Ann. Zool. Fennici 49: 69–80 ISSN 0003-455X (print), ISSN 1797-2450 (online)
Helsinki 20 April 2012

Are reserves enough? Value of protected areas for boreal forest birds in southeastern Norway

Astrid Haavik & Svein Dale*

Department of Ecology and Natural Resource Management, Norwegian University of Life Sciences, P.O. Box 5003, NO-1432 Ås, Norway (corresponding author's e-mail: svein.dale@umb.no)

Received 2 Aug. 2011, final version received 20 Dec. 2011, accepted 17 Jan. 2012

Haavik, A. & Dale, S. 2012: Are reserves enough? Value of protected areas for boreal forest birds in southeastern Norway. — *Ann. Zool. Fennici* 49: 69–80.

Most of the boreal forest in Norway is used for forestry, and only 2% of the productive forest is protected. However, low spatial coverage of reserves may be compensated for by higher species' densities and higher number of species so that larger fractions of total population sizes occur inside reserves than their area alone suggests. We compared densities of boreal birds and proportion of known sites for species found within boreal forest reserves and unprotected boreal forest in SE Norway. Point counts showed that neither mean density nor species numbers differed between areas, and only a few species were more common inside reserves. To increase data quantity for rarer species, we used species lists from 429 sites. Several species occurred more frequently inside reserves than outside, and reserves most often had 5%–35% of known sites of individual species. Many of the reserves were protected in 1993, when a number of other areas, still unprotected, were proposed as reserves. Logging has occurred in 74% of proposed reserves and 28% of their total area has been logged after 1993. Although boreal forest reserves had higher proportions of known sites for many species than the size of the reserves would suggest, the majority of the populations of most species occurred outside reserves. Thus, the future of boreal bird species in Norway will to a large degree depend on how unprotected forest is managed.

Introduction

Forests with modern harvesting regimes have replaced a large proportion of the boreal old-growth forest in Fennoscandia (Esseen *et al.* 1997, Berntsen & Hågvar 2008). Large numbers of species have been affected and have experienced population declines (Helle & Järvinen 1986, Martikainen *et al.* 2000). In Norway, about 20% of all red-listed species are linked to old-growth forest (Kålås *et al.* 2010). Only 2% of the productive forest is protected today, although specialist evaluations claim that at least 4.5% of productive forest should be protected in order to preserve the most important features of boreal forest ecosystems in Norway (Norwegian Directorate for Nature Management 1988, Framstad *et al.* 2002, Berntsen & Hågvar 2008).

Many boreal forest specialist birds are declining in numbers as a consequence of logging (Väisänen *et al.* 1986, Virkkala 1987). This decline is related to their specific habitat requirements which include dead wood, trees of large dimensions, deciduous trees and shelter from predators (Helle & Järvinen 1986, Swenson 1993, Angelstam *et al*. 2003). Woodpeckers and several hole-nesting birds prefer forest reserves over managed forest in Finland (Virkkala *et al*. 1994a, 1994b). In particular, the three-toed woodpecker (*Picoides tridactylus*) has been identified as an indicator bird species for valuable boreal forest, being strongly dependent on old-growth spruce forest (Angelstam & Mikusiński 1994, Roberge & Angelstam 2006). In addition to the problem of low spatial coverage of reserves, protected forests are skewed towards sites at high elevation and low productivity, even though boreal forests at low elevations and high productivity have the highest biodiversity and occurrence of threatened species (Stokland 1997, Framstad *et al*. 2002, Kålås *et al*. 2010). Thus, it may be questioned whether current reserve networks can support sustainable populations of old-growth boreal forest species.

In Oslo and Akershus, two counties situated in the southeastern part of Norway, there are currently 24 coniferous boreal forest reserves with a total area of 5331 ha, which constitute 1.6% of the productive forest (Tomter *et al*. 2002, *see* also www.dirnat.no/kart/naturbase/). In an inventory from 1993, 26 additional sites, comprising 5284 ha, were proposed as possible candidates for nature reserves because of their high conservation value (Korsmo & Svalastog 1993a, 1993b), but still remain unprotected. Non-protected forests are subjected to modern forestry, with only 2% more than 160 years old and with little or no room for old-growth demanding species (Tomter *et al*. 2002). The low spatial coverage of reserves and biased distribution in Norway call for a more systematic conservation plan in order to increase the efficiency of the reserve network (Margules & Pressey 2000).

In this study, we compared the distribution of birds, especially boreal old-growth forest specialists, within nature reserves, proposed protected areas and non-protected control areas. The purpose was to assess whether existing boreal forest reserves were efficient in conserving boreal forest bird species. One could argue that the small size of the protected areas could be compensated for by higher densities and higher species numbers within reserves so that large proportions of populations are under protection. We used point counts to test whether bird densities were higher in nature reserves as compared with those in unprotected forest. We used species lists from 429 different sites to assess how large proportions of known sites of boreal bird species were in nature reserves and proposed protected areas. If reserves alone are supposed to protect species from extinction, one would expect that large proportions of total populations should be within nature reserves. Finally, the current status of proposed protected areas was assessed. To our knowledge, no comprehensive study has been conducted to estimate how much of this forest has been lost since they were proposed as nature reserves.

Methods

Study area

This study was conducted in Oslo and Akershus, two counties in the southeastern part of Norway. The study area lies on the border between southern boreal and boreonemoral vegetation types (Moen *et al*. 1999). This implies a conifer-dominated forest with Norway spruce (*Picea abies*) and Scots pine (*Pinus sylvestris*). Deciduous trees, such as birches (*Betula* spp.), aspen (*Populus tremula*) and willows (*Salix* spp.) are found in early successional stages, as single trees in mature forest and along streams and bogs (Esseen *et al*. 1997). Three categories of forest were surveyed; nature reserves with boreal forest, areas that have been proposed as boreal forest reserves and boreal forests that are not protected. Areas that are not protected were sampled as control areas to reserves and proposed protected areas.

Site selection

An updated list of nature reserves was extracted from the online database Naturbase (www.dirnat.no/kart/naturbase/). Areas proposed for protection were described in reports on boreal forest areas of conservation value (Korsmo & Svalastog 1993a, 1993b). Twenty-six areas of conservation value that were proposed as possible candidates for reserves were still not protected in 2009. Supplements and enlargements to these areas later on, have added three more sites of 1022 ha, and together these constituted the sample called proposed protected areas (PPAs) (Røsok 2007). Unprotected control areas were sampled in randomly selected forest areas adjacent to reserves or proposed protected areas, to enable pairwise comparisons. A total of 20 nature reserves (16 with corresponding controls) and 26 proposed protected areas (22 with corresponding controls) were visited. In some locations, we were unable to visit control areas, and four reserves and three PPAs were not visited due to logistical constraints.

Forest characteristics

Forest characteristics were measured by maturity class and proportion of spruce, pine and deciduous trees in each 50-m radius census point. Maturity class is a forestry term used to categorize size and relative age of the stand. It ranges from 1 to 5, where 1 refers to a clear-cut area ready to regenerate and 5 implies a mature forest where growth has culminated and is ready to be harvested (Fitje & Strand 1989). Categories refer to productive forest and are less applicable to low production sites and forests that are not even-aged (Fitje & Strand 1989). We chose in these cases to focus on age more than tree size. Thus an old, slow-growing forest or a forest with many age-classes present (e.g. natural forest), including old forest, was in our study assigned a score of 5 even though it was not harvestable.

Point counts

Bird censuses were based on the point sample method (Bibby *et al*. 2000) and were conducted during 28 April–29 June 2009. Points were placed 300 metres apart. Number of points within each site varied with the size of the forested areas. Each point was censused for three minutes, and every bird within a 50-m radius was noted, but analyses were restricted to forest birds (excluded birds were mainly wetland species). Censuses were carried out between sunrise and midday. All points were placed at least 100 m from the edge of reserves or proposed protected areas. All control points were at least 100 m outside the reserves or proposed protected areas. Visits to nature reserves and proposed protected areas were alternated during the entire field period, and control areas were visited the same day as the corresponding reserve or PPA (two exceptions). In total, 46 days were spent in the field, 630 points were censused [126 in nature reserves (median 7 points/site, range 2–11), 112 in control areas for nature reserves (median 7, range 4–11), 206 in PPAs (median 7.5, range 2–16), and 186 in control areas for PPAs (median 8, range 3–10)] and 2867 individuals were recorded.

There was no significant difference in sampling dates for nature reserves and proposed protected areas (*U*-test: $z = -0.88$, $p = 0.38$). There was a significant difference in time of day for point counts in nature reserves and PPAs ($t_{330} = 2.35$, $p = 0.019$) as the reserves were sampled on average 24 minutes later than PPAs (mean: 08:07 *vs*. 07:43). However, this small difference was regarded to have a negligible effect on the results, because number of individuals per point (mean = 4.55) decreased with only 0.13 individuals/hour from sunrise until midday. There was no significant difference in time for sampling nature reserves and their corresponding control sites ($t_{236} = 0.92$, $p = 0.36$), nor for PPAs and their corresponding control sites ($t_{390} = -1.74$, $p = 0.08$).

Species lists

Species lists from 429 different boreal forest sites in Oslo and Akershus have been compiled based on visits mainly during 1995–2009, by SD and local birdwatchers (mean 30.4 species/site). Sites have been chosen partly with the aim to survey possible areas for remnant old-growth forest, other areas because of easy access or popularity for outdoor activities. Sites covered roughly one third of the total boreal forest area in Oslo and Akershus (productive forest covers 3378 km^2 out of a total area of 5372 km^2 in the two counties). There were 216 sites with at least one thorough visit during the breeding season (May–June), comprising 23 nature reserves, 28 proposed protected areas and 165 unprotected sites (mean 39.0 species/site). Of these 216 sites, 188 were used to compare species' frequency of occurence in nature reserves with that in unprotected sites (i.e. proposed protected areas were not included in this analysis). The full sample of 429 sites was used to calculate the percentage of all known sites that were within reserves and proposed protected areas for each species. The species lists will have a bias in that reserves generally will have more complete lists, because they have been visited more frequently and more thoroughly than other sites (mean = 55.1 species/site). Unprotected sites usually had an area of 1–4 km^2, in general somewhat larger than reserves and PPAs (cf. Results).

Current status of proposed protected areas

In the proposed protected areas, we estimated how much of the area had been logged after the inventory of Korsmo and Svalastog (1993a). This was done in the field by marking onto maps where clear-cuts and young forest assumed to have regenerated after 1993 were found, and then estimating their proportion of the total area of each site.

Data analysis

For each bird species, a mean observation rate (individuals/census point) was calculated for each site in order to control for differences in number of sampling points between sites. Mean observation rate was used as an estimate of relative densities because the area of each census point was the same. Paired comparisons were made between each reserve (or PPA) and respective control site. Unpaired tests were used to compare reserves and PPAs. Census data had skewed distributions hence non-parametric tests were used (Wilcoxon signed-rank test for paired and Mann-Whitney *U*-test for unpaired tests). All the tests were two-tailed.

Results

Forest characteristics

The forest reserves in Oslo and Akershus varied in size from 6 ha to 1782 ha (median = 96 ha, mean = 222 ha, $n = 24$). The proposed protected areas varied in size from 10 ha to 1231 ha (median = 150 ha, mean = 210 ha, $n = 28$). There was a significantly higher proportion of mature forest (maturity class 5) in census points in nature reserves as compared with that in control areas and proposed protected areas (ANOVA: $F_{3,78} = 17.31$, $p < 0.001$; Fig. 1). The proportion of clear-cuts, and recently harvested areas (maturity class 2) was lower in nature reserves than in other site types (clear-cuts: $F_{3,78} = 3.53$, $p = 0.02$; recently harvested: $F_{3,78} = 7.01$, $p < 0.001$). All areas had spruce as a dominant tree species (Fig. 2). Tree composition was in general even, but proposed protected areas had a significantly higher proportion of pine forest in the census points (pine: $F_{3,78} = 2.77$, $p = 0.05$; spruce and deciduous trees: not significant).

Bird point counts

There was no difference in total bird density between reserves, PPAs and control areas [ANOVA: $F_{3,626} = 0.34$, $p = 0.80$, mean = 4.41 individuals of all species combined for each census point for nature reserves ($n = 126$), mean = 4.49–4.66 for PPAs and control areas (n = 112–206)], and also no difference in number of species per census point ($F_{3,626} = 0.25$, $p = 0.86$, reserves: mean = 3.37, other site types: 3.48–3.51).

Pairwise comparisons of nature reserves with their adjacent control areas ($n = 16$), showed that the common goldcrest (*Regulus regulus*) and the common crossbill (*Loxia curvirostra*) had higher densities inside nature reserves than in control areas (Wilcoxon signed-ranks test: $z = -2.08$, $n = 9$, $p = 0.04$, and $z = -2.20$, $n = 6$, $p = 0.03$, respectively; Table 1). The robin (*Erithacus rubecula*) and the willow warbler (*Phylloscopus trochilus*) were more common in the control areas of nature reserves ($z = -2.23$, $n = 14$, $p = 0.03$, and $z = -2.56$, $n = 15$, $p = 0.01$, respectively; Table 1).

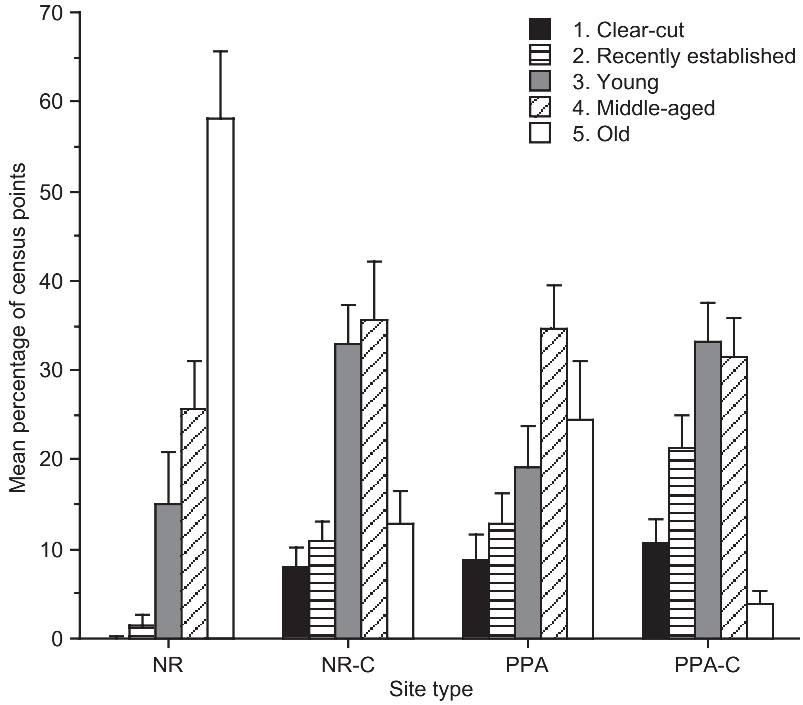

Fig. 1. Forest maturity class composition of nature reserves (NR), proposed protected areas (PPA), and their respective control areas (NR-C and PPA-C). Numbers are presented as mean coverage in census points within a 50-m radius. The scale goes from young to mature forest where 1 is a clear-cut area and 5 is old (harvestable) forest.

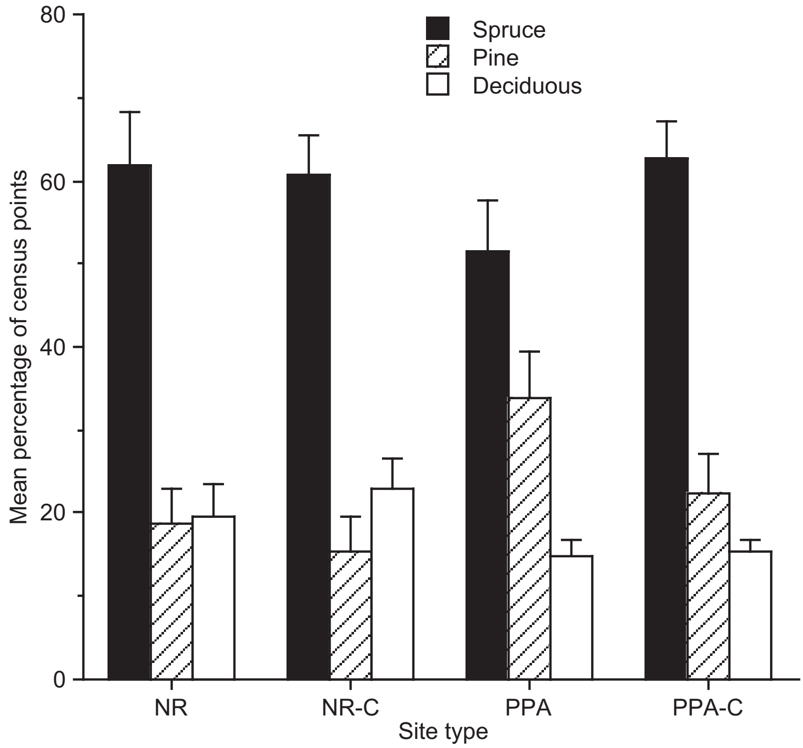

Fig. 2. Tree species composition of nature reserves (NR), proposed protected areas (PPA), and their respective control areas (NR-C and PPA-C). Numbers are presented as mean coverage in census points within a 50-m radius.

Pairwise comparisons of proposed protected areas with their controls ($n = 22$) showed that the tree pipit (*Anthus trivialis*) and the common crossbill were more common inside the PPAs than in their respective control areas ($z = –2.86$, $n = 22$, $p = 0.004$, and $z = –2.85$, $n = 11$, $p = 0.004$, respectively; Table 1), and none were more common in the respective control areas.

Comparisons between nature reserves ($n = 20$) and proposed protected areas ($n = 26$) showed that

Table 1. Results from point count censuses in nature reserves (NR), proposed protected areas (PPA) and their respective control areas (NR-C and PPA-C). Mean observation rate (± SE; individuals/census point) is an index of relative population densities (*see* Methods). The 'Tests' column shows results from statistical testing of differences in observation rates where: 1 = NR *vs.* NR-C, 2 = PPA *vs.* PPA-C, 3 = NR *vs.* PPA; numbers are given only if comparisons had enough data for testing, and those set in boldface indicate significant differences. Wilcoxon signed-ranks test was carried out only if sample sizes ≥ 5, and *U*-test if the smallest sample was ≥ 2 and the largest ≥ 3.

	Total *n*	Mean observation rate ± SE				Tests
		NR ($n = 20$)	NR-C ($n = 16$)	PPA ($n = 26$)	PPA-C ($n = 22$)	
Tetrao tetrix	8	0	0	0.04 ± 0.02	0.01 ± 0.01	
Tetrao urogallus	4	0	0	0.02 ± 0.01	0	
Scolopax rusticola	4	0.01 ± 0.01	0.01 ± 0.01	0.01 ± 0.01	0	
Columba palumbus	45	0.07 ± 0.03	0.06 ± 0.02	0.09 ± 0.03	0.07 ± 0.02	1,2,3
Cuculus canorus	1	0	0	0.01 ± 0.01	0	
Jynx torquilla	5	0	0	0.01 ± 0.01	0.01 ± 0.01	
Dryocopus martius	6	0.01 ± 0.01	0.03 ± 0.02	0	0.01 ± 0.01	
Dendrocopos major	20	0.04 ± 0.02	0.06 ± 0.02	0.01 ± 0.01	0.03 ± 0.01	1,2,3
Picoides tridactylus	6	0.01 ± 0.01	0	0.02 ± 0.01	0	
Anthus trivialis	155	0.19 ± 0.04	0.18 ± 0.04	0.36 ± 0.04	0.20 ± 0.04	1,**2**,**3**
Troglodytes troglodytes	49	0.13 ± 0.04	0.08 ± 0.02	0.10 ± 0.04	0.06 ± 0.02	1,2,3
Prunella modularis	75	0.14 ± 0.06	0.17 ± 0.04	0.10 ± 0.03	0.16 ± 0.05	1,2,3
Erithacus rubecula	231	0.29 ± 0.06	0.36 ± 0.05	0.39 ± 0.07	0.44 ± 0.10	**1**,2,3
Phoenicurus phoenicurus	21	0.04 ± 0.02	0.03 ± 0.02	0.03 ± 0.01	0.02 ± 0.01	2,3
Saxicola rubetra	11	0	0.01 ± 0.01	0.04 ± 0.03	0	
Turdus merula	78	0.13 ± 0.04	0.16 ± 0.04	0.10 ± 0.03	0.13 ± 0.03	1,2,3
Turdus pilaris	21	0.06 ± 0.05	0.03 ± 0.02	0.05 ± 0.03	0.03 ± 0.02	3
Turdus philomelos	89	0.20 ± 0.06	0.11 ± 0.03	0.11 ± 0.03	0.14 ± 0.03	1,2,3
Turdus iliacus	65	0.10 ± 0.04	0.13 ± 0.04	0.08 ± 0.03	0.13 ± 0.05	1,2,3
Turdus viscivorus	10	0	0.02 ± 0.02	0.03 ± 0.01	0.01 ± 0.01	2
Sylvia curruca	6	0	0	0.01 ± 0.01	0.02 ± 0.01	2
Sylvia borin	2	0.01 ± 0.01	0.01 ± 0.01	0	0	
Sylvia atricapilla	42	0.09 ± 0.04	0.08 ± 0.03	0.06 ± 0.02	0.09 ± 0.03	1,2,3
Phylloscopus trochilus	517	0.57 ± 0.08	0.87 ± 0.09	0.74 ± 0.09	0.89 ± 0.08	**1**,2,3
Regulus regulus	53	0.08 ± 0.02	0.06 ± 0.03	0.09 ± 0.02	0.10 ± 0.03	**1**,2,3
Muscicapa striata	13	0.01 ± 0.01	0.01 ± 0.01	0.02 ± 0.01	0.03 ± 0.01	2
Ficedula hypoleuca	10	0.03 ± 0.02	0.01 ± 0.01	0.01 ± 0.01	0.02 ± 0.02	1,3
Poecile montana	16	0.03 ± 0.03	0.04 ± 0.02	0.02 ± 0.01	0.03 ± 0.02	2,3
Lophophanes cristatus	13	0.01 ± 0.01	0.02 ± 0.02	0.02 ± 0.01	0.02 ± 0.01	2
Periparus ater	14	0.05 ± 0.03	0.01 ± 0.01	0.03 ± 0.01	0	3
Parus major	159	0.27 ± 0.05	0.24 ± 0.05	0.27 ± 0.05	0.27 ± 0.07	1,2,3
Cyanistes caeruleus	35	0.11 ± 0.05	0.05 ± 0.02	0.06 ± 0.02	0.04 ± 0.02	1,2,3
Certhia familiaris	13	0.04 ± 0.03	0.01 ± 0.01	0.03 ± 0.02	0.02 ± 0.01	2,3
Lanius collurio	1	0	0	0.004 ± 0.004	0	
Garrulus glandarius	4	0	0.01 ± 0.01	0.004 ± 0.004	0	
Corvus cornix	7	0	0.03 ± 0.02	0.02 ± 0.01	0.01 ± 0.01	
Corvus corax	3	0.01 ± 0.01	0	0.01 ± 0.01	0	
Fringilla coelebs	463	0.72 ± 0.09	0.62 ± 0.06	0.74 ± 0.08	0.78 ± 0.08	1,2,3
Carduelis chloris	18	0	0.08 ± 0.05	0.06 ± 0.05	0.04 ± 0.03	
Carduelis spinus	373	0.69 ± 0.16	0.57 ± 0.12	0.56 ± 0.08	0.56 ± 0.09	1,2,3
Loxia curvirostra	125	0.33 ± 0.16	0.14 ± 0.09	0.24 ± 0.10	0.06 ± 0.04	**1**,**2**,3
Pyrrhula pyrrhula	11	0	0.04 ± 0.02	0.01 ± 0.01	0.02 ± 0.02	3
Emberiza citrinella	24	0.01 ± 0.01	0.06 ± 0.03	0.03 ± 0.02	0.05 ± 0.02	1,2,3

the tree pipit was more common in PPAs than in reserves (Mann-Whitney *U*-test: $W = 355.0$, $p = 0.01$; Table 1), but no species were more common in reserves than in PPAs.

Species lists

Twenty-two out of sixty-two boreal forest species had a higher frequency of occurrence in nature reserves than in unprotected forests (Table 2, based on 188 sites that had at least one thorough visit during the breeding season). In particular, several species that were found in too low numbers in the point censuses to assess differences between occurrence in reserves and unprotected sites, appeared to prefer reserves on the basis of analyses of species lists, including birds of prey, the hazel grouse (*Bonasa bonasia*), the capercaillie (*Tetrao urogallus*), owls and the three-toed woodpecker. Furthermore, on the basis of species lists several more common species [e.g. redstart (*Phoenicurus phoenicurus*), pied flycatcher (*Ficedula hypoleuca*), coal tit (*Periparus ater*) and treecreeper (*Certhia familiaris*)], whose densities did not differ significantly (Table 1) occurred more frequently in reserves.

For a number of species, reserves or proposed protected areas contained larger percentages of the total number of known sites than expected if occurrences were randomly distributed across all sites (Fig. 3; reserves comprised 5.4% and PPAs 6.5% of the full sample of 429 sites visited more or less thoroughly). Percentages of known sites within reserves were in general around 5%–20% (median 11%, range = 0%–35%; Fig. 3). A boreal forest specialist species such as the three-toed woodpecker had 29% of known sites within reserves. PPAs contained similar proportions of known sites, and combined, reserves and PPAs typically had 15%–25% of known sites (median 21%, range = 12%–54%; Fig. 3).

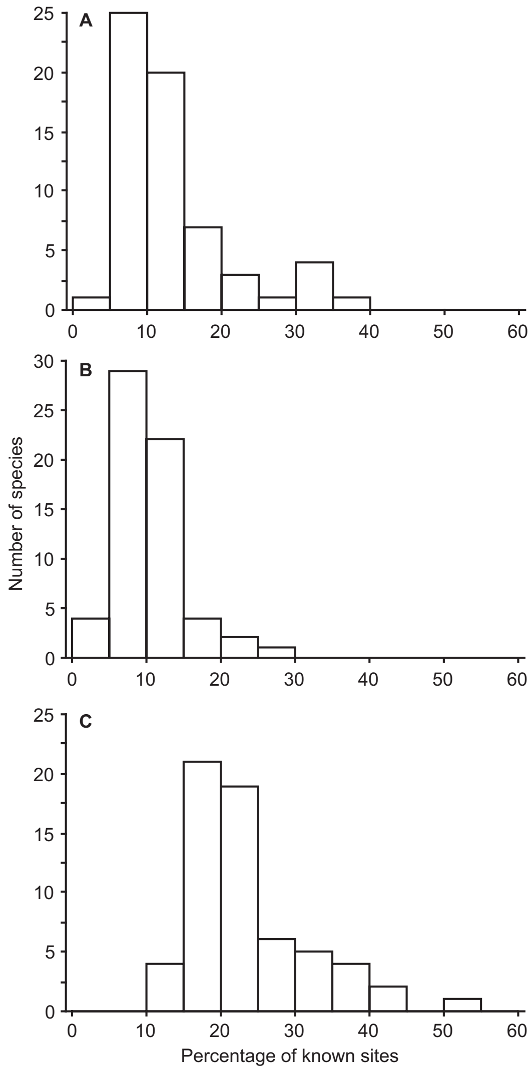

Fig. 3. Proportion of known sites of 62 boreal forest bird species that were within (**A**) nature reserves (NR), (**B**) proposed protected areas (PPA), or (**C**) nature reserves and proposed protected areas combined (NR + PPA). Figures are based on the data from 429 sites, of which 5.4% were reserves and 6.5% were PPAs. Observations from all year were used for species which had a low number of observations within the breeding season (cf. Table 2).

Current status of proposed protected areas

Seventeen of twenty-three areas proposed protected in 1993 showed signs of recent logging (Fig. 4). In the two most affected areas, 90%–95% of the forest had been clear-cut. The results indicated that 28% of the total area of PPAs has been logged (1317 ha out of 4714 ha investigated). Among the 17 areas affected by forestry, 37% of the total area had been logged.

Table 2. Comparisons of number of nature reserves and unprotected boreal forest sites in which each species has been recorded.

	Period	Nature reserves ($n = 23$)	Unprotected ($n = 165$)	*p*		Period	Nature reserves ($n = 23$)	Unprotected ($n = 165$)	*p*
Accipiter gentilis	All year	12	19	< ***0.001***	*Sylvia curruca*	Breed.	10	60	0.66
Accipiter nisus	All year	9	32	0.06	*Sylvia borin*	Breed.	12	59	0.20
Buteo buteo	All year	6	23	*0.21*	*Sylvia atricapilla*	Breed.	20	112	0.10
Buteo lagopus	All year	4	5	***0.014***	*Phylloscopus sibilatrix*	Breed.	9	18	***0.001***
Bonasa bonasia	All year	13	35	< **0.001**	*Phylloscopus collybita*	Breed.	6	6	< ***0.001***
Tetrao tetrix	Breed.	10	51	0.33	*Phylloscopus trochilus*	Breed.	23	165	*1.00*
Tetrao urogallus	Breed.	7	20	***0.028***	*Regulus regulus*	Breed.	23	154	*0.37*
Scolopax rusticola	Breed.	10	24	***0.002***	*Muscicapa striata*	Breed.	17	77	**0.026**
Columba oenas	Breed.	5	10	***0.023***	*Ficedula hypoleuca*	Breed.	13	44	**0.007**
Columba palumbus	Breed.	23	150	0.22	*Poecile montana*	Breed.	19	110	0.19
Cuculus canorus	Breed.	10	39	0.08	*Lophophanes cristatus*	Breed.	18	92	0.07
Glaucidium passerinum	All year	9	20	***0.003***	*Periparus ater*	Breed.	22	105	**0.005**
Aegolius funereus	All year	9	15	< ***0.001***	*Parus major*	Breed.	23	156	*0.38*
Caprimulgus europaeus	Breed.	3	5	*0.06*	*Cyanistes caeruleus*	Breed.	13	84	0.78
Jynx torquilla	Breed.	3	12	*0.40*	*Sitta europaea*	Breed.	8	49	0.79
Picus canus	All year	4	7	***0.032***	*Certhia familiaris*	Breed.	22	97	**0.001**
Picus viridis	Breed.	6	30	*0.40*	*Lanius collurio*	Breed.	3	20	*1.00*
Dryocopus martius	Breed.	9	46	0.39	*Garrulus glandarius*	Breed.	13	64	0.16
Dendrocopos major	Breed.	19	116	0.33	*Perisoreus infaustus*	All year	1	1	*0.23*
Picoides tridactylus	Breed.	11	14	< ***0.001***	*Nucifraga caryocatactes*	All year	6	37	0.89
Anthus trivialis	Breed.	21	147	*1.00*	*Corvus cornix*	All year	16	79	0.08
Troglodytes troglodytes	Breed.	18	121	0.81	*Corvus corax*	All year	18	64	< **0.001**
Prunella modularis	Breed.	21	133	*0.26*	*Fringilla coelebs*	Breed.	23	165	*1.00*
Erithacus rubecula	Breed.	23	164	*1.00*	*Fringilla montifringilla*	Breed.	4	7	**0.032**
Phoenicurus phoenicurus	Breed.	14	39	< **0.001**	*Carduelis chloris*	Breed.	8	58	(–) 0.84
Saxicola rubetra	Breed.	0	21	(–) *0.08*	*Carduelis spinus*	Breed.	22	162	(–) *0.41*
Turdus merula	Breed.	23	155	*0.37*	*Carduelis flammea*	All year	15	67	**0.045**
Turdus pilaris	Breed.	14	95	0.92	*Loxia curvirostra*	All year	21	131	*0.26*
Turdus philomelos	Breed.	22	157	*1.00*	*Loxia pytyopsittacus*	All year	4	24	*0.75*
Turdus iliacus	Breed.	20	139	*1.00*	*Pyrrhula pyrrhula*	Breed.	14	57	**0.027**
Turdus viscivorus	Breed.	12	47	**0.040**	*Emberiza citrinella*	Breed.	6	45	0.89

'All year' = recordings of the species all year, 'Breed.' = recordings during the breeding season; *p* values for χ^2-test or Fisher's exact test (in italics) indicating significant differences are set in boldface. (–) indicates cases in which proportions were lower in reserves than in unprotected areas; in all other cases proportions were higher in reserves. *p* values should be treated with caution because they indicate best-case scenarios for reserves due to more complete species lists in reserves. Note that proposed protected areas were not included in these comparisons.

Discussion

Point counts

We assessed the value of boreal forest reserves for birds in SE Norway using two methods: point counts to assess densities, and species lists to assess proportion of known sites within reserves. The point counts showed that there were only a few species that had significantly higher observation rates in reserves as compared with those in unprotected areas. One could argue that levels of statistical significance should be corrected because of multiple testing (22 species used in comparisons of reserves *vs*. control areas), in which case none of the reported differences would be significant. On the other hand, when assessing the whole suite of species in the boreal forest bird community, most species will have low densities and give small sample sizes in censuses. Thus, the power of tests for many species will be low. Since a number of species of conservation concern (e.g. goshawk *Accipiter gentilis*, hazel grouse, Siberian jay *Perisoreus infaustus*) were not recorded during our point counts (despite a total count of 2867 individuals), we also used species lists to assess less common species (*see* below).

Nilsson (1979) found that total bird and population densities of most species was much higher in old-growth forest as compared with those in mature managed forest in southern Sweden, but the study area had limited extent. In a more extensive study, Virkkala (1987) did not find differences in total bird densities between natural and managed forest in northern Finland. However, unmanaged forests harboured much higher densities of northern resident birds that were known to be boreal forest specialists, while managed forest had higher occurrence of southern generalist species. In our study, trends in the same direction were observed. In Finland, proportion of resident birds and hole-nesting bird species has been shown to increase with forest age, and northern resident species have declined by 80% between 1945 and 1975 due to logging (Helle 1985, Väisänen *et al*. 1986, Haila & Järvinen 1990). This suggests that reserves may provide refuges for forest species vulnerable to forestry although, as compared with managed forest, reserves in Scandinavia in general do not have higher total bird densities.

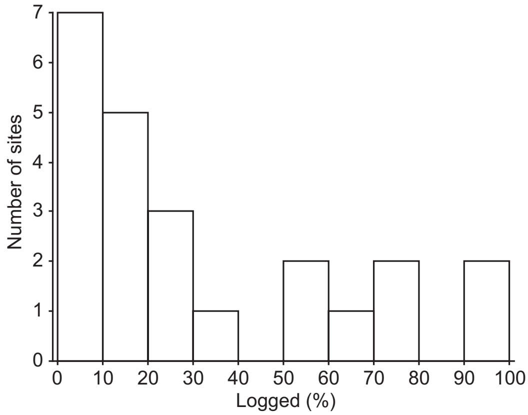

Fig. 4. Frequency distribution of proportion of area of proposed protected boreal forest areas (*n* = 23) in southeastern Norway that has been logged after 1993 (when they were proposed for protection).

Species lists

Analyses of species lists from 188 sites that had at least one thorough visit during the breeding season (23 reserves and 165 unprotected areas) suggested that many species occurred more frequently within reserves than in unprotected areas. This included many species of conservation concern, in particular hole-nesting species and species requiring old-growth (*see* Table 2). There was also a striking similarity to a set of species that has been identified as preferring old-growth forest in Finland (Virkkala & Rajasärkkä 2006). The proportion of known sites for individual species covered by reserves was usually 5%–20%, and up to 35% for a few species (based on data from all 429 sites), even though reserves covered only 2% of the study area. However, we regard these figures as best-case scenarios for several reasons. (1) Reserves were visited more frequently so that species lists are more complete than for unprotected sites. (2) All but one reserve were visited whereas species lists are still lacking for about two thirds of the total boreal forest area in the two counties, implying that the total number of sites may be higher than reported here, although non-surveyed areas were the areas most affected by forestry and, hence, least likely to have sensitive species. (3) *p* values reported in Table 2 were not adjusted for multiple testing. Thus, the analyses of species lists suggest that, although reserves had higher proportions of known sites for many species than the size of the reserves would suggest, the majority of populations of most species occurred outside reserves.

The combination of point counts and analyses of species lists leaves open one question. Rarer species which were not covered well or at all by the point counts, could have larger proportions of their total populations within reserves if reserves consistently had multiple territories whereas unprotected sites had single territories. However, the small size of most reserves (median 96 ha) makes it unlikely that this will be the case for a number of boreal forest species of conservation concern, which typically have low density/large territories (e.g. raptors, grouse, woodpeckers, Siberian jay). Our database enables assessment of this for one species in particular, the three-toed woodpecker, because drumming during spring gives a good opportunity to record multiple males. Only two reserves have documented multiple territories (five and four territories, respectively), whereas two proposed reserves may have two territories each. In conclusion, proportion of number of known sites probably reflects proportion of population fairly well for many species with low densities.

Studies in Finland have also shown that reserves usually cover only small or moderate proportions of total populations of boreal birds (Virkkala *et al*. 1994b, Virkkala & Rajasärkkä 2007). However, coverage differed strongly between northern and southern Finland because of a gradient in proportion of forests protected, from 1%–2% in southern parts up to 40% in the extreme north. Thus, northern boreal forest bird species had on average 29% of populations within reserves, whereas for southern species the figure was only 7% (Virkkala & Rajasärkkä 2007). The situation in south-eastern Norway is therefore most similar to that of southern Finland. Both areas have much productive lowland forest with a long history of commercial forestry which has left little virgin forest intact. In contrast, no parts of Norway have extensive areas of protected boreal forests, not even in high-altitude or northern areas. Thus, we believe our results from SE Norway may be fairly typical for the whole of Norway, and northern boreal species therefore seem to be more at risk in Norway than in Finland.

Proposed protected areas

The analyses suggested that the areas that were proposed to be protected in 1993 were similar to nature reserves regarding species composition and density, and — because their total size was similar — they typically covered an additional 5%–15% of known sites for boreal bird species, and combined, reserves and PPAs covered up to 50% of known sites. Formal protection of proposed sites would therefore have nearly doubled the conservation value of the reserve network. Instead, because of intense opposition from forest owners against creating nature reserves on their land, the authorities have recently changed their policy and opt for voluntary forest conservation where forest owners propose areas for protection (Ministry of Environment 2003) to reduce conflict levels. Many of the areas proposed in 1993 are therefore unlikely to be protected. Sites evaluated according to the new policy still suffer from biases so that areas with high biodiversity are underrepresented (Framstad & Blindheim 2010), and at least in Oslo and Akershus tend to cover less productive pine forests (S. Dale pers. obs.).

Furthermore, our data showed that the majority of previously proposed protected areas has been subjected to logging since 1993, and logged areas amounted to 28% of the total area of PPAs. Two sites have been almost completely logged. Given the low proportion of old-growth in unprotected areas, these losses have substantial implications for future development of the reserve network. Designing a sufficient reserve network is further complicated because when a formal proposal of protection of an area in private hands is made public, owners have hurried to start harvesting as economic compensation for protection was thought to be inadequate (Korsmo 1991), although the attitude has changed somewhat after the policy of voluntary protection was implemented.

Importance of unprotected areas

The more common passerines seemed to have similar densities in unprotected areas and reserves, whereas larger species (many of conservation concern) occurred less frequently in unprotected sites. Despite this, large proportions of populations of most species occurred outside protected areas. The process of increasing the percentage of protected boreal forest is slow and it will take many years to get much higher than the present level of 2% (Berntsen & Hågvar 2008). This means that management of sensitive boreal-forest bird species cannot be based only on a protected-area strategy, in particular because it has been suggested that protection of as much as 10%–30% of forest areas may be needed for safeguarding species that do not thrive in managed forest (Framstad *et al*. 2002, Hanski & Walsh 2004), far from what can realistically be expected in Norway. Thus, the future of many of these bird species will depend on how unprotected areas are managed, and conservationists need to focus on the implementation of wise-use rules or a revision of forestry subsidy policy (*see* below).

A further problem with conservation being based on reserves only, is that the sizes of reserves established so far in this part of Norway are small relative to area requirements of some species (e.g. woodpeckers which may need up to several km^2). Northern boreal bird species in large undisturbed forest tracts (> 1000 km^2), did not show the same changes in populations that have occurred in the rest of Finland, suggesting that areas of this size were needed to preserve these species (Virkkala 1991). Birds living in smaller unmanaged forest tracts were more affected by landscape changes on a regional scale than the local forest structure in reserves, because of their high mobility and large territory requirements (Väisänen *et al*. 1986).

Management implications

Recently, there has been a growing awareness among foresters and consumers of the need for more sustainable forestry practices. The Living Forests Standard for sustainable forest management in Norway contains a number of guidelines and is the basis for forest certifications in Norway (Living Forests Council 2006). For instance, requirements include that at least 5% of the productive forest areas shall be managed as areas of ecological importance (key habitats), to leave ten old and large retention trees per hectare of clear-cut, dead trees should not be cut, and there must be buffer zones of 25–30 m along bogs, lakes and rivers (Living Forests Council 2006). However, the relatively modest requirements in the Living Forests standard makes it unlikely that anything close to primeval conditions can be maintained or recreated, and a key issue seems to be a fundamental incompatibility of forestry and old-growth species. As we have shown, reserves provided a somewhat limited opportunity for such species to persist because the majority of most populations are outside reserves. Populations outside reserves depend to a large degree on areas that have been more or less out of reach for forestry, especially steep terrain, hill tops and areas far from existing forestry roads. Counteracting efforts to increase the percentage of protected areas, the government continues to provide subsidies for building forestry roads and for clear-cutting in difficult terrain (Aanderaa 2010). Total subsidies averaged 44 million NOK per year during 2001–2007 which was 23% of total amount spent on silviculture (Statistics Norway 2009). This highlights that the most cost-effective way of preserving forest of value for boreal forest birds and other species as well, may simply be to cut subsidies. If necessary, banning the construction of new roads or maintenance of old roads will effectively make logging operations in many areas uneconomical, and thereby protect relict stands of unprotected old-growth forest and allow regeneration of previously logged areas.

Acknowledgements

We thank T. Bakke, S. Hågvar, A. Johnsen, V.M. Kristiansen, J.O. Vallestad and R. Virkkala for comments on the manuscript. Financial support was received from the Norwegian Directorate for Nature Management and the Environmental Authorities in Oslo and Akershus.

References

Aanderaa, R. 2010: Fjern perverse subsidier. — *Aftenposten* 31 May 2010.

Angelstam, P. & Mikusiński, G. 1994: Woodpecker assemblages in natural and managed boreal and hemiboreal forest — a review. — *Annales Zoologici Fennici* 31: 157–172.

Angelstam, P. K., Butler, R., Lazdinis, M., Mikusiński, G. & Roberge, J. M. 2003: Habitat thresholds for focal species at multiple scales and forest biodiversity conservation — dead wood as an example. — *Annales Zoologici Fennici* 40: 473–482.

Berntsen, B. & Hågvar, S. 2008: *Norsk natur — farvel? En illustrert historie*. — Unipub, Oslo.

Bibby, C. J., Burgess, N. D., Hill, D. A. & Mustoe, S. H. 2000: *Bird census techniques*. — Academic Press, London.

Esseen, P. A., Ehnström, B., Ericson, L. & Sjöberg, K. 1997: Boreal forests. — *Ecological Bulletins* 46: 16–47.

Fitje, A. & Strand, L. 1989: *Tremåling*. — Landbruksforlaget, Oslo.

Framstad, E. & Blindheim, T. 2010: Assessment of voluntary forest protection sites based on natural science criteria. — *NINA-rapport* 534: 1–108.

Framstad, E., Økland, B., Bendiksen, E., Bakkestuen, V., Blom, H. & Brandrud, T. E. 2002: Assessment of forest protection in Norway. — *NINA Fagrapport* 54: 1–146.

Haila, Y. & Järvinen, O. 1990: Northern conifer forests and their species assemblages. — In Keast, A. (ed.), *Biogeography and ecology of forest bird communities*: 61–86. SPB Academic Publishing, Den Haag.

Hanski, I. K. & Walsh, M. 2004: *How much, how to? Practical tools for forest conservation*. — BirdLife European Forest Task Force, Helsinki.

Helle, P. 1985: Effects of forest regeneration on the structure of bird communities in northern Finland. — *Holarctic Ecology* 8: 120–132.

Helle, P. & Järvinen, O. 1986: Population trends of north Finnish land birds in relation to their habitat selection and changes in forest structure. — *Oikos* 46: 107–115.

Korsmo, H. 1991: Problems related to conservation of coniferous forest in Norway. — *Environmental Conservation* 18: 255–259.

Korsmo, H. & Svalastog, D. 1993a: Inventering av verneverdig barskog i Akershus og Oslo. — *NINA Oppdragsmelding* 227: 1–128.

Korsmo, H. & Svalastog, D. 1993b: Inventering av verneverdig barskog i Østfold. — *NINA Oppdragsmelding* 217: 1–100.

Kålås, J. A., Viken, Å., Henriksen, S. & Skjelseth, S. (eds.) 2010: The 2010 *Norwegian Red List for Species*. — Norwegian Biodiversity Information Centre, Norway.

Living Forests Council. 2006: *Living Forests. Standard for sustainable forest management in Norway*. — Living Forests Council, Oslo.

Margules, C. R. & Pressey, R. L. 2000: Systematic conservation planning. — *Nature* 405: 243–253.

Martikainen, P., Siitonen, J., Punttila, P., Kaila, L. & Rauh, J. 2000: Species richness of Coleoptera in mature managed and old-growth boreal forests in southern Finland. — *Biological Conservation* 94: 199–209.

Ministry of Environment 2003: *Regjeringens miljøvernpolitikk og rikets miljøtilstand*. — Stortingsmelding nr. 25 (2002–2003).

Moen, A., Lillethun, A. & Odland, A. (eds.) 1999. *National atlas of Norway: vegetation*. — Norges geografiske oppmåling, Hønefoss.

Nilsson, S. G. 1979: Effect of forest management on the breeding bird community in southern Sweden. — *Biological Conservation* 16: 135–143.

Norwegian Directorate for Nature Management 1988: *Forslag til retningslinjer for barskogsvern*. — DN-rapport 1988-3, Trondheim.

Roberge, J. M. & Angelstam, P. 2006: Indicator species among resident forest birds. A cross-regional evaluation in northern Europe. — *Biological Conservation* 130: 134–147.

Røsok, Ø. 2007: *Kartlegging av naturverdier i Gaupesteinmarka*. — Biofokus, Oslo.

Statistics Norway. 2009: *Forestry statistics 2007*. — Official Statistics of Norway D 413, Oslo/Kongsvinger.

Stokland, J. N. 1997: Representativeness and efficiency of bird and insect conservation in Norwegian boreal forest reserves. — *Conservation Biology* 11: 101–111.

Swenson, J. E. 1993: The importance of alder to hazel grouse in Fennoscandian boreal forest — evidence from 4 levels of scale. — *Ecography* 16: 37–46.

Tomter, S. M., Eriksen, R. & Aalde, H. 2002: *Statistikk over skogforhold og -ressurser i Akershus og Oslo*. — Landsskogtakseringen 1995–99. NIJOS, Ås.

Väisänen, R. A., Järvinen, O. & Rauhala, P. 1986: How are extensive, human-caused habitat alterations expressed on the scale of local bird populations in boreal forests? — *Ornis Scandinavica* 17: 282–292.

Virkkala, R. 1987: Effects of forest management on birds breeding in northern Finland. — *Annales Zoologici Fennici* 24: 281–294.

Virkkala, R. 1991: Population trends of forest birds in a Finnish Lapland landscape of large habitat blocks: Consequences of stochastic environmental variation or regional habitat alteration? — *Biological Conservation* 56: 223–240.

Virkkala, R. & Rajasärkkä, A. 2006: Spatial variation of bird species in landscapes dominated by old-growth forests in northern boreal Finland. — *Biodiversity and Conservation* 15: 2143–2162.

Virkkala, R. & Rajasärkkä, A. 2007: Uneven regional distribution of protected areas in Finland: Consequences for boreal forest bird populations. — *Biological Conservation* 134: 361–371.

Virkkala, R., Rajasärkkä, A., Väisänen, R. A., Vickholm, M. & Virolainen, E. 1994a: Conservation value of nature reserves. do hole-nesting birds prefer protected forests in southern Finland? — *Annales Zoologici Fennici* 31: 173–186.

Virkkala, R., Rajasärkkä, A., Väisänen, R. A., Vickholm, M. & Virolainen, E. 1994b: The significance of protected areas for the land birds of southern Finland. — *Conservation Biology* 8: 532–544.