowledge and practical experience.

Certain moist habitats in ravines, stream gorges, north slopes, bog forests, etc. are best managed by setting aside forest areas, or by only harvesting limited quantities of timber.

In drier habitats, partial cutting and the protection of certain habitat elements or groups of elements may be more appropriate.

The aim of selecting certain habitat areas is the conservation of their environmental qualities.

The implemented measures should secure the continued survival of species within the selected areas containing environmental features. The size of a habitat area required in order to secure satisfactory living conditions varies between species. For some species, a single, large tree is sufficient as a habitat. For example, one large, hollow oak can serve as a stable habitat for many different species, even if there are no other such trees around. Other species, such as lichens living in tree crowns, require a continuously moist habitat as well as a certain minimum area. There is a lack of knowledge regarding species' requirements to habitat size, but in general, small habitats are more vulnerable than larger ones.

For some species, a single, large tree is sufficient as a habitat.

Description of relevant measures:

- *Total protection*
  This implies that no felling operations are carried out in a habitat, and that the forest is allowed to develop freely until new management practice is decided upon.

- *Release cutting*
  The removal of trees and bushes which in the short- or long run can impair or outcompete important environmental features. This mainly includes the felling of spruce in order to release pollards and large trees, as well as the tending of wooded pastures.

- *Partial cutting*
  Maintaining the continuity of the tree layer. The aim of partial cutting is to cut economically mature trees, while at the same time maintaining the long-term continuity of the tree layer. The term 'partial cutting' includes different types of selection felling, thinning and certain types of mountain forest felling of spruce. In the forest management plans, one should use locally familiar terms. Shelterwood felling is not recommended, since it doesn't give the desired continuity of the tree layer. Partial cutting is mainly appropriate for securing continuity in the root and crown layers, for

species growing or living in the humus layer, or that require a stable stand climate. In general, at least 400 trees per hectare should be left standing after felling (spacing of 5 m).

- *Setting aside groups of trees*
  Securing the future supply of large / old trees and dead-wood. «Groups of trees» are defined as groves of up to about 0.2 ha. This measure is mainly relevant on dry and sunny sites, where the species to be protected are associated with habitats that normally are exposed to the sun and wind.

Buffer zones

Buffer zones are necessary on sites which are heavily exposed to the wind and sun after felling. Local conditions such as tree species, forest structure, moisture (topography) and prevailing winds must be taken into consideration. There is insufficient documentation regarding the optimal size of buffer zones, but as a rule of thumb, 25-50 m are sufficient. The size of a buffer zone must also be varied according to how much protection is required (e.g., areas facing south, bordering lakes, etc. require larger buffer zones).

Table 5. Management recommendations for protecting biodiversity in forest habitats

Habitat element	Habitat	Most relevant measures	Use of buffer zone
1. Snags	Deciduous trees – moist	Total protection	Buffer zone ca 25 m
	Deciduous trees – dry	Partial cutting	No buffer zone
	Coniferous trees – moist	Total protection	Buffer zone ca 25 m
	Coniferous trees – dry	Partial cutting	No buffer zone
		Setting aside groups of trees	
2. Logs	Deciduous trees – moist	Total protection	Buffer zone ca 25 m
	Deciduous trees – dry	Partial cutting	No buffer zone
	Coniferous trees – moist	Total protection	Buffer zone ca 25 m
	Coniferous trees – dry	Partial cutting	No buffer zone
		Setting aside groups of trees	
3. Trees with nutrient-rich bark	Moist	Total protection	Buffer zone ca 25 m
	Dry	Partial cutting	No buffer zone
4. Trees with pendant lichens	Moist	Total protection	Buffer zone ca 50 m
	Dry	Partial cutting	No buffer zone
5. Late successions of deciduous trees	Moist	Total protection	No buffer zone
		Release cutting	
	Dry	Total protection	No buffer zone
		Release cutting	
6. Old trees	Deciduous trees – moist	Total protection	No buffer zone
		Release cutting	
	Deciduous trees – dry	Partial cutting	No buffer zone
	Coniferous trees – moist	Total protection	No buffer zone
	Coniferous trees – dry	Partial cutting	No buffer zone
		Setting aside groups of trees	
7. Hollow deciduous trees		Setting aside groups of trees	No buffer zone
		Release cutting	
8. Burned forest		Total protection	No buffer zone
9. Rich ground vegetation	Moist	Partial cutting	No buffer zone
		Release cutting	
	Dry	Partial cutting	No buffer zone
		Release cutting	
10. Rock walls	Nutrient-rich – moist	As for habitats 1 to 9	Buffer zone as for habitats 1 to 9
	Nutrient-rich – dry	As for habitats 1 to 9	Buffer zone as for habitats 1 to 9
	Nutrient-poor – moist	As for habitats 1 to 9	Buffer zone as for habitats 1 to 9
	Nutrient-poor – dry	As for habitats 1 to 9	Buffer zone as for habitats 1 to 9
11. Clay ravines		As for habitats 1 to 9	Buffer zone as for habitats 1 to 9
12. Stream gorges	Nutrient-rich	As for habitats 1 to 9	Buffer zone as for habitats 1 to 9
	Nutrient-poor	As for habitats 1 to 9	Buffer zone as for habitats 1 to 9

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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

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