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MASTER OF SCIENCE

Ecology

Nest site selection by northern goshawk *Accipiter gentilis* in northern coastal birch forests

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May, 2008

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Abstract

Most studies of nest site selection by northern goshawk, *Accipiter gentilis*, have been done in mixed – or coniferous forests, and emphasis has been put on the importance of large trees and relatively intact, old forest stands for nesting sites. However, goshawks in northern Norway are found in birch forests characterized by relatively small trees and a high natural level of fragmentation. In this study nest site selection by goshawk was studied by measuring the forest and vegetation structure of selected nesting stands in northern coastal birch forests. Twenty two nesting sites and twenty two paired random sites were used. PCA was used to analyse the structural and vegetation variables. Non-centred PCA was used to analyse differences between the vegetation and forest structure of nesting and random sites. The results indicated a selection for forest stands with larger trees and a higher density of birch trees. Nest sites had higher grass and spleenwort cover. The goshawk avoided habitats characterized by high cover of dwarf shrubs (bilberry, crowberry). Taller shrubs like juniper and raspberry did not appear to influence nest site selection. Distance to power lines and topographical variables did not affect nest site selection either. Goshawks therefore selected nest sites according to criteria partly similar to those described for mixed/coniferous forests – large trees in dense forests – even if what was available differed since birch trees are much smaller than e.g. spruce or pine trees used elsewhere. Forest management in northern Norway should aim at conserving enough areas with this kind of habitat (rich birch forests with tall and dense trees), and disturbance should be avoided in the breeding period as for other birds of prey.

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Introduction

An umbrella species

The northern goshawk (*Accipiter gentilis)* is a medium-sized bird of prey, and is defined as vulnerable in the Norwegian red list (Kålås, Viken et al. 2006). Prioritizing the protection of birds of prey is often advocated for at least three reasons: i) as top predator species, they often occur at relatively low densities, and are therefore vulnerable; ii) they are often emblematic and spectacular; iii) protecting their habitat will usually result in conserving habitat and resources for many other species living in the same area. In other words – birds of prey, as other top predators, are often used as umbrella species (e.g. Sergio, Newton et al. 2006; see Cabeza, Arponen et al. 2008; Sergio, Newton et al. 2008 for further discussion). However, their general utility as a conservation tool has been disputed, because of their tendency to adjust to changes in environmental conditions (Kenward 2006). They can shift their foraging or breeding sites and consequently do not select sites with high biodiversity values. The goshawk may therefore be rather an habitat generalist, a label it shares with other birds of prey (e.g. Honey Buzzard (*Pernis apivorus*) and Golden Eagle (*Aquila chrysaetos*) (Ozaki, Isono et al. 2006). This might, however, be dependent on habitat availability which is highly variable within the large distribution area of this species.

Goshawk biology, sensitivity to disturbance and limiting factors

The goshawk is a generalist predator and its diet varies according to available prey. There is evidence to suggest that goshawk abundance is correlated with food availability, in particular tetranoid birds in Fennoscandia (Widén 1997; Selås 1998; Gundersen, Rolstad et al. 2004). If environmental conditions such as forest composition and structure influence prey availability, then prey resources within each forest type may limit goshawk reproduction. Food supply is often recognised as the ultimate limiting factor of reproduction because variation in the abundance of food may determine nest-site quality, the ability of females to produce eggs, the number of eggs produced, and nestling survival rates. Fewer fledglings are produced during periods of low food resources, suggesting that food is an important factor regulating goshawk populations (Salafsky, Reynolds et al. 2007) . The abundance of prey varies with habitat; variation in predator reproductive rates is often associated with prey resources. An effective conservation strategy for the goshawk indeed requires an understanding of the process that limit population dynamics, especially how these processes vary over space and time (Salafsky, Reynolds et al. 2007).

The goshawk might be more sensitive to various kinds of direct disturbances to their nesting sites than in their foraging areas. Timber harvesting, particularly if it occurs close to the nest site, might be particularly critical. Disturbances may lead to breeding failure and therefore preserving favourable nesting habitats is claimed to be important for this red-listed species (e.g. Penteriani and Faivre 2001; Poirazidis, Goutner et al. 2007). Penteriani and Faivre (2001) have shown that the goshawk can tolerate some degree of disturbance, if the disturbance is avoided in the breeding period (April and May) (see also Lõhmus 2005) and as long as the nest tree requirements are fulfilled (Lõhmus 2006).

Changes in Goshawk population size in Norway, Fennoscandia and North America

People have for a long time blamed the goshawk for decline in small game, which was an important economic and food resource. In 1845 the law about extermination of predators and conservation of other game was voted by the Norwegian Parliament (Grønlien 2004). This "war of extermination" continued over at least 100 years, until the "Game Law" (Viltloven) was voted in 1971. This law arranged that all birds of prey (except owls), were protected (Axelsen 1999).

The decline in the bounty statistics for each of the counties in Norway up to 1971 indicated that the goshawk control partly succeeded (Statistics Norway 2008). This did not result, however, in an increase in the population of small game, which was the reason for the whole extermination campaign against the small game predators. Due to the conservation measures taken in 1971, one had hoped to see an increase in the population of birds of prey. This was indeed observed for several species, but not for the goshawk (Grønlien 2004). Indeed goshawk populations have been declining before and after the species was protected in 1971 (Axelsen 1999). The Norwegian goshawk population could have been as high as about 10 000 pairs at the end of the 19th century. By 1950, this might have been reduced by as much as 50% (Grønlien 2004), despite good conditions for goshawks at the beginning of the 20th century (Søgnen 2003). The population was estimated in 1976 to be approximately 2000 pairs (Bergo 1995), and in 2000 approximately 1765 pairs (Grønlien 2004). But there are, according to Yoccoz (2005) no strong evidence towards a decline in population size in recent years, because of the use of incorrect statistical analysis and inaccurate data sampling design (Yoccoz 2005).

An evaluation of the situation in Fennoscandia indicated that there has been a decline in the population size in the years from 1950s to 1980s (Widén 1997; Gundersen, Rolstad et al. 2004). This decline coincides in time with an intensification of the forestry, which fragmented and decreased the amount of mature forest. Changes in habitat and prey populations are both important factors that are affected by forestry, and decline in prey densities may be associated with this (Widén 1997).

In North America, there is no evidence of a population decline, and most studies show goshawk densities to be highly variable spatially and temporally (Kennedy 1997). Fecundity fluctuates widely, but there is no evidence of a negative trend. This can either mean that goshawk populations are not declining, or that goshawk populations are declining but it has not been detected with current sampling techniques (Kennedy 1997).

Forestry, habitat structure and Goshawk habitat selection

The absence of population increase since 1971 in Norway has been attributed to the intensification of forestry practices and in particular large scale clear cutting forestry, which has replaced traditional way of selective cutting (Widén 1997; Gundersen, Rolstad et al. 2004). Large areas have been cut down and goshawk nesting habitat is likely to have been reduced. Clear cutting forestry management has been the dominant practice in Norway the last 50-60 years. Recently interest for more selective cutting has been revived. This is caused partly by growing concerns for biodiversity. Selective cutting is defined as "logging based on defined criteria for choices of trees that develops or preserves a layered/stratum forest structure" (Lexerød and Gobakken 2006). The hallmark of selective forestry is that parts of the forest are logged at the same time as the conditions are made favourable for recruitment of new trees to the tree layer to ensure a layered forest structure (Lexerød and Gobakken 2006). This type of logging protects a large part of the forest, and avoids that large areas are logged as in clear-cutting forestry. Goshawk can tolerate some degree of timber harvesting, but if the forest is altered more than 30 %, goshawk move away, to the nearest intact mature stand. There is a need to understand whether goshawks can cope with a small amount of logging within their nesting habitat, as long as not too much habitat in their home ranges is degraded in terms of prey abundance and available hunting territory (Penteriani and Faivre 2001).

Habitat selection is dependent on the structure of the forest and not the abundance of prey at the nesting site (Greenwald, Crocker-Bedford et al. 2005). The goshawk selects towards mature forest stands that are structurally similar with high canopy closure, substantial shrub cover and large amount of woody debris. The nesting stands consisted of taller trees with larger diameter than the trees found on the forging stands (Hayward and Escano 1989; Boal, Andersen et al. 2005; Greenwald, Crocker-Bedford et al. 2005).

Goshawk populations in North Norway: importance of birch forests

Most studies of goshawk populations have been done in mixed/coniferous forests (e.g. Reynolds, Meslow et al. 1982; Hayward and Escano 1989; Greenwald, Crocker-Bedford et al. 2005). Forest ecosystems in Northern Norway, however, are dominated by mountain birch (*Betula pubescens*). Mixed/coniferous forests are restricted to inner valleys, except for spruce plantations interspersed in birch forests (Hausner, Yoccoz et al. 2002). Birch forests are naturally fragmented because of fjords and mountains, and forestry adds to this natural level of fragmentation (Yoccoz, Hausner et al. 2005). Birch trees are relatively small trees (often less than 15 m), and combined with the more open structure one would expect goshawk to occur at relatively low densities due to their requirements for large trees, closed canopy and tracts of connected forested patches (Boal, Andersen et al. 2005; Greenwald, Crocker-Bedford et al. 2005; Kudo, Ozaki et al. 2005; Lõhmus 2005). Goshawk populations in northern Norway are, however, rather abundant. The high density of black and willow grouse in northern birch forests (Statistics Norway 2008) may explain why the goshawk can sustain viable population forests so far north. However, there is a need for understanding habitat selection, and particularly nest site selection, by goshawk in birch forest.

The objective

My main objective was to understand the structural habitat characteristics that characterize goshawk nesting locality in deciduous birch forests. I compared habitat structure of nesting sites with paired random sites. I also focused on human physical disturbances, and the distance between those and goshawk nesting sites.

Material and methods

Study area

Field work took place in the municipalities of Tromsø, Karlsøy and Balsfjord (69°N, 18-19°E), in Troms County (Figure 1).

The study areas are below the tree-line and are dominated by mountain birch, ferns, mosses and herbs. The exact coordinates of the nesting localities are not given in this thesis because the species is red listed.

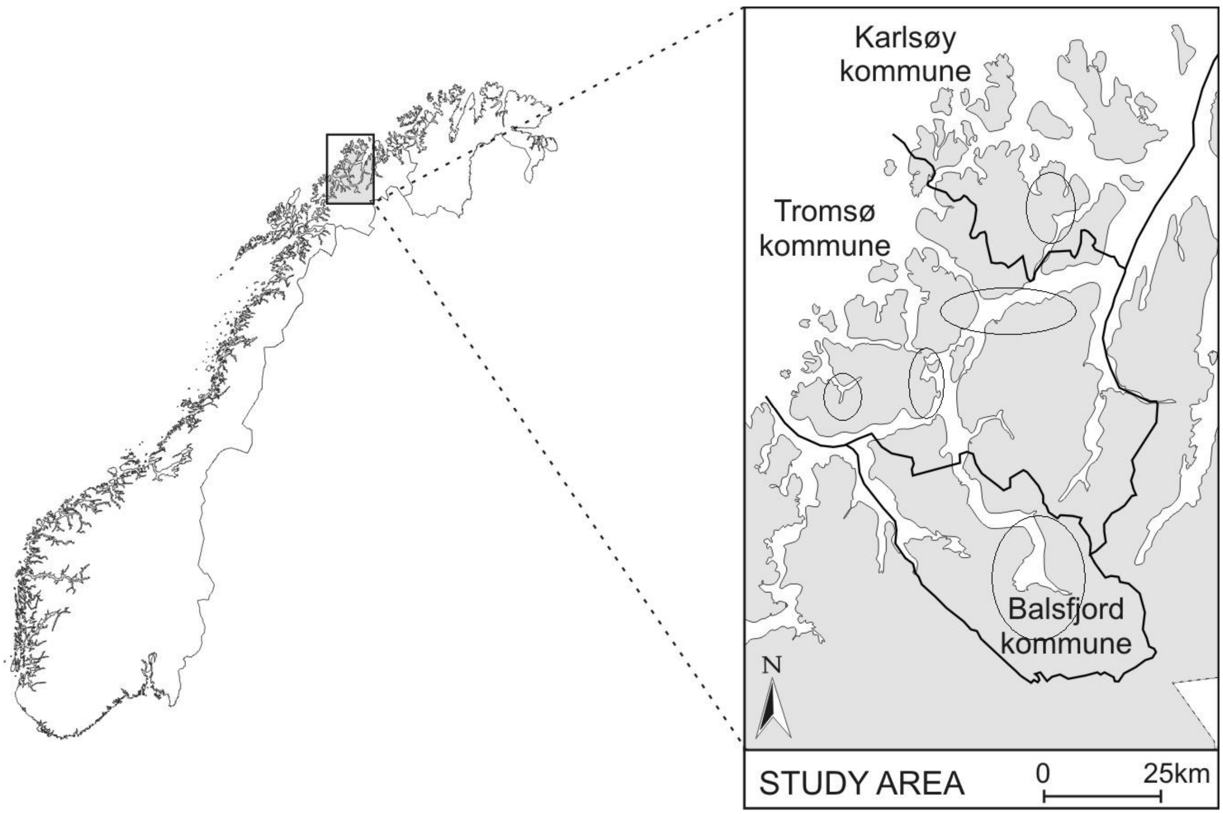

Figure 1: Study area, with nesting localities located within the circles.

Study design

We used a paired design: habitat structure was measured at a nesting and a paired random site. For each goshawk nest, a random forest site was selected within a 500 meter radius and in the same altitudinal range (±50 m) by walking a random number of steps in a random direction. The number of steps from the nesting site to the random site was decided on beforehand, and was randomly selected between 200 and 500. If there were more than two nesting trees at the nesting locality, only two random sites were selected by using the two outermost nesting trees as starting points. This is to avoid that the random sites would overlap with the sites of the nesting trees (Fig 2).

The same habitat variables as for the nesting site were measured at the random, non-used site.

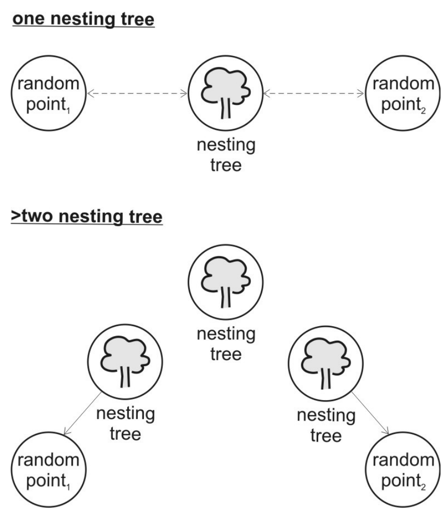

Figure 2: One nesting tree in the nesting locality: random point 1 or random point 2 was chosen. Two or more nests in the nesting locality: random point 1 and random point 2 was chosen from the outermost trees at the locality.

Vegetation structure

Birch forest vegetation structure was quantified in a 100 m radius around the selected point (nest or random) using four transects crossing the selected point, each stretching towards north, south, east, west. Vegetation variables were sampled every 10 meter (fig 3). The variables measured at each selected point were dominant vegetation cover of the different layers, and the dominant tree species were also registered at each of the selected points. The different layers are defined as ground (0 meters), field (> 0.5 m), bush (> 1m) and tree (> 2m). Some variables are registered for both ground and field layer. The variable grass cover for the field layer is registered as straws, and the spleenwort registered in the same layer is larger ferns. See table 1 for details.

Table 1: Registered variables in the different layers

Ground (0 m)	**Field (> 0.5 m)**	**Bush (> 1 m)**	**Tree (> 2 m)**
Grass	Grass	Willow – *Salix spp.*	Birch - *Betula pubescens* - 2-4 m
Herb – *Filipendula ulmaria* / *Geranium sylvaticum*	Herb - *Filipendula ulmaria* / *Geranium sylvaticum*	Raspberry – *Rubus idaeus*	Birch - *Betula pubescens* - > 4 m
Spleenwort – *Dryopteris phegopteris* / *Phegopteris connectilis*	Spleenwort – *Athyrium distentifolium*	Birch - *Betula pubescens*	Alder - *Alnus spp.* - 2-4 m
Moss – *Hylocomeum splendence*	Horsetail - *Equisetum spp.*	Juniper - *Juniperus communis*	Alder - *Alnus spp.* - > 4 m
Lingonberry - *Vaccinium vitis-idaea*	Bilberry - *Vaccinium myrtillus*	Alder – *Alnus spp.*	Willow – *Salix spp.* - 2-4 m
Bilberry - *Vaccinium myrtillus*	Rowan - *Sorbus aucuparia*	Rowan - *Sorbus aucuparia*	Willow – *Salix spp.* - > 4 m
Dwarf cornel- *Cornus suecica*	Spruce - *Picea abies*	Spruce - *Picea abies*	Spruce - *Picea abies* - 2-4 m
Bog bilberry - *Vaccinium uliginosum*			Spruce - *Picea abies* - > 4 m
Crowberry – *Empetrum hermaphroditum*			Rowan - *Sorbus aucuparia* - 2-4 m
Horsetail – *Equisetum spp.*			Rowan - *Sorbus aucuparia* - > 4 m
Club moss – *Lycopodium spp.*			
Common heather – *Calluna vulgaris*			

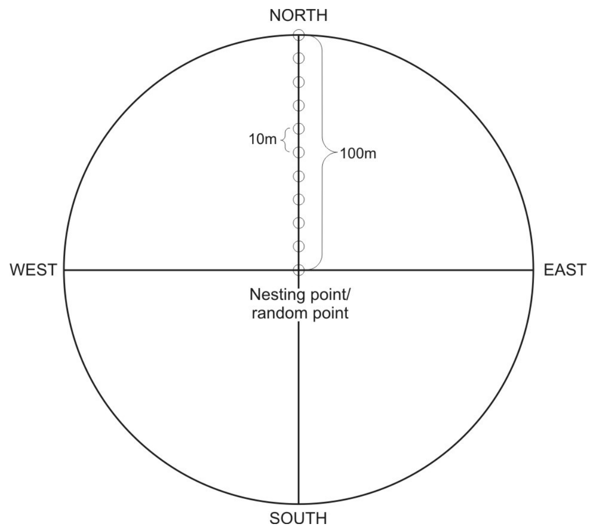

Figure 3: Design of the forest structure measurements with the nesting or random point in the middle. The radius is 100 meters and the sampling points are every 10 meters. The sampling design is identical in all four directions.

Forest structure

Structure was measured at the selected point (nest and random). Trees at the end of the transect crossing the 100 m radius of the selected point were measured using height and diameter at breast height, DBH. In addition to this the structure data consisted of slope at selected point and the density of the birch trees surrounding the selected point. Height of the nesting tree and the height of nests were only measured at the nesting sites.

Statistical analysis

Vegetation variables were summed up for each site, i.e. values represent sum of occurrences over the 40 points (Figure 3). Forest structure represents the averages over the 4 points at the end of each transect. The main habitat patterns were described using a multivariate method, Principal Component Analysis, PCA (Jongman, ter Braak et al. 1995). PCA estimates linear combinations of the original variables that are maximally correlated with the original variables. Linear relationships were checked using scatter plots of variable pairs. Eigenvalue measures the sum of the squared correlations between the original variables and the linear combination of the variables represented by the PCA axes. Scores for variables represent the individual correlations (and are plotted within a unit circle as their length cannot exceed 1).

Variables with too few positive observations (less than 25) were grouped. Common heather, club moss and horsetail were grouped in the ground stratum, spruce and rowan in the field stratum and in the bush stratum raspberry, juniper, spruce and alder were grouped with rowan. To analyse the differences between the paired nest and random (available) sites, we used a non centred PCA (Noy-Meir 1973; ter_Braak 1983) on the table of differences. Given that average values for the differences reflect the habitat selection intensity (i.e. positive values measure preference and negative values avoidance), we did not use centred PCA since that would remove these average differences. We scaled, however, the difference by dividing each variable difference by its standard deviation as the different variables were measured on different scales. The statistical analyses were done in R (R Development Core Team 2005).

Results

In total 48 sites were measured; 26 nesting sites and 22 random sites. Only the nests with a paired random site are used in the statistical analysis; i.e. 22 pairs.

PCA revealed a pattern of vegetation types, which represented three different vegetation types. The groups represented heath vegetation, herbs and deciduous trees (Fig 4). Heath vegetation, represented by, among others, crowberry, bilberry and bog bilberries indicated a lean forest type with birch in the tree layer (Fremstad 1997). The herbs and the deciduous trees indicated a eutrophic forest type dominated by, among others, herbs like meadowsweet (*Filipendula ulmaria*) and small spleenwort like beech fern (*Dryopteris phegopteris*) (Fremstad 1997).

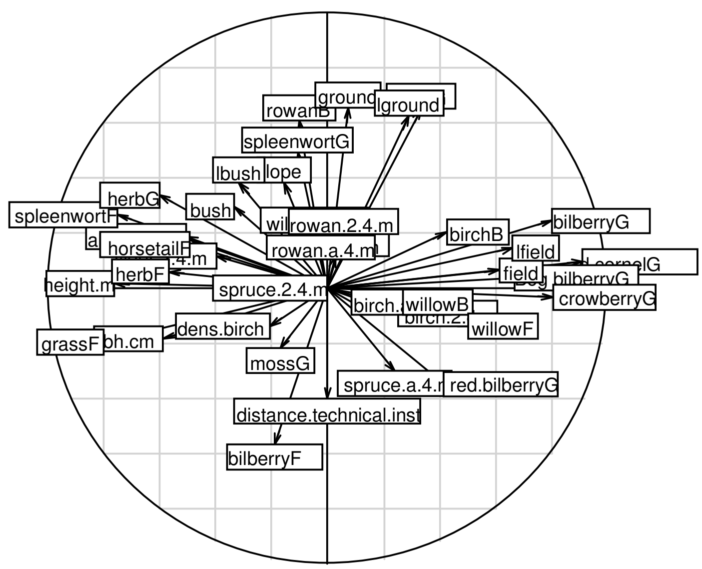

Figure 4: Correlations between vegetation variables and the first two principal components. The first axis explained 18% and the second axis 10% of the total variance.

The non centred PCA on pair differences revealed a clear pattern in the selection of the nesting habitat (Fig 5). Nest sites had higher grass and spleenwort cover in the field stratum and moss cover in the ground stratum. With respect to forest structure, density of birch trees, height of trees and DBH were higher at nest sites than at random sites (figures 6, table 2). Habitats that were avoided (negative difference nest site – random site) were characterized by higher cover of dwarf cornel and other low shrubs like bilberry and crowberry (fig 5, table 2). Taller shrubs such as juniper and raspberry did not appear to influence nest site selection.

There was no evidence for difference in distance to technical installations (table 2). Topographical variables did not seem to have large influence on nest site selection, with an average slope of 6°at the nesting sites and 3.8° at the random sites.

Table 2: The variables influencing the nest site selection.

Species	Layer	Range cover random site	Mean and 95 % CI for difference nest – random
Grass	Field	1 – 33 obs	24.05 [15.68, 26.50]
Spleenwort	Field	0 – 39 obs	20.18 [6.84, 16.07]
Moss	Ground	0 – 12 obs	29.86 [0.93, 8.52]
Dwarf cornel	Ground	0 – 35 obs	9.11 [-23.00, -13.46]
Bilberry	Ground	0 – 26 obs	6.64 [-13.23, -3.50]
Crowberry	Ground	0- 28 obs	4.14 [-10.62, -3.75]
Juniper	Bush	0 – 9 obs	0.75 [-1.58, 1.13]
Raspberry	Bush	0 – 1 obs	0.55 [-0.58, 2.58]
Dist. to technical installation		0 – 1300 meters	375.60 [-46.94, 78.03]
Slope		0 – 30 degrees	5.30 [-2.64, 5.64]
Density birch		0 – 25 numbers	12.75 [1.69, 10.76]
Heigh of trees		4 – 12 meters	10.45 [4.18, 7.03]
DBH		19 – 49 centimeters	42.06 [13.23, 26.55]

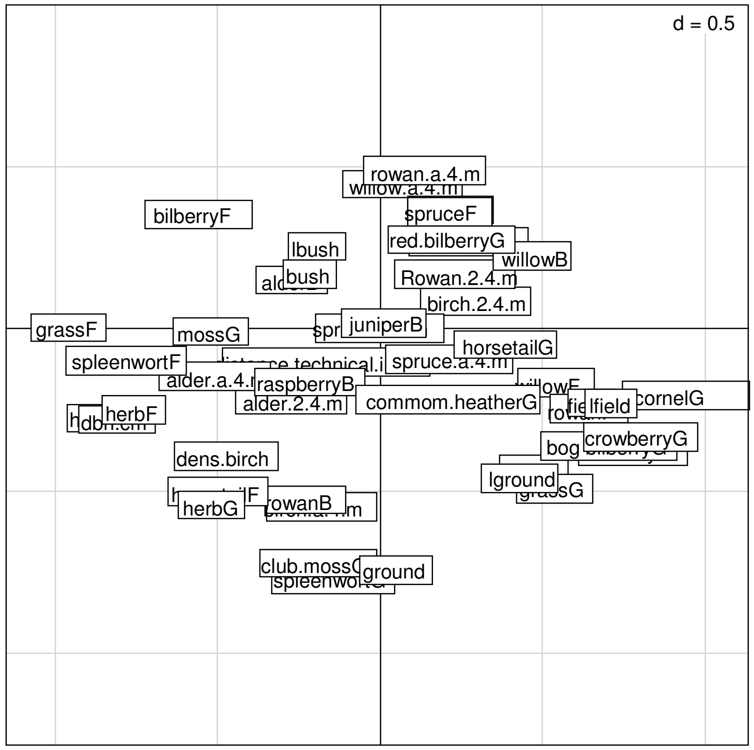

Figure 5: Non centred PCA on pair difference. The first axis explained 25% and the second axis 12% of the total variance. The preferred variables are at the left, and the avoided at the right.

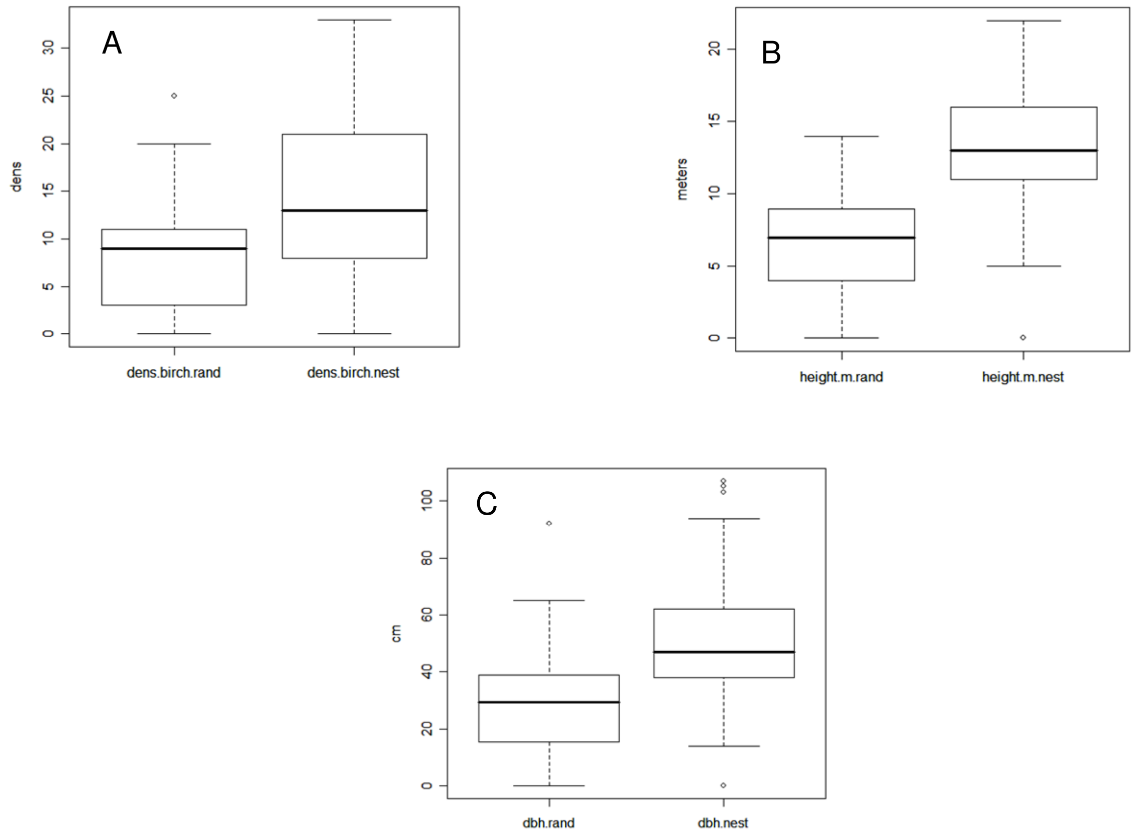

Figure 6: A: Mean density of birch trees at the nesting and random site

B: Mean height of birch at the nesting and random site

C: Mean diameter breast height, DBH, at the nesting and random site

Discussion

This study showed that goshawk in birch forests selected nest sites with higher grass and herb cover, larger trees and higher tree density compared to the random non used sites. Goshawk avoided heath vegetation type with shrubs like dwarf cornel, crowberry and bog bilberries. The distance to technical installations did not influence nest site selection, neither did topographical variables.

My results are somewhat difficult to compare to other studies since most studies have been done in mixed – or coniferous forests (e.g. Reynolds, Meslow et al. 1982; Hayward and Escano 1989; Greenwald, Crocker-Bedford et al. 2005), and selection of habitat is by definition dependent on availability. Large trees (i.e. height > 20m, or DBH > 80 cm) are mostly absent from coastal birch forests. There is however similarities in the forest structure of sites selected for nesting compared to random sites. In birch forests goshawk selected stands with a higher density of birch trees and trees with larger DBH than the ones found at the random sites. This is consistent with previous studies and is interpreted as requirement for cover and also a preference for older forests with larger trees to carry the large nest (Hayward and Escano 1989; Boal, Andersen et al. 2005; Greenwald, Crocker-Bedford et al. 2005; Lõhmus 2005).

Goshawk did not select nest sites according to topographical variables at the scale of the study, as the slope was not steep at either nest or random sites. Goshawks preferred stands that had a weak slope because steeper slopes might reduce the flying area under the canopy (Hayward and Escano 1989; Kudo, Ozaki et al. 2005; Poirazidis, Goutner et al. 2007). The preference for weak slope can lead to a potential conflict with human activity (Kudo, Ozaki et al. 2005), in particular trekking paths, cottages and forest roads. Lush birch forests might invite to more comfort and light for trekking than the closed coniferous forests. The large nests and the loud activity of the goshawk easily catch people's attention, due to the naturally open forest, in the vulnerable breeding period. This make the goshawk more exposed for disturbances in the birch forests, more than in the dark and denser conifer forests. Human activity around the nest site during nesting period might cause abandoning the nest the following year to try to find a new nesting site. A study done by Penteriani and Faivre (2001) in Europe shows that the goshawk can tolerate timber harvesting in their nesting habitat if the alteration is kept under a threshold level of 30 %, and the logging is avoided during the incubation period, February to July (Penteriani and Faivre 2001). This emphasises the importance of not disturbing the nesting sites in the breeding period and show respect for the goshawk delicate nature.

Distance to the power lines, described as technical installations, was very variable. There was no evidence it affected nest site selection by goshawk. The reason might be that the building of the power line was accomplished before the goshawk settled down in the area. Further the power lines do not disturb the nests actively, and the clearings in the forest along the power lines might be preferred by the goshawk for hunting. Studies have found a preference for open terrain near the nesting site (Hayward and Escano 1989), and the importance of having these open areas close to the nest might be due to a higher density of prey in these openings compared to closed habitats (Kudo, Ozaki et al. 2005). The goshawk uses the forest edge for hunting by approaching and attack the prey off guard (Kenward 1982). But even though the power lines did not contribute to disturbances at the same level as logging and trekking paths, they lead to fragmentation of the area. The goshawk need connectivity between forest patches in their home ranges (Kudo, Ozaki et al. 2005), even though the northern coastal birch forests might be less fragmented than the forests in e.g. central Europe and Japan, it might be an important limiting factor (Kudo, Ozaki et al. 2005).

The vegetation type the goshawk preferred in my study area is classified as lush birch forest with dominance of tall herbs, spleenwort and large grasses, but also elements of low herbs. The different vegetation layers did not seem to influence nest site selection, but the understory composition is likely to be dependent on forest structure. For instance lush birch forests with tall trees don't usually have crowberry in their understory (Fremstad 1997). Much understory gives the prey shed and forage and makes it more difficult for the goshawk to catch it. It is important to have in mind that the goshawk selects nesting stands based on the forest structure and not on available prey. In other words, the choice of nesting habitat is not determined by the access to prey, but by the structure of the forest which further is an index of prey availability (Greenwald, Crocker-Bedford et al. 2005). Due to these facts it will make it possible for the goshawk to nest in a large variety of forest types and fragmentation. This might differ between regions and this difference should be taken into account when discussing the management of the northern goshawk (Kudo, Ozaki et al. 2005).

Perspective

Understanding goshawk nesting habitat selection is important for the management of this red listed species as it is the breeding stage which is likely to be the most sensitive to disturbance and in particular forestry. By identifying the nesting habitats of the goshawk one can contribute to the protection of the species without time-consuming and costly investigations of potential forests. Ultimately goshawk populations depend on an adequate resource base, particular grouse in north Norway as other prey such as squirrels are not available, and this is likely to depend on other factors than direct effects of forest management (e.g. hunting, predators like red fox and hooded crow) (Angelstam, Lindstrom et al. 1984; Pedersen, Steen et al. 2004).

The most important action is to preserve nesting biotopes, avoid disturbances during the nesting period and in the future conserve the forest with the right structure (Penteriani and Faivre 2001). A local cooperation between forest owners, environmental agencies and scientists is required to improve management of goshawk populations (Søgnen 2003). The forest owners do have a set of laws they have to follow when logging and managing the forest (Flock and Stuevold 2002). It is important that information about the distribution of goshawk is well documented for both management agencies and the forest owners, or at least the forest structure preferred by the goshawk, to create a viable management.

Now, the nesting habitat of the goshawk in northern Norway is about to get known. It is important for the management and the forest owners that one can distinguish the goshawks most important habitat from the entire forest to make a sustainable collaboration.

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Først og fremst vil jeg takke for 5 fantastiske år her ved Universitetet og på IB! Jeg har vokst mye på de årene og de er proppfulle av gode minner og gode venner. Æ føle mæ nu som en ækte nordlænning, og det skal jeg aldri legge av meg selv om jeg nå skal gjøre søring av meg igjen nå.

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Ellen F. Andersen

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