Chapter 12
Is There Something Wild in Austria?

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Abstract This chapter presents the first spatially explicit wilderness map for the Austrian territory. This is modelled using the spatial patterns of four aspects of wilderness, an approach developed by the Australian Heritage Commission: remoteness from settlements, remoteness from access, apparent naturalness and biophysical naturalness. In order to combine these four layers we applied two approaches, which reflect two different aspects of wilderness quality, namely a weighted overlay and a minimum operator. These two approaches were merged to gain a spatially explicit estimation of the wilderness continuum for all of Austria. By applying two different thresholds to the continuum, we identified core as well as extended areas, which can be considered as wild areas with high potential for wilderness. In total 1.98 % and 6.16 % of the country can be classified as core and extended areas, respectively. The vast majority of these areas are located in mountain regions with higher elevations occurring especially in the western parts of Austria. Despite some shortcomings of this approach, e.g. the lack of data describing extensive land use like grazing, we hope that this assessment can serve as a policy- and management relevant tool to improve wilderness quality in Austria.

Keywords Wilderness mapping • Wilderness continuum • Austria

12.1 Introduction

Due to their long history of human colonization, Central European landscapes hold only a few remaining areas of true wilderness. The shift in nature conservation that has occurred over recent decades, changing from a species-focused point of view to a more ecosystem-oriented approach, has drawn attention to the importance and value of wilderness areas, intact ecosystems and full functioning of ecological

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processes. While only 1 % of the total land territory of Europe is currently protected as wilderness, numerous pristine or near-natural areas that should be protected as Europe's Natural Heritage are suffering from increasing intensification and land-use changes.

Beyond protecting existing wilderness, there is a high potential for 'rewilding' the landscape and restoring the ecological processes in Europe through upcoming land-use changes and demographic transitions (Secretariat of the Convention on Biological Diversity 2010). These 'rewilding areas' or secondary wilderness are a unique conservation opportunity to establish new wilderness for future generations. This goal entails that human influence be pushed back and a 'non-intervention' management be established. In addition, wildlife reintroduction programmes should – where possible – be considered to allow natural processes to determine the composition of native habitats and species.

This awareness led to a resolution of the European Parliament in 2009 to improve protection and funding for wilderness in Europe. In the same year, a conference on Wilderness and Large Natural Habitat Areas was organized through the Wild Europe Initiative, an initiative on wilderness incorporating European environmental NGOs and European Commission.

Following the conference, the Austrian Ministry of Environment placed the idea of wilderness at the heart of its new National Park strategy (endorsed in 2010), declaring that all Austrian national parks shall henceforth focus on ecological process management in their core zones explicitly referred to as "wilderness". Austria is located at the centre of Europe and the majority of its area (83,900 km^2) is dominated by the Alps. These mountain ranges still offer many aspects connected to wilderness, showing a considerable amount of wild areas. Wild areas are known to keep many facets of wilderness (Wild Europe Initiative 2012), hence these areas have both an intrinsic value and moreover a high potential to become – by changing current land use – secondary wilderness regions (Kohler et al. 2012). Nonetheless, there exists only one official wilderness area in Austria, the "Wilderness Dürrenstein", approved by the IUCN in 2003 with a total size of approx. 3500 ha, including 400 ha of untouched forest.

Thus, there is a substantial need to identify existing regions of high wilderness value as well as areas suited for wilderness in scenarios assuming policy relevant to lowering human impact. These areas could serve to establish more protected areas meeting the wilderness criteria of IUCN 1b (Dudley 2008) and also of Wild Europe (Wild Europe Initiative 2012). The latter is aimed specifically at the small-structured land-use situation on the densely populated continent of Europe.

To meet the demand for spatially explicit information, we are now able to present a GIS-based assessment of Austria's wilderness quality, based on the wilderness continuum concept, a concept initially developed by Roderick Nash in the 1960s (Nash 2001) and implemented by Lesslie and Taylor (1985) in the Australian National Wilderness Inventory. Based on this idea, various methods were applied to assign each locality of a study area a quantitative wilderness quality index score, indicating and distinguishing relative wildness on a continuous scale. European cases for this approach have been applied to several regions, for example, The

United Kingdom (Carver et al. 2002), Scotland (Carver et al. 2012), the Alps (Kaissl 2002) and even the entirety of European territory (Fisher et al. 2010; Kuiters et al. 2013). These examples have proven the feasibility and utility of wilderness continuum mapping.

12.2 Materials and Methods

In order to model the wilderness continuum, we used the approach of Lesslie et al. (1988), which distinguishes four different aspects of wilderness: (1) remoteness from settlement (remoteness from places of permanent habitation); (2) remoteness from access (remoteness from constructed vehicular access routes like roads and railways; (3) apparent naturalness (the degree to which the landscape is free from the presence of the permanent structures of modern technological society); and (4) biophysical naturalness (the degree to which the natural environment is free from biophysical disturbance caused by the influence of modern technological society) (See Chap. 2).

Similar to Fritz et al. (2000) we estimated and combined these four indicators using a multi-criteria evaluation (MCE) framework implemented in a Geographic Information System (GIS). We used ArcGIS 10.0 (ESRI 2011) and its ModelBuilder-tool to calculate weighted distance decay models with a spatial resolution of 100 m using the following input data sets.

12.2.1 Remoteness from Settlement

A map of soil sealing (Kopecky and Kahabka 2009) served as a proxy for settlements. This layer indicates the percentage of sealed area per grid cell and was derived using satellite images and remote sensing techniques. Areas without information due to cloud cover were filled using CORINE land cover (Coordinated Information on the European Environment, EEA-ETC/LUSI 2007).

To assess the ‘remoteness from settlements’, a weighted Path Distance to places indicating sealed soil was calculated. The Path Distance was favoured over the Euclidian distance because it considers topographical surface conditions. As the first step, the Path Distance was calculated using a Digital Elevation Model (Jarvis et al. 2008) as surface grid. To obtain weights, the grid layer ‘sealed soil’ was converted to points and a point kernel density was calculated. In the next step, a weighted sum was used to overlay the Path Distance and the kernel weights to gain the weighted distances. In the final step, we performed a linear stretch to receive values between 0 and 1 (0: lowest wilderness quality, 1: highest wilderness quality).

12.2.2 Remoteness from Access

We used data from the Open Street Map (OSM, Geofabrik 2012) as input to calculate traffic-weighted Path Distance models. The road lines served as street layer (proxy for private transport), while sections in tunnels were excluded, supposing that adjacent areas cannot be accessed by persons in the tunnels. Transport points indicated stops (proxy for public transport). We assigned weights to each class of these layers (Table 12.1), higher weights indicating a higher negative effect on the wilderness quality, and calculated weighted Path Distances for each weight separately. We then overlaid these layers using a weighted overlay as well as a minimum operator (for further explanation see Sect. 12.2.3) differentiating between private and public transport. In the next step, these two layers were combined and stretched between 0 and 1, yielding the final result for the aspect of remoteness from access.

Table 12.1 Weights for the several input layers used for remoteness from access and apparent naturalness

Class	Weight
Roads	
Bridleway	1
Cycleway	1
Footway	1
Living street	3
Motorway	5
Motorway link	3
Path	1
Pedestrian	2
Primary	5
Primary link	3
Residential	3
Road	4
Secondary	4
Secondary link	3
Service	2
Steps	1
Tertiary	3
Track	2
Track grade1	2
Track grade2	2
Track grade3	1
Track grade4	1
Track grade5	1
Trunk	5
Trunk link	3
Unclassified	1
Unknown	1

(continued)

Table 12.1 (continued)

Class	Weight
Transport points	
Aerialway station	2
Airfield	3
Airport	5
Bus station	1
Bus stop	1
Ferry terminal	2
Helipad	2
Railway halt	3
Railway station	4
Taxi rank	1
Tram stop	1
Power lines	
Cable	
Line	2
Minor cable	
Minor line	1
Points of interest	
Alpine hut	3
Restaurant	3
Ruins	3
Shelter	1
Tower	3
Railways	
Cable car	3
Chair lift	3
Drag lift	2
Funicular	3
Light rail	2
Miniature railway	2
Monorail	2
Narrow gauge	2
Rail	3
Subway	
Tram	1
Buildings	3
Skiing areas	4
Power stations	
Pole	1
Station	5
Station fossil	5
Station nuclear	5

(continued)

Table 12.1 (continued)

Class	Weight
Station solar	4
Station water	
Station wind	4
Substation	3
Hydroelectric power stations	
Storage power plants	5
Transverse structures	1
Run-of-river plants:	
standard operating capacity (GWh)	Weight
<486000	1
<850000	2
<1221600	3
<1617400	4
<1967600	5

12.2.3 Apparent Naturalness

Similar to the remoteness from access, weighted distance-decay functions were calculated using data on human infrastructure and artefacts as inputs: skiing areas (Umweltbundesamt 2012), hydroelectric power stations (Walder and Litschauer 2010), other power stations, power lines, alpine huts & shelters, the railway network and buildings (all Geofabrik 2012). We assigned weights to the different classes of the input layers (Table 12.1), calculated Path Distances followed by a weighted sum or a minimum operator (see Sect. 12.3) and a final linear stretch.

12.2.4 Biophysical Naturalness

This aspect of the wilderness quality index reflects the degree to which an area is free from the biophysical disturbances of human society. Various factors can be included here, e.g. land-use relevant activities (such as farming, forestry, fertilization and grazing) or even remote influences like emissions.

Due to a lack of adequate land use data, we used the CORINE land cover data set (EEA-ETC/LUSI 2007) as proxy, applying weights according to the degree of naturalness of land cover (Table 12.2). CORINE is a product of the European Environment Agency covering all of the EU27 territory and offering a standardized and hierarchical classification system. In wooded areas the degree of hemeroby (Grabherr et al. 1998) was included additionally. The concept of hemeroby measures the degree of naturalness of ecosystems and is used in ecological sciences.

Table 12.2 Weights for the CORINE land cover data set

Land cover class	Weight
Continuous urban fabric	5
Discontinuous urban fabric	4
Industrial or commercial units	5
Road and rail networks and associated land	4
Port areas	4
Airports	5
Mineral extraction sites	4
Dump sites	5
Construction sites	4
Green urban areas	3
Sport and leisure facilities	3
Non-irrigated arable land	3
Vineyards	3
Pastures	3
Annual crops associated with permanent crops	3
Complex cultivation patterns	3
Land principally occupied by agriculture, with significant areas of natural vegetation	3
Pastures	3
Broad-leaved forest	1–3[a]
Coniferous forest	1–3[a]
Mixed forest	1–3[a]
Natural grasslands	1
Moors and heathland	1
Transitional woodland-shrub	1
Bare rocks	1
Sparsely vegetated areas	1
Glaciers and perpetual snow	1
Inland marshes	1
Peat bogs	1
Water courses	1
Water bodies	1

[a] Weights using degree of hemeroby

12.3 Integration of Intermediate Results

For the integration of all intermediate results described above (remoteness from settlement, remoteness from access, apparent naturalness and biophysical naturalness), we followed two distinct approaches. To obtain an overall estimation of wilderness quality, we used a weighted overlay, similar to Carver et al. (2012). This approach considers all factors within a certain radius of a given location, calculating the weighted average. For finding weights (Table 12.3), we drew on Carver et al.

Table 12.3 Weights of the four intermediate layers

Layer	Weight
Remoteness from settlement	4
Remoteness from access	3
Apparent naturalness	3
Biophysical naturalness	1

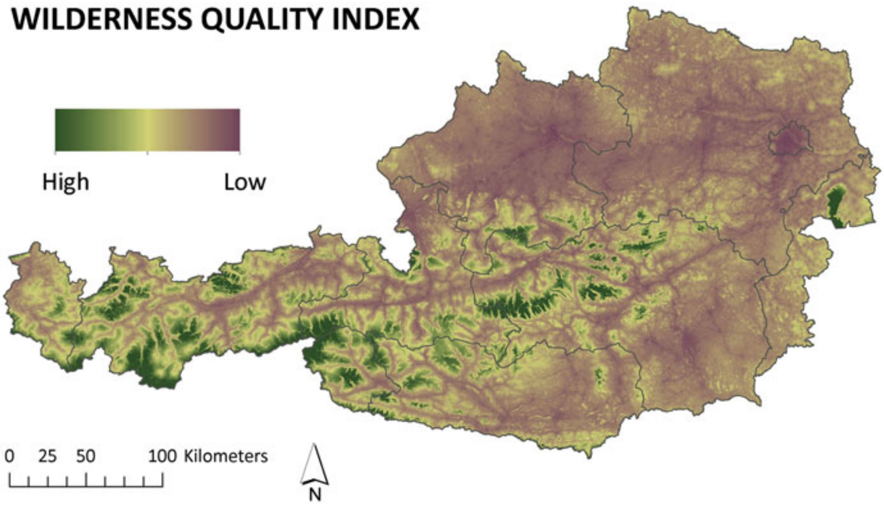

Fig. 12.1 Austrian wilderness continuum, combining a weighted overlay approach and a minimum operator approach

(2012), but had to adapt the figures for this study. We assigned the weights using a best guess considering spatial and thematic accuracy, underlying richness of information and local relevance.

This method is suited for highly populated areas, such as most European landscapes, and differs from the Australian approach (Lesslie et al. 1988; Lesslie and Maslen 1995), which only takes the most important factor into account (Fritz et al. 2000). In the case of Austria, this method tends to underestimate the influence of single facilities in remote areas (like alpine huts), because they accumulate much less weight compared to crowded localities. To be able to consider such facilities in these sensitive areas, we adapted the Australian approach and applied a so-called 'minimum operator' (which corresponds to a logical 'and'). As a consequence, for each locality the smallest and hence most influential distance value was taken into account. This minimum operator was applied using the first three aspects of the wilderness quality. The result thus reached was divided by the biophysical naturalness stretched between 0 and 1.

To obtain a final spatially explicit estimation of the wilderness quality index for all of Austria, we calculated the average of these two layers (Fig. 12.1).

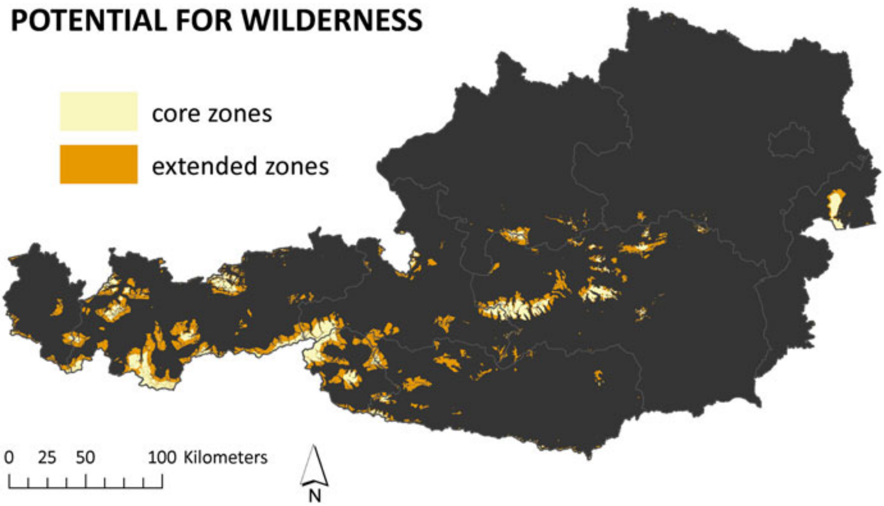

Fig. 12.2 Core and extended zones showing potential for wilderness in Austria

12.4 Delineation of Areas with Potential for Wilderness

The wilderness continuum provides valuable information with which to evaluate potential wilderness areas. However, a delineation of areas with a high potential for wilderness is also desirable for special tasks. To achieve this goal, two (arbitrary) thresholds were applied to designate such areas. To identify core areas, a threshold of 0.52 was determined, whereas a threshold of 0.39 was determined for extended areas. We sampled 100 wilderness quality index values in 500 m distance to 10 randomly chosen single objects in the alpine regions (alpine huts) and calculated the mean to derive the threshold for core areas. We proceeded analogously using 100 sample points in a distance of 2500 m to skiing areas to receive the threshold for extended areas.

The result shows that 1.98 % of Austrian territory can be considered as core areas for wilderness potential and 6.16 % show extended potential for wilderness (Fig. 12.2, Table 12.4). It must be noted that Lake Neusiedl in the east of Austria represents a considerable portion of these areas, since we did not exclude water bodies from this study.

12.5 Land Use Change Scenario

The approach presented here reflects the potential for wilderness under recent land use. To estimate the potential under changed land use, a discontinuation of certain land use activities was simulated. The simulation excluded relevant input data

Table 12.4 Distribution of areas with potential for wilderness by Austrian federal states

Federal state	Total area	Areas with potential for wilderness	Areas with potential for wilderness	Extended areas with potential for wilderness	Extended areas with potential for wilderness
	ha	*ha*	*%*	*ha*	*%*
Burgenland	395,877	11,632	2.94	17,834	4.50
Carinthia	953,513	6,431	0.67	49,369	5.18
Lower Austria	1,917,837	170	0.01	2,141	0.11
Upper Austria	1,197,522	1,908	0.16	9,723	0.81
Salzburg	715,378	22,005	3.08	60,931	8.52
Styria	1,639,656	37,854	2.31	101,729	6.20
Tyrol	1,263,032	83,728	6.63	258,061	20.43
Vorarlberg	259,672	2,221	0.86	16,915	6.51
Vienna	41,463	0	0	0	0
AUSTRIA	8,383,954	165,952	1.98	516,706	6.16

Table 12.5 Distribution of areas with potential for wilderness by Austrian federal states using the land use change scenario

Federal state	Total area	Areas with potential for wilderness	Areas with potential for wilderness	Extended areas with potential for wilderness	Extended areas with potential for wilderness
	ha	*ha*	*%*	*ha*	*%*
Burgenland	395,877	11,713.65	2.96	18,008	4.55
Carinthia	953,513	14,980.58	1.57	70,964	7.44
Lower Austria	1,917,837	175.41	0.01	4,942	0.26
Upper Austria	1,197,522	2,038.20	0.17	14,241	1.19
Salzburg	715,378	25,381.29	3.55	75,382	10.54
Styria	1,639,656	50,942.28	3.11	141,618	8.64
Tyrol	1,263,032	152,821	12.10	367,301	29.08
Vorarlberg	259,672	1,443	0.56	29,513	11.37
Vienna	41,463	0	0	0	0
AUSTRIA	8,383,954	259,496	3.10	721,973	8.61

(skiing areas, forest tracks, alpine huts and cable cars) from the model, and the whole model was rerun. Some of the alpine huts were associated with 'aerial ropeway stations' and 'helipads', so these facilities had to be excluded as well. Additional areas with potential for wilderness were added to the existing set of areas.

The spatial patterns of the results show marginal changes, there is an increase of core areas with potential for wilderness to 3.10 % and an increase to 8.61 % for extended areas with potential for wilderness (Table 12.5). Figure 12.3 shows the difference for the core zones.

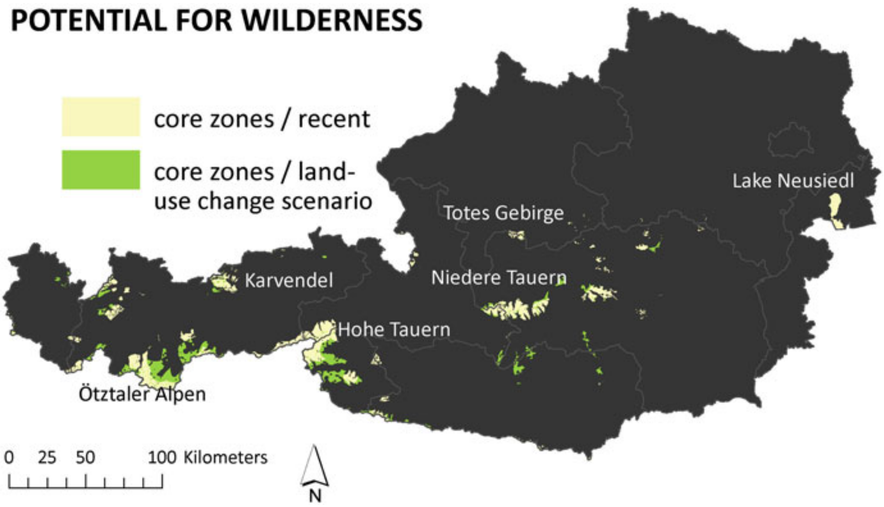

Fig. 12.3 Core zones of potential for wilderness in Austria under recent conditions and under a land use change scenario, assuming the closure of skiing areas, forest tracks, alpine huts and cable cars

12.6 Conclusion

The spatial pattern of the Austrian wilderness continuum shows that mountain ranges are favoured over lowlands. Areas with high wilderness quality are located especially in the western parts of Austria, for example the mountain regions Hohe Tauern, Niedere Tauern, Ötztaler Alpen, Lechtaler Alpen, Karwendel and Totes Gebirge. One exception is the large body of water of Lake Neusiedl, situated in the east at the border to Hungary. As expected, the populated regions of Vienna, Lower Austria, Upper Austria, the south-western parts of Styria and the large alpine valleys show consistently low wilderness quality values. This result was to be expected inasmuch as in Central European landscapes usually land-use intensity as well as most human activities decline with increasing altitudes.

Nevertheless, we are able to present this effect on a quantitative basis, corroborating the importance of alpine habitats for preserving natural processes and services on a large scale. Moreover, this approach is able to provide a point of departure for comparing the level of naturalness of different regions and localities, considering various aspects of anthropogenic disturbances. Detailed local studies could offer scenarios for how to protect existing aspects of wilderness as well as for how to change recent management and land use to develop wilderness in a sustainable way. Although the land use change scenario result shows only a small increase in the total amount of potential for wilderness (1.98–3.10 % for core zones and 6.16–8.61 % for extended areas respectively), some areas like Ötztaler Alpen and Hohe Tauern would see a considerable growth of wild land. It should be noted that the high wilderness quality value of Lake Neusiedl is a consequence of the input data used. We faced a lack of data focused on human activities on lakes – like ferries, sailing or fishery – resulting in an underestimation of human impact in freshwater habitats. Because of the national importance of Lake Neusiedl and its National Park, we decided not to exclude lakes for this study, but this bias has to be considered when reviewing the result and highlights the importance of data quality and completeness. It is clear that the assessment given here is missing several factors that would be important for a full and extensive evaluation of Austria's wilderness continuum. For example, grazing or hunting, which represent extensive land use or special human activities both affecting wilderness quality, are reported on administrative units and therefore lacking sufficient spatially explicit data sets.

Nonetheless, we hope that our work can serve as a spatially explicit tool to help develop conservation policy- and management-relevant strategies that, in the long run, will make Austria a wilder place.

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