Predicted animal species distribution: use of expert models and satellite data in a geographic information system (GIS)

J.P. Bolstad [a], T. Krogh [a], K. Bevanger [b], M. Finne [c], L. Kastdalen [d]

[a] Directorate for Nature Management, N-7485 Trondheim, Norway – (jan-paul.bolstad, terje.krogh)@dirnat.no
[b] Norwegian Institute for Nature Research, N-7485 Trondheim, Norway – kjetil.bevanger@nina.no
[c] Utmarksavdelingen for Akershus og Østfold, N-1870 Ørje, Norway – mats.finne@havass.skog.no
[d] Norwegian Space Centre, N-0212 Oslo, Norway – lkastdal@online.no

Abstract – Mapping of potential habitat was made for all vertebrate species considered to breed consistently in at least one province of Norway, on the basis of spatial units equivalent to 30m Landsat TM pixels. Habitat models were developed as spreadsheets with columns representing habitat variables and rows representing species. The habitat variables were based on assumed or known species affinity for 21 available land cover categories that were identified from Landsat ETM+. These 21 categories were supplemented with GIS layers proving data on vegetation zones, elevation, and topography.

Keywords: vertebrate mapping, land cover, habitats, nature management

1. INTRODUCTION

The latest report on Norwegian compliance with the Convention on Biological Diversity is Report no. 42: Biological Diversity – Sector Responsibility and Co-ordination, produced by the Norwegian Government. The main focus of the report is on the establishment of co-ordination between all management sectors involved in the protection and sustainable use of biodiversity. To follow up this report a cross-sector National Programme for Mapping and Monitoring Biodiversity in Norway has been established.

The Directorate for Nature Management and the Norwegian Space Centre developed the SatNat-programme in 2001 as an important element of the National Programme for Mapping and Monitoring. Many early efforts to use satellite data in nature management were related to specific projects and were not suitable as management tools for nature management authorities. The main objective of the SatNat-programme is to "utilise the possibilities of satellite data to provide a better and more cost-efficient management of use and protection of biodiversity". The programme aims to produce decision support systems for use in the management of biodiversity.

According to the Norwegian Red List (Directorate for Nature Management, 1999), the main threat to biodiversity in Norway is loss of habitats due to forestry, agriculture, road construction, watercourse regulation to produce hydroelectricity and general urbanisation. Productive coniferous forests, wetlands, mires, swamp woodland and certain coastal habitats are all examples of habitats whose acreage has been reduced.

Mapping important areas of biodiversity is one of the most necessary and basic elements for preventing further erosion of biological resources. The SatNat programme initiated a project with the goal of mapping potential habitats for vertebrate species considered to breed consistently in Østfold Province. An accuracy assessment was carried out (Finne 2005) and the results indicate that this type of mapping is valuable for wildlife mapping based on field surveys on a regional level. The principles of this type of vertebrate mapping are derived from the National GAP Analysis Programme in USA (Csuti & Crist 2000).

2. STUDY AREA AND DATA SET

Østfold County (4183 km^2) is located in southeast Norway, bordering Sweden (Fig.1). The area is characterized by farming landscape, forests and cities with up to 83 000 habitants each. The topography is quite flat, ranging from sea level to 336 m. a.s.l. Typically, the farming landscape is located below the marine limit in clay, silt and sandy soils, while hilly forests on subglacial till soils dominate the areas above the marine limit.

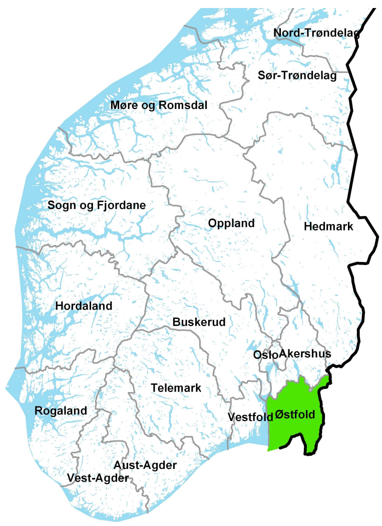

Figure 1. Østfold County, Norway. Test County for mapping potential habitats for vertebrate species.

To map the potential habitats we used parameters from land cover maps produced in Østfold province based on multitemporal Landsat ETM+ images, data from private and public forestry, and data from non-forested areas (Vikhamar, et al. 2004). The estimated forest parameters were: selection of tree species, cutting classes, wood volume per hectare and productivity class. For non-forest areas we used crop fields, pastures and impervious areas (eg. roads, parking lots, buildings) with more or less than 50% green areas.

Different qualities of the environment tend attract, or repel, a given wildlife species. We used topographic maps (scale 1:50 000), vegetation zones (Moen, 1999) and digital elevation models (25 meters) from the Norwegian Mapping Authority to discriminate environmental qualities that are used or not used by a given species (eg. roads, water, built-up areas, etc.).

Distribution data from the Norwegian Ornithological Association, the Norwegian Zoological Association, and species distribution data from the County Governor of Østfold were used to delimit the species range extent in 10x10km quadrats (Figure 2). The species range extent was used to delimit the habitat maps for each species. Continuous habitats that intersect with the quadrats were included.

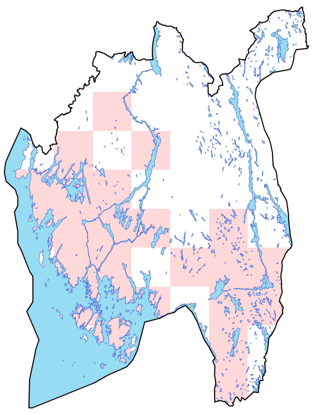

Figure 2. Data from the Norwegian Ornithological Association indicate the range of Woodlark (*Lullula arborea*) in 10x10km quadrates in Østfold County.

Habitat models were developed as spreadsheets, with columns representing habitat variables and rows representing species. Habitat variables from land cover, vegetation zones, elevation and topographic maps were coded with 0 (not relevant to the species), 1 (habitat type required by the species) or 2 (habitat type may be used by the species/insufficient knowledge of use). Buffers were used when avoidance of, or attraction to, different environmental qualities were known for the species.

The analyses were performed employing a GIS extension in Arc View 3.2, using data from the habitat model and the species range extent. All map layers were transformed to a raster format equivalent to 30m Landsat TM pixels. Habitat variables of land cover, topographic maps, elevation and vegetation zones were related to each species in different map layers. The map layers were reduced to one map layer with the use of overlay and merge operations in the extension. The range extent and majority filter were used to reduce the distribution and to eliminate single pixels.

3. RESULTS AND DISCUSSION

For all species included in the analysis, 168 habitat map layers were produced for Østfold County. An accuracy assessment was performed for four avian forest species with observational data (Finne 2005). Counts of Black Grouse (*Tetrao tetrix*) and Capercaillie (*Tetrao urogallus*) were done by hunters with free running pointing dogs and GPS. Counts and tracks were sampled and used to analyse percent of estimated habitat and percent of counts inside a 60-meter buffer around the tracks. Data from Nightjar (*Caprimulgus europaeus*) and Woodlark (*Lullula arborea*) were sampled by drawing circles with a radius of 100 meter on topographic maps in areas were the species had been observed. We also defined a study area to analyse percent of estimated habitats and number of observations in estimated habitats. Leks were located with GPS in Halden municipality and we calculated number of leks in estimated habitat.

We suggested that if there were a low percent of estimated habitats inside the transect area, and the observational points covered a high percent of estimated habitats, we could conclude that the habitat model had a high degree of usability for predicting a distribution. Nightjar and Woodlark (Fig. 3) had a high percent of observational points in the estimated habitat (Tab.1). We conclude that there is a good match between the habitat model and the habitat variables described in section 2. Capercaillie (Fig. 3) had a high percent of observational points in estimated habitat and a high percent of estimated habitat inside the buffer (Tab. 1). The result is not unexpected due to the high percent of estimated habitat inside the controlled area (buffer). Black Grouse (Fig. 3) had a low percent of estimated habitats in controlled areas and the observational points covered a low percent of the estimated habitat (Tab 1.). The conclusion from the assessment of Capercaillie and Black Grouse is that the habitat variables from the land cover map are insufficient due to the habitat requirements for these two species. Biased sampling of observational points seems also to be a problem in this assessment.

Census data from Halden municipality indicate a number of 49 leks in the eastern part, and we used this data in an overlay procedure explained above. App. 80 % of the leks was matching the estimated habitat map (Tab. 1). Three of the leks were disappeared due to deforestation. The results indicate that the estimated habitat map gives a good prediction of the distribution of potential lek areas (Fig. 4).

Table 1. Accuracy assessment based on observational data and estimated habitats for four wood living species.

Species	**A (%)**	**B (%)**
Nightjar	39	85
Woodlark	37	76
Capercaillie	84	92
Black Grouse	43	45
Capercaillie leks	39	77

A – percent cover of estimated habitats in controlled areas
B – percent cover of observational points in estimated habitats

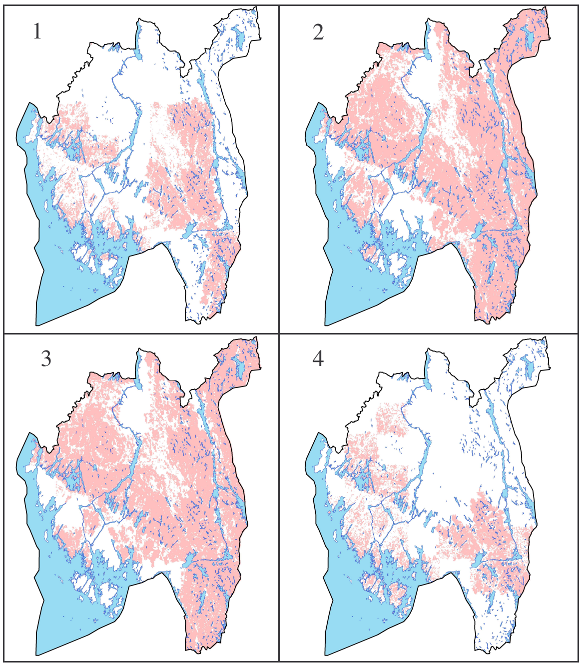

Figure 3. Predicted distributions of 1.) Nightjar, 2.) Woodlark, 3.) Black Grouse and 4.) Capercaillie.

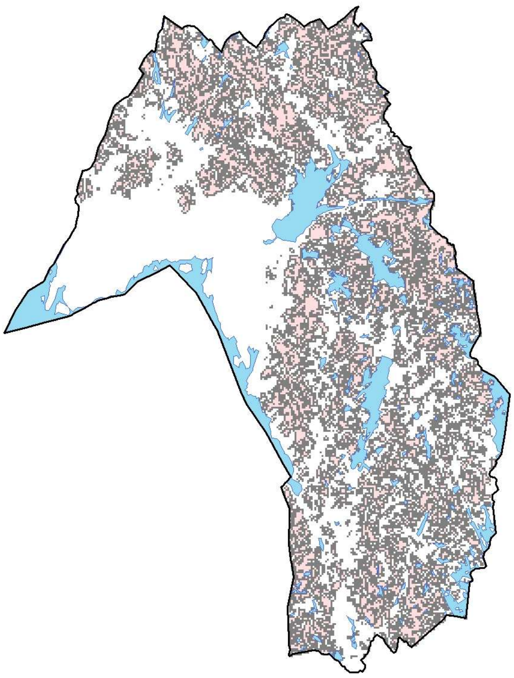

Figure 4. Predicted distribution of Capercaillie leks in Halden Municipality, Østfold County.

4. CONCLUSIONS

Recommendations from the accuracy assessment on four species indicate that the habitat maps are useful as a supplement to wildlife mapping based on field surveys to delimit areas of interest. Especially for species that have a good match between habitat model and land cover variables. Field-tests in some areas with nesting sites and observational points show that the estimated land cover variables forest age (cutting classes) and tree density (wood volume per hectare) are different than the real vegetation. This indicates that it will be essential to classify land cover variables more exactly for use in local wildlife mapping. Generally, results from land cover mapping show that the accuracy is higher on a regional level than on a pixel level. This suggests the main potential for this type of wildlife mapping is on a regional level, and as a supplement for wildlife mapping based on field surveys.

5. REFERENCES

A. Moen. 1999. National Atlas of Norway. Vegetation. Norwegian Mapping Authority, Hønefoss

Csuti, B & Crist, P. 2000. Methods for Developing Terrestrial Vertebrate Distribution Maps for GAP Analysis. Ver. 2.0.0. Idaho Co-operative Fish and Wildlife Research Unit. University of Idaho, Moscow, ID, USA.

D. Vikhamar, G. Fjone, L. Kastdalen og J.P. Bolstad. 2004. Satellittdata til kartlegging av arealdekke. Utprøving av beslutningstremetodikk i Østfold fylke. DN-Utredning 2004-3. Trondheim, Norway, Direktoratet for Naturforvaltning (DN): 64s

Directorate for Nature Management 1999. Norwegian Red List 1998. DN-report 1999-3 (in Norwegian with English summary).

M. Finne. 2005. Test av satellittbaserte viltkart for Østfold fylke. Utmarksavdelingen for Akershus og Østfold.

St. meld. Nr. 42 (2000-2001). Biologisk mangfold. Sektoransvar og samordning. (Report No. 42 to the Storting (2000-2001). from the Government on Biodiversity - sector responsibility and co-ordination). Ministry of the Environment 2001.

6. ACKNOWLEDGEMENTS

The work has been carried out within the national program SatNat, which is funded by the Norwegian Space Centre and the Directorate for Nature Management. Local hunters in Østfold County made observational data of Capercaillie and Black Grouse available. Stein Bukholm and Arnfred Antonsen have been helpful with observational data on leks, Woodlark and Nightjar. We gratefully acknowledge the data providers. A special thank to Duncan Halley for an English correction.