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**Examensarbete i ämnet biologi**
Department of Wildlife, Fish, and Environmental studies
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## Abstract

The Ortolan Bunting population has decreased in Sweden by about 80 % since 1975. Nowadays, the largest part of the Ortolan Bunting population occurs on the northern coast where the majority breeds on clear-cuts. The aim of the study was to describe the Ortolan Bunting breeding habitat characteristics in northern Sweden to provide a basis for management plan. In Phase 1, I investigated if Ortolan Buntings were more present on prescribed burnt clear-cuts than on non-burnt clear-cuts with a presence/absence survey. Unfortunately the occupancy rate in the study area appeared to be very low. As a second step, I extended the study on habitat characteristics within a study area closer to the coast (Phase 2). There was a positive relationship between clear-cut size and Ortolan Bunting presence, but when accounting for random spatial distribution, presences on small clear-cuts were as common or even higher as on large ones. Proximity to farmland had no significant effect on presence of Ortolan Bunting. These two conclusions may be explained by the fact that Ortolan Buntings had the possibility to use multiple clear-cuts and thus find additional resources on a nearby clear-cut, relaxing resource shortage on the clear-cut of the nesting territory. Within 70 km from the coast, there was no coast-inland gradient in Ortolan Bunting presence. The studied parameters could not explain the low Ortolan Bunting presence in the studied area used in Phase 1 but they supplied management plan of the species by pointing out that prescribed burning did not seem to have to take into account neither clear-cut size, distance to farmland nor distance to the coast (< 70 km). This study also provided some information for future researches about the distribution of the Ortolan Bunting in the region and pointed out further questions to be considered to get a global vision of Ortolan Bunting breeding habitat in the region.

Keywords: Emberiza hortulana, breeding habitat, clear-cut, prescribed burning, farmland.

## Symbols and abbreviations

GLM: Generalized Linear Model

$\chi 2$: Chi-square test value

df: Degree of freedom

AIC: Akaike's Information Criterion

AICc: Akaike's Information Criterion adjusted for small samples

$\boldsymbol{\rho}$: Spearman's rank correlation coefficient

## Introduction

The Ortolan Bunting (*Emberiza hortulana*) has undergone a strong and wide decline during recent decades in temperate Europe (Conrads 1968, Voříšek *et al.*, 2010). Many local breeding population have gone extinct or close to extinction (Revaz 2005, Menz *et al.* 2009b). The causes of the decline are still not fully understood (Menz & Arlettaz 2011). Von Bülow (1990) showed that mortality during migration and in wintering was an important factor, and Dale (2001) and Vepsalainen *et al.* (2005) showed that loss of suitable breeding habitat, driven by homogenization of agricultural landscapes, was also associated with the decline. The Ortolan Bunting seems to be a specialist in term of small scale habitat structure, but an opportunist in terms of landscape habitat structure (Brotons *et al.* 2008). Analyzing habitat characteristics in areas with strong population could improve the scientific basis for conservation management of the species (Menz & Arlettaz 2011).

The Ortolan Bunting breeds in Europe and Central Asia, and winters in sub-Saharan Africa. From May until August, they are present in the European breeding range (Menz & Arlettaz 2011). Territories typically have a radius of approximately 100 m (Cramp *et al.* 1994, Dale & Olsen 2002). Females build the nest on or near the ground, often in relatively tall grass (Conrads 1968).

Previous studies have revealed that Ortolan Buntings breed in a wide spectrum of habitats, including peat bogs, pastures, clear-cuts, forest burns, bare alluvial deposits and rocky ground covered with shrubs (Von Lang 1990, Grützmann 2002, Vepsalainen *et al.* 2005). It has been noted that Ortolan Buntings show a noticeable preference for sparse vegetation and a large proportion of bare ground ( Menz *et al.* 2009a). Generally, the species prefers sunny and low rainfall sites (Cramp *et al.* 1994, Fonderflick *et al*. 2005, Menz *et al.*, 2009a).

Habitat affected by fire has also been reported to attract Ortolan Bunting (Brotons *et al.* 2008). In the Mediterranean region, Ortolan Bunting made extensive use of recently burnt areas (Pons & Prodon 1996, Herrando 2002, Pons & Bas 2005). In Norway and Switzerland, the species also nested on burnt area (Dale & Olsen 2002, Revaz 2005).

Farmland is another habitat feature which have been observed in the proximity of breeding sites (Conrads 1968,Von Lang 1990, Dale 2000, Dale & Olsen 2002) . The diet during the breeding season, when provisioning nestlings, consists mainly of invertebrates taken from patches of bare ground, but can be complemented with seeds (Cramp *et al.* 1994, Menz *et al.* 2009b). Farmland can offer both bare ground and seeds (Tagmann-Ioset *et al.* 2012). In Norway, Ortolan Bunting made foraging flights to farmland areas up to 2.7 km away from their resting sites (Dale & Olsen 2002).

In Sweden, the Ortolan Bunting population has decreased by about 80 % since 1975 (Ottosson *et al.* 2012). The species had a broad distribution prior to the1980s (Svensson *et al.* 1999), but is now mainly restricted to the eastern parts of Västerbotten and Norrbotten (northeastern part of Sweden) (Stolt 1993, Ottvall *et al.* 2008). Västerbotten hosts an estimated 2000 out of Sweden´s 6 300 pairs based on bird monitoring data (2007) and landscape data (2006) (Ottvall *et al*. 2008).
According to Stolt (1993) and Ottvall *et al*. (2008), Ortolan Buntings breed mainly on clear-cuts in northern Sweden.
The landscape of northern Sweden is dominated by boreal forest. Farmland areas are scattered in small patches (Robertson *et al.* 1990). In Västerbotten country, farmland covers a mere 1% (Västerbotten 2010).

The aim of the study was to analyze the Ortolan Bunting breeding habitat characteristics in northern Sweden. The primary goal was to investigate if Ortolan Buntings were more present on burnt clear-cuts or not (Phase 1) with the hypothesis: “Ortolan Bunting presence rate on burnt clear-cuts is higher than on comparable non-burnt clear-cuts.”

Results from the first round of three planned visits showed that the occupancy rate for the studied clear-cuts was very low (2 observations only on 106 surveyed clear-cuts). After a mini-symposium in which Svein Dale, Julie Percival and Adriaan de Jong participated, I decided to abandon Phase 1, and to extend the study to Phase 2 with the objectives:

- to test the correlation between clear-cut size and Ortolan Bunting presence;
- to test the empirical observation of a gradient in Ortolan Bunting presence from the Baltic coast towards North-West (i.e. the uplands), in order to get a possible explanation of the low Ortolan Bunting occurrence in the Phase 1studied area;
- to test the influence of farmland proximity on the occupancy of Ortolan Bunting on clear-cut;
- to test the effect of proximity to other clear-cuts on the occupancy of Ortolan Bunting
- and testing the likelihood of false presence by attracting Ortolan Bunting from outside the focal clear-cuts.

## Material and methods

### Study area

The study was conducted around Umeå in the county of Västerbotten, North-Eastern Sweden (Fig. 1).

In Phase 1, the sampling units were prescribed burnt clear-cuts and non-burnt clear-cuts. Clear-cut data was extracted from the "FaktisktAvverkatNya-24", a GIS shape file supplied by The Swedish Forest Agency (URL: http://193.183.24.13/Geowebshare/default.asp) on the 2nd of March 2013. The shape file represented all the clear-cuts in the Västerbotten county with additional information in a data base table (e.g. date of the clear-felling, forest type and forest management, size of the clear-cut). Clear-cuts subjected to prescribe burning were extracted from the "Branddatabas" supplied by Andreas Garpebring at the Västerbotten County Board on the 2nd of May 2013. This Branddatabas was a GIS shape file of burnt forest land in the county with additional information in a data base table (e.g. on date and type of burning, forest type and forest management, size of the clear-cut). The sampling space was defined by an area of approximately 150 km around Umeå (Fig. 1). The size of the study area was a compromise between limiting the driving distance and having an area containing an acceptable amount of sampling units (Table 1).

In Phase 2, the sampling units were clear-cuts, extracted from the same "FaktisktAvverkatNya-24" GIS shape file. The study area was restricted to a 70x70km square with a virtual base line just outside the Baltic coast. The orientation matched the landscape structure dominated by the northwest – southeast direction of the rivers (Fig. 1).

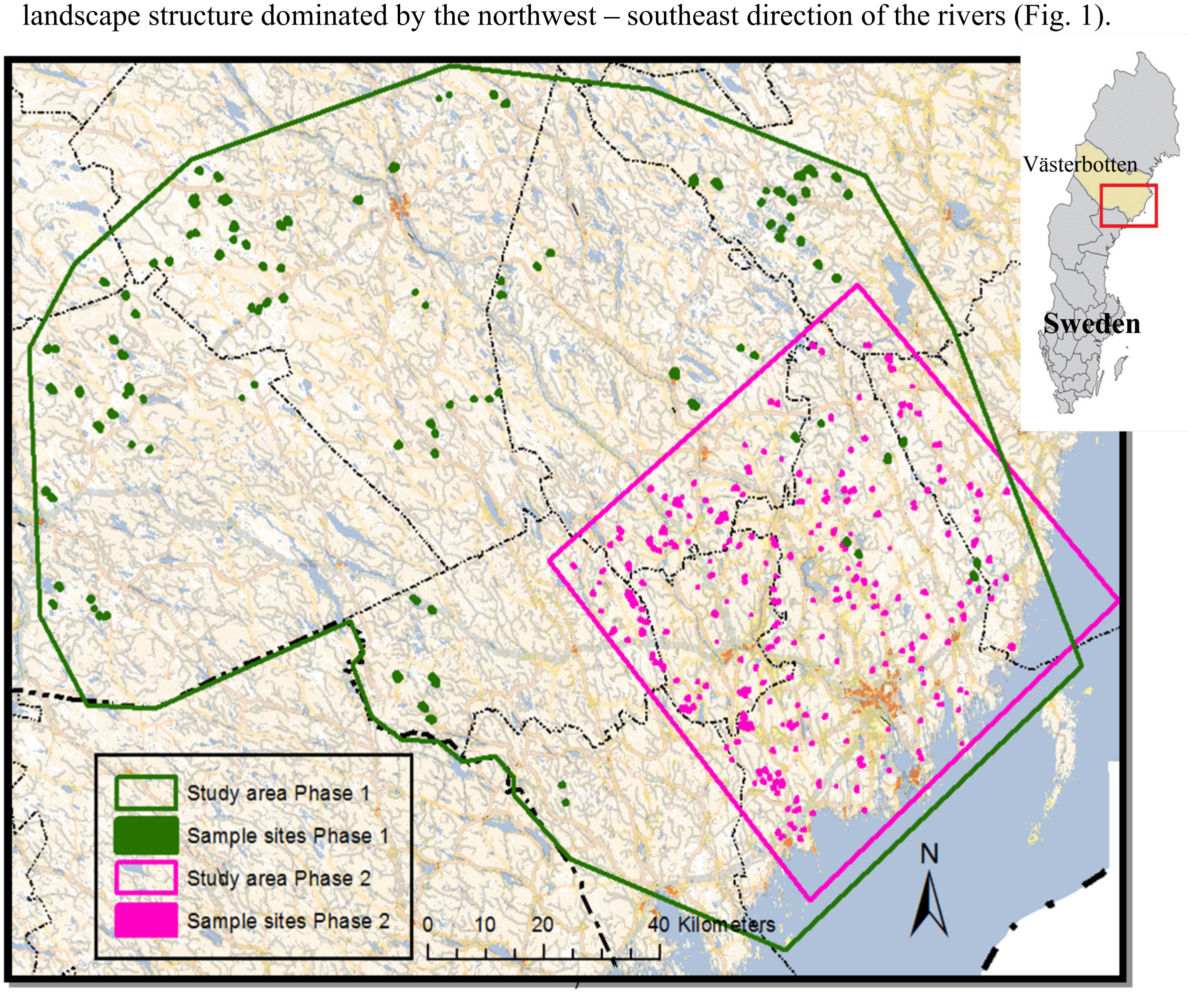


Figure 1: Location of the two survey areas in the Västerbotten County in Sweden, and their sample sites.

## Study design

*Sampling of clear-cuts*

For Phase 1, the sampling units were prescribed burnt clear-cuts and non-burnt clear-cuts of similar age and size. I chose clear-cuts 1-8 years after burning because sites can be settled or abandoned rapidly by Ortolan Bunting (Dale & Steifetten 2011) following major disturbance events (e.g. fire, clear-felling) (Brotons *et al.* 2008,).

I then did a random selection of 53 burnt clear-cuts among this pre-sample (n=124), but to reduce the risk of an effect of pseudoreplication, I set the minimum distance between clear-cuts to 1 km. To do so, when a clear-cut was selected, the surrounding clear-cuts within a circle of 1 km radius were deleted from the list. Each sampled burnt clear-cut was then matched with a non-burnt partner (1-8 years after clear-felling, n=12 636) according to the following criteria in order of priority (Fig. 2):

- Similar clear-cut size,
- As close as possible, but further than 1 km,
- Clear-felling date corresponding with burning date (+/- 3 years).

In this sampling scheme, clear-cuts smaller than 0.5 ha and inaccessible clear-cuts (surrounded by water) were excluded. Finally, the sample was composed of 53 burnt clear-cuts (range: 1.3 - 49 ha; $\bar{x}$=16 ha) paired with non-burnt clear-cuts (range: 1.6 - 70 ha; $\bar{x}$ =15.6 ha).

Figure 2: Non-burnt clear-cut (left) vs. burnt clear-cut (right) - Clear-felling 2008 (5 years old).

For Phase 2, the sampling units were clear-cuts originating from between 2009 and 2012 within the sampling space. I applied stratified sampling over three size classes intervals (Table 1). Because I expected the potential effect of clear-cut size on presence/absence to be expressed in the 4-16 ha range, I used a larger number of samples in the middle class. Some inaccessible clear-cuts were excluded during the field work, leading to a slightly unbalanced number for each size classes.

The size range of all sampled clear-cuts went from 0.6 - 55.5 ha ($\bar{x}$= 9.91 ha).

Table 1: Distribution of available and sampled clear-cuts in the sampling space (clear felled after 2008), among size classes.

| | **Size classes** | **0.5-4 ha** | **4-16 ha** | **>16 ha** | **∑** |
|---|---|---|---|---|---|
| Available clear-cuts in the sampling space | Nr. | 1540 | 766 | 61 | 2367 |
| | Total area of (ha) | 2880 | 5685 | 1527 | |
| | % | 65.1 | 32.4 | 2.6 | |
| Sampled clear-cuts | **Nr.** | **53** | **155** | **38** | **246** |
| | Total area (ha) | 108 | 1358 | 1022 | |
| | % | 21.5 | 63.2 | 15.4 | |

*Bird observations*

Phase 1 was conducted between the 15th -27th of May and Phase 2 between the 29th of May and the 15th of June 2013. Observations were made between 4:00 and 12:00. Weather conditions with rainfall or strong wind were avoided. Date, time and weather conditions were recorded for each clear-cut visit.

Sampled clear-cuts were visited in clusters for logistic reasons (one cluster every day), but these daily clusters were randomly scattered over the study area. In Phase 1, the paired clear-cuts were visited on the same morning.

In both Phase 1 and Phase 2, the unit of observation was presence/absence of Ortolan Bunting on the focal clear-cut.

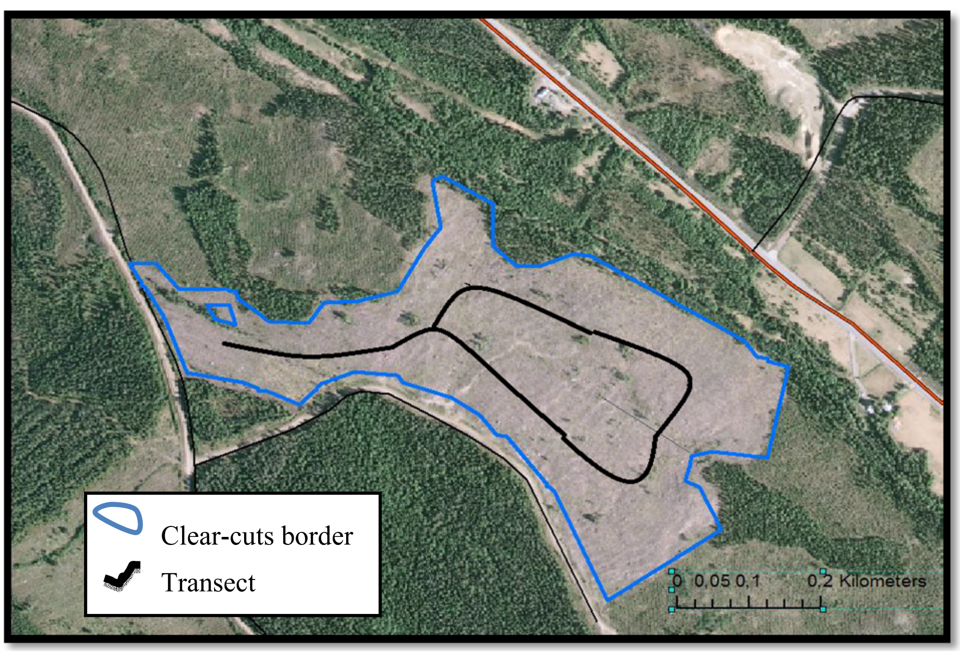


Figure 3: Sample clear-cut example with the line transect

Observations of presence/absence of Ortolan Bunting within each clear-cut were assessed with the aid of audio playback. Line transects were used (Bibby *et al*., 2000) in such a way that all parts of the clear-cut came within 150 m from the transect/observer, but staying 150 m away from the borders (Fig. 3). While walking along the transect, I made a stop every 3$^{rd}$ min to display a 1-min playback sequence of Ortolan Bunting song. Playback of Ortolan Bunting song increases detecting rate by triggering birds to come closer and vocalize. According to Osiejuk *et al.* (2007) only playback of local dialects will provoke a strong response in Ortolan Bunting. The song used was recorded in Sweden by Gunnar Fernqvist (birdvideosweden, Arosfilm) the 17$^{th}$ May 2012. It was a "typical" 1 min song with 6 phrases. I amplified the call using a 3 W speaker and with a frequency response of 90 Hz to 20 kHz. Under good weather conditions I could hear the broadcasted song at a distance of 200 m and I assume that the hearing distance of Ortolan Bunting was longer than 200 m.

In order to evaluate the likelihood of false presence by attracting Ortolan Bunting from outside the focal clear-cuts, I calculated the total area (ha) of the surrounding clear-cuts (clear-felled after 2008) within a 300 m buffer zone outside the edge of the focal clear-cut.

When a bird was detected, I left the clear-cut. The maximum time spend on a clear-cut was standardized over clear-cut sizes by intervals of 5 ha: 5 min for 0-5 ha, 10 min for 5-10 ha, etc. (Table 2).

Table 2: Size intervals (ha) with the maximum observation time affiliated (min).

| **Size (ha)** | **Max. time spend on the clear-cut (min)** |
|---|---|
| 0-5 | 5 |
| 5-10 | 10 |
| 10-15 | 15 |
| 15-20 | 20 |
| 20-25 | 25 |
| 25-30 | 30 |
| 50-35 | 35 |
| 35-40 | 40 |
| 40-45 | 45 |
| 45-50 | 50 |
| 50-55 | 55 |
| 55-60 | 60 |
| 60-65 | 65 |
| 65-70 | 70 |

*Habitat description*

For both Phase 1 and 2, I assessed the average proportion of bare soil and the type of site preparation. Bare soil included all non-vegetated surfaces, except rock, such as machine tracks and site preparation. The percentage of Bare soil was classified into three categories : low = 0-5%, medium = 5-20% and high = >20%. Site preparation was separated into Disc-trenching, Mounding and None.

For Phase 1, the collection of clear-cuts data was synchronised with a study on Ortolan Bunting in Västerbotten by Julie Percival and Svein Dale. The following parameters were assessed (appendix 1): main tree species, density of snags, presence and type of forest impediments (rocky or wet patches), caracteristics of remaining conifers and broadleaf trees (density, distribution, height, condition), vegetation types within the entire clear-cut (following the vegetation type classification scheme of Hägglund & Lundmark (1984)), stump / tree tops / branches harvest, soil type, topography and wetness.

For Phase 2, data collection on the field was limited for logistic reasons and the new parameters (Table 3) were extracted from ArcMap v10.2 GIS software (Environmental Systems Research Institute Inc., California). The framland polygones were extracted from “Fastighetskartan” supplied by the SLU GIS database (http://www.lantmateriet.se, 15$^{th}$ of June 2013).

Table 3: Description of clear-cuts variables of Phase 2, extracted from ArcMap v10.2 GIS

| Variables | Name | Sites informations | Type | Categories | Units |
|---|---|---|---|---|---|
| Clear-cut size | Size | | continuous | | ha |
| Clear-cut size classes | Size classes | | discrete | 0-4<br>4-16<br>>16 | ha |
| Distance to the Baltic Coast | DistCoast | | continuous | | km |
| Distance to nearest farmland | DistFarm | farmland under cultivation after 2006 | continuous | | km |
| Surrounding farmland area (within 3km) | FarmArea | | continuous | | ha |
| Distance to nearest clear-cut | DistCC | clear-felling after 2008 | continuous | | km |
| Surrounding clear-cut area (within 3km) | CCArea | | continuous | | ha |
| Surrounding clear-cut area (within 300m) | CCArea300 | | continuous | | ha |
| Age of the clear-felling | Age | | discrete | 2009;2010;<br>2011; 2012 | years |
| Bare soil | Bare soil | | discrete | 0-5<br>5-20<br>>20 | % |

Continuous variables were tested for pair-wise correlation using Spearman’s Rank Correlation Coefficient (ρ) with a threshold at $\rho>0.6$, for being included as predictors in the same model. DistFarm and FarmArea were correlated ( $\rho>0.6$); so I excluded DistFarm because its estimate had the highest $P$-value ($P$=0.98 vs. $P$=0.6).

Observed presences did not show any spatial auto-correlation with the Moran's *I* test (Fig. 4).

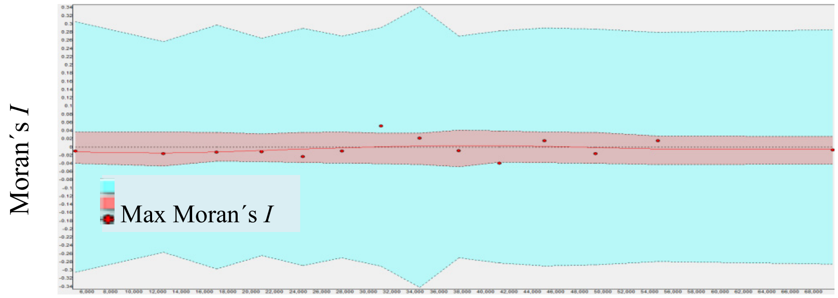


Figure 4: Moran´s *I* on the presences of the Phase 2 clear-cut sample (n=246).

Statistical analysis

Phase 1

In Phase 1, the extremely low occurrence rate precluded any statistical analyses.

Phase 2

*Clear-cut size*

In Phase 2, I tested the distribution of presence/absence over the clear-cut size classes with a $\chi^2$ test of homogeneity.

Under random spatial distribution of Ortolan Bunting ("Ortolan Buntings raining randomly from the heavens"), the likelihood of presence increases with clear-cut size (Connor & McCoy 1979, Anderson & Marcus 1993). (Thus an observed correlation between occurrence and area could be due to sampling phenomenon rather than biological processes.) To control for this potential bias, I randomly merged small clear-cuts (n=53) into 'virtual large clear-cuts', summing up area and presence of Ortolan Bunting until the mean size of these 'virtual large clear-cuts' was the same as the mean size of clear-cuts in the >16 ha size class ($\bar{x} = 26$ ha ) (de Jong, 2012) (Fig. 5). I ensured that the two populations, virtual clear-cuts of the small size class and clear-cuts of the large size class, were equally large (n=38). I then tested occupancy rate of virtual large clear-cuts and truly large clear-cuts.

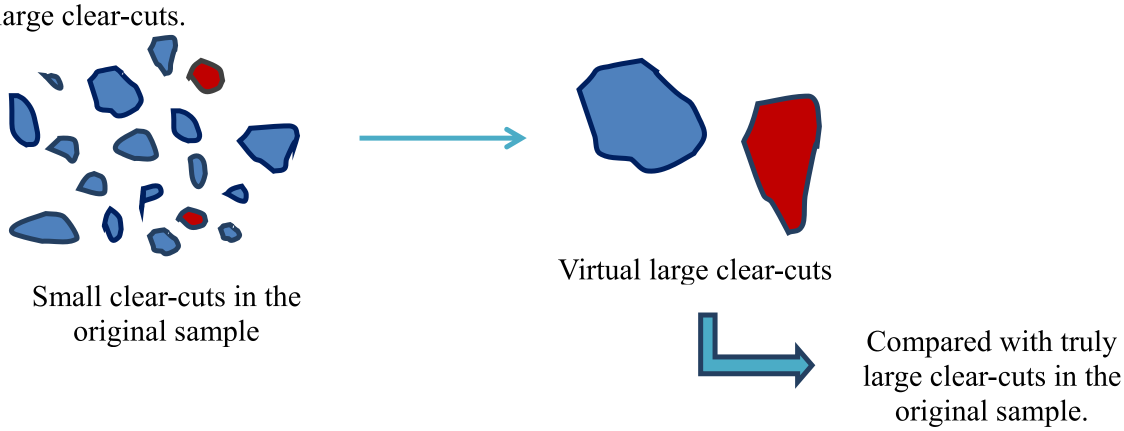


Figure 5: Schema of the method to control the potential bias of sampling phenomena under random spatial distribution of Ortolan Bunting on their presence on clear-cuts of different size.

*Habitat modeling*

I used binomial logistic regressions to explore the role of potentially explanatory variables Size, DistCoast, DistFarm, FarmArea, DistCC, CCArea, and Age (Table 3) on the presence/absence of Ortolan Bunting. The modelling was carried out in three steps.

In the first I ran univariate logistic regressions (GLM´s) with presence/absence of Ortolan Bunting as response variable for each of the seven variables (Table 3). I also plotted these models (Faraway 2005).

I then chose the variables to include in the modelling process. In addition to the variables recorded, quadratic functions of FarmArea, CCArea and DistCoast were included to allow for non-linear relationships. I also included the interaction terms between Size and CCArea (Size: CCArea), because I expected the effect of Size to decrease with CCArea. No other interactions were included because they were not deemed ecologically meaningful.

In the second step, I started with a binomial GLM with the variables selected in step 1: Size, DistCoast, DistCoast$^2$, FarmArea, FarmArea$^2$, DistCC, CCArea, CCArea$^2$, Age and (Size: CCArea). Then I simplified this model by removing one, by one, the variables with the highest P-value of the estimated coefficient, thus gradually approaching the most parsimonious model. I stopped when all the variables´ $P$ value of the model were <0.1.

In the third step, I used Akaike's Information Criterion corrected for small samples (AIC*c*) to compare all 15 possible models based on variables selected in step 2 (Johnson & Omland 2004).

Finally I evaluated the overall fit of the best model in a classification table of presences/absences fitted by the best model against the observed ones.

*Bare soil*

I used $\chi^2$ test of homogeneity to test the distribution of presence/absence over Bare soil classes.

*False presence*

I did a univariate logistic regression for the variable Surrounding clear-cuts area within 300m (CCArea300) in order to evaluate the likelihood of false presences, which could have been caused by attracting Ortolan Bunting outside the focal clear-cuts.

I used SAM (Rangel *et al.* 2010) v4.0 to calculate Moran´s I and the statistical program R v2.15.1 (R Development Core Team 2008) including MASS (Venables & Ripley 2002), MuMIn (Barton 2013) and car (Fox & Weisberg 2011) for all other analyses.

## Results

Phase 1

*Burnt clear-cuts*

Of 106 clear-cuts visited in Phase 1, Ortolan Buntings were observed on only two clear-cuts (Fig. 6). One was on a burnt clear-cut from 2005 with an area of 38.4 ha, and the second was on a non-burnt clear-cut from 2006 of 15.9 ha. On both clear-cuts, Bare soil was estimated to cover 0-5 %.

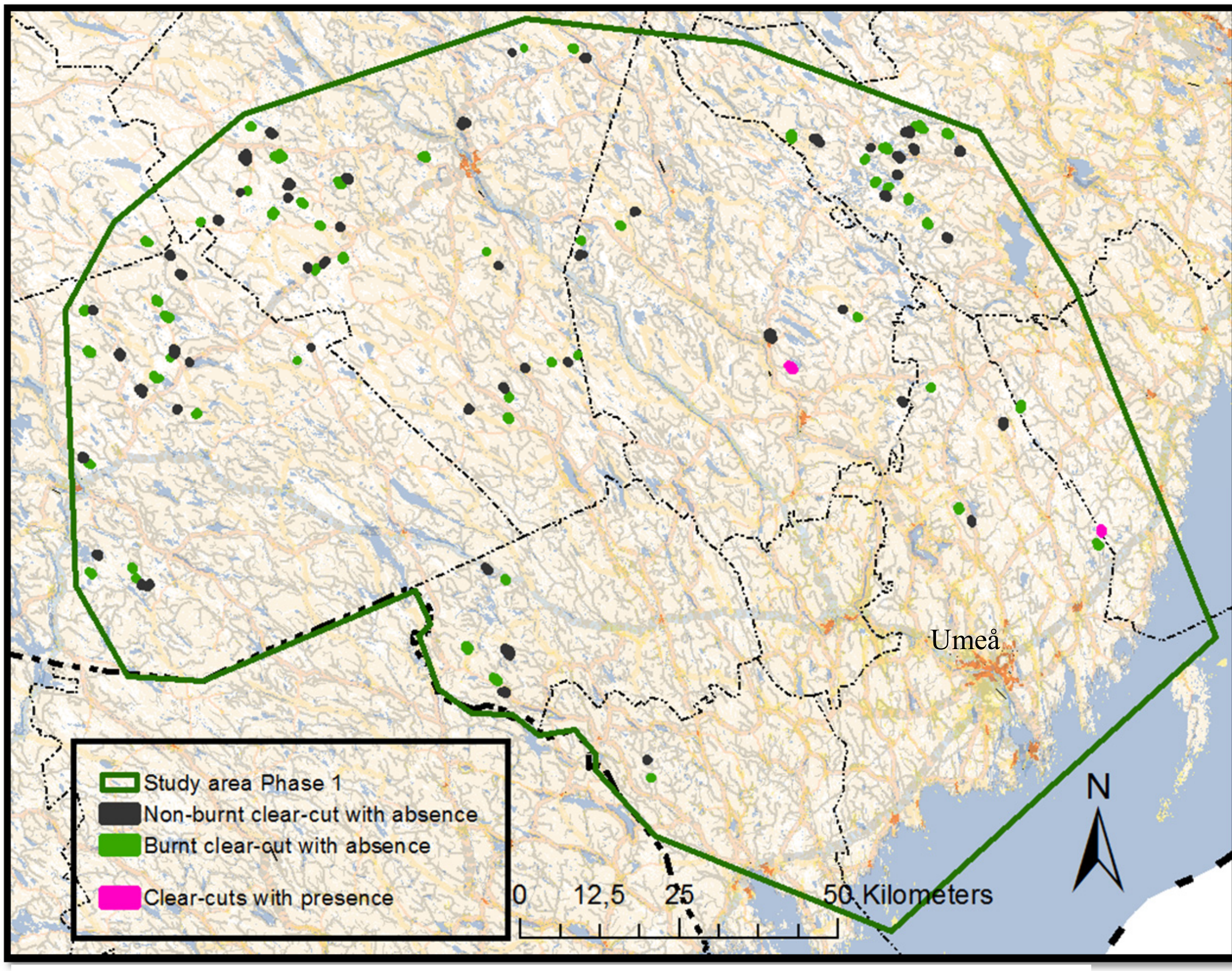


Figure 6: Map over the Phase 1 study area showing sampled burnt and non-burnt clear-cuts and the occurrence of the Ortolan Bunting among these plots.

Phase 2

Of 246 clear-cuts visited in Phase 2, Ortolan Buntings were observed on 57 clear-cuts (Fig. 7).

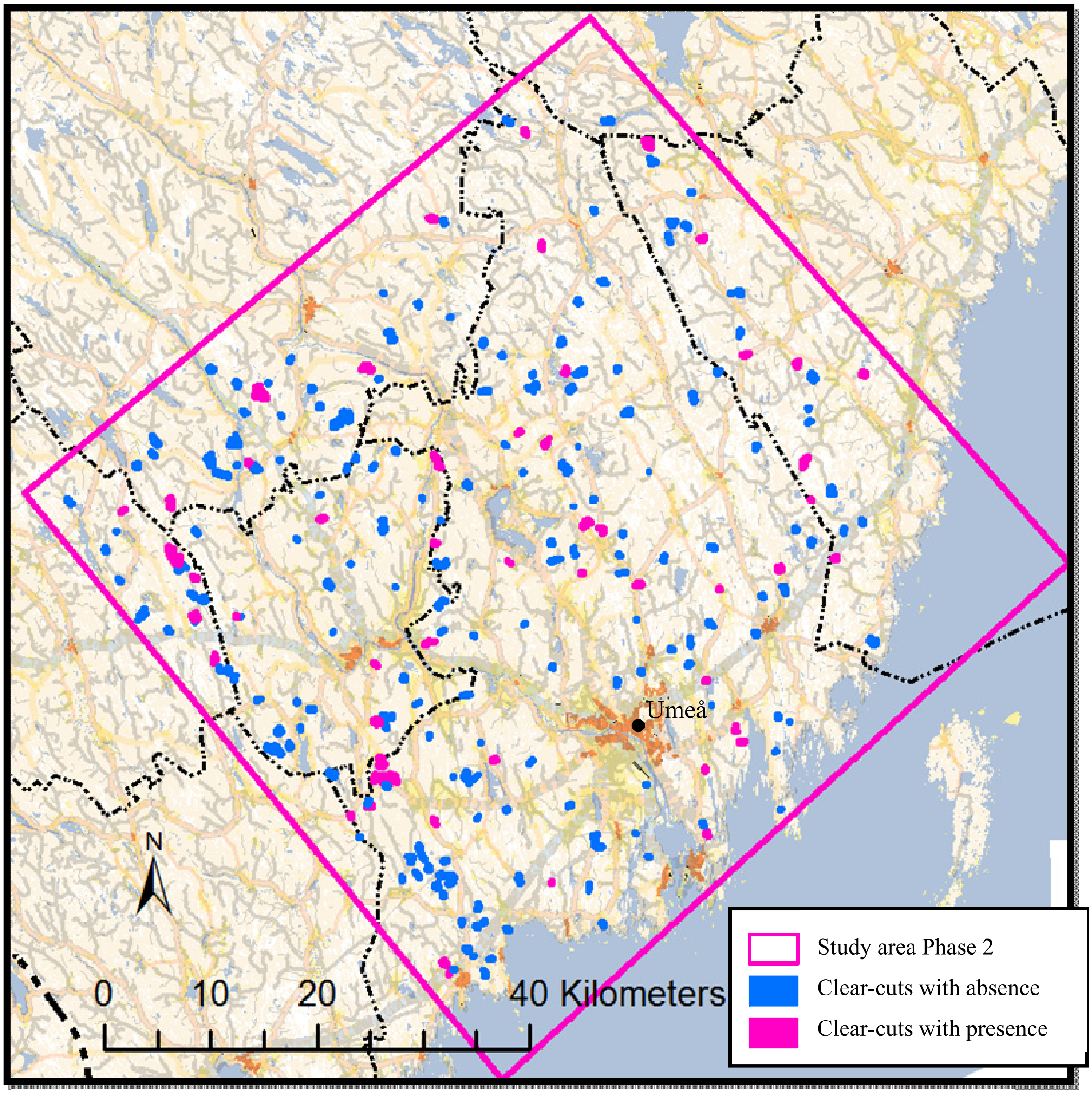


Figure 7: Map of sampled clear-cuts and the occurrence of the Ortolan Bunting among Phase 2 plots (n=246).

*Clear-cut size*

Ortolan Bunting presence differed significantly with clear-cut size ($\chi^2_2$= 18.7, *P<0.0001*). Ortolan Buntings were present on 13 % of clear-cuts in the 0.5-4 ha class, on 20 % in 4-16 ha, and 49 % in >16 ha class. (Fig. 8).

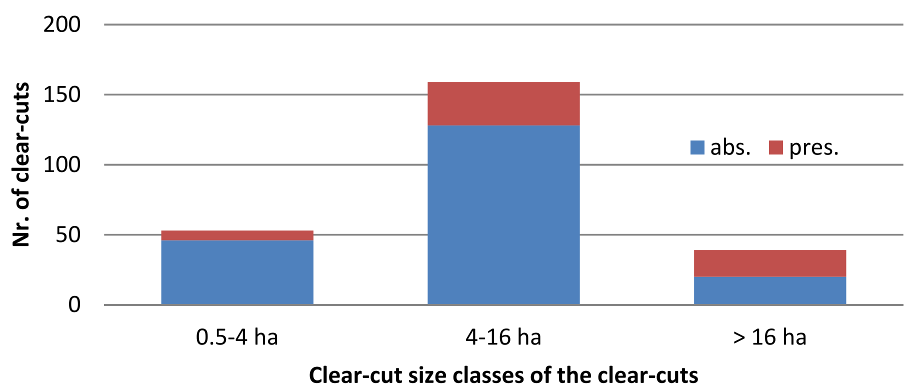


Figure 8: Number of clear-cuts with presence and absence of Ortolan Bunting in size classes: 0.5-4 ha (n=53), 4-16 ha (n=155) and >16 ha (n=38).

However, virtually large clear-cuts had a significant higher occupancy rate than true large clear-cuts (92.3% vs. 49 %, $\chi^2_1$= 15.8, P *<0.0001*).

*Habitat modelling*

Minimum, maximum and mean for the variables Size, DistCoast, DistFarm, FarmArea, DistCC and CCArea on clear-cuts with presence and absence respectively are given in Table 4.

Table 4: Minimum, maximum and mean for potentially explanatory variables for clear-cut with presence (n= 57) and absence (n=190) of Ortolan Bunting.

| | **Presence** | | | **Absence** | | |
|---|---|---|---|---|---|---|
| **Independent variables** | **min** | **max** | **mean** | **min** | **max** | **mean** |
| **Size (ha)** | 1.2 | 40 | 13.8 | 0.6 | 55.5 | 8.8 |
| **DistCoast (km)** | 10 | 71 | 42 | 7 | 75 | 42 |
| **DistFarm (km)** | 0 | 3 | 0.9 | 0 | 7 | 0.9 |
| **FarmArea (ha)** | 0 | 634 | 157 | 0 | 656 | 146 |
| **DistCC (km)** | 0 | 1.1 | 0.23 | 0 | 2.0 | 0.35 |
| **CCArea (ha)** | 12 | 223 | 78 | 4 | 246 | 73 |

Modelling process step 1

In univariate regression models ($\alpha$=0.05), significant positive effect on Ortolan Bunting occurrence could be shown for Size (*P*<0.001), but even the negative effect of DistCC (*P*=0.07) and the positive effect of Age (*P*=0.08) come close to significance (Table 5 and Fig. 9).

Table 5: Results of univariate Generalized Linear Models with a binomial distribution (n=246) relating Ortolan Bunting presence/absence to potentially explanatory variables.

| Independent variable | Coef. | Sdt.Err. | Z | P>\|z\| |
|---|---|---|---|---|
| **Size (ha)** | 0.06 | 0.01 | 3.7 | <0.001 |
| **DistCC (km)** | -0.81 | 0.45 | -1.8 | 0.07 |
| **Age** | 0.24 | 0.15 | 1.76 | 0.08 |
| **CCArea (ha)** | 0.002 | 0.003 | 0.73 | 0.46 |
| **FarmArea (ha)** | 0.0005 | 0.001 | 0.52 | 0.60 |
| **DistCoast (km)** | -0.0003 | 0.009 | -0.04 | 0.97 |
| **DistFarm (km)** | -0.004 | 0.17 | -0.021 | 0.98 |

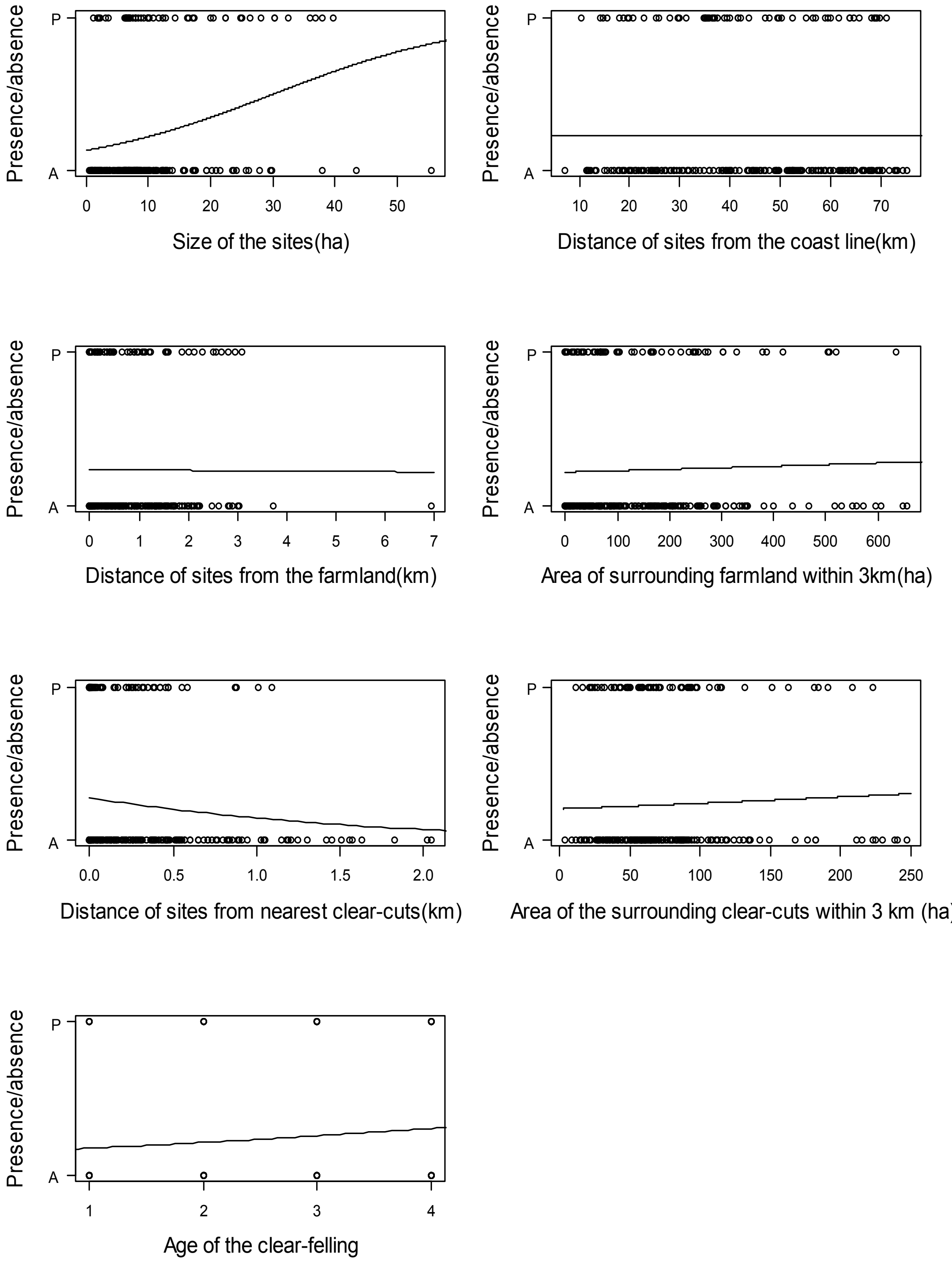


Figure 9: Plot of the univariate Generalized Linear Models for the potentially explanatory variables Size, DistCoast, DistFarm, FarmArea, DistCC, CCArea, and Age (n=246). On the y-axis, A represents absence (0) and P represents presences (1).

Modelling process steps 2 and 3

The final model of the second step contained the variables Size, DistCoast, DistCC and Age.
The model including Size, DistCC and Age was the most parsimonious model of the 15 possible models based on the four variables selected in step 2 (Size, DistCoast, DistCC and Age). However, all top five models fell within a two ΔAICc range (Table 6), so these models were approximately equally adequate to describe Ortolan Bunting presence on clear-cuts.

The variables Size and DistCC were included in all the top four models, with a positive and negative effect respectively. This was consistent with the results of the univariate regression models (Table 5). The variable Age was included in 3 of the top five models with a positive effect (Table 6 and 7).

The best model (Presence/absence ~ Size, DistCC, Age) correctly predicted 55% of the observed presences and 78% of the absences.

Table 6: Ranking of hierarchical logistic regression models for clear-cut selection of Ortolan Bunting using. Models are ranked according to the Akaike's Information Criterion adjusted for small samples (AICc). For each model, the difference between AICc (ΔAICC) with the best model is given.

| Nr | Models | AICc | ΔAICc |
|---|---|---|---|
| 1 | Size+DistCC+Age | 254.2 | 0 |
| 2 | Size+DistCC+Age+ DistCoast | 254.3 | 0.11 |
| 3 | Size+DistCC | 255.3 | 1.13 |
| 4 | Size+DistCC+DistCoast | 255.7 | 1.52 |
| 5 | Size+Age | 256.0 | 1.76 |
| 6 | size | 256.3 | 2.14 |
| 7 | Size+DistCoast+Age | 256.4 | 2.17 |
| 8 | Size+DistCoast | 256.9 | 2.70 |
| 9 | Age+DistCC | 264.4 | 10.16 |
| 10 | DistCoast+DistCC+Age | 266.3 | 12.12 |
| 11 | DistCC | 266.7 | 12.46 |
| 12 | Age | 267.2 | 13.04 |
| 13 | Null model | 268.4 | 14.14 |
| 14 | DistCoast+DistCC | 268.7 | 14.49 |
| 15 | DistCoast+Age | 269.3 | 15.07 |
| 16 | DistCoast | 270.4 | 16.17 |

Table 7: Results of Generalized Linear Models for the top five models (n=246).

| | Size | | DistCC | | Age | | DistCoast | |
|---|---|---|---|---|---|---|---|---|
| **Models Nr.** | **Coef.** | **P>\|z\|** | **Coef.** | **P>\|z\|** | **Coef.** | **P>\|z\|** | **Coef.** | **P>\|z\|** |
| 1 | 0.06 | <0.001 | -0.87 | 0.07 | 0.23 | 0.08 | | |
| 2 | 0.07 | <0.001 | -0.91 | 0.06 | 0.27 | 0.06 | -0.01 | 0.16 |
| 3 | 0.06 | <0.001 | -0.77 | 0.10 | | | | |
| 4 | 0.07 | <0.001 | -0.79 | 0.09 | | | -0.01 | 0.20 |
| 5 | 0.06 | <0.001 | | | 0.22 | 0.12 | | |

*Bare soil*

The occupancy rate differed significantly over the three bare soil classes ($\chi^2_2$= 30.6; *P <0.0001*). Clear-cuts with small percentages of bare soil had higher probability of Ortolan Bunting presence than clear-cuts with high percentages (Fig. 10).

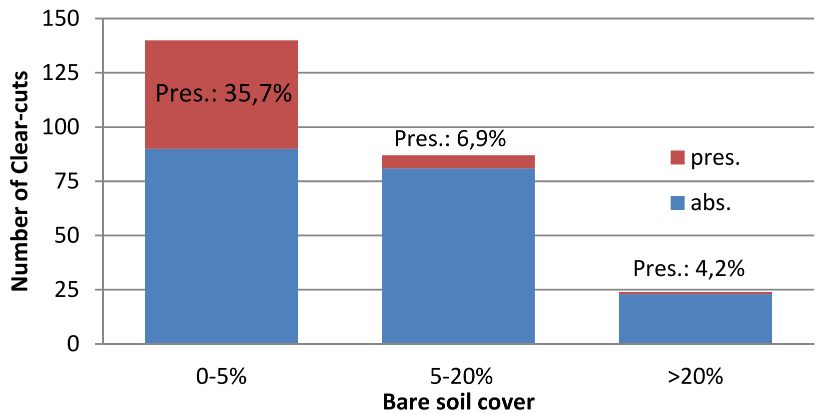


Figure 10: Number of sample clear-cuts (n=246) with presence and absence of Ortolan Bunting in each of the bare soil classes: 0-5%, 5-20% and >20%.

## Discussion

## Phase 1

Burnt clear-cuts

The hypothesis that burnt clear-cuts are preferred by Ortolan Bunting in northern Sweden could not be tested due to data deficiency. However, the question on the relevance of including prescribed burning for Ortolan Bunting management in the region should not been put aside. Further studies should be done and improved based on the experiences gained from Phase 1.

Non-concordance between study area and the distribution of the species could have decreased the number of occurrences. The Ortolan Bunting range limits are not well known in northern Sweden, but according to Stephens & Sutherland (1999), the spatial distribution of a species is determined by the strength of the Allee effects to which it is subject. They suggested that if the population is close to the critical level of local abundance, less suitable habitat might support lower population densities in the edges of the species range and thus lead to declines towards the extremes of their range. Also, the colonization of new clear-cuts for Ortolan Bunting (Brotons et al. 2008) and other open- habitat species (Brotons et al. 2005) occurred most frequently near previously occupied areas. We could suspect that Phase 1 study area was outside or on the edge of the range, and thus decrease the probabilities of Ortolan Bunting presence on clear-cuts even if they fulfilled all physical requirements for a “breeding” site.

The clear-cut characteristics studied in Phase 2 could also potentially have explained the low number of Ortolan Bunting observed in Phase 1.

## Phase 2

Clear-cut size

Firstly, Ortolan Buntings seem more present on large clear-cuts (Fig. 8, 9 and Table 6, 7). This observation is consistent with the study of Santos *et al.* (2002) who showed a positive relationship between patch size and presence of Ortolan Bunting as well as other birds in Mediterranean landscapes.

However, neither the study of Santos et al. (2002) nor my results mentioned above were based on a random spatial distribution of Ortolan Bunting. Also, by taking out the size effect on a spatially random distribution of Ortolan Bunting, the virtual large clear-cuts showed that presence would have occurred more likely on small clear-cuts. This means that the higher probability of presence of the Ortolan Bunting on the large clear-cuts, stated above, was probably more due to random effects than an ecological preference for bigger clear-cuts. Thus, the likelihood to have Ortolan Bunting present was higher on bigger clear-cuts than small ones, but the preference was for the small ones. However, it must be kept in mind that this conclusion is based on presence-absence data; it does not take into account possible differences in breeding density between large and small clear-cuts.

Clear-cuts size results in Phase 2 could not explain the low number of Ortolan Bunting in Phase 1, although the clear-cuts were almost twice as big as Phase 1.

## Habitat modelling

### *Model fit*

The residual/null deviance ratio of the best model was 92 %, which shows that only 8% of the variation in the data was explained by the best model. However the AICc of the best model was relatively good compared to the null model (ΔAICc=14).

The best model was rather poor at predicting presences, but better at predicting absences.

Ortolan Bunting presences were partly explained by the model, but the model fit could probably have been improved by including additional variables like a description of the vegetation on the clear-cut as mentioned below.

### *Distance to the coast*

The chances of presence of Ortolan Bunting tended to increase toward the coast (Table 6) but not significantly (Table 7). So the difference of Ortolan Bunting presences between Phase 1 and Phase 2 study areas could not be explained by this parameter.

However, the presences recorded in Phase 1 and 2 were all not further than 70 km from the coast whereas the majority of the burnt clear-cuts where further inland. So even if the data did not show it, the distribution of Ortolan Bunting presences seems to show that Phase 1 study area was outside or on the edge of the range. The statistical analyses were done only on Phase 2 study area, 70km from the coast only, which was probably not enough far inland to detect this observed change in the Ortolan Bunting distribution pattern.

### *Proximity of farmland*

Farmland area did not affect the presence of Ortolan Bunting (table 5 and 6).

Previous studies have shown that Ortolan Bunting nesting on raised peat bogs (Dale, 2000) and burnt forest area (Dale & Olsen 2002) choose their nesting sites close to farmland for foraging. However, in Mediterranean habitats, Fonderflick *et al.* (2005) found that proximity to farmland was not important for Ortolan Bunting occupancy and he suggested that foraging in agricultural land could simply result from the unavailability of foraging habitat elsewhere. In Dale (2000) and Dale & Olsen (2002) studies, nesting sites had infertile soil making foraging on the nesting site difficult; in contrary, clear-cuts in northern Sweden seem more fertile with tall grass and presence of insects. Furthermore farmland areas are rare in northern Sweden (Statistics Sweden 2013). A potential explanation for the non-significance of the distance of farmland for Ortolan Bunting in northern Sweden is that they have the possibility to feed and nest on clear-cuts and then do not have the need to go to farmland for foraging.

Farmland area could not explain the low Ortolan Bunting number in Phase 1 because the parameter did not show any significant effect and total farmland surface did not seem to have any difference between Phase 1 and Phase 2 study areas.

*Proximity of other clear-cuts*

Ortolan Bunting occurrence was higher when surrounding clear-cuts were closer (Table 5, 6 and 7). This leads to two hypotheses. The first one is that Ortolan Buntings prefer clear-cuts located close to other clear-cuts due to conspecific attraction. However, Moran's I analysis showed that there was no autocorrelation for presences, which mitigated this hypothesis. The second hypothesis is that Ortolan Buntings could use more than one clear-cut, which supports the hypothesis that Ortolan Buntings in Northern Sweden could forage on clear-cuts rather than farmland.

However, the contribution of the variable DistCC was really small. The improvement of adding DistCC to a model with Size alone was ΔAICc= 1. Furthermore, the alternative variable Surrounding clear-cuts area within 3 km (CCArea) was not selected in Step 2. So the nearest distance to other clear-cuts was probably not a limiting factor for the Ortolan Bunting. This could be explained by the fact that in the study sample, clear-cuts were abundant and the maximum distance to the nearest clear-cut was < 2 km, which is a relatively small distance compare to what an Ortolan Bunting can handle.

Cramp *et al.* (1994) and Dale (2002) concluded indeed that Ortolan Bunting have nesting territories with a 100 m radius (≈3,14 ha). Furthermore, Ortolan Bunting were found on feeding areas up to 2.7 km away from the nesting territory (Dale & Hagen 1997, Dale 2000). This suggests that Ortolan Bunting could find additional resources (egg. Tall grass, seeds, insects) on a nearby clear-cut and thus relax shortage on the clear-cut of the nesting territory.

Proximity of other clear-cuts could nevertheless not explain the difference on the low number of Ortolan Bunting in Phase 1 because total clear-cut surface did not seem to have any difference between Phase 1 and Phase 2 study areas.

*Age of the clear-cuts*

Ortolan Buntings presences slightly increased with clear-cuts age (Table 6 and 7). This could be explained by the increasing diversity of the soil cover. Over time, the clear-cut presented a mosaic with grasses and bare soil patches which was favored against the high habitat uniformity of bare soil after clear-cutting.

This study shows the effect until four years after clear-felling but the studies of Sirami (2007) and Herrando (2002) indicates that bird occupancy rates will decrease when the vegetation got too high. Further studies including the age effect on a longer term could precise the age threshold when the clear-cuts attractive characteristics for Ortolan Bunting fade out.

Bare soil

Ortolan Bunting were significantly more present on clear-cuts with few bare soil (0-5%) (Fig. 10). This is in contradiction with previous study where bare soil has been reported to be one of the principal drivers of the Ortolan Bunting's habitat selection pattern (Menz *et al.* 2009a), like a number of other terrestrially foraging bird species are known to be more present on habitat with high percentage of bare soil / sparsely vegetated which likely provides enhanced prey accessibility (Maurer 2006, Ioset & Arlettaz 2007, Tagmann-Ioset *et al.* 2012).

However, Vepsalainen *et al.* (2005) and Berg (2008) expressed that Ortolan Bunting seem to prefer habitat with a mix of tall vegetation for nest-site and bare soil / sparsely vegetated patches for foraging. Furthemore, Fonderflick *et al*. (2005) showed that if bare soil is not a limiting factor, it has little effect on the habitat suitability.

In this study, bare soil did not seem to be a limiting factor and although I did not register the amount of grass, a negative correlation between percentage of area covered by grass and bare soil could be expected. Thus, the negative relationship between percentages of bare soil (Fig. 10) could be an effect of a positive relation with grass, suggesting that the Ortolan Bunting were seeking habitats with a mosaic vegetation. More studies on the Ortolan Bunting/bare soil/vegetation issue in northern Sweden could clarify the relationship.

Observation bias

*False presence*

False presence could have occurred by recording Ortolan Buntings singing outside the focal clear-cut. However, this is unlikely to have happen because most of the birds were detected in the middle of the clear-cut.

False presences could also have arisen from attracting Ortolan Buntings from neighbouring clear-cuts. To minimize that effect, survey transects were 150 meter away from clear-cut edges. To make sure that there were no such attraction from outside the focal clear-cut, I analyzed the relation between presence/absence and the total clear-cuts area within a 300 m buffer from the edges of the focal clear-cut. This variable did not show any significant effect, so false presence were unlikely to have caused data bias.

*False absence*

Phase 1 was planned on 106 clear-cuts with 3 visits. But in Phase 2, I was forced to apply a single visit taking the risk of false absences to get a sufficient data set.

The time spent on each clear-cut was standardized over clear-cut sizes in order to have a system of equal effort per hectare, but it may have caused a slight increase in false absences on small clear-cuts: I spend only 5 minutes on clear-cuts smaller than 5 ha, this could be too short to hear the bird vocalize. Despite this, virtually large clear-cuts had higher rates in presence than true ones (92.3 % against 49%). Thus, the estimates of presence on small clear-cuts were conservative.

Also, to minimize the risk of false absences, observations of Ortolan Bunting presence / absence were assessed with the aid of playback which triggered the birds to come closer and vocalize.

Because most of the detections were based on vocal clues, reduction in song activity, e.g. during the incubating period (Dale personal comments) or bad weather conditions, could have led to false absences. These possible effects of low song activity were reduced by avoiding days with strong wind or rainfall and by visiting clear-cuts in a pseudo-random order, breaking potential correlation between singing activity and the habitat variables.

Overall, false presences and absences didn´t seem too important in my data; however repeated visits would have given more power to my results.

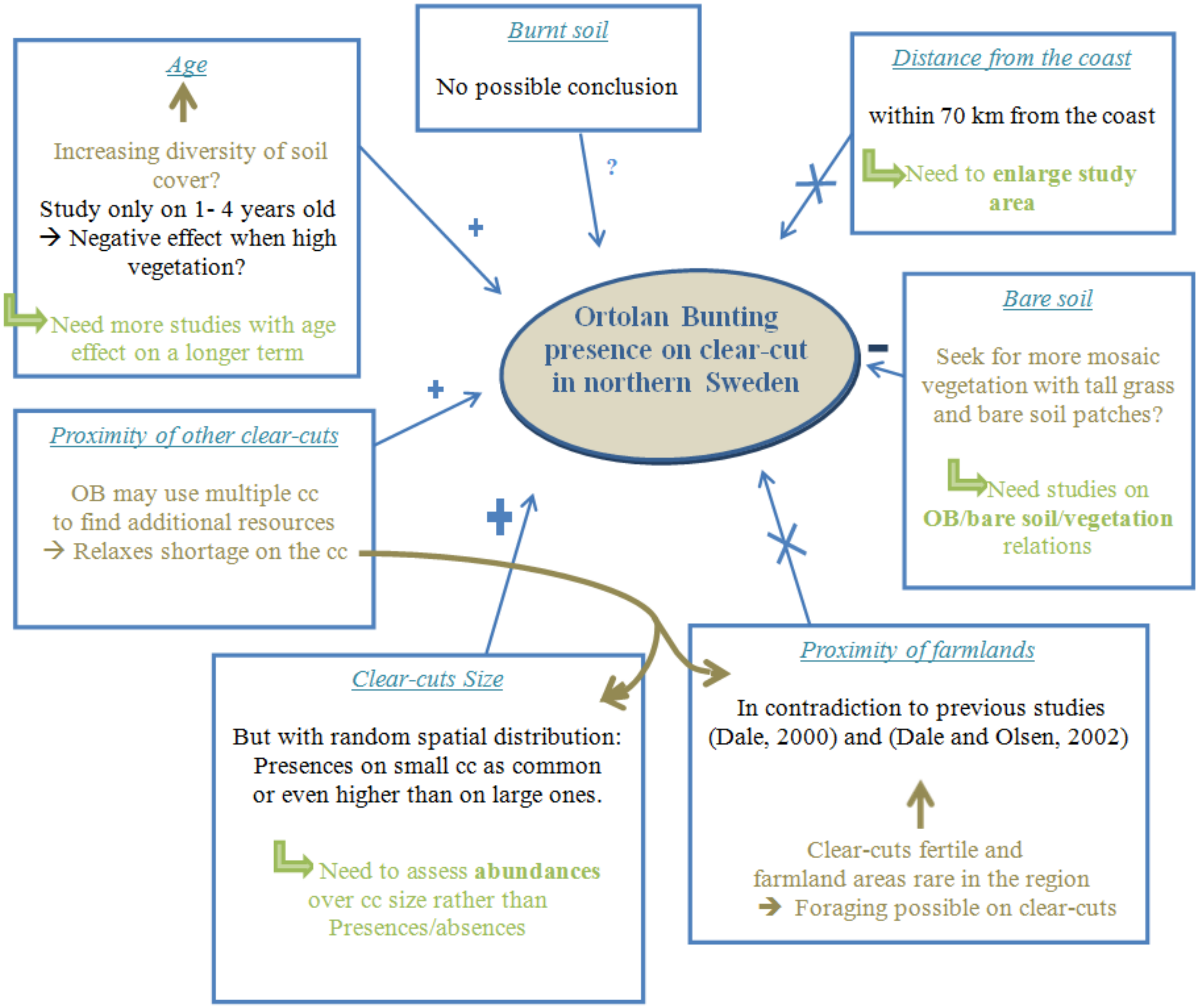


Figure 10: Synthetic scheme

## Conclusion, management implications and further researches

From this study the following conclusions can be made:

- There is a positive relationship between clear-cut size and Ortolan Bunting presence, but when accounting for random spatial distribution, presence on small clear-cuts is as likely or even higher as on large ones.
- Proximity to farmland did not increase the possibility of presence of Ortolan Bunting on clear-cut
- Ortolan Bunting presence is higher on clear-cuts with 0-5 % bare soil than on clear-cuts with >5% bare soil.
- The negative effect of distance to other clear-cuts leads to the hypothesis that individual Ortolan Buntings may make use of multiple clear-cuts.
- Within 70 km from the coast, there is no significant coast-inland gradient in Ortolan Bunting presences.

None of the factors studied in Phase 2 were able to explain the low Ortolan bunting presences observed in Phase 1. Thus, decisions of prescribed burning do not seem to have to take into account neither clear-cut size, distance to farmland nor distance to the coast (< 70 km).

Nevertheless, this study raised some questions that could not be answered with its results. In order to clarify some issues on the Ortolan Bunting habitat, the method could be improved by:

- Visiting sites multiple times
- Enlarging the study area
- Assessing abundances over clear-cut size rather than presence/absence
- Measuring actual breeding success (as opposed to only abundance)
- Improving the bare soil description
- Adding details to the habitat description

This study seek for conservation management plans for the Ortolan Bunting, based on the hypothesis that breeding habitat loos or degradation account for the main threat of the Ortolan Bunting decline.
However, identification of the principal threats is complicated by the variability in habitat choice across Europe and factors inducing Ortolan Bunting decline could also came from wintering ground condition or from the migration travel.
Today, Ortolan Bunting management needs more information on their reproduction success and survival to identify the main threat; and since the decline occurs on large scale, the survey should be conducted on the same large scale.

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# Appendices

1- Field data collection sheet Phase 1

2- Correlation boxplots

## Survey I

Site N_: ............

Date: ..................

Pic n_:........

*Time*

| | |
|---|---|
| Arrive on the site: | |
| Start survey: | |
| Finish survey: | |
| Leave the site: | |

*Observer(s):*

*Weather*

**Temperature:**

| **Wind:** | **Visibility:** | **Clouds and rain:** |
|---|---|---|
| ☐ Calm or weak<br>☐ Weak or moderate<br>☐ Moderate or brisk (occasionally hindered obs.) | ☐ Good<br>☐ Good or moderate (birds far away difficult to see)<br>☐ Moderate or bad (occasional problems in obs.)<br>☐ Bad (obs. Nearly hindered) | ☐ Mostly clear<br>☐ Varying cloudiness<br>☐ Mostly cloudy<br>☐ Occasional rain or snow hindered obs. |

## Ortolan Bunting

Present: ☐ Yes ☐ No

Time:

Heard: ☐ Song ☐ Alarm call ☐ Flight call

Seen: ☐ Song post ☐ Ground ☐ Flying

Observations:

## Vegetation

Main tree species: ☐ Spruce ☐ Pine ☐ Deciduous

Regrowth: ☐ Planting ☐ Sowing

Högstubbe: ☐ 0/ha ☐ 1-10/ha ☐ >10/ha

Impediment: ☐ None ☐ Rocky ☐ Wet

Tree cover *(fill up in the table : "S"- for Scattered and "C"- for Clumped in the column corresponding at the number/ha .)*

**Conifer**

| Height (m) | | 0 | 1-10 | >10 |
|---|---|---|---|---|
| 0 -1,3 | Dead | | | |
| | Alive | | | |
| 1,3 – 10,0 | Dead | | | |
| | Alive | | | |
| >10,0 | Dead | | | |
| | Alive | | | |

**Broadleaf**

| Height (m) | | 0 | 1-10 | >10 |
|---|---|---|---|---|
| 0 -1,3 | Dead | | | |
| | Alive | | | |
| 1,3 – 10,0 | Dead | | | |
| | Alive | | | |
| >10,0 | Dead | | | |
| | Alive | | | |

*Forest Type:*

*(Distribution of the total area (%). )*

## Survey I

**Site N_: ………….**

Date: ………………

Pic n_:………

| | | |
|---|---|---|
| **Underordnade Örttyper** | Örttyp utan ris | % |
| | Örttyp med blåbär | % |
| | Örttyp med ris utan blåbär | % |
| **Grästyper** | Bredbladig grästyp + örnbräken | % |
| | Smalbladig grästyp | % |
| | Starrfräkentyp | % |
| **Ristyper** | Blåbärstyp | % |
| | Lingonstyp | % |
| | Kråkbärljungtyp | % |
| | Fattigristyp | % |
| **Lavmarkstyper** | Lavriktyp | % |
| | Lavtyp | % |

## Physical environment

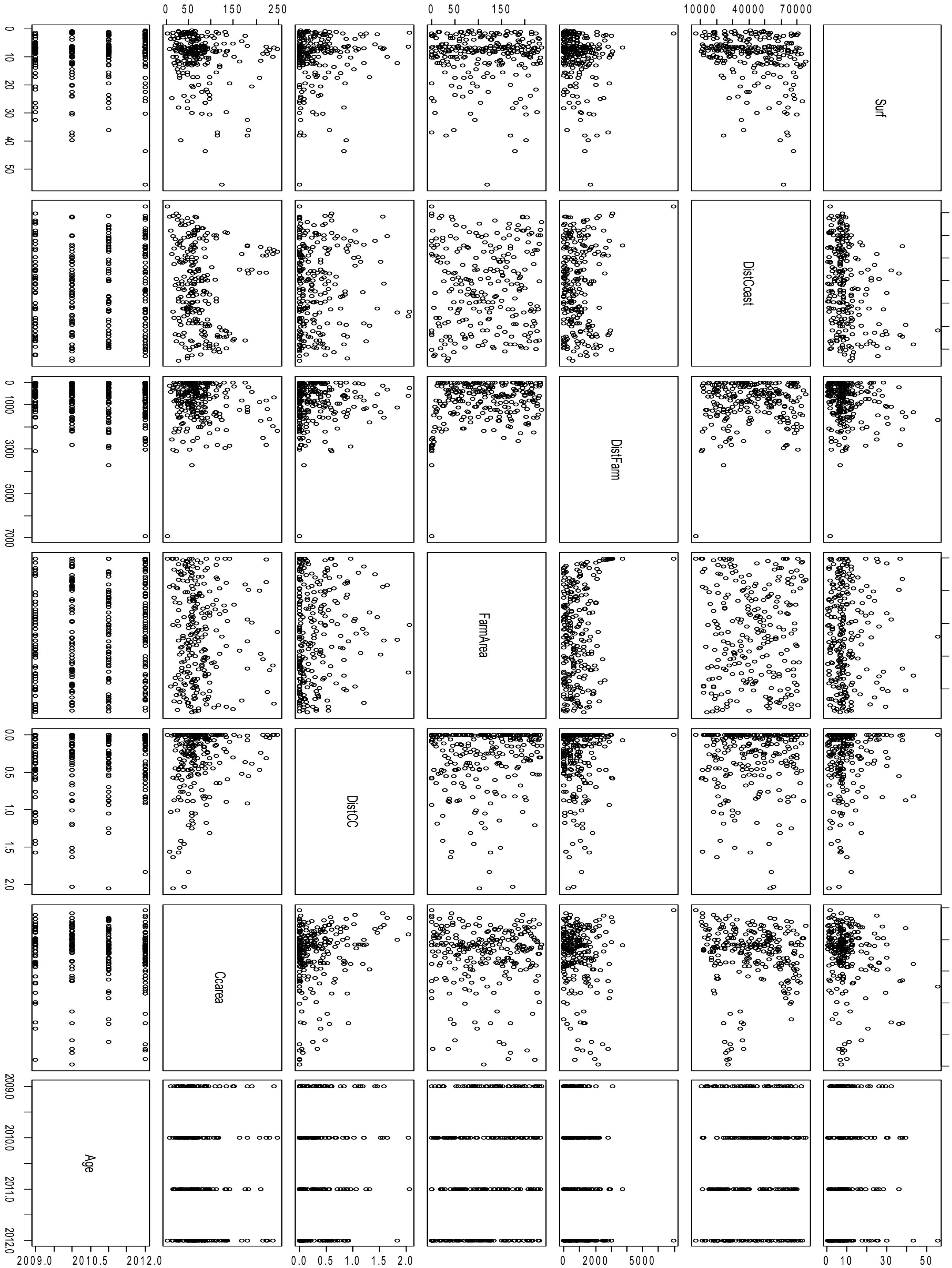
Degree of burning: ☐ None ☐ Low ☐ Medium ☐ Intense
Site preparation: ☐ None ☐ Disc trenching ☐ Högläggning
Stamps: ☐ Harvested ☐ Remain
Grot (tree top and branches): ☐ Harvested ☐ Remain
Bare soil: ☐ 0-5% ☐ 5-20% ☐ >20%

*(Distribution of the total area in each parameter (%). )*
Soil type: Sand……% Moraine……% Peat……% Rocky terrain……%
Topography: Bottom land……% Slope……% Top……%
Moisture: Dry……% Medium……% Wet……%

## Other

Electric poles: ☐ None ☐ Present
Clear-cuts juxtaposed: ☐ Yes ☐ No

*Observations:*




Plot of the correlation between the 7 variables : Size of clear-cuts (Size), distance from coast line (DistCoast), nearest distance from farmland (DistFarm), surrounding farmland area within 3km (FarmArea), nearest distance from clear-cuts (DistCC), surrounding clear-cuts area within 3km (CCarea), and age of the clear-felling (Age). n=246.

## SENASTE UTGIVNA NUMMER



Hela förteckningen på utgivna nummer hittar du på www.slu.se/viltfiskmiljo