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Forsmark site investigation

Validation of GIS-maps and inventory of vegetation types in Forsmark

Validation and inventory of marshland, swamp forest, fertile land & woodland

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December 2004

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Abstract

In order to predict the possible outcomes or scenarios, in the event of a leakage from nuclear waste material capsules stored deep underground, the vegetation above the storage facility plays a significant part. The Forsmark area is one of the two considered sites for such facility and has therefore been subjected to extensive research. In 2003 a GIS map for field layer vegetation was constructed from soil, vegetation and wetness data. This map could be used to extrapolate collected data's over a large area. In order to evaluate the accuracy and consistency of this map, a validation project was conducted in the summer of 2004. 32 sites in four different field vegetation types (woodland, fertile land, marshland, and swamp forest) were classified in field and kappa values for these vegetation types were calculated. A vegetation inventory was also conducted to see how much the vegetation composition differs within the same category of land. The results from the validation of the four field classes showed that the map had a high accuracy at marshlands (K = 1.0), an acceptable accuracy at swamp forest (K = 0.67) but a not acceptable accuracy at fertile land and woodland (K=0.30 and K=0.36). Our conclusions are that the definition of these two later classes are inappropriate and diffuse, and the problem could be solved by classifying these areas in a different way. The inventory of the 32 sites showed a great variety of flora in the area of Forsmark. Even in woodland, the field vegetation was often dominated by herbs normally found in groves. The most common vegetation type is though broad grass-type (BRGR).

Contents

1 Introduction

1.1 Background

In order to predict the possible outcomes or scenarios, in the event of a leakage from nuclear waste material capsules stored deep underground, the vegetation above the storage facility plays a significant part. The Forsmark area is one of the two considered sites for such facility and has therefore been subjected to extensive research. It is of importance to be able to quantify both the productivity of the area in terms of carbon assimilation or sequestration as well as the true biomass of the area. Both factors are critical when assessing the results/outcomes of a possible leakage. To be able to apply the information collected over a larger area GIS-maps are used.

GIS-maps are meant to give an indication of the actual field situation and are composed of several layers of, in this case, vegetation. The GIS-maps may not be entirely accurate though, considered that the layers are made from source data that can be misinterpreted /Boresjö Bronge and Wester, 2003/ and also due to the natural dynamics of ecosystems and anthropogenic activities in the area. Natural dynamics may include succession of some kind like for example the re-growth of cultivated areas /Štolcová, 2002; Kennard, 2002/ or late succession of wetlands /Odland and Moral, 2002/. Anthropogenic activities may in turn include the harvesting itself or other kinds of disturbances that may lead to ecological changes.

Temporal factors may thus affect the quality of the maps and it is therefore of importance to verify the accuracy or consistency of the maps to the actual situation on ground if they are to be used to assess the productivity and biomass of the areas in question. Outdated or incorrect maps yield false and unusable information.

The aim of the study was to see how well the present field layer vegetation map for the Forsmark area, which is based on the soil map, constructed by /Lundin et al. 2004/ and modified in /Lindborg (ed.), 2005/, corresponds to reality by estimating a kappa value for each of the four selected field layer vegetation types (woodland, fertile land, marshland, and swamp forest). A vegetation inventory was also conducted to see how much the vegetation composition differs within the same category of land.

2 Material and method

2.1 Site description

The current study took place at the Forsmark site in Östhammar municipality, Uppsala County in Sweden in June 2004. The area is in the hemi boreal zone /Ahti et al. 1968/ and is predominated by conifer evergreens as Scotch Pine, (*Pinus sylvestris*) and Norway Spruce (*Picea abies*). The area is characterized by extensive forestry. Within the conifer dominated areas, smaller surfaces of other vegetation types like marshland, swamp forests and fertile land make a mosaic in the landscape.

2.2 Validation and calculation of kappa

The map, that is used to describe the field and ground layer in the descriptive ecosystem model, is a combination of information from the soil map, the vegetation map, a wetness index and the quaternary deposit map, in the Forsmark area /Lundin et al. 2004/. To see how this map relates to reality, a validation of this map was performed by choosing those vegetation types that were characteristic for the area and important for biomass and NPP estimation. The vegetation types of the GIS-map were then compared to the actual conditions. The chosen vegetation types were: 1) Woodland, 2) Fertile land, 3) Marshland and 4) Swamp forest. Grosslands and agricultural fields were deliberately left out in the study since they are well documented.

Each of the four vegetation types was tested at eight plots (the total number of tested plots were 32). In order to avoid homogeneity in sampling, the plots for each vegetation type were spread as much as possible over the whole area. A GIS-map of the field layer vegetation in the scale 1:32,000 was used for the plotting. Horizontal lines were placed along the map with an interval of 2 cm. The placement of the plots was performed by laying them out at vegetation types that were nearest to each 2 cm line in order to gain as uniformly spread of plots of each vegetation type as possible (Appendix I).

The base of the validation was a previously done definition for each vegetation type:

1. Woodland
    i. Tree layer: more than 30% cover, coniferous trees dominating
    ii. Ground moisture: Dry to fresh
    iii. Boulders and rocks
2. Fertile land
    i. Tree layer: Deciduous trees dominating
    ii. Ground moisture: Fresh to fresh/moist
    iii. No boulders or rocks, previously cultivated or used for agriculture
3. Marshland (including reed)
    i. Tree layer: Less than 30% cover
    ii. Ground moisture: Moist to wet
4. Swamp forest
    i. Tree layer: More than 30% cover
    ii. Ground moisture: Moist to wet, temporally flooded

To decide ground moisture, the field instructions of /Lundin et al. 2002/ was used. The instructions were based on how deep the groundwater was found in the soil, but there was also field instructions for how to classify without instrument. Topografy, soil structure, position in the landscape, visible water and traces of visible water were characters used for determine the moisture level.

A comparison between the GIS-map and the real actual conditions in field were thereafter conducted with a confusion matrix /Kohavi and Provost, 1998; Eklund, 2001/ and the resulting values treated to give the coefficient κ kappa /Cohen, 1960/, which describes the relationship between maps and reality, where 0 is random and 1,0 is total correspondence between map and reality.

The formula used for the calculation is:

$$K = (p_{ii} – q_{ii}) / (p_i – q_{ii})$$

where:

K is Kappa, coefficient of agreement ranging from –1 to +1 and 0 being at random
i is the class index
p_i represents the proportion of charted sites for each class,
p_{ii} represents the proportion of correctly charted sites for each class and
q_{ii} represents the proportion of expected random sites of each class.

Together with the kappa value, the users accuracy- A_i and the producers accuracy- B_i were calculated. A_i is the probability in percent (%) that a randomly chosen point at the map is correct classified and B_i is the probability in percent that a randomly chosen point in field is correct classified on the map.

$$A_i = P_{correct} / P_{map} \times 100$$

$$B_i = P_{correct} / P_{evaluated} \times 100$$

where:

$P_{correct}$ is the number of correct classified sites for class i.

P_{map} is the number of evaluated sites for class i.

$P_{evaluated}$ is the number of evaluated sites for class i found in field study.

2.3 Inventory of vegetation at sites

In field, a circle with a radius of 5 m was used as a representative surface area to define the vegetation of each site. The categories of interest were the bottom layer and field layer.

Each plot was treated by making a thorough inventory of the present vegetation. The material used for the inventory were the books "Den nordiska floran" /Mossberg and Stenberg, 1992./ as well as "Svensk Flora" /Krok et al. 1994/.

Each inventory was then translated into the according field vegetation classification already defined /Lundin et al. 1999/. For method used for translation into defined field vegetation classes see App II. Two tables were constructed to see which field vegetation classes that dominated each vegetation type. One table for the types (woodland etc) found in field, and one for the types defined by the map.

3 Results

3.1 Validation

From the field validation, following classification of the 32 points were made (Table 3-1).

Table 3-1. The columns show the sites at map which have been evaluated and the rows show the actual numbers of sites at each type found in field.

	Woodland	Fertile land	Marshland	Swamp forests	Total
Woodland	6	6	0	0	12
Fertile land	1	3	0	2	6
Marshland	0	0	6	0	6
Swamp forests	0	0	2	6	8
Total	7	9	8	8	32

The calculation of the user accuracy (A_i), the producers accuracy (B_i) and the kappa value for each type was calculated and is shown in Table 3-2. When not all types present on the map were tested, the kappa for the total map could not be calculated.

Table 3-2 Results from validation. Users, and producers accuracy (A_i, B_i) and kappa for each type. (For explanation of p_i, p_{ii} and q_{ii}, see methods.)

	A_i (%)	B_i (%)	p_i	p_{ii}	q_{ii}	kappa
Woodland	85.71	50.00	0.38	0.19	0.08	0.36
Fertile land	33.33	50.00	0.19	0.09	0.05	0.30
Marshland	71.43	100.00	0.19	0.19	0.05	1.00
Swamp forests	75.00	75.00	0.25	0.19	0.06	0.67

3.2 Inventory of vegetation at sites

Total inventory results with species and classification are present in App III-VI.

Table 3-3. Distribution of field vegetation classes based on the Swedish bonitering /Hägglund, 1999/. The vegetation types (woodland etc.) are the vegetation types found in field. Dominating classes in bold text.

	Woodland	Fertile land	Marshland	Swamp forest	Total
HÖUR	1	1	0	2	4
LÖUR	3	3	0	0	6
HÖMR/BLÅ	0	0	0	0	0
LÖRM/BLÅ	1	0	0	0	1
LÖRM/ej BLÅ	0	0	0	0	0
HÖRM/ej BLÅ	0	0	0	0	0
UF	0	0	0	0	0
BRGR	2	1	4	2	9
SMGR	1	1	0	0	2
STA-FRÄ	0	0	2	4	6
BLÅ	3	0	0	0	3
LING	1	0	0	0	1
KRÅK-LJU	0	0	0	0	0
FA-RIS	0	0	0	0	0
Total	12	6	6	8	

Table 3-4. Distribution of field vegetation classes when the vegetation types from the map were used. Dominating classes for each type in bold.

	Woodland	Fertile land	Marshland	Swamp forest	Total
HÖUR	0	1	0	3	4
LÖUR	1	4	0	1	6
HÖMR/BLÅ	0	0	0	0	0
LÖRM/BLÅ	1	0	0	0	1
LÖRM/ej BLÅ	0	0	0	0	0
HÖRM/ej BLÅ	0	0	0	0	0
UF	0	0	0	0	0
BRGR	2	1	4	2	9
SMGR	0	2	0	0	2
STA-FRÄ	0	0	4	2	6
BLÅ	2	1	0	0	3
LING	1	0	0	0	1
KRÅK-LJU	0	0	0	0	0
FA-RIS	0	0	0	0	0
Total	7	9	8	8	

4 Discussion

4.1 Validation

The sites situated in small patches of vegetation, as well as sites situated at the edge of a vegetation field where sometimes wrong classified but vegetation type reported at map started close nearby. This shift between map and reality could of course also have been the case in the large areas of vegetation, but was not discovered. When the GPS used in this study had a precision on approximately 15 m, the classification of the map was considered correct if the vegetation type of interest was less than 15 m from site.

The validation was supposed to be carried out at eight points at each of the four different vegetation types. By mistake, nine sites at the fertile land and only seven at the woodlands were validated and inventoried, but the calculation of kappa, user and producers accuracy should not be affected by this /Eklund, 2001/.

The validation showed that mainly woodlands and fertile lands were mixed up (Table 3-1). The areas of Forsmark are in general rich, with high lime content and the vegetation is therefore not typical for south Swedish forest lands /Boresjö Bronge and Wester, 2003/. The areas are also highly affected by forest cultivation and because of this, the vegetation types of fertile and forested areas are not easy to distinguish. One definition of woodland was that the tree layer cover more than 30% and consists mainly of coniferous trees. The definition of fertile land was almost the same but the tree layer consists mainly of deciduous trees. When a pasture has been planted with spruce or when woodland has been clear cut, these definitions do not represent the vegetation types for more than some years.

The reasons for mistaking swamp forest for marshland could be that the vegetation map was partly based on moistness of the ground. /Lundin et al. 2004/. It could also be an issue of natural succession in wetlands /Odland and Moral, 2002/. The B_i value for marshland was though 100%, which means that all existing marshland are correct classified.

There are no exact rules for how to assess Kappa significance, and it differs between different scientific disciplines. The hardest scale is proposed by /Krippendorff, 1980/, his scale discounts $K < 0.67$, allows tentative conclusions when $0.67 < K < 0.8$ and definite conclusions when $K \geq 0.8$. This scale is the one mostly used when evaluating kappa values /Di Eugenio, 2000/ even if other scales exist and in some studies even kappa values less than 0.6 could be accepted. We consider though the Krippendorff scale as the most appropriate to use in this study.

The kappa value of marshland is 1.0 due to the B_i value of 100% (Table 3-2). For mathematical explanation to this high value, /see Eklund, 2001/.

The kappa value for swamp forest is 0.67, which tangent the lower limit for acceptance as result. If marshland and swamp forest do not differ much in variables of interest (such as biomass production, NPP or nitrogen fixation), this is not a problem and the map is appropriate to use for calculations. If there is a great difference though between swamp forest and marshland for the variable in question, calculations from the map may give misleading results.

The kappa value for fertile land and woodland: 0.30 and 0.36 respectively, are not in the range of acceptable agreement between map and reality. The relevance of these two classes could be questioned with respect to the above mentioned problem with forestry and cultivated land. Forested land including clear cuts with young birches and deciduous forests including wooded pastures would be better and more relevant ways of classify the forested areas of Forsmark.

4.2 Inventory of vegetation at sites

How representative are sites with a radius of 5 m for a vegetation type? When validating a map in field, the site size must correlate in some way to the object on map. The larger the site of observation becomes, precision in validation will suffer and become less than acceptable. Some of the vegetation types were in small patches, not much larger than the actual test site of 5 m radius, so the site size had to be adapted to the smallest plots of observation.

The inventory of the 32 sites showed a great variety of flora in the area of Forsmark. Even in woodland, the field vegetation was often dominated by herbs normally found in groves (Table 3-3, HÖUR and LÖUR). In Table 3-4, a distribution of the field vegetation classes for the vegetation types on the map (woodland etc) was made, in order to see if it had any effect on the distribution of vegetation classes, which vegetation type the map showed (especially if it had any effect on woodland and fertile land). The results show that woodlands on the map were less dominated by HÖUR and LÖUR, but the difference is not very obvious. This is possibly a result from that the map mainly was constructed from the soil map, and on soils classified as fertile land, HÖUR and LÖUR dominated even if coniferous forest grew on the soil. Maybe the map can be used for extrapolation of field vegetation over the whole area of Forsmark, when the field vegetation layer seems to be decided by soil type more than other variables, like vegetation types.

The most common field vegetation class is broad grass-type (BRGR) with species like Calamagróstis arundinácea, Milium effúsum etc. The domination of this field vegetation class is due to the many rich marshlands, but is also a common class in woodlands. Carex and Equisetum-species dominated the nutrient poor marshland (class STA-FRÄ) as well as the swamp forests with high diversity of plants like Pyrola spp, Menyánthes trifoliáta etc (Appendix III–VI).

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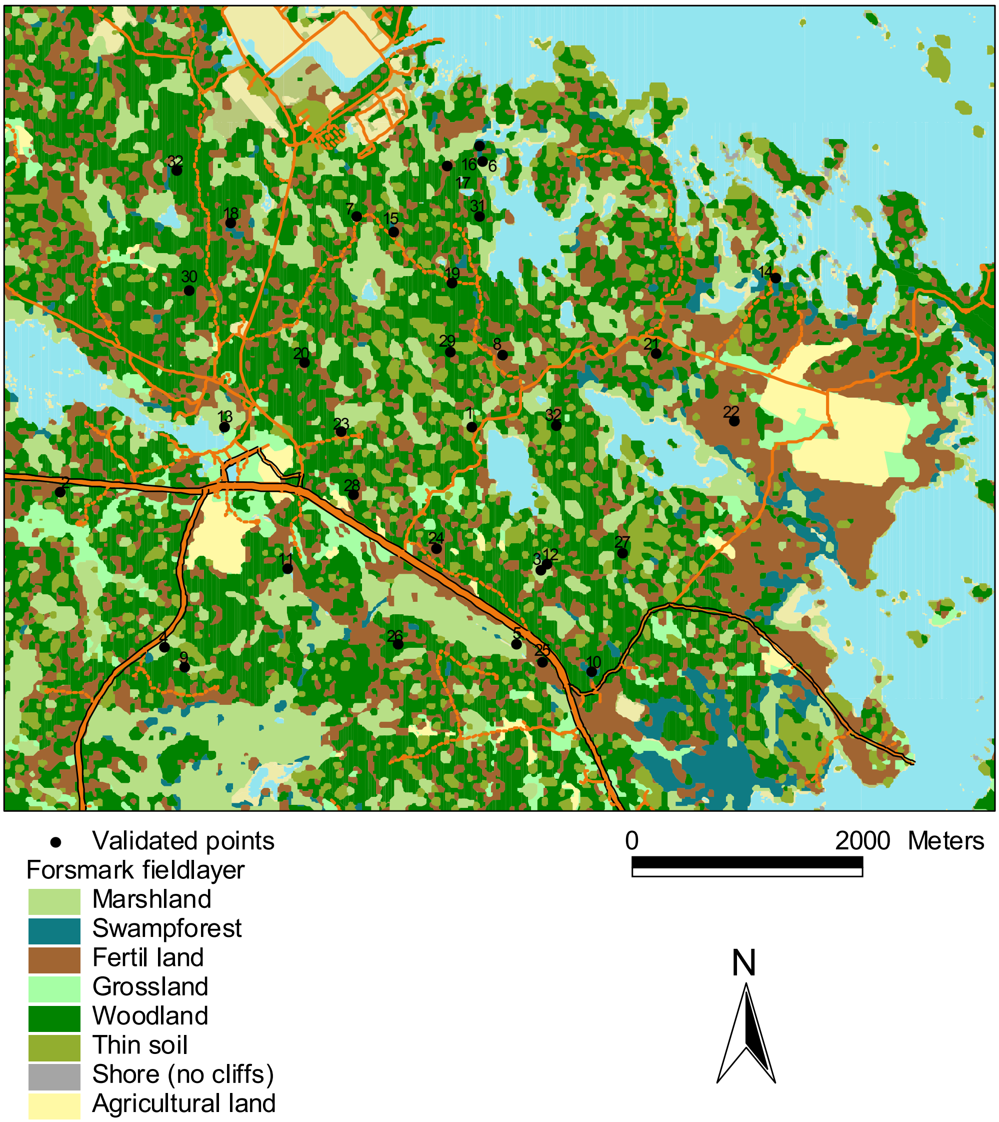
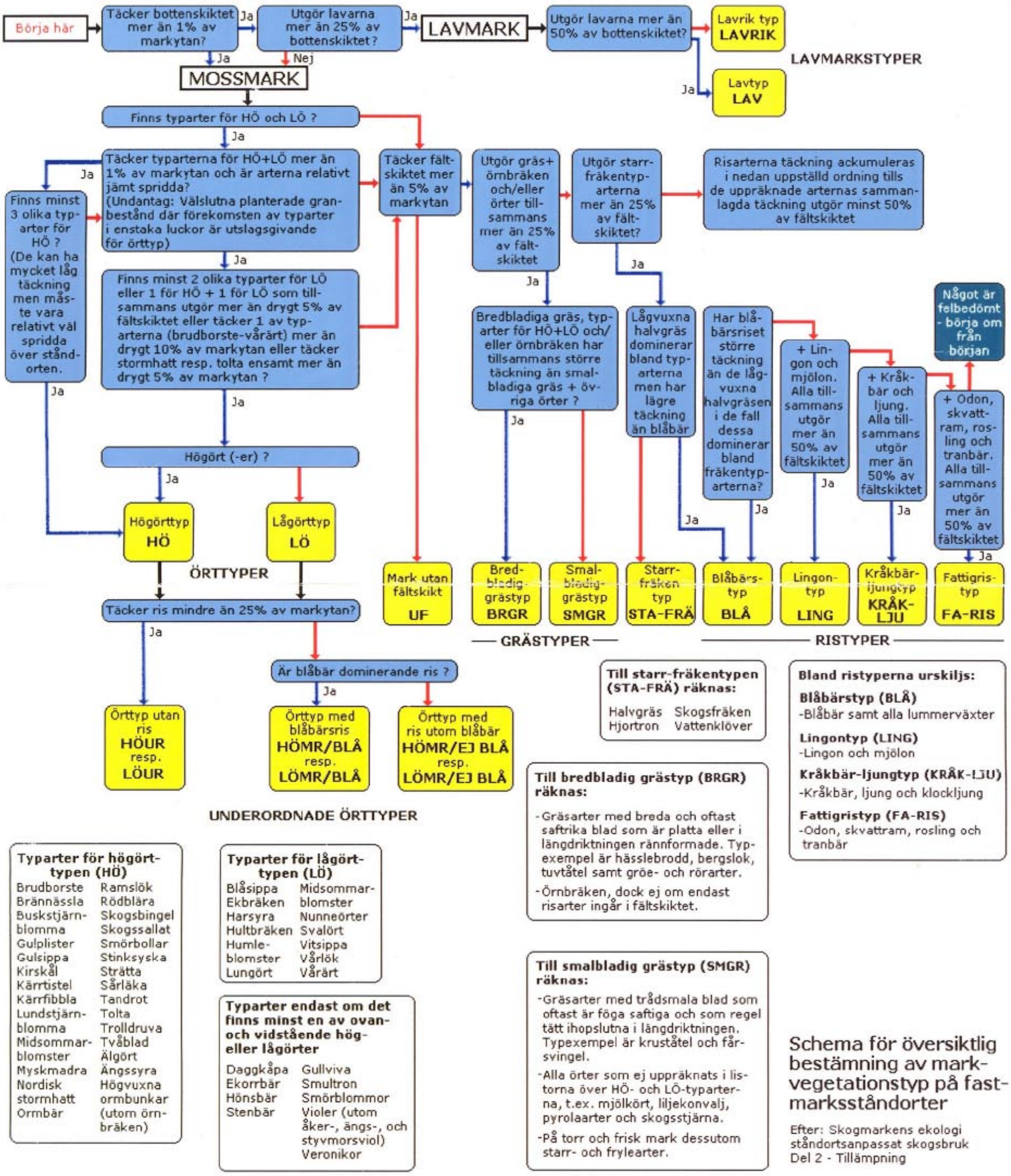
Appendix I

The map shows validated sites in the area of Forsmark in June 2004. Scale of map 1:32,000 /after Hägglund and Lundmark, 1999/



Appendix II

Following scheme was used to classify field vegetation at each site in the area of Forsmark in June 2004



Appendix IIIa

The marshland sites examined in the study. The classification in field was made by the instructions in the methods. All data in the appendix was found in field

Site/ photo	Classification of vegetation types in field	Coordinates	Field vegetation class	Ground moisture	Ground-layer vegetation	Field-layer vegetation
1	marshland	1,631,610 6,697,386	STA-FRÄ	moist	–	*Carex elata*, *Salix sp*.
2	marshland	1,628,067 6,696,787	BRGR	wet	–	Carex vesicaria, Poaceae spp, Filipendula ulmaria, Carex elata, Thalictrum flavum, Aquilegia vulgaris
3	swamp forest	1,632,233 6,696,166	STA-FRÄ	moist-wet	–	Ledum palustre, Menyanthes trifoliata, Vaccinium myrtillus, Myrica gale, Vaccinium oxycoccos, Empetrum nigrum, Equisetum palustre, Eriophorum vaginatum, Carex sp.
4	swamp forest	1,628,954 6,695,438	STA-FRÄ	wet	*Sphagnum sp, Polytrichum sp.*	Menyanthes trifoliata, Moneses uniflora, Equisetum fluviatile, Equisetum palustre, Potentilla erecta, Potentilla palustris, Carex elata, Poaceae spp, Sorbus aucuparia, Salix sp.
5	marshland	1,632,023 6,695,484	BRGR	moist	Mnium undulatum, Mnium sp.	Betula sp, Phragmites australis, Salix sp, Iris pseudacorus, Carex spp, Filipendula ulmaria, Urtica dioica, Alnus sp, Ranunculus sp, Equisetum palustre, Lathyrus palustris, Poaceae spp.
6	marshland	1,631,723 6,699,652	STA-FRÄ	moist-wet	Pleurozium schreberi	Empetrum nigrum, Salix spp, Phragmites australis, Carex elata, Potentilla erecta, Carex flacca, Rubus saxatilis, Picea abies, Pinus sylvestris, Lysimacchia vulgaris, Salix repens, Corallorhiza trifida
7 [1)]	marshland	1,630,604 6,699,162	BRGR	moist	–	Filipendula ulmaria, Melica nutans, Phragmites australis, Rubus idaeus, Betula sp, Poaceae spp, Salix sp, Potentilla erecta.
8	marshland	1,638,860 6,697,984	BRGR	moist	–	Phragmites australis, Filipendula ulmaria, Lysimachia thyrsiflora, Equisetum fluviatile, Poaceae spp, Urtica dioica, Carex elata

[1)] The area is at present moment a cut forest. Our assessment was that the area was a marshland when the original classification was made.

Appendix IIIb

Photos of the marshland sites

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Appendix IVa

The swamp forest sites examined in the study. The classification in field was made by the instructions in the methods. All data in the appendix was found in field

Site/ photo	Classification of vegetation types in field	Coordinates	Field vegetation class	Ground moisture	Ground-layer vegetation	Field-layer vegetation
9	swamp forest	1,629,130 6,695,272	STA-FRÄ	wet	Hylocomium splendens	*Potentilla erecta, Menyanthes trifoliata, Lysimachia vulgaris, Vaccinium vitis-idaea, Ledum palustre, Vaccinium oxycoccos, Equisetum fluviatile, Juniperus communis, Picea abies, Fraxinus excelsior, Carex sp*.
10 [1)]	swamp forest	1,632,649 6,695,233	BRGR	fresh-moist	–	Poa sp, Poaceae spp, Carex sp, Iris pseudacorus, Cardamine pratensis, Ranunculus lingua
11	fertile land	1,630,026 6,696,119	LÖUR	fresh	–	Convallaria majalis, Oxalis acetocella, Anemone nemorosa, Anemone hepatica, Fragaria vesca, Rubus saxatilis, Polygonatum odoratum, Viola sp, Maianthemim bifolium, Trientalis europea
12	swamp forest	1,632,274 6,696,156	HÖUR	moist-wet	Sphagnum sp, Hylocomium splendens, Pleurozium schreberi	Menyanthes trifoliata, Potentilla palustris, Trientalis europea, Equisetum palustre, Dryopteris filix-mas, Vaccinium myrtillus, Carex sp, Ledum palustre
13	swamp forest	1,629,485 6,697,353	HÖUR	moist-wet	–	Carex sp, Iris pseudacorus, Urtica dioica, Equisetum arvense, Filipendula ulmaria, Poaceae spp, Geranium robertianium
14	fertile land	1,634,251 6,698,609	HÖUR	fresh-moist	–	Fraxinus excelsior, Filipendula ulmaria, Anemone nemorosa, Anemone hepatica, Polygonatum odoratum, Geum rivale, Stachys sylvatica, Sorbus aucuparia, Primula veris, Sanicula europaea, Melampyrum sylvaticum, Polygonatum multiflorum
15	swamp forest	1,630,925 6,699,071	STA-FRÄ	moist	Sphagnum sp, Sphagnum fuscum, Polytrichum sp, Pleurozium schreberi	Eriophorum vaginatum, Carex elata, Iris pseudacorus, Potentilla palustris, Vaccinium oxycoccos, Vaccinium myrtillus, Vaccinium vitis-idaea
16	swamp forest	1,631,708 6,699,793	BRGR	moist	Rhytidiadelphus squarrosus	Fraxinus excelsior, Filipendula ulmaria, Cirsium palustre, Phragmites australis, Lysimachia vulgaris, Melica nutans, Potentilla erecta, Potentilla anserina, Cardamine bulbifera, Geum rivale

[1)] At present time a cut forest/spruce plantation. It was quite obvious that the site previously had been a swamp forest.

Appendix IVb

Photos of the swamp forest sites


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Appendix Va

The fertile land sites examined in the study. The classification in field was made by the instructions in the methods. All data in the appendix was found in field

Site/ photo	Classification of vegetation types in field	Coordinates	Field vegetation class	Ground moisture	Ground-layer vegetation	Field-layer vegetation
17	woodland	1,631,427 6,699,625	BLÅ	dry-fresh	Hylocomium splendens, Pleurozium schreberi, Polytrichum sp.	Vaccinium myrtillus, Vaccinium vitis-idaea, Lycopodium annotinum, Convallaria majalis, Trientalis europaea, Paris quadrifolia, Melica nutans, Linnea borealis, Potentilla erecta, Carex sp, Calamagrostis arundinacea, Rosa dumalis, Filipendula ulmaria, Luzula pilosa, Melanpyrum sylvaticum, Rubus saxatilis
18	fertile land	1,629,542 6,699,115	LÖUR	fresh	–	Convallaria majalis, Primula veris, Ribes alpinum, Galium album, Melampyrum nemorosum, Calamagrostis arundinacea, Veronica sp, Fragaria vesca, Alchemilla sp, Geranium sylvaticum, Lathyrus vernus, Lathyrus pratensis, Dentaria bulbifera
19	fertile land	1,631,453 6,698,594	SMGR	dry-fresh	Hylocomium splendens, Dicranum sp, Polytrichum sp, Mnium sp.	Calamagrostis arundinacea, Melica nutans, Lycopodium annotinum, Filipendula ulmaria, Vaccinium vitis-idaea, Potentilla erecta, Lysimachia vulgaris, Equisetum pratense, Poaceae spp.
20	woodland	1,630,158 6,697,907	HÖUR	fresh-moist	Mnium sp, Rhytidiadelphus squarrosus	Equisetum arvense, Tussilago farfara, Rubus saxatilis, Geum rivale, Calamagrostis arundinacea, Dryopteris filix-mas, Vaccinium myrtillus, Filipendula ulmaria, Viola sp, Cardamine sp, Lysimachia thyrsiflora, Iris pseudacorus, Oxalis acetocella, Caltha palustris, Paris quadrifolia
21	woodland	1,633,197 6,697,987	LÖUR	fresh	Ptilium crista-castrensis, Rhytidiadelphus squarrhosus, Pleurozium schreberi	Maianthemum bifolium, Listera ovata, Anemone nemorosa, Viola riviniana, Gymnocarpium dryopteris, Oxalis acetocella, Poaceae spp, Rubus saxatilis, Plathantera bifolia
22	woodland	1,633,882 6,697,394	SMGR	fresh	Pleurozium schreberi, Hylocomium splendens, Dicranum sp.	Convallaria majalis, Maianthemum bifolium, Melampyrum sylvestris, Trientalis europaea, Anemone nemorosa, Calamagrostis arundinacea, Dryopteris filix-mas

23	woodland	1,630,499 6,697,299	LÖUR	dry-fresh	Pleurozium schreberi, Rhytidiadelphus squarrosus, Mnium sp.	Oxalis acetocella, Tussilago farfara, Rubus idaeus, Urtica dioica, Anemone nemorosa, Sorbus aucuparia, Silene dioica, Alchemilla sp, Taraxacum sp, Mycelis muralis, Geranium robertianium, Festuca sp, Galium sp, Fragaria vesca, Dryopteris filix-mas, Luzula multiflora, Cerastium sp, Vicia sepium
24	woodland	1,631,331 6,696,307	BRGR	fresh	Hylocomium splendens, Rhytidiadelphus squarrosus, Pleurozium schreberi	Sorbus aucuparia, Linnea borealis, Pteridium aqulinium, Calamagrostris arundinacea, Vaccinium myrtillus, Trientalis europea, Paris quadrifolia, Maianthemum bifolium, Anemone nemorosa, Viola rivinaria, Convallaria majalis, Luzula pilosa, Melica nutans, Oxalis acetocella, Rubus saxatilis, Gymnocarpium dryopteris
25	fertile land	1,632,239 6,695,335	LÖUR	fresh	Rhytidiadelphus squarrosus, Pleurozium schreberi	Melanpyrum sylvaticum, Convallaria majalis, Pteridium aquilinum, Corylus avellana, Poa nemoralis, Rubus saxatilis, Paris quadrifolia, Betula sp, Verónica sp, Calamagrostis arundinacea, Vicia sepium, Geranium sylvaticum, Anthriscus sylvestris, Viola sp, Melica nutans, Anemona nemorosa, Anemone hepatica, Maianthemum bifolium, Lonicera xylosteum

Appendix Vb

Photos of the fertile land sites

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Appendix VIa

The woodland sites examined in the study. The classification in field was made by the instructions in the methods. All data in the appendix was found in field

Site/ photo	Classification of vegetation types in field	Coordinates	Field vegetation class	Ground moisture	Ground-layer vegetation	Field-layer vegetation
26	fertile land	1,630,972 6,695,459	BRGR	fresh	–	Convallaria majalis, Anemone nemorosa, Maianthemum bifolium, Paris quadrifolia, Vaccinium myrtillus, Potentilla erecta, Oxalis acetocella, Dryopteris filix-mas, Rubus saxatilis, Gymnocarpium dryopteris, Equisetum arvense, Poaceae spp.
27 [1)]	woodland	1,632,937 6,696,265	BLÅ	dry-fresh	Rhytidiadelphus squarrosus, Pleurozium schreberi, Dicranum undulatum, Polytrichum sp.	Calamagrostis arundinacea, Festuca sp, Melampyrum sylvaticum, Vaccinium myrtillus, Vaccinium vitis-idaea, Luzula pilosa
28	woodland	1,630,592 6,696,765	LÖUR	fresh	Hylocomium splendens, Dicranum undulatum, Pleurozium schreberi, Rhytidiadelphus squarrosus, Mnium undulatum	Picea abies, Betula sp, Sorbus aucuparia, Acer platanoides, Anemona nemorosa, Anemone hepatica, Ribes alpinum, Rubus saxatilis, Paris quadrifolia, Lonicera xylosteum, Viola rivinaria, Calamagrostis arundinacea, Vaccinium myrtillus, Lathyrus linifolius
29	woodland	1,631,420 6,698,011	LÖMR/ BLÅ	dry-fresh	Dicranum sp, Hylocomium splendens, Pleurozium schreberi	Vaccinium myrtillus, Equisetum sylvaticum, Dryopteris filix-mas, Tussilago farfara, Viola sp, Pyrola sp, Melampyrum sylvaticum, Anemone nemorosa, Paris quadrifolia, Potentilla erecta, Linnea borealis, Sorbus aucuparia, Pteridium aquilinium, Oxalis acetocella, Fragaria vesca, Poaceae spp, Listera ovata, Melica nutans
30 [2)]	woodland	1,629,184 6,698,573	BRGR	dry	Pleurozium schreberi	Filipendula ulmaria, Ribes alpinum, Equisetum arvense, Poa sp, Veronica sp, Melica nutans, Calamagrostis arundinacea, Oxalis acetocella, Vaccinium myrtillus, Maianthemum bifolium
31	woodland	1,631,691 6,699,181	BLÅ	dry-fresh	Hylocomium splendens, Ptilium crista-castrensis Dicranum sp. Rhytiadelphus squarrosus	Vaccinium myrtillus, Pteridium aquilinium, Luzula pilosa, Dryopteris carthusiana, Linnea borealis, Sorbus aucuparia, Melanpyrum sylvaticum, Oxalis acetosella

32	woodland	1,629,062 6,699,574	LING	dry	Rhytidiadelphus squarrosus, Hylocomium splendens, Pleurozium schreberi, Dicranum sp.	Vaccinium vitis-idaea, Juniperus communis, Ribes alpinum, Linnea borealis, Calamagrostis arundinacea, Luzula multiflora, Polypodium vulgare

[1)] The site was a small, open area surrounded by a rather big woodland area. We therefore decided to classify the site as woodland.

[2)] The site was a spruce plantation surrounded by woodland, making the classification as woodland.

Appendix VIb

Photos of the woodland sites

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