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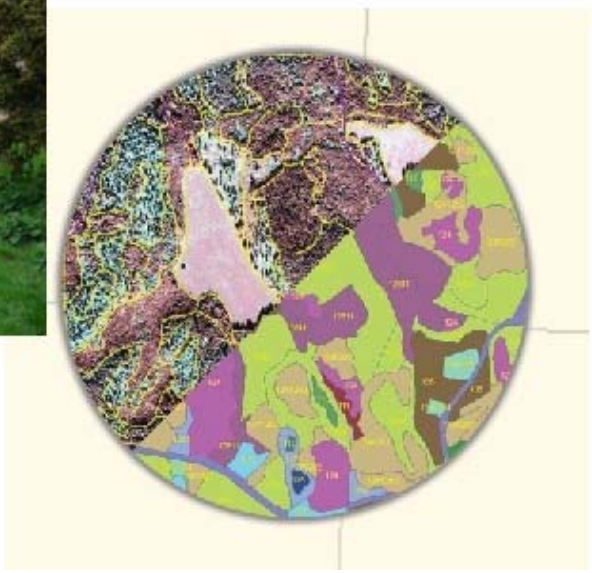

Photo: Anna Allard

Anna Allard

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Introduction

The European Biodiversity Observation Network (EBONE) has run since 2007 and has a long list of member countries or partners in the project (Bunce et al, 2008). Personnel at the Swedish University of Agriculture (SLU) in Umea and Uppsala, Sweden and the Swedish Environmental Protection Agency acts as the representatives from Sweden.

EBONE is a project under the European framework program FP7. The main aim is the development of a cost effective system of biodiversity data collection at regional, national and European levels. Specifically this means that the project tries to develop a coherent system for biodiversity data collection that can be used for comparable assessments across country borders. This project initiates common approaches and harmonisation of data observations from both field and different types of remote sensing.

The official objective of the project is:

1. The provision of a sound scientific basis for the production of statistical estimates of stock and change of key indicators that can then be interpreted by policy makers responding to EU Directives regarding threatened ecosystems and species;

2. The development of a system for estimating past change but also for forecasting and testing policy options and designing mitigating management strategies for threatened ecosystems and species.

This is elaborated in the following working objectives: 1) The elaboration of a monitoring concept including common indicators for biodiversity, 2) The stratification of Europe and other regions involved for monitoring purposes, 3) Development and testing of standard field–site observations and database management, 4) Intercalibration of field data with remotely sensed earth observation data and 5) Development of a cost effective framework for European and world-wide biodiversity.

To meet these objectives the EBONE project is organized in 10 work packages which are described in figure 1, the figure is taken from the EBONE project. For further details about the specific work made in the different packages I refer to the EBONE homepage (http://www.ebone.wur.nl/UK/). Personnel at SLU are involved in different work packages.

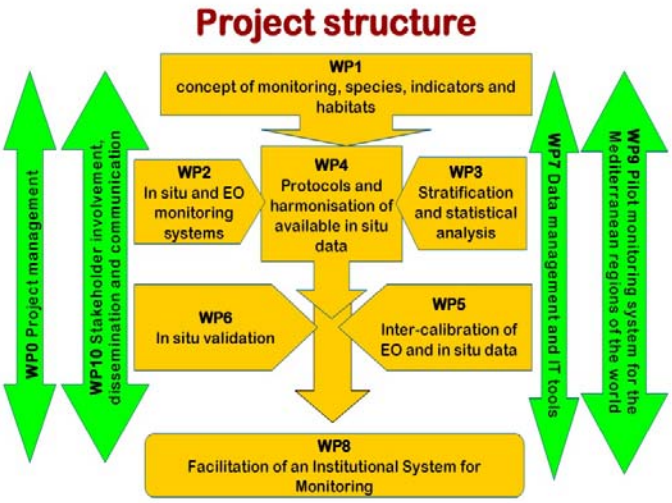

Figure 1. The structure of the 10 work packages of the EBONE project, as can be seen also on the homepage, http://www.ebone.wur.nl/UK/.

The work described in this report deals with one of the tasks in work package 5. The task is for each country to try setting up some areas of 100 km x 100 km, and within them make an inventory of a number of sample units, squares of 1 x 1 km, according to the classification scheme chosen by the project. The larger areas should represent both areas for ecological research and also be representative of biogeographical zones (Jongman et al. 2006, Metzger et al. 2005) occurring in the country. These areas often coincide with the, so called, Long Term Ecosystem Research (LTER) sites. In Sweden, no such areas had been designated, so three have been created for this project, see the chapter LTER sites for Sweden.

In Sweden, there is already a national monitoring programme running since 2003, the NILS programme (Ståhl et al, in press), monitoring the prerequisites for biological diversity. The sample units of 1 x 1 km were fitting for the EBONE. As the programme monitors the entire area in detail, using infrared aerial photos in stereo, the most fitting way of reporting to the EBONE, was to convert the gathered information into the EBONE classification, rather than doing the whole inventory anew. The way of using the stereo images, with a very detailed level of spatial resolution and thus gather detailed data on the objects monitored with biological, geological and geomorphological structures and texture means that several of the objectives of the EBONE were possible to combine.

As the NILS programme works with a large number of variables and subclasses, instead of a ready-made classification system it is possible, with a few adjustments, to convert them into the classification system. This report describes how it was made and how further work can be used for the different sublevels of the General Habitat Categories, used by the EBONE project.

General Habitat Categories

The description of the General Habitat Categories is largely taken from the website of the EBONE project (http://www.ebone.wur.nl/UK/Project+background/Habitat+Monitoring/) and is further described in Bunce et al. (2010, 2008, 2005). Most of the work was being done, when a new handbook was published, in 2010. The new handbook contains a sixth superlevel, terrestrial, dealing with naturally occurring bare substrate. It also contains more combination codes. These new categories are not converted in this current work, but how to convert into them is mentioned in the text. The bare substrate polygons in the NILS data is currently dealt with within the super category called "Sparsely vegetated". The categories were developed in the BioHab project, which was a concerted action of European fifth framework program, to construct a framework for the coordination of biodiversity and habitats (Bunce 2005).

When recording habitats and biodiversity at the landscape level, the difficulty has always been in reconciling the observed complexity of points, lines and patches with recognizable categories that can be consistently and repeatedly recorded in the field and then converted into national and regional estimates. It is therefore necessary to link the detailed records to a strategic framework. Monitoring and surveillance also have to be integrated spatially and temporally with other data sources. This approach enables the landscape ecological resources of the continent to be determined and, because it is based on plant life forms which are applicable throughout the world, further categories could therefore be developed for other continents.

Throughout the world there are many products at a strategic scale derived from satellite imagery, but usually with no link to in situ data. Regional landscape ecological studies are more common, and whilst there had been successful development of methods for broad scale assessment, a critical limitation can be that field based methods many times has proved to be inconsistent.

The basis of the General Habitat Categories (GHC) is the classification of plant Life Forms produced by the Danish botanist Raunkiaer early in the 20th century. These Life Forms e.g. annuals or trees, transcend species and enable the consistent recording of habitats with comparable structures within contrasting biogeographical zones that nevertheless have similar habitat structures. They are based on the scientific hypothesis that habitat structure is related to the environment and therefore will correspond closely to phytosociological classes at a high level. For example, temperate grassland has comparable structures through the world but has different names e.g. veld, steppe, pampa or grass-savannah. Below the first tier of five super-categories, all possible combinations of Life Forms are included, even though some of them may be rare. This has provided a statistical rule for determining the number of GHC's.

The General Habitat Categories cover the pan-European region (except Turkey) with 130 GHC's derived from 16 Life Forms (LF's). The field testing across the major environmental zones has shown that no other significant areas of other Life Forms occur although small patches below the mappable area may be present. However, generalizations have been made, e.g. for tall succulents, which would need to be expanded for extension into a world biome system.

Variation within a General Habitat Category can be expressed by environmental and global qualifiers, which are combinations of soil humidity, nutrient status, acidity and other habitat characteristics. Important additional information is given by adding codes from predefined lists of site and management qualifiers.

The principal reason for the GHC's is that they enable the primary decision on the habitat category actually to be made in the field without the necessity of subsequent data analysis. However, the latter are necessary for many objectives; e.g., relationships with drivers; and because the data are disaggregated, they can be used for multiple objectives. The detailed rules provided for GHC's mean that they can act as the lowest common denominator to link existing habitats recorded in detailed studies of biodiversity. They could also be used as the basis to link other sources of data essential for defining and monitoring biodiversity e.g. phytosociology, birds and butterflies.

The definitions below are based on the practical experience of the GB Countryside Survey (see http://www.countrysidesurvey.org.uk/) adapted for Europe on the basis of workshops.

1 Urban / Constructed

The urban categories have aggregated life forms to form the second tier, e.g. herbaceous includes all herbaceous life forms e.g. caespitose, hemicryptophytes and therophytes.

The term urban applies to technically "urban" or "built-up" land, within the boundary of the land functionally related to buildings, but also refers to parks and recreation areas. It is recognised that the term is not based on life forms, but is a land-use division. For example, two grasslands that are identical in terms of life forms and species may be in recreational use around an industrial building or in agricultural use and grazed by animals.

The definition of urban and constructed codes land covers "elements associated with built structures and routes of communication. Elements which are immediately adjacent to an urban element are not to be recorded, except for roads".

Land is defined as urban, when it "is an area of ground that is associated with a building and which has a use linked to that building e.g. garden".

1.1 Urban Artificial (URB/ART): This category includes all built up land that is covered in buildings, tarmac, concrete or other artificial material. Street lights, electric pylons and telephone poles are not recorded.

1.2 Urban Non-vegetated (URB/NON): This category includes all non-vegetated land that is within an urban boundary, whether a construction e.g. a fence as an arbitrary boundary e.g. around a quarry. Mostly these categories are the result of urban activity rather than agriculture e.g. quarries, excavation sites and non-tarmac car parks, but water bodies in urban areas are also included here with appropriate qualifiers.

1.3 Urban Vegetables (URB/VEG): This category includes land that is under vegetables and/or fruit trees within an urban area and includes, for example, allotments. These categories will rarely form over 400 m2 as a pure category and will mainly be recorded as combinations.
1.4 Urban Herbaceous (URB/GRA): This category includes land that is within the urban definition and covers less than 30% woody vegetation. This will include mainly grass e.g. playing fields, lawns and recreation areas, but also includes other herbaceous life forms.
1.5 Urban Woody (URB/TRE): This category includes land that is over 30% tree/shrub habitats as defined by the description of urban above. It may form an MME around large houses, but will often be recorded as combinations. Percentages below 30% are not recorded as separate GHC's.

2 Cultivated

Crops are mainly the product of plant breeding, but also of native species such as walnut. Wild species collected from semi-natural vegetation are excluded. The individual crops are recorded in the same way as plant species in field

2.1 Cultivated bare ground (CUL/SPA): elements with no crops planted or less than 30% cover of vegetation, including volunteers (self-seeded crop plants). Includes therefore only bare fallow or recently ploughed land which otherwise is recorded as a qualifier (Section 3.4) together with appropriate GHC. This code should only be used if the element has no woody crops.
2.2 Cultivated herbaceous crop (CUL/CRO): includes both annual e.g. barley and sunflowers and perennials, e.g. lucerne and strawberries. Also includes crops that are technically bulbs e.g. daffodils.
2.3 Cultivated woody crops (CUL/WOC): includes all elements with trees or shrubs, using the definition provided in 3.1.5, e.g. orchards, vineyards and olive groves. Cover cannot be used as a criterion because of pruning. Therefore the rule is that there should be at least 20 trees/shrubs per ha, otherwise the scattered tree code can be used. The names of crops, both English and Latin are given in section 3.5.1.2 Any vegetation cover over 30% should be recorded with appropriate life forms in field five.

3 Sparsely vegetated

Elements which have less than 30% cover of vegetation, excluding saxicolous, lichens and bryophytes. Percentage cover estimates should be made of the entire surface of the element regardless of slope.

3.1 Sea (SEA): sea below mean low water mark.
3.2 Tidal (TID): coastal platforms/sediments between mean low water mark and mean high water mark i.e. the main tidal zone.
3.3 Aquatic (AQU): permanent water bodies, whether rivers, canals, lakes or ponds, with less than 30% cover, otherwise use LF's.
3.4 Terrestrial (TER): naturally occurring bare ground whether of rock, soft material or peat. Recorded with appropriate qualifiers.
3.5 Ice/snow (ICE): permanent ice/snow.

4 Herbaceous

Examples of widespread species with short descriptions of all the following LF's are given in Annex 1 of the BioHab Handbook (Bunce et al. 2010, 2005).

4.1 Submerged hydrophytes (SHY): plants that grow in aquatic conditions the whole plant in water. This category includes marine species and floating species which overwinter below the surface. Excludes aquatic bryophytes.
4.2 Emergent hydrophytes (EHY): plants that grow in aquatic conditions with the main plant above water.
4.3 Helophytes (HEL): plants that grow in waterlogged conditions
4.4 Leafy hemicryptophytes (LHE): broad leaved herbaceous species, sometimes termed forbs.
4.5 Caespitose hemicryptophytes (CHE): perennial monocotyledonous grasses and sedges.
4.6 Therophytes (THE): annual plants that survive during the unfavourable season as seeds.
4.7 Succulent chamaephytes (SUC): with succulent leaves
4.8 Geophytes (GEO): plants with buds below the soil surface
4.9 Cryptogams (CRY): non saxicolous bryophytes and lichens. Includes aquatic bryophytes, e.g. Sphagna and Racomitrium lanuginosum which is not saxicolous
4.10 Herbaceous chamaephytes (HCH): with non succulent leaves and not shrubby form.

5 Shrubs and trees

Most of the following are woody – the term usually used in habitat classifications - but some chamaephytes e.g. Phagnalon spp., Artemisia spp. and Asparagus spp. do not have secondary ligneous woody thickening in strict botanical terminology. However these genera have a shrubby form and have perennating buds above ground level. Height is therefore the only consistent arbiter. The woody trees and shrubs refer to individual plants and life forms. In the landscape groups of trees and shrubs combine to form forest and scrub habitats.

5.1 Dwarf chamaephytes (DCH): dwarf shrubs below 0.05 m e.g. Dryas octopetala, Salix herbacea.
5.2 Shrubby chamaephytes (SCH): undershrubs 0.05-0.3 m. e.g. Thymus vulgaris, Lavendula stoechas
5.3 Low phanerophytes (LPH): low shrubs, buds between 0.30-0.6 m, e.g. Myrica gale, Betula nana
5.4 Mid phanerophytes (MPH): mid shrubs, buds between 0.6-2.0 m, e.g. Pistacia lentiscus, Cornus mas
5.5 Tall phanerophytes (TPH): tall shrubs, buds between 2.0-5.0 m, e.g. Salix cinerea, Corylus avellana
5.6 Forest phanerophytes (FPH): trees over 5.0 m, e.g. Quercus robur, Fagus sylvatica

The following life forms apply to the six height categories with over 70% being a single category and 40-60% being combinations. The different height categories can consist of the following five types of woody vegetation, again with over 70% being a single category and 40-60% being combinations. The cover is recorded in 10-percent steps, and so is for example all cover between 30-39, recorded as 30.

1. **Winter deciduous (DEC)**: e.g. Quercus robur, Fraxinus excelsior
2. **Evergreen (EVR)**: Quercus ilex, Laurus nobilis
3. **Conifers (CON)**: Pinus nigra., Juniperus communis.
4. **Non-leafy evergreen (NLE)**: e.g. Sarothamnus scoparia, Ulex europaeus.
5. **Summer deciduous and/or spiny cushion (SPI)**: Sarcopotherium spinosum, Astragalus massiliensis

Involvement from SLU

The work from the University for Agricultural Sciences (SLU), outside the scope of this report, involves other tasks such as a poststratification procedure of satellite data, with classification enhancement from the results of the converted NILS inventory data (Nilsson et al. unpubl.), harmonisation of field computers for data gathering and to work in WP 7, to assimilate the data into a European database. Some work is also done in WP 1, and will be performed in WP: s 8 and 10.

The NILS Programme

The NILS programme started in 2003 as an answer to the demands of monitoring information for the Swedish Environmental Protection Agency. NILS includes structural and functional attributes of different spatial and temporal scales and gathers environmental data in a strategic sample scheme nationwide. The layout consists of 631 permanent squares in 10 different strata, based on the regions in the rural statistics and the biogeographical regions (Statistics Sweden 2001, von Sydow 1988) and during five years all are inventoried in a revolving system. The permanent squares are rather big, 5*5 km, where different inventories are carried out and they also work as the landscape context to the inner square of 1*1 km where the detailed biodiversity data is gathered.

The programme conducts two parallel inventories, one in the field and one mapping the area using colour infrared aerial photos. Each inner square is inventoried in two ways, both as a field inventory (12 plots per square) and in aerial photos (entire square). The design was selected so that data could be captured at different geographical scales and the sampling unit consists of the following parts (Fig. 2). The aerial photos provide important information on landscape composition and the extent of land cover types (Skånes 1996, Allard 2003, Ihse 2007). The combination of all levels is very useful for monitoring purposes (e.g. Bunce et al. 2008).

The strategy is to inventory a set of variables, even when using the aerial photos (156 variables and subclasses in the aerial inventory). This very choice makes the programme compatible with a multitude of other inventories. It also makes it possible to extract variables for certain purposes, or to meet demands from different governing authorities. The aerial photo inventory is made in stereo models with digital images, using 0.5 m resolution in colour infrared which enables assessment of different vegetation and of different coverage, and also of the height of elements or even single trees and bushes. The view from above also makes it possible to distinguish between patterns, both in the different growing layers and in the geomorphology of the land. The design of the variable system is described in English, in Allard et al. (2003). The different variables and subclasses used, and not used, for this current work are summarised in appendix 1.

Data from NILS is used in many constellations in Sweden, examples are follow-up on the Habitats Directive for Europe, national reporting on small biotopes in the rural landscape, follow-up on a programme for inventory of valuable pastures and meadows, inventory on

bumblebees and butterflies, and regional examples are inventories on the status of mires and waterways and more, to help with reporting to the National Authorities on the 16 Environmental Quality Objects that Sweden has decided upon (Ståhl et al. in press., Allard et al. unpubl, Inghe 2001).

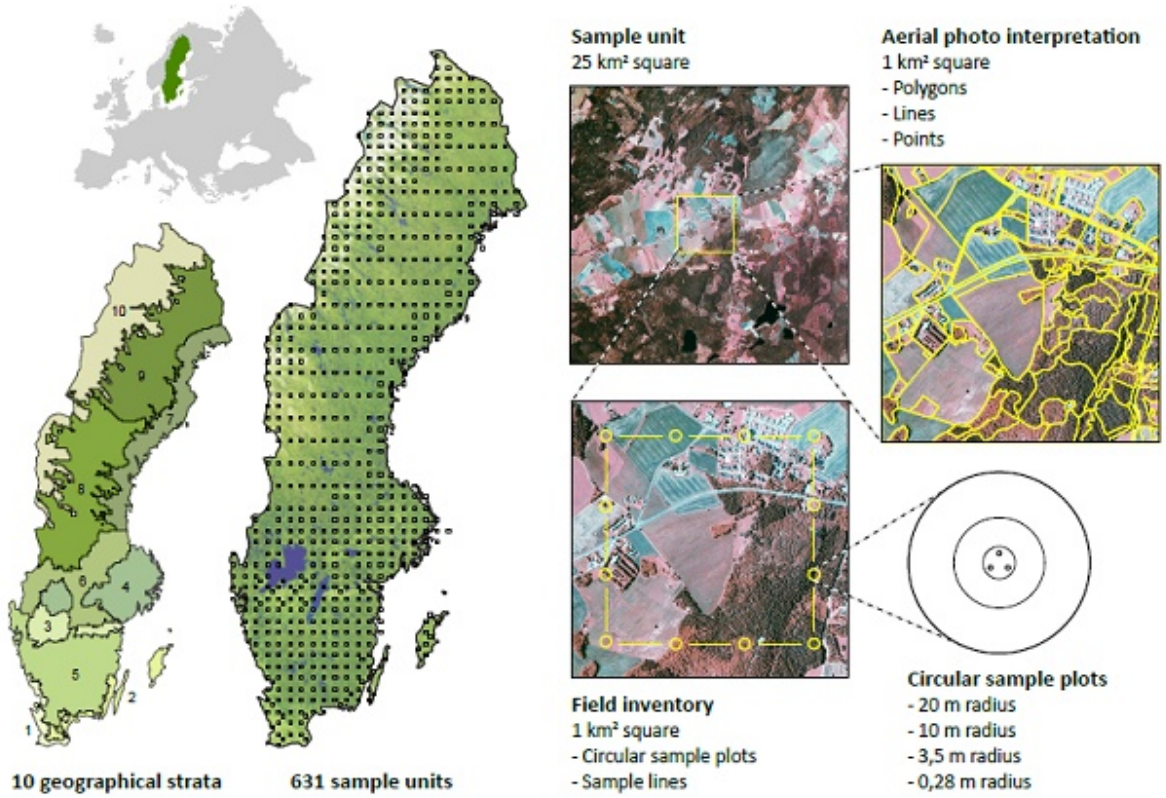

Figure 2. Design of the NILS programme, the figure is taken from Ståhl et al, in press.

LTER sites for Sweden

One of the steps in the EBONE project is to carry out tests on linking the data from LTER (Long-term Ecosystem Research, http://www.lter-europe.ceh.ac.uk/index.htm) sites with data from nation-wide habitat monitoring programmes and EO observations. Sweden had no such LTER areas designated and within the SLU part of the project some areas were suggested as such areas. The criteria for choosing were that the areas should include at least 10 NILS squares and be situated in each of the three main biogeographical zones in Sweden. Along the southern tip, there is a narrow strip of a fourth zone, the Continental zone. Due to the narrowness, and the fact that it lies within the edge and would consist of a mixture of the habitats of the neighbouring

Nemoral zone, it would not suffice as a representative area and therefore sites were chosen for the other three, Nemoral, Boreal and Alpine North zones.

Three sites were chosen as priority one-sites, they are all represented on the right hand side of figure 3 and table 1. The sites were; the Abisko site for the Alpine north zone, the Krycklan site for the Boreal zone and the Remningstorp site for the Nemoral zone. In addition another area was suggested as an alternative for the Alpine north zone (Vindelfjäll site), see figure 3.

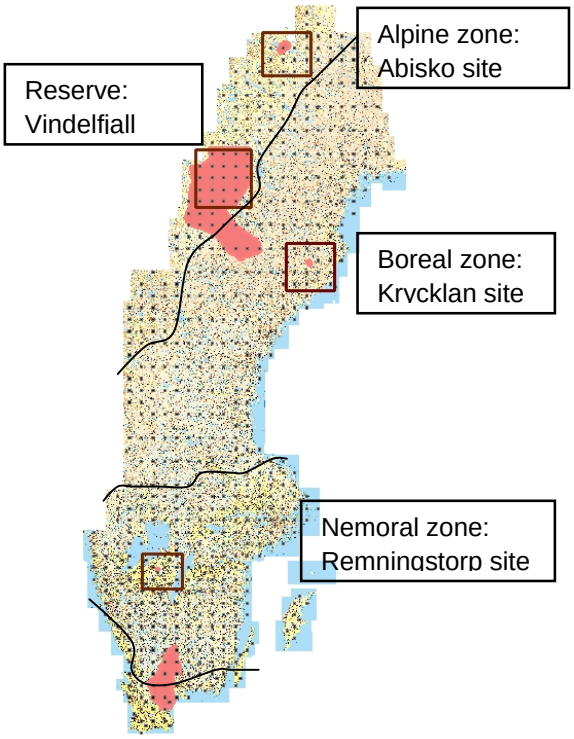

Figure 3. Sites for LTER-regions and NILS-representation in Sweden for the EBONE project.

Table 1. Centre coordinates for the three sites suggested.

	RT 90 2,5 g W		*WGS 84 / SWEREF 99*	
Area	**Center E-W**	**Center N-S**	**Center Lat**	**Center Long**
Alpine zone: Abisko	1651435	7567129	68 9 22	19 27 7
Boreal zone: Krycklan	1697783	7122496	64 9 7	19 52 16
Nemoral zone: Remningstorp	1389872	6466809	58 18 39	13 55 35

There are an uneven number of NILS squares in the three sites, since the grid is not even everywhere, this is due to cost reasons where sometimes the grid can be thinner, since Sweden has other inventories. The 10-km square in the Nemoral zone, Remningstorp lies between the two largest lakes in the country and the NILS-squares that are covered by water is mirrored in to the rest of the grid, using well-known statistical methods (the criteria is less than 5 % of the 5 x 5 km square of the NILS program is covered by land).

Abisko site, Alpine north zone

The area is situated around Abisko, about 200 km north of the Arctic Circle and approximately 385 m above sea level, on the south shore of Lake Torneträsk, see figure 4. The area has a varied topography, geomorphology, geology and climate, as well as flora and fauna. The lake surface is at 341 m and the highest mountain in the area reaches 1991 m. Annual precipitation at the lake varies from about 1000 mm in the west to 400 mm in the east, with a minimum of 304 mm (among the lowest in all Scandinavia) in the sheltered Abisko valley.

The Abisko Scientific Research Station is held by The Royal Swedish Academy of Sciences. The Station hosts the Climate Impacts Research Centre (CIRC) and the Man and Biosphere (MAB) Lake Torne Biosphere Reserve project office. Investigations within many areas of biosciences and geosciences are carried out at the station. The main objectives of the ecological projects are to study the dynamics of plant populations and to identify the controlling factors at their latitudinal and altitudinal limits. The meteorological projects deal with recent climate changes in the region, and also with local variations of the microclimate in subalpine and alpine ecosystems. Research from many of the Swedish universities is carried out around this area, field-based studies (such as paleological, dendrochronological or geomorphological) and studies using remote sensing, laser and radar. Recently a laser scan project was carried out here. The dense pink area in figure 4 constitutes a research perimeter, within which several remote sensing projects are carried out by SLU.

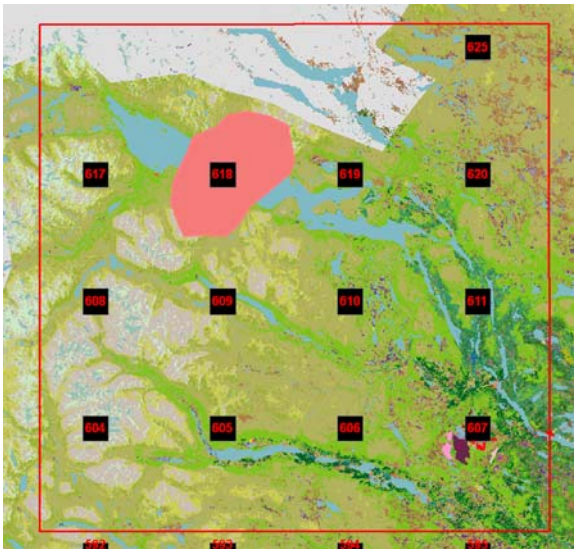

Figure 4. The LTER-site at Abisko (dense pink area), the perimeter of the red line is 100 km x 100 km. The NILS squares are shown in black. The map background is taken from national cover of Swedish Land Cover Data (SMD). The grey area in the northwest is a part of Norway.

The NILS programme has one Flagship area at the site of the laser data from 2008, not marked in the figure. A flagship area consists of the usual 1 x 1 square, with the outer square of 5 x5 km. These are public areas outside of the statistical grid, and the coordinates can be published, which is not the case with the ordinary NILS grid.

Krycklan site, Boreal zone

This is a research site in the forested area of the Boreal zone. This site covers a lot of the dynamics of the northern part of the Boreal zone. The coast line and adjacent area constitutes the more densely inhabited part with the major towns at the estuaries of the large rivers. Agricultural land is shown in yellow and urban areas in red, see figure 5. Due to the land upheaval, they are now situated some way upriver and smaller new villages and industrial sites have formed further out to sea. Towards the inland, the all-prevailing income derives from forestry. The land is covered in forests, with mires and lakes in varying sizes. Inland, the inhabited areas are widespread and lie predominantly along lakesides or rivers.

The area is on the Precambriam peneplane and rather flat, although scattered hills and mountains are found. Much of the topsoil is made up from glaciofluvial deposits but range from the finest grains to boulder plains.

Krycklan is one of the most studied streams in Sweden, e.g. by Cold Climate Research in Boreal Watersheds (cCREW), a multidisciplinary project related to water quality, hydrology, stream biodiversity and climate effects (http://ccrew.sek.slu.se/krycklan/index.html).

It is the site of many remote sensing projects by SLU, the research area is marked by a dense pink area in figure 5. For gathering an improved terrain model the area has been scanned by

laser. Also for forestry research, the area has been scanned twice. To obtain knowledge about future radar satellites, the latest scanning of dense laser was made very recently, together with a radar scan.

The NILS programme has a Flagship area at the eastern part of the town Umeå, and the surrounding forested and agricultural areas. The town of Umea can be seen in red to the lower right in the 100 x 100 km square. An additional Flagship area is situated at the estuary just below Umea (south), it is designated due to the expected environmental changes that might be caused by a new national railway being built across the area. The Flagship areas are not marked in the figures.

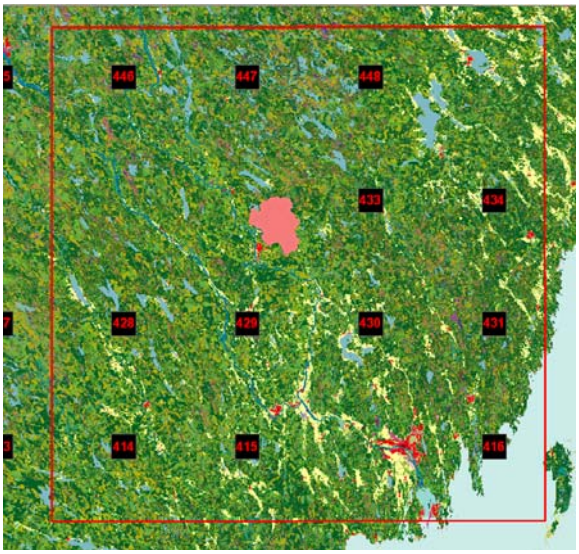

Figure 5. The LTER-site at Krycklan (dense pink area), the perimeter of the red line is 100 km x 100 km. The background is taken from national cover of Swedish Land Cover Data (SMD). The uneven grid of NILS squares (in black) is due to the stratum of the coastline, which is denser than the north inland.

Remningstorp site, Nemoral zone

This research site in the Nemoral zone and contains much agricultural land. It is situated between the two largest lakes in Sweden, Vänern (top left in figure 6) and Lake Vättern to the right in the figure. Special to this part of the country, are the plateau mountains, which are areas preserved from erosion by caps of diabase. The underlying layers of soil constitute different deposits, ranging from sandstone and shale to limestone. The slopes of these mountains are rich in nutrients and people have been living here since prehistoric times. Along the slopes of one of them, together with parts of the cap and the town of Skövde, is the site of one the NILS Flagships (not marked in the figure). This site lies centrally in the 100 x 100 km square.

The dense pink area in figure 6 shows the research area of the estate Remningstorp. This area is a centre for forestry research and consists of 1200 ha of forest land, although it is situated in more densely populated areas. Research teams from SLU, Swedish Defence Research Agency (FOI), Chalmers University of Technology, are working on the possibilities for using remote sensing to

solve problems in forestry science. Many projects use digitally registered aerial photos and images from optical satellite sensors to solve the problems, such as estimations of stem volume, and species recognition. And to investigate the possibilities enhance results and/or find alternative ways, a project is carried together with the European Space Agency (ESA), using radar and laser data. One result hoped for is to find young forest or bushes under a close canopy; another is to find small forest parts that have been felled during storms. Also single trees have been scanned, for recognition purposes.

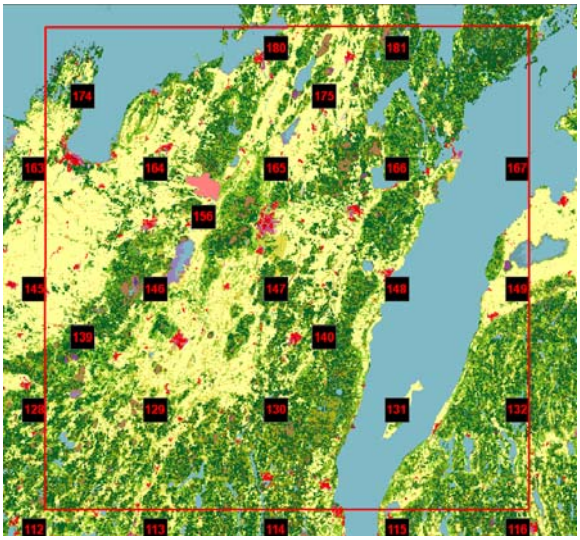

Figure 6. The LTER-site at Remningstorp (the dense pink area between the NILS squares no. 164 and 165). The perimeter of the red line is 100 km x 100 km. The background is taken from national cover of Swedish Land Cover Data (SMD). The uneven grid of NILS squares (in black) is due to the mirroring-in of squares that are totally situated in water, since NILS is dealing with terrestrial areas.

Vindelfjäll Nature Reserve, reserve site for the Alpine north zone

A large portion of the Vindelfjäll Nature Reserve in the western part of Västerbotten County is a study area over which several different sources of remote sensing data have been collected and is used in a PhD-project, see figure 7. The remote sensing data range in different scales, from high resolution colour and colour infrared digital aerial photographs taken at 500 meters flying height, additional digital aerial photographs at 1:30000 scale, and recent satellite data at 10m, 25m, 60m and 300m resolution. Using a combination of field visited sites and aerial photography interpretation, vegetation maps produced from the different scale remote sensing data will be compared.

The Vindelfjäll Nature Reserve area is of interest for several reasons, including the access to a multi-university research station in the village of Ammarnäs, the presence of some areas of limestone- influenced vegetation, and the variation in the topography which results in areas of both mountain birch forest and high alpine ecosystems (elevations range from approximately 330 – 1768 m). The area contains the southernmost occurrence for *Rhododendron lapponicum*, and in the Artfjället area, other rare plants also occur. Most of the alpine vegetation types occurring

throughout the mountain chain are found here, including mountain birch forest, xeric and mesic heaths, alpine meadows, snowbed vegetation, and bare rock. The study area also contains a large and unique water/land complex at the southern end of Lake Tärna, where rare water plants also occur. Due to the abundance of water throughout area, it is rich in bird life, and several areas are protected. Indeed the Nature Reserve is under consideration for National Park status, however, this transformation to National Park status has not yet been fully supported.

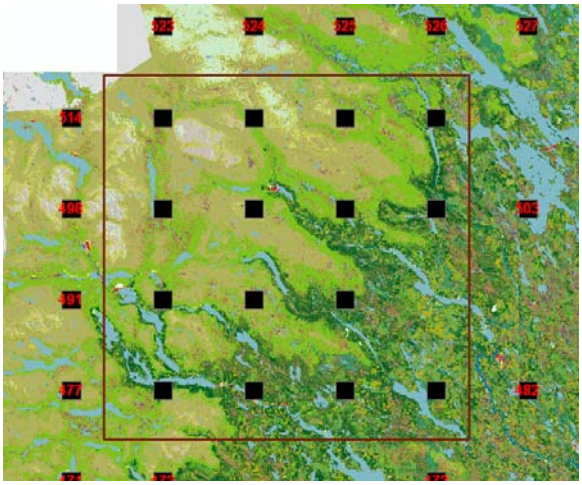

Figure 7. The alternative LTER-site at Vindelfjäll Nature Reserve, the perimeter of the red line is 100 km x 100 km. The background is taken from national cover of Swedish Land Cover Data (SMD). To the left in the area is the mountainous area of Sweden and at the right hand side is the forested inland.

Results

To be able to convert between the systems, careful study of them both was necessary. The comparisons are summarised in 7 tables, with the possibilities of conversion in mind (tables 2-8). The text describing the tables and the actual conversion is given in the next section. The work is made on the variable set, as it is in the NILS interpretation manual of 2005, which is not yet translated into English. Therefore the relevant variables and subclass codes are translated and shown in appendix 1.

The work was carried out using Arc GIS software, and especially the SQL query function, on a copy of the NILS database, taken in May 2009. Not all the NILS squares were then inventoried. Since the programme have been dealing with many new issues and is still in its infancy, there is a back log of inventoried squares. The first three years are inventoried in full, and because the designated fifth of the NILS squares that are inventoried each year is spread out over the country, there are some missing data in each 100 x 100 km square. This is also the reason for using the interpretation manual of the year 2005 (which is the third year and most up-to-date). One of the advantages of using aerial photos is that, given the actual photos are obtained in the right time and right part of the vegetative season, the inventory can be carried out at any time. Another great advantage is that the very same inventory can be carried out by several persons, and be revisited at will.

Some features are fully possible to convert; others are possible with exceptions such as differences in height or dominant cover while others are not possible to convert, due to differences in collection or the features not being present in Sweden. The types of feature are separated into several tables to be easier to comprehend, and are dealing with first the general possibilities and difficulties, and then specially noted issues in the five major categories and lastly in the linear and point objects (tables 2-8).

Table 2. General possibilities and difficulties in the conversion of the NILS variable system into the classes of the General Habitat Categories.

Features recorded	General Habitat Categories and qualifiers	NILS Variables and subclasses	Easy conversion Yes / No
Minimum mappable unit	400 m²	100 m²	Yes
Polygon minimum width	5 m	10 m	Y/N Linear elements in NILS can complete the conversion.
Inventory outside square	Yes	No	Not important for the conversion.
Species	"Indicator species" used as identifiers, no fixed list.	Fixed list of species to consider, although only in the field inventory.	No
Slope angle, aspect, altitude of ground	Data from field inventory and to some degree from external sources.	Terrain model used together with map data in the computer.	Possible, with GIS analysis.
Level II in classification	Qualifiers used for sublevels in the hierarchy.	Management or land use is recorded in 46 classes.	Yes
Total cover of vegetation	Vertical perspective of the ground is recorded.	Vertical perspective of the ground is recorded.	Yes
Land surface	100 % of the surface is recorded.	100 % of the surface is recorded.	Yes
Multiple layers in forest	Multiple layers are not recorded, top layer is.	Two-story forests are recorded; multiple layers are recorded in field data.	Yes
Single General Habitat Category, criteria	Over 70 % of one life form has to be present to be recorded.	Continuous cover percentage is recorded.	Yes
Combination of two General Habitat Categories	The coverage has to be within the relation of between 30 - 60 % to be recorded. Recording is done in even steps of 10 %.	Continuous cover percentage is recorded.	Yes, but will have to be a combination of coverages between 31-69 %.
More than 40 % bare ground + > 2 Life forms	Recorded.	Continuous cover percentage is recorded.	Yes, but will have to be from 31 % and in certain combinations.
Life form < 10 %	Not recorded.	Continuous cover percentage is recorded.	Yes
Single species > 30 %	Single species with coverage of more than 30 % are recorded separately.	Field layer classes are recorded, not single species.	Yes/No, yes if species in General Habitat Categories can be put into groups, otherwise no.
Complex areas with many elements.	The dominant habitat is recorded.	The dominant land cover is recorded and also up to 3 extra deviations from the dominant, type and percent of cover.	Yes, with moderation.
Ecotones	A special code is used for ecotones, as for uncertain boundaries.	Ecotones can only be inferred from the analysis of variables in adjacent polygons.	No

Uncertain boundaries	Codes exist for arbitrary lines or for transitions zones.	No uncertainty allowed in the variable and class system. The most likely boundary is chosen during the inventory by analysis of the surroundings.	Yes, but with caution. Analysts need to take this metadata into consideration.

Table 3. Possibilities and difficulties in the conversion of the NILS variable system into the class Urban of the General Habitat Categories.

Features recorded	General Habitat Categories and qualifiers	NILS Variables and subclasses	Easy conversion Yes / No
Urban codes	Single boundaries, the composition of elements are not recorded inside. One individual building is not recorded as an area. Although a group of 3 or more buildings is large enough, they can be one coded area.	Records all elements inside an area, even in urban conditions. Farms or other houses are recorded as built-up areas. One building can constitute a polygon if large enough for minimum mappable unit. Others are recorded as point objects, although the land cover of the polygon surrounding will be "Built up". Fenced-in pastures are not recorded as urban, they can only be inferred from land use (pasture).	Yes, with moderation. The conversion will need GIS analysis with shape-layers that show towns and villages for "uncoding" of urban areas. Fenced-in areas are not always seen and are therefore missed if the area is not currently used for pasture. Fences are recorded along fixed inventory lines in the field data – and statistical occurrences can be derived.
	Glass house or polytunnels for vegetable or flower production are marked as agricultural.	Glass house or polytunnels are marked as built-up areas.	No
	Water bodies inside urban areas are included in urban codes and not recorded singularly.	Water bodies are stand-alone features and always recorded, given the right size.	Yes, but with GIS analysis to recode them as urban.
	Recreational areas in and around towns are recorded as urban ground.	Most recreational areas have codes, but forest areas in and around towns are recorded as forestry.	Yes, but with GIS analysis to recode them as urban. The land use in forests used for walking and skiing can possibly be obtained from cadastral map layers. Otherwise as buffer zones.

Table 4. Possibilities and difficulties in the conversion of the NILS variable system into the class Cultivation of the General Habitat Categories.

Features recorded	General Habitat Categories and qualifiers	NILS Variables and subclasses	Easy conversion Yes / No
Cultivation codes	Individual crop species are recorded.	Groups of crops are recoded together.	Yes, but will have to be merged/clustered for conversion.
	Bare ground is recorded where no crops have been planted or otherwise being kept bare. Except for herbaceous crops.	No bare ground recorded for crop fields. Cultivation types meant in GHC, where the ground is bare, e.g. under orange trees, is not applicable in Sweden. Berry bushes and apple trees do have mostly bare ground, but the ground is not recorded especially.	No. Bare cultivated ground will be merged with other cultivated ground.
	Woody crops are recorded specially, and species are noted.	Woody crops are recorded, but merged into groups.	Yes, but will have to be merged/clustered for conversion.
	Abandonment 5 years or more of woody crops are recorded.	Abandonment within 5 years are not always seen in aerial photos, but will be recorded for all types of ley/cultivation/pasture when evidence of decay has set in.	Yes, but with unclear time difference.
	Cover is recorded for all crops, except woody crops, where the rule is 20 trees/bushes per ha.	Cover is not recorded in ground with crops. Type of crop is distinguished into woody and non-woody crops.	No.

Table 5. Possibilities and difficulties in the conversion of the NILS variable system into the class Sparsely vegetated, including water and ice of the General Habitat Categories.

Features recorded	General Habitat Categories and qualifiers	NILS Variables and subclasses	Easy conversion Yes / No
Sparsely vegetated codes	Sea ground below mean water mark is recorded.	Such ground is not usually applicable in NILS, and is not distinguished with good accuracy in aerial photos.	No
	Tidal zone areas are recorded.	Tidal zone areas are usually too small for minimum mappable unit and therefore not recorded in Sweden.	No
	Water bodies are only recorded as water if the cover of vegetation is less than 30 %, otherwise as vegetated by submerged or emergent hydrophytes.	Submerged and emergent hydrophytes are recorded as aquatic ground with vegetation in four classes but without percentages. Vegetation is recorded as yes, if reaching 5 %.	Yes, but some codes will have to be merged/clustered in both systems.

Table 6. Possibilities and difficulties in the conversion of the NILS variable system into the class Shrubs and trees of the General Habitat Categories.

Features recorded	General Habitat Categories and qualifiers	NILS Variables and subclasses	Easy conversion Yes / No
Shrubs and trees	Dwarf and Shrubby chamaephytes (< 0.05 m and 0.05 -0.3 m) are recorded as single life forms.	Bottom and field layer below 0.03 m are recorded together.	Yes but the two codes DHC and SCH will have to be merged.
	Low and Mid phanerophytes (0.3 - 0.6 m and 0.6 - 2.0 m) are recorded as single life forms.	All phanerophytes between 0.03 - 3.0 m are recorded as one code. However, mountain birches are recorded as trees when mean stand height reaches 2.0 m.	Yes but the two codes LPH and MPH will have to be merged. And the difference of 1 m higher in NILS will have to be noted. For the mountain birches that make up the zone up to the mountain timber line, NILS has the limit of 2 m for recording phanerophytes as trees.
	Tall and Forest phanerophytes (2 - 5 m and above 5 m) are recorded as single life forms.	All phanerophytes above 3.0 m, and for mountain birch, 2.0 m, are recorded as one code. And mean stand height is recorded above this limit. As the mean stand height is the measured variable, the range of the phanerophytes can lie between 2-5 m and will have to be accepted as possible to convert to GHC.	Yes, but the two codes TPH and FPH will have to be merged.
	Pine, Larch and Lodgepole pine are recorded separately.	In the expression "Pine" the Larch and Lodgepole pine species are included.	Yes, but species of pine will have to merged.
Shrubs and trees, Level II and III	Winter deciduous and Conifers are recorded as single codes.	Winter deciduous and Conifers are recorded as single codes.	Yes. BUT there is much overlap due to single species recording in GHC, and many will have to be merged.
Exotic trees, to Swedish conditions	Evergreen trees, Non-Leafy evergreen and Summer deciduous are recorded as single codes. Codes are: EVR, NLE and SPI.	These categories are not viable in Sweden.	No

Table 7. Possibilities and difficulties in the conversion of the NILS variable system into the class Herbaceous of the General Habitat Categories.

Features recorded	General Habitat Categories and qualifiers	NILS Variables and subclasses	Easy conversion Yes / No
Herbaceous	Broad leaved herbaceous species and grasses/sedges are recorded as single codes, based on 70 % or more occurring of one type.	Broad leaved herbaceous species and grasses/sedges are recorded in one group and by dominance, 50 % or more. In this code is also the field/bottom layer "dwarf shrub of grass type" included. At 12 single points per square percentages are recorded in field data.	Yes, but the two codes LHE and CHE will have to be merged. Note that GHC records when occurrence is at or above 70 % and NILS records above or below 50 % occurrence.
	Therophytes (plants that survive as seeds under unfavourable seasons, such as drought) are recorded.	Therophytes does not occur in quantities large enough to cover an entire minimum mappable unit, often enough to merit a variable in Sweden.	No
	Succulent chamaephytes are recorded.	Succulents does not occur in quantities large enough to cover an entire minimum mappable unit, often enough to merit a variable in Sweden.	No
	Geophytes are recorded.	Geophytes do occur but the plant bodies are similar to other plants, and are therefore not possible to distinguish in the aerial photos.	No
	Cryptogams are recorded.	Cryptogams occur in quantities in wetlands and in the mountainous areas. In forests the trees take precedence.	Yes
	Herbaceous chamaephytes are recorded.	Herbaceous chamaephytes does not occur in quantities large enough to cover an entire minimum mappable unit, often enough to merit a variable in Sweden.	No

Table 8. Possibilities and difficulties in the conversion of the NILS variable system into the Linear and Point objects of the General Habitat Categories.

Features recorded	General Habitat Categories and qualifiers	NILS Variables and subclasses	Easy conversion Yes / No
Linear objects, minimum length for recording	30 m	20 m	Yes
Always record linear features	Yes	Yes	Yes
Fences, walls etc.	Fences and walls in and around urban areas are not recorded. Otherwise they are recorded.	Stand-alone features. Only walls are recorded in the aerial photos.	Yes, but only walls.
Roads, tracks, hedges, grass strip, herbaceous strip, water course	Always recorded.	Always recorded. Water courses are recorded as lines if under 10 m, otherwise as areal features. Strips of grass/herbaceous are recorded together.	Yes
Water edge, line of scrub, species rich hedge, line of trees	Always recorded.	Not recorded, lines of trees **are** recorded, if planted.	No
Line of sparsely vegetated	Always recorded.	Scree and erosion banks along rivers are recorded as line features.	No
Point objects	Recorded as single or in groups of point objects.	Always recorded as single point objects.	Yes, but since they are an optional feature in GHC, and arbitrarily recorded, the conversion becomes pointless.
Point object type recorded	The actual point objects to be recorded are decided for each survey, and differ.	A fixed list of point objects is recorded.	No

Conversion

The tables in this section describe the actual conversions and the combinations of variables necessary to make up the different General Habitat Categories. They are separated into subsections, one for each major category. As described earlier the conversion was done directly in the SQL server program and the result could be directly analysed in the GIS software. Figures 8-11 show the work in progress, as screen dumps from the ArcGIS program, the stereo effect from the interpretation, done in another software, is not shown here. The analysis of results during the process is greatly simplified when using the ancillary data of maps and ortho photos and also the delineated NILS polygon layer with all captured data available. It enables corrections during the conversion process and, more importantly, to decide whether polygons already converted should be recoded, all depending on hierarchy in the classification system. What remains to be done is to create a hierarchical list for the generalisation of the more detailed NILS data, minimum mappable unit 0.1 ha and in some special instances down to 0.05 ha, into

the 0.4 ha of the General Habitat Categories. Since there are no real hierarchy between the superlevels, this needs to be addressed by the EBONE project before that list can be made.

In figure 8 a NILS square is shown, of 1 x 1 km, plus a border of 50 m extra outside which is put there for edge-effect reasons, with area objects (polygons), linear objects and point objects. The lines and dots are displayed on an ortho photo, made from the NILS aerial photos over the area. In figure 9, the polygons have been converted into GHC:s and have the numbers that were used during the conversion process, simplifying the database work. The next figure (10) shows the screen of the ArcGIS software, where maps make a useful tool for corrections and for understanding the reasonability of choices. Lastly, figure 11 shows another square, with more agricultural land and the converted polygons with the GHC names asked for from the project.

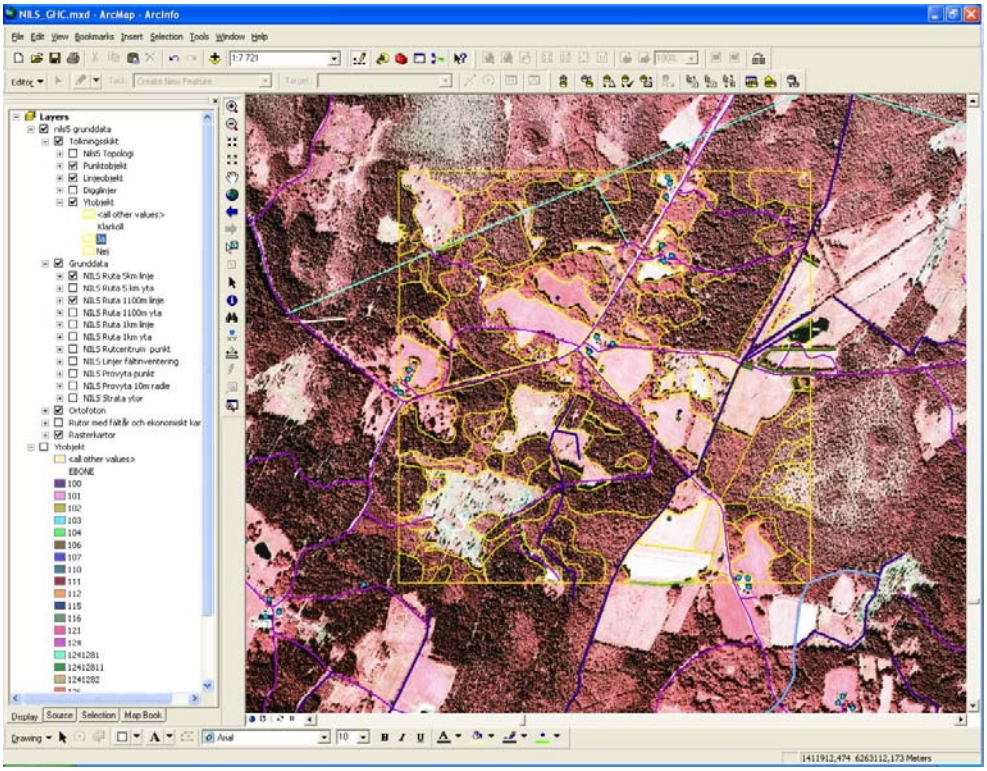

Figure 8. A NILS square 1 x 1 km, plus a border of 50 m extra outside, with area objects (polygons), in yellow. Linear objects are shown in different types of blue or purple, and point objects are shown as light blue dots. The lines and dots are displayed on an ortho photo, made from the NILS aerial photos over the area.

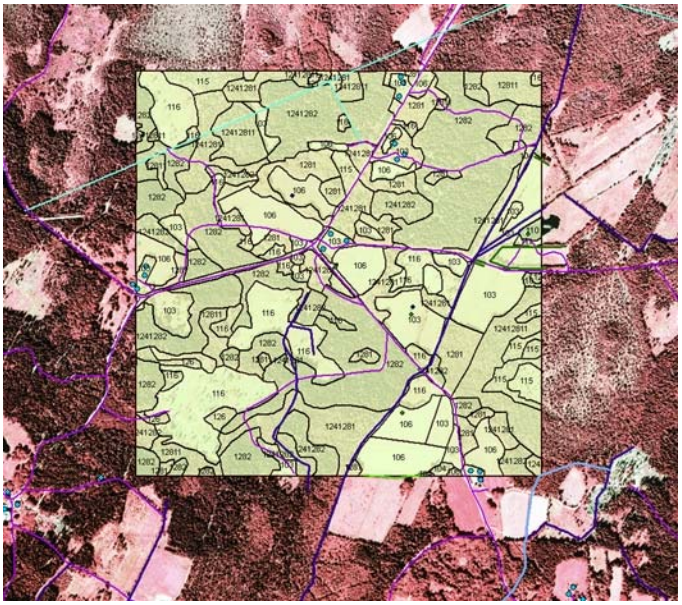

Figure 9. The NILS square from figure 8, with the polygons classified as General Habitat Categories, using temporary numbers for simplicity when working with the database.

Figure 10. A NILS square with the display of ortho photo, polygons, lines and points, and the background of one of the map layers available through server for all working within the SLU.

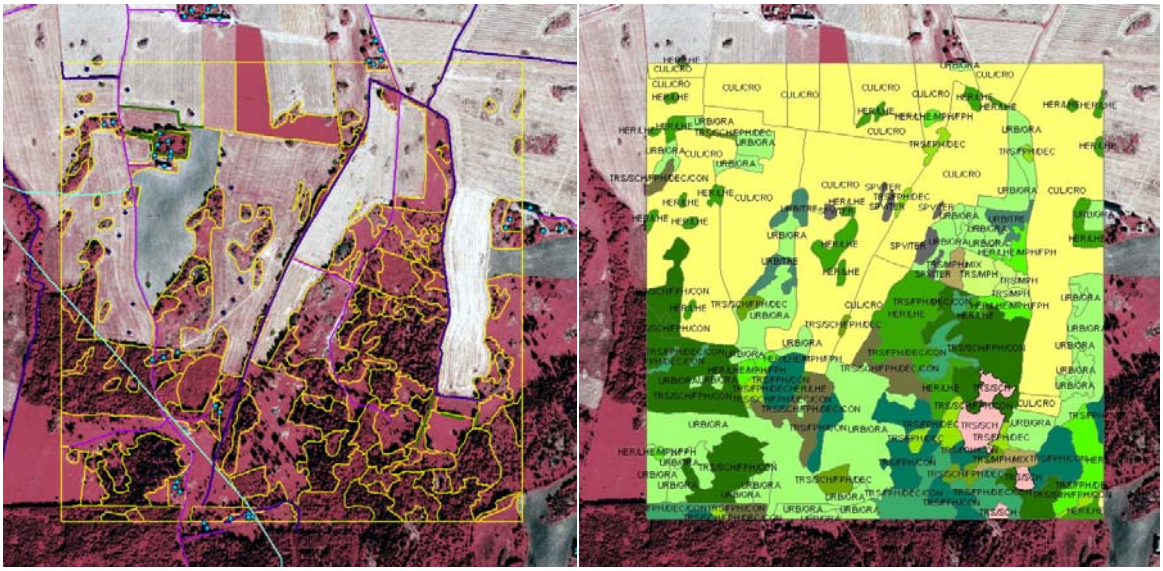

Figure 11a-b. A square with more agricultural land and with the names of the General Habitat Categories for the converted polygons.

The following tables point out what basics should be kept in mind when putting the different variables and percentages together to form a general habitat category. Since the work was done before the new handbook of 2010 was published, there are the five sections based on the original superlevels instead of the new six superlevels, including terrestrial grounds and more combinations. The new handbook is an improvement, and the naming of mixtures might be easier. Terrestrial grounds are no problem to convert, and they are now in the sparsely vegetated section. In NILS, the type of ground is recorded when the naturally occurring substrate reaches 10 %, although the types of bare ground are only four; mineral soil, gravel, boulders and rock. Mixtures of two types are not recorded, the dominant types will give the subclass. The detailed polygon sizes that are recorded can be used for eventual mixtures, along beaches or other areas where bare ground occur.

For the conversion process, first all the simple codes were converted, which consists of 70 % or more of some life form in cover. After these habitats came the combination codes where the polygons have a cover of 30 % or more, but less than 70 % of the life form in question, regardless of what else was there. The third layer of combinations consists of between 30 and 69 % of two life forms. The handbook states that it is between 40-60 %, but also states that 30 % is a “turning point” for a habitat to be recorded, therefore the conversion of the continuous percentages recorded in NILS, is made from 30 to 69. It is not quite clear how to name these combinations as General Habitat Categories, so they are also given a class number in the database. The five superlevels worked with are Urban ground, Cultivated ground, Ground with sparse vegetation (also including terrestrial or bare ground, water and ice), Ground with shrubs and trees and Mires and herbaceous ground. In the conversion process one hierarchy has been used between the superlevels, which is an adjustment to Swedish conditions. Where the mixed polygons have equal chance of ending up in either Shrubs and Trees or Mires and Herbaceous,

the forested categories have been predominantly chosen, since many of the polygons lie in areas with forestry as land use. When inserting the qualifiers, as conversion functions, this will be taken care of in a better way. These sublevels will pinpoint such things as moisture regime, and different land uses within one and the same superlevel. The sublevels are outside the scope of this work, and examples of how to make them are given instead.

The tables 9-13 show what variables and subclasses are necessary to put in to the SQL query, in order to classify the polygon into a certain General Habitat Category. For simplicity during the work the GHC:s were given a numerical name, hence the two columns headed GHC in EBONE and GHC as number. The numerical name is unique to this work and can largely be disregarded, they are put in this report for clarity if the conversion process will be continued and others will work on the database. Some of the combinations are unclear how to name, and if some are unnecessary, they can be merged with other GHC:s. The number names show a hierarchy in the system and can be helpful for the deeper mixes, which is where the naming rules become fuzzy. The names given here have been chosen as logically as possible. The need for names becomes apparent when using database column heads instead of the field protocols.

The numbering follows this type of rule: the highest level of trees (forest phanerophytes) is called TRS/FPH which is number 128. The two Swedish types of forest phanerophytes are winter deciduous (TRS/FPH/DEC, and given the number 128**1**) and coniferous (TRS/FPH/CON and given the number 128**2**). Many forest stands do not cover as much as 70 % of the ground and mixtures have to be created in order to classify the forest polygons. Especially not with winter deciduous or coniferous trees as stand-alone type. Since there is no hierarchy between these two types, the mixtures become somewhat complex. So, the combination of forest phaneropytes where the two types together make up 70 % cover is called TRS/FPH/DEC/CON and given the number 128**11**. Then, for the polygons under 70 % cover, which are very common, the combinations with other ground, which commonly constitutes undershrubs, TRS/SCH = number 124, (and dwarf shrubs, but shrubs have been given the highest hierarchy), have been given the name TRS/SCH/FPH/DEC and the number 124/128**1** and corresponding TRS/SCH/FPH/CON and the number 124/128**2**. And, in conclusion, the mixture of the two tree types and other ground will be TRS/SCH/FPH/DEC/CON and the number for that is 124/128**11**.

It is entirely possible that these mixtures have been misunderstood, and that there is a hierarchy in function that have been missed in this work. However, all but the last mixture was needed for classification of the Swedish conditions. All of the polygons that fitted in the last expression were already classified into other combinations, and none were reclassified.

Again, for the NILS variables used and not used, see appendix 1, and for a fuller understanding of what they entail, see the English version of the 2003 manual (Allard et al. 2003).

Urban ground

To convert the variables into some of the urban or constructed categories is in one way rather straightforward. There are some issues, as shown in table 3 and 9. In NILS, the ground is monitored in detail, regardless of being urban areas, and polygons will have different terrestrial, semiaquatic or aquatic codes, even if they are situated within urban boundaries. For such things as parks, or greenery around villas and houses, there is no problem. But forests or lake areas in and around towns, used largely for recreational purposes will not be coded as urban. If a forest has built paths for exercise or horseback riding, the land use of "recreational area" will give the code, otherwise they will be coded as "forestry" for the land use. Aquatic surfaces will only be given a land use when the actual water body is used, e.g. for breeding fish, and they will stand alone in this urban concept, as will completely vegetated areas that have no apparent land use. The recoding of these types will have to be made with some predefined "urban mask" in the GIS, or by buffer zones. Or, the differences in urban codes will have to be allowed.

If a pasture is under current use for grazing, they will be coded, but any other land that is fenced-in, will not. This is because the spotting in of the smaller fences or string fences is uncertain in the aerial photos. A statistical measure of how many fences there are, can be obtained from the NILS field data, where all fences crossed are recorded along twelve 200-m lines within the square.

Glass houses or poly tunnels are in NILS marked as built-up areas and will end up as urban codes and not as agricultural as in the GHC system. Only orchards and berry bushes planted on farming fields are marked as agricultural. Poly tunnels and glass houses are not very common occurrences in Sweden, but will be missed when they do occur.

Table 9. Conversion of the NILS variables and subclasses into the Major class Urban in General Habitat Categories.

GCH in EBONE	GHC as Number	Criteria	NILS variables and subclasses
URB/ART	100	All built-up land: ≥ 70 % covered in buildings tarmac, concrete or other artificial material	**[Land cover] in (5, 6)** AND ([Substrate Percent] + [Cover Buildings Percent]) >=70 AND [Land use] in (34, 35, 36, 37, 40, 41, 42, 43, 44, 45, 46, 47, 50, 51, 52, 53)
URB/NON	101	All non-vegetated land ≥ 70 % within an urban boundary. Urban activity, such as quarries, gravel car parks and excavation sites. Water bodies are included, but with qualifiers	**[Land cover] in (6, 8, 9)** AND [Substrate Percent] >=70 AND [Land use] in (30, 31, 32, 33, 34, 35, 36, 37, 40, 41, 42, 43, 44, 45, 46, 47, 50, 51, 52, 53, 70, 71, 72, 73, 80, 81, 82, 90, 97)
URB/VEG	102	Vegetables and fruit trees ≥ 70 % , e.g. allotments and gardens for growing. (Mainly as combinations since these categories usually are smaller than MME. But in conversion a set percentage have to be used)	[**Land cover**] in (**1, 4, 7**) AND ([Tree cover_1] + [Tree cover_2]+ [Shrub cover]) >= 70 AND ([Broadleaved trees_1]] + [Broadleaved trees_2]) >= 70 AND [Land use] in (15, 16, 37)
URB/GRA	103	Herbaceous and land with graminids, together covering ≥ 70 % in urban areas. Less than 30 % woody vegetation.	**[Land cover]** in (**1, 5, 7**) AND ([Substrate Percent] + [Cover Buildings Percent]) <30 AND [Field cover Type] in (1, 2) AND ([Tree cover_1] + [Tree cover_2] + [Shrub cover]) <30 AND [Land use] in (0, 11, 18, 30, 31, 32, 33, 34, 35, 36, 40, 41, 42, 43, 44, 45, 46, 47, 50, 52, 53, 70, 90, 97, 98, 99) OR **[Land cover] = 5** AND ([Cover Artificial Green Area] + [Cover Natural Vegetation]) >= 70
URB/TRE	104	Land with > 30 % woody vegetation, from 0.05 m - more than 5 m.	**[Land cover]** in (**1, 5, 7**) AND ([Substrate Percent] + [Cover Buildings Percent]) <30 AND [Field cover Type] in (1, 2) AND ([Tree cover_1] + [Tree cover_2] + [Shrub cover]) >= 30 AND [Land use] in (0, 11, 18, 30, 31, 32, 33, 34, 35, 36, 40, 41, 42, 43, 44, 45, 46, 47, 50, 52, 53, 70, 90, 97, 98, 99)

URB/ART/ MIX	1001	Ground that consist of a mixture of the above Urban artificial ground with other urban ground. When these polygons coincide with other classification possibilities, they are of a lower hierarchy.	**[Land cover] in (5, 6)** AND ([Substrate Percent] + [Cover Buildings Percent]) < 70 AND [Land use] in (34, 35, 36,40, 41, 42, 43, 44, 45, 46, 47, 50, 51, 52, 53)
URB/NON/ MIX	1011	Ground that consist of a mixture of the above Urban non-vegetated ground with other urban ground. When these polygons coincide with other classification possibilities, they are of a lower hierarchy.	**[Land cover] in (8, 9)** AND [Substrate Percent] < 70 AND [Land use] in (70, 71, 72, 73, 80, 81, 82)

Cultivated ground

The main discrepancies, summarised in table 4, are that the farmed fields, although they are delineated separately and marked as a number of subclasses in NILS, are not marked with individual crops. Neither are ploughed, and therefore bare, fields marked separately. They are all marked as "Arable land in rotation of crops". In Sweden, there are almost no arable land in rotation of crops that are kept bare (other than e.g. weeding between potato strands), and this type has not been incorporated in the NILS variable set.

The types of woody crops that are especially marked, are fruit trees and berry bushes and they can be converted. Other types of woody crop will have to be merged with the arable land in rotation of crops.

In the EBONE system, abandonment of woody crops is recorded, if going on for 5 years of more. This is a bit tricky. Abandonment of grasslands or fields in general, can be derived from NILS data, since those are main expected changes in the Swedish landscape. Longer abandonment of woody crops can be spotted when the grounds are overgrown with saplings or young trees/bushes, and will then be recorded as "No apparent land use". When analysing together with "Earlier land use", abandoned land of all types can be found. This is not done here, since the NILS programme has not been running long enough. The different general habitat categories that can be converted are shown in table 10.

Table 10. Conversion of the NILS variables and subclasses into the Major class Cultivated ground in General Habitat Categories.

GCH in EBONE	GHC as Number	Criteria	NILS variables and classes
CUL/SPA	105	All cultivated land with: ≥ 70 % bare ground, no crops planted yet, no volunteer plants	CUL/SPA is merged together with CUL/CRO
CUL/CRO/SPA	106	All cultivated herbaceous crops, both annual and perennial. Also includes bulbs, e.g. daffodils. Also includes ploughed fields, CUL/SPA. Always single fields in NILS.	**[Land cover] = 4** AND [Land use] in (10, 11, 12, 13, 17)
CUL/WOC	107	All cultivated land with woody crops. Cover is **not** used as criterion, since trees can be pruned. The rule is 20 trees per ha.	**[Land cover] = 4** AND [Land use] in (14, 15, 16)

Sparsely vegetated ground, water and ice

The category of sparsely vegetated ground also contains water and ice, and in the 2010 handbook, the naturally occurring bare ground is extracted from this and has a superlevel of its own, as is mentioned before. In this work it is still taken into account together with the sparsely vegetated. In NILS the grounds below mean water mark is not recorded especially, since it is very uncertain to pinpoint the mean water mark in aerial photos. As the inventory has to be carried out at the point in time when the aerial images have been obtained, it becomes a varying factor, even though they are within the vegetative season, the country is large and the clear days for photographing may have to be waited for. The possibility for researching the difference of the water line of the photo, is to make an analysis against the water line on the official digital maps (assuming that they show the mean water mark), and thereby see which parts of the polygons lie below this line. This analysis is not done here.

The tide shifts in Sweden are small, and this type of variable is therefore not incorporated in the NILS variable set.

In the general habitats, water bodies are only recorded as water if the vegetation covers less than 30 %, this is a major difference to the NILS monitoring, where a water body takes precedence over the water vegetation. Even thick vegetation, standing in water is recorded as water with vegetation. This is one instance where the NILS inventory takes help from the map, to distinguish the water line in a stand of reed (*Phragmites australis*), as these often grow some way up on the shores. However, the cover percentage of vegetation in water is not recorded, much for the same reasons as the mean water mark, as the cover is steadily changing over the relatively short summer. When the cover has reached 5 % the area is recorded as water with

vegetation, or delineated as vegetated water from other clear water. The type of vegetation is clustered into four types only, since the species are hard to pinpoint in aerial photos.

For the naturally occurring bare ground, over 30 % of substrate, the conversion is straightforward, and in this group also the non-permanent snow patches have been put. Some of these, so called, snow beds actually have vegetation, dormant until the snow melts and then growing very fast for a month or so, until next fall. It is not possible to see if there is vegetation underneath or not and the patches have therefore been treated as mostly bare ground. Naturally occurring bare peat is not a variable in NILS, but if the mosses on top are removed, it is found in the land use "Peat workings". The parts of a mire that is mainly flark pools and mud bottoms, are given as percentages under the semi-aquatic land cover. They are almost never large enough to merit a polygon on their own, and has been disregarded in this work.

Table 11. Conversion of the NILS variables and subclasses into the Major class Sparsely vegetated ground, which also contains water and ice, into General Habitat Categories.

GCH in EBONE	GHC as Number	Criteria	NILS variables and classes
SPV/SEA	108	Sea below mean low water mark.	Not applicable
SPV/TID	109	Tidal zone	Not applicable
SPV/AQU	110	Permanent water bodies, rivers, lakes, ponds, canals. Less than 30 % cover of vegetation. Is here merged with the herbaceous codes for water plants HER/SHY and HER/EHY, since they are not recorded with coverage in NILS.	**[Land cover] = 3** AND [Aquatic Type] in (1, 2, 3, 4)
SPV/TER	111	Naturally occurring bare ground, rock, soft material or peat with less than 30 % of vegetation cover. Peat rarely occur naturally bare, it almost always covered in mosses and has been disregarded.	**[Land cover]** in (**1, 2**) AND [Substrate Percent] >= 30 AND [Substrate Type] in (1, 2, 3, 4) AND **[Land cover] = 3** AND [Glacier Type] in (2, 3)
SPV/ICE	112	Permanent ice and snow.	**[Land cover] = 10** AND [Glacier Type] = 1

Shrubs and Trees

As is summarised in table 6 and further shown in table 12, in NILS the field layer and the bottom layer is recorded as one in the aerial inventory, and the two categories of DHC (below 0.05 m) and SHC (between 0.05 m and 0.3 m) cannot be separated. The two of them are converted into

the category shrubby chamaephytes (SHC). The same goes for the two types Low (LPH, 0.3 - 0.6 m) and Mid (MPH, 0.6 - 2.0 m) phanerophytes, which are not recorded separately in NILS. All phanerophytes between 0.3 -3.0 m are recorded together, and the conversion of them therefore became mid phanerophytes, MPH. All phanerophytes above 3 m (measured as the mean stand height) is recorded together with the height. In theory it could work to convert separately into the two categories tall (2.0 – 5.0 m) and forest phanerophytes (above 5 m). But since the rules for delineation of adjacent polygons states that the stand height of the next polygon should differ one third in meters from the first, the separation becomes very uncertain and the two categories are merged into forest phanerophytes (FPH) in the conversion.

All types of pine are recorded as one code in NILS, even the larch ends up in this cluster. Spruce and pine is separated, as good as possible. The evergreen trees, non-leafy evergreen and the summer deciduous trees are not occurring in such amounts that they have merited a variable in the NILS set.

For the conversion (table 12), all the original polygons of forest phanerophytes were reclassified into the combinations or classifiers, above 70 % of conifers or winter deciduous, then above 70 % of the two types combined, and then between 30-69 % of either one or of a combination of both.

The clear cut forest areas that sometimes have no field cover, or where the field layer consists of woody debris, grass, or grass/undershrubs, have no real equivalent in the general habitat categories. It was decided that the best choice for these areas, which are in a succession stage of being reforested, would be to classify them as low phanerophytes or combination of low to mid phanerophytes, depending on the shrub cover. A suggestion for naming the latter would be TRS/SCH/MPH. Some clear-cuts of course are vegetated by herbs and grasses, mixed with small shrubs of different kind and then it could be TRS/CHE/MPH.

Such polygons that were already classified as Urban codes due to their location and/or land use, but had more than 30 % of woody vegetation were removed from the SQL-query list and kept as Urban.

Table 12. Conversion of the NILS variables and subclasses into the Major class Shrubs and Trees in General Habitat Categories.

GCH in EBONE	GHC as Number	Criteria	NILS variables and classes
TRS/DHC	123	Dwarf chamaephytes, below 0.05 m	Will be merged shrubby chamaephytes SCH.
TRS/SCH/DHC	124	Shrubby chamaephytes, undershrubs between 0.05-0.3 m. Includes all dwarf shrubs.	**[Land cover] = 1** AND [Substrate Percent] < 30 [Field cover Type] in (0, 2, 3, 4, 5, 11, 99) AND ([Tree cover_1] + [Tree cover_2] + [Shrub cover]) < 30 AND [Land use] in (0, 1, 2, 3, 4, 19, 90, 97, 98, 99)
TRS/LPH	125	Low phanerophytes, low shrubs, height between 0.3-0.6 m.	Will be merged with Mid phanerophytes MPH.
TRS/MPH/LPH	126	Mid phanerophytes, mid shrubs, height between 0.6-2.0 m. Includes all low phanerophytes. Together covering 70 % and more.	**[Land cover] in (1, 2)** AND [Substrate Percent] <30 AND [Shrub cover] >= 70 AND [Land use] in (0, 1, 2, 3, 4, 19, 90, 97, 98, 99)
TRS/THP	127	Tall phanerophytes, tall shrubs, height between 2.0-5.0 m.	Will be merged with Forest phanerophytes FPH. Can be extracted as a class of its own, but with very high uncertainty.
TRS/FPH/TPH	128	Forest phanerophytes, trees, height over 5.0 m. Includes Tall phanerophytes. Together covering 70 % and more.	**[Land cover]** in (**1, 2**) AND ([Tree cover_1] + [Tree cover_2]) >= 70
TRS/MPH/MIX	1261	Combination: Other ground, mostly undershrubs with shrubs (mid phanerophytes) covering between 30 - 69 %.	**[Land cover] in (1, 2)** AND [Substrate Percent] <30 AND [Shrub cover] Between 30 and 69 AND [Land use] in (0, 1, 2, 3, 4, 19, 90, 97, 98, 99)
TRS/FPH/DEC	1281	Winter deciduous trees. Together covering 70 % and more.	**[Land cover]** in (**1, 2**) AND ([Tree cover_1] + [Tree cover_2]) >= 70 AND ([Broadleaved trees_1] + [Dry Wood_1] + [Beech_1] + [Other deciduous hardwood_1] + ([Broadleaved trees_2] + [Dry Wood_2] + [Beech_2] + [Other deciduous hardwood_2]) >= 70

TRS/FPH /CON	1282	Conifers. Together covering 70 % and more.	**[Land cover]** in (**1, 2**) AND ([Tree cover_1] + [Tree cover_2]) >= 70 AND ([Pine_1] + [Spruce_1] + [Pine_2] + [Spruce_2]) >= 70
TRS/FPH /DEC/CO N	12811	Combination: Winter deciduous trees/Conifers. Together covering 70 % and more.	**[Land cover]** in (**1, 2**) AND ([Tree cover_1] + [Tree cover_2]) >= 70 AND ([Broadleaved trees_1] + [Dry Wood_1] + [Beech_1] + [Other deciduous hardwood_1] + ([Broadleaved trees_2] + [Dry Wood_2] + [Beech_2] + [Other deciduous hardwood_2]) Between 30 and 69 AND ([Pine_1] + [Spruce_1] + [Pine_2] + [Spruce_2]) Between 30 and 69
TRS/SCH /FPH/DE C	124 / 1281	Combination: Other ground, mostly under-shrub and Winter deciduous trees covering between 30- 69 %	**[Land cover]** in (**1, 2**) AND ([Tree cover_1] + [Tree cover_2]) Between 30 and 69 AND ([Broadleaved trees_1] + [Dry Wood_1] + [Beech_1] + [Other deciduous hardwood_1] + ([Broadleaved trees_2] + [Dry Wood_2] + [Beech_2] + [Other deciduous hardwood_2]) >= 70
TRS/SCH /FPH/CO N	124 / 1282	Combination: Other ground, mostly under-shrub and Conifers covering between 30- 69 %	**[Land cover]** in (**1, 2**) AND ([Tree cover_1] + [Tree cover_2]) Between 30 and 69 AND ([Pine_1] + [Spruce_1] + [Pine_2] + [Spruce_2]) >= 70
TRS/SCH /FPH/DE C/CON	124 / 12811	Combination: Other ground, mostly under-shrub and a combination between Winter deciduous trees/Conifers together covering between 30- 69 %	**[Land cover]** in (**1, 2**) AND ([Tree cover_1] + [Tree cover_2]) Between 30 and 69 AND ([Broadleaved trees_1] + [Dry Wood_1] + [Beech_1] + [Other deciduous hardwood_1] + ([Broadleaved trees_2] + [Dry Wood_2] + [Beech_2] + [Other deciduous hardwood_2] Between 30 and 69 AND ([Pine_1] + [Spruce_1] + [Pine_2] + [Spruce_2]) Between 30 and 69
EVR		Evergreen trees, not conifers.	Not applicable.
NLE		Non-leafy evergreens	Not applicable.
SPI		Summer deciduous or spiky cushions.	Not applicable.

Herbaceous ground and mires

Some of the main differences in the category of Herbaceous ground (summarised in table 7), are that herbs and grasses/sedges are recorded as one category in NILS, and not separated. This means that the two categories Leafy hemicryptophytes (LHE) and Caespitose hemicryptophytes (CHE) has to be merged into one in the conversion. Therophytes, succulent chamaephytes, geophytes and herbaceous chamaephytes are not recorded as single variables or subclasses, and cannot be converted. Some of them may occur in quantities large enough for a polygon to be delineated, but they are not distinguishable enough in the aerial photos to be recorded with any certainty.

As mentioned before, the two categories of plants that grow in water (SHY and EHY), are merged into the water (SPV/AQU). Table 13 shows the conversions possible. Some combinations were necessary to convert all the polygons; one was plants that grow in waterlogged conditions, with a shrub/tree cover between 30-69 %. In reality it is a shrub/tree cover of < 50 %, since that is the limit of field cover recording in NILS. The two other were, broadleaved herbaceous species and bryophytes and lichens, with a shrub/tree cover between 30-69 %.

Table 13. Conversion of the NILS variables and subclasses into the Major class Herbaceous ground and mires in General Habitat Categories.

GCH in EBONE	**GHC as Number**	**Criteria**	**NILS variables and classes**
HER/SHY HER/EHY	113/114	Plants that grow in water, either complete under or sticking up.	Not applicable. The water plants are registered, that have the main plant above water, but the percentage is not recorded. Will be water body in the conversion, SPV/AQU.
HER/HEL	115	Plants that grow in waterlogged conditions	**[Land cover]** in (**1, 2**) AND [Substrate Percent] < 70 AND ([Tree cover_1] + [Tree cover_2] + + [Shrub cover]) < 30 AND [Field cover Type] in (6, 7, 8) OR **[Land cover] = 2** AND [Semiaquatic Type] = 1 AND [Lawn dominated by dwarf shrub] >= 70
HER/LHE /CHE	116	Leafy hemicryptophytes, broad leaved herbaceous species	**[Land cover]** =1 AND [Substrate Percent] < 70 AND ([Tree cover_1] + [Tree cover_2] + [Shrub cover]) < 30 AND [Field cover Type] in (1, 2) AND [Special case] in (0,2,3) AND NOT [EBONE] = '111'
HER/CHE	117	Caespitose hemicryptophytes. Perennial monocotyledonous	Is merged with the previous class LHE.

		grasses and sedges.	
HER/THE	118	Therophytes. Plants that survive during unfavourable seasons (drought) as seeds.	Not applicable.
HER/SUC	119	Succulent-leaved chamaephytes.	Not applicable.
HER/GEO	120	Geophytes, plants with buds below the soil surface.	Not applicable. Geophytes exist, but are not distinguishable in aerial photos.
HER/CRY	121	Non saxicolous (growing on or among rocks) bryophytes and lichens. Includes aquatic bryophytes, e.g. Sphagna and Racomitrium lanuginosum.	**[Land cover] = 2** AND [Substrate Percent] < 70 AND ([Tree cover_1] + [Tree cover_2] + [Shrub cover]) < 30 AND [Semiaquatic Type] = 1 AND ([Lawn dominated by dwarf shrub] + [Other Lawn] + [Carpet]) >=70 AND NOT [EBONE] = '115'
HER/HCH	122	Herbaceous chamaephytes, and not shrub formed.	Not applicable.
HER/HEL /TRS/MPH /TRS/FPH	1151	Combination: Plants that grow in waterlogged conditions, with a shrub/tree cover between 30-69 %. In reality it is a shrub/tree cover of < 50 %, since that is the limit of field cover recording in NILS.	**Land cover]** in (**1, 2**) AND [Substrate Percent] < 70 AND ([Tree cover_1] + [Tree cover_2] + [Shrub cover]) Between (30, 69) AND [Field cover Type] in (6, 7, 8) OR **[Land cover] = 2** AND [Semiaquatic Type] = 1 AND [Lawn dominated by dwarf shrub] >=70
HER/LHE /TRS/MPH /TRS/FPH	1161	Combination: Broadleaved herbaceous species, with a shrub/tree cover between 30-69 %. In reality it is a shrub/tree cover of < 50 %, since that is the limit of field cover recording in NILS.	**[Land cover] = 1** AND ([Tree cover_1] + [Tree cover_2] + [Shrub cover]) < 30 AND [Field cover Type] in (1, 2) AND [Special case] in (0, 2, 3) AND NOT [EBONE] = '111'

HER/CRY /TRS/MPH /TRS/FPH	1211	Combination: Bryophytes and lichens, with a shrub/tree cover between 30-69 %. In reality it is a shrub/tree cover of < 50 %, since that is the limit of field cover recording in NILS.	**[Land cover] = 2** AND [Substrate Percent] < 70 AND ([Tree cover_1] + [Tree cover_2] + [Shrub cover]) Between (30, 69) AND [Semiaquatic Type] = 1 AND ([Lawn dominated by dwarf shrub] + [Other Lawn] + [Carpet]) >=70 AND NOT [EBONE] =in ('115', '1151')

From these conversions all the polygons in the copy of the NILS database could be converted and the deliverable could be met. Figure 12 shows the result with only the highest level of General Habitat Categories generalised, which was desired. In figure 13 the combinations occurring in the same NILS square is shown.

Figure 12. A NILS square with the polygons converted into General Habitat Categories and generalised into the superlevels as required by the EBONE project.

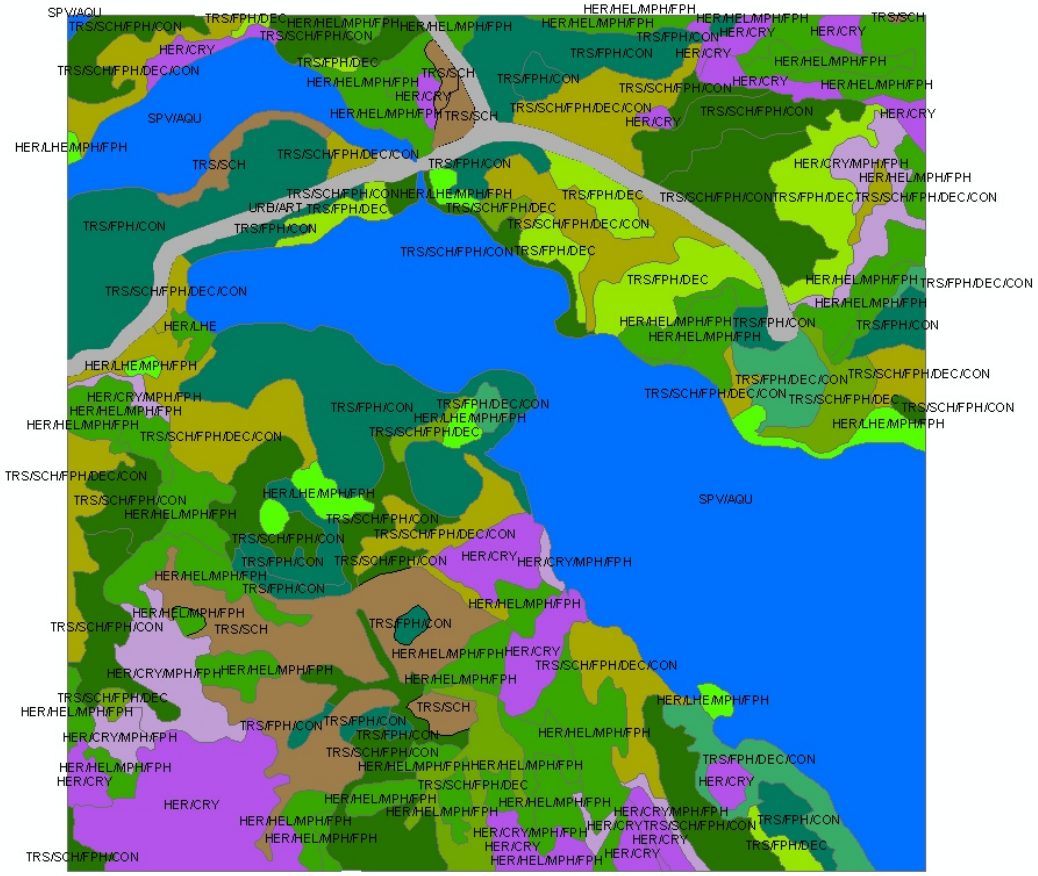

Figure 13. The NILS square in figure 12 with the polygons converted into General Habitat Categories with the combinations.

Possibilities for sublevel conversions

Variation within a General Habitat Category can be expressed by environmental and global qualifiers, which are combinations of soil humidity, nutrient status, acidity and other habitat characteristics. Important additional information is given by adding codes from predefined lists of global, environmental and site qualifiers. These are listed in the 2010 handbook and only summarily handled here.

The global qualifiers refer to the setting of an element (height or scattered trees) or to the accessibility of the element or reference previous data (data missing). Some of them can be gotten from the Macro pattern of trees and of shrubs in NILS, where the way of scattering is recorded, and also the structure/texture of the canopy in forests. The complex of linear elements from GHC:s is only recorded in NILS for the special type of ditches, which are common in wet forestry areas, otherwise all lines are recorded as they are, even if complex.

Environmental qualifier codes are used for areal and linear elements in order to express variation between elements that have the same GHC. They are not applied to urban/constructed, crop or sparsely vegetated elements in the EBONE project. Here the moisture is recorded in a number of subclasses, and also the Ellenberg values. In NILS the moisture is also recorded, but not the Ellenberg values, they can sometimes be inferred, and some of them may be gotten from the field data, but not with great certainty.

The site qualifiers is very long list of special conditions where the Geomorphological elements are in some cases also recorded in NILS, such as solifluction terraces, cliffs, rocks, snow patches or glaciers but others are not, such as drumlin, esker or canyons. None of the geological qualifiers are recorded in NILS, soil types are recorded in the field inventory of NILS but not in the aerial inventory. Of the inland water qualifiers, water courses, lakes and ponds are recorded. Springs can be recorded, but are usually only evident from above if they are emerging in mires. Historical/archaeological elements such as ruins, mark pits or hut circles are not recorded in NILS. Nor are the sea/marine elements, although fish farm is recorded in inland lakes or rivers. Of the coastal elements maritime exposure is recorded, but from the other side, such as erosion from water, instead of the salty waters effect on the vegetation. The Bogs/mires/wetlands are in many instances recorded also in NILS, valley mire and transition mire are not, and fens are recorded using the angle of slope as distinguishing feature, mainly due to the large portion of mountainous area in Sweden. Out of the elements with woodland or sparse trees (as most of the geological or geomorphological elements), most of them have to be gained by map analysis. From the many types of waterways, paths and tracks, fences, walls and hedges, only stone wall is recorded, and hedge with the distinction of deciduous or coniferous. Most of the distinctive types (mortared wall, if there are gaps or not in the wire fence, hedge stock proof or non stock proof) have to be visited in the field to be possible to pinpoint.

The management qualifiers are mostly possible to incorporate. Also some of the agricultural, such as annual crops, fallow and grazing. Peat working is recorded in the semiaquatic land cover and field margins are recorded if they reach 5 meters wide. In the forestry section, clear cut, standing dead wood and thinning are recorded. Recreational areas are recorded as just that, recreational areas in NILS, but golf courses, bathing site, camping and slalom slopes are distinguished from “other”. Of the urban qualifiers, NILS records agricultural, airport, commercial, fish farm, industrial, opencast mine, port/harbour area, quarry, railway, recreational, residential, road, sand pit, gravel pit, track and waste deposit (although not distinguished into domestic and industrial).

Type of crop or species of grazing animal is not recorded in NILS.

The detailed life forms and species composition is not recorded in NILS, a fixed list of species is recorded in the field data, and statistical measures can be obtained of the species from this list.

Annex 1 habitats are recorded in the field data, and statistical measures can be obtained from the twelve field points in each square.

Of the Farmed and Non-Farmed features, five of the seven types can be derived from NILS data. These are; (1) Fields managed only for agricultural objectives
(5) Linear or point features on, or adjacent to, farmland that are managed directly or are likely to be highly influenced by farming activities e.g., hedges on farmland and grass strips between fields.
(6) Linear or point features on, or adjacent to, farmland that are indirectly influenced by current agriculture but are not managed actively (e.g., field corners and small woodlands surrounded by agricultural land).
(7) Land not used by agriculture (usually urban herbaceous) and managed usually by mowing, e.g., roadside verges, recreation areas and sport fields.

So, in conclusion, many but not all of the objects and elements that can be derived from long field works, can also be derived from a detailed NILS square of 1 x 1 km, which is fully inventoried in 3 days, on average.

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Appendix 1: Variables in NILS used for the conversion into General Habitat Categories

These variables and their subclasses are given here as their name only. When working with the inventory, each person has a thick manual, describing how to view each variable and subclass and also lengthy definitions for what they do, and do not, entail. The variables that are not used in this current work are even more summarised, and without their subclasses. In Allard et al. (2003), a better understanding might be gained. The publication is downloadable from the NILS home page (http://nils.slu.se).

The interpretations follow a set path through the variables and allowed choices, made possible by a digital protocol. The protocol is to inhibit any logical inconsistencies, which are directly pointed out, or if the percentages do not add up to 100 %, e.g. for moisture or tree species mixture. These inconsistencies have to be corrected by the inventory personnel, in order to be able to proceed. A digital protocol is also made for the line and point objects.

When using aerial photos in stereo mode, the interpreter uses all his/her biological, geological, geomorphological, cultural and landscape-ecological skills to read the landscape and its details. Due to the infrared photos (once developed by the military forces, as they make it impossible to hide camouflage-painted equipment in green vegetation), such things as the health of the vegetation, the thickness of leaves and cuticulas, moisture regime, soil types and herbal content in woody underbrush can be determined. Also the percentages of vegetation cover in total over an area. Due to the stereo effect, also the height of the objects can be measured, as well as the logical understanding colour differences due to differences in moisture, nutrition and shadow effects from sun inclination.

Variable:
Land cover and naturalness

Code	Subclass	Remark
1	Terrestrial ground	Refers to natural and semi-natural ground
2	Semi-aquatic ground	Refers to natural and semi-natural ground
3	Aquatic	
4	Arable land	
5	Built-up area (founded)	
6	Artificial impervious area/ paved ground	
7	Artificial green area	
8	Pit, quarry, peat extraction	
9	Waste, deposits	
10	Glacier or snow covered ground	
99	Non-interpretable	Clods, shadows

Variable:
Substrate cover

Variable	Allowed values
Substrate cover	1 – 100 %

Variable:
Tree cover

Variable	Allowed values
Tree cover	1 – 100 %

Variable:
Composition of tree species.
The tree species are listed below in groups and are registered as a percentage of the tree cover.

Subclass	Part of total tree cover
Pine (Pinus sylvestris) (including Lodgepole pine (Pinus contorta) and Larch (Larix spp.))	0 – 100 %
Spruce (Picea abies)	0 – 100 %
Broad-leaved trees (”trivial” broad-leaved tree species except deciduous hardwood)	0 – 100 %
Dead trees (standing dead trees)	0 – 100 %
Beech (Fagus sylvatica)	0 – 100 %
Other deciduous hardwood	0 – 100 %

Variable:
Cover of shrubs and smaller trees

Code	Subclass	Cover proportion
0	No occurrence of shrubs	0
1	Occurrence of shrubs, cover can be interpreted	1 – 100 %
2	Occurrence of shrubs, cover cannot be interpreted	
99	Shrub layer cannot be interpreted	

Variable:
Field layer and ground layer

Code	Subclass
0	Field layer/Ground layer missing
1	Grass- or herb dominated
2	Mixture of dwarf-shrub and grasses
3	Dwarf-shrub dominated
4	Dwarf-shrub of lichen type
5	Lichen type
6	Belt formation of Phragmites australis, Typha sp. and Iris pseudacorus
7	Tall Carex species, Equisetum spp. and Scirpus lacustris
8	Low-growing carex species (mat forming)
9	Sphagnum dominated
10	Dominated by mosses –not Sphagnum
11	Logging residues
99	Field layer/Ground layer cannot be interpreted (e. g. in shadow)

Variable:
Type of semi-aquatic ground

Code	Subclass
1	Mire (bog or fen)
2	Ground, at times waterlogged, with connection to freshwater
3	Ground, at times waterlogged, with connection to salt or brackish water
4	Other wet land

Variable:
Hydrological mire type

Subclass	Percentage
Lawn dominated by dwarf-shrub	0 – 100 %
Other lawn	0 – 100 %
Carpet	0 – 100 %
Mud-bottom	0 – 100 %
Flark pools	0 – 100 %
Pools	0 – 100 %
Swamp fen	0 – 100 %

Variable:
Type of aquatic surface

Code	Subclass
1	Open freshwater
2	Fresh water with water vegetation
3	Open salt- or brackish water
4	Salt- or brackish water with water vegetation

Variable:
Type of water vegetation

Code	Subclass
1	Belt formation of Phragmites australis, Typha sp. and Iris pseudacorus
2	Tall Carex species, Equisetum spp. and Scirpus lacustris
3	Floating-leaved plants
4	Other

Variable:
Glacier or snow covered ground

Code	Subclass
1	Glacier and other permanent snow and ice-covered ground
2	Occasionally snow-covered ground
3	Incomplete snow cover (area with a mosaic pattern, where the vegetation cannot be interpreted, usually due to late thaw)

Variable:
Cover proportion on built-up area

Subclass	Cover proportion
Buildings	1 – 100 %
Artificial impervious ground	0 – 99 %
Substrate	0 – 99 %
Artificial green area	0 – 99 %
Other/natural ground	0 – 99 %

Variable:
Land use

Code	Subclass	Code	Subclass
0	No apparent land use	43	Industrial activities, trade, technical establishments
1	Forestry	44	Churchyard, burial ground
2	Forestry, area left for nature conservation purposes	45	Petrol station
3	Seed orchard	46	Public service and activities
4	Power line clearing strip	47	Public place, square
10	Arable land in rotation of crops	50	Road, vehicle parking
11	Grazed ley	51	Railway, railway yard
12	Ley for hay making	52	Airport
13	Arable field hard to classify	53	Harbour
14	Energy forest plantation	60	Power station dam, magazine
15	Fruit orchard cultivation	61	Purification dam
16	Berry bushes	62	Fish-breeding, aquaculture
17	Other cultivation	63	Irrigation pond
18	Grazing (excluding pasture in arable field)	70	Sand and gravel pit
19	Enclosure for reindeer	71	Quarry, mine
30	Park (inclusive public lawns)	72	Peat workings
31	Golf course	73	Vegetable topsoil stripping
32	Ski slope	77	(”Blocked number”)
33	Bathing area	80	Refuse dump
34	Camping ground	81	Sand, gravel, stone and soil deposits (waste)
35	Stadiums and other buildings assigned for exercises	82	Sedimentation pond
36	Other recreational area, semi-natural	88	(”Blocked number”)
37	Allotment cultivation, flowerbeds	90	Area under military command
40	Estate, Property (outside urban areas)	97	Ongoing exploitation
41	Agricultural built-up area	98	Other land use
42	Cluster of dwelling houses	99	Land use cannot be interpreted

Variable:
Special cases – forestland/climate-induced non-productive land

Code	Subclass
0	Not applicable
1	Productive forestland (height and m^3 production)
2	Alpine areas, including alpine forest
3	Climate-induced, treeless, non-productive land below alpine forest limit

Variables in NILS not used in the GHC conversion

Areal features

- Non-interpretable - reason
- Type of substrate
- Deviating part of a land cover and natural class
- Type of deviating main type/land cover class
- Tree height
- Areal distribution of trees, Macro pattern
- Height dispersal
- Occurrence of broadly crowned trees
- Areal distribution of shrubs and small trees, macro pattern
- Conifer proportion of shrubs and small trees
- Moisture
- Hydro-topographic mire type
- Earlier land use
- Growth phase in productive forestland
- Measures taken, anthropogenous influence
- Influence of grazing
- Patterns in built-up areas
- Attribute
- Notation

Line objects

- Transport routes
- Enclosures
- Vegetation strip
- Soil banks and banks
- Ditch/watercourse
- Manmade rows of trees and shrubs
- Cables, pipelines, lifts, etc.
- Screes, steeps and artificial steeps
- Other line objects

Point objects

- Broadly crowned solitary tree
- Biotope islet
- Mound of stones/boulder/rock outcrop
- Ponds, wetlands, wells
- Pit, waste
- Buildings
- Building constructions in water