ORNIS SVECICA 26:89–103, 2016 https://doi.org/10.34080/os.v26.22527

Habitat selection of Ortolan Buntings *Emberiza hortulana* on forest clear-cuts in northern Sweden

Biotopval hos ortolansparv Emberiza hortulana *på kalhyggen i nordsvenska skogar*

JULIANNA ANNE PERCIVAL & SVEIN DALE

Abstract

Ortolan Buntings *Emberiza hortulana* in Sweden used to occur mainly in farmland. Nowadays, a large proportion of the remaining population is found on forest clear-cuts in northern Sweden. Few studies have identified the types of clear-cuts that Ortolan Buntings prefer and whether these habitats are used for both breeding and foraging. We recorded presence and abundance of ortolan buntings on clear-cuts in Västerbotten County, northern Sweden. We sampled 123 clear-cuts (present N = 48, absent N = 75; total of 93–100 territories) and our results showed that clear-cut size, the number of remaining trees, bare soil percentage (≥10%) and narrow-leaved grass vegetation had a positive influence on ortolan bunting occupancy. The number of territories on clear-cuts was positively related to clear-cut size and number of remaining trees. Proximity to nearby farmland did not influence occupancy on clear-cuts. Behavioural observations indicated that the forest clear-cuts were used for both nesting and feeding. We discuss these results in relation to forest management policies and conservation of the ortolan bunting.

Julianna Anne Percival, Department of Ecology and Natural Resource Management, Norwegian University of Life Sciences, P.O.Box 5003, NO-1432 Ås, Norway.
Svein Dale, Department of Ecology and Natural Resource Management, Norwegian University of Life Sciences, P.O.Box 5003, NO-1432 Ås, Norway. Email: svein.dale@nmbu.no

Received 4 November 2015, Accepted 18 March 2016, Editor: Å. Lindström

Introduction

The Ortolan Bunting *Emberiza hortulana* is a long-distance migratory bird currently experiencing large population declines and range contractions across most of Europe (Menz & Arlettaz 2011). Ortolan Buntings were once common in large parts of Sweden. However, changes in farming practices and agricultural intensification has led to widespread habitat loss and deterioration of suitable breeding habitat for both the Ortolan Bunting and farmland species in general and subsequent population declines (Svensson et al. 1999, Wretenberg et al. 2006, Green & Lindström 2014). Consequently, the Ortolan Bunting is classified as vulnerable on the Swedish red list (ArtDatabanken 2015), and the current population size is only 2600–5000 breeding pairs (Ottosson et al. 2012, Martin Green, pers. comm.).

Ortolan Buntings have almost disappeared in south and central Sweden. However, a large proportion of the remaining population is found in northern Sweden, where they are found mostly on forest clear-cuts (Ottvall et al. 2008). However, little is known about what kind of clear-cuts are preferred by Ortolan Buntings (but see Gustafsson 2014, Lucas 2014), and whether clear-cuts provide both breeding and feeding habitat. Studies of the Ortolan Bunting in Norway have suggested that farmland is an important feeding habitat for buntings breeding in non-farmland habitats such as raised peat bogs, forest burns and clear-cuts, and most territories are therefore located close to farmland (Dale 2000, Dale & Olsen 2002, S. Dale personal observations). Based on data from the Swedish breeding bird survey, Ottvall et al. (2008) found that abundance of Ortolan Buntings on clear-cuts did not depend on distance from farmland. Thus, clear-cuts used by Ortolan Buntings may provide both breeding and feeding habitat in contrast to the situation in Norway, but detailed knowledge of habitat use and feeding behaviour on clear-cuts in Sweden is lacking.

We aimed to identify the main habitat variables influencing presence of Ortolan Buntings on 123 clear-cuts in Västerbotten County in northern

Sweden by comparing clear-cuts with and without Ortolan Buntings. We also analysed the relationship between number of territories in each clear-cut and habitat variables. Furthermore, we analysed habitat selection at a local scale with pairwise comparisons of neighbouring clear-cuts with and without Ortolan Buntings present. Finally, we also collected data on foraging behaviour to assess which kind of clear-cut habitats provided food and whether farmland was used for foraging.

Methods

Study area and study species

Fieldwork was conducted in Västerbotten County, northern Sweden (63.8–64.4°N, 19.6–21.9°E; Figure 1) during the breeding season from mid-May to late June 2013. The study area is located in the northern boreal forest zone where forests are dominated by Norway spruce *Picea abies* and Scots pine *Pinus sylvestris*, and interspersed with deciduous species such as birch *Betula spp.* and aspen *Populus tremula* (Arnborg 1990). Most of the forests in the study area are managed for timber and pulp production and are harvested at an age of 60–100 years.

The Ortolan Bunting is a small (20–25 g) long-distance migratory passerine bird which returns to the breeding areas in May. Males establish territories and sing to attract females, and males often settle in loose groups because of conspecific attraction (Darrud 2006). Later in the season breeding pairs can be located by alarm calls. The species is single-brooded and nestlings fledge from nests on the ground in the middle of June.

Selection of clear-cuts

Clear-cuts were selected based on a map obtained from the Swedish National Forest Agency. In order to obtain a large sample of clear-cuts, we selected

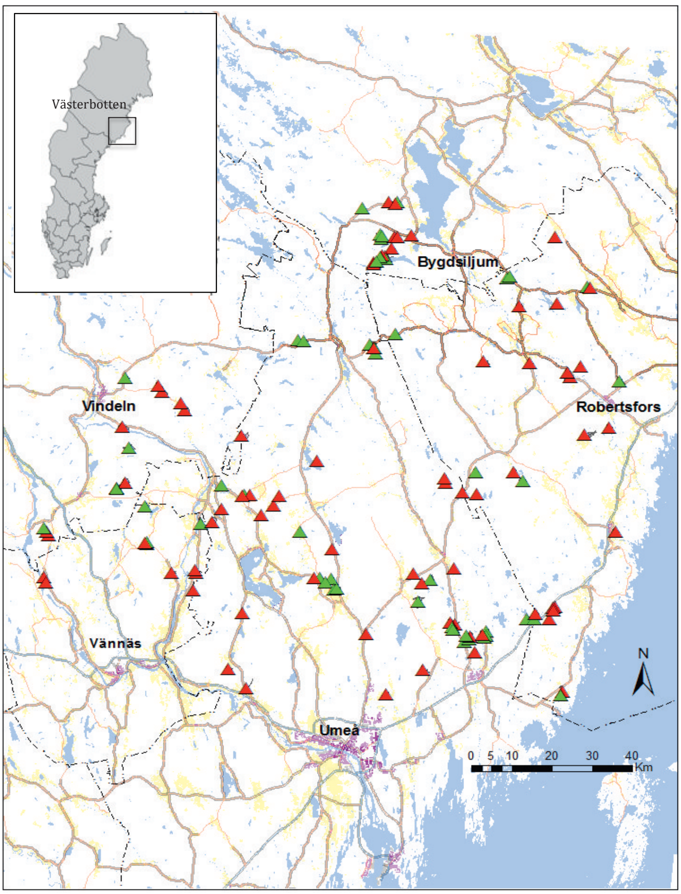

Figure 1. Map of study area showing clear-cuts visited in Västerbotten County, northern Sweden (municipalities included: Robertsfors, Umeå, Vindeln, Vännäs and Skellefteå). Green triangles show clear-cuts where Ortolan Buntings were present, and red triangles show clear-cuts where ortolan buntings were absent.
Kart over studieområdet som viser besøkte hogstfelter i Västerbotten, Nord-Sverige (inkludert følgende kommuner: Robertsfors, Umeå, Vindeln, Vännäs and Skellefteå). Grønne trekanter viser hogstfelter hvor hortulan var tilstede, og røde trekanter viser hogstfelter hvor hortulan var fraværende.

sites that were easily reached from publicly accessible roads. Clear-cuts that would have required access to closed roads, driving on roads in poor condition or walking long distances were not visited. The differences between accessible and inaccessible sites were most likely differences in topography: main roads generally go into valleys, and clear-cuts at higher elevations (e.g. hilltops) may therefore be under-represented. However, because hilltops were not in areas of high elevation (most of the study area was < 300 m a.s.l.), such areas probably do not include important habitat variation that was not present in the selected sites. Thus, despite some potential biases in site selection, the sample included in this study probably contained the full range of habitat variability present in the study area. In addition, our selection ensured that we also obtained a sufficient number of sites close to farmland (65 sites were <500 m from nearest farmland, 83 sites were <1 km from nearest farmland). In total, 123 clear-cuts were visited (see Percival 2014 for a list of geographical coordinates and number of Ortolan Bunting territories in each clear-cut).

At the time of fieldwork, clear-cuts felled early in 2013 were not registered in the Swedish Forestry Database. Clear-cuts less than one year old (post-harvest) at the time of fieldwork were therefore only sampled when they were seen by chance in the field. The database also did not include clear-cuts older than 13 years (post-harvest) and such sites were also not included in the sample. Overgrown clear-cuts with more than 50% regrowth were not sampled, as ortolan buntings are known to prefer sparsely vegetated areas. We did not include burnt clear-cuts in our sample because this was the topic of another study (Lucas 2014).

Field methods

A different part of the study area was visited each day to avoid a time-bias, meaning that clear-cuts in the northern, southern, eastern and western part of the study area were systematically alternated over time. If an Ortolan Bunting was found on a clear-cut, adjoining clear-cuts were also sampled if possible in order to obtain material for paired comparisons of neighbouring clear-cuts with and without Ortolan Buntings. Each clear-cut was visited between 04:00–14:30 hours, and sampling at each clear-cut took between 45 min and 3.5 h, depending on size. We walked around in a loop on each clear-cut, ensuring an approximate equal distance from the centre to the edge of the clear-cut, and on larger clear-cuts we also made cross transects so that no parts of the clear-cuts were >100 m from the walking routes. This was done to minimize the risk of false absences of Ortolan Buntings and in order to assess habitat characteristics of all parts of each clear-cut. Playback was not used, but we made frequent pauses to listen for songs and calls in order to increase chances of detection.

Clear-cuts were classified as occupied (buntings present) if birds were seen or heard. If birds were present, we recorded the number of territories in the clear-cut. Individual territories were distinguished based on singing activity and distance between birds. The position of each Ortolan Bunting and their respective territories were also noted on a sketch of the clear-cut to help determine the total number of territories, in particular on large clear-cuts. In some cases, it was difficult to determine the exact number of territories, particularly on large clear-cuts. In these cases, an approximate number of territories, e.g. 2–3 (indicated as 2.5 in the statistical analyses) was used. Clear-cuts were not visited during heavy rain or wind. Coordinates at each site were recorded with GPS. Each clear-cut was visited once, except to do behavioural observations (see below).

Habitat variables

Habiat variables (Table 1) were collected in the field or retrieved on ArcGIS 10.1 from the shapefile “notification of felling” (in Swedish: Avverkningsanmälningar), which was downloaded from the Swedish National Forest Agency website (http://www.skogsstyrelsen.se/Aga-och-bruka/Skogsbruk/Karttjanster/Skogens-Kalla/).

Vegetation type was classified according to Hägglund & Lundmark (1984) and was based on the abundance of indicator species found in the field-layer. Small, localized variation in vegetation was pooled within the dominant vegetation type(s). However, clear-cuts could have two or more vegetation types when an additional vegetation type was large enough for an Ortolan Bunting territory, or composed more than 10% of the entire clear-cut area.

Regeneration age (age of planted seedlings) was estimated by counting the number of yearly shoots of planted trees. If no planted trees were observed, regeneration age was recorded as zero. Regeneration age differed from post-harvest age (number of years since felling) because planting occurred at variable time intervals after felling, often several years. From the perspective of an Ortolan Bunting, regeneration age may better reflect habitat suitabil-

Table 1. Habitat variables collected for clear-cuts.
Habitatvariabler registrert på hogstfelter. För vegetationstyp både norsk och svensk terminologi för vegetationstyp.

Variable	Type	Categories	Units
Field collected *Samlet i felt*			
Vegetation type *Vegetasjonstype*	Categorical	Broad-leaved grass *Urterik, Bredbladig grästyp* Narrow-leaved grass *Smyle-dominert, Smalbladig grästyp* Sedge-horsetail *Starr-snelle, Starr-fräkentyp* Bilberry *Blåbær, Blåbärstyp* Lingonberry *Tyttebær, Lingontyp* Crowberry-heather *Røsslyng-blokkebær, Kråkbär-ljung-typ* Poor dwarf-shrub *Fattigris, Fattigristyp* Lichen *Lav, Lavmark*	
Regeneration age *Regenerasjonsalder*	Continuous		years *år*
Remaining trees *Gjenværende trær*	Continuous		trees/ha *trær/ha*
Regrowth *Gjenvekst*	Categorical	0, 1–5, ≥ 10%	
Bare soil *Naken jord*	Categorical	0, 1–5, ≥ 10%	
Vegetation litter *Vegetasjonsstrø*	Categorical	0, 1–5, ≥ 10%	
Rockiness *Steiner*	Categorical	None, few, medium, many per ha (for both medium-sized and large rocks) *Ingen, få, middels, mange per ha (for både middels store og store steiner)*	
Soil type *Jordtype*	Categorical	Sand, moraine, peat, rocky *Sand, morene, torv, steinete*	
Topography *Topografi*	Categorical	Bottomland, slope, hill *Flat mark, skråning, ås*	
Aspect *Himmelretning*	Categorical	N, NE, E, SE, S, SW, W, NW	
ArcGIS collected *Data fra ArcGIS*			
Size *Størrelse*	Continuous		ha
Post-harvest age *Tid siden hogst*	Continuous		years *år*
Distance to farmland *Avstand til dyrket mark*	Continuous		m

ity in terms of vegetation structure than post-harvest age because if regeneration age is only a few years the regrowth is still sparse and the site may be attractive to Ortolan Buntings even though the clear-cut may be old according to the post-harvest age.

Remaining trees was based on a visual estimation of the average number of individual isolated trees >2 m that were remaining per hectare. Retention patches (groups of trees) were not included because these patches varied considerably in size from small clusters of individual trees to remnants of intact forest covering several ha. Thus, the variable remaining trees mostly had low values (cf. Figure 2b) and few sites had more than 10 remaining trees/ha.

Regrowth was based on an overall visual estimation of the percentage ground coverage of regenerating vegetation > 2 m and was estimated as 0%, 1%, 3%, 5% and for ≥10% to the closest 5% step. For analyses, regrowth was classified as no regrowth (0%), little regrowth (1–5%) and significant/substantial regrowth (≥10%). The same method applied to the variables *bare soil* and *vegetation litter.* Bare soil was ground coverage of exposed soil from soil disturbance, wheel tracks, or root upheaval. Vegetation litter was ground coverage of freshly fallen or slightly decomposed organic debris such as leaf litter, needles, and in particular cut branches.

Rockiness was measured in the field by counting the number of medium-sized rocks (rocks visible up to 1 m tall) and large-sized rocks (rocks more than 1 m tall) per ha. Medium-sized rocks were categorized into the following groups: none, few (<10 per ha), some (10–50 per ha), many (>50 per ha). Large-sized rocks were categorized into the following groups: none, few (1–2 per ha), some (3–5 per ha), many (>5 per ha). A rockiness index was created to account for both medium and large rocks. Medium-sized rock categories had the following values assigned: 0 (none), 1 (few), 2 (some), and 3 (many). Large-sized rock categories had the following values assigned: 0 (none), 1 (few), 2 (some), 3 (many) and were multiplied by 2. The rockiness index combined the values from the medium-sized rocks and the large-sized rocks to create a scale from 0-9.

Clear-cut size was taken from the Swedish National Forest Agency website, but if neighbouring and adjoining clear-cuts were not easily distinguished in the field because of a difference in time of felling of only 1–2 years, they were merged into one site in our analyses. In these cases post-harvest age was taken as the average of the two felling sites. Two measures of *distance to farmland* were used. One measured the distance to the nearest farmland of any size above 1 ha, the other the distance to the nearest large farmland (size ≥10 ha).

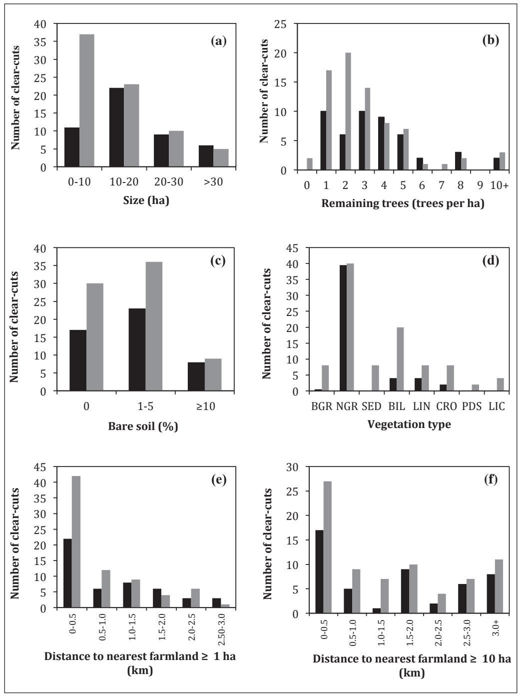

Figure 2. Frequency distributions of main habitat variables at clear-cuts occupied by Ortolan Buntings (N = 48) and unoccupied clear-cuts (N = 75). *Black columns* = occupied clear-cuts; *grey columns* = unoccupied clear-cuts. In (d), vegetation types were abbreviated as follows: BGR = broad-leaved grass, NGR = narrow-leaved grass, SED = sedge-horsetail, BIL = bilberry, LIN = lingonberry, CRO = crowberry-heather, PDS= poor dwarf-shrub, and LIC = lichen). Note that vegetation type has a larger sample size (present N = 50, absent N = 98) because some sites had > 1 vegetation type.
Frekvensfordelinger av de viktigste habitatvariablene på hogstfelter med hortulan tilstede (N = 48) og hogstfelter uten hortulan tilstede (N = 75). Svarte søyler = hogstfelter med hortulan tilstede; grå søyler = hogstfelter uten hortulan tilstede. I (d) ble vegetasjonstyper forkortet som følger: BGR = urterik, NGR = smyle-dominert gressmark, SED = starr-snelle, BIL = blåbær, LIN = tyttebær, CRO = røsslyng-blokkebær, PDS= fattigris, og LIC = lav). Legg merke til at vegetasjonsype har større materialstørrelse (tilstede N = 50, fraværende N = 98) fordi noen steder hadde > 1 vegetasjonstype.

Behavioural observations

Nineteen focal observations lasting 30 min each were conducted on an opportunistic basis when foraging individuals were active. During the 30-min focal observations, we recorded time periods and positions during singing and foraging, and noted movements within or away from the clear-cut. When possible, detailed information was recorded on foraging activity, such as habitat of foraging sites. If an individual was lost for more than five minutes (unless it was seen leaving the clear-cut to nearby farmland), the sampling period was not included among the 30-min focal observations, but instead included as a casual behavioural observation (N = 4). Together with seven other observations, a total of eleven casual behavioural observations were made in the field of birds that were foraging.

Statistical analyses

Presence and abundance of Ortolan Buntings on clear-cuts were analysed using logistic and linear regression models. Prior to analyses, the number of predictor variables was reduced due to collinearity and lack of variation. *Post-harvest age* was excluded because it was strongly correlated with *regeneration age* ($r_s = 0.88$, $P < 0.0001$). *Soil type* and *topography* were excluded due to small variation in observed categories. Two variables were recoded to reduce the number of degrees of freedom used and to increase the stability of the model: *aspect* was recoded to two categories [north (including east) and south (including west)], and the rockiness index was recoded to three categories (0–1, 2–5, 6–9). *Regeneration age*, *remaining trees*, *clear-cut size* and *distance to farmland* were log-transformed. Two separate models were performed to test for the effect of different farmland sizes: one with distance to nearest farmland of any size above 1 ha, and one with distance to nearest large farmland (size ≥10 ha).

Twenty-three clear-cuts were composed of more than one vegetation type. In clear-cuts that had more than one vegetation type, the dominant vegetation type was used for the analysis, except in two cases where the Ortolan Bunting(s) were found only in the non-dominant vegetation type. In another case, the density of birds was higher in the non-dominant vegetation type, and therefore the non-dominant vegetation type was used to indicate the vegetation type of the clear-cut. Clear-cuts with two different vegetation types that were equally dominant (i.e. 50% coverage each) were excluded from the analyses (N = 3). Analyses were further simplified

Table 2. Habitat selection of Ortolan Buntings on clear-cuts in northern Sweden. Comparisons are made between clear-cuts with Ortolan Buntings present (N = 48) and clear-cuts with buntings absent (N = 75). Values represent means (SE). P-values refer to Mann-Whitney U-tests of each variable separately.
Habitatvalg hos hortulan på hogstfelter i Nord-Sverige. Tabellen viser sammenligninger mellom hogstfelter med hortulan tilstede (N = 48) og hogstfelter uten hortulan tilstede (N = 75). Verdiene representerer gjennomsnitt (standardfeil). P-verdier er fra Mann-Whitney U-tester av hver variabel for seg.

Variable	Present *Tilstede*	Absent *Fraværende*	P
Vegetation type[1] *Vegetasjonstype[1]*	6.4 (0.2)	5.7 (0.2)	0.04
Regeneration age (years) *Regenerasjonsalder (år)*	3.3 (0.4)	3.3 (0.3)	0.82
Remaining trees (trees/ha) *Gjenværende trær (trær/ha)*	3.7 (0.4)	3.3 (0.4)	0.08
Regrowth (%) *Gjenvekst (%)*	3.6 (1.1)	4.2 (1.2)	0.76
Bare soil (%) *Naken jord (%)*	3.4 (0.7)	3.2 (0.8)	0.42
Vegetation litter (%) *Vegetasjonsstrø (%)*	2.7 (0.6)	3.6 (0.9)	0.99
Rockiness index (0–9) *Steinindeks (0–9)*	3.6 (0.4)	3.6 (0.3)	0.95
Aspect (1 = south, 2 = north) *Himmelretning (1 = sør, 2 = nord)*	1.4 (0.1)	1.5 (0.1)	0.53
Size (ha) *Størrelse (ha)*	17.2 (1.3)	13.4 (1.2)	0.005
Post-harvest age (years) *Tid siden hogst (år)*	6.4 (0.4)	6.3 (0.4)	0.84
Distance to farmland of any size (m) *Avstand til dyrket mark uansett størrelse (m)*	854 (122)	643 (85)	0.24
Distance to large farmland (m) *Avstand til større areal dyrket mark (m)*	1618 (218)	1489 (176)	0.64

[1] Vegetation type was ranked from most nutrient-poor (lichen = 1) to most nutrient-rich (broad-leaved grass = 8).
[1] Vegetasjonstype rangert fra mest næringsfattig (lav = 1) til mest næringsrik (urterik = 8).

by removing clear-cuts with vegetation types that only had a few observations [broad-leaved grass (N = 3), sedge-horsetail (N = 4), lichen (N = 4); poor dwarf-shrub had no observations, analyses were therefore based on four vegetation types]. The total sample size for the logistic and linear regression models was therefore reduced from 123 to 109 clear-cuts (47 with buntings present).

Regression analyses were done using stepwise backward elimination of non-significant variables. The final reduced models corresponded well with the full models. In the Results, the full model output is reported because this shows the relative importance of all variables included. Analyses of Ortolan Bunting abundance (number of territories) were performed both with all clear-cuts (N = 109) included, and also using only clear-cuts with buntings present (N = 46, the only occupied clear-cut in crowberry-heather vegetation type was excluded). Statistical analyses were performed with JMP software (version 10.0, SAS Institute Inc., Cary, North Carolina).

Results

Presence/absence on clear-cuts

Ortolan Buntings were found on 48 of the 123 clear-cuts. Clear-cuts that had buntings present were on average larger and tended to have more remaining trees per ha (Table 2, Figure 2). A majority of occupied clear-cuts had narrow-leaved

Figure 3. Photographs showing examples of clear-cuts used by Ortolan Buntings in Västerbotten County, northern Sweden. (a) Clear-cut with 3–4 male territories, showing narrow-leaved grass vegetation type, 0% bare soil, and individual trees used as song posts. (b) More recent clear-cut with one male territory, showing narrow-leaved grass vegetation, >10% bare soil.
Fotografier som viser eksempler på hogstfelter brukt av hortulan i Västerbotten, Nord-Sverige. (a) Hogstfelt med 3–4 territorier og smyle-dominert gressmark, 0% naken jord, og enkelttrær brukt som sangplasser. (b) Ferskere hogstfelt med ett territorium og smyle-dominert gressmark, >10% naken jord.

Table 3. Logistic regression (likelihood-ratio tests) of the relationship between habitat variables and presence/absence of Ortolan Buntings on clear-cuts in northern Sweden. Model with distance to nearest large farmland ($N = 109$, $R^2 = 0.29$). Significant results are in bold.
Logistisk regresjon (likelihood-ratio test) av sammenhengen mellom habitatvariabler og tilstedeværelse (tilstede/fraværende) av hortulan på hogstfelter i Nord-Sverige. Modell med avstand til nærmeste større areal dyrket mark (N = 109, $R^2 = 0.29$). Signifikante resultater er vist med fet skrift.

Variable	df	χ^2	P
Vegetation type *Vegetasjonstype*	**3**	**10.75**	**0.014**
Regeneration age *Regenerasjonsalder*	1	0.20	0.66
Remaining trees *Gjenværende trær*	**1**	**17.76**	**< 0.001**
Regrowth *Gjenvekst*	2	0.42	0.81
Bare soil *Naken jord*	**2**	**8.52**	**0.014**
Vegetation litter *Vegetasjonsstrø*	2	1.89	0.39
Rockiness *Steiner*	2	2.84	0.24
Aspect *Himmelretning*	1	0.70	0.40
Size *Størrelse*	**1**	**22.69**	**< 0.001**
Distance to large farmland *Avstand til større areal dyrket mark*	1	1.40	0.24

grass vegetation type (Table 2, Figures 2 and 3). Other habitat variables did not differ substantially between occupied and unoccupied clear-cuts (Table 2). Occupied clear-cuts had bare soil in 65% of cases, and 42% of occupied clear-cuts were ≥1 km from nearest farmland of any size above 1 ha and 54% were ≥1 km from nearest large farmland (size ≥10 ha; Table 2, Figure 2).

Logistic regression analysis of the relationship between habitat variables and presence/absence of Ortolan Buntings indicated that the probability of presence increased with clear-cut size and number of remaining trees (Table 3, model with distance to nearest large farmland). Furthermore, the results indicated that buntings were more often present when clear-cuts had ≥10% bare soil and had narrow-leaved vegetation type (Table 3). Results were almost identical in the model using distance to nearest farmland of any size above 1 ha (results not shown).

Table 4. Linear regression (effect tests) of the relationship between habitat variables and number of Ortolan Bunting territories on clear-cuts in northern Sweden. Model including only clear-cuts with buntings present, and distance to nearest large farmland ($N = 46$, $R^2 = 0.47$). Significant results are in bold.
Lineær regresjon (effekt test) av sammenhengen mellom habitatvariabler og antall hortulanterritorier på hogstfelter i Nord-Sverige. Modellen inkluderer bare hogstfelter med hortulan tilstede, og avstand til nærmeste større areal dyrket mark (N = 46, $R^2 = 0.47$). Signifikante resultater er vist med fet skrift.

Variable	df	F-ratio	P
Vegetation type *Vegetasjonstype*	2	2.02	0.15
Regeneration age *Regenerasjonsalder*	1	0.17	0.69
Remaining trees *Gjenværende trær*	**1**	**5.11**	**0.031**
Regrowth *Gjenvekst*	2	0.27	0.77
Bare soil *Naken jord*	2	1.32	0.28
Vegetation litter *Vegetasjonsstrø*	2	0.24	0.79
Rockiness *Steiner*	2	2.86	0.07
Aspect *Himmelretning*	1	0.33	0.57
Size *Størrelse*	**1**	**13.20**	**< 0.001**
Distance to large farmland *Avstand til større areal dyrket mark*	1	0.02	0.90

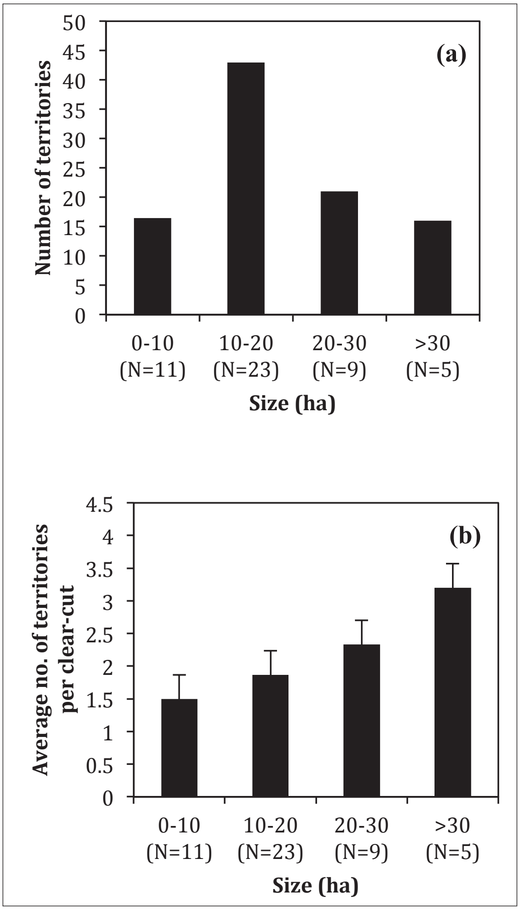

Figure 4. Frequency distribution of number of territories, and mean number of territories (± SE) in relation to clear-cut size at clear-cuts occupied by Ortolan Buntings (N = 48).
Frekvensfordeling av totalt antall territorier, og gjennomsnittlig antall territorier (± standardfeil) i forhold til størrelsen på hogstfeltene for hogstfelter med tilstedeværelse av hortulan (N = 48).

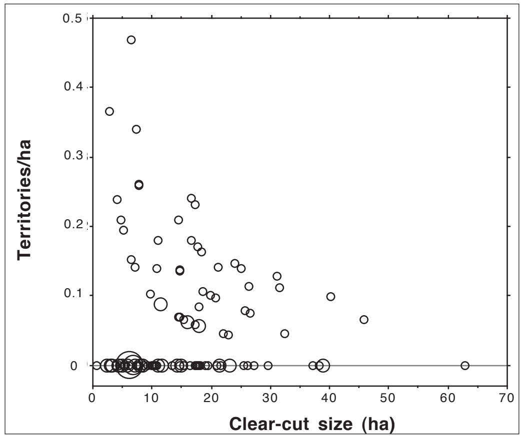

Figure 5. Relationship between clear-cut size (ha) and number of Ortolan Bunting territories per ha. Larger symbols indicate overlapping data points.
Sammenheng mellom størrelsen på hogstfeltene (ha) og antall hortulanterritorier per ha. Større symboler viser overlappende datapunkter.

Number of territories on clear-cuts

In total, 93–100 territories were found on the 48 clear-cuts that had Ortolan Buntings present (range 1–4 territories, median 2). Twenty-nine clear-cuts had more than one territory. Linear regression analysis of the relationship between habitat variables and number of Ortolan Bunting territories indicated that the number of territories increased with clear-cut size and number of remaining trees (Table 4, model including only clear-cuts with Ortolan Buntings present and distance to nearest large farmland). The results remained similar when using a model that included all clear-cuts (results not shown) or models using distance to nearest farmland of any size above 1 ha (results not shown).

Most territories were found on clear-cuts that were between 10 and 20 ha (Figure 4a), however, the largest clear-cuts (>30 ha) had the highest average number of territories (Figure 4b). Although larger clear-cuts had a higher total number of territories, analyses showed that territory density (i.e. number of territories per ha) did not increase significantly with clear-cut size (r_s = 0.16, N = 123, P = 0.08; Figure 5), and even declined among occupied clear-cuts (r_s = -0.55, N = 48, P <0.001). Overall, clear-cuts that were smaller than 20 ha had higher territory density [0–10 ha: total of 16.5 territories on a total area of 286 ha (0.058 territories/ha); 10–20 ha: 43 territories on 694 ha (0.062 territories/ha)] than clear-cuts that were larger than 20 ha [20–30 ha: 21 territories on 455 ha (0.046 territories/ha); >30 ha: 16 territories on 397 ha (0.040 territories/ha)].

Paired comparisons of neighbouring clear-cuts

Comparisons of neighbouring clear-cuts with and without Ortolan Buntings did not reveal significant differences in habitat, perhaps due to moderate sample sizes. Clear-cut size showed the largest contrast in which buntings were present on the largest of the two neighbouring clear-cuts in 14 out of 20 cases (two-tailed binomial test: P = 0.12). Other variables were not close to significance (narrow-leaved grass vegetation type chosen in 8/12 cases, present on clear-cuts of older regeneration age in 12/19 cases, with more remaining trees in 11/17 cases, more regrowth in 8/15 cases, more bare soil in 10/17 cases, and more vegetation litter in 5/10 cases). A comparison within clear-cuts that had two different vegetation types present, but Ortolan Buntings present in only one of the vegetation types, indicated a preference for narrow-leaved grass (chosen in 10/11 cases, expected frequency based on coverage of each vegetation type: 6.1/11; $\chi^2 = 5.60$, $P = 0.018$).

Behavioural observations

Ten of the nineteen focal observations occurred at clear-cuts within 500 m from nearby farmland, but in only three cases were Ortolan Buntings seen flying toward farmland. In two cases, nearby farmland was directly adjoining the clear-cut and birds were away from the clear-cut for 16-20 minutes. In the third case, the clear-cut was 252 m from nearby farmland, and the individual was away from the clear-cut for 26 minutes. In the other focal observations birds were only seen foraging within the clear-cut, and individuals were seen making 1–3 foraging attempts on the ground during the 30-min focal period. Each foraging attempt lasted between 30 seconds and 9 minutes (total number of foraging attempts observed = 27, mean foraging time = 3.8 min).

Seven of the eleven casual behavioural observations occurred at clear-cuts within 500 m from

Figure 6. Photographs showing examples of observed foraging sites of Ortolan Buntings in Västerbotten County, northern Sweden. (a) One male was observed foraging in a patch dominated by wavy hairgrass *Deschampsia flexuosa* and taking seeds from mountain melick *Melica nutans* (narrow-leaved grass vegetation type, 0% bare soil). (b) One male was observed foraging in a patch of bare soil (lingonberry vegetation type, 1–5% bare soil). (c) One male was observed in old wheel tracks in a site dominated by wavy hairgrass and patches of fireweed *Chamerion angustifolium* (narrow-leaved grass vegetation type, ≥10% bare soil) (d) One male was observed with an insect in his bill in an area dominated by fireweed (narrow-leaved grass vegetation type, 0% bare soil overall on clear-cut).

Fotografier som viser eksempler på observerte furasjeringssteder for hortulaner i Västerbotten, Nord-Sverige. (a) En hann lette etter mat på et sted dominert av smyle Deschampsia flexuosa *og han tok frø fra hengeaks* Melica nutans *(smyle-dominert gressmark, 0% naken jord). (b) En hann lette etter mat på et sted med naken jord (tyttebær-vegetasjonsype, 1–5% naken jord). (c) En hann lette etter mat i gamle hjulspor på et sted dominert av smyle og partier med geitrams* Chamerion angustifolium *(smyle-dominert gressmark, ≥10% naken jord) (d) En hann ble observert med et insekt i nebbet på et sted dominert av geitrams (smyle-dominert gressmark, 0% naken jord totalt sett på hogstfeltet).*

nearby farmland (five of these were less than 100 m from farmland), and only one individual was seen flying toward nearby farmland. In all other casual observations, individuals were seen engaging in foraging activities on the clear-cut, even when farmland was nearby. Foraging on the ground lasted 1–10 min (total number of foraging attempts observed = 12, mean foraging time = 2.9 min).

Common vegetation of foraging areas included a high proportion of wavy hairgrass *Deschampsia flexuosa*, fireweed *Chamerion angustifolium*, and some moss (Figure 6a,b). Individuals were also observed on the ground pecking at seeds from grasses (*Deschampsia flexuosa* and *Melica nutans*) and spore capsules from haircap moss *Polytrichum spp*. Foraging areas included those with exposed bare soil, quite often in old wheel tracks, but also in areas nearly or completely void of exposed bare soil (Figure 6c,d). Individuals were also observed with insects in their bill (beetles, caterpillars) in foraging areas without exposed bare soil.

Discussion

Habitat selection

In this study, the four most important variables positively influencing presence of Ortolan Buntings on forest clear-cuts in Västerbotten, northern Sweden were clear-cut size, the number of remaining trees per ha (sites with at least 4–5 trees/ha had Ortolan Buntings present most often), percentage of bare soil (≥10%) and narrow-leaved grass vegetation. The first two variables were also related to abundance of Ortolan Buntings (number of territories). Further, proximity to farmland did not influence presence or abundance of Ortolan Buntings, which suggests that forest clear-cuts may provide both suitable nesting and foraging habitat.

Ortolan Bunting occupancy and abundance on clear-cuts was most strongly influenced by clear-cut size, as also indicated in the studies by Gustafsson (2014) and Lucas (2014). Larger clear-cuts can be expected to have higher habitat heterogeneity and could also be more attractive to the Ortolan Bunting simply because they provide large open spaces which is attractive the species (Cramp & Perrins 1994). However, we also found that the density of Ortolan Buntings (i.e. number of territories per ha) actually *declined* with clear-cut size (among occupied sites), which indicates that larger clear-cuts did not attract more buntings at the same rate as clear-cut size increased (see further below under *Management implications*).

We found that a larger number of remaining trees on clear-cuts was positively related to Ortolan Bunting presence and abundance. Ortolan Buntings are known to use single large trees, large shrubs, large rocks, electricity wires and other similar features as song posts and perching sites (Cramp & Perrins 1994, Tryjanowski 2001, Vepsäläinen et al. 2005, 2007). Thus, such structural features appear to be important for making a site attractive to Ortolan Buntings, and our results indicate that current practice of leaving retention trees on clear-cuts should be continued (Gustafsson et al. 2010, Kruys et al. 2013). Note, however, that the differences found were related to a higher probability of presence on clear-cuts with at least 4–5 remaining trees/ha than on clear-cuts with only 1–2 remaining trees/ha.

We found that presence of Ortolan Buntings on clear-cuts was related to ≥ 10% bare soil, although we did not find that bare soil increased number of territories. Our finding that bare soil was attractive to Ortolan Buntings is in line with a number of other studies of the species across Europe (Berg 2008, Menz et al. 2009a, Menz et al. 2009b, Morelli 2012; see also Schaub et al. 2010). Surprisingly, a concurrent study in our study area found an opposite pattern, i.e. Ortolan Buntings were more frequent in areas with low coverage of bare soil (Lucas 2014). We have no clear explanation for this discrepancy, but we suggest that the preference for bare soil may be stronger than indicated by survey data because of a combination of (1) bare soil disappearing gradually during vegetation succession on clear-cuts, (2) male Ortolan Buntings having a high breeding site fidelity when older despite habitat changes (Dale et al. 2005, S. Dale personal observations), and (3) younger males using older males as a conspecific cue for habitat selection (Darrud 2006). Thus, bunting presence on clear-cuts without bare soil may be a legacy of initial clear-cut conditions with bare soil present which stimulated buntings to settle. We also note that our findings were backed by behavioral observations showing that bare soil was used frequently for foraging. Our behavioural data are not amenable for statistical analyses, but our subjective impression from the field is that bare soil was clearly overrepresented as foraging habitat. Our conclusion is therefore that bare soil is beneficial for Ortolan Buntings on forest clear-cuts in northern Sweden.

Ortolan Buntings were mostly present on clear-cuts that had narrow-leaved grass vegetation type. This was supported both by the presence/absence analysis, and by territory locations on clear-cuts that also had another type of vegetation present. Narrow-leaved grass was the dominant vegetation type and is fairly nutrient-rich. Poorer vegetation types (bilberry, lingonberry and crowberry-heather) were used less often than expected. This is in contrast to the situation in Norway where Ortolan Buntings mostly nest on forest clear-cuts that are nutrient-poor (in particular lingonberry-type, Percival 2014). In Sweden, foraging appeared to take place to a large degree on the clear-cuts, whereas in Norway clear-cuts are used for nesting while feeding takes place mostly on farmland (see further below). Thus, the preference for narrow-leaved grass vegetation type in northern Sweden may be related in some way to resource availability, e.g. potentially richer supply of invertebrates.

Availability of food resources on clear-cuts may be correlated with the availability of nutrients for plant growth, which in turn may be related to forestry practices. Before clear-felling, much of the forest in the study area is composed of bilberry, lingonberry and crowberry vegetation types (Arnborg 1990). After clear-cutting, mechanical soil scarification increases mineral nutrient availability and decreases the abundance of late successional dwarf shrubs such as bilberry, and increases the abundance of fast-growing, early-successional species like grasses and forbs (Bergstedt & Milberg 2001). In particular, wavy hairgrass *Deschampsia flexuosa* increases in abundance with increased intensity of soil preparation and increased light (Bergstedt & Milberg 2001, Strengbom et al. 2004), and clear-cuts thereby often develop into narrow-leaved grass vegetation type. Thus, occurrence of Ortolan Buntings on clear-cuts in northern Sweden may be dependent on mechanical soil scarification, and, interestingly, this forestry practice is uncommon in Norway (Stokland et al. 2003).

Distance to farmland

We did not find any evidence that distance to farmland influenced presence or abundance of Ortolan Buntings on clear-cuts. This is in line with other studies conducted in northern Sweden (Ottvall et al. 2008, Gustafsson 2014, Lucas 2014). We found that 42% of all occupied clear-cuts were > 1 km from farmland which makes it unlikely that birds on these clear-cuts had the option to utilize farmland for foraging. Ottvall et al. (2008) found that 61% of occupied clear-cuts had no farmland within a distance of 400 m. Furthermore, our behavioural observations indicated that even those Ortolan Buntings that occurred on clear-cuts close to farmland only occasionally used farmland for foraging. In contrast, Dale (2000) found that 75% of Ortolan Bunting territories on raised peat bogs in Norway were ≤100 m from farmland and he made many observations of birds flying back and forth between the raised peat bogs and farmland. The situation is similar for buntings breeding on a forest burn and on forest clear-cuts in Norway (Dale & Olsen 2002, S. Dale personal observations). These results support our conclusion above that clear-cuts in northern Sweden apparently have enough resources to permit foraging within the clear-cuts. Thus, clear-cuts with narrow-leaved grass vegetation may provide both suitable nesting and foraging habitat, and nearby farmland is therefore not needed for foraging.

Management implications and conservation

The results of the present study have several implications for how forestry practices can help maintain a viable population of Ortolan Buntings in northern Sweden. Habitat preferences of the Ortolan Bunting imply (1) that the practice of leaving retention trees on clear-cuts should be continued, (2) that there is no need to have very large clear-cuts, and (3) that soil disturbance to create patches of bare soil is important. However, one should bear in mind that these measures may conflict with the interests of conservation-dependent forest species. Such a conflict arises partly because the Ortolan Bunting is an open-country species which in northern Sweden occupies a short-lived early-successional forest habitat that is dependent on modern forestry practices. However, clear-cuts provide important habitat also for other conservation-dependent species (e.g. Red-backed Shrike *Lanius collurio*; Söderström & Karlsson 2010).

We found that presence of Ortolan Buntings on clear-cuts increased with number of remaining trees, but it is important to be aware that very few of the clear-cuts had more than 10 remaining trees per hectare. Thus, even the most attractive clear-cuts were fairly open. However, in a study with a larger variation in retention tree densities than in our study (up to 20–30% of original tree density), Söderström (2009) found that open-country species were negatively affected by increasing green-tree retention, whereas forest species were positively affected. This shows that clear-cuts cannot be managed for all species simultaneously, hence, a diversity of clear-cuts may be needed to provide habitat for a wide range of species (see also further below).

Larger clear-cuts had Ortolan Buntings present more often than smaller clear-cuts, and the number of territories increased with clear-cut size, similar to results for other open-country species breeding on forest clear-cuts in Sweden (Söderström 2009). Despite this, *territory density* did not increase with clear-cut size and actually declined among occupied clear-cuts (see Figure 5). This indicates that larger clear-cuts did not attract more buntings at the same rate as clear-cut size increased. Hence, the value of a clear-cut depends on two opposing processes; larger size makes it more likely that Ortolan Buntings are present, but given that a clear-cut is occupied, territory density declines with size. The data on territory density for different classes of clear-cut size (0–10 ha, 10–20 ha, 20–30 ha, >30 ha) presented in the Results suggested that if there are plans to harvest e.g. 150 ha forest, approximately 50% more Ortolan Buntings may be attracted if one makes ten separate clear-cuts of 15 ha each instead of three clear-cuts of 50 ha each (expected number of territories: 10 × 15 ha × 0.062 territories/ha = 9.3, respectively 3 × 50 ha × 0.040 territories/ha = 6.0). Thus, large clear-cuts do not maximize the number of Ortolan Buntings, and they may also have negative consequences for forest interior species because of forest fragmentation and loss of forest cover. Thus, we suggest that clear-cut sizes of 10–20 ha may be optimal for the Ortolan Bunting.

The Ortolan Bunting, as well as a number of other ground-foraging species of open habitats, benefit from patches of bare soil (Schaub et al. 2010). In Sweden, mechanical soil scarification is the most common method of site preparation after clear-cutting, and is practiced in 92% of Sweden's forested areas (Swedish Forest Agency 2013). Soil scarification is intended to increase the survival and growth of seedlings by exposing the mineral soil underneath and increasing soil temperatures (Örlander et al. 1990). There are also other methods of soil scarification with varying degrees of intensity, e.g. disc trenching and mounding. For the Ortolan Bunting it appeared that more than 10% bare soil was most attractive, but it should be noted that we had few sites with more than 20% bare soil, and among these buntings were present on only 1 of 6 sites (sites that had between 10% and 20% bare soil had buntings present on 7 out of 11 sites, Fisher exact test, P = 0.13). Thus, some site preparation may be favourable to the Ortolan Buntings, but too much may be unfavourable. Disturbances from mechanical soil scarification may also create suitable habitats for species that previously benefited from fire-disturbed habitats (Granström 2001). However, soil disturbance is likely to have negative impacts on a number of organisms and is at odds with conservation goals of preserving intact ecosystems. Because Ortolan Bunting territories rarely occupied entire clear-cuts, one option is to continue current soil disturbance practices in one part of a clear-cut, but leave other parts undisturbed.

In conclusion, this study has identified several factors that influence habitat selection of Ortolan Buntings on clear-cuts in northern Sweden. The species has declined rapidly in many parts of Europe, in particular in farmland habitats. In Sweden, the population on clear-cuts is the last stronghold and efficient management of these breeding sites is crucial for long-term survival of the species. Our suggestions provide a basis for management, and should be followed up with detailed studies of breeding success and individual survival in relation to habitat characteristics to refine management.

Acknowledgements

We thank the Swedish Ornithological Society (Gustav Danielsson's Fund) and the Norwegian Environmental Agency for funding, Adriaan de Jong, Jonas Bohlin and Cloé Lucas for practical help, and Åke Berg, Åke Lindström, Tore Slagsvold and Ville Vepsäläinen for comments on the manuscript.

References

Arnborg, T. 1990. Forest types of northern Sweden. *Plant Ecology* 90: 1–13.

ArtDatabanken. 2015. *Rödlistade arter i Sverige 2015*. ArtDatabanken SLU, Uppsala, Sweden.

Berg, Å. 2008. Habitat selection and reproductive success of ortolan buntings *Emberiza hortulana* on farmland in central Sweden - the importance of habitat heterogeneity. *Ibis* 150: 565–573.

Bergstedt, J. & Milberg, P. 2001. The impact of logging intensity on field-layer vegetation in Swedish boreal forests. *Forest Ecology and Management* 154: 105–115.

Cramp, S. & Perrins, C.M. (eds). 1994. *The Birds of the Western Palearctic. Volume IX: Buntings and New World Warblers*. Oxford Univ. Press, Oxford, UK.

Dale, S. 2000. The importance of farmland for ortolan buntings nesting on raised peat bogs. *Ornis Fennica* 77: 17–25.

Dale, S., Lunde, A. & Steifetten, Ø. 2005. Longer breeding dispersal than natal dispersal in the ortolan bunting. *Behavioral Ecology* 16: 20–24.

Dale, S. & Olsen, B. 2002. Use of farmland by ortolan buntings *(Emberiza hortulana)* nesting on a burned forest area. *Journal of Ornithology* 143: 133–144.

Darrud, A.K. 2006. *The importance of conspecific attraction in settlement decisions for the ortolan bunting*. Master thesis, Norwegian University of Life Sciences, Ås, Norway.

Granström, A. 2001. Fire management for biodiversity in the European Boreal Forest. *Scandinavian Journal of Forest Research* 16: 62–69.

Green, M. & Lindström, Å. 2014. *Övervakning av fåglarnas populationsutveckling*. *Årsrapport för 2013*. Department of Biology, University of Lund, Sweden.

Gustafsson, L., Kouki, J. & Sverdrup-Thygeson, A. 2010. Tree retention as a conservation measure in clear-cut forests of northern Europe: a review of ecological consequences. *Scandinavian Journal of Forest Research* 25: 295–308.

Gustafsson, S. 2014. *Gynnar stora hyggen ortolansparven? Resultat från en inventering i Västerbotten 2013*. Master thesis, SLU, Umeå, Sweden.

Hägglund, B. & Lundmark, J.-E. 1984. *Handledning i Bonitering med Skogshögskolans boniteringssystem*. *Del 3 Markvegetationstyper - Skogsmarksflora*. Skogsstyrelsen, Jönköping, Sweden.

Kruys, N., Fridman, J., Götmark, F., Simonsson, P. & Gustafsson, L. 2013. Retaining trees for conservation at clear-cutting has increased structural diversity in young Swedish production forests. *Forest Ecology and Management* 304: 312–321.

Lucas, C. 2014. *Burnt forest clear-cuts, a breeding habitat for ortolan bunting Emberiza hortulana in northern Sweden?* Master thesis, SLU, Umeå, Sweden.

Menz, M.H.M. & Arlettaz, R. 2011. The precipitous decline of the ortolan bunting *Emberiza hortulana*: time to build on scientific evidence to inform conservation management. *Oryx* 46: 122–129.

Menz, M.H.M., Brotons, L. & Arlettaz, R. 2009a. Habitat selection by ortolan buntings *Emberiza hortulana* in post-fire succession in Catalonia: implications for the conservation of farmland populations. *Ibis* 151: 752–761.

Menz, M.H.M., Mosimann-Kampe, P. & Arlettaz, R. 2009b. Foraging habitat selection in the last ortolan bunting *Emberiza hortulana* population in Switzerland: final lessons before extinction. *Ardea* 97: 323–333.

Morelli, F. 2012. Correlations between landscape features and crop type and the occurrence of the ortolan bunting *Emberiza hortulana* in farmlands of Central Italy. *Ornis Fennica* 89: 264–272.

Ottosson, U., Ottvall, R., Elmberg, J., Green, M., Gustafsson, R., Haas, F., Holmqvist, N., Lindström, Å., Nilsson, L., Svensson, M., Svensson, S. & Tjernberg, M. 2012. *Fåglarna i Sverige - antal och förekomst*. Sveriges Ornitologiska Förening, Halmstad, Sweden.

Ottvall, R., Green, M., Lindstrom, Å., Svensson, S., Esseen, P.-A. & Marklund, L. 2008. Ortolansparvens *Emberiza hortulana* förekomst och habitatval i Sverige *Ornis Svecia* 18: 3–16.

Percival, J.A. 2014. *Habitat selection of ortolan buntings (Emberiza hortulana) on forest clear-cuts in northern Sweden*. Master thesis, Norwegian University of Life Sciences, Ås, Norway.

Schaub, M., Martinez, N., Tagmann-Ioset, A., Weisshaupt, N., Maurer, M.L., Reichlin, T.S., Abadi, F., Zbinden, N., Jenni, L. & Arlettaz, R. 2010. Patches of bare ground as a staple commodity for declining ground-foraging insectivorous farmland birds. *PLoS ONE* 5: e13115.

Söderström, B. 2009. Effects of different levels of green- and dead-tree retention on hemi-boreal forest bird communities in Sweden. *Forest Ecology and Management* 257: 215–222.

Söderström, B. & Karlsson, H. 2010. Increased reproductive performance of red-backed shrikes *Lanius collurio* in forest clear-cuts. *Journal of Ornithology* 152: 313–318.

Stokland, J.N., Eriksen, R., Tomter, S.M., Korhonen, K., Tomppo, E., Rajaniemi, S., Söderberg, U., Toet, H. & Riis-Nielsen, T. 2003. *Forest biodiversity indicators in the Nordic countries. Status based on national forest inventories*. (TemaNord 2003: 514). Nordic Council of Ministers, Copenhagen, Denmark.

Strengbom, J., Näsholm, T. & Ericson, L. 2004. Light, not nitrogen, limits growth of the grass *Deschampsia flexuosa* in boreal forests. *Canadian Journal of Botany* 82: 430–435.

Svensson, S., Svensson, M. & Tjernberg, M. 1999. *Svensk Fågelatlas*. Sveriges Ornitologiska Förening, Stockholm, Sweden.

Swedish Forest Agency. 2013. *Statistical Yearbook of Forestry 2013*. Skogsstyrelsen, Jönköping, Sweden.

Tryjanowski, P. 2001. Song sites of buntings *Emberiza citrinella*, *E. hortulana* and *Miliaria calandra* in farmland: microhabitat differences. Pp. 33-41 in *Bunting studies in Europe* (Tryjanowski, P., Osiejuk, T.S. & Kupczyk, M. eds). Bogucki Wydawnictwo Naukowe, Poznan, Poland.

Vepsäläinen, V., Pakkala, T., Piha, M. & Tiainen, J. 2005. Population crash of the ortolan bunting *Emberiza hortulana* in agricultural landscapes of southern Finland. *Annales Zoologici Fennici* 42: 91–107.

Vepsäläinen, V., Pakkala, T., Piha, M. & Tiainen, J. 2007. The importance of breeding groups for territory occupancy in a declining population of a farmland passerine bird. *Annales Zoologici Fennici* 44: 8–19.

Wretenberg, J., Lindström, Å., Svensson, S., Thierfelder, T. & Pärt, T. 2006. Population trends of farmland birds in Sweden and England: similar trends but different patterns of agricultural intensification. *Journal of Applied Ecology* 43: 1110–1120.

Örlander, G., Gemmel, P. & Hunt, J. 1990. Site preparation: a Swedish overview. *FRDA Report* 105: 1–61.

Sammendrag

I Sverige pleide hortulanen *Emberiza hortulana* først og fremst å forekomme i kulturlandskapet. I våre dager finnes en stor del av den gjenværende bestanden på hogstfelter i Nord-Sverige. Få studier har undersøkt hva slags hogstfelter hortulanen foretrekker, og om slike hogstfelter brukes til både hekking og næringssøk. Vi registrerte tilstedeværelse og antall hortulaner på hogstfelter i Västerbotten i Nord-Sverige. Vi undersøkte 123 hogstfelter (hortulan tilstede N = 48, fraværende N = 75, totalt antall territorier var 93–100) og fant at størrelsen på hogsfeltet, antall gjenværende trær, prosent naken jord (≥10%) og smyle-dominert vegetasjon hadde positiv effekt på tilstedeværelse av hortulan. Antall

territorier på hogstfeltene økte med størrelsen på hogstfeltet og antall gjenværende trær. Avstand til nærmeste jordbruksmark påvirket ikke forekomsten av hortulan på hogstfelter. Atferdsobservasjoner tydet på at hogstfeltene ble brukt til både hekking og næringssøk. Vi diskuterer disse resultatene i forhold til skogbruksmetoder og vern og forvaltning av bestanden av hortulan.