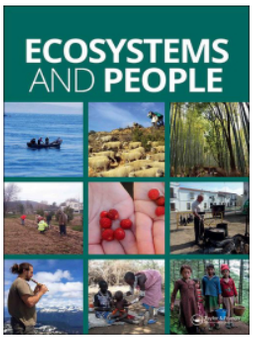

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Plural valuation in space: mapping values of grasslands and their ecosystem services

Thomas M. Schmitt [a] Rebekka Riebl [a] Berta Martín-López [b] Maria Hänsel [a] and Thomas Koellner [a]

[a]Professorship of Ecological Services, Bayreuth Center of Ecology and Environmental Research (BayCEER), University of Bayreuth, Bayreuth, Germany; [b]Leuphana University of Lüneburg, Faculty of Sustainability, Social-Ecological Systems Institute (SESI), Lüneburg, Germany

ABSTRACT

The agricultural management of grasslands not only is strongly linked to fodder production but also provides other valuable ecosystem services such as carbon sequestration, nutrient regulation, and recreation. Capturing the values that society places on such ecosystem services is a step to provide management recommendations. To elicit the societal value of grasslands and their ecosystem services, it is important to consider multiple dimensions, namely, instrumental, intrinsic, and relational values. We conducted surveys with citizens in 2018 and 2020 in two study areas in Bavaria, Germany: one grassland-dominated and one with mixed agricultural land use. In the surveys, the respondents were invited to map up to seven points in their respective regions where they perceived grasslands to be 'especially valuable'. Also, the respondents could provide reasons for this selection. These verbatims were classified into instrumental, intrinsic, and several sub-types of relational values using Qualitative Content Analysis. Next, we conducted a hotspot analysis that revealed spatial hotspots and coldspots for each value type . Besides some overlaps, we found that hotspots of instrumental, intrinsic, and relational values varied in space. A Constrained Correspondence Analysis underlined the trade-offs between instrumentally valued grasslands that are perceived as suitable to supply provisioning services and intrinsically valued grasslands that are closely related to relational values such as care. The results show that grasslands and their ecosystem services are valued for a variety of reasons on different locations, and point out the need for further investigations of the spatial distribution of values associated with ecosystem services.

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Grasslands; hotspots; sociocultural valuation; relational values; spatial valuation

1 Introduction

Ecosystems and their services are declining at alarming rates globally (IPBES, 2019). Human decisions and resulting behavior heavily influence the ability of ecosystems to provide such ecosystem services (Daily et al. 2009; Díaz et al. 2015). These decisions are also influenced by the multiple ways in which nature, ecosystems, or ecosystem services are valued by people (Díaz et al. 2015; Pascual et al. 2017; Arias-Arévalo et al. 2018). Besides decisions taken by land managers that directly affect the supply of ecosystem services incorporating citizens' values in future land use decisions can be very important for policy- and decision-making that leads to sustainable outcomes (Harmáčková et al. 2021). For example policy-making processes in the EU that incorporate values of citizens have been identified to be increasingly important for setting up land-use policies (Newig and Koontz 2014).

Values are understood here as the 'importance, worth or usefulness' of nature and ecosystem services to people (Díaz et al. 2015; Pascual et al. 2017). One person can hold multiple diverse values associated with ecosystem services, but differences can also occur between societal actors (e.g. Arias-Arévalo et al. 2017; Martín-López 2021). It is important to understand, acknowledge, and address this diversity of values to foster sustainable outcomes (Pascual et al. 2017; Jacobs et al. 2020; Zafra-Calvo et al. 2020). While the need for plural valuation moving beyond merely monetary value metrics has received widespread attention (e.g. Jacobs et al. 2016 2018; Pascual et al. 2017; Arias-Arévalo et al. 2018) different approaches to integrating multiple values are still under development. For example, Muradian and Pascual (2018) suggest to use a typology of human-nature relations for taking into account the diversity of values that underlie individual and social behavior. Additionally Jacobs et al. (2018) provide a comprehensive review of valuation methods and their capacity to elicit multiple values of nature.

Following the recent valuation guidelines developed by the Intergovernmental Science-Policy Platform for Biodiversity and Ecosystem Services

CONTACT Thomas M. Schmitt thomas.m.schmitt@uni-bayreuth.de
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(IPBES), we differentiate in this study between instrumental, intrinsic, and relational values (Díaz et al. 2015; Pascual et al. 2017). While intrinsic values are considered independent of any human experience and refer to the inherent value of nature and ecosystem services as end in itself instrumental and relational values are human-driven (Díaz et al. 2015). Instrumental values represent the direct and indirect benefits people obtain from ecosystem services and relational values link to the meaningfulness of relationships such as those among people and between people and nature (Chan et al. 2016; Pascual et al. 2017; Schröter et al. 2020). Because instrumental values refer to the importance of nature and ecosystem services as a means to an end, they implicitly involve substitutability (Arias-Arévalo et al. 2018). As an example, Martín-López (2021) refers to the instrumental value of an apple tree 'as a means to achieve a certain amount and quality of apples'. The instrumental value of an apple tree may then be replaced by the same number of apples with similar quality provided by a supermarket. Framing the importance of an apple tree in instrumental terms might overlook the many ways that farmers might relate to that particular apple tree and the orchard. As the relationships among humans and between humans and nature can be diverse several sub-types of relational values exist, such as a feeling of belonging and sense of place, sense of agency, social cohesion, or appreciation of recreation in nature (Arias-Arévalo et al. 2018; Riechers et al. 2021).

In order to elicit plural values of ecosystem services, including intrinsic, instrumental, and relational values, plural valuation approaches are needed (Jacobs et al. 2016; Pascual et al. 2017). However plural valuation of ecosystem services is still in its infancy (Jacobs et al. 2018; Christie et al. 2019). This is particularly true for agro-ecosystems where monetary valuation techniques have been mostly used to elicit instrumental values of ecosystem services (Nieto-Romero et al. 2014). Yet many studies agree that plural valuation exercises that include relational values are vital to capture additional reasons by which people express the importance of nature and ecosystem services (e.g. Chan et al. 2016; Arias-Arévalo et al. 2017, 2018; Klain et al. 2017; Himes and Muraca 2018). For example in agricultural landscapes, Chapman (2019) found that including farmers' relational values in the design of agro-environmental incentive programs can increase enrolment rates and foster conservation stewardship. In the Cape Floristic Region Topp et al. (2021) found that when farmers endorse plural values including several relational values, the decision-making regarding the management of the farm might lead to more ecosystem services.

In agricultural landscapes, grasslands provide a variety of ecosystem services depending on their management regime and intensity (Le Clec'h et al. 2019). Grasslands of low management intensity characterized as hotspots of biodiversity, are highly threatened due to abandonment, afforestation, and transformation into crop fields (Habel et al. 2013). Notably grasslands remain one of the most understudied ecosystems in ecosystem services research (Bengtsson et al. 2019; Zhao et al. 2020) and have mainly been studied from the biophysical perspective i.e. the capacity of biodiversity to provide services (e.g., Crouzat et al. 2015; Schirpke et al. 2016; Le Clec'h et al. 2019). In fact assessments concerning socioeconomic aspects of ecosystem services in grasslands, such as social perceptions, demand, and values, still remain elusive (Zhao et al. 2020). In contrast to values perceptions of ecosystem services can be loosely defined as a way of observation, understanding, interpretation, and evaluation (Bennett 2016). Yet few studies have explored social perceptions of ecosystem services provided by grasslands. For example, Schmitt et al. (2021) found that most ecosystem services provided by grasslands were perceived as highly important in farmers' management considerations in (pre-)Alpine grasslands. Also Pachoud et al. (2020) found that most ecosystem services of Alpine summer farms are positively perceived by visitors. Despite this recent sociocultural research plural valuation of ecosystem services in grasslands where relational, intrinsic, and instrumental values are included is still in its infancy.

Values of ecosystem services vary in terms of their spatial distribution due to geographical, biophysical, and accessibility factors (Fagerholm et al. 2019). Thus a focus on place when assessing values can reveal connections between people and their biophysical surroundings (Fagerholm et al. 2012, 2019) and can help to inform land managers and decision-makers about areas of high and low value (e.g. Karimi et al. 2020). This can be crucial for landscape management (De Vreese et al. 2016) as well as to identify land use conflict potential (Brown and Raymond 2014; Brown and Fagerholm 2015) as space needs to be recognized as the product of the interrelations between humans and nature (Massey 2005). The use of public participation GIS and participatory GIS has frequently been applied to capture the spatial allocation of values (Brown and Fagerholm 2015). A prominent example of participatory mapping techniques is the GIS application of Social Values for Ecosystem Services (SolVES) developed by Sherrouse et al. (2011) to quantitatively assess, map, and quantify social values of ecosystem services. However, uncovering relational values often requires qualitative methods for data collection, such as interviews, in order to allow social

actors to express their real connections with nature and ecosystem services (Stålhammar and Thorén 2019). In this study we apply a mixed-method approach, including qualitative and quantitative data collection and analytical techniques.

With an analysis of the spatial distribution of intrinsic, relational, and instrumental values of ecosystem services provided by grasslands, we aim to shed further light on the trade-offs and synergies between values in a spatial context. We specifically aim to (1) elicit and map instrumental, intrinsic, and relational values of grasslands and their ecosystem services; (2) spatially assess the trade-offs and synergies that might exist between values and (3) analyze the associations between values, perceptions of ecosystem services, and sociodemographic characteristics.

2 Methods

2.1 Study areas and characteristics

We conducted this research in two study areas in Bavaria (Germany) to represent two different agricultural systems in Central Europe, namely the grassland-dominated (pre-)Alpine Ammer study area and the Red and White Main (RWMain) study area (Figure 1) which is characterized by mixed agricultural land use. We chose to conduct the surveys in different study areas to compare two typical landscapes, one dominated with grassland and the other with a mixed cropland–grassland ratio.

The Ammer study area entails the catchment of the river Ammer and parts of the Isar, Lech, and Loisach catchments. The pre-Alpine and Alpine environments consist of 36% agricultural land, 41% forest patches, 5% water bodies, 4% human settlements, and 14% other land cover including mountainous rock and peat environments. This area's unique characteristic is its dominance of grasslands in the agricultural sector consisting of 71% of the agricultural land use (LDBV, 2016). A gradient of intensity from north to south characterizes the study area. In the northern part approximately 50% of the agricultural land use is grassland-based (County Starnberg), and in the south, grasslands dominate agricultural land use with 99% (County Garmisch-Partenkirchen). Specifically, in the southern, Alpine part, very extensively managed grasslands are still present. These include traditional humpback meadows (*Buckelwiesen*) and Alpine summer pastures (*Almen*). The north to south gradient is also visible in topography. It ranges from the hilly pre-Alpine northern part to the Ammergau Alps, Bavarian Prealps, and Wetterstein mountains in the south, including Germany's highest peak, 'Zugspitze' with an altitude of 2,969 m.a.s.l (NASA, 2009). The largest towns in the Ammer study area are Garmisch-Partenkirchen (pop. 27000) and Weilheim (pop. 23,000). In the northern counties Weilheim-Schongau and Landsberg, the primary and secondary economic sectors are highly important, due to the prominence of agricultural activities and the proximity to Munich in the north. In the southern county Garmisch-Partenkirchen, characterized by the Alpine environment, tourism takes a high stake leading to a very high importance of the service industry (Table B1). The study area is located within the European Metropolitan Area of Munich. With the Ammer Alps Nature Park (IUCN category V), the study area includes a protected area that targets to conserve

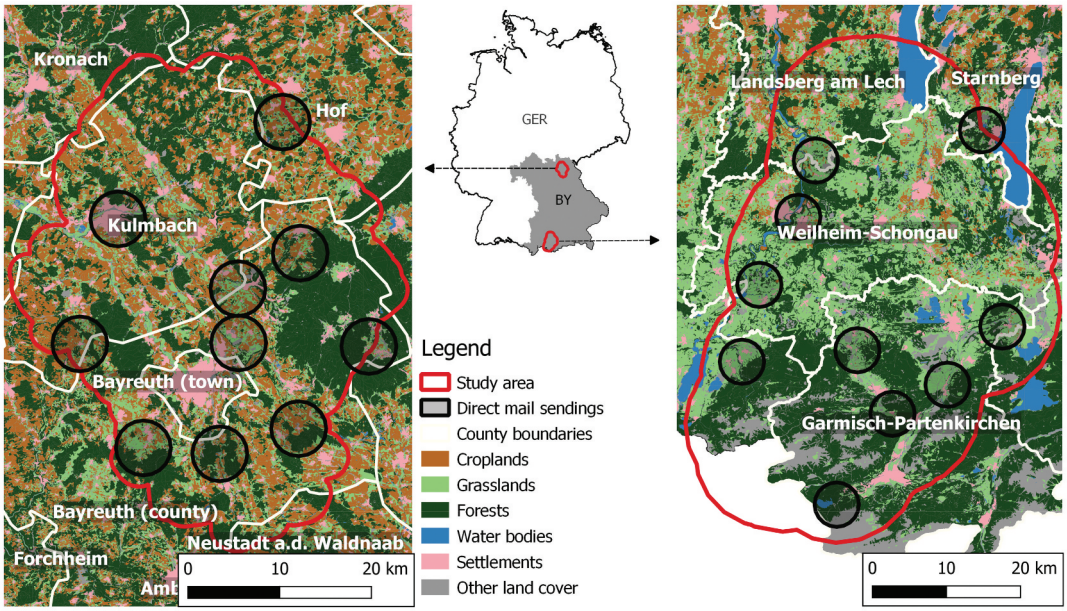

Figure 1. Location and characteristics of the RWMain study area (left) and the Ammer study area (right) in Bavaria (BY), Germany (GER).

nature by supporting its utilization through sustainable land use practices and recreational activities.

The study area along the Red and White Main catchment (RWMain) entails parts of the catchments of the Saale, Naab, Eger, and Regnitz rivers. The two separate streams Red Main and White Main confluence in the northwest of the study area marking the start of the river Main, one of Germany's major streams. The region is characterized by mid-altitude mountain ranges, including the Fichtel Mountains (*Fichtelgebirge*) in the east, Franconian Switzerland (*Fränkische Schweiz*) in the west, and the Franconian Forest (*Frankenwald*) in the north (see Figure A1). These three regions are also classified as Nature Parks (IUCN category V). The study area consists of 41% agricultural land, 42% forest patches, 7% human settlements, and 10% other land covers including rock environments and human infrastructure. The agricultural land use is mixed and consists of approximately 40% grasslands. In the counties of Bayreuth and Kulmbach, the primary and secondary sectors are economically important, while in the town of Bayreuth, most employment takes place in the service industry (Table B1). The highest peak of Northern Bavaria, 'Schneeberg', (1051 m.a.s.l.) is in the Fichtel Mountains. The largest towns in the study area are Bayreuth (pop. 74,000) and Kulmbach (pop. 26,000). The study area is located within the European Metropolitan Area of Nuremberg. The home institution of some authors is in Bayreuth, located in the RWMain study area.

2.2 Data collection and sample characteristics

We conducted surveys with citizens living in the Ammer and RWMain study areas in 2018 and 2020. We chose these years to test potential bias towards distinct events. For example, the surveys 2020 might have been influenced by the Covid-19 pandemic that impacted activities of citizens in nature (Schweizer et al. 2021). Also a Bavarian referendum that included legal changes in agriculture took place in 2019. As many of these changes intended to increase biodiversity-friendly farming focused on grassland management and preservation (Hartmann et al. 2021) the referendum had the potential to influence the values of ecosystem services expressed by the respondents.

Households located in a 3 km radius of 20 randomly selected points received an invitation card to participate in the online survey (Figure 1). We provided a link and a QR code in the postal cards to the online survey that could be filled out on any electronic device with internet connection. We slightly modified the final centroids of the circles from the random allocation in areas of very low population (Figure A2). In total 79,313 invitations were sent via direct mail by the German Federal Post Office from which 1139 respondents at least partially filled out the survey. All surveys were conducted anonymously and analyzed separately from any personal data (optionally provided). We pre-tested the questionnaire in the pedestrian zone of Garmisch-Partenkirchen prior to the execution of the study by conducting 188 questionnaires in spring 2018.

The surveys covered the theme 'Agriculture, Climate Change, and Nature Conservation'. Alongside other questions related to ecosystem services provided by grasslands, we asked participants to indicate on a map of their respective regions up to seven points where they perceive grasslands to be especially valuable. In total, 627 respondents mapped 3645 points. The map was not scalable or zoomable to ensure a uniform map size for all respondents. After mapping each point, an open question followed in which respondents indicated the reason why they perceive these grasslands as valuable. This open question was used to infer values that the respondents attached to the grasslands. The response rate of this question out of all respondents that at least partially filled out the survey (1139) was 45% (515 responses). In addition, to explore social perceptions of ecosystem services, we asked citizens to rate on a 5-point Likert scale how suitable they perceive grasslands for the supply of certain ecosystem services, namely, fodder production, animal production, energy plant production, soil fertility, groundwater quality, climate regulation, soil erosion reduction, flood risk reduction, pollination, biological pest control, and recreation. In this study, we understand perceptions as a way of observing, understanding, interpreting, and evaluating the capacity of grasslands to supply ecosystem services (Schmitt et al. 2021). The selection of ecosystem services was based on expert knowledge on relevant grassland ecosystem services (see Schmitt et al. 2021). The questionnaire also included sociodemographic characteristics of respondents and the private activities they frequently do in nature (see Table B1 and C1 in the Supplementary Material).

2.3 Data analysis

2.3.1. Elicitation of values: content analysis and statistical analysis

First, we conducted a Qualitative Content Analysis (QCA) with MaxQDA Plus 2020 (Release 20.4.0) to code the reasons why respondents consider the mapped grasslands as valuable. These reasons given, also referred to as verbatims, were coded according to the classification of intrinsic, relational, and instrumental values following Arias-Arévalo et al. (2018) and Pascual et al. (2017). Since the notion of intrinsic value is considered independent of human experience and therefore valuation (Díaz et al. 2015) we

considered the 'subjective' intrinsic value as suggested by O'Connor and Kenter (2019). The elicitation of 'subjective' intrinsic value is based on the idea that humans can express regard for biodiversity and ecosystem services independent of human interest (O'Connor and Kenter 2019).

Responses that could not be clearly attributed to a value category were discarded. Here, it is important to note that intrinsic, instrumental and relational values are connected and might be simultaneously present when respondents articulate why grasslands matter to them. For example, Arias-Arévalo et al. (2017) show such an interaction with the verbatim '(the Otún watershed) is indispensable for life on the planet [*intrinsic value*]. Having good-quality water ensures a good health and good quality of life [*relational and instrumental values*]'. Therefore when respondents expressed the importance of grasslands, they might refer to the three categories of values.

In addition, concerning relational values, we coded them in different relational value sub-types since the emergence of the articulated values resulting from the relationship humans have with nature can be manifold. For coding relational values, we followed the classification provided by Arias-Arévalo et al. (2018). In this case we are aware that a particular statement can refer to different relational values as they can be strongly intertwined. For example, the verbatim *'[. . .] I explored these areas already 60 years ago with my father [. . .] (2,020,361)'* refers to the relational value 'social relations' (see Table 1) but it can be also interpreted as 'cultural heritage' when the statement adds some nuances regarding traditional knowledge or traditions. In addition, we only considered relational value sub-types that were mentioned more than ten times for further statistical analysis (see Table 2). We also conducted a hierarchical cluster analysis for the articulated relational values in order to combine them for the mapping exercise and further statistical analysis using the R package *FactoMineR* (Husson et al. 2020).

The coding was a reiterated process that involved two rounds of internal review by all authors (see Table 1 for examples). We could allocate at least one value to the statements of 304 respondents out of the 515 respondents to the question.

Finally, we conducted the Mann-Whitney-U-Test for each value domain to explore differences of the articulated values between the study areas and over time. For the statistical analysis and data processing, we used RStudio Version 1.3 and R Version 4.0.2 (RStudio 2020).

2.3.2. Mapping values: Getis-Ord Gi* hotspot analysis

We applied Getis-Ord Gi* statistics (Getis and Ord 1992) for each articulated value to uncover spatial clusters of grassland locations where the respective values prevail. We employed Getis-Ord Gi* hotspot analysis as frequently used in the study of ecosystem services' hotspots (Brown and Raymond 2014). The hot- and coldspots revealed using this method represent a spatial cluster of points associated with the respective values more frequently than by random choice within the context of neighboring points. Hotspots (and coldspots) can be defined as an area where a variable in our case value prominence, is significantly higher (or lower) than average in the study area. The delineation is based on the Getis-Ord Gi* statistics that considers not only the value of each point, but also of surrounding points. This local sum must be significantly higher (or lower) than the expected local sum based on all features in the study area (Getis and Ord 1992). We conducted the analysis in ArcGIS 10.7.1. Getis-Ord Gi* offers several advantages over other density maps or spatial clustering methods such as being able to differentiate hotspots and coldspots of high and low values (Zhu et al. 2010). Bagstad et al. (2017) suggest that Getis-Ord Gi* can provide useful results for ecosystem service hot-/coldspots mapping to inform landscape-scale planning. For this analysis we joined the coded articulated value(s) (see 2.3.1) to all points marked by the respective respondent to be valuable grasslands (see 2.2). Unless respondents differentiated values for specific grassland locations, we assume that articulated values per respondent apply to all marked grassland locations by the respective respondent. For each value, the points were coded as '1' if the respondents articulated the respective value and '0' if not. We only considered points mapped by respondents who expressed at least one value (304 participants indicated values and mapped 1656 points).

2.3.3. Associations between values, ecosystem service perceptions and sociodemographic characteristics: constrained correspondence analysis

We conducted a Constrained Correspondence Analysis (CCA), a multivariate ordination technique frequently used to explain patterns in sociocultural valuation of ecosystem services, by relating perceptions to potential predictors (e.g. Casado-Arzuaga et al. 2013; Al-assaf et al. 2014; Morales-Reyes et al. 2018). We related the values that respondents associated with grasslands to respondents' characteristics (age gender, education level, employment in a job related to nature, and private activities in nature) and ecosystem service perceptions (Likert-based ratings of the perceived suitability of grasslands to supply certain ecosystem services). A Monte Carlo permutation test (999 permutations) was used to identify the significance of the model. We used the R package vegan v. 2.4. for this analysis (Oksanen et al. 2020)

Table 1. Value types, sub-types of values, description (modified from Arias-Arévalo et al. (2018)), times the value was stated (n) and a translated example from the coded dataset. Respondent IDs are reported in brackets. ES: Ecosystem services.

Value types	Value sub-type	Value description	n	Illustrative examples
Instrumental		Direct or indirect monetary benefit; utility	20	*'Easily economically usable (location, field size) (2,020,302)'* *'Size of the area and proximity to consumers (2,020,286)'*
'Subjective' intrinsic		Nature's right to exist	121	*'In my experience these are important places where wild plants or wild animals exist that should simply be further protected (2,020,438)'* *'Especially along lakes and rivers we need large amounts of grasslands as many animals live close to waters, give birth and raise their offspring (2,018,327)'*
Relational	Security	ES critical for achieving security including meaningful livelihood, energy and health goals	14	*'I am convinced that untouched grasslands are important for clean drinking water [. . .] (2,020,376)'*
	Ecological resilience	Capacity of ecosystems to maintain their integrity in the face of disturbances (e.g. prevention of hazards such as flooding)	23	*'Notable landscapes with an intact ecosystem and rare plants and animals. The conservation of these is important for a stable system in the pre-Alpine region (2,018,281)'*
	Mental and physical health	Physical benefits perceived from ecosystems' regulation of water, air and diseases, and mental benefits due to exposure to nature	7	*'It has stress-reducing effects (2,018,526)'*
	Sense of place	Emotional attachment to a place/feelings of belonging, commitment, identity or community (e.g. notions of 'home' or attributes to locations signaling feelings of belong such as 'my surroundings')	39	*'It is just typical Bavaria, I got to know it like this as a child and kept it in my memories. This is why I moved back here after my studies in Baden-Württemberg (2,018,277)'*
	Cultural heritage	Tangible and intangible features of landscapes which are historically significant (e.g. buildings, monuments, traditions, stories, traditional ecological knowledge, other knowledge systems)	6	*'I am a farmer and an "Alpler" (herdsman) in the Ammer mountains and would like to continue to manage it as I always have. The Ammer mountains are so beautiful due to the management, so we do not need a change (2,020,335)'*
	Aesthetic	Appreciation of the beauty of nature, grounded on sensations and emotions	39	*'Personal connection to beautiful landscape (2,020,327)'*
	Recreational	Appreciation of tourism, recreational and leisure activities in natural areas	60	*'The grasslands towards Unternogg/Halbammer are a beautiful place for recreation for my family and me (2,020,159)'*
	Cognitive Development	Appreciation of ecosystems' features within special educational and scientific interest	3	*'The River Lech runs through our town and there is still quite some valuable nature that is taught to us by Lech Rangers (2,025,252)'*
	Care	Core values about nature as related to universal moral values such as care, responsibility and stewardship towards nature, landscape and land (e.g. motions of "we should protect	92	*'[. . .] Here we should protect and use nature, not interfere with it (2,020,230)'*
	Social relations/ cohesion	Nature as a platform where social relationships are fostered	1	*'[. . .] I explored these areas already 60 years ago with my father [. . .] (2,020,361)'*
	Altruism	Concern for biodiversity, ecosystems or ES in favor of a present larger community of (future) generations	14	*'As close to towns as possible so that people who are not mobile are close to grasslands (2,020,436)'*
	Meaningful occupation	Occupations related to biodiversity and ecosystems that allow people to fulfill a good human life	1	*'[. . .] I think that the farmers are doing very responsible great work for uncountable years!! [. . .] (2,020,577)'*

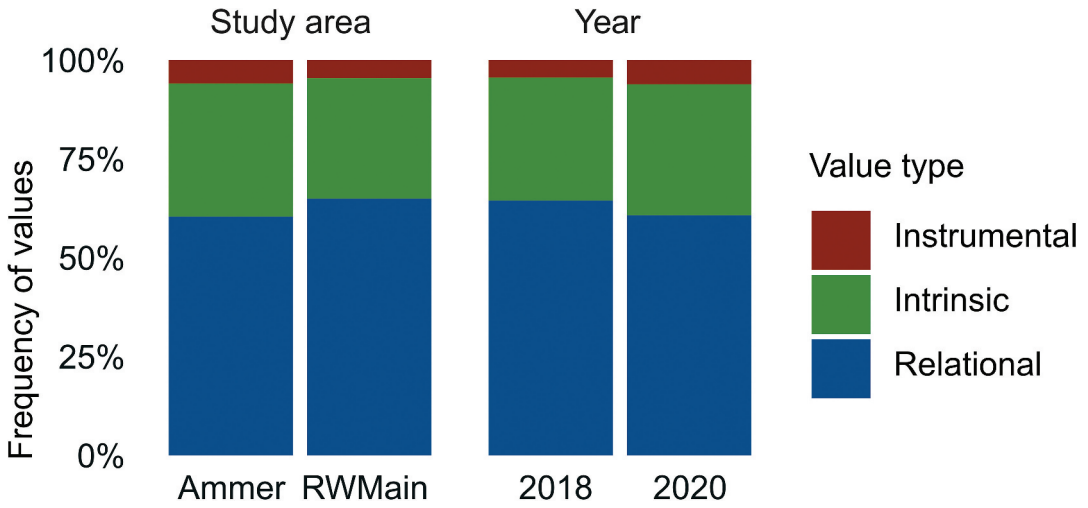

Figure 2. Frequency (in %) of respondents (n = 304) that expressed instrumental, intrinsic, or relational values. Per respondent, only one count per value type is included in this figure, even if a value type was indicated multiple times by the same respondent.

3 Results

3.1 Values associated with grasslands

Respondents referred to various values when they explained why certain grasslands are important to them, including instrumental, 'subjective' intrinsic and relational values (Table 1). Out of the 304 respondents who indicated at least one value relational values were the most frequently expressed (62.5% of the respondents), followed by 'subjective' intrinsic values (32.2%) and instrumental values (5.3%). We did not find statistical differences in articulated values between study areas and between 2018 and 2020 with the Mann-WhitneyU-Test (Figure 2; Table D2).

We identified 12 different articulated sub-types of values in the domain of relational values. Seven sub-types were mentioned more than ten times (Table 1). The hierarchical clustering revealed five groups of relational values: namely aesthetics, care, recreation, sense of place, and a cluster consisting of ecological resilience, security, and altruism (Table 2; Figure D1). We found statistically significant differences between the two study areas for the articulated relational values of care and recreation (Table D3). As shown in Table 2 respondents indicated recreational values more often in the RWMain study area than in the Ammer study area. Care was mentioned significantly more often in the Ammer study area than in the RWMain study area. We did not find significant differences in the articulated relational values between 2018 and 2020.

3.2. Spatial hotspots of values associated with grasslands

The Getis-Ord Gi* Hotspot Analysis indicated distinct hotspots and coldspots of articulated values in both study areas (Figure 3). In the Ammer study area hotspots of grasslands associated with instrumental values were clustered along the river Lech in the western part of the study area and coldspots were located around the Murnau peatlands in the southeast of the study area (see Figure A1 for geographical features). The opposite pattern emerged for hotspots of 'subjective' intrinsic values. These were located in the east of the study area, specifically along the Murnau peatlands and the southern, mountainous part of the study area, and the drainage into Lake Starnberg. In the RWMain study area, this opposing pattern is less distinct, but still visible. Hotspots of instrumental values are clustered in the east and southeast of Bayreuth and north of the Fichtel Mountains. Hotspots of 'subjective' intrinsic values were revealed along the River Red Main, surrounding

Table 2. Differences in relational articulated values between regions and years; ** indicates statistically significant results at $p < 0.05$; * indicates significance at $p < 0.10$.

Relational value subtype	Total	Study area			Year	
		Ammer	RWMain		2018	2020
Aesthetic	39	24	15		24	15
Care	92	56	36	*	45	47
Recreation	60	24	36	**	26	34
Sense of place	39	18	21		18	21
Altruism, security, ecological resilience	47	20	27		21	26

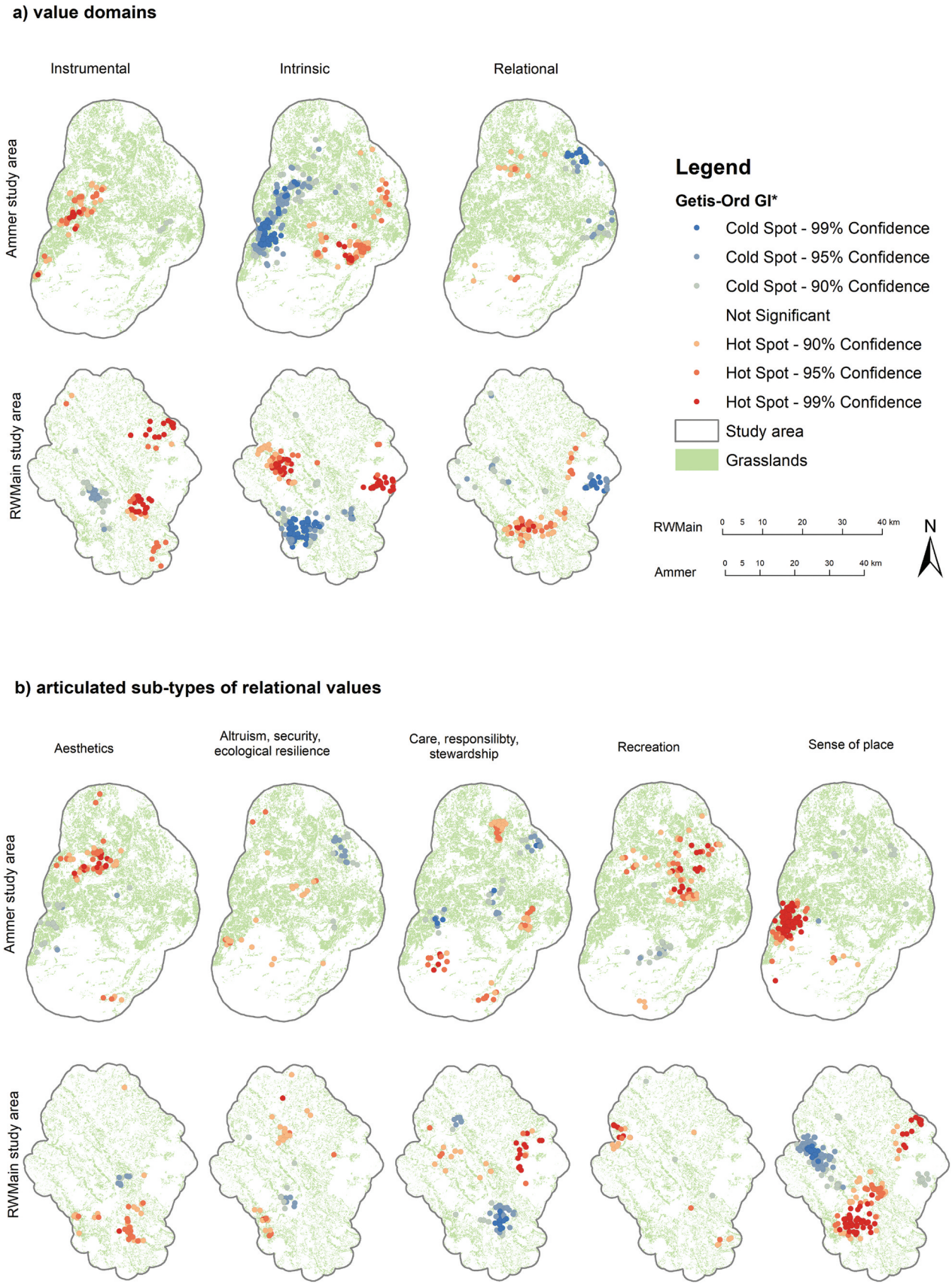

Figure 3. Getis-Ord Gl* hot- and coldspots (dots) of (a) value domains (Instrumental, 'subjective' intrinsic, relational) and (b) articulated sub-types of relational values associated with grasslands in the Ammer (top) and RWMain (bottom) study areas.

the conjunction of the Red Main and White Main streams, and in the Fichtel Mountains.

Concerning relational values, we also found spatial patterns according to the value sub-type. Some articulated relational values are strongly clustered in space (e.g. sense of place), while others are more widely spread out throughout the study area (e.g. altruism, security, and ecological resilience).

Hotspots of sense of place overlap with hotspots of instrumental values in the southwest of the Ammer study area along the river Lech, in the RWMain study area north of the Fichtel Mountains and in the southwest. The hotspots of the relational value of care are, similar to hotspots of 'subjective' intrinsic value, located in prominent natural areas, such as the Murnau peatlands, estuaries of lake Ammer and the Alps in the Ammer study area. In the RWMain study area, hotspots of care are in the conjunction of the streams Red and White Main as well as the Fichtel Mountains. Interestingly, the hotspots located in the Fichtel Mountains overlap not only with 'subjective' intrinsic hotspots in the center of the natural park, but also with instrumental values in the north of the park. Prominent overlaps also exist between hotspots of recreational and aesthetic values in both study areas (Figure 3).

3.3 Connections between values, perceptions of ecosystem services, and sociodemographic characteristics

The Constrained Correspondence Analysis (CCA) indicated a statistically significant association between certain values attached to specific grasslands, perceptions on the suitability of grasslands to supply ecosystem services, and sociodemographic characteristics ($p = 0.013$ with 999 permutations; Figure 4). Axis 1 (30.14%) of the CCA showed in the negative scores an association between citizens that indicated instrumental value as well as sense of place and aesthetics and those citizens that perceived grasslands as very suitable to supply provisioning (fodder production animal production, energy plant production) and some regulating services (pollination, climate regulation, groundwater regulation). Male citizens most often expressed these instrumental values. In the positive scores of Axis 1, elderly people, higher educated respondents, citizens who enjoy nature for various private activities (go hiking, running, or cycling, observe wild animals, and collect wild berries and herbs) and those citizens who perceive flood risk reduction and soil erosion reduction as particularly suitable to be supplied by grasslands expressed 'subjective' intrinsic values as well as the relational values of care, recreation, and security, altruism, and ecological resilience.

Scores of Axis 2 (22.05%) revealed differences between people who are employed in a nature-related job and people who rated ecosystem services

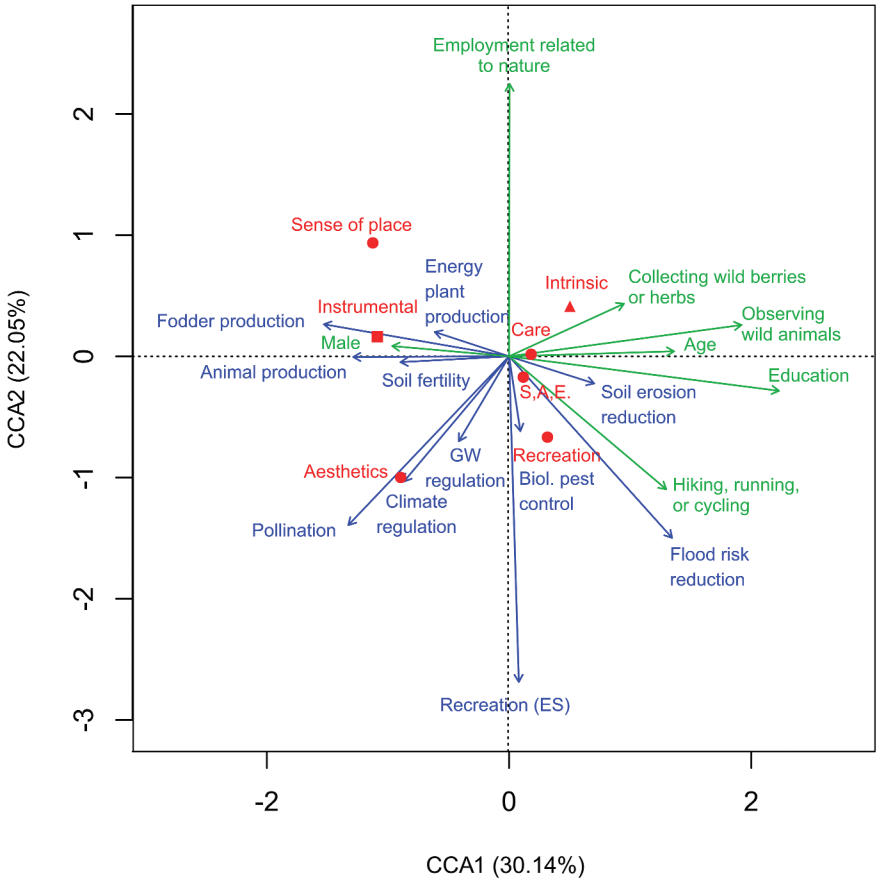

Figure 4. Constrained correspondence analysis indicating the connections between intrinsic (red triangle), instrumental (red square), and relational (red circles) values associated with grasslands, the perceptions of ecosystem services (blue), and further personal characteristics (green). (S,A,E = Security, Altruism, Ecological Resilience; Biol. pest control = Biological pest control; GW regulation = Groundwater regulation).

Table 3. Results of the first two axes of the CCA.

	Axis 1	Axis 2
Eigenvalue	0.137	0.084
Proportion explained (%)	33.5	20.7
Cumulative proportion explained (%)	33.5	54.2

as particularly suitable to supply recreational ecosystem services. This axis did not present major associations of sociodemographic characteristics and perceptions on the suitability of grasslands to supply ecosystem services with values. In total, however, only 54% of the variance could be explained (Table 3).

4 Discussion

The goal of this study was to gain further insights into the values that citizens associate with grasslands and how these vary in space. We also aimed to identify the connections between values of grasslands, perceived suitability of grasslands to supply certain ecosystem services, and sociodemographic characteristics. In the following, we firstly discuss the social and spatial trade-offs and synergies concerning values attached to grasslands. Next, we show the importance of studying the spatial dimension of plural valuation for management recommendations. Finally, we draw attention to methodological limitations of the study.

4.1 High societal value of grasslands: distribution of 'subjective' intrinsic, instrumental, and relational values

The results of the Qualitative Content Analysis (QCA) revealed a wide range of values that citizens associated with grasslands. Overall, relational values resonated more frequently than instrumental or 'subjective' intrinsic values in our study. The high occurrence of relational values illustrates, that, besides the utilitarian purpose of grasslands to supply fodder and its 'subjective' intrinsic value of biodiversity, there is a need to acknowledge the complex, non-substitutable relationships between nature and people (Himes and Muraca 2018). The high tally of relational values corresponds with the findings of previous research in other contexts. Arias-Arévalo et al. (2017) for example, found in a study on values associated with nature in the central Colombian Andes a likewise low amount of people who valued nature for purely instrumental reasons while the majority of respondents indicated relational values. Similarly, in a study on values, rules, and knowledge in the Cape Floristic Region, Topp et al. (2021) found that farmers articulated relational values much more frequently than instrumental and 'subjective' intrinsic values. In a quantitative questionnaire-based study in Guanacaste, Costa Rica, Klain et al. (2017) found very high agreements with relational value statements from farmers, residents, and tourists. Among relational values, we found that care was the most important relational value expressed by respondents (Table 2). Klain et al. (2017) also found that the level of agreement for the statement associated with the notion of care responsibility and stewardship towards nature was higher than the ones referring to other relational values.

Besides the very high amount of verbatims associated with relational values, we found a proportionally larger number of statements attributed to 'subjective' intrinsic values than previous research (Arias-Arévalo et al. 2017; Topp et al. 2021). A potential reason for this might be the overall high biodiversity of grasslands compared to other agricultural land use especially grasslands of low management intensity (Marini et al. 2007; Habel et al. 2013). Moreover there is a thin line regarding the attribution of some verbatims to value categories, such as 'subjective' intrinsic and relational values. In fact, the regard expressed by respondents for grasslands independent of human interest, that is 'subjective' intrinsic values, can be also seen as a kind of relational value (O'Connor and Kenter 2019). For example while some studies classified the moral duty towards nature as an intrinsic value (Arias-Arévalo et al. 2017; Coelho-Junior et al. 2021) others considered it as a relational value (Topp et al. 2021). A relational view of intrinsic values is proposed by the value categorization of Muradian and Pascual (2018) suggesting that intrinsic values could indeed be classified as a 'wardship' relational model.

4.2 Dichotomy between instrumental and 'subjective' intrinsic values: the spatial and social trade-offs

Trade-offs between instrumental and 'subjective' intrinsic values, often referred to as a dichotomy, have been extensively described in the scientific literature of nature valuation (Chan et al. 2016; Arias-Arévalo et al. 2018; Himes and Muraca 2018). The results of our study of grasslands support the occurrence of such trade-offs in a spatial context. Hotspots of 'subjective' intrinsic values were located in places of high biodiversity and nature conservation such as the Murnau peatlands and the estuary to Lake Starnberg in the Ammer study area. In the RWMain study area, the Fichtel Mountains as a natural park and the conjunction of the Red and White Main rivers are prominent natural sites that were also

characterized as hotspots of 'subjective' intrinsic values. The coldspots of these 'subjective' intrinsically valued grasslands located along the river Lech in the west and north of the Ammer study area were nearly exclusively mapped to be hotspots of instrumental value. Similarly, in the RWMain study area, there were no overlaps of hotspots of 'subjective' intrinsically and instrumentally valued grasslands. More quantitative GIS-based studies also found differences between 'subjective' intrinsic and tangible values. For instance, in a study on wilderness values in Alaska, Brown and Alessa (2005) found that people placed intrinsic values inside wilderness areas while areas outside of such received more tangible values including immediate economic uses.

The dichotomy between instrumental and 'subjective' intrinsic values can also be observed in the results of the Constrained Correspondence Analysis (CCA). Both value domains are placed on the opposing first axes. Furthermore, instrumental values were closely connected to provisioning services, so citizens who articulated instrumental value also indicated that they perceive grasslands to be very suitable to supply provisioning services. Verbatims such as *'size of the fields and proximity to customers (2,020,286)*' or '*these (grasslands) are easily economically usable (2,020,302)*' show that the perceptions of grasslands as especially suitable to supply provisioning services aligns with the existence of instrumental values. These results imply that agricultural production of food in the study areas is highly connected to utilitarian values of grasslands aiming at economic profit, and less about relational values such as sustaining livelihoods to maintain (food) security. Furthermore, instrumental values were not only associated with agricultural production, but also in combination with tourism, which could explain the close connection on the first axis of the CCA to aesthetics. Grasslands have high aesthetic values, irrespective of whether they are used for fodder production in lower elevations or grazing in higher elevations (Schirpke et al. 2021). Concerning sociodemographic characteristics we found that male respondents were more likely to value grasslands for instrumental reasons and to perceive grasslands to be suitable for the provisioning for fodder and animal production. This supports findings of a review on gender perspectives in ecosystem service research by Yang et al. (2018) that concluded that women had closer connections to certain regulating services and biodiversity while men had more knowledge of provisioning services.

4.3 Relational values acting as a bridge: synergies between values

Besides trade-offs between 'subjective' intrinsic and instrumental values, values are also connected with each other. On the one side, different types of values can overlap in their meanings (Schröter et al. 2020). On the other side different values can be expressed simultaneously by the same respondents (Arias-Arévalo et al. 2017; Himes and Muraca 2018; Martín-López 2021). For instance one citizen in our study expressed that grasslands are *'important for nature, recreation and climate; dairy farming, milk, agriculture (2,020,304)'* exemplifying the multiple values that can simultaneously be associated with grasslands. We also observed several synergies between values on a spatial scale. Here, it becomes prominent that relational values spatially overlap with both instrumental and 'subjective' intrinsic values, acting as a bridge between these contrasting values.

'Subjective' intrinsic values, opposed to instrumental values, show a strong connection to respondents who indicated to privately spend time in nature and are higher educated in the results of the CCA. This pattern aligns with the maps of value hotspots since those places that were hotspots of 'subjective' intrinsic values partially overlapped with those places important for their recreational value (Figure 3; Figure A1). The association between 'subjective' intrinsic values and conducting private activities in nature can be explained because the repetitive act of going to nature to observe wild animals, collect wild berries or go hiking can foster meaningful relationships with nature and a sense of care for nature (i.e. relational values) that with time might lead to the endorsement of moral rights and the recognition of 'subjective' intrinsic values (Martín-López 2021). The emergence of a certain value (e.g. 'subjective' intrinsic) by activities motivated through a different value (e.g. recreation) also exemplifies that values can nurture each other (Chan et al. 2016; Arias-Arévalo et al. 2018). Hence locations in which hotspots of different values were mapped can have a distinct role in fostering other values.

We also found clear spatial overlaps between hotspots of 'subjective' intrinsic values and the relational value of care in both study areas. When care is expressed in terms of biodiversity protection, this connection can be essential for stewardship and conservation activities (West et al. 2018). Caring for nature through policy and management practices, plays a fundamental role regarding stewardship actions and relates to the concept of 'People for Nature and Landscape' (De Vreese et al. 2019). On the contrary we found some overlaps between care and instrumental values in the RWMain study area in the north of the Fichtel Mountains (Figure 3). This interesting result supports recent findings showing that care as a concept can give vital insights into understanding what an area is supposed to be used for and what practices are accepted by society (Jax

et al. 2018). Care in this regard, also illustrates the intermediate position of relational values between 'subjective' intrinsic and instrumental value domains. The reasons why people care for specific grassland areas and take actions to preserve grasslands that sustain specific habitats are manifold in our dataset. Hence, further investigation of what grasslands are being cared for could be very helpful to disentangle the intermediary position of care between instrumental and 'subjective' intrinsic values (Jax et al. 2018).

Another example of synergies between values is hotspots of instrumental values that partially overlap with those places that were hotspots of the relational value sense of place. Sense of place is created through social and ecological interactions that foster a feeling of home and belonging. Such connections can contribute to nurture values of social cohesion and stewardship (Masterson et al. 2017; Martín-López 2021). The spatial overlap of grassland locations valued for instrumental values and sense of place indicates that feelings of belonging and feelings of home do not necessarily conflict with utilitarian management of the grassland but can also nurture each other. The fact that agricultural land, such as grasslands, is used economically might be important for this place to be kept intact and avoid abandonment or conversion to cropland. This result is also shown by the CCA, which illustrates that instrumental values and sense of place are related to provisioning ecosystem services.

4.4 The added value of plural valuation in space: recommendations for grassland management

Environmental values cannot fully explain the actions of people (Kaiser et al. 1999) but it is prominent that the values that people hold towards nature and ecosystem services do contribute to how nature is used and how future scenarios are envisioned (Pascual et al. 2017; Harmáčková et al. 2021). In this regard plural valuation can help to unravel values that are not yet integrated in management objectives and can foster recommendations for environmental management (Arias-Arévalo et al. 2017). De Vreese et al. (2019) also found that using social representations of nature that include relational values can result in more effective planning and management of ecosystem services and contribute to a better understanding among and between actor groups. In a recent study on riparian buffers in the northwestern USA Chapman (2019) concluded that several conservation programs conflicted with values of farmers. Fortunately integrating relational values of potential participants can help to better design the programs leading to both increased participation and sustaining the values needed to maintain such programs by reflecting values such as stewardship or care (Chapman 2019). Relational values like care also play a role in our sample concerning the management decisions of farmers. For instance there are dominant hotspots of care in the Ammer study region in areas of extensive management such as the alpine regions of the Ammer and Wetterstein mountains. One respondent explained – *'I am a farmer and an "alpine herdsman" in the Ammer mountains and would like to continue to manage it as I always have. The Ammer mountains are so beautiful due to the management, so we do not need a change (2,020,335)'*. This finding is in line with other studies claiming that the relational value of care can help to better understand the cultural dimensions behind stewardship actions (Jax et al. 2018; West et al. 2018). The Ammer mountains indeed are a valid example of extensively managed grasslands that are part of a cultural heritage of seasonal alpine farming a tradition that is heavily endangered although it provides various ecosystem services and high biodiversity (von Heßberg et al. 2021).

Regarding changes in the landscape, the maintenance of relational values can be threatened. If rapid and extreme landscape changes take place, this might erode human-nature connectedness and relational values (Riechers et al. 2021). Examples of landscape changes regarding grasslands are the abandonment of alpine pastures but also the intensification of grasslands and the conversion into croplands. These are also highly relevant in our study region, exemplified by a farmer in our sample who indicated that – *'[…] a certain balance between grassland and cropland should be maintained. In the areas with more cropland we have less grasslands – reason enough to give grassland a higher value. Grasslands have to establish themselves against cropland, also in times of conversion bans […] (2,018,314)'*.

Interestingly, not only relational values, but also instrumental values can be linked to an extensive management of grasslands. The respondent cited above also indicated that *'[…] a further important point is the usage of the area in relation to the amount of cattle you have. In dairy farm areas with a lot of cropland, I find grassland more valuable as a farmer, as better fodder can be taken from grassland if cutting intensity is kept low. From cropland, on the other hand I receive lower quality fodder which is mainly good to receive quantity (2,018,314)'*. This statement exemplifies that instrumental values linked to provisioning services can positively affect the management of extensively management grasslands. Extensive management practices provide ample ecosystem services such as carbon sequestration and recreation (Le Clec'h et al. 2019).

The results of this study imply that combining the qualitative study of relational values with

quantitative and spatial methods can reveal important connections between values, people's characteristics, and perceptions on the suitability of grasslands to supply ecosystem services. This underlines the call of previous research for more mixed methods approaches in valuation studies (Jacobs et al. 2016; Tadaki et al. 2017; Schulz and Martin-Ortega 2018). Integrating the spatial dimension in plural valuation is a crucial step as space represents the dimension of simultaneity where things, events, and people exist at the same time and deals with the question how we can live together (Massey 2014). Grasslands located at hotspots of instrumental values might be accepted by the public to be managed intensively as these are predominantly valued by citizens that also indicated that they perceive grasslands to be very suitable to supply provisioning services. On the contrary, conservation might be socially acceptable and prioritized in those locations where citizens perceived 'subjective' intrinsic values and relational values of care. Similar outcomes were found by De Vreese et al. (2016) who identified a clear link between nature conservation statuses and the social value of ecosystem services. The meaningfulness of certain geographical places to people can also be enhanced by peoples' engagement with nature illustrating the necessity to disentangle the values people place on distinct sites (Karimi et al. 2020). Nevertheless our spatial results also claim that even sites with high instrumental values are not purely valued for their utility as relational values are also present.

Due to its diversity, we addressed relational values in a more detailed categorization than intrinsic and instrumental values. Based on values that were articulated more than ten times, we only found one significant cluster of relational sub-types. The articulated values of security and resilience resonated in the cluster analysis with altruistic verbatims. This suggests that aspects of resilience that can bring security in the long run (Plieninger and Bieling 2013) are also related to altruism towards other people and other generations regarding the present values of grasslands.

4.5 Methodological limitations

In this study, we used a mixed-methods approach to investigate values of grasslands. Combining a qualitative assessment of values with spatial hotspot analysis proved to be very suitable to better understand the distribution of values associated with grasslands and their ecosystem services. Nevertheless, we acknowledge limitations in line with the data acquisition and analytical techniques.

The questionnaire titled 'Agriculture, climate change, and nature conservation' might have predominantly motivated citizens with interest in this topic to respond. This means that it is likely that citizens with an interest in conservation are overrepresented in the sample. Also, the sample characteristics revealed a bias towards higher educated citizens (Table B1). This could also be caused by the implementation of the survey as an online version that might not be accessible or attractive to some potential participants. These limitations need to be acknowledged, as a central point of plural valuation is recognizing and including marginalized stakeholders and less powerful people, for which other methods might be more suitable such as storytelling, photovoice or transdisciplinary approaches (Zafra-Calvo et al. 2020; Martín-López 2021). The results also need to be considered with care as the respondents are not distributed equally over the entire study area (Figure A3). This is specifically relevant because land use types located in the respondents' surroundings have a stronger influence on preferences than land-use types that are located further away (Hedblom et al. 2020). In a study on social representation of nature and landscape De Vreese et al. (2019) pointed out the risk of collectivization of results with a small sample which we also acknowledge for this study. Also, not every citizen might be equally familiar with the area, which could have led to erroneous mapping of valuable grasslands (Brown and Alessa 2005; Zhu et al. 2010). We acknowledge the limitation that the map was not zoomable. Hence the locations are only an estimate of the specific grasslands meant, which resulted in the inability of conducting further spatial statistical analyses with the dataset. Overall, we obtained a relatively low response rate (1.4%) compared to similar studies. For example, in Sherrouse et al. (2011) 33% of households returned a mail survey in Colorado, USA. Wagner et al. (2019) at least obtained a response rate of 7% in a study on stakeholders' perceptions on urban green spaces. A discussion with the postal agency revealed that direct mail circulars frequently even obtain lower response rates than ours as the mail can easily be considered to be bulk mail. The high number of postcal cards sent allowed us to still conduct meaningful analyses with the dataset.

We further acknowledge uncertainties that we encountered during the QCA with data from questionnaires without the possibility to follow up on the answers. Several respondents did only indicate short or imprecise statements about why they value specific grasslands that we could not allocate to a value category leading to less data points for the spatial analysis and a missing recognition of underlying values. In order to keep the subjectivity bias for assigning value types to verbatims as low as possible, decisions regarding value categorization were discussed by all authors.

The limitations outlined should be addressed in future research in order to fine-tune our understanding of values that predominate in grasslands and give precise location-specific policy and management recommendations. Nevertheless, our results combining qualitative methods with a spatial analysis provided interesting insights into the distribution of values in two study regions in Bavaria, Germany, that can be used to identify trade-offs and synergies between values in a spatial dimension and showed the possibilities to gain practical insights for prioritization of certain grassland management practices.

5 Conclusion

The goal of this study was to explore the spatial distribution of values associated with grasslands and their ecosystem services. By means of combining qualitative and quantitative data and analytical techniques, we conclude that *(i)* trade-offs between instrumental and intrinsic values that have been reported in recent studies can also be found spatially; *(ii)* relational values, such as care or sense of place, overlap in several locations with each other as well as with intrinsic and instrumental values, which means that relational values can act as a bridge between the two opposing values; *(iii)* sociodemographic variables and perceived suitability of grasslands to supply ecosystem services are clearly linked to the verbatims coded as instrumental, intrinsic, or relational values.

The results of this study on the values of grasslands underline the importance of plural valuation including relational values for sustainable land management. The methods employed can help to understand which people are more likely to benefit or lose from decisions about agricultural management, economic development, or biodiversity conservation and can provide important information for land use prioritization and management advice.

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ORCID

Thomas M. Schmitt http://orcid.org/0000-0002-7287-6648
Rebekka Riebl http://orcid.org/0000-0002-8218-4717
Berta Martín-López http://orcid.org/0000-0003-2622-0135
Maria Hänsel http://orcid.org/0000-0003-4530-8968
Thomas Koellner http://orcid.org/0000-0001-5022-027X

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