Conference Volume | 5th Symposium for Research in Protected Areas | 10 to 12 June 2013, Mittersill | pages 211 - 214

Distribution, abundance and habitat requirements of protected bird species in the Hohe Tauern National Park (Austria): combining field work and habitat modelling

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Abstract

Designing conservation strategies and implementing conservation measures for protected species requires reliable knowledge about i) habitat requirements, ii) spatial distribution, and iii) population size of the target species in the area of interest. The Hohe Tauern National Park is the largest protected area in the Alps and includes, e. g., extensive areas of alpine grassland, rocky habitat, and montane to subalpine forest. With aid from the European Union (EU), a study was launched which covered 67 % of the national park and focused on 12 bird species listed in Annex I of the EU Birds Directive, including, e. g., grouse, woodpeckers and owls. As these species occur at low densities and are difficult to detect, the rough alpine terrain and a limited amount of resources available for field work posed considerable challenges to gain sufficient data. Thus, we implemented a multi-step approach which included the selection of 133 sample plots on the basis of preliminary MaxEnt-models of suitable habitat for the target species using pre-existing bird records; bird mapping during the breeding season in 2011 and 2012; the collection of habitat data at the bird's locations and at independent random points (e. g. deadwood, canopy cover); the use of spatial models of preferred habitat features and other environmental data for the creation of final models of suitable habitat for the target species; and the estimation of their population sizes by linear extrapolation of the correlations between the total amount of suitable habitat and the bird's numbers within the sample plots. According to our estimates, the study area holds populations of international importance of two species (Rock Partridge *Alectoris graeca*, Pygmy Owl *Glaucidium passerinum*) and 8-9 species meet the thresholds for national importance. Our results suggest that there is a need for more large-scale studies of 'difficult' species, and that some previous regional and national estimates should be revised. This is because major under- or overestimations of populations may lead to the setting of inappropriate conservation priorities and to inefficient use of available funds. We will discuss some advantages of our methodological approach, which yielded distribution maps of comparably high spatial precision, reasonably accurate population estimates, and information about habitat requirements and potential risks which provide a sound basis for planning and implementation of conservation measures, and for monitoring as well. We argue that the importance of the Hohe Tauern National Park in particular for the conservation of alpine species like Ptarmigan (*Lagopus mutus*) will increase as climate change is proceeding.

Keywords

Hohe Tauern National Park, sampling design, bird mapping, population estimates, habitat suitability models, MaxEnt, conservation, climate change

Introduction

With app. 1,857 km², the Hohe Tauern National Park is the largest protected area in the Alps. As altitudes range from 1,000 to 3,798 m a. s. l., it holds a great variety of habitats and species. More specifically, its importance is related to the extensive areas of alpine grassland, dwarf heath and rocky habitat, and – to a lower extent – of montane to subalpine forest. As these habitats are supposed to hold important populations of associated species, almost the whole national park area is designated as Special Protected Area under the EU Birds Directive. However, knowledge about some of the qualifying bird species listed in Annex I of the Directive is insufficient, because i) they occur at low densities, ii) they are difficult to detect or nocturnal, and iii) dedicated investigations are particularly demanding in the rough alpine environments. This is a serious drawback for the design and implementation of suitable management measures aimed at securing or improving their conservation status as required by the Birds Directive, and for the establishment of monitoring schemes. Therefore, from 2009 to 2012, with financial aid of the EU, a detailed study was carried out in the fraction of the national park belonging to the federal states of Carinthia and Salzburg, which account for 67 % of the park's surface. We focused on 12 species of Annex I of the EU Birds Directive: Hazel Grouse *Tetrastes bonasia*, Ptarmigan *Lagopus mutus helveticus*, Black Grouse *Lyrurus tetrix*, Capercaillie *Tetrao urogallus*, Rock Partridge *Alectoris graeca*, Pygmy *Glaucidium passerinum* and Boreal Owl *Aegolius funereus*, Grey-faced *Picus canus*, Black *Dryocopus martius*, Three-toed *Picoides tridactylus*, and White-backed Woodpecker *Dendrocopos leucotos* and Red-backed Shrike *Lanius collurio*. The aim of the project was to gain reliable knowledge about i) the species' habitat requirements, ii) their spatial distribution and iii) their population size in the study area.

Methods

In a first step we produced preliminary models of the birds' potential habitats with MaxEnt, a recently but well established technique, which achieves high predictive power by using presence data only (ELITH et al. 2006; PHILLIPS et al. 2006). To this purpose, we used pre-existing bird records and environmental data available for the whole study area (e. g. habitat type, elevation model, etc.) as predictors. The models had a resolution of 50 x 50 m and served for the selection of sample plots as follows: i) they included at least app. 20 % of total potential habitat in the study area for those species expected to be reasonably common; ii) the share of potential habitat was highest in those species which were supposed to be least numerous and/or most difficult to detect; iii) the plots represented a wide range of habitat quality; and iv) the plots were nearly evenly distributed over the whole study area. In total, we selected 133 sample plots (mean size 1.68 km², altitude 1,000 to 2,670 m a. s. l.), which accounted for app. 18 % (223.5 km²) of the study area.

Woodpeckers, grouse and the Rock Partridge were mapped three times (103 plots); two night mappings were carried out for owls (30 plots); the Red-backed Shrike was mapped only in Salzburg. In total, 369 days of field work has been spent during the season of territorial activity by 23 experienced ornithologists. When a target species was located, its position was determined by GPS and information about sex, behaviour etc. was recorded as well as data relating to a number of small-scale habitat features. The same habitat features were collected independently at a random sample stratified by habitat types (n = 657).

These two data sets were used to identify species-specific preferences for habitat features by multivariate statistical analysis. The locations of such preferred habitat features were treated in the same way as bird records, as we created MaxEnt-models to estimate the probability of their occurrence for the whole study area. Together with the other environmental data, those 'modelled habitat features' were used as predictors to build the final models of suitable habitat for each bird species. Within the limitations of available sample sizes, bird records were selected with respect to their information content. All MaxEnt were validated by using 50 % of bird records as 'training data' and 50 % as 'test data', which allowed us to carry out binomial tests. The selection of the most informative predictor variables was based on the jackknife-procedure performed by MaxEnt.

For each sample plot and each species, we determined i) the number of territories (or displaying males in the case of Black Grouse and Capercaillie) using conventional methods (BIBBY et al. 1995); and ii) the total amount of suitable habitat by summing up predicted occurrences over all 50 x 50 m grids. Circumstantial evidence (e. g. lack of accessibility during periods of maximal territorial activity) indicated that the real numbers were most likely underestimated in a number of sample plots. After exclusion of sample plots with likely underestimation, we computed linear correlation coefficients between total suitable habitat and the numbers of territories or males. Finally, estimates for the total numbers of territories or males within the whole study area were obtained by linear extrapolation of those correlation coefficients.

Table 1: Estimates for current population size in the two surveyed fractions of the Hohe Tauern National Park (Carinthia and Salzburg).

species	number of pairs in np Carinthia	number of pairs in np Salzburg	Total number of breeding pairs
Hazel Grouse	60-90	140-210	200-300
Ptarmigan	400-650	770-1.250	1,170-1,900
Black Grouse*	190-250	290-380	480-630
Capercaillie*	25-35	55-70	80-105
Rock Partridge	170-210	120-150	290-360
Pygmy Owl	40-80	60-130	100-210
Boreal Owl	55-65	90-105	145-170
Grey-faced Woodpecker	30-60	35-80	65-140
Black Woodpecker	14-18	26-30	40-48
White-backed Woodpecker**	0	1-5	1-5
Three-toed Woodpecker	250-320	300-390	550-710
Red-backed Shrike**	n.a.	5-10	n.a.

* males with territorial behaviour

** estimate based on expert judgment

Results

In total, bird data included 1,159 records. Ptarmigan, Black Grouse, and Three-toed Woodpecker were the most common species with 453, 190 and 128 records, respectively. 39 records belonged to the elusive Rock Partridge. Even after partial exclusion of records, the remaining data were sufficient to build habitat suitability models for all species with the exception of White-backed Woodpecker (three records) and Red-backed Shrike (seven). The predictive power of all models may be rated as 'outstanding' (HOSMER & LEMESHOW 2000). Moreover, all Binomial-tests of omission performed by MaxEnt were significant at $p < 0.0001$. Also, the predictions resulted to be quite precise even at small scale after visual inspection.

In all 10 species, the models gained most predictive power from the ‚modelled habitat features', which represent small-scale habitat information that initially was not available for the whole study area. According to the jackknife-procedure, such habitat features accounted for most information gain in every habitat model. For example, the most important predictor for the Black Woodpecker were ≥ 20 dead trees with a diameter of at least 20 cm at breast height.

Overall, the occurrence of forest species was positively correlated to mature stands with not too steep slope (< 35°). A medium canopy cover or tree gaps, interspersed open areas and a high density of thick standing dead trees were the most important habitat features. Several species were positively associated with forestry practices which support such habitat structures (single tree felling). The habitat requirements of the three species of open habitats in the subalpine to alpine belt were less homogeneous and rather showed specific preferences regarding vegetation. However, subalpine and alpine grasslands grazed by cattle and sheep appeared to be suitable habitats for all tree species. Also, wind-exposed hills play an important role as they provide access to food during periods with snow cover and are used for courtship displaying and territorial calling. Ptarmigans were positively correlated with the occurrence of snow fields, where protein-rich herbs become accessible during snow-melting. The population estimates resulting from linear extrapolation to the whole study area are presented in table 1.

Discussion

Our results suggest that the methodological approach chosen for the selection of sample areas was efficient within the given availability of resources for field work. Instead of sampling habitats in proportion to their share in the study area, using preliminary habitat suitability models we markedly increased our sampling effort in habitats for those species supposed to be less numerous and/or less detectable at the expenses of habitats of commoner species. As a result, we got a quantity of records which allowed us to produce satisfactory habitat suitability models for all species as well as reasonably accurate population estimates except for those species present with less than 10 territories. A retrospective analysis revealed that we mapped 19.5 % (Ptarmigan) to 35.4 % (Black Woodpecker) of suitable habitat, but only 18 % of the whole study area; these values are negatively correlated to estimated population size, which is a desirable pattern.

Another aspect of our approach – the use of spatial models of preferred habitat features as predictors in the bird's habitat models – may be considered as very successful, as they improved considerably the predictive power of the bird's models and accounted for most information in all instances.

Our results suggest that recent population estimates for the two federal states Carinthia and Salzburg should be revised. For instance, SLOTTA-BACHMAYR et al. (2012) estimated 11-100 pairs of Rock Partridge in the whole federal state of Salzburg. We estimate 120-150 pairs only within the national park, while the species is occurring even outside. According to FELDNER et al. (2006), the national park would include 43-80 % of the regional Ptarmigan population in Carinthia. This is unlikely, as the national park accounts for app. 12 % of alpine grasslands in that federal state only. As similar or even more pronounced disproportions indicate, it is very likely that the regional figures are underestimates in several species.

According to our results the study area holds nationally very important populations of Rock Partridge (30-32 % of Austria) and Three-toed Woodpecker (15-25 %), national important populations of Ptarmigan, Black Grouse, Capercaillie, Pygmy and Boreal Owl, Grey-faced Woodpecker. More significant, two species (Rock Partridge, Pygmy Owl) are of international importance as they meet the 0.1 % threshold (Ramsar Convention Secretariat, 2011) and three species have 'higher relevance than average' (Ptarmigan, Boreal Owl, Three-toed Woodpecker). But, these ratings may change if more accurate national estimates would be available. However, as our study was carried out on app. 67 % of the Hohe Tauern National Park, and because most species are markedly exceeding the mentioned thresholds, it seems unlikely that the general picture of its importance will substantially change.

Under the conditions of ongoing climate change, rising temperatures will reduce the surface of habitat suitable for birds of higher altitudes, and habitat quality may decrease as well. The Ptarmigan will face substantial habitat losses by upward expansion of the forest. Thus, this species will probably become extinct in many mountain ranges. In Switzerland, Ptarmigan decreased markedly in the last decades (REVERMANN et al. 2012), in Austria there is no evidence for a decrease, but this is most probably due to the lack of long-term studies. In our study area, the species was found between 1,800 and 2,800 m with highest suitability values between 2,100 and 2,400 m. In the Hohe Tauern National Park, where more than 260 peaks are higher than 3,000 m, Ptarmigan may retain a substantial, even if substantially reduced population because of the mentioned time delays and, simply, because surface is decreasing with altitude. Nonetheless, the importance of this protected area could increase in the foreseeable future in particular for species of subalpine to alpine habitats.

A major achievement of this study was the gain of knowledge about species-specific habitat requirements and potentially adverse human influences on habitat suitability. Within forests, the preservation of stands with low to medium degree of canopy cover, with mature trees of different age classes and with high densities of large-sized standing deadwood is essential. In the management zone of the national park, timber harvesting should be limited to single-tree felling. Our results clearly show that many species are benefitting from the use of forest for cattle grazing, whereas some stakeholders are promoting the spatial segregation of livestock grazing and timber production, we strongly recommend supporting this traditional practice by dedicated funds. Similarly, the grazing of cattle and sheep on subalpine to alpine grasslands and dwarf shrubs should be continued and, where possible, re-established to maintain the open character of those habitats. This is even more important as climate change is stimulating forest expansion above the current tree-line.

Conclusions

The discrepancies between our and other recent estimates demonstrate that there is a need for further field work in combination with habitat modelling to improve knowledge about the distribution and the size of populations of bird species associated with montane to alpine habitats in Austria. Lack of reliable figures causes considerable uncertainty for the assessment of the importance of already designated or potential protected areas, entailing some risk that inappropriate conservation priorities are set.

Especially in the case of species difficult to detect or living at low densities, an efficient sampling design is crucial. Our results demonstrate that even a huge effort (mapping of 223.5 km²) yielded just sufficient data for the rarer species, as habitat models based on less than 30 suitable records may result in unsatisfactory spatial predictions and population estimates. Thus, we argue that studies aiming at the production of reliable distribution maps and population estimates for grouse, woodpeckers and owls inhabiting montane to alpine environments are only cost-efficient if they cover very large and if they are based on approaches which include careful selection of sample plots, statistical analysis and habitat modelling. This is even more true because the effort for planning and analysing will increase only marginally with the total size of the area investigated.

Our findings regarding habitat use and habitat preferences allowed us to describe the habitat requirements of 10 species of conservation concern in the study area and to draw some conclusions about recent population trends on the basis of known land-use changes. These results are a reliable basis to identify suitable management measures, to define specific and quantitative targets for the preservation or achievement of a favourable conservation status as well as for long-term monitoring.

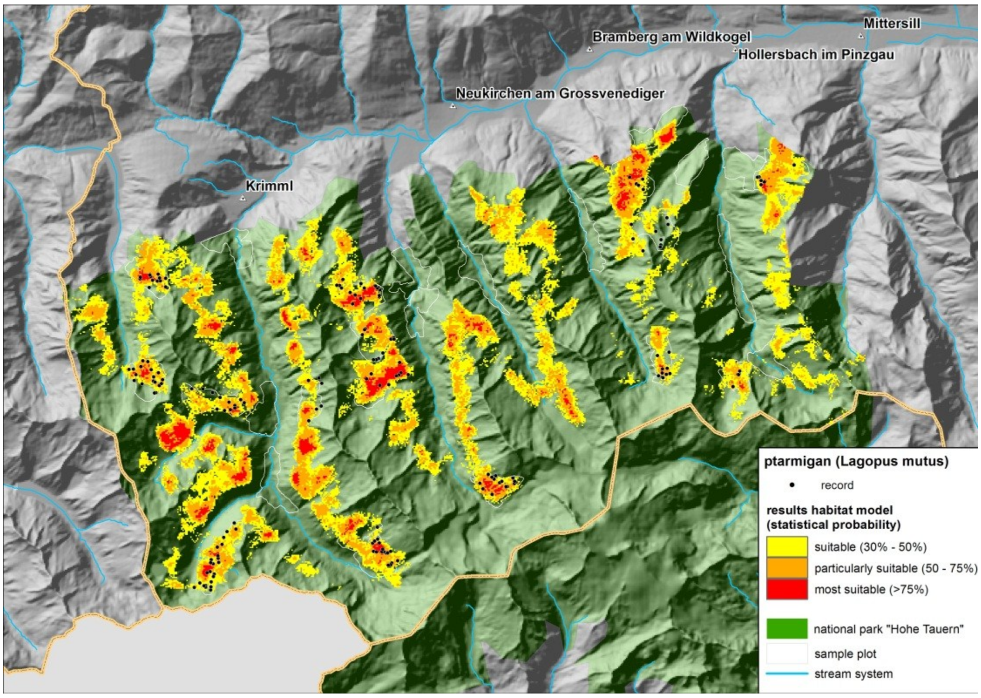

Figure 1: Partial view of the habitat model for the ptarmigan (*Lagopus mutus)* covering a representative part of the national park Hohe Tauern within the federal state of Salzburg.

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