

# Skogbruk og biologisk viktige områder i Norge

## GIS-basert dokumentasjon av areal med restriksjoner i forhold til miljøsertifisering av skog

Heidrun Miller

*Heidrun Miller: Forestry and Areas of Ecological Importance in Norway. GIS-based documentation of forest area set aside for conservation by certification*

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An important aspect of the revised Norwegian forest certification scheme is the area subject to restrictions in use as specified by the requirement sections of the Living Forests Standard. In this paper, available geographical data on the municipal level are analyzed regarding the requirements for certification and the level of standardization of the data. A conceptual model is then constructed which extracts all possible restricted areas from existing geographical data. A workflow model is implemented in ModelBuilder based on the conceptual model. The conceptual model provides excellent documentation of the processes run to extract the areas subject to restrictions. Using the workflow model it is possible to document areas set aside for restricted use at the municipal level all over Norway.

*Key words:* Forestry, certification, Areas of Ecological Importance, graphical programming languages, workflow model

*Heidrun Miller:* Z\_GIS Salzburg University – Austria . GIS-leder: ALLSKOG BA, Ingvald Ystgaardsvei 13A, NO-7047 Trondheim. E-post: heidrun.miller@allskog.no

### Introduction

In Norway the forest certification scheme called Living Forests Standard (LS) was revised from 2003 to 2006. One of the main changes in the revised LS is a requirement for a minimum of five percent of the forest area to be compromised and set aside for conservation as Areas of Ecological Importance (AEI). In these areas all logging operations are prohibited or forestry coupe is allowed only in order to preserve special habitats and living conditions. Documentation can be carried out on the regional level (Living forests – Standard for sustainable forest management in Norway, 2006).

In this paper it is assumed that the forest area treated as Areas of Ecological Importance on a regional level can be documented using already existing geographical data (geodata) and results from previous forest inventory and biodiversity appraisal in each municipality. To test this assumption, methods are developed to create and extract the

geodata. I also demonstrate that available geodata at municipality level are standardized well enough to support a conceptual model for documenting AEI which is valid for all municipalities in Norway. In addition, a workflow model is established on basis of the conceptual model to test the assumptions made when documenting AEI. Graphical programming languages are used to create the workflow model, making it transferable, reliable and repeatable. Other major advantages expected by implementing the workflow model with a graphical programming language is the visual documentation value and the opportunity for non-geoinformatics-specialists without having special programming competence to implement a model.

Following a brief introduction to the requirement sections of the LS concerning AEI, the geodata available on behalf of the forest owners are described. A conceptual model is then developed that extracts or creates polygons fulfilling the criteria for AEI.

Finally, a workflow model is implemented in ModelBuilder, within an ArcGIS environment. This workflow model makes it possible to run AEI documentations for municipalities all over Norway.

### Living Forests Standard

The Living Forests Standard is the basis for the Program for the Endorsement of Forest Certification Schemes (PEFC) certification scheme in Norway. The standard has 25 requirement sections. The requirements pertain to a wide range of forest activities from waste management to correct handling of Sami rights.

Several of the requirement sections refer directly to the requirement to set aside AEI. These sections are: (I) Key habitat appraisal. (II) Forests protected in nature reserves and forests protected in national parks pursuant to the national Nature Conservation Act. (III) Natural old growth and mature forests. (IV) Pasture woodland (V) Sump and bog forests. (VI) Coastal spruce forests. (VII) Broad-leaved temperate forests. (VIII) Buffer zones to rivers and brooks wider than 1 m. (IX) Buffer zone to agricultural landscape patches larger than 2 decares. (X) Buffer zone to marshes and mires larger than 2 decares. (XI) Economically unproductive forest bordering on key habitats and other AEI in productive forests. The buffer zones are defined to be 10 metres on average. Some conditions allow narrower buffer zones; others require broader zones (Living forests – Standard for sustainable forest management in Norway, 2006). All the listed sections are considered and their requirements are compared to the available geodata in the conceptual model.

### Available and accessible geodata

Existing geodata on municipality level are presented and analyzed here, in the search for geodatasets that can be used in the AEI documentation. Geodata from three main sources are considered. First 'Felles kartdata base' (FKB-dataset) is introduced. FKB is a versatile large-scale dataset including everything from cadastral data and a full Land cover dataset to Water and Elevation data.

Second, the geodata specified by the Norwegian Forest and Landscape Institute are described, including Regional forest inventory and Key habitat appraisal data. Finally, municipal data and data managed by the Norwegian Directorate for Nature Management concerning the standards requirements are analyzed.

### FKB-dataset

The FKB-dataset is produced at scales from 1:500 to 1:20000 and is intended for use by all sectors of municipal administration, the road traffic department and the power authorities. The FKB-dataset uses the SOSI standard (Samordet Opplegg for Stedfestet Informasjon) which is, together with the GEOVEKST agreement, a major part of the national geodata infrastructure. GEOVEKST is a nationwide program for co-operation in the collection and management of digital geographic data in Norway (Høstmark, 2002).

FKB-dataset produced and specified in the SOSI standard is within GEOVEKST also defined to be available in the shape format used by ESRI (Environmental Systems Research Institute). In the context of this article, one main difference between SOSI-format data and shape-format data is that SOSI-format data can include point, line and polygon objects in one file, whereas shape-format data need one file each. The following files will be used:

- Land cover (polygon features)
- Administratively protected areas (polygon features)
- Water (polygon features)
- Water (line features)

All four of the listed files can be used to document areas restricted by at least one of the requirement sections. All the attributes described in the following sections are based on version 3.4 of the SOSI standard since the AEI documentation project began in 2007.

### Land cover

Much information for the AEI documentation can be extracted from the Land cover dataset. The attribute «ATIL» assigns a value to the land cover type of each patch. The most important values of this attribute are

listed in Table 1. Other relevant attributes are site classes and additional information for forest sites («TSKOG»).

Several selections can be performed on basis of these values, shown in Table 2. First, all sites classified as forest can be extracted.

This is a reference file used to distinguish forest areas from buffer zones in other operations. Second, bog forests and mires are extracted in a dataset each. Lastly, cultivated landscape requiring a buffer zone is selected from this dataset.

Table 1: List of «ATIL» values in the Land cover dataset

Value	Explanation
11	Bog or Mire
12	Bog with coniferous trees
13	Bog with coniferous and broadleaved trees
14	Bog with broadleaved trees
21	Fully cultivated landscape
22	Superficial cultivated landscape
23	Other farming land
24	Coniferous woodland
25	Broadleaved woodland
26	Coniferous and broadleaved mixed woodland

Table 2: Selection and usage of the Land cover dataset for AEI documentation

Dataset	Attribute	Selection value	AEI relevance
Land cover dataset	Land cover type («ATIL»)	'12','13','14', '24','25','26'	Reference dataset for all forest classified land
Land cover dataset	Land cover type («ATIL»)	'12','13','14'	Bog forests
Land cover dataset	Land cover type («ATIL»)	'21','22','23'	Cultivated land requiring buffer zone

### Administratively protected areas

This dataset includes polygon data for areas that are administratively protected in National Parks, Landscape preservation and Nature reserves. The purpose of protection is defined in an attribute («FORMAL»). This is relevant because some polygons, such as groundwater protection areas, do not put any restrictions on forestry except the usual sustainable forest management according to the LS, and would not be selected in the AEI model.

### Water

The polygons in the dataset include lakes, ocean polygons bordering on mainland and

rivers broader than 3 meters. All of these features require a buffer zone according to the LS. The line features include rivers, brooks and ditches to a very detailed level. For the AEI documentations the object class value 'ElvBekkMidtlinje' defines rivers and brooks. The attribute «VANNBR» helps identify rivers that require a buffer zone. The value '2' of this attribute defines rivers and brooks with a breadth of 1–3 metres. The standard demands a buffer some for both the polygon features and the rivers from 1–3 meters. Table 3 lists the selections of administratively protected areas and both water datasets.

Table 3: Selection and usage of the Administrative protected area and Water datasets for AEI documentation

Dataset	Attribute	Selection value	AEI relevance
Administratively protected areas	Purpose of protection (« <i>FORMAL</i> »)	No fixed set of values defined, areas that don't restrict forestry have to be filtered out	Administratively protected areas set aside from forestry
Water dataset (polygon features)	Object type (« <i>OBJTYPE</i> »)	Rivers (« <i>ElvBekk</i> »), Lakes (« <i>Innsjø</i> »), Ocean (« <i>Havflate</i> »)	Required buffer zones
Water dataset (line features)	Object type (« <i>OBJTYPE</i> ») and breadth of the river « <i>VANNBR</i> »	Rivers and brooks (« <i>ElvBekkMidtlinje</i> ») Breadth of the river and brooks 1–3 meters (« <i>2</i> »)	Required buffer zones

### Regional forest inventory and Key habitat appraisal

In 2006 the Norwegian Forest and Landscape Institute (NFLI) issued a specification for the delivery of Regional forest inventory and Key habitat appraisal data that includes only the most important attributes. The NFLI requires all geodata deliveries to be in the ESRI shape format (Norsk institutt for jord- og skogkartlegging (NFLI), 2006).

The Regional forest inventory dataset will mainly be used as reference data to calculate

the percentage of productive forest qualifying as AEI. The dataset is also used to evaluate the AEI sites with regard to maturity classes, site productivity classification and dominating tree species. Maturity classes, especially, are important for further assessments of the AEI sites.

In Norway, five maturity classes are defined, each of these having two subcategories for density. Only forests on economically productive sites are classified according to maturity. Table 4 shows the division into classes.

Table 4: Maturity classes in productive forest sites

Maturity class	Description
1 ('11', '12')	Forest under regeneration
2 ('21', '22')	Young forests
3 ('31', '32')	Younger production forests
4 ('41', '42')	Older production forests
5 ('51', '52')	Older and more mature forests

Key habitat appraisal (KHA) has been part of the Living Forests Standard certification program since 2001. The specification of the NFLI defines a set of attributes for the KHA, such as classification of the habitat, vegetation types and topography at the site. The important attribute for this AEI documentation is the attribute «*UTVALGT*». This attribute is given the features after registration of key habitats for a whole municipality. If the feature is defined to be rare the value for «*UTVALGT*» will be set to '1'. If the feature is not that extremely valuable after all the value '2' will be given.

### Naturbase

Naturbase collects and administers in one database data on: (I) Nature types; (II) Wildlife species demanding special care; (III) Wildlife species of great economic importance; (IV) Threatened species; (V) National parks, Landscape preservation and Nature reserves; (V) Suggested Nature reserves and (VI) Biodiversity in general.

The Norwegian Directorate for Nature Management (DN) assembles, administers and publishes these data in a web client and as a Web Map Service (WMS). However, it is the responsibility of the municipalities and

their respective county governments to gather the data. While the data in Naturbase that are covered by a part of SOSI standard are reliable within the definitions given there, the accuracy of data on other features such as wildlife habitats is often unknown. Habitats are often registered on a small scale (less detail) and there are often no metadata available on the origin of these data.

Naturbase is for this reason considered the least standardized dataset used in the conceptual model. Before using this dataset, one has to decide what parts of the dataset can be used. There is no fixed set of possible values for the most important and descriptive attribute «NATURTYPE», but this attribute can nevertheless be used to select features found in one of the requirement sections of the LS.

### Conceptual model

The basis for the documentation of Areas of Ecological Importance has been introduced above. In this section a conceptual model will be developed that connects the given conditions with the requirements for documenting AEI within a municipality. Polygons that are likely to have high ecological importance can be extracted or constructed from each of the datasets mentioned under the heading 'Available and accessible geodata'. Some of the AEI can simply be extracted using an attribute query in the dataset. Others datasets are input to a geographical analysis in order to extract and create polygons fulfilling criteria of the AEI. All input datasets are defined such that they have no overlapping features within the dataset.

The figures below show the conceptual workflow model. They all have a similar structure. A part of the model can be read from left to right, and the processes are run in that order. Processes in horizontal rows can be run independently from other processes in other rows as long as they are not vertically connected and there is no indication to the contrary. Dark blue ellipses symbolize existing data which are given as a basis. Yellow rectangles represent an action such as an attribute search, a field update or a geoprocessing operation. The light blue el-

lipses are parameters of the model that can be adjusted before running the model. The green ellipses represent the results of an action. These results are often reused in the next action and are temporary results, or they may be a final result of the model.

Figure 1 shows the processes to extract the gross Area of Ecological Importance. Since the defined datasets don't always cover the same geographical area and one may wish to run the analyses for a given area at some point, a dataset called «Area of analysis» is introduced. The user will have to define the area of analysis before running the model. All source datasets will be clipped to the Area of analysis before the rest of the model is run. Features chosen from the KHA file, features that require set a side for conservation from Naturbase and bog forests from the Land cover dataset can be selected from their source data. As a result the first three gross AEI files are extracted.

In the next step, all water features, mires and cultivated land patches are selected according to the attributes described in the FKB-data section. A buffer zone operation is then performed for each of these selections. The buffer distance is implemented as a parameter and can be chosen before running the model. The results of the buffer zone operation include all land cover types. They have to be clipped against the selection of forest land from the Land cover dataset as selected in Table 2. Administratively protected areas cover all land cover types as well. A «clip» operation is run on the selection of protected areas that restrict forestry and the dataset on forest covered land.

With these steps of selections and geoprocessing operations the gross Areas of Ecological Importance have been extracted and created. At this point the AEI for other requirement sections cannot be extracted from the available geodata.

The next step is to create a net AEI by combining the gross AEI with a «union» operation. A «union» operation is necessary to make sure that overlapping features are clipped to each other. Accordingly non-overlapping features with all original attributes are the result.

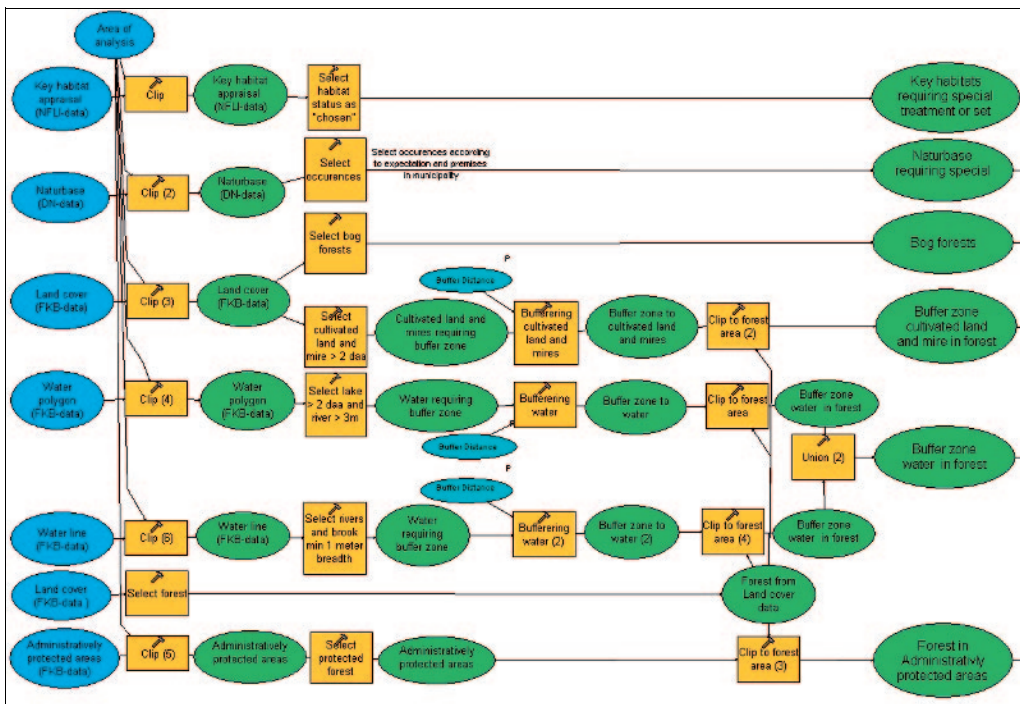


Figure 1: Conceptual workflow model for the gross Area of Ecological Importance

After this, a quality control is included that ensures that the net areas actually are entities that are manageable on their own in forestry. The workflow model contains steps to reduce stand-alone polygons smaller than 2 decares from the dataset. This is shown in the continuation of the conceptual model in Figure 2. The polygons sharing a border in the net AEI dataset are first merged together to ensure that only small, stand-alone polygons are deleted. In this new, temporary dataset, the

area in each polygon is recalculated and only polygons up to an area of 2 decares are selected. Polygons from the net AEI dataset in the same geographical locations as the selected polygons up to 2 decare from the temporary dataset, can then be chosen by a geographical selection «are contained by» and deleted from the original net AEI dataset.

The following step will update the AEI with attributes from datasets for Forest Inventory and from Land cover data. To update

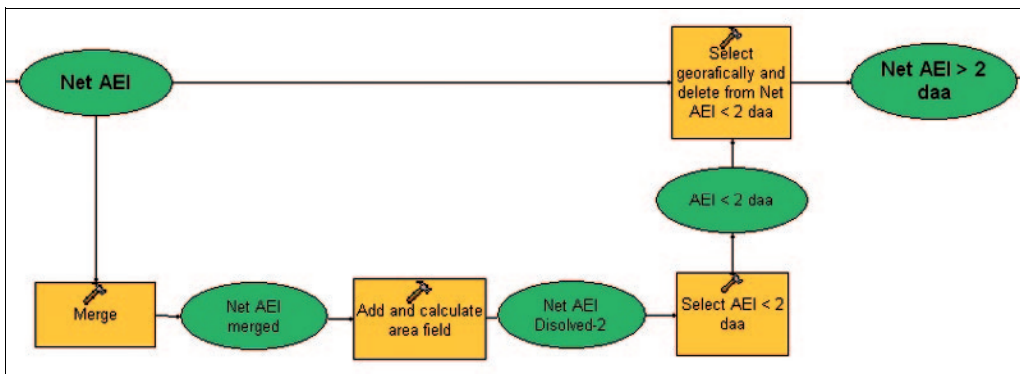


Figure 2: Conceptual workflow model for reducing AEI of unmanageable polygons

with attributes from the Land cover dataset an «intersect» operation is run between the net AEI and the forest selection of the Land cover data. To update with Regional forest inventory, a «union» operation is run. This is because forest inventory does not necessarily cover all of the area of analysis. Within administratively protected areas, especially, Regional forest inventory is often not carried out. After the «union» operation, features that are not AEI have to be deleted.

The resulting AEI file needs to be further evaluated. Even though the AEIs created are ecologically valuable, it is not expected that all of them have *high* ecological importance.

The AEI file therefore has to be further examined to divide it into sites that are either productive forest or economically unproductive forest, and to determine the ecological value of the different locations.

Figure 3 shows the selections made. The labels describe which areas are deemed to be of ecological high value and which areas are not taken into account. Of the possible AEI areas in productive forest, those from the Key habitat appraisal, Administratively-protected area and Naturbase registrations are completely counted.

The decision about whether to include buffer zones depends on the maturity class of

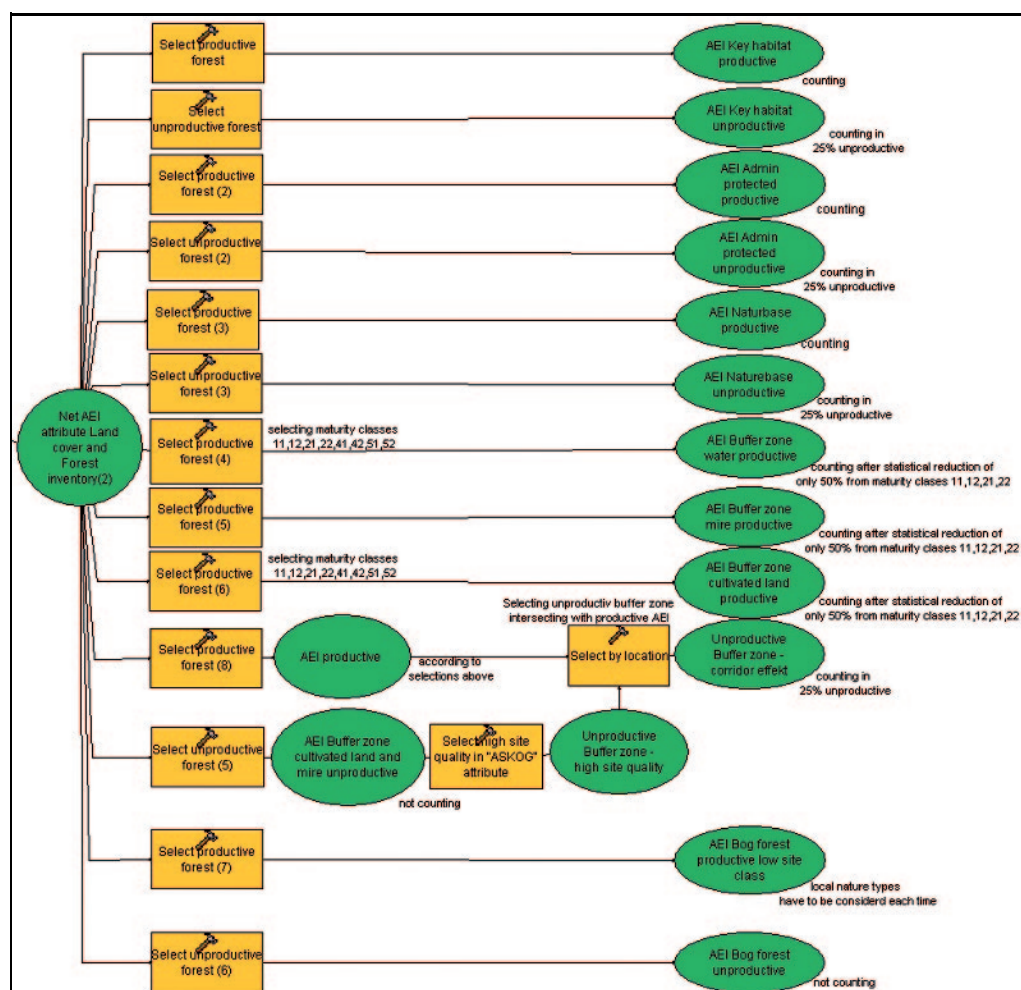


Figure 3: Conceptual workflow model for the division into origin classes and extraction of complementary buffer zones for the documentation

the location. In 2004 a report by Hobbelstad et al. (2004) evaluating the Living Forest Standard investigated the percentage of logging sites within buffer zones. The report showed that only 50 percent of today's maturity class 1 and 2 sites have an intact buffer zone. At the other sites the buffer zone is not intact due to poor conditions of the site before logging, lack of compliance with the certification conditions by forest owners, or inclusion of logging sites from before 1995 (i.e. before the LS was established) in this maturity classes (Hobbelstad et al, 2004). Buffer zones will therefore only count completely in maturity classes 4 and 5. They count 50% in maturity class 1 and 2 and not at all in maturity class 3, because this younger productive forest developed before the LS and it is not expected to have high biodiversity at this point.

Bog forests have to be evaluated with respect to the predominant nature type of the municipality and other local attributes, since many of these sites disappeared due to drainage (Often et al., 2004).

Unproductive forest sites can enlarge the AEI by up to 25 percent of the AEI of the productive forests. Unproductive areas from Key habitat appraisal, Administratively protected areas and Naturbase registrations and complementary buffer zones can be part of this group.

Complementary buffer zones are in direct contact with the productive AEI that are most likely to have high biodiversity. The complementary buffer zones typically have a corridor function, which is very important for connecting AEI from productive forest sites with each other. To extract the corridor zones, a geographical selection of all buffer zones in unproductive forest that intersect with AEI in productive forest (described in the previous section) can be performed. The resulting area is added to the documentation. The conceptual model of this evaluation process is included in Figure 3.

## Implementation

The conceptual model from the previous section shows how available geodata can be related to the requirement sections of the LS, and thus contribute to documentation of AEI.

An implementation was created in ArcGIS ModelBuilder (ArcEditor 9.2) based on the conceptual model, which is of overriding importance. ArcGIS and ModelBuilder are chosen because the datasets described are defined as available in shape format. ModelBuilder also offers an extensive selection of out-of-the-box geoprocessing tools, which are used in the conceptual model. The implementation of the main workflow follows the conceptual model closely where possible. Some parts of the concept model were not straightforward, however, and had to be implemented through extra steps and workarounds.

First of all, a structure for the model and its environment was defined to ensure that the model can be shared with other users. All model components are stored in one folder. It was defined in the model properties as storing intermediate data within this folder structure.

The first step when building the model was to create a personal geodatabase where reference files are stored, such as the forest selection from the Land cover data, the gross AEI files and the net AEI file. Extraction of KHA features and bog forests follows the conceptual model strictly. The selections for Naturbase and Administratively protected areas, which don't have a fixed set of values, are implemented as parameters of the model. This allows the selection to be adjusted to local conditions each time the model is run.

Implementing the buffer zone operations in ModelBuilder was problematic. Due to software limitations the operation could not be run for water polygons and mire polygons. ArcGIS, being native 32-bit environment software, cannot make use of the extended memory space available in the 64-bit systems (ESRI technical article, 2005). As a solution both datasets have been divided into two temporary datasets according to the polygon area. One file contains polygons from 2 – 10 decares and another file includes polygons larger than 10 decares. The buffer operation on these files works, and the temporary datasets can be merged together again by a «union» operation to ensure that no overlapping features are created.

A similar limitation caused a workaround when merging net AEI in order to delete un-



manageable polygons (q. v. Figure 2). This «merge» («dissolve») operation also crashes because of memory limitations. The work-around presented in the implementation is based on the tiling system, which ArcGIS is supposed to use if all available memory would be in use. The idea is to merge first within smaller areas and then continue to a bigger area. This idea is realized manually in the model. Two «intersect» operations are run. The first uses an index file of the ordinance survey on a 1: 5 000 scale and the second one a file scaled at 1: 10 000. These two files are distributed together with the model.

The selections to evaluate the net AEI shown in Figure 3 were implemented without any problem as described in the conceptual model.

## Result

The implemented model was run using two quite different municipalities in Norway. Since these are located in climatically and

geologically very different regions in Norway, the possibilities for utilising the area for agriculture, forestry and wilderness area also differ. The areas of analysis are the same as the area covered by Regional forest inventory but include administratively protected areas.

The resulting AEI of 10,7% in the municipality of Snåsa (Northern-Trøndelag) (see Table 5) is a much higher percentage of AEI than required for the whole municipality. This is not unexpected for this municipality as the climate is very harsh in the region. Agriculture and forestry are carried out only non intensively in large parts of the municipality. The table below also shows a summary of AEI as a percent of productive forest area only. This number can be an interesting assessment as well. At 8,8% in this municipality it is still very high, more than the required 5%, even without including unproductive forest.

The map in Figure 4 shows different AEI areas in a random part of Snåsa municipality.

Table 5: AEI results for Snåsa municipality

AEI net area	Area in daa
KHA productive	3110.36
Administratively protected productive	1593.45
Naturbase productive	1367.07
Buffer zone water productive (reduced maturity class 1+ 2 with 50%)	9327.16
Buffer zone mire productive (reduced maturity class 1+ 2 with 50%)	5816.76
Buffer zone cultivated land productive (reduced maturity class 1+ 2 with 50%)	1365.92
Bog forest productive (reduced to maturity class 51 and 52)	1248.03
<b>Productive AEI</b>	<b>23828.75</b>
<b>% AEI of productive forest</b>	<b>8.81</b>
KHA unproductive	21.27
Administratively protected unproductive	2333.68
Naturbase unproductive	58.56
Complementary buffer zones	3425.33
<b>Unproductive AEI</b>	<b>5838.84</b>
<b>Reduced (if more) to max 25 % of productive AEI</b>	<b>5838.84</b>
<b>Sum AEI</b>	<b>29667.59</b>
Productive forest area	270400.46
Forest area (Land cover data) in Area of analysis	399843.99
<b>productive forest area + unproductive AEI</b>	<b>276239.30</b>
<b>AEI % Snåsa municipality</b>	<b>10.74</b>

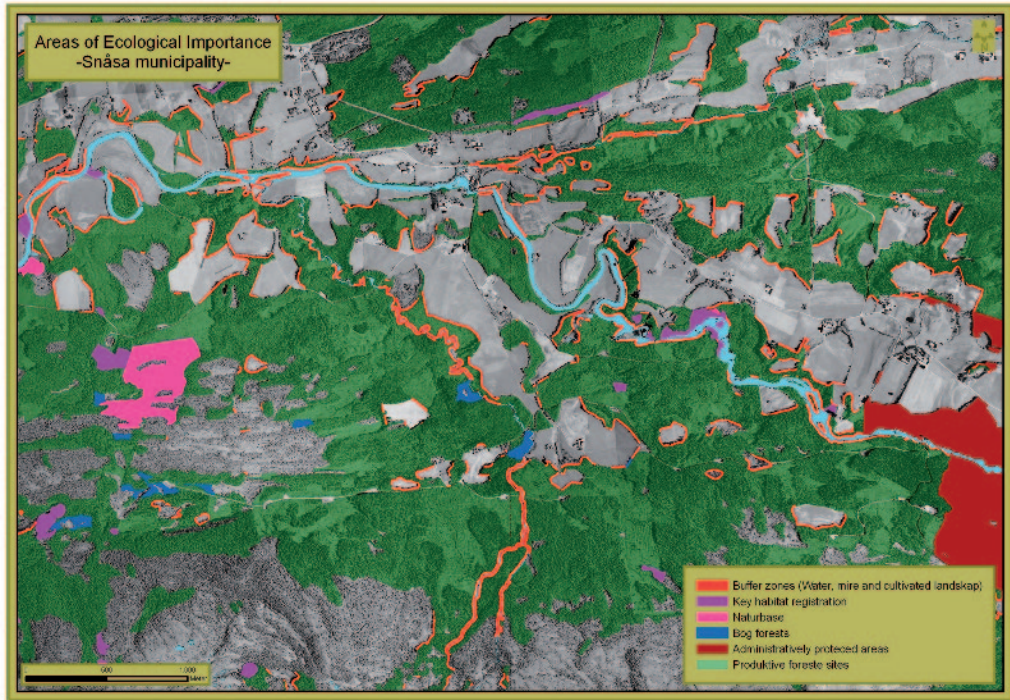


Figure 4: AEI in Snåsa municipality

The result for Løten municipality in Hedmark county is only 5.4%. This is much lower than in Snåsa and only slightly above the 5% mark required for the certification. Løten is known to be an intensively managed municipality. It is very well suited for agriculture and intensive farming has been taking place there for centuries. This also applies to forestry, which is still the dominating land use in the area.

### Conclusion

This paper shows how existing geodata on municipality level can be used for documentation of Areas of Ecological Importance in Norway. According to the demands set by the requirement sections of the LS, the following kinds of AEI can be extracted or created from the available geodata.

- Areas from Key habitat appraisal
- Administratively protected areas
- Areas registered in Naturbase
- Buffer zones to water

- Buffer zones to mire
- Buffer zones to cultivated land
- Bog forests

All source data for the areas mentioned in the list above, with the exception of the data from Naturbase, are standardized either through SOSI (the Norwegian geodata format and standardization scheme) or the Norwegian Forest and Landscape Institute. Naturbase is a non standardized dataset that the Norwegian Directorate for Nature Management assembles, administrates and publishes. It contains data on nature types, wildlife habitats, threatened species, etc. This dataset can be used where the data quality and accuracy are considered satisfactory.

The visual value the implemented model is far less than expected. Many parts of the model such as adding and calculating a field have to be done in several steps plus the workarounds, due to software or licence limitations. This leads to a very complex visual

impression of the model. The implemented model is not expected to have presentation value for non-GIS-specialists. The conceptual model is exclusively used for that task as it is a more appropriate level for non-specialists. Nevertheless, the necessary software skills were easily acquired, even though some challenges and limitations of the software had to be solved by workarounds.

Quality control of the data used in the model is not discussed in the article. Control of data quality as related to the data definition and data quality from a professional point of view are assumed to be part of the documentation process before running the model. The intention of the model itself is to document the amount of AEI in the municipality but it does not include quality control at this point.

Another issue that remains to be discussed is the currency of the data. This is not considered an issue for the conceptual model or the implementation in terms of the AEI requirements. However, it can have an impact on the availability of the data in the first place. Regional forest inventory data, for example, were originally supposed to be collected in a ten year cycle. In reality the available data can be much older than this. An evaluation of whether the data are up-to-date enough to calculate AEU in a municipality is therefore recommended, before running the model.

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