

A GIS-based habitat-suitability model as a tool for the management of beavers *Castor fiber*

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A geographical information system (GIS)-based model, including major parameters of topography, hydrology and vegetation, was developed to assess suitable habitats for beavers in the Federal Province of Salzburg, Austria. Beavers *Castor fiber* Linnaeus, 1758 are on the verge of their distribution in the study area. At present, the 18 existing colonies show a rather scattered pattern, which suggests that the sub-population has not yet reached its carrying capacity, and a rapid growth phase as seen in other regions is expected. Suitable habitats have been calculated for the regions Alpenvorland, Salzburger Becken, Kalkvoralpen and Kalkhochalpen. Here optimal habitat is covering 429 ha (meeting all requirements of beavers) and suboptimal habitat is covering 187 ha (meeting all requirements except a winter food source). This represents 3.4% optimal and 1.5% sub-optimal habitat of the total available area. There are 13–14 suitable regions large enough to host at least one beaver colony. A total of 31 (23–51) colonies were calculated by the model. Based on the current sub-population of 18 colonies (36–100 animals), an average increase of 72% was expected. In an intensively managed landscape, beaver-human conflict should be anticipated and management policies established. Continuous assessment of suitable, unsuitable and sensitive habitats, extending existing conservation areas and river bank habitats, and pursuing protective measures against individuals causing conflicts are presented for the study areas.

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Introduction

Beavers *Castor fiber* Linnaeus, 1758 were completely eradicated from the Danube watershed

during the course of the 19th century (Schwab and Lutschinger 2001). Re-introduction programmes were set up in Bavaria at the beginning of the 1960s and in Austria in the 1970s. Today, beavers are again gradually becoming a fairly

common mammal throughout Europe (Halley and Rosell 2002). In 1869 beavers had become extinct in the Federal Province of Salzburg (Kollar and Seiter 1990). Nearly 120 years later, in 1983, two beavers were re-introduced to a riparian forest along the River Salzach (Slotta-Bachmayr and Augustin 2003). The sub-population had increased during the previous 22 years and initial conflicts arising from damage caused by beavers had been reported. In the Federal Province of Salzburg they are protected by the Federal Game Law (LGBl. 100/1993) and by the European Union's Habitats Directive (92/43/EEC). The landscape in the Federal Province of Salzburg is intensively managed and the tolerance level of forestry and agriculture to damage caused by beavers is low. A drop in the quality of habitat has limited any potential re-colonisation. Therefore, an assessment of the quality and quantity of available habitats is essential in order to predict population development. Potential colonies must be assessed to the extent that development and management policies can be implemented to avoid any beaver-human conflict.

This study, based on the development of a geographical information system (GIS) model, targeted the following questions: (1) where are suitable beaver habitats sited? (2) what is the expected carrying capacity in the study area? and (3) does the beaver population require management measures and, if so, in what regions?

Material and methods

Study area

The study was conducted in summer 2005. We used data layers defined in Table 1. The total area of the Federal Province of Salzburg, Austria (Fig. 1) is 7154 km² (47°30'N, 13°00' E). About 45% of this area is covered by forest, 15% is grassland, 13% forms a part of the high mountain region and the remainder is divided among dwarf-shrub heath, rivers and lakes, agricultural land and urban areas (CORINE Land Cover 2000).

Salzburg, Austria, is characterised by 7 rivers (Witmann *et al.* 1987). The main river system is the Salzach, which rises in the west, flows east, turns north, penetrating the calcareous Alps and then flows through the pre-Alps towards the River Inn. The Saalach rises near Saalbach and later meets the Salzach north of the city of Salzburg. The other river systems are the Mur, in the north-eastern part of the Province, the Inn in the west, the Enns in the east, the Traun, east of the city of Salzburg, and the Mattig, north of the city of Salzburg (Fig. 1). All rivers are of an alpine character with a typical runoff regime. River width varies from spring rivulets (< 1 m) to rivers (> 90 m). A large proportion of these rivers have either had banks reinforced or hydroelectric power plants built alongside them (Jäger *et al.* 2004).

Viable population

The beaver social unit is typically a family group defending a territory commonly called a colony (Djoshkin and Safonov 1972, Jenkins and Busher 1979). Single animals may also defend a territory, and in such instances constitute a colony (Rosell *et al.* 2006). Beavers occupy a pond or section of stream more or less exclusively (Djoshkin and Safonov 1972, Jenkins and Busher 1979) and the quantity and size of colonies, in comparison to available habitat, is limiting the viable population in an area.

Table 1. Environmental parameters used in the model.

Parameter	Type of data	Source of data
Land use, water bodies	raster	land register
Forest	raster	CORINE Land Cover Level 3 (2000)
Slope, elevation	raster	digital elevation model (DEM)
Permanent water	line	stream network
Water level	point	Hydrographisches Jahrbuch von Österreich 2001
Barriers	point	Austrian Map
Beaver colonies	point	Austrian Map