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The impact of environmental factors on distribution of Scops Owl *Otus scops* in the wider area of Kras (SW Slovenia)

Vpliv okoljskih dejavnikov na razširjenost velikega skovika *Otus scops* na širšem območju Krasa (JZ Slovenija)

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The aim of the study was to determine the key environmental factors affecting Scops Owl *Otus scops* occurrence in the wider Kras plateau area (SW Slovenia, 665 km^2). Scops Owl was systematically censused in 2006 (180 calling males) and in 2008 (167 calling males). Males were distributed either solitarily or clumped in groups, mostly situated in villages and its surroundings, indicating the species' synanthropic character. Crude densities were 0.3 males/km^2 in 2006 and 2008, respectively, while ecological densities were 1.0 males/km^2 in 2006 and 0.9 males/km^2 in 2008. Population distribution remained roughly the same in both years, with the highest densities in the western and central parts of the Kras plateau, on Kraški rob and on Podgorski kras plateau. Habitat selection was analyzed at three spatial scales (regional, settlement and territory scales), based on spatial data layers (22 environmental variables), using Chi-square goodness-of-fit test and logistic regression. Results revealed that at the regional scale, Scops Owl preferably selected open habitats (extensively managed orchards, built-up areas, vineyards, permanent grasslands) and avoided dense forest and agricultural land with forest trees. As far as settlements were concerned, Scops Owl was more prone to select those that were more distant from the highway, with better preserved traditional agricultural landscape (with more hedgerows) and with higher average annual air temperature. In territory selection, Scops Owl occurrence was associated with longer distance from the highway, larger number of old buildings and higher landscape mosaics. The species seems to be threatened by traffic noise, habitat loss through abandonment and intensification of land and, potentially, by lack of breeding niches within settlements. Conservation measures should include the preservation of mosaic farmland, promotion of extensive agricultural practices, prevention of scrub and forest expansion, and maintenance of breeding niches (old trees, cavities in buildings).

Key words: Scops Owl, *Otus scops*, environmental variables, distribution, habitat selection, GIS, logistic regression, Kras
Ključne besede: veliki skovik, *Otus scops*, okoljski dejavniki, razširjenost, izbor habitata, GIS, logistična regresija, Kras

1. Introduction

The Scops Owl *Otus scops* is a small, insectivorous, nocturnal raptor, typical for open and semi-open grassland habitats, rich in insects (Cramp 1998). In Europe, it is considered depleted due to its large historical decline between 1970 and 1990 (BirdLife International 2004). Steep declines have been reported for countries in the northern breeding range, e.g. Switzerland (Arlettaz *et al.* 1991) and Austria (Samwald & Samwald 1992), and even for Mediterranean countries that hold the largest part of European population of this species, such as Spain, Croatia and Italy (Sacchi *et al.* 1999, BirdLife

International 2004, Martinez *et al.* 2007).

In Slovenia, Scops Owl has a status of endangered species (status E2 in the Slovenian Red list of threatened species, Uradni list RS 2002). It is a protected species (Uradni list RS 2004a) as well as a qualifying (triggering) species in the following three Slovene Special Protection Areas (SPA): Kras, Goričko, and Ljubljansko barje (Uradni list RS 2004c). The most recent estimate of the Slovene Scops Owl population is 600–1,000 pairs (Denac *et al.* 2011a). The most important breeding areas are in SW Slovenia (Kras, Snežnik - Pivka and Slovenian Istria), in central Slovenia (Ljubljansko barje), and in eastern and NE Slovenia (Goričko, Kozjansko). In Kras, the population is currently estimated at 120–200 pairs, in Snežnik - Pivka at 40–50 pairs and in Slovenian Istria at 20–40 pairs (Denac *et al.* 2011a). At Ljubljansko barje, the population fluctuated greatly during the 1998–2010 period when ranging between 40–65 pairs (Senegačnik 1998, Denac 2000a & 2003, Rubinič *et al.* 2004 & 2008, Denac *et al.* 2010). In Goričko, the Scops Owl population was reduced by more than 70% during the 1997–2011 period (Štumberger 2000, Rubinič *et al.* 2004, 2007 & 2009, Denac *et al.* 2011b) and was estimated at 100–160 pairs in the 2004–2009 period (Denac *et al.* 2011a). In the Kozjansko area, the population is estimated at 60–70 pairs (Denac *et al.* 2011a). Several other localities scattered throughout the country jointly hold a few tens of breeding pairs (Polak 2000, Denac *et al.* 2011a).

Previous studies have suggested that the Scops Owl population in Europe is declining mainly because of changes in agricultural practices (Arlettaz *et al.* 1991, Sacchi *et al.* 1999, Sergio *et al.* 2009). At Ljubljansko barje, the intensification of farmland and urbanisation are estimated to be the two major threats to this species (Denac 2009), while in Goričko the intensification of farmland, especially through land consolidation, is probably the cause for the recent steep decline of Scops Owl population (Denac *et al.* 2011b). In the wider area of Kras, Scops Owl is still widespread in some areas, but an overall population decline was noted in the 2006–2010 period (Rubinič *et al.* 2006 & 2008, Denac *et al.* 2010). Therefore, a better understanding of habitat requirements is needed for conservation purposes. Based on census data from 2006 and 2008, we studied: (1) abundance, spatial distribution and density of Scops Owl, and (2) habitat selection at three different spatial scales in the wider area of Kras. *Habitat* in our study means a space in which a species finds suitable living conditions (environmental characteristics) necessary for its survival and reproduction (Tarman 1992), whereas *habitat selection* indicates a hierarchical process of selecting a habitat at different spatial scales (Hutto 1985).

2. Study area

The study area (665 km^2, SW Slovenia) extends over the Kras (*eng.* Karst, *it.* Carso) plateau, Kraški rob, which is a cascade of limestone cliffs, Podgorski kras plateau, Matarsko podolje valley, mountainous Čičarija plateau with Mt Slavnik, Mt Vremščica and southern edge of the Vipava River Valley (Figure 1). We named the study area after the largest geographical unit – Kras. The study area has been almost entirely declared an Important Bird Area, IBA SI003 Kras (Polak 2000), an Ecologically Important Area (Uradni list RS 2004b), and a Special Protection Area, SPA SI5000023 Kras (Uradni list RS 2004c).

The study area is a flat to hilly, predominantly limestone area (karst). The average altitude is 425 m a.s.l. (GURS 2006), with the highest mountains being Mt Slavnik (1,028 m a.s.l.) and Mt Vremščica (1,027 m a.s.l.). The climate is submediterranean, with average annual air temperature around 11 °C (ARSO 2007a) and average annual rainfall ranging from 1,100 to 2,000 mm (ARSO 2007b). The landscape is dominated by a large proportion of forests, extensively cultivated grasslands, small vineyards, numerous hedgerows, scattered trees and stonewalls. Settlements are small and regularly distributed over the study area, with buildings clustered in groups and often built of stone. Today, 61.0% of the study area consists of forests, 22.0% of permanent grasslands, 4.4% of agricultural land in early successional stages of forest, 4.0% of built-up areas, 3.4% of agricultural land with forest trees, 2.0% of trees and scrub, 1.6% of vineyards, and only 0.3% of extensively managed orchards (MKGP 2007). Farming land has been abandoned over vast areas, which are now undergoing natural succession to scrub land and forest (Trontelj 2000). Extensive habitats in the study area have been lost due to highway construction (Božič 2003). The most widespread are sheep breeding and winegrowing. Intensive farming is practiced only in southern part of the Vipava River Valley, where amelioration and land consolidation changed the landscape drastically in the 1980s. Hedgerows and individual trees were removed almost entirely, arable fields were enlarged, ditches were dug, and permanent grasslands were replaced by intensive crops (e.g. vineyards and intensive fruit plantations) (Gabrijelčič *et al.* 1996).

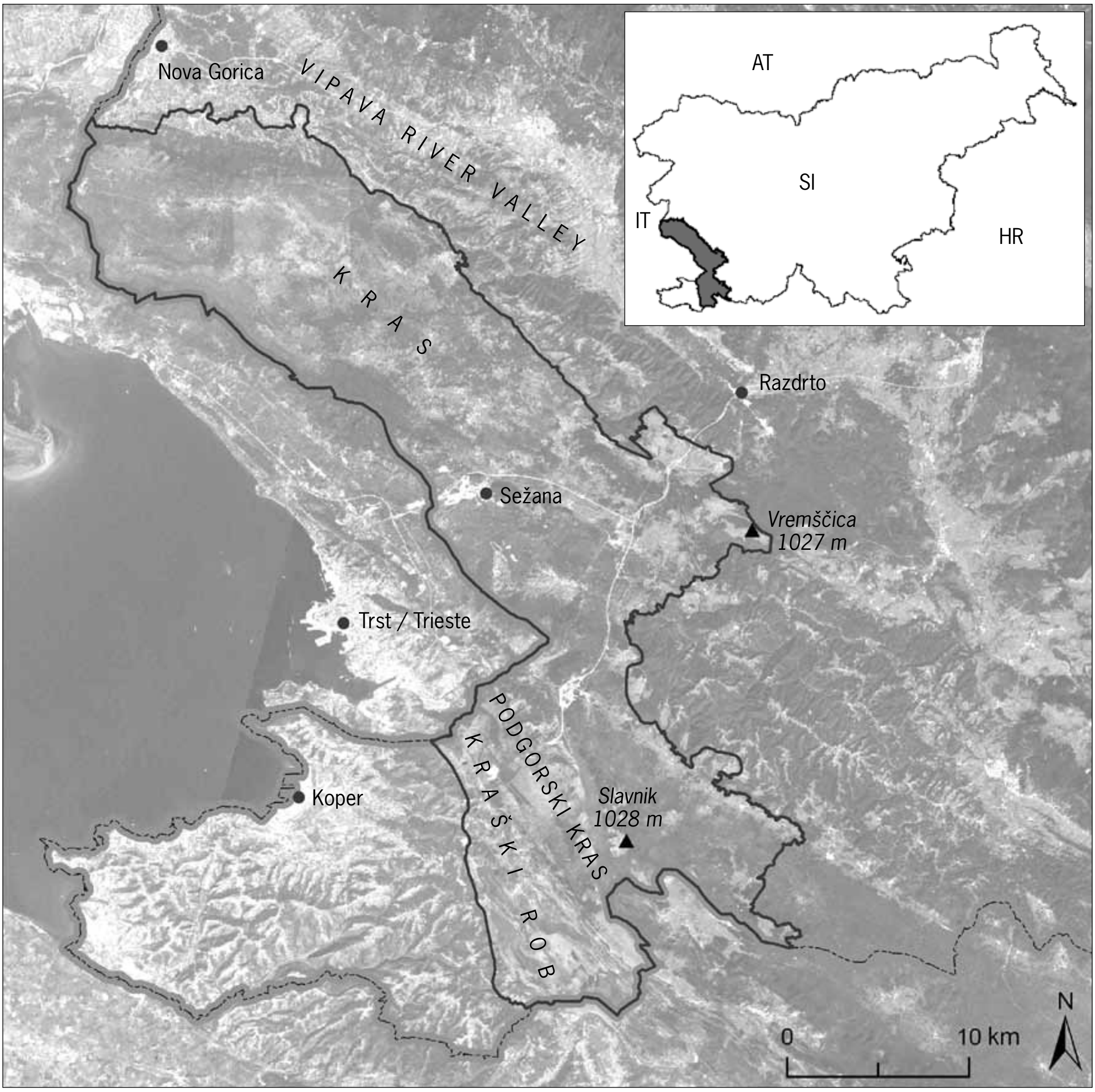

Figure 1: Location of the study area (SW Slovenia)

Slika 1: Lokacija območja raziskave (JZ Slovenija)

3. Methods

3.1. Census method

The Scops Owl census was carried out in 2006 and 2008 during their pre-incubation period in the beginning of May, in a clear weather. Each time it was performed during a single night (12/13 May 2006, 9/10 May 2008). At each census point we first listened to spontaneously calling Scops Owls for 2 min, then broadcast a play-back of a male call for 2 min and waited for another 2 min for response (Samwald & Samwald 1992). The census was carried out mainly from points selected in the habitats that we considered potentially suitable for Scops Owl (settlements with their surroundings, larger cliffs and rocky hillsides, groups of old trees). Additionally, we also checked for Scops Owl in less suitable habitats (dense forest, areas with higher altitude). *A priori* suitable habitat was estimated on the basis of literature (Galeotti & Gariboldi 1994, Keller & Parrag 1996, Benussi *et al.* 1997, Štumberger 2000, Denac 2000a, 2003 &

2009, Marchesi & Sergio 2005, Martinez *et al.* 2007, Sergio *et al.* 2009). According to their size, settlements were censused at one to three census points. Distance between census points was at least 500 m. Altogether, we selected 351 census points in 2006, while in 2008 we visited additional 55 census points in less suitable habitat beside those from 2006 (for details see Šušmelj 2012). The described census method was standardized for monitoring Scops Owl in Slovenia to enable comparison of data between different areas (Rubinič 2005).

3.2. Selection of scales and habitat variables

We entered 406 census points and 347 male locations (180 recorded in 2006 and 167 in 2008) into the Geographic Information System (ESRI 2005) using digital cartography on a scale of 1 : 25,000. Only males were entered as very few females were recorded duetting with males. Into GIS, the publicly available data layers were also entered, and layers of environmental variables were prepared on their basis. For the habitat selection study, we selected three scales, which we adapted to the aims of our research.

At the *regional scale*, we aimed to asses the effect of land-use on spatial distribution of Scops Owl, since landscape has been found to affect patterns of abundance and distribution of birds (Seoane *et al.* 2004). We compared the occupied land-use types (number of locations of males in each land-use type) with the available land-use types (relative area of each type).

At the *settlements scale*, we aimed to find out why Scops Owl was not present in many settlements, although looking similar as the occupied ones. Therefore, we compared occupied with unoccupied settlements, which we described as circular plots with a radius of 500 m around the centres of settlements (villages or towns). Radius of 500 m was chosen to encompass the major part of open farmland surrounding the settlements and the majority of males, and at the same time to minimize overlapping of circles. Settlement was defined as occupied if it had at least two males recorded within the circle during both census years (n = 63 settlements) and as unoccupied if there was no male recorded within the circle in both years (n = 66 settlements). Settlements which had only one male recorded during both census years (n = 33 settlements) were excluded from the analysis because they probably represent a sub-optimal habitat and cannot be reliably classified into one of the two groups (occupied, unoccupied).

At the *territory scale*, we wanted to determine the key environmental factors influencing territory selection. Therefore, we compared unoccupied with occupied census plots, which we described as circular plots with a radius of 200 m around the census points. Since a playback was broadcast, territorial males usually approached the observers and possibly changed their usual position. Moreover, the locations of calling males could have been inaccurately entered into the map by observers. Therefore, we decided to choose an occupied census plot as the best approximation of Scops Owl's territory (e.g. Vrezec & Tome 2004). A radius of 200 m is in agreement with the territory size observed in other areas; 100 m in Streit & Kalotás (1991), territory size of 0.6 ha in Galeotti & Gariboldi (1994) that would give a radius of 44 m, 70 m in Keller & Parrag (1996), and 183 m in Martinez *et al.* (2007). Census plot was defined as occupied if it had at least one male recorded within the circle in one of the two census years (n = 106 census plots) and was defined as unoccupied if no male was recorded within the circle in both census years (n = 185 census plots).

Habitat of Scops Owl was described by 22 environmental variables (Table 1) (for details see Šušmelj 2012). Values of environmental variables were calculated using ArcGIS (ESRI 2005). All the independent variables are continuous, except for the discrete variable »predominant orientation«.

3.3. Statistical analyses

Distribution pattern of Scops Owl was estimated by the Nearest Neighbour Index R_n (Clark & Evans 1954) using ArcGIS (ESRI 2005). Values smaller or larger than 1 indicate clumped or uniform patterns, respectively. Crude densities and ecological densities were calculated (suitable habitat was determined in the analysis of habitat selection at the regional scale; 187 km^2, Table 2). To present the density of Scops Owl calling males in a separate census year, a map of kernel density was created (Worton 1989).

In the habitat selection analysis at the regional scale, each location of a male was assigned to a particular land-use type. Males from both census years were aggregated into one data set because we assumed that only a small proportion of the same individuals returned to the same location during 2006–2008 (Galeotti & Sacchi 2001) and therefore each site represents an independent (new) habitat selection process. Chi-square goodness-of-fit test was used to test the null hypothesis that Scops Owl uses each land-use type in proportion to its availability within the study area (Neu *et al.* 1974, Byers *et al.* 1984).

Table 1: Environmental variables included in habitat selection analyses at each of the three scales (• = variable included)

Tabela 1: Okoljske spremenljivke, vključene v analizo izbora habitata na posameznem prostorskem nivoju (• = spremenljivka vključena v analizo).

Environmental variable/ Okoljska spremenljivka	Regional scale/ Pokrajinski nivo	Settlements scale/ Nivo naselij	Territory scale/ Nivo teritorija
Land-use / Raba tal			
Fields / Njive (%)[a]	•		•
Vineyards / Vinogradi (%)[a]	•	•	•
Extensively managed orchards / Ekstenzivni oz. travniški sadovnjaki (%)[a]	•	•	•
Permanent grasslands / Trajni travniki (%)[a]	•	•	•
Agricultural land in early succesional stages of forest/ Kmetijska zemljišča v zaraščanju (%)[a]	•	•	•
Trees and scrub / Površine z drevesi in grmičevjem (%)[a]	•		
Agricultural land with forest trees/ Kmetijska zemljišča, porasla z gozdnim drevjem (%)[a]	•		
Built-up and similar areas / Pozidana in sorodna zemljišča (%)[a]	•		
Forest edge (50 m wide) / Gozdni rob (50-metrski pas v gozd) (%)[a]	•	•	•
Dense forest / Notranji gozd (%)[a]	•	•	•
Indicators of traditional farmland / Kazalci tradicionalne kmetijske krajine			
Landscape mosaics (number of land-use polygons)/ Mozaičnost krajine (št. vseh poligonov rabe tal)[a]		•	•
Landscape heterogeneity (number of different land-use types)/ Heterogenost krajine (št. različnih vrst rabe tal)[a]		•	•
Length of hedgerows / Dolžina mejic (m)[a]		•	•
Average size of arable fields / Povprečna velikost ornih površin (m^2)[a]		•	
Physiography / Fizično-geografske značilnosti			
Average annual air temperature / Povprečna letna temperatura zraka (°C)[b]		•	•
Average annual precipitation / Povprečna letna količina padavin (mm)[c]		•	•
Altitude / Nadmorska višina (m)[d]		•	•
Slope / Naklon površja (°)d		•	•
* Predominant orientation / Prevladujoča ekspozicija[d]		•	•
Nesting, foraging, roosting requirements / Zahteve za gnezdenje, prehranjevanje, počivanje			
Number of old buildings (built before 1940) / Število starih stavb (zgrajenih pred 1940)[e]		•	•
** Potentially suitable habitat / Potencialno ustrezni habitat (%)[a]		•	•
Human disturbance / Antropogene motnje			
Distance from highway / Oddaljenost od avtoceste oz. hitre ceste (m)[f]		•	•

Data source / Vir podatkov: a – MKGP 2007, b – ARSO 2007a, c – ARSO 2007b, d – GURS 2006, e – GURS 2009, f – GURS 2005

* Orientation: north-, NE-, east-, SE-, south-, SW-, west- and NW-facing slopes / Ekspozicija: S, SV, V, JV, J, JZ, Z in SZ usmerjeno pobočje

** Variable includes following land-use types (with original codes, after MKGP 2007): vineyards (1211), permanent grasslands (1300), extensively managed orchards (1222), agricultural land with forest trees (1800), built-up and similar areas (3000), dry open land with special herb layer (5000) and open land with or without insignificant herb layer (6000) / Spremenljivka vključuje naslednje vrste rabe zemljišč (z originalnimi kodami, MKGP 2007): vinograd (1211), trajni travnik (1300), ekstenzivni oz. travniški sadovnjak (1222), kmetijsko zemljišče, poraslo z gozdnim drevjem (1800), pozidano in sorodno zemljišče (3000), suho, odprto zemljišče s posebnim rastlinskim pokrovom (5000) in odprto zemljišče brez ali z nepomembnim rastlinskim pokrovom (6000)

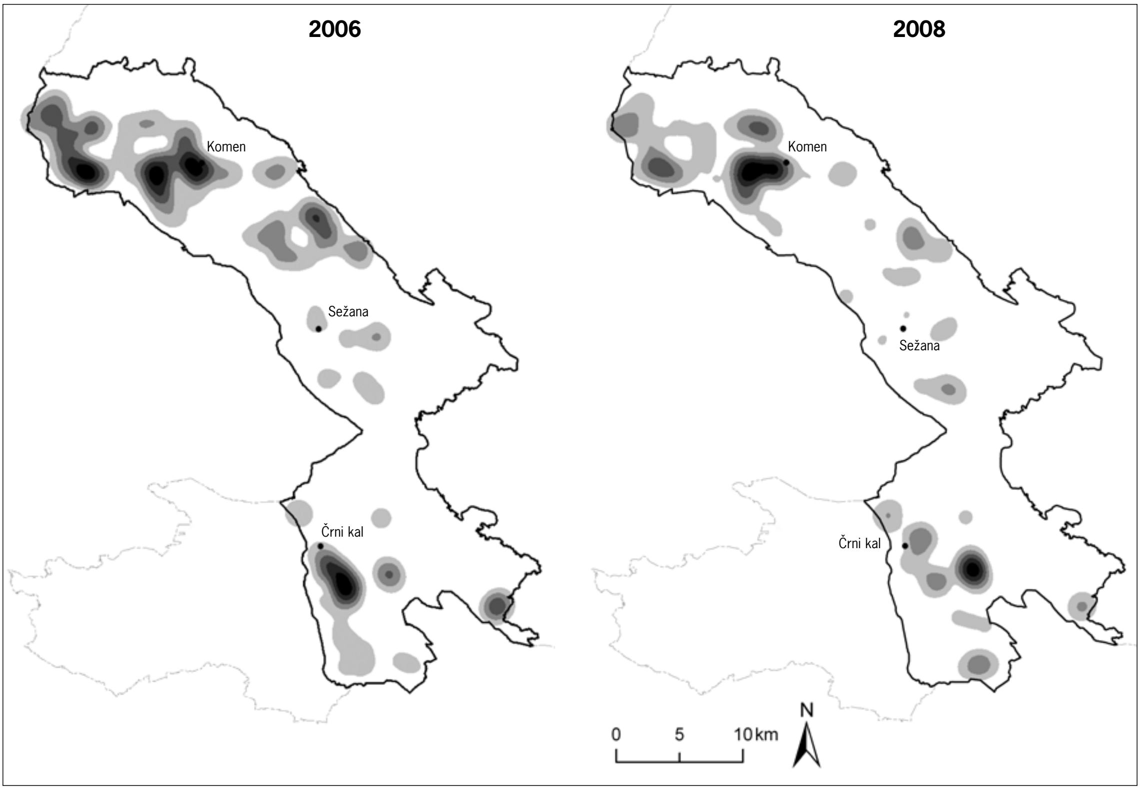

Figure 2: Local densities of Scops Owl *Otus scops* in the study area in 2006 and 2008 after kernel method, where darker areas delineate higher densities. Outside these areas, Scops Owl occurs as well, although in very small densities (only individual males).

Slika 2: Lokalne populacijske gostote velikega skovika *Otus scops* na območju raziskave v letu 2006 in 2008 po kernelski metodi, kjer temnejša območja ponazarjajo večjo gostoto. Veliki skovik se pojavlja tudi zunaj teh območij, vendar so tam gostote zelo majhne oz. gre le za posamične osebke.

To determine which land-use types are selected and which are avoided, selectivity index was calculated (the proportion of observed males within each land-use type divided by the proportion of total area of each land-use type) (Manly *et al.* 2002). An index value > 1 indicates preference, while value < 1 demonstrates avoidance of particular land-use type. Bonferroni adjusted confidence intervals were used to check whether preference or avoidance of particular land-use type is statistically significant (Neu *et al.* 1974, Byers *et al.* 1984).

At the settlement and territory scale, the effects of environmental variables on occurrence of Scops Owl were analysed with binary logistic regression, the stepwise forward algorithm in the Windows software package SPSS 17.0. (SPSS 2008). The presence/absence binary response was used as dependent variable and environmental variables as independent variables at each of the two scales (Table 1). At the territory scale, occupied census plots were weighted by the number of males recorded within the circle, but only data from one census year (the year with more males recorded) was included in order to avoid pseudoreplication of census points. Multicollinearity of independent variables was checked by the Spearman coefficient. If Spearman's correlation exceeded a threshold value of 0.5, the variable with lower predictive power in univariate models (with lower *R-square Nagelkerke*, Nagelkerke 1991) was omitted from the analysis (e.g. Graf 2005). Logistic regression assumes a linear relationship between the independent variables and the log odds (logit) of the dependent variable (Garson 2009). To check this relationship, the method proposed by Garson (2009) was applied. Thus, for each independent variable a new variable was created, which divides the existing variable into categories of equal intervals. Then a univariate logistic regression with newly categorised variable was run.

Table 2: Utilization-availability analysis for land-use types in the wider area of Kras; utilization is based on 346 locations of Scops Owl *Otus scops* (aggregated males from 2006 and 2008). Selectivity index indicates the preference (+) or avoidance (–) of land-use types; land-use types are ranked according to the selectivity index value. Confidence intervals show whether the result is statistically significant (n.s. = not statistically significant). Land-use types with statistically significant difference between actual and expected utilization ($P < 0.05$) are in boldface.

Tabela 2: Analiza zasedenosti in razpoložljivosti vrst rabe tal na širšem območju Krasa; zasedenost temelji na 346 lokacijah velikega skovika *Otus scops* (združeni samci iz 2006 in 2008). Indeks selektivnosti kaže preferenco (+) oz. izogibanje (–) posamezni vrsti rabe tal; vrste rabe tal so rangirane glede na vrednost indeksa selektivnosti. Intervali zaupanja kažejo statistično značilnost parametra (n.s. = ni statistično značilne razlike). Vrste rabe tal s statistično značilno razliko med dejansko in pričakovano zasedenostjo ($P < 0.05$) so označene s krepkim tekstom.

Land-use type/ Vrsta rabe tal	No. of observed males/ Št. zabeleženih samcev	Total area/ Razpoložljiva površina (km²)	Proportion of observed males / Delež zabeleženih samcev (p_i)	Proportion of total area / Delež razpoložljive površine (p_{io})	No. of expected males/ Pričakovano št. samcev (E_i) *	Selectivity index/ Indeks selektivnosti	Confidence interval for p_i/ Interval zaupanja za p_i
Extensively managed orchards/ Ekstenzivni oz. travniški sadovnjaki	**10**	**1.76**	**0.03**	**0.0027**	**1**	**10.83 (+)**	$\mathbf{0.01 \leq p_1 \leq 0.05}$
Built-up and similar areas/ Pozidana in sorodna zemljišča	**76**	**26.60**	**0.22**	**0.04**	**14**	**5.46 (+)**	$\mathbf{0.18 \leq p_2 \leq 0.26}$
Fields/ Njive	8	4.98	0.02	0.01	3	3.07 (+)	$0.01 \leq p_3 \leq 0.04$ (n.s.)
Vineyards/ Vinogradi	**17**	**10.61**	**0.05**	**0.02**	**6**	**3.06 (+)**	$\mathbf{0.03 \leq p_4 \leq 0.07}$
Trees and scrub/ Drevesa in grmičevje	14	13.30	0.04	0.02	7	2.01 (+)	$0.02 \leq p_5 \leq 0.06$ (n.s.)
Permanent grasslands/ Trajni travniki	**115**	**147.78**	**0.33**	**0.22**	**77**	**1.49 (+)**	$\mathbf{0.28 \leq p_6 \leq 0.38}$
Forest edge/ Gozdni rob	77	171.99	0.22	0.26	90	0.85 (–)	$0.18 \leq p_7 \leq 0.27$ (n.s.)
Agricultural land in early succesional stages of forest / Kmet. zemljišča v zaraščanju	11	29.39	0.03	0.04	15	0.71 (–)	$0.01 \leq p_8 \leq 0.05$ (n.s.)
Agricultural land with forest trees / Kmet. zemljišča, porasla z gozdnim drevjem	**3**	**22.63**	**0.01**	**0.03**	**12**	**0.25 (–)**	$\mathbf{0.00 \leq p_9 \leq 0.02}$
Dense forest/ Notranji gozd	**15**	**233.42**	**0.04**	**0.35**	**121**	**0.12 (–)**	$\mathbf{0.02 \leq p_{10} \leq 0.06}$
Total / Skupaj	346	662.47	1.00	1.00	346		

* $E_i = p_{io} \times n$

Table 3: Statistical parameters of environmental variables for unoccupied and occupied settlements in the wider area of Kras, measured at circular plots with a 500 m radius around the centres of settlements. Variables with statistically significant difference between groups ($P < 0.05$) are in boldface.

Tabela 3: Statistični parametri okoljskih spremenljivk za nezasedena in zasedena naselja na širšem območju Krasa; statistična enota so krogi z radijem 500 m okoli središč naselij. Spremenljivke s statistično značilno razliko med skupinama ($P < 0.05$) so označene s krepkim tiskom.

Environmental variable/ Okoljska spremenljivka	Unoccupied settlements/ Nezasedena naselja (n = 66)	Occupied settlements/ Zasedena naselja (n = 63)	*P*
Vineyards / Vinogradi (%)	**3.8 ± 6.2**	**5.7 ± 6.6**	**0.003**
Extensively managed orchards/ Ekstenzivni oz. travniški sadovnjaki (%)	1.1 ± 1.1	1.0 ± 1.0	0.475
Permanent grasslands / Trajni travniki (%)	31.3 ± 15.0	31.5 ± 11.5	0.713
Agricultural land in early succesional stages of forest/ Kmetijska zemljišča v zaraščanju (%)	3.1 ± 3.0	4.4 ± 7.4	0.682
Forest edge (50 m wide)/ Gozdni rob (50-metrski pas v gozd) (%)	25.7 ± 11.7	27.0 ± 10.8	0.785
Dense forest / Notranji gozd (%)	13.2 ± 10.2	12.7 ± 11.7	0.451
Landscape mosaics (number of land-use polygons)/ Mozaičnost krajine (št. vseh poligonov rabe tal)	**88.3 ± 27.5**	**103.3 ± 32.7**	**0.010**
Landscape heterogeneity (number of different land-use types)/ Heterogenost krajine (št. različnih vrst rabe zemljišč)	9.3 ± 1.6	9.5 ± 1.4	0.210
Length of hedgerows / Dolžina mejic (m)	3330 ± 2540	3902 ± 2889	0.256
Average size of arable fields/ Povprečna velikost ornih površin (m^2)	1847 ± 1302	1572 ± 836	0.910
Average annual air temperature/ Povprečna letna temperatura zraka (°C)	11.3 ± 1.2	11.5 ± 1.1	0.409
Average annual precipitation/ Povprečna letna količina padavin (mm)	1549 ± 112	1531 ± 1515	0.708
Altitude / Nadmorska višina (m)	344.2 ± 168.1	319.4 ± 142.6	0.090
Slope / Naklon površja (°)	8.9 ± 4.1	8.6 ± 4.6	0.378
Settlements with predominant S and SW-facing slopes/ Naselja s prevladujočo J in JZ ekspozicijo (%)	47	52.4	* 0.439
Number of old buildings / Število starih stavb	**40.6 ± 29.3**	**56.0 ± 33.8**	**0.004**
Potentially suitable habitat / Potencialno ustrezni habitat (%)	49.9 ± 15.0	51.4 ± 16.3	0.528
Distance from highway/ Oddaljenost od avtoceste oz. hitre ceste (m)	**3669 ± 2868**	**5889 ± 3044**	**< 0.001**

* Difference between groups tested by Pearson Chi-square test / Razlika med skupinama testirana s Pearsonovim χ^2-testom

If there is linearity with the logit, the parameter estimate (*b*) for each class of the newly categorised explanatory variable should increase or decrease in roughly linear steps. If the relation was clearly non-linear, this variable was discretized (Garson 2009). Descriptive statistics were used to describe the mean and standard deviation values of the environmental variables for the two groups (occupied/unoccupied sites), while differences in mean values between the two groups were analyzed with the Mann-Whitney U test (SPSS 2008).

4. Results

4.1. Abundance, spatial distribution and density of Scops Owl

In 2006, 180 males were recorded; 163 of them within IBA Kras and 144 within SPA Kras. On average, 1.2 ± 1.8 males per settlement were recorded (range 0–12). Settlements with the highest number of males were Brestovica pri Komnu (12 calling males), Komen (8), Gorjansko (7), Golac (6), Kostanjevica

Table 4: Logistic regression model for habitat selection at the settlement scale: effect of environmental variables on Scops Owl *Otus scops* occurrence in the wider area of Kras

Tabela 4: Model logistične regresije za izbor habitata na nivoju naselij: vpliv okoljskih spremenljivk na pojavljanje velikega skovika *Otus scops* na širšem območju Krasa

Environmental variable/ Okoljska spremenljivka	Parameter estimate/ Ocena parametra (*b*)	St. error/ Stand. napaka	Wald statistics/ Wald statistika	df	*P*	Odds ratio/ Razmerje obetov (Exp(b))	95% C.I. for odds ratio / 95 % interval zaupanja za razmerje obetov	
* Distance from highway/ Oddaljenost od avtoceste oz. hitre ceste:			26.096	3	< 0.001			
2106–4077 m	–0.744	0.723	1.058	1	0.304	0.475	0.115	1.961
4078–6897m	1.471	0.633	5.407	1	0.020	4.353	1.260	15.037
≥ 6898 m	2.618	0.663	15.609	1	< 0.001	13.703	3.740	50.207
* Length of hedgerows/ Dolžina mejic:			10.341	3	0.016			
1601–3000 m	1.827	0.636	8.247	1	0.004	6.218	1.786	21.643
3001–4800 m	0.197	0.680	0.084	1	0.773	1.217	0.321	4.618
≥ 4801 m	1.300	0.661	3.873	1	0.049	3.669	1.005	13.394
Average annual air temperature / Povprečna letna temperatura zraka	0.552	0.245	5.057	1	0.025	1.737	1.073	2.810
Number of old buildings/ Število starih stavb	0.014	0.007	3.554	1	0.059	1.014	0.999	1.029
Constant / Konstanta	–8.716	2.916	8.934	1	0.003	0.000		

* Discrete variable; reference class is the first class (≤ 2105 m from highway, ≤ 1600 m of hedgerows) / Kategorična spremenljivka; referenčni razred je prvi razred (≤ 2105 m od avtoceste oz. hitre ceste, ≤ 1600 m mejic)

na Krasu (5), Ivanji Grad (5) and Podgorje (5). Crude density was 0.3 males/km^2 and ecological density was 1.0 males/km^2.

In 2008, we recorded 167 males (158 within IBA Kras and 133 within SPA Kras). On average, 1.1 ± 1.8 males per settlement were recorded (range 0–12). Settlements with the largest number of males in 2008 were Podgorje (12 calling males), Brestovica pri Komnu (9), Ivanji Grad (7), Gorjansko (7), Komen (5), Preserje pri Komnu (5), Črnotiče (5) and Rakitovec (5). Crude density was 0.3 males/km^2 and ecological density was 0.9 males/km^2.

Distribution pattern of males was clumped in 2006 (R_n = 0.511, $z < -1.96$) and in 2008 (R_n = 0.598, $z < -1.96$), respectively. Roughly, 82% of calling males were recorded within the settlements (within a 500 m radius from the settlement centres).

In 2006, the population was concentrated in four areas within the study area: (1) western part of the Kras plateau (with the highest densities in the villages of Komen, Gorjansko, Brestovica pri Komnu), (2) central part of the Kras plateau (with the highest densities in the villages of Ponikve, Dutovlje and Kazlje), (3) Kraški rob, and (4) Čičarija plateau (Golac and surrounding villages). In, 2008 core-areas with the highest densities of Scops Owls were on: (1) western part of the Kras plateau (Komen, Gorjansko, Brestovica pri Komnu), (2) central part of the Kras plateau (Dobravlje), and (3) Podgorski kras plateau (Podgorje) (Figure 2).

4.2. Habitat selection at the regional scale

A total of 347 males recorded in 2006 an 2008 were distributed in 11 of the 25 land-use types (MKGP 2007). Land-use type „Olive groves" had a very small proportion of the total area and only one male recorded, so we excluded it from the analysis to meet the assumptions proposed by Neu *et al.* (1974). Chi-square goodness-of-fit test showed significant difference between the utilization and availability of the land-use types (χ^2 = 530.7, critical value = 16.9, df = 9, $P < 0.01$), confirming that Scops Owl in the wider

Table 5: Statistical parameters of environmental variables for unoccupied and occupied census plots in the wider area of Kras, measured at circular plots with a 200 m radius from the census points. Variables with statistically significant difference between groups ($P < 0.05$) are in boldface.

Tabela 5: Statistični parametri okoljskih spremenljivk za nezasedene in zasedene popisne ploskve na širšem območju Krasa; statistična enota so krogi z radijem 200 m okoli popisnih točk. Spremenljivke s statistično značilno razliko med skupinama ($P < 0.05$) so označene s krepkim tiskom.

Environmental variable/ Okoljska spremenljivka	Unoccupied census plots / Nezasedene popisne ploskve (n = 185)	Occupied census plots / Zasedene popisne ploskve (n = 148 **)	*P*
Fields / Njive (%)	**2.1 ± 3.6**	**2.6 ± 3.0**	**0.001**
Vineyards / Vinogradi (%)	**4.8 ± 8.7**	**7.5 ± 10.1**	**< 0.001**
Extensively managed orchards/ Ekstenzivni oz. travniški sadovnjaki (%)	**1.8 ± 3.3**	**2.2 ± 3.1**	**0.012**
Permanent grasslands / Trajni travniki (%)	34.5 ± 21.6	32.2 ± 15.0	0.459
Agricultural land in early succesional stages of forest/ Kmetijska zemljišča v zaraščanju (%)	2.6 ± 4.8	2.9 ± 7.3	0.327
Forest edge (50 m wide)/ Gozdni rob (50-metrski pas v gozd) (%)	20.3 ± 15.9	20.9 ± 14.4	0.445
Dense forest / Notranji gozd (%)	9.4 ± 20.7	3.5 ± 6.3	0.094
Landscape mosaics (number of land-use polygons)/ Mozaičnost krajine (št. vseh poligonov rabe tal)	**25.3 ± 11.0**	**31.1 ± 8.3**	**< 0.001**
Landscape heterogeneity (number of different land-use types) / Heterogenost krajine (št. različnih vrst rabe zemljišč)	**6.4 ± 2.0**	**7.3 ± 1.3**	**< 0.001**
Length of hedgerows / Dolžina mejic (m)	630 ± 572	656 ± 443	0.099
Average annual air temperature/ Povprečna letna temperatura zraka (°C)	11.3 ± 1.1	11.5 ± 1.1	0.060
Average annual precipitation/ Povprečna letna količina padavin (mm)	1549 ± 128	1527 ± 141	0.092
Altitude / Nadmorska višina (m)	**336 ± 147**	**298 ± 140**	**0.001**
Slope / Naklon površja (°)	7.3 ± 4.5	7.0 ± 4.7	0.481
Census plots with predominant S and SW-facing slopes/ Popisne ploskve s prevladujočo J in JZ ekspozicijo (%)	47.1	50.7	* 0.862
Number of old buildings / Število starih stavb	**10.9 ± 15.4**	**23.4 ± 21.4**	**< 0.001**
Potentially suitable habitat / Potencialno ustrezni habitat (%)	64.9 ± 26.6	70.2 ± 18.9	0.274
Distance from highway/ Oddaljenost od avtoceste oz. hitre ceste (m)	**4273 ± 3024**	**5744 ± 2800**	**< 0.001**

* Difference between groups tested by Pearson Chi-square test / Razlika med skupinama testirana s Pearsonovim χ^2-testom
** Occupied plots were weighted with the number of males within the plot / Zasedene popisne ploskve smo obtežili s številom samcev v krogu

area of Kras actually selects and avoids certain land-use types. Selectivity index reflects strong preference for built-up areas and open agricultural land (extensively managed orchards, vineyards, permanent grasslands) and avoidance of dense forest and agricultural land with scattered forest trees (Table 2).

4.3. Habitat selection at the settlement scale

Parameters of four variables differed significantly between occupied and unoccupied settlements. Occupied settlements were characterized by more vineyards, higher landscape mosaics, more old buildings and larger distance from the highway (Table 3).

Logistic regression model predicted that at the settlement scale the Scops Owl occurrence was best clarified by three variables: (1) larger distance from the highway, (2) longer length of hedgerows, and (3) higher average annual air temperature. Variable "number of old buildings" was not statistically significant (Table 4). Distance from the highway was by far the most important predictor; probability of

Table 6: Logistic regression model for habitat selection at the territory scale: effect of environmental variables on Scops Owl *Otus scops* occurrence in the wider area of Kras

Tabela 6: Model logistične regresije za izbor habitata na nivoju teritorija: vpliv okoljskih spremenljivk na pojavljanje velikega skovika *Otus scops* na širšem območju Krasa

Environmental variable/ Okoljska spremenljivka	Parameter estimate/ Ocena parametra (*b*)	St. error/ Stand. napaka	Wald statistic/ Wald statistika	df	*P*	Odds ratio/ Razmerje obetov (Exp(b))	95 % C.I. for odds ratio/ 95 % interval zaupanja za razmerje obetov	
* Distance from highway/ Oddaljenost od avtoceste oz. hitre ceste:			33.943	3	< 0.001			
2001–4000 m	0.106	0.427	0.062	1	0.804	1.112	0.481	2.568
4001–6000 m	1.691	0.405	17.393	1	< 0.001	5.424	2.450	12.006
≥ 6001	1.708	0.375	20.731	1	< 0.001	5.517	2.645	11.506
* Number of old buildings/ Število starih stavb:			33.148	3	< 0.001			
1–9	1.528	0.408	14.020	1	< 0.001	4.608	2.071	10.254
10–24	1.357	0.412	10.851	1	0.001	3.885	1.733	8.710
≥ 25	2.453	0.428	32.782	1	< 0.001	11.624	5.020	26.918
* Landscape mosaics/ Mozaičnost krajine:			10.326	3	0.016			
21–28	1.121	0.399	7.887	1	0.005	3.069	1.403	6.712
29–34	1.227	0.430	8.136	1	0.004	3.411	1.468	7.924
≥ 35	1.085	0.407	7.098	1	0.008	2.960	1.332	6.577
Constant / Konstanta	–3.612	0.515	49.270	1	< 0.001	0.027		

* Discrete variable; reference class is the first class (≤ 2000 m distance from highway, 0 old buildings, ≤ 20 land-use polygons) / Kategorična spremenljivka; referenčni razred je prvi razred (≤ 2000 m od avtoceste oz. hitre ceste, 0 starih stavb, ≤ 20 poligonov rabe tal)

Scops Owl occurrence started to increase statistically significant when the distance was larger than ca. 4 km, and was 14-folds greater in settlements, which are at least 7 km away from the highway compared to settlements right next to it (≤ 2105 m). The described logistic model correctly classified 73.6% of the cases (76.2% of occupied and 71.2% of unoccupied settlements).

4.4. Habitat selection at the territory scale

At the territory scale, differences between occupied and unoccupied census plots were statistically significant in eight variables. Occupied census plots were characterized by more fields, vineyards and extensively managed orchards, with higher landscape mosaics and landscape heterogeneity, with lower altitude, greater availability of old buildings and larger distance from the highway (Table 5).

Logistic regression analysis predicted that at the territory scale the occurrence of Scops Owl was best clarified by three variables: (1) larger distance from the highway, (2) greater number of old buildings, and (3) higher landscape mosaics. Probability of Scops Owl occurrence increased statistically significant in areas at least 4 km away from the highway (compared to areas which are right next to the highway), while further increase of distance did not contribute to greater probability. Variable "number of old buildings" in the model indicates that the probability for occurrence of the species increased gradually with the increased number of old buildings and was at its maximum in patches (census points with a 200 m radius), which contain 25 or more old buildings. Variable "landscape mosaics" in the model predicts that probability of Scops Owl occurrence is 3-folds greater in patches with higher landscape mosaics (with 21 and more polygons of land-use) compared to patches with lower landscape mosaics (≤ 20 polygons). The described logistic model correctly classified 74.5% of cases (70.9% of occupied and 77.3% of unoccupied census plots).

5. Discussion

Systematic and comprehensive monitoring of Scops Owl' population in the wider area of Kras started in 2006 and continued in 2008 (and 2010, Denac *et al.* 2010). During these three surveys, the population varied between 120–180 males. Therefore, the preliminary population estimate in IBA Kras (300–600 pairs; Trontelj 2000) was probably overestimated. Further censuses are required to produce long-term population trend estimates. In 2011, the last part of Slovenia, where data on numbers were lacking (Slovenian Istria), was surveyed for Scops Owl (Hanžel *et al.* 2011), so now we can definitely conclude that the population of Scops Owl in the wider area of Kras makes the largest local population of this species in Slovenia.

Most males were recorded in villages and agricultural land in their surroundings, while some individual males were also registered on the forest edge or in the open agricultural land far away from settlements (Kmecl & Šetina 2008). Since roughly 82% of males were recorded within the settlements, Scops Owl can be considered a highly synanthropic species. In some settlements, the distances between the individual males were very small, e.g. from 50 to 100 m in Kazlje, Ivanji Grad and Preserje pri Komnu, indicating on formation of calling groups (e.g. Sacchi *et al.* 1999, Štumberger 2000, Vrezec 2001, Denac 2003, Marchesi & Sergio 2005).

Spatial distribution of the Scops Owl population did not change significantly between 2006 and 2008, what may indicate more favourable conditions and high quality of areas occupied both years (Sergio & Newton 2003). The only substantial change was a shift of a local population from Kraški rob towards the less warm Podgorski kras plateau. High densities of Scops Owl on Kraški rob can be explained by numerous factors: (1) cavities and shelves in the rocky cliffs provide suitable breeding niches (Lipej *et al.* 2005, T. Mihelič *pers. comm.*), (2) the favourable microclimate on the S- and SW-facing slopes probably results in greater prey availability, e.g. grasshoppers (Galeotti & Gariboldi 1994) and suits a thermophilic species such as the Scops Owl (Cramp 1998), and (3) 3–4 pairs of Eagle Owl *Bubo bubo* nest in the rocky walls of Kraški rob regularly (Rubinič *et al.* 2004, Rubinič *et al.* 2009, Denac *et al.* 2010) and as Tawny Owls *Strix aluco* avoid the territories of Eagle Owl (Galeotti & Gariboldi 1994, Benussi *et al.* 1997), the predation pressure by this species might be much smaller in some parts of Kraški rob. It is surprising that a small isolated population was observed in the coldest and wettest parts of the study area, that is in village of Golac (640 m a.s.l.) and surrounding small villages on the Čičarija plateau. Scops Owl might have found favourable conditions in those villages due to high availability of decaying and abandoned rural houses, potentially suitable for nesting, many hedgerows, scattered trees, extensively managed grasslands in different successional stages, and sufficient distance (3.5 km) from the very busy road leading through the Matarsko podolje Valley. Another surprising discovery was the two males found at about 800 m a.s.l. in vast dry grasslands between Kojnik and Golič on the Čičarija plateau. Since Scops Owls usually avoid extensive open areas (Cramp 1998), their occurrence there could possibly be attributed to locally very high abundance of grasshoppers and other insects in overgrown sinkholes in that area (Koce 2007). Abundance of grasshoppers in SW Slovenia appears to be much greater in karst areas on limestone bedrock compared to the flysch bedrock (Koce 2007), what is probably one of the factors for Scops Owl's absence on the southern edge of the Vipava River Valley, where dominant north-facing slopes are less warm and the soil on flysch bedrock is more humid.

Crude density of Scops Owl was quite similar to that in Goričko (0.2 males/km^2, Denac *et al.* 2011b) and at Ljubljansko barje (0.4 males/km^2, Denac *et al.* 2010). Among these three sites, ecological density was the highest in the wider area of Kras owing to the specific landscape structure (small surface area of suitable habitat, large forest areas). Similar crude densities as in our study area were recorded in some Mediterranean parts of Europe, e.g. on the small Croatian island of Šolta (0.25 male/km^2, Mužinič & Purger 2008) and in the Italian Alps in the Vallarsa Valley (0.5–0.6 male/km^2), which is characterized by a particularly warm and dry climate and a mosaic landscape of extensive cultivations (Marchesi & Sergio 2005). In the other parts of the Mediterranean, crude densities were much higher compared to our study area: 0.7–1.4 males/km^2 on Oleron island in France (Hardouin *et al.* 2007) and 1.0–1.5 males/km^2 on the Croatian Pelješac peninsula (Vrezec 2001). Surprisingly, very high crude densities were also recorded locally in Central Europe. For example, in the upper part of the Rhone Valley in Central Wallis, Switzerland, the overall densities observed in 1986 and 1988 were 5.6–7.6 males/km^2, but this population underwent a steep decline in the second half of the 20th century and is on the verge of extinction (Arlettaz *et al.* 1991).

Results of habitat selection study at the three spatial scales can be summarized in a conclusion that a suitable habitat for Scops Owl in the wider area of

Kras constitutes areas that as far as possible meet the following conditions: (1) have sufficient availability of open habitats (extensively managed orchards, vineyards, permanent grasslands), (2) have sufficient availability of old buildings, potentially suitable for nesting, (3) are far enough from the heavy-traffic roads (highways), (4) have well-preserved traditional agricultural landscape (landscape mosaics, hedgerows), and (5) have an average annual air temperature of at least 11.5 °C.

At the regional scale, the observed distribution pattern of Scops Owls and the order of preferred land-use types are in tight connection with land-use pattern in the study area. Forest covers more than half of the surface and is obviously not a suitable habitat for Scops Owl (Bavoux *et al.* 1997, Denac 2000a, 2003 & 2009, Kmecl & Šetina 2008, *this study*), while settlements with surrounding agricultural land constitute »islands« of suitable habitat, over which the Scops Owl is distributed. The most preferred were extensively managed orchards, which are usually located right next to the houses or villages, then a little further are a little less preferred vineyards, small fields and permanent grasslands. Usually, the most distant from the settlements are agricultural land with scattered forest trees and dense forest, which Scops Owl avoids. We suppose that Scops Owl avoids dense forests, as they are too cold and humid for its main prey, the grasshoppers (Arlettaz *et al.* 1991, Keller & Parrag 1996, Marchesi & Sergio 2005, Hein *et al.* 2007, Rubinič *et al.* 2008, Muraoka 2009) and possibly because of predation pressure from the Tawny Owl (Galeotti & Gariboldi 1994, Marchesi & Sergio 2005). The very high preference for extensively managed orchards is probably related to their suitability for foraging and nesting, although their availability in the study area is very small (0.3%, MKGP 2007) and no nest in a tree hole has been found yet. Based on very high preference for built-up areas, we suppose that in the study area more Scops Owls nest in old buildings than in tree-holes. Anyway, further field studies are needed to test this hypothesis. Preference for permanent grasslands is obvious, as they are very rich in insects, including grasshoppers (Hein *et al.* 2007). Preference for vineyards is more difficult to interpret. It may indicate their suitability as foraging habitat (Lipej 2000, Malus 2007) or as breeding habitat (Galeotti & Gariboldi 1994, Benussi *et al.* 1997, Lipej 2000). In the nearby Rosandra Valley (Italy), Scops Owl demonstrated clear preference towards vineyards, too, although availability of this habitat type was very small (Galeotti & Gariboldi 1994). Lipej (2000) stressed the importance of the surroundings of vineyards, where Scops Owl may nest in stonewalls, old buildings, hedgerows or tree holes. It is also possible that the observed preference for vineyards is fictive because of inaccurate entry of males' locations on the map by observers. Vineyards in the study area are mainly small, narrow and located in a mosaic agricultural landscape, therefore it is difficult to accurately determine the location of individuals, especially at night. The variable "Vineyards" was strongly correlated with the variables "Landscape mosaics" and "Landscape heterogeneity", what may indirectly indicate actual importance of landscape heterogeneity and mosaics for Scops Owl. In addition, the comparison of two main wine-producing areas within the study area showed big differences in Scops Owl presence. On the southern edge of the Vipava River Valley (e.g. settlements of Tabor, Dornberk, Gradišče nad Prvačino) Scops Owl was not recorded in neither of the years, while in the viticultural area of the central Kras plateau it was quite common. Due to the higher relative humidity (water evaporating from the Vipava River), vineyards in the Vipava Valley are more intensively sprayed by pesticides than vineyards on the Kras plateau (J. Žgur *pers. comm.*), so higher pesticide-use can be a factor contributing to the absence of Scops Owl in the Vipava River Valley. Comparison of these two sites also indicates many other landscape differences. Viticultural settlements on the southern edge of Vipava Valley have less hedgerows, less permanent grasslands, more dense forests, smaller landscape mosaics, a much smaller percentage of the S- and SW-facing slopes and are closer to highway than viticultural settlements on the Kras plateau. Obviously, multiple aspects interact and influence the Scops Owl occurrence, and not just one variable (vineyards). However, wine growing in the areas of Scops Owl's occurrence should not be too intensive. The rapid expansion of intensively managed vineyards was identified as the main factor for a steep decline of Scops Owl populations in Northern Italy (Sacchi *et al.* 1999) and Switzerland (Arlettaz *et al.* 1991).

Scops Owl preferably occupied sites with greater availability of old buildings, especially when selecting a patch for a territory. This may indicate that Scops Owl uses old buildings for nesting or there is some other indirect reason for such result, e.g. nesting in old trees in gardens next to houses. Denac (2009), for example, reports that at Ljubljansko barje Scops Owls regularly called from large old trees in farmyards (e.g. Horse Chestnut *Aesculus hippocastanum*, Large-leaved Lime *Tilia platyphyllos*, Small-leaved Lime *Tilia cordata*), and that two nests were found in extensively managed orchards, located next to houses. In our study area, no nests have been found in buildings yet. T. Mihelič (*pers. comm.*) reports that 2–3 pairs of Scops Owl were calling from buildings in the village of Osp under Kraški rob during the whole breeding season of 1993, indicating that they were probably breeding in them. Nesting in old buildings is very common in the Italian Alps (Vallarsa), where most nests were found in walls of inhabited buildings, in cracks at the junction between the outer wall and roof and in holes within church towers (Marchesi & Sergio 2005). As proposed by Marchesi & Sergio (2005), nesting in buildings seems to have many advantages. Firstly, cavities in buildings may be relatively cool during hot days, preventing nestlings from overheating, while the heat released at night by rocky walls may compensate for heat loss at night and provide a more favourable thermal environment for nesting (Marchesi & Sergio 2005). Secondly, placing the nest within the village may minimize distance to hunting areas in its vicinity during breeding, what is likely to be important for Scops Owl because of a high frequency of prey delivery to the nest (Marchesi & Sergio 2005, Muraoka 2009). Thirdly, as observed by Vrezec (2001), roadside lamps, which are mainly restricted to settlements, attract large numbers of insects and consequently Scops Owls. In bigger settlements of the study area (e.g. Sežana, Divača, Hrpelje, Kozina), Scops Owl was mainly absent, probably due to the lack of breeding niches and foraging areas. In the last few decades, urbanisation changed the architecture of settlements and rural houses very much (Zelnik 2008). Building of new houses, loss of abandoned rural buildings, renovation of old houses in the way which does not maintain the breeding niches in the walls, and removal of old (fruit) trees from gardens together with introduction of ornamental shrubs and dwarf trees, all lead to reduced availability of nests for Scops Owl (Rubinič *et al.* 2008, Denac 2009).

Our analyses showed that Scops Owl consistently avoided highways. Daily traffic on the motorway at the Razdrto–Socerb section is estimated at 17,000 vehicles/day, while traffic density on the Razdrto–Nova Gorica trunkroad is estimated at 7,500 vehicles/day and is still increasing (DARS 2007). The area affected by road traffic, within which the Scops Owl was absent or less common, was ca. 4,000 m away from the highway, with some exceptions due to more favourable topography (e.g. Osp village is ca. 1 km distant from the highway, but as it is situated under the rocky walls of Kraški rob, the noise is reduced there a great deal; three males were recorded in 2006 and 2008). Similar effect-distances of 2,000–3,000 m from the road have also been reported for numerous grassland and woodland bird species (Reijnen *et al.* 1996, Forman *et al.* 2002). Scops Owl is acoustically very active, i.e. using calls for recognition between individuals and for maintenance of their territories while using hearing to locate their prey (Heller & Arlettaz 1994, Galeotti *et al.* 1997). Therefore, we estimate that the main cause for the negative impact of roads is traffic noise, beside car-collisions (Bavoux *et al.* 1997, Denac 2000b, Pavelčík 2000, Marchesi & Sergio 2005). The reason for Scops Owls colliding with vehicles could be in its low-flight, as one of the preferred foraging strategies is flying onto bush crickets, beetles and butterflies within a layer of 2–6 m above the ground (Šotnár *et al.* 2008). As roads obviously have an extremely negative effect on Scops Owl, this aspect should be subjected to further studies. Indicators of traditional farmland, such as length of hedgerows and landscape mosaics, predicted Scops Owl occurrence at the settlement and territory scales. Farmland rich in hedgerows may benefit Scops Owl in providing hunting perches, nesting holes, places for day roosting and a diversified landscape rich in prey (Rubinič *et al.* 2008, Denac 2009, Sergio *et al.* 2009). Similarly, high degree of landscape mosaics is important for smaller species such as the Scops Owl (Streit & Kalotás 1991, Galeotti & Gariboldi 1994, Keller & Parrag 1996), since it offers well-diversified entomofauna in small area (e.g. Marchesi & Sergio 2005). Arlettaz & Fournier (1993) even noticed a difference in the choice of prey between the sexes, which possibly indicates spatial segregation in the hunting range. The authors suggested that females hunt in denser vegetation (woodland edges, hedgerows) and males in more open areas (meadows and pastures). All this probably explains, why during all three Scops Owl surveys (2006, 2008 and 2010) the species was absent in settlements on the southern edge of Vipava Valley, where expansion of intensive land-uses, especially vineyards and fruit plantations, accompanied by the removal of hedgerows, resulted in a habitat, unsuitable for Scops Owl. Such landscape changes are known to have a negative effect on populations of Tettigoniid grasshoppers (Köhler 1996).

As expected, variable average annual air temperature predicted Scops Owl occurrence at the settlement scale, since it is too robust to show microclimatic conditions at finer scales. Areas of relatively higher air temperature and lower precipitation correspond very well to areas with the highest densities of Scops Owl (e.g. western part of the Kras plateau, Kraški rob). This is probably due to higher availability of grasshoppers.

(e.g. Arlettaz *et al.* 1991, Keller & Parrag 1996, Marchesi & Sergio 2005, Rubinič *et al.* 2008, Muraoka 2009), which are positively influenced by increased temperatures (Hein *et al.* 2007). In the last two decades, average annual temperatures in Slovenia have increased significantly, being 0.5 to 1 °C higher in all Slovene regions than the average temperatures between 1961 and 1990 (Ogrin 2004). Due to global warming, the species is most likely going to expand its present distribution to higher latitudes and altitudes across Slovenia (Huntley *et al.* 2007), which has already been observed in Slovakia (Krištín & Kaňuch 2009).

Based on habitat selection analysis, the following conservation measures for Scops Owls in the wider are of Kras are recommended:

- promotion of extensive farming practices on permanent grasslands (low or no fertilizer use, ideally with one grassland harvest per year (Sergio *et al.* 2009), or by low-intensity grazing systems),
- preservation of traditional mosaic landscape, especially in surroundings of villages,
- prevention from scrub-encroachment and afforestation,
- prevention from removal of semi-natural elements in traditional landscapes (hedgerows, stonewalls etc.),
- promotion of organic farming, especially for extensively managed orchards and vineyards (e.g. ecological wine-production, organic fruit production etc.),
- preservation of extensively managed orchards and other old trees with tree-holes, potentially suitable for nesting (e.g. hedgerows, willows in vineyards, chestnut avenues etc.),
- preservation of cavities in outer walls of buildings when they are renovated, or promotion of installation of nestboxes.

According to habitat requirements, the main threats to Scops Owl and its habitat in the wider area of Kras are: (1) traffic noise, (2) intensification of farmland, especially evident in the lower Vipava River Valley, (3) land abandonment, followed by scrub encroachment and forest expansion, resulting in loss of open habitat, which is a dominant process in the major part of the study area (Trontelj 2000), and (4) urbanisation of settlements and rural houses.We can conclude that in the long-term, Scops Owl population in the wider area of Kras is threatened if these negative trends continue.

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6. Povzetek

Cilj raziskave je bil odkriti ključne okoljske dejavnike, ki vplivajo na pojavljanje velikega skovika *Otus scops* na širšem območju Krasa (JZ Slovenija, 665 km^2). Na tem območju je bil veliki skovik sistematično popisan v letih 2006 (180 kličočih samcev) in 2008 (167 kličočih samcev). Samci so bili razporejeni bodisi posamično bodisi gručasto, in sicer večinoma po naseljih in okoliških kmetijskih površinah, kar kaže na sinantropnost vrste. Navadna gostota je znašala 0,3 samca/km^2 v letih 2006 in 2008, ekološka pa 1,0 leta 2006 in 0,9 samca/km^2 leta 2008. Prostorska razporeditev populacije, z najvišjimi lokalnimi gostotami na zahodnem in osrednjem delu Krasa, Kraškem robu in Podgorskem krasu, se med popisnima letoma ni bistveno spremenila. Izbor habitata je bil analiziran na treh prostorskih nivojih (pokrajinski nivo, nivo naselij, nivo teritorija), na podlagi prostorskih podatkovnih slojev (22 okoljskih spremenljivk), z uporabo χ^2-testa ujemanja

in logistične regresije. Rezultati so pokazali, da na pokrajinskem nivoju veliki skovik izmed različnih vrst rabe tal prednostno izbira odprte habitate (ekstenzivne oz. travniške sadovnjake, pozidana zemljišča, vinograde ter trajne travnike), izogiba pa se strnjenega gozda in kmetijskih zemljišč, poraslih z gozdnim drevjem. Izmed naselij raje izbira tista, ki so bolj oddaljena od avtoceste oz. hitre ceste, imajo dobro ohranjeno tradicionalno kmetijsko krajino (več mejic) in višjo povprečno letno temperaturo zraka. Pri izbiri teritorija pa je bilo pojavljanje velikega skovika v tesni povezavi z večanjem oddaljenosti od avtoceste oz. hitre ceste, z večanjem števila starih stavb in z večanjem mozaičnosti krajine. Vrsto ogrožajo hrup s prometnih cest, izguba habitata zaradi opuščanja in intenziviranja kmetijske rabe ter (potencialno) pomanjkanje gnezdilnih mest znotraj naselja. Ukrepi za ohranitev vrste bi morali temeljiti na ohranjanju mozaične kmetijske krajine, spodbujanju ekstenzivne rabe zemljišč, preprečevanju širjenja zarasti in gozda ter vzdrževanju gnezdilnih niš znotraj naselij (dreves z dupli, lukenj v zidovih stavb).

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