Landscape Ecol (2018) 33:711–730
https://doi.org/10.1007/s10980-018-0628-x

RESEARCH ARTICLE

Symbolic species as a cultural ecosystem service in the European Alps: insights and open issues

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Received: 31 August 2017 / Accepted: 24 February 2018 / Published online: 2 March 2018

Abstract
Purpose Symbolic plants and animals are recognised as a cultural ecosystem service (CES), which is still underrepresented in ecosystem services assessments. Thus, this study aims at identifying and mapping important symbolic species in the European Alps, which are of cultural significance to large parts of the Alpine population.
Methods Symbolic species were identified by ten expert groups, and their use was assessed in a qualitative way. The spatial distribution of all species across the Alpine Space area was mapped at the municipality level. Through hotspots analysis, we identified spatial patterns in the distribution of species. Spearman correlation was used to evaluate the relationship between symbolic species and selected environmental and social variables.
Results Ten species were identified (edelweiss, gentian, alpenrose, larch, pine, Alpine ibex, chamois, marmot, brown bear, and golden eagle) that are widely used for symbolic representations, i.e., depiction on flags, emblems, logos, and naming of hotels and brands. Hotspots of symbolic species were found in several locations in the European Alps and could be related to high elevation, steep slopes, open land cover, and naturalness.
Conclusions This study proposes a methodology to map and assess symbolic species as a CES. As the spatial distribution of symbolic species depends on environmental characteristics and human activities, our results provide important insights for landscape planning and management. However, it remains unclear whether associated cultural values depend on the presence of the species and further research is needed to understand the relationships between the distribution of symbolic species and social benefits.

Keywords Cultural ecosystem services · Habitat maps · Cultural identity · Spatial analysis

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s10980-018-0628-x) contains supplementary material, which is available to authorized users.

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Introduction

Plant and animal species are incorporated in many ways in human culture representing religious, social and political beliefs as well as society's values (Castells 2011). They contribute to the shaping of peoples' emotions, experiences, thoughts, values, and cultural identity (Kellert and Wilson 1995). Accordingly, the cultural importance of species is reflected in art, literature and language, mythology and religion, music, politics and world events, among others (Grabherr 2009; Malamud et al. 2007; Manning and Serpell 1994; Shoemaker 1994). Plants and animals can hold a great symbolic value for a particular place through social and political developments, representing the cultural identity and heritage of the people at the local, regional, or national level, and are recognisable to people from other places (Forristal et al. 2014; Urbanik 2012). The edelweiss that is a well-known mountain flower, for example, is closely associated with the European Alps; it is used by the tourism industry for promoting Alpine tourist destinations, it appears in Alpine folklore, and some enterprises or products carry its name (Dweck 2004).

The cultural significance of symbolic plants and animals relates to environmental, social, and economic contexts in different ways. In some cases, people associate certain attributes or ideas with symbolic species; for example, the bald eagle was adopted as the national bird symbol of the United States of America and many Americans relate to its qualities such as beauty, power, and long life (Lawrence 1990). Symbolic species, which were chosen as national symbols, are often represented on flags or emblems, such as the maple leaf on the flag of Canada, the quetzal on the flag of Guatemala or the grey crowned crane on the flag of Uganda. In other cases, plants or animals have become symbolic of a specific region playing a significant role in the livelihood of the population; for example, the olive tree is emblematic of the Mediterranean regions, as it has shaped the cultural landscape for centuries and still constitutes the primary source of livelihood for many people (Loumou and Giourga 2003). The perceived values of a particular species depend greatly on the use and may change over time. The Alpine ibex, for example, has been a source of traditional medicine and a valuable trophy until its extinction in the early modern age in most parts of the Alps due to hunting (Hitz 2010). After its reintroduction during the last century, it is admired for its strength and wiriness and symbolises the Alps with their steep slopes and harsh environmental conditions.

The attributes that are associated with symbolic species may be used to promote products of industrial enterprises or artisanal businesses by selling a certain image or feeling, such as colourful tropical birds that may represent an exotic, luxurious, or unconventional way of life (Anderson 2010). As specific species are representative for certain regions or convey particular emotions, they are also of great importance to the tourism industry for promoting certain tourist destinations such as national parks (Newsome and Hughes 2016). For example, the 'Big Five' animals (lion, leopard, buffalo, elephant, and rhino) are often used as characteristic species to promote sub-Saharan Africa to wildlife tourists (Williams et al. 2000). In the European Alps, different symbols has been used to promote mountain destinations since the beginning of tourism; for example, the edelweiss, as a symbol for alpinism (Grabherr 2009), or cows representing the Swiss mythos of the idyllic world, a traditional alpine landscape, with values such as innocence, peacefulness, naturalness, and calmness (Nyffenegger 2013). Wild animals, such as marmot, Alpine ibex or bear, which symbolise the rediscovery of the wild nature, appear only after the 1970s on advertisements for destination marketing (Roth 2010).

Due to their cultural significance, symbolic species may be adopted to represent environmental or social issues, and conservation projects often use them as flagship species (Jepson and Barua 2015), although it is greatly debated whether their habitats and co-occurring species really benefit from conservation efforts focusing on flagship species (Brambilla et al. 2013). Nevertheless, the role of symbolic species in tourism may help to financially support the conservation of these species and their habitats (Naidoo et al. 2016; de Pinho et al. 2014), as people are willing to pay more for the conservation of animals if they could observe them in their natural environment (Tisdell and Wilson 2001). Conservation actions often focus on certain species (keystone species), as the importance of these species for the functioning of ecosystems has long been recognised (Mills and Doak 1993). Recently, studies have expressed also the need to include cultural values and preferences into conservation efforts by identifying cultural keystone species, i.e., species with a powerful role in society and that are symbolic for the cultural identity of a community (Garibaldi and Turner 2004; Poe et al. 2014).

In summary, the cultural values of symbolic species are important in many ways for people and societies. Hence, 'symbolic interactions with biota, ecosystems, and land-/seascapes' are included in the Common

International Classification of Ecosystem Services (CICES) (Haines-Young and Potschin 2013) as a cultural ecosystem service (CES), providing the non-material benefits originating from interactions between humans and ecosystems (Chan et al. 2012; Fish et al. 2016). Numerous studies on ecosystem services, have emphasised the ecological and economic value of plant and animal species as part of the natural environment (Gascon et al. 2015), but only few studies included their symbolic significance as a CES (e.g. Cáceres et al. 2015; Gee and Burkhard 2010; Hooper et al. 2017; Sutherland et al. 2016; Wangai et al. 2017). In the light of increasing exploitation rates, massive land-use/cover transformations, and accelerating climate change, which are mainly responsible for the decline of species (Cumming et al. 2014), evaluating CESs, and the knowledge about their spatial distribution in particular, can support their integration in landscape management and foster conservation efforts (Poe et al. 2014; Raymond et al. 2013). Preserving symbolic species helps to maintain associated cultural values; however, about a third of the animal species used as national symbols worldwide are classified as "at risk" (Hammerschlag and Gallagher 2017) and the conservation status of most plant species used as national symbols is even unknown (Feeley 2017).

Thus, this study aims at mapping the spatial distribution of the CES 'symbolic species' and evaluating spatial patterns using landscape indicators. Here, we focus on wild plant and animal species that are symbolic to large parts of the Alpine population, not including domesticated animals such as cows, dogs and sheep, which may also be of great cultural significance but have already been addressed recently by Marsoner et al. (2017). Firstly, symbolic species and their symbolic use are identified. Secondly, symbolic species are mapped at the landscape scale and aggregated to the municipality level. Thirdly, spatial relationships between symbolic species and environmental as well as social variables are analysed to reveal spatial structures and patterns. Based on the findings, the paper discusses this CES with regard to landscape planning and conservation and indicates open issues in research on symbolic species.

The methodological approach is applied to the Alpine Space area, focusing on the European Alps, which are rich in flora and fauna. Further, this area comprises different European cultures for which symbolic species contribute to a common Alpine cultural identity and heritage, i.e. the different Alpine populations associate similar values with this specific mountain area as environment and life conditions are rather comparable within the different regions of the European Alps, but which differ greatly from the surrounding lowlands. Here, we define symbolic species according to the CICES as 'plants and animals that are considered as emblematic or charismatic for the European Alps; these symbolic species form part of the cultural identity and heritage of the Alpine area and represent its nature to people inside and outside the Alps'. We always use the term symbolic, synonymously to charismatic, emblematic, and iconic.

Materials and methods

Study area

The Alpine Space Programme cooperation area comprises the European Alps with the surrounding foothills and lowlands. Covering a surface of about 390,000 km^2, it includes Austria, Liechtenstein, Slovenia, and Switzerland, as well as several regions of France, Germany, and Italy (Fig. 1). The Alpine Space area contains 17,042 municipalities with a mean size of 22.77 km^2. About 70 million people live mostly in large cities in the adjacent lowlands (Dematteis 2009), whereas the mountainous zone is one of the most important global tourist destinations, with about 500 million visitors a year (Bartaletti 2007). The European Alps, comprising a great variety of ecosystems and landscapes, are home to many plants and animals of symbolic meaning, such as edelweiss, gentian, Alpine ibex, marmot, and golden eagle, which are depicted on flags, coins, and tourism brochures and used as names or logos for associations, hotels, restaurants, and brands (Fig. 2).

Identifying symbolic species and their use

To identify symbolic plants and animals for the European Alps, we first collected opinions from ten expert groups of different Alpine regions (two in Austria, one in Germany, one in France, four in Italy, one in Liechtenstein, and one in Slovenia), which represented in large part the variety of the different cultures of the study area. All participants were

Fig. 1 Study area with national and regional borders. The delimitation of the European Alps corresponds to the Alpine Convention area (Ruffini et al. 2004)

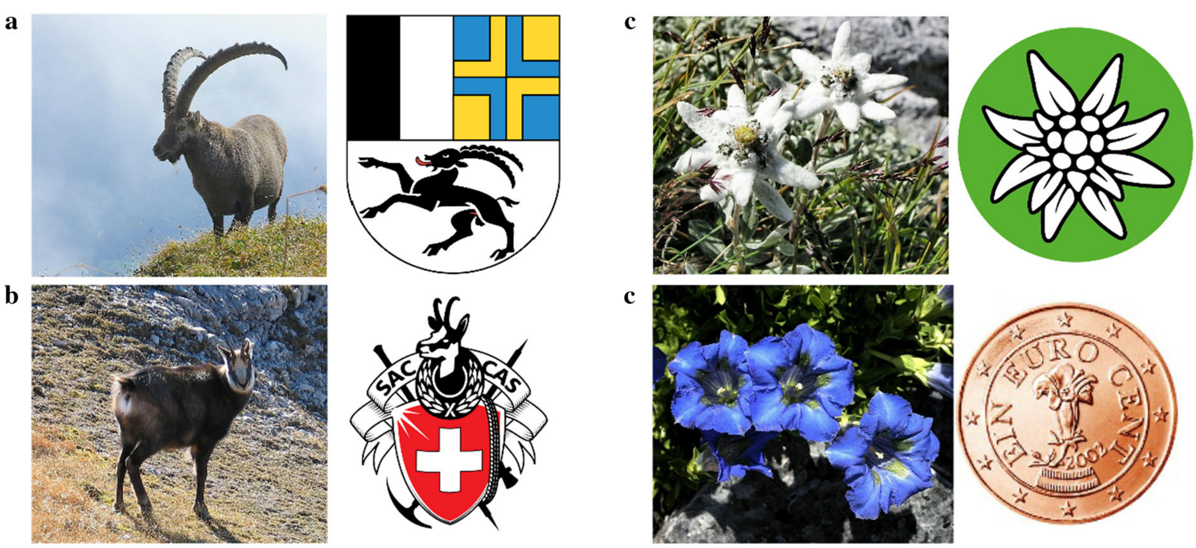


Fig. 2 Plants and animals in the European Alps and examples of symbolic use: **a** Alpine ibex on the coat of arms of the Swiss canton Grisons, **b** chamois on the logo of the Swiss Alpine Club, **c** edelweiss on the logo of the Alpine Association of Austria, and **d** gentian on the Austrian one cent coin

knowledgeable about the ecosystem services concept, as they have collectively collaborated on a common understanding in the Alpine space area and are working on or implementing the ecosystem services concept within their territories. Thus, the expert groups differentiated from lay people through a high level of expertise in ecological and environmental sciences. The ten groups were broadly gender-balanced (55% men and 45% women) and covered different age groups between 25 and 60 years. Table S1 of the supplementary material reports all participating experts. The experts were asked to list all plants and animals that they considered as symbolic for the study area without further limitations (e.g., wild or domesticated species). After ranking the resulting species by their number of entries (Appendix Table A1), we selected those species that were indicated by at least three expert groups to define symbolic species that are representative for large parts of the Alps and not only for some regions. We also crosschecked whether the groups came at least from two different countries to assure the significance of the identified species for different cultures.

To verify whether the selected species were currently used in the Alpine region as symbols, we carried out a screening of websites, using the common names of the selected species in different Alpine languages (French, German, Italian, and Slovenian) as well as regional dialects. We defined a symbolic use when at least 30 symbolic representations (pictures, names) of the selected species existed in different locations of the study area. We included depictions on flags, coins, souvenirs, logos and names of brands, organisations, associations, hotels, and restaurants, as these representations carry socio-cultural values and document the cultural identity of a specific place (Hammerschlag and Gallagher 2017; Malamud et al. 2007; Nyffenegger 2013; Roth 2010). We thereby concentrated on current visual and verbal representations of the selected symbolic species, disregarding appearance in literature, music or folklore, as many of such representations originated during the last century or earlier and the significance to the present generation is unclear. Finally, we collected examples of symbolic use for each species.

Mapping symbolic species

We mapped the spatial distribution of symbolic species similarly to studies using or proposing indicators for other CESs (Burkhard et al. 2014; Szücs et al. 2015; Graves et al. 2017). The distribution of plant and animal species in the study area was derived from actual distribution maps of the individual species or by modelling their potential habitat if the former were not available (Table 1). The presence (1) or absence (0) of each species was mapped in a raster map with a spatial resolution of 100 m. Given the great scale of the study area and in order to carry out further analyses using data (population, tourists) that referred to administrative boundaries, two quantitative maps for the Alpine Space area were created at the municipality level. The first map, indicating the total number of different symbolic species within each municipality, was derived by testing whether each individual species occurred within the municipality and counting all occurring species. The second map, depicting an area-weighted index, was obtained by summing the area-weighted mean values of the different species within each municipality and rescaling them to 0-1.

Analysing spatial distribution of symbolic species

As the distribution of the selected symbolic species was mainly concentrated in the European Alps, the following analyses were carried out only for the mountainous core area of the Alpine Space area, using the delimitation by the Alpine Convention, which is an International treaty aiming at the protection and sustainable development of the Alps (Ruffini et al. 2004) (Fig. 1). For all analyses, we used the area-weighted index at the municipality level. To measure whether the spatial pattern of the symbolic species as well as the individual species is a clustered, dispersed, or random spatial pattern, we calculated spatial autocorrelation using Moran's I measure (Moran 1950), which accounts for both locations of municipalities and CES values. To identify statistically significant hot and cold spots of municipalities with either high or low values, we used the Getis–Ord Gi* statistic (Getis and Ord 1992). All analyses were carried out in ArcGIS 10.4 using the Spatial Statistics extension.

To evaluate the strength and direction of the relationship between a set of environmental (land

Table 1 Used methods and related data sources for mapping selected symbolic Alpine species

Species	Mapping method	Data sources
Fauna		
Alpine ibex (*Capra ibex*)	Distribution map	Aulagnier et al. (2008a)
Brown bear (*Ursus arctos*)	Permanent and sporadic distribution	DINALP BEAR Population Status Report 2016[a]
Chamois (*Rupicapra rupicapra*)	Distribution map	Aulagnier et al. (2008b)
Golden eagle (*Aquila chrysaetos*)	Occurrences since 2000 with buffer of 9 km, corresponding to the core home range (Soutullo et al. 2006)	GBIF.org[b]
Marmot (*Marmota marmota*)	Habitat model based on Galluzzi et al. (2017):	EEA (2016a, 2016b)
	Elevation between 2000 and 2500 m a.s.l.	
	Slope between 0° and 20°	
	South-facing aspect (112.5–247.5°)	
	Subalpine–alpine open grasslands	
	Herbaceous vegetation and shrubs and heath (CORINE 231-Pastures, 321-Natural grasslands, 322-Moors and heathland, 323-Sclerophyllous vegetation, 333-Sparsely vegetated areas)	
Flora		
Edelweiss (*Leontopodium alpinum*)	Habitat model based on Ischer et al. (2014) and results compared to distribution maps of Meusel and Jäger (1992):	EEA (2016a, 2016b), Hijmans et al. (2005)
	Steep slopes > 30°	
	Mean summer temperature (June–August) < 10°	
	South-facing aspect (112.5–247.5°)	
	Subalpine–alpine open grasslands with a low grass cover (CORINE 321-Natural grasslands, 333-Sparsely vegetated areas)	
Gentian (*Gentiana acaulis, Gentiana clusii*)	Habitat model based on Bilz (2013) and Oberdorfer et al. (2001) and results compared to distribution maps of Meusel et al. (1978):	EEA (2016a, 2016b)
	Elevation between 800 and 3000 m a.s.l.	
	Subalpine–alpine grasslands with a low grass cover (CORINE 231-Pastures, 321-Natural grasslands, 333-Sparsely vegetated areas)	
Alpenrose (*Rhododendron hirsutum*, *Rhododendron ferrugineum*)	Habitat model based on Francon et al. (2017) and results compared to distribution maps of Meusel et al. (1978):	EEA (2016a, 2016b)
	Elevation between 1600 and 2200 m a.s.l.	
	North, west, and northwest-facing slopes (0–67.5°, 292.5–365°)	
	(CORINE 323-Sclerophyllous vegetation, 324-Transitional woodland-shrub, 333-Sparsely vegetated areas)	

Table 1 continued

Species	Mapping method	Data sources
European larch (*Larix decidua*)	Distribution map	Da Ronch et al. (2016)
Pine (*pinus cembra, Pinus halepensis and P. brutia, Pinus mugo, Pinus nigra, Pinus pinaster, Pinus pinea, Pinus sylvestris*)	Distribution maps	Caudullo and de Rigo (2016)

[a] http://dinalpbear.eu/wp-content/uploads/Annex-C5-2-PopulationStatusReport2016.v1.pdf

[b] http://www.GBIF.org, GBIF Occurrence Download http://doi.org/10.15468/dl.j82qce (downloaded on 29 May 2017)

Table 2 Methods and related data sources for mapping environmental and social variables that were correlated to the distribution of symbolic species

Variables	Mapping method	Data sources
Environmental variables		
Land cover	Area covered by each land cover type (CORINE 2nd level)	CORINE land cover (EEA 2016a)
Topography	Elevation and slope derived from the digital elevation model (DEM)	DEM (EEA 2016b)
Land cover diversity	Number of different land cover types per km^2	CORINE land cover (EEA 2016a)
Naturalness	Hemeroby classes associated to land cover classes (Paracchini and Capitani 2011) and inverted	CORINE land cover (EEA 2016a)
Social variables		
Protected areas	Area covered by protected areas	Natura 2000 network (EEA 2015a), Common Database on Designated Areas (CDDA) (EEA 2015b)
Population	Number of inhabitants	National census data[a]
Tourists	Number of overnight stays	Occupancy rates of tourist accommodation establishments[a]

[a] http://www.statistik.at, http://www.bfs.admin.ch, http://www.destatis.de, http://www.istat.it, http://www.insee.fr, http://www.stat.si, http://www.llv.li

cover, topography, land cover diversity, naturalness) and social (protected areas, population, tourists) variables and the distribution of symbolic species as well as the individual species in the main distribution area, the European Alps, we calculated the Spearman correlation coefficient in SPSS Statistics (IBM SPSS 24). Table 2 provides an overview of the variables, mapping methods and related data sources. All variables were aggregated to the municipality level by calculating area-weighted mean values.

Results

Symbolic species

Five symbolic plants and five symbolic animals were identified for the European Alps (Table 3) selected from a total of 29 identified plant and 23 identified animal species (Appendix Table A1). The selected species were used in many symbolic ways, ranging from depiction on flags, coins, emblems, and logos to naming of hotels, restaurants, brands, and political parties.

Table 3 Examples of symbolic use of selected species in the European Alps

Species	Examples for symbolic use
Fauna	
Alpine ibex	Coat of arms of the Swiss canton Grisons[a]
	Emblem of the Gran Paradiso National Park (Italy)[b]
	Name of numerous hotels and restaurants in the Alpine region
	Alpine souvenirs
	Name of companies[c]
Brown bear	Coat of arms of the Swiss cantons Bern[d] and Appenzell[e]
	Coat of arms of numerous cities and villages, e.g. Petzenkirchen[f] and Berndorf[g] (Austria), Freising (Germany)[h]
	Emblem of the Adamello Brenta Nature Park (Italy)[i]
	Name of numerous hotels and restaurants in the Alpine region
Chamois	Logo of the Swiss Alpine Club[j]
	Logo of Pro Natura (Swiss League for the Protection of Nature)[k]
	Coat of arms of villages, e.g. Bergün (CH)[l]
	Logo for the French ski manufacturer Duret[m]
	Emblem of the Triglav National Park (Slovenia)[n]
	Name of numerous hotels and restaurants in the Alpine region
	Alpine souvenirs
Golden eagle	Coat of arms of the Swiss canton Geneva[o]
	Coat of arms of Tyrol in Austria[p]
	Emblem of the Stelvio National Park (Italy)[q]
	Emblem of the Kalkalpen National Park (Austria)[r]
	Name of numerous hotels and restaurants in the Alpine region
Marmot	Name of numerous hotels and restaurants in the Alpine region
Flora	
Alpenrose	Name of numerous hotels and restaurants in the Alpine region
Edelweiss	Austrian two cent coin and Swiss coins[s]
	Symbol of the Swiss national tourism organisation[t]
	Logo of the Alpine Associations of Austria[u], Germany[v], South Tyrol[w]
	Logo of the Mountain Rescue Service of Austria[x]
	Name of a brewery and beer in Austria[y]
	Name and logo of Swiss charter airline (Edelweiss Air)[z]
	Name and logo of a regional political party in Italy (Aosta Valley)[aa]
	Name and label of French rope manufacturer[ab]
	Name of numerous hotels and restaurants in the Alpine region
	Alpine souvenirs
Gentian	Austrian one cent coin
	Name of numerous hotels and restaurants in the Alpine region
	Alpine souvenirs
	Symbol for gentian liquor[ac,*]

Table 3 continued

Species	Examples for symbolic use
Larch	Name of numerous hotels and restaurants in the Alpine region
Pine	Name of numerous hotels and restaurants in the Alpine region
	Coat of arms of Augsburg (Germany)[ad] and its soccer club FC Augsburg[ae]
	Use for Internet address of several pine products, e.g. wooden decorations[af], liquor[ag]

[a]http://www.gr.ch/

[b]http://www.pngp.it/

[c]http://www.caib.ch/, http://www.steinbock.at/

[d]http://www.be.ch/

[e]http://www.ar.ch/ and http://www.ai.ch/

[f]http://www.petzenkirchen.at/

[g]http://www.berndorf.gv.at/

[h]http://www.freising.de/stadtportrait/stadtwappen/

[i]http://www.pnab.it/

[j]http://www.sac-cas.ch/

[k]http://www.pronatura.ch/

[l]http://www.berguen.ch/

[m]http://www.duretskis.com/

[n]http://www.tnp.si/

[o]http://www.ge.ch/

[p]http://www.tirol.gv.at/

[q]http://www.stelviopark.it/

[r]http://www.kalkalpen.at/

[s]http://www.fleur-de-coin.com/eurocoins/austria-euro-coins, http://www.admin.ch/gov/en/start/documentation/media-releases.msg-id-65322.html

[t]http://www.myswitzerland.com/

[u]http://www.alpenverein.at/

[v]http://www.alpenverein.de/

[w]http://www.alpenverein.it/

[x]http://www.bergrettung.at/

[y]http://www.edelweissbier.at/

[z]http://www.flyedelweiss.com/

[aa]http://www.stella-alpina.org/

[ab]http://www.edelweiss-ropes.com/

[ac]https://www.bmlfuw.gv.at/land/lebensmittel/trad-lebensmittel/getraenke/enzian.html, *only used for labelling, the liquor is produced from the great yellow gentian (*Gentiana lutea*)

[ad] http://www.augsburg.de/buergerservice-rathaus/rathaus/stadtwappen/

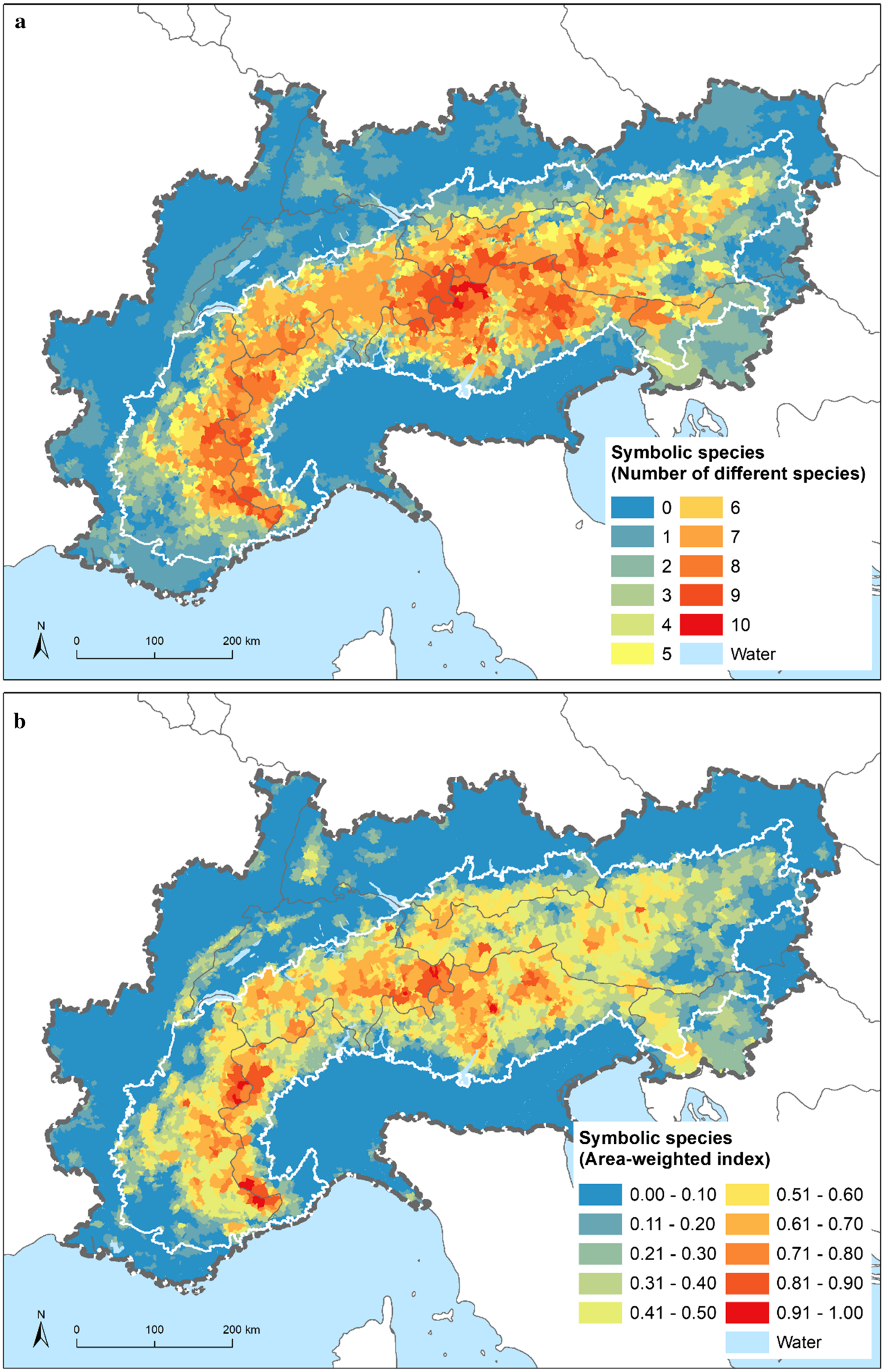
[ae]http://www.fcaugsburg.de/

[af]http://www.zirbenherzen.at/

[ag]http://www.zirben.at/

Spatial distribution of symbolic species

The following results relate only to the mountainous core area as delimitated by the Alpine Convention, as the distribution of symbolic species was mainly concentrated in the European Alps (Fig. 3). A high positive Moran's *I* indicated a high spatial clustering of symbolic species (Table 4). Hotspots were located


a
Symbolic species
(Number of different species)
0
1
2
3
4
5
6
7
8
9
10
Water
N
0
100
200 km
b
Symbolic species
(Area-weighted index)
0.00 - 0.10
0.11 - 0.20
0.21 - 0.30
0.31 - 0.40
0.41 - 0.50
0.51 - 0.60
0.61 - 0.70
0.71 - 0.80
0.81 - 0.90
0.91 - 1.00
Water
N
0
100
200 km

◀**Fig. 3** Distribution of symbolic species in the Alpine Space area at the municipality level: **a** total number of different species within each municipality, **b** area-weighted index (area-weighted mean values of each individual species were summed up and are rescaled to 0–1). The white line indicates the delimitation of the European Alps by the Alpine Convention

along the border between France and Italy, in Grisons in eastern Switzerland, and in the Italian provinces of Trentino, South Tyrol, and Belluno (Fig. 3). The maps illustrating the distribution of the individual species reveal an uneven distribution of several species across the Alps (Fig. 4); for example, the brown bear was present only in the Southeastern Alps, whereas the Alpine ibex was more frequent in the Western, Northern, and Central Alps. The distribution of some species (e.g., brown bear, chamois, and larch) was spatially clustered; other species were rather evenly distributed (e.g., edelweiss and Alpine ibex) over the Alps (Table 4).

The correlation analysis revealed strong positive relationships of symbolic value with elevation, slope, open areas, and naturalness, whereas scrub/herbaceous vegetation, glaciers, protected areas, and tourists showed weak but positive correlations (Table 5). Except for urban green, forest, and water, which were not significantly correlated to symbolic species, all other variables had negative effects on the symbolic value, in particular arable land, heterogeneous agricultural areas, and residents. Although the direction of the relationships for individual species was generally in line with that for the total symbolic value, the strength roughly coincided for alpenrose, gentian, edelweiss, chamois, and marmot, but differed considerably for larch, pine, brown bear, and eagle.

Discussion

In addition to their ecological and economic value, plant and animal species have frequently been used as symbolic representations of national as well as regional identity or as flagship species (Gascon et al. 2015; Shoemaker 1994). In this study, we contributed to the mapping and understanding of symbolic species as a CES, focusing on selected symbolic species in the European Alps. Our analysis revealed a wide range of symbolic uses of the identified plants and animals, ranging from depiction on flags, coins, emblems, and logos to the use of their names for associations or brands. Our collection of examples of use highlights the cultural importance of symbolic species for the Alpine countries, even though there seem not be a direct relationship between the product and the label. For example, the naming of enterprises such as the Swiss charter airline "Edelweiss" or the Austrian traditional fashion label "Steinbock" may rather represent a certain location or refer to the values associated with the symbolic species. The spatial distribution of symbolic species provides an important information basis to integrate symbolic species into landscape management, as it puts the cultural values associated with natural landscape elements into a transdisciplinary framework, facilitating ecological and social science communication. Our spatial analysis related landscape and social characteristics of municipalities to specific symbolic species, but further research is needed to adequately account for CESs in decision-making at the overlap of social values and ecological functioning.

Methodological considerations

The selected symbolic species are intended to be representative for the entire Alpine region and their population, but other species might be of greater

Table 4 Moran's I and related co-variables for testing spatial autocorrelation

	Moran's Index	z-score	p value
Symbolic value	0.767	19.324	< 0.0001
Alpenrose	0.214	5.402	< 0.0001
Edelweiss	0.259	6.550	< 0.0001
Gentian	0.451	11.366	< 0.0001
Larch	0.622	15.680	< 0.0001
Pine	0.577	14.560	< 0.0001
Alpine ibex	0.284	7.167	< 0.0001
Brown bear	0.718	18.112	< 0.0001
Chamois	0.764	19.262	< 0.0001
Golden eagle	0.844	21.265	< 0.0001
Marmot	0.284	7.176	< 0.0001

Positive Moran's I values close to + 1 indicate high spatial clustering of high values and/or low values, values close to 0 indicate a random distribution

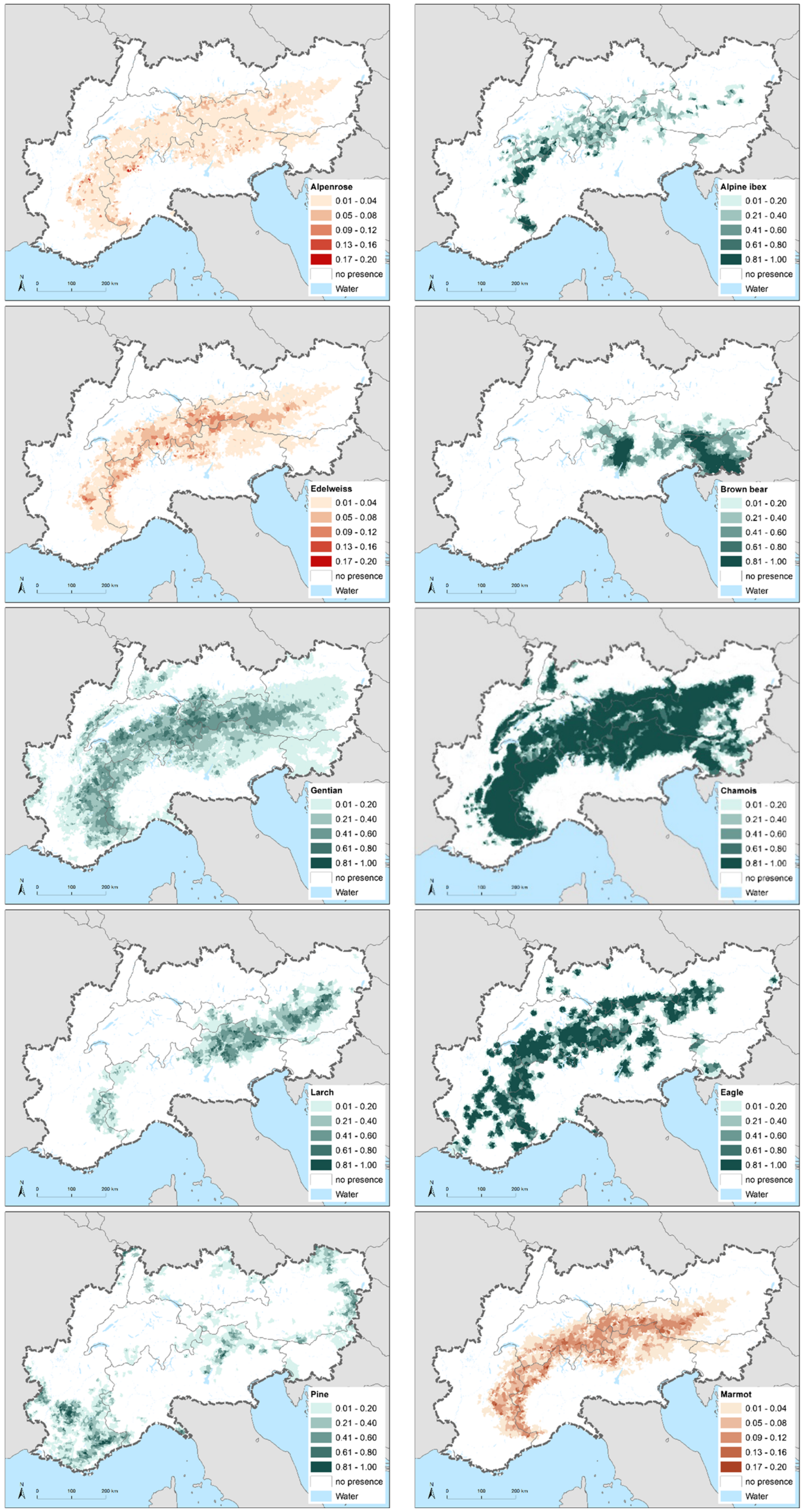


Fig. 4 Probable spatial distribution of selected symbolic plant and animal species in the Alpine Space area at the municipality level on a scale from 0 to 1. The maps of alpenrose, edelweiss, and marmot are displayed using a smaller value range to indicate spatial pattern

Table 5 Spearman correlation coefficients (Spearman's ρ) between area-weighted index, including all identified symbolic species as well as single symbolic species and environmental and social variables (pairwise, N = 5697)

Variables	Area-weighted index	Alpenrose	Edelweiss	Gentian	Larch	Pine	Alpine ibex	Brown bear	Chamois	Eagle	Marmot
Elevation	0.728**	0.699**	0.732**	0.866**	0.414**	0.077**	0.440**	0.121**	0.635**	0.236**	0.756**
Slope	0.605**	0.617**	0.639**	0.618**	0.308**	0.022	0.364**	0.164**	0.526**	0.225**	0.639**
Urban	− 0.279**	− 0.249**	− 0.252**	− 0.369**	− 0.115**	− 0.258**	− 0.118**	− 0.057**	− 0.232**	− 0.025	− 0.270**
Urban green	0.025	0.051**	0.060**	0.037**	0.068**	− 0.073**	0.029*	− 0.022	0.039**	0.032*	0.050**
Arable	− 0.351**	− 0.261**	− 0.249**	− 0.380**	− 0.174**	0.012	− 0.152**	− 0.065**	− 0.333**	− 0.091**	− 0.252**
Permanent cultures	− 0.102**	− 0.145**	− 0.141**	− 0.231**	− 0.012	0.136**	− 0.075**	0.119**	− 0.181**	0.003	− 0.134**
Pasture	0.039**	− 0.014	− 0.006	0.225**	0.026	− 0.170**	0.046**	− 0.076**	0.091**	− 0.029*	− 0.033*
Heterogeneous agricultural areas	− 0.439**	− 0.329**	− 0.365**	− 0.461**	− 0.103**	0.096**	− 0.266**	0.019	− 0.402**	− 0.251**	− 0.329**
Forest	0.001	− 0.095**	− 0.218**	− 0.106**	0.143**	0.089**	− 0.206**	0.152**	0.049**	− 0.121**	− 0.231**
Scrub/herbaceous vegetation	0.356**	0.416**	0.359**	0.338**	0.186**	0.255**	0.121**	0.091**	0.292**	0.149**	0.370**
Open areas	0.609**	0.718**	0.723**	0.651**	0.260**	0.155**	0.429**	0.094**	0.510**	0.264**	0.725**
Glacier	0.303**	0.312**	0.436**	0.293**	0.063**	− 0.023	0.470**	0.065**	0.186**	0.202**	0.428**
Wetland	− 0.037**	− 0.043**	− 0.042**	− 0.051**	− 0.032*	− 0.091**	− 0.031*	− 0.037**	0.017	− 0.011	− 0.070**
Water	− 0.021	− 0.015	− 0.027*	− 0.101**	− 0.071**	− 0.085**	0.029*	0.031*	− 0.011	0.069**	− 0.055**
Naturalness	0.563**	0.553**	0.557**	0.652**	0.284**	0.159**	0.316**	0.121**	0.502**	0.136**	0.565**
Land use diversity	− 0.159**	− 0.111**	− 0.165**	− 0.192**	− 0.172**	0.166**	− 0.144**	− 0.085**	− 0.121**	− 0.051**	− 0.175**
Protected areas	0.161**	0.175**	0.151**	0.153**	0.083**	0.155**	0.086**	0.028*	0.120**	0.076**	0.127**
Residents	− 0.411**	− 0.403**	− 0.406**	− 0.507**	− 0.185**	− 0.307**	− 0.224**	− 0.043**	− 0.349**	− 0.082**	− 0.409**
Tourists	0.225**	0.222**	0.214**	0.172**	0.202**	− 0.070**	0.109**	0.161**	0.207**	0.095**	0.207**

* Correlation is significant at the 0.05 level (two-tailed)

** Correlation is significant at the 0.01 level (two-tailed) importance at the local scale or symbolic to specific social groups such as farmers or tourists. Some species are not only 'Alpine' species; for example, bear and eagle are used all over the world as symbols due to their characteristic attributes such as power and strength. Furthermore, we concentrated on wild species, as no expert group indicated domesticated animals as symbolic, but domesticated animals such as cows, sheep, goats, or the Saint Bernard dog are also characteristic of the European Alps (Marsoner et al. 2017) and often used on tourism brochures and souvenirs (Nyffenegger 2013). Hence, our results may be constrained by the selection of the symbolic species. To obtain a more representative selection of symbolic species, expert groups should be include a variety of experts in different environmental and social sciences. Broad surveys involving residents and tourists can further uncover the cultural and social importance of species.

The spatial distribution of symbolic species was mapped using large-scale distribution maps or simple spatial models to locate potential habitats. Specific local environmental conditions and variations across the Alpine Space area could therefore not be considered, and the study does not claim to precisely predict species occurrences or to quantify their densities. Nevertheless, the resulting maps indicate the probable existence of symbolic species at the municipality level for the entire Alpine Space area, which were not available in this form in the past. They are useful to evaluate the spatial pattern of this CES at a large scale and to provide some insights into the relationships between symbolic species and environmental as well as social variables through correlation analysis. Indeed, our spatial analysis revealed that hotspots of symbolic species can be explained by topography and (semi-)natural land cover, whereas high levels of human presence and intensively used agricultural areas reduced the presence of symbolic species. The less strong relationships among larch, pine, brown bear, and eagle with environmental and social variables may originate from their concentration on few regions within the study site. Moreover, the great spatial scale and the low number of available social variables may limit our results of the correlation analysis. Further research on smaller spatial scales and applying more sophisticated analyses methods could provide deeper insights into causal relationships between symbolic species and ecological and social conditions.

This study focused on a single CES to advance the understanding of this specific cultural service. To operationalise ecosystem services for landscape management and enhance environmental policy and strategies, the relationships with other ecosystem services should be analysed, including social and cultural benefits that are inseparably connected to provisioning, regulating, and cultural services (Klain et al. 2014). People often perceive these indirect benefits equally valuable to direct benefits (Asah et al. 2014) and their integration are of particular importance for conservation projects, increasing trust and collaboration on the one hand, and reducing conflicts and resilience on the other hand (Poe et al. 2014). In general, the incommensurability of cultural values needs to be overcome to support decision-makers with valuable information (Plieninger et al. 2015).

Maintenance of symbolic species and associated values

The value of symbolic species may depend on the existence of the selected species, although the species' rareness and inaccessibility of its habitat might increase its mythos, i.e., the meaning for a particular cultural area, as in the case of edelweiss (Dweck 2004). The symbolic value can persist in case of extinction (e.g., dodo as national symbol of Mauritius) or emerge with changing cultural preferences and values (e.g., edelweiss outran other charismatic plants of the European Alps with the development of tourism (Grabherr 2009; Roth 2010)). Our results revealed only a weak positive correlation between tourists and symbolic species, which may indicate the importance of the presence of symbolic species to attract tourists (Newsome and Hughes 2016), but visual representations of symbolic species are often used to sell the idea of a certain place even though the species may not be present in the promoted area. Accordingly, many examples of symbolic use are linked to tourism, e.g., names of hotels and restaurants as well as Alpine souvenirs. Although certain types of outdoor recreation such as wildlife watching rely on the presence of the species, for example in sub-Saharan Africa (Williams et al. 2000), organised wildlife watching tours are rather unimportant in our study area. Hence, there is little evidence that symbolic values depend on the presence of the species in our case. Nevertheless, we argue that it is important to safeguard symbolic species and related cultural values to manage successfully social-ecological systems on the long-term (Noble et al. 2016). Symbolic species are emotionally significant to many Alpine residents, but they may be vulnerable to global change and their extinction may affect their symbolic meaning. In the following, we therefore discuss major threats and opportunities to preserve the selected symbolic species in the Alps.

The identified symbolic species are classified as least concern in the IUCN Red List of Threatened Species (IUCN 2017), but categories differ between countries; for example, the brown bear is considered critically endangered in Italy (Rondinini et al. 2013), vulnerable in Austria (Spitzenberger 2005), and extinct in Germany (Ludwig et al. 2009). Moreover, the presence of symbolic species in the European Alps was not always secure. For instance, the Alpine ibex was almost exterminated due to over-hunting, and present populations have been reintroduced during the past century (Apollonio et al. 2014). The reintroduction of large carnivores such as the brown bear is particularly challenging because of habitat needs and conflicts with humans (Peters et al. 2015), and hunters and farmers may undermine conservation projects (Kaczensky et al. 2011). In these cases, the symbolic significance of these species may provide a valuable argument for supporting their protection in specific locations.

The biggest threat to symbolic species in the European Alps are human disturbance and land-use change (Chemini and Rizzoli 2014). Our spatial analysis indicates that exploited landscapes negatively affect the presence of symbolic species, reflecting the similar relationships between land use and general plant species richness (Zimmermann et al. 2010). In contrast to overall species richness, which decreases with elevation (Körner 2003), most symbolic species concentrate on high mountain areas, which are less influenced by human presence. Hence, conservation efforts focusing only on symbolic species will not successfully protect other ecological important species.

To protect symbolic species from the disturbance of human recreational activities such as climbing, paragliding, snowmobiling, and helicopter activities, important tourist destinations that are located in areas with a high index of symbolic species should adopt an improved visitor management (Marion 2016). Recreational activities affect, for example, the nesting of golden eagles (Chamberlain et al. 2016; Pedrini and Sergio 2002) or force chamois to flee to forests and causing energy loss (Schnidrig-Petrig and Ingold 2001). Further, increasing tourism and expansion of infrastructure to reach more remote places may increase collection of edelweiss and gentian (Dweck 2004).

Land-use changes in the European Alps are twofold: intensification of agricultural use and urbanisation in favourable areas such as valley bottoms and abandonment of alpine and subalpine grassland with subsequent forest regrowth (Egarter Vigl et al. 2016; Price et al. 2015). Both developments cause habitat loss, as many symbolic animal species require natural open areas for foraging (Armitage 2013; Pedrini and Sergio 2002). As our results suggest, this is especially true for Alpine ibex, chamois and marmot. Forest regrowth decreases suitable habitat for Alpine flowers that grow mostly on subalpine and alpine open grasslands (Francon et al. 2017; Ischer et al. 2014). Moreover, altered management practices of grassland such as increased grazing and the use of manure and fertiliser lead to a decline of plant species (Bassin et al. 2012). Urbanisation is a further limiting factor for animal species that need large habitats, such as brown bear (Ordiz et al. 2011). Indeed, our maps indicate that current distribution of brown bear in the Alps is concentrated on areas with low population density.

In the future, land-use change and climate change will have mixed impacts on the focal species of this study (Bürgi et al. 2017; Tasser et al. 2017). Rising temperatures may force animals to move upwards to smaller habitats (Mason et al. 2014), which applies in particular for species for which we found a strong relationship with elevation such as chamois and marmot. Some species such as marmots are further sensitive to droughts and earlier snowmelt (Armitage 2013). Rising temperature may result in an upward shift of vegetation zones (Niedrist et al. 2016) and threatens cold-mountain habitats, which will become climatically unsuitable (Dullinger et al. 2012). Edelweiss, rhododendron, and gentian could therefore be at risk at lower elevations (Grabherr 2009), limiting their presence to few isolated regions of the Alps. Some plant species (e.g., rhododendron, larch and pine) might benefit from rising temperatures because of more favourable climate conditions, especially at or above the treeline (Francon et al. 2017; Vittoz et al. 2008).

Hence, decision makers should incorporate the assessment of CESs to integrate landscape management plans. Attention should be paid to managing the landscape and the ecosystems in a way that preserves suitable habitats for symbolic species in order to safeguard related cultural values such as cultural identity and heritage. Maintaining natural environments and applying sustainable management practices also support other CESs, such as aesthetic (Schirpke et al. 2016), recreational (Gios et al. 2006), and spiritual values (Zoderer et al. 2016). In order to maintain the richness of the habitat and ecosystem structure of the Alpine Space area, a well-coordinated conservation strategy is needed. Our distribution maps can provide a basis to develop suitable transnational strategies, as they indicate hotspots of symbolic species. Here, we assessed the current distribution of symbolic species, but research gaps on potential future dispersion rates need to be conducted to inform the conservation of these prominent species and, at the same time, to foster the sustainable development of the area.

Future research directions

Increasingly, studies differentiate between supply, demand, and actual use (flow) of ecosystem services (Burkhard et al. 2014; Villamagna et al. 2013). This study focused on the spatial assessment of the supply side of symbolic species and exemplified their use, but further research should address social demand as well as spatial patterns of use to evaluate this CES in a more comprehensive way. We selected symbolic species based on expert opinions, but surveys could be used to assess the demand of the Alpine cultures for specific species, providing insights on their importance for the Alpine population with regard to cultural identity and heritage or tourism. Surveys could also reveal differences in social perceptions and preferences between tourists and residents, as well as the meaning of symbolic species for the selection of holiday destinations. The actual use of symbolic species was demonstrated qualitatively here based on examples of use across the study area. Together with the distribution maps of this study, a spatial assessment of the actual use could foster the understanding of the spatial relationships between their (former) presence and use. The limitations of the present mapping exercise are within the intersection of societal values and ecosystems. While we link symbolic associations to ecosystems in a clear broad framework, more research is needed on how the cultural and the ecosystem plane interact in detail (Castells 2011; Kellert and Wilson 1995). The exact linkage between ecosystem functioning and symbolism remains blurry and would greatly benefit from further research, including the development of the symbolic associations with ecosystems to the correlation between the need of protection and symbolic value.

Symbolic values may also be related to landscapes or landscape features; for example, Mount Triglav, Slovenia's highest peak, is depicted on the flag of Slovenia. Unique landscapes such as the Dolomites, the Swiss Alps Jungfrau-Aletsch, and the Swiss Tectonic Arena Sardona are recognised as natural heritage sites by the UNESCO convention (UNESCO 2017), promoting sustainable regional development in addition to safeguarding these landscapes (Conradin and Hammer 2016). The symbolic role of cultural landscapes (e.g., alpine pastures, larch meadows) needs to be further evaluated to support the maintenance of these landscapes and associated ecosystem services (Fontana et al. 2013; Schirpke et al. 2017). Traditionally used landscapes were found to be hotspots of aesthetic, recreational, and spiritual values (Zoderer et al. 2016), and the presence of symbolic species increases recreational opportunities (e.g., observing wildlife, nature photography, game) (Ament et al. 2016).

Conclusions

This study provides a methodology to map and assess symbolic species as a CES, providing specifically insights into the spatial distribution of symbolic species in the Alpine Space area. Symbolic species contribute to the provision of cultural identity and heritage in the European Alps, and they are widely used for symbolic representations and names. Based on our spatial maps, transnational strategies can account for symbolic values and include them in managing the landscape and associated ecosystem services. Environmental characteristics and human activities shape the spatial distribution of symbolic species in the European Alps. However, our results revealed little evidence that the presence of symbolic species increases their cultural value, as we found only a weak positive correlation between tourists and symbolic species in our study area. Nevertheless, many examples of symbolic use were linked to tourism, which uses the visual representations of symbolic species to sell the idea of a certain place. Although it remains unclear whether the disappearance of symbolic species affects their symbolic meaning, species are vulnerable to global change and land-use policies and conservation projects should account for symbolic species and related cultural values. For example, the increasing demand for outdoor recreation might have negative effects on species distribution, if not adequately managed; at the same time, the tourism industry relies on these species for promoting Alpine tourist destinations. Our distribution maps and the examples of use of symbolic species can serve as a basis for considering these species in landscape planning and management, but future research is needed in order to deepen the understanding of the relationships between various types of ecosystem services and social benefits as well as cultural values and preferences.

Acknowledgements Open access funding provided by University of Innsbruck and Medical University of Innsbruck. This study was co-financed by the European Regional Development Fund through the Interreg Alpine Space programme (‘AlpES’ project, CUP: D52I16000220007) and by the Austrian Federal Ministry of Science, Research and Economy with the HRSM—cooperation project KLIMAGRO. UT is a member of the research focus ‘Alpine Space—Man and Environment’ at the University of Innsbruck. We thank all experts from the AlpES project team (http://www.alpine-space.eu/projects/alpes/en/about/about/partners). We also thank the editor and the two anonymous reviewers for their valuable comments.

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