

Habitat and nesting site modeling for the bearded vulture *gypaetus barbatus* in the Swiss Alps

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INTRODUCTION/BACKGROUND

The bearded vulture is one of the largest birds of prey of the old world. It was widespread in the whole Alpine arc until the end of 19th century. Due to human persecution and worsening environmental conditions it became extinct at the beginning of the 20th century (Robin et al. 2003). At present, bearded vultures are being reintroduced to the Alps. In recent years, the area around the Swiss release site (Swiss National Park, near Zernez) has evolved into a densely populated nucleus. To prevent aggressive intraspecific interactions due to overpopulation and to close the gap to the western population (Valais), new potential release sites are being evaluated at the moment. Assuming that bearded vultures are philopatric (i.e. after the juvenile wandering phase they return close to their birth place for settlement), not only the conditions at the release site but also the nesting site and habitat potential in the surrounding area of the release site are crucial factors of the evaluation. Previous studies analysing the spatio-temporal pattern of the first birds being released in Switzerland show this clearly. Most observations concentrate around the release site in the vicinity of the Swiss National Park (Allgöwer & Haller, 1998). We present for the first time a spatially high-resolution analysis for bearded vultures in the whole Swiss Alpine arc that distinguishes between the nesting site and habitat potential.

MATERIAL & METHODS

The study area with a size of 32'251 km² includes the Alpine arc of Switzerland and the boarder area of the adjacent countries (Abb.4.1). The analysis is based on different types of data: The digital elevation model of Switzerland (DHM25, resolution 25 m), the digital vector map of Switzerland (VECTOR25), actual natural nesting sites and bearded vulture sightings (1987 to 2007)

Often statistical methods are used to describe and predict habitat suitability. But as there are yet not enough natural nesting sites for a statistical analysis in Switzerland and the surrounding areas, the multi criteria evaluation (Malczewski et al. 1999) is an ideal method for habitat analysis.

The ecologic requirements of the bearded vulture were characterized and parameterized based on literature research and expert knowledge. Nesting site potential and habitat potential were considered different as different features. Therefore a separate multi criteria evaluation was performed for each feature.

Nesting site model

The nesting site potential was evaluated following the multi criteria evaluation procedure and

the analytic hierarchy process according to Malczewski et al. (1999). The selection and parameterization of the criteria and constraints (AHP-level 3) resulted from literature research and expert interviews. The criteria were classified as either positive or negative environmental factors (AHP-level 2) and each criterion map layer was divided into five suitability classes. The nesting site potential (AHP-level 1) resulted from the combination of all environmental factors. Seven experts filled in comparative weighting matrices for the AHP-levels 2 (1 matrix) and 3 (2 matrices). The criterion weights were derived from the averaged results of the matrices. The values of the criteria-layers were multiplied according to their weights and AHP-level. The recommendation was given in form of a suitability map.

Habitat model

The main focus of the habitat model was set on the potential food supply. Due to lacking information about the actual distribution of animals serving as food basis, the food factor was modeled indirectly through other criteria. Therefore the model is less complex than the nesting site model. The selection and parameterization of the criteria resulted from literature research and expert knowledge. The model is divided into three suitability classes and constraints were set for absolutely non-suitable areas.

RESULTS

Nesting site model

Bearded vultures usually build their nesting sites in steep cliffs. Therefore, rock and steepness (50° at least) were considered fundamental conditions for nesting potential. Other important environmental factors are the presence of niches and caves in the rock, good thermal conditions and adequate climate. These criteria are represented by the factors *Type of Rock*, *Aspect*, *Relief Energy* (i.e. relative height difference in a certain area) and *Height*. Whereas the positive factors can be described by abiotic and biotic conditions of the surrounding area, the factors which have a negative influence on the nesting site quality are mostly of anthropogenic nature. Four kinds of disturbance were classified: *Touristic Impact* in the surroundings of ski resorts and Alpine lodges, *Noise* in areas close to shooting stands, *Flight Obstacles* such as power lines or aerial passenger lines and *Flying Objects* (helicopters, gliders etc.) in areas close to airports. The intensity of a disturbance can be measured by the distance of a potential nesting site to the source of disturbance. The hierarchic structure of all factors and their importance is shown in fig. 1.

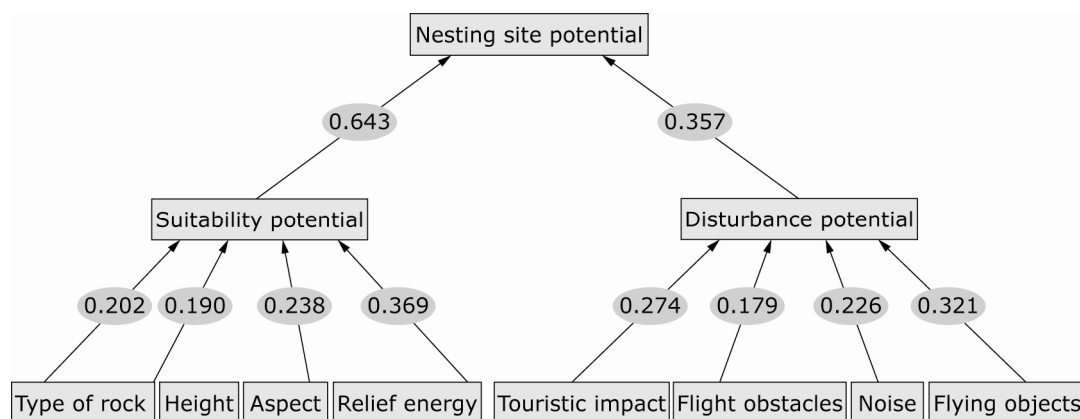


Fig. 1: Criteria and criterion weights according to AHP-Hierarchy

Habitat model

Besides abiotic factors like topography and thermal lift, the water and food supply is a basic condition for suitable habitats (Robin et al. 2003). The irregular topography in the Swiss Alps

has positive effects on the formation of thermal lifts and water supply is given everywhere. Although the food supply is not a limiting factor, it has still a huge influence on habitat selection. The criteria *Vegetation* and *Slope* serve as an indicator for the ground visibility which is necessary for the bearded vulture to find food. The climatic conditions and the intensity of anthropogenic land use and thus potential human impact were taken into account by the inclusion of the criterion *Altitude*. This criterion in combination with the ground visibility shows the general distribution potential for animals which serve as food basis for the bearded vulture and therefore have a strong influence on habitat selection. All criteria were divided into three suitability classes and combined for the recommendation in form of a suitability map.

Fig. 2 shows the synthesis of both models, a combination of the nesting site and habitat potential.

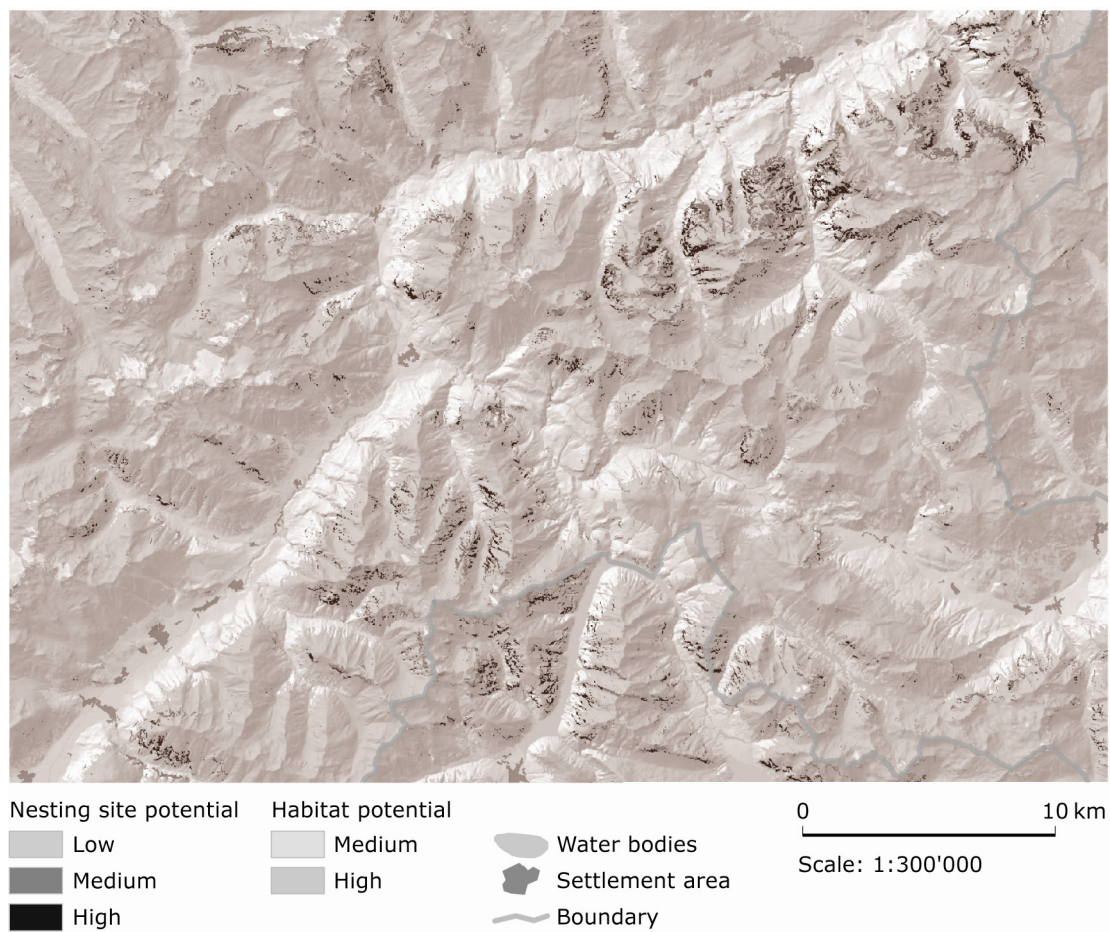


Fig. 2: Map of the nesting site and habitat potential near Zernež, GR.

CONCLUSIONS & OUTLOOK

The MCE has shown to be a good choice for handling uncertainties. The combination of literature research and expert knowledge makes it possible to develop acceptable models even without the inclusion of system data.

While the preferences of the experts about criterion parameterization and weighting differed very much, the MCE showed to be a very useful tool for modeling the nesting site potential. With the selected criteria and the averaged weighting most of the requirements could be followed. Overall, the nesting site potential was captured very well and experts consider the

model useful. Food supply is very important for habitat selection. Even though food supply is not a limiting factor in Switzerland, areas with more food are preferred to other areas. In spite of the lack of data about actual food supply, the habitat suitability was modeled through indirect criteria.

Despite of data uncertainties and operational uncertainties the aims of the study were achieved. The nesting site and the habitat potential in the Swiss Alpine range could be modeled with a high resolution. Both models as well as their synthesis are considered useful by experts and can be used as a basis for the evaluation of new release sites.

The perceptions of the study can be deepened by an enhancement of the developed models. One aspect is the food supply that was so far modeled only indirectly. Another aspect is the possible integration of the habitat model as a criterion into the nesting site model. A transfer of the model into other Alpine regions is possible. If the bearded vulture population continues growing, it will soon be possible to perform statistical analyses on the nesting sites. Another possibility is the development of a population-dynamic model for evaluating the spatial and temporal dispersion coming from the actual population nuclei.

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