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Alma Maria Moroder & Maria Lee Kernecker

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Grassland farmers' relationship with biodiversity: a case study from the northern Italian Alps

Alma Maria Moroder and Maria Lee Kernecker

Research Area for Land Use and Governance, Leibniz Center for Agricultural Landscape Research, Müncheberg, Germany

ABSTRACT

To successfully understand and shape biodiversity conservation in Alpine grasslands, it is crucial to understand how farmers' relationship to biodiversity influences their goals and associated practices. We explored how farmers perceive and value biodiversity, how this is related to agricultural and land use practices, and how they view their roles in affecting it. Semi-structured interviews were conducted with 22 farmers in the northern Italian Alps and with 6 experts in the fields of grassland management, agriculture, and environmental conservation in 2020. The farmers' answers were analyzed using a mental model approach, relational thinking, and the literature on the 'good farmer'. The experts' responses were used to discuss and contextualize the farmer's answers. We found that the farmers' mental model of biodiversity is associated to different aspects of agricultural management practices and farmers' roles in mountain agricultural landscapes. Instrumental values of biodiversity are negative and strongly perceived as such by farmers, while relational values associated with biodiversity are positive, but more weakly perceived. These differing perceptions and values seem to be associated with two roles that farmers have, as producers and landscape stewards, and how they value fodder quantity and quality. Most farmers don't include considerations related to the conservation of biodiversity in their management decisions, and mostly do not envision any changes in biodiversity or management in the future. Effective biodiversity conservation in Alpine grasslands will therefore need to tap into these dual roles and the associated instrumental and relational values of biodiversity for a meaningful dialogue on conservation.

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1. Introduction

Mountains are considered biodiversity hotspots that are particularly sensitive to global change (Körner 2004; Grêt-Regamey et al. 2012; Palomo 2017; Rogora et al. 2018). While mountains make up only 3% of the European continent, 25% of the entire European flora can be found there (Spehn et al. 2011; Bätzing 2015). Agricultural landscapes in the Alps are dominated by semi-natural grasslands, which present the highest level of biodiversity among mountain ecosystems (Habel et al. 2013; Bätzing 2015). These habitats were created by humans through deforestation or alteration of natural grasslands and maintained through traditional agricultural practices (Maurer et al. 2006; Tälle et al. 2016). This high endemic biodiversity provides several ecosystem services (e.g. Gilhaus et al. 2017; Körner 2004; Hooper et al. 2005; Tälle et al. 2016; Lavorel et al. 2017), that are essential to local economies and people's well-being (Bieling et al. 2014). Therefore, conservation of and in these Alpine grasslands is particularly important (Martín-López et al. 2019).

Alpine semi-natural grasslands and the landscapes they are embedded in are endangered due to infrastructure development, unsustainable tourism, habitat fragmentation, and climate change (Martín-López et al. 2019). These factors as well as changes in land use practices (EEA 2002) like farm abandonment or agricultural intensification (Schermer et al. 2016) cause loss of grasslands and biodiversity therein (Lavorel et al. 2017). Grassland conservation in the Alps therefore means accounting for complex socialecological relationships that make up Alpine agriculture (Moon et al. 2019). However, the current pathway of grassland management and conservation is largely dichotomous: while agri-environmental schemes support extensive management in support of biodiversity, market demands simultaneously support more intensive production of fodder stemming from less diverse swards. To move away from this dichotomy, and understand how biodiversity can complement production, farmers' ideas regarding both management of fields but also of the use of fodder yields are needed. Conservation scientists are increasingly acknowledging the importance of social dimensions in relation to biodiversity (Moon and Blackman 2014; Fazey et al. 2020). Thus, deeper insight to how Alpine farmers think about biodiversity and how they make daily management decisions in regard to their grasslands could provide a more nuanced pathway towards conservation.

Farmers' knowledge can highlight interactions between practice, biodiversity, and yield production (e.g. Lamarque et al. 2011; Kreitzman et al. 2022). Farmers are aware of biodiversity, although this awareness plays out differently in their management and in their relationship to their land (Kelemen et al. 2013; Schümann et al. 2022), particularly regarding questions of how biodiversity is related to fodder yield quantity and also quality. More specifically, farmers' perceptions of grassland plants (Winter et al. 2011) can shape decisions regarding management practices, while shifting social norms of what it means to be a "good farmer" can define how farmers conservation pursue biodiversity objectives (Westerink et al. 2021). It is not only the individual farmer whose perceptions matter, but also how collective perceptions of biodiversity affect management decisions. Farmers' roles have always been embedded in a social context which simultaneously shaped and was shaped by ideas of what constituted a "good farmer" and what "good farming" was, reflected in the symbols in fields and across landscapes (e.g. tidy fields: Burton et al. 2020). As such, how biodiversity is perceived, incorporated into Alpine agricultural management, accounted for in agricultural production, and symbolically represented in fields and the landscape still needs clarification.

We contribute to the literature on Alpine grassland conservation by exploring how farmers' relationships to biodiversity both shape and are defined by Alpine grassland management and use, and how these relationships are intertwined with farmers' roles. We specifically aim to understand: 1) how farmers perceive biodiversity, 2) the value and meaning they attribute to biodiversity in the context of Alpine agriculture, and 3) if their perceived role in managing biodiversity aligns with their reported actions. To this end, interviews were conducted with farmers in three municipalities in the northern Italian Alps as well as with several local experts. We used mental models to analyze the relationships defining biodiversity and to understand farmers' roles.

2. Materials and methods

2.1. Theoretical background and approach

We draw upon a mental models approach, relational thinking, and the literature on farmers' roles to situate our research. Mental models reflect people's perceptions, values, or attitudes, and link them to actions and practices (Jones et al. 2011; Prager et al. 2016; Moon et al. 2019). These perceptions, values, and attitudes are highly subjective and cannot necessarily be separated from one another. Mental models are cognitive representations of external reality, based on

personal life experiences and understandings of how the world works (Jones et al. 2011). They are longterm knowledge structures, determined by the situation in which the individuals find themselves and the roles they take on (Lynam et al. 2012). Importantly, mental models can help depict the various realities that co-exist within an individual's ways of thinking, and are thus a helpful construct to disentangle how co-existing roles are related to different perceptions and values of biodiversity (Busse et al. 2021). Each individual holds a unique mental model since every mind is different (Lynam et al. 2012). Therefore, eliciting individual mental models reveals the structure and content of each person's individual model of a system (Moon et al. 2019). However, mental models can be shared, e.g. in the form of cultural understandings of the world (Jones et al. 2011) or of social representations (Buijs et al. 2008). Collective mental models represent how groups of individuals make decisions, revealing whether individuals share values and similar roles or responsibilities (Moon and Adams 2016; Moon et al. 2019). We show to which extent certain mental models are shared among the farmers while others differ, and we present them in an aggregated conceptual model.

Mental models are helpful for understanding the relationships among different components in a study system - in our case, Alpine grasslands. Relational values describe relationships between people and nature, including relationships that are between people but involve nature (Deplazes-Zemp and Chapman 2021). Using a relational approach means acknowledging that all knowledge is situated within an association between entities and/or actors. In our context, this specifically means understanding farmers' mental model of biodiversity in terms of its relationship to different aspects of farmers' environment, land use, agriculture, and farmers' roles (Darnhofer 2020). Farmers will observe the plants and animals they care for, acting in an external world, but also are acted upon by other entities (i.e. policy, biodiversity, yields) (Darnhofer 2021). Relational thinking offers a way to unify different epistemologies in eliciting farmers' complex considerations on biodiversityyield relationships (e.g. West et al. 2020; Busse et al. 2021). We thereby assume that each farmer imposes their own meaning to biodiversity and fodder yields in grasslands, both now and in the future, and that as a result, various realities can co-exist within an individual farmer's experience. In applying relational thinking to the analysis of the data collected, we moreover consider ourselves as part of the data production and analysis, and the methods we use as inextricably linked with the data that we present. While we did not frame our questions in a way that used relational thinking explicitly, it emerged as a useful way to analyze and interpret the collected data. As researchers, we are never completely neutral observers or analysts of our study object, and we always influence our outcomes since we too have our own mental models. Relational thinking allows us to integrate this aspect into our analysis and interpretation.

A relational approach to studying biodiversity in Alpine grasslands moreover begs for an understanding of identity and symbolic meanings inherent to agriculture, since they define how biodiversity is perceived and contextualized. Farmers have diverse and evolving roles within a social and cultural context that reflect changing norms of "good farming", including shifts from maximizing productivity, to conserving biodiversity across landscapes (Burton 2004). Mental models can deconstruct what "biodiversity" is in an Alpine farming environment, what it represents, and how this relates to a sense of place and the role of farmers in that place. These roles, in turn, reflect how farming is understood and how this understanding will shape ideas of what biodiversity is in relation to agriculture from now into the future.

2.2. Study areas

Three municipalities in the northern Italian Alps were chosen as study areas: Kastelruth, Predazzo, and Cortina d'Ampezzo. All three municipalities are located within the Alpine mountain range of the Dolomites. The municipal territories extend to from 388 m a.s.l. to 3,238 m a.s.l. (see Table 1 and Figure 1) and are mainly covered by forest and grassland.

Agriculture in the Dolomites is characterized by permanent grassland, which is predominantly used for livestock farming (cattle and sheep). These grasslands are managed at different intensities, but mostly regularly mown or used as pastures. Mowing frequency depends on slope altitude and exposure to sunlight. Lower and south-facing slopes are mown more frequently than higher and north-facing slopes. Furthermore, lower slopes are usually fertilized several times per year while higher slopes are fertilized less frequently. During the summer months, livestock is brought to the pastures on upper slopes for grazing and brought back to the lower slopes in autumn. Mown grasslands are typically used for hay and silage production, which are then used as fodder. The

Table 1. Summary of geographic characteristics of study regions.

	Location coordinates	Elevation of village center	Municipal territory area	Language	Province/ Jurisdiction	Mean annual rainfall	Mean monthly temperature	Farm abandonment
Kastelruth Predazzo	46°33′ N, 11°33 E 46°18′ N, 11°35′ E	1060 m 1018 m	117.90 km² 109.97 km²	German Italian	Südtirol Trentino	778 mm 792 mm	−3.4°C and 16.6°C −0.3°C and 18.6°C	Low Moderate
Cortina d'Ampezzo	46°32′ N, 12°08′ E	1200 m	252.81 km ²	Ladin	Belluno	816 mm	−5.0°C and 15.4°C	High

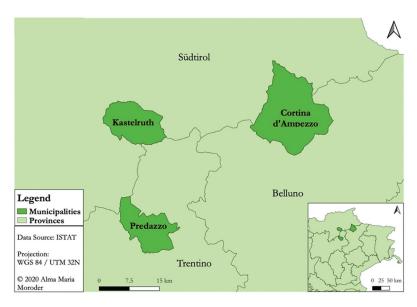


Figure 1. Political borders around the three study regions: Kastelruth in the Province of South Tyrol, Cortina d'Ampezzo in the Province of Belluno and Predazzo in the Province of Trentino.

farmers' livestock is mainly used for dairy and/or meat production.

The shift from a predominantly agrarian area to a predominantly tourism-driven area (Bätzing 2015) has led to high rates of farm abandonment throughout the Dolomites since the 1950s. However, the extent of farm abandonment differs significantly among the study areas, (Tappeiner et al. 2007; Table 1). The differences between the municipalities in terms of their agricultural practices and of the farming intensity is rooted in their differing topography and legislations. Kastelruth and Predazzo are at a slightly lower altitude than Cortina d'Ampezzo, allowing for more frequent mowing and fertilization. Financial incentives for agriculture in Cortina d'Ampezzo are fewer, connected to scenery and decoupled from productivity. This has led to simultaneous agricultural abandonment and extensification, as opposed to Kastelruth and Predazzo, where policy incentives (e.g. to livestock units per ha/area based payments) and contracts with marketing agents (e.g. milk quotas, Briner and Finger 2013) are linked to productivity and therefore facilitate a more intensive grassland management.

2.3. Interviews

22 structured interviews with farmers were conducted in the study areas: 10 in Kastelruth, 7 in Predazzo, and 5 in Cortina d'Ampezzo. The interviews were initially planned as face-to-face interviews, but were all conducted via telephone due to the Covid-19 pandemic. Most of the interviewees were selected through snowball sampling. Moreover, 6 expert interviews were conducted with local representatives of agriculture, grassland management and nature conservation, and with researchers and lecturers within the fields of Alpine environment, Alpine farming and grassland management.

Here, Alpine grasslands include mown meadows and pastures used for livestock grazing at the valley bottom as well as mowed meadows and pastures at higher altitudes. All types of managed grassland, regardless of the level of intensiveness of agricultural practices, are included. We refer to them as "fields" or "grasslands". Grassland farmers were selected based on if they were the main managers and decision makers of the fields (Table 2). We refer to them as "farmers", "respondents", or "interviewees".

Most interviewed farmers are between the ages of 40 and 60 and have a second source of income. Only 2 out of 22 interviewed farmers are women. This onesided representation of grassland management is reflective of the disparity and homogeneity within grassland management itself (Tappeiner et al. 2007).

The questionnaire for the farmers (Supplementary information) consisted of open questions covering topics such as the farmers' knowledge on biodiversity, their perception of their own role as farmers, the farmers' future vision of their fields and the local landscape, and the relationship between biodiversity and grassland management decisions. The questionnaire for the experts expanded on the farmers' answers from a scientific and practitioners' point of

Table 2. Farmers by age, gender, altitude of their fields, owned and managed grassland area, and type of income (K = kastelruth, P = Predazzo, C = Cortina d'Ampezzo).

Respondents code	Age (years)	Gender	Altitude (m a.s.l.)	Owned grassland area <i>(ha)</i>	Managed grassland area <i>(ha)</i>	Type of income from grassland management
K1	42	f	950	5.5	5,5	Main (+ additional second income
K2	51	m	1250-2000	15	31	Main (+ additional second income
K3	82	m	1100-1900	16	16	Main (+ additional second income
K4	52	m	1000-2200	15	28	Main (+ additional second income
K5	29	m	800-2000	14.5	18	Main (+ additional second income
K6	42	m	1200-1600	19	33	Main (+ additional second income
K7	45	m	1150-1900	8.3	16.3	Main (+ additional second income
K8	44	m	1200-2100	15	15	Main (+ additional second income
(9	27	m	800-1000	11.5	16.5	Main (+ additional second income
K10	56	m	1200-1300	9.7	9.7	Main (+ additional second income
P1	47	m	1000-1600	8	28	Main
P2	46	m	1000-1500	10	34	Main
P3	58	m	950-2000	5	55	Main
P4	54	m	1000-1800	25	52	Main
P5	34	f	800-1100	25	1.5	No income from grassland mgmt
P6	27	m	1000-1600	25	36	Main (+ additional second income
P7	47	m	1000-1500	25	42	Main (+ additional second income
C1	73	m	1200-1350	25	24	Main (+ additional second income
C2	35	m	1300-1400	25	92	Main (+ additional second income
C3	56	m	1,300-1,400	25	50	Main
C4	53	m	1,300-1,450	25	21	Main (+ additional second income
C5	56	m	1250-1450	25	55	Main
Share	Avg. 43	91% male 9% female		Avg. 17.1	Avg. 32.1	68% Main (+ add. sec. income) 27% Main 5% No income

view. Each interview lasted 30-90 minutes, and were recorded with the interviewees' permission. Each interviewee was provided with/read an accompanying ethics letter ensuring the anonymity of the data collected.

2.4. Data analysis

Recorded interviews with farmers were transcribed and then coded according to the qualitative content analysis framework (Mayring 2014). The codes were developed based on the main themes within the answers. In most cases, only one coding category per question was elaborated. In other cases, subcategories were created, generating a hierarchical gradient. The codes were not developed in advance of the data collection but were developed inductively (Newing et al. 2011). By doing so, coding could be carried out based on the reappearing and main underlying themes. To assure a higher level of objectivity, a second coder examined the coding process. Hereby, results were validated and diverging results were discussed and adjusted in the final coding set (Mayring 2014).

With our analysis, we interpret insights from interview transcripts. We used interview data to infer the aggregate mental model amongst all interand then viewed grassland farmers a conceptual, relational network diagram showing how farmers understand biodiversity in relation to

grassland farming (Figure 2). The concepts (nouns or phrases) are the nodes and lines or arrows are the relationships between the concepts (Busse et al. 2021). This diagram summarized all information from all interviews with all farmers, and allowed us to construct meaning from the similarities and shared statements, particularly pertaining to perceived relations and roles. Transcripts from expert interviews are used to discuss findings from interviews with farmers.

3. Results

The differences in the role of agriculture for each of the local economies in the different municipalities, were not reflected by differences in the responses from farmers. The collective mental model of how farmers across all municipalities largely perceive biodiversity-yield relationships now and in the future is associated with co-existing roles that farmers have or take on (Figure 2). Farmers' responses are explained in the following sub-sections.

3.1. Perception of biodiversity

Two thirds of the farmers (15) described the term "biodiversity" with scientific expressions such as "variety of species" or "number of species" in order to explain biodiversity. The most common response to this question was 'biodiversity is the variety of species

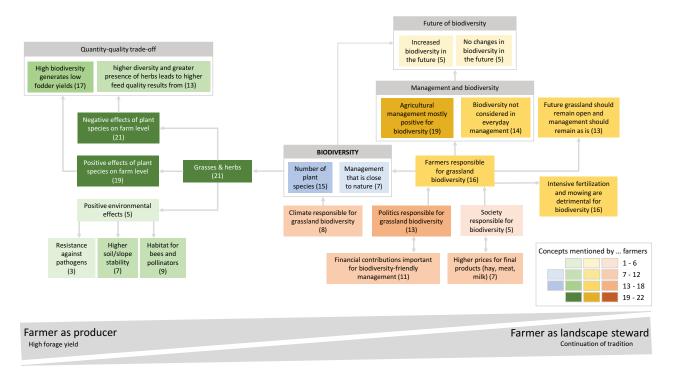


Figure 2. Aggregated conceptual model of how farmers perceive biodiversity in relationship to agriculture and fodder yields, and also in relation to responsibilities associated with conservation-production relationships. Green boxes relate biodiversity to fodder yield, blue boxes define biodiversity, yellow boxes relate biodiversity to farming and landscapes more broadly, orange boxes relate biodiversity to those responsible for it. The darker the color of a box, the more farmers share the concept. Number of farmers in brackets. (Figure design inspired by Busse et al., 2021).

that can be found on a field' (K8). Most of the respondents (9) who gave this type of definition associated the term biodiversity with flora. However, some also associated biodiversity with fauna or livestock, and several (5) did not specify the domain they referred to. The remaining third of farmers (7) understood biodiversity in what we interpret as a relational way (West et al. 2020). They usually used expressions such as "nature cycle", "in harmony with nature", "interaction between nature and the economy" or "management that is close to nature". For example, these respondents understood biodiversity as 'working in an environmentally friendly way, not overfertilizing and everything that comes from the livestock should go back to the natural cycle [...]' (K1). This quote highlights that biodiversity might be considered an all-encompassing term that includes things and actions related to farmers' interaction with nature.

Even though the interview question regarding what biodiversity is did not specify any domain, almost all of the respondents (21) referred exclusively to plant and tree species. Only one respondent included animal species. Farmers named 7 to 8 plant species that exist on and around their fields. The most frequently named plant species were Trifolium (mentioned 16 times), Taraxacum (mentioned 10 times), Dactylis glomerata (mentioned 9 times), Lolium perenne (mentioned 8 times), Alopecurus pratensis (mentioned 6 times), Phleum pratense (mentioned 6 times) and Festuca pratensis (mentioned 6 times). Most of these species are grass species with a high fiber content. Here, it should be noted that throughout the interviews, most farmers drew a distinction between "grasses" (Gräser, erbe) on one side, understood as those plant species that are rich in raw fiber and are generally referred to as "fodder plants" (e.g. Gramineae), and "herbs" (Kräuter, fiori) on the other side, understood as flowering, usually aromatic plants (e.g. Lamiaceae and Asteraceae).

3.2. Values associated with biodiversity

Perceptions of benefits and disadvantages of individual plant species and biodiversity in general varied greatly. About three quarters of the interviewed farmers relate the benefits of certain individual plant species to their production value (e.g. for hay or silage production). A characteristic quote is '[...] English Raygrass etc., all these intensive grass species work really well as fodder' (K2), and 'Timothy grass, dactylis glomerata and clover - these species give you a higher yield' (P7), demonstrating that plant species are mostly judged by their usefulness for the farm. On the other hand, two of the interviewees associated the benefits of the mentioned species exclusively with their importance for the environment. Three respondents mentioned benefits associated both to the production value and the environmental value of the species. Similarly, negative effects of certain mentioned species were perceived via their influence on the production value of fodder. Most of the farmers (21) named only negative effects of certain grassland plant species associated with the productivity and efficiency of the farm. Negative effects include biomass loss due to crumbling of hay, low fodder value, poisonousness of certain species, and higher chances of an open sward: 'Tufted hairgrass is detrimental because it produces relatively rough hay' (K3) and 'There should be less rough bluegrass since it creates an open sward' (K4) were among the responses. Furthermore, farmers consider certain species to be weeds and thus damaging to the fodder, such as the thistle, a species that was mentioned 6 times in this context.

Most of the respondents consider grasslands with high biodiversity to generate lower fodder yields in terms of quantity. One characteristic quote is 'The yield of a field of a species-poor field is surely higher if the intensive grasses are in it. A species-rich field will never have the level of growth of an intensively managed species-poor field.' (K6). This demonstrates that for most respondents, biodiversity is negatively correlated to the field's productive yield. The farmers who support this view associate a higher yield in the sense of both fodder quantity and quality to speciespoor fields, stressing the importance of certain highly productive species. None of the respondents associated a species-rich field with a higher yield. A few of them did, however, point out the importance of a diverse field in terms of fodder quality and thus differentiated between harvest quantity and quality as components of yield.

Over half of the respondents stated that biodiversity has an effect on fodder quality, and all respondents associated higher biodiversity with a higher quality of the feed and, as a consequence, of the final product (e.g. hay, milk, cheese, meat). However, in many of these cases, even though pointing out the positive effects of biodiversity on fodder quality, the lack of positive effects on harvest quantity was iterated. Similarly, when asked whether biodiversity of Alpine grassland is generally a worthwhile aim, most respondents said "yes" whereas 3 farmers, while also answering in the affirmative, stressed the irrelevance of biodiversity in terms of yield and fodder quantity.

Beyond yield, biodiversity was also perceived as having wider-reaching, positive effects on the environment according to four categories: (1) climate, weather events and soil, (2) fauna, (3) flora, (4) resistance against pathogens. Nine farmers think biodiversity has beneficial effects on animals or insects. In particular, the positive effects for bees were pointed out by several respondents. A third of the respondents mentioned positive effects of biodiversity on the soil, including soil stability and resistance against extreme weather events ('A field with many species makes the field more stable. There will be less landslides' (C5)). Three farmers mentioned the increased resistance against pathogens as a result of biodiversity. Only one out of 22 mentioned the symbiotic effects on other plants through a higher level of biodiversity (flora), stating that 'there are plants that live in a symbiosis with other plants, they help each other [...]' (P5). Over a third of all the farmers did not specify which effects they attributed to biodiversity. In general, most interviewees mentioned exclusively positive effects of biodiversity on the environment, including statements which do not specify the kind of effects but still entail a generally positive attitude or feeling towards biodiversity ('I think the more biodiversity there is on a field, the better' (C2)). None of the interviewees attributed negative effects to biodiversity, and only one farmer stated that biodiversity does not have any effects on the abovementioned categories.

3.3. Farmers' roles in managing biodiversity

When asked who should be responsible for pursuing and preserving biodiversity of Alpine grassland, 16 respondents think that farmers themselves should be responsible for it. However, 13 farmers also think that politicians should bear some of the responsibility, and 5 farmers think that preserving biodiversity should be assigned to society ('Everybody, not only us farmers. More people should respect the environment, in different areas, not only when it comes to agriculture' (P2)). This quote shows that farmers feel left alone with the responsibility of preserving biodiversity in farmland, whereas they want to share this task.

Most interviewees indicated that the primary objective of their management in the field is to achieve high yields to sustain themselves and their families. Several farmers indicated that in addition to achieving high yields, working in a way that is as sustainable and as non-invasive as possible was also important. Likewise, some farmers also mentioned the continuation of tradition as their main goal.

Most respondents stated that intensive agriculture decreases biodiversity. Thus, according to these farmers, biodiversity and intensiveness of agriculture are negatively correlated. Intensive agriculture was generally associated with excessive fertilizer application of fertilizers. Some farmers also mentioned excessive mowing frequency as being detrimental to biodiversity. Two of the interviewees identified an optimal degree of farming intensiveness and stated that both a complete lack of agricultural activity and overly intensive agricultural practices lead to a decrease in biodiversity.

Nine farmers stated that they hadn't observed any long-term change in the presence or composition of species in their fields, many of them pointing out that change in species composition is a short-term development and that it differs from year to year, depending on the weather conditions such as precipitation and temperature. In contrast, over half of the respondents have noticed a change in the species presence or composition (both increase and decrease in the number of certain species). Change was mainly associated to management decisions (predominantly fertilization) and partly to "external" factors such as climate.

All farmers think that their work affects the environment in some way. Almost all stated that their work has a positive or rather positive impact on the environment. In contrast, about a third stated that their work has a negative or rather negative effect on the environment ('[...] if I work well, my work has a positive effect on the environment, especially visually speaking [...]. However, usually the impact is rather negative, for example if one exaggerates with fertilization' (P3)). All farmers named both positive and negative effects of management on biodiversity.

There is a general consensus among the farmers on how grasslands and the local landscape should develop in the future. Most farmers want their fields and the local landscape to remain as they currently are, that fields should be operated and managed as they are today, and that the landscape should remain open. Statements on how farmers wish future grasslands and landscape to look and how they think these will develop differed. Five farmers stated that biodiversity will not change in the future, while another 5 farmers think that biodiversity will increase in the future. Only 2 of the farmers think that biodiversity will decrease in the future while another 8 do not specify any type of change but state that external factors such as policies or climate change will determine the direction which biodiversity will change towards, but did not mention how their own management will shape biodiversity.

Two thirds of the farmers did not think that their attitude regarding biodiversity change affects their management decisions, whereas a third thought otherwise. Most farmers therefore do not think about biodiversity during their daily work on their fields and only consider it afterwards, if at all ('That is a thought that comes afterwards. It doesn't influence me. I'm influenced by other criteria. Of course, I want biodiversity, but I don't want to reduce my production because of it' (K10)). Answers to some specific questions about the farmers' daily management practices underpin the finding that most of the farmers don't consider biodiversity in their daily management decisions. Mowing dates and frequency mainly depend on weather conditions and on the stage of maturation of the grass (the fields should be mown at the

beginning of the blooming season and not during the maturation period for a better hay production), fertilizers are chosen based on convenience and spread according to the weather and soil conditions, and seed mixtures are usually selected based on their suitability for grasslands at higher altitudes. Concepts such as enabling a longer pollination period through a later first mowing date, choosing speciesrich seed mixtures or reducing the application of fertilizers in order to promote a more diverse growth were not mentioned here. However, most farmers have very clear opinions on which of their measures could increase the level of biodiversity on grassland. Most farmers associate the decrease of biodiversity with the excessive use of fertilizers and some farmers believe that less frequent mowing would increase biodiversity while other farmers believe that more frequently mowed fields present a higher level of biodiversity because it prevents bush encroachment. Furthermore, the correct choice of seed mixtures was pointed out by several farmers, highlighting that farmers intentionally adapt their management based on the role they have for particular fields in particular locations throughout the landscape. Other mentioned measures conducive to increasing biodiversity were the elimination of pesticides and herbicides, the reduction of soil damages caused by heavy machinery and the reduction of livestock number on the field. Farmers mentioned that to implement such measures would require financial contributions both from public administration (e.g. incentives, direct payments) and from consumers. A third of them believe that a higher price for the final product (milk, meat, hay, etc.) would be more effective ('If I get double the amount for my milk, then I can work more extensively' (K10)). These farmers attribute the responsibility to the consumers rather than to the public administration. However, both groups consider financial compensation - in whichever form - to be a decisive factor in this regard.

4. Discussion

We discuss the main findings that emerged from the interviews in a similar structure as the results section, relying on the mental model (Figure 2). However, we expand on the farmers' roles by discussing management intensity and yield parameters more in-depth. The themes that emerged and the connections between them were identified in the analysis of interview transcripts, and therefore are subjective interpretations of the data. In the future, these findings could be relayed to farmers and discussed further to deepen the analysis and to identify applicable interventions.

4.1. Perceptions of biodiversity

The mental model shared among most farmers (Figure 2) is strongly contingent on the agricultural setting in which farmers live and work. We can therefore assume that the interviewed farmers have a broader understanding of biodiversity and its effects on agriculture than of biodiversity and its role in the ecosystem. Farmers' interpretations of the term "biodiversity" differed, which reflects the plurality inherent to the broader, societal understanding and interpretation of what biodiversity is (Buijs et al. 2008). The term can refer to heterogeneity at different ecological levels (Haila and Kouki 1994), the functional characteristics of organisms present in an ecosystem, and the distribution and abundance of those organisms over space and time (Hooper et al. 2005). Biodiversity is also understood as encompassing the relations and functions between species within a biotic system (Wilmanns 1993). Moreover, the definition of biodiversity is dependent on the subjectivity of experience and on how biodiversity is socially represented in narratives guiding action (Wyborn et al. 2020). As such, local knowledge of biodiversity is often not connected to scientific definitions but to the respondents' daily practices and their own experiences (Buijs et al. 2008). Our findings show that many farmers think of biodiversity in both a modernist and also relational way. They mostly referred to it as the variety and number of species present in a given area, simultaneous to associating biodiversity with non-invasive grassland management and, more broadly, with an equilibrium between economic interests and nature conservation. As biodiversity is an umbrella term that is perceived in different ways by individuals, conducting interviews with farmers in regard to this umbrella term might have hidden specific insights related to specific plant species. Farmers had a broad appreciation for biodiversity in an abstract sense, as it is related to functional diversity or culturally appreciated species, while they likely attempt to suppress undesired species in their management (see Results section). Future work might uncover the different types of value that farmers attribute to specific species for even more nuanced results that can be translated to action.

4.2. Values associated with biodiversity

Farmers draw symbolic capital from the comparison with their peers, from the comparison with previous generations of farmers, or from the aesthetic results of their practices. We thus understand that management practices symbolize farmers' relationship with nature, and the way they value nature. When speaking about the value of biodiversity, it mattered whether farmers spoke about the effects of diverse, individual plant species on fodder yields, or biodiversity in general. When speaking about specific plant species, farmers generally described a negative relationship to farming. This contrasted with the statement made by most of the farmers that biodiversity of Alpine grassland is generally worth being aimed for, and this was associated with the cultural landscape, of which they also considered themselves stewards. This highlights a discrepancy between the farmers' value of biodiversity related to agricultural practices (negative instrumental value) and the value of biodiversity related to their landscapes or tradition (positive relational value). In fact, different mental models can be held about different aspects of the same system (Cannon-Bowers et al., 1993, Figure 2). A possible explanation is that farmers consider biodiversity an instrument for better fodder quality, more aesthetically pleasing fields, or positive public perception. In any case, biodiversity might be considered detrimental to the production yield of the farm while at the same time being seen as beneficial in terms of fodder quality and scenery. In order to understand the different weighting of these opposing values and to identify the true value attributed to biodiversity by the farmers, it is important to take the farmers' main goal into consideration, which for most of the farmers is the pursuit of high yields, and for others, the pursuit of high yields together with caring for the land or continuing tradition. We can therefore argue that the value of biodiversity is perceived as overall negative or negligible by most farmers since it is primarily associated to low production yields, overshadowing the relational values associated with continuing tradition.

Although farmers seem to draw indirect symbolic capital from different activities such as keeping their grassland neat and tidy, managing profitable farms, or keeping the landscape open by counteracting bush encroachment, it is unclear whether this applies to keeping species rich grassland too. The perceived growing prevalence of diverse seed mixtures that will be incorporated into grassland management in the future reconciles the everyday value of production-oriented activities with stewardship-oriented activities (Figure 2). Since farmers seem to attribute some positive instrumental value to biodiversity (i.e. forage quality), the predominating disregard of biodiversity in their management decisions can either be explained by the outweighing positive instrumental value attributed to tidiness and productivity of the fields or by the lack of relational value of biodiversity, insofar as it does not significantly improve their reputation among their peers. The phenomena of instrumental values increasing as relational values decrease has been found in Germany, when agricultural management intensity increased (Riechers et al. 2021). Given the co-existence of different values in farmers' mental models of biodiversity associated with grassland management, instrumental values might indeed outweigh relational values. This might make biodiversity conservation challenging in the current paradigm where conservation and production are seemingly mutually exclusive. While certifications such as the use of "Geographic Indicators" are potentially more inclusive, they alone have not been shown to achieve both goals (e.g. in France, Lamarque and Lambin 2015).

4.2.1. Intensiveness of practices

There is a broad consensus among the farmers that the intensification of agriculture leads to a decrease in biodiversity. Additionally, several farmers believe that both intensive farming and the complete lack of agriculture have a negative effect on biodiversity. This is true for grassland in many European countries and especially in mountainous areas, where the two opposite trends of intensification of practices and farm abandonment pose a danger to biodiversity in terms of species number (Plantureux et al. 2005; Newbold et al. 2015; Gossner et al. 2016) and composition (Hilpold et al. 2018). The farmers are knowledgeable about the agricultural practices which favor biodiversity and are beneficial to the ecosystem (e.g. reduction of fertilizer application on the fields, change in mowing patterns, altitudebased application of seed mixtures, avoidance of pesticides), and they seem to acknowledge the impacts of their practices on biodiversity. In fact, farmers attribute both observed changes in biodiversity in the past and expected future change of biodiversity on their fields more to grassland management and its intensity than to factors such as climate change or legislation. This shows that most farmers recognize the consequences of their own actions and that they attribute the changes of biodiversity to factors which they can directly influence, suggesting a strong sense of agency regarding biodiversity conservation. Despite this sense of individual agency in their ability to impact biodiversity, most farmers don't consider biodiversity in their daily management decisions. This might be explained by the farmers' contrasting relationships with biodiversity, and how it in turn is understood in different contexts (i.e. number of species, yield parameters, and broader environment: Figure 2; see also Busse et al. 2021). Despite their knowledge on biodiversity-increasing measures and their sense of agency, the relational value attributed to biodiversity might not be sufficient, or the negative instrumental values associated with biodiversity might outweigh the relational values associated with biodiversity and its conservation. Further research can clarify this.

4.2.2. Yield quality and quantity parameters

The importance of biodiversity is strongly connected to its diverse roles within agriculture. There is a broad consensus among the interviewed farmers that a species-rich field generates lower production yields (i.e. fodder quantity), while past research from experimental systems suggests the contrary (Hector et al. 1999; Tilman et al. 2001). According to most of the interviewed experts, grassland management intensiveness must decrease if the goal is to achieve high biodiversity levels, even if such a decrease leads to lower production yields. On the other hand, there is an even broader consensus among the farmers that a higher level of biodiversity does not lead to lower fodder quality. Even though some studies confirm this by showing that plant diversity substantially increases quality-adjusted yield and revenues (Schaub et al. 2020), one expert (Alpine environment) stated that a higher level of biodiversity would lead to a deterioration of fodder quality in terms of nutrient concentration and digestibility. Timing of fodder use via grazing or mowing can substantially affects fodder quantity and quality. While later mowing or grazing in biodiverse swards is essential for seed dispersal and biodiversity conservation, some research has shown that when mown at the same time, the quality between swards with lower diversity swards is similar to that of higher diversity swards (Bruinenberg et al., 2021). It is only later on in the season, when phenological diversity among more diverse swards can lead to lower quality of the fodder yield (Tallowin and Jefferson 1999), making negative effects on milk production apparent (Chilliard et al., 2007). Therefore, exploring ways in which species-rich fields can be maintained while not foregoing on fodder quality losses is highly relevant. This could include providing more space for experimentation (e.g. timing of grazing or mowing, certain seed mixtures) in conserving biodiversity simultaneous to producing high quality Alpine agricultural products (e.g. flavor in cheese: Bugaud et al. 2001; Manzocchi et al. 2021). The goal would be to make the issue of quantity losses less

Currently, farmers seem to have a clear preference for fodder quantity over fodder quality since an increase in income yield through fodder quantity increase exceeds a possible income yield increase through improved quality. Moreover, farmers seem to be highly satisfied with the quality of their final products. Farmers in all municipalities declare the wish to produce and sell high quality products, such as hay, milk, and cheese. Their reluctance towards improving fodder quality via biodiverse fields could stem from their satisfaction with the current quality of their products, and perceived little need to experiment or change yield outcomes. The farmers' potential actions towards increasing biodiversity might also

be impeded by certain signals that are being sent by incentive programs. It can be assumed that the direct and indirect incentives for agricultural products still focus on fodder quantity and that it is therefore more profitable for the farmers to produce a lot rather than to produce high quality goods with more diverse flavor spectrums (e.g. Manzocchi et al. 2021). Several experts (nature conservation, Alpine environment, grassland management) emphasize that local and European incentive policies are primarily targeted towards maximizing the production in terms of quantity (of fodder, livestock units etc.) instead of increasing biodiversity and thus optimizing the production in terms of quality. This can be ascribed to the Common Agricultural Policy (CAP) failing to incentivize biodiversity conservation and instead focusing on productivity, farm income, and affordable prices (Pe'er et al. 2019; Pe'er et al., 2020). The CAP's direct payments, which make up for more than half of the CAP budget, are distributed to farmers based on the hectares of farmed land and are mostly decoupled from environmental or qualitative goals (Pe'er et al. 2019; Pe'er et al., 2020; Regulation 1306/2013). While a smaller part of the CAP, including agri-environmental and climate measures (AECM), is targeted towards biodiversity and nature conservation, its requirements are vague and proper law enforcement is lacking (Pe'er et al., 2020). On a local level, we can also see the tendency to set minimal requirements for AECM, e.g. a relatively high maximum density of livestock units per hectare on grassland (Provinz Bozen 2016). Continued exploration of possible solutions for improving and making the most of diversity-quality relationships could be a possibility for more nuanced pathways towards effective, practical conservation.

The share of farmers who attribute such positive effects on fodder quality to biodiversity is higher in Cortina d'Ampezzo than in the two other municipalities. This could be explained by the fact that grassland management incentives in Cortina are less contingent on productivity, which lead farmers to focus on improving the quality of the final products instead of increasing the biomass quantity. Furthermore, since biomass increase is limited due to the high elevation of the slopes in Cortina d'Ampezzo, the farmers might have shifted their focus from fodder quantity to fodder quality, and it is possible that diversified incomes due to higher tourism in this region also provide some insurance (Wanner et al. 2021). Moreover, two experts (nature conservation, Alpine environment) stressed that the overall potential income yield of extensively managed fields can still be high because of lower investment costs, less labor input, and consequently a higher chance for farmers to pursue other jobs outside their farms. Such a shift in management would



mean that farmers would reevaluate their values and revisit the roles that shape their relationship to biodiversity.

4.3. Farmers' roles in managing biodiversity

Farmers' roles have always been embedded in a placebased agricultural context which simultaneously shaped and was shaped by ideas of what constituted a "good farmer" and what "good farming" was (Burton et al. 2020). In order to understand how farmers evaluate their actions' impact on biodiversity, it is important to examine their perceived role within this agricultural context. Farmers can have identities not only as farmers, but also as producers or as stewards of the land (Chapman et al. 2019; Kreitzman et al. 2022). Within these roles, they usually act according to what they consider "good farming" practices. Farmers generate symbolic capital through their activities and skilled role performance (Burton et al. 2020). Thus, farmers do not necessarily benefit from an objective measure of farming practices, but from the comparison and the visual representation of their practices with those of their farming peers. An example for such good farming symbols is a tidy agricultural landscape and its recognition by the farming community. Good farming symbols can also entail economic considerations: fields without bush encroachment and with intact swards are not only evidence of the farmers skilled role performance and tidiness in managing their land (e.g. through correct fertilizer application and successful weed control) but also of higher yields and greater profits (Sutherland and Calo 2020). Based on the farmers' conception of good farming", they might have certain relational values, meaning an idea of what the relationship between humans and land should look like.

The aggregated, collective mental model of biodiversity that emerged from our findings reflects that the farmers in this study see themselves, first and foremost, as producers (see left side of Figure 2). High yields in exchange for their work are their highest priority. They thus seek recognition for their entrepreneurial actions and derive symbolic capital from their profits. Secondly, they perceive themselves as preservers of the cultural landscape since they keep the landscape open and tidy and, by doing so, demonstrate their skills in managing their fields to their peers (upper right of Figure 2). Considerations related to history and tradition play a key role when it comes to the farmers' identity as preservers of the cultural landscape. In our study, many of the farmers aim to keep the landscape open in order to continue in the tradition of their ancestors. In fact, symbols of good farming often entail long term practices that have been passed on between generations and the farmers' socialization within the farm household (Sutherland and Calo 2020) or fostered with the use of agri-environment schemes (Cusworth 2020). However, one expert argues that the current generation of farmers, since not having witnessed the drastic change that grasslands have undergone during the previous decades, cannot know what the traditional cultural landscape looks like and therefore cannot consider themselves as its preservers. The idea of what is considered to be a good farmer is crucial to the decision-making processes of farmers and might also help explain why farmers are resistant to change (Sutherland and Calo 2020). Most farmers in our study seem to have a rather un-dynamic vision of the future development of grassland management. They wish for the local landscape to remain open, and they want to avoid farm abandonment. What moves and motivates the farmers is not so much the adaptation of grassland management to possible future shocks but rather the preservation of grassland farming as it is today. Most farmers do not think of their fields as in need of change or improvement but as something they want to preserve and protect from change.

In their perceived role as preservers of the landscape, many of the farmers also consider themselves as landscape stewards since they prevent farm abandonment and bush encroachment by keeping the landscape open, thus counteracting biodiversity loss. The biodiversity they are thereby preserving is essential for the wider environment (lower mid-right part of Figure 2). Their role as preservers of the cultural landscape and their role as environmental stewards seem to be strongly intertwined: most farmers believe that they positively impact the environment through these practices and act as preservers of the cultural landscape. It can be argued that their understanding of a "good farmer" (i.e. managing profitable fields and continuing the tradition of keeping the landscape open) fully justifies their idea of environmental stewards and conservers of biodiversity. The pursuit of biodiversity in grasslands via measures other than of keeping the landscape open cannot be observed. While most experts agree that farmers contribute to the cultural landscape by managing steep slopes and impractical grasslands, several experts (Alpine environment, nature conservation) argue that grassland management has also led to numerous bonification and melioration measures, forest clearance, conversions of forests into grasslands, and the disappearance of landscape features - measures which ultimately have led to an increased simplification of the landscape and cannot be considered as beneficial to the environment, nor to relational values (e.g. Riechers et al. 2020).



5. Conclusion

This study showed how farmers perceive biodiversity, and how their perceptions of biodiversity relate to different aspects of Alpine agriculture now and in the future. Using a mental model approach was helpful to map out how farmers perceive biodiversityagriculture relationships in grasslands now and in the future, and how these are associated with coexisting roles that farmers have or take-on. We have five main findings from our study: 1) farmers have different understandings of what 'biodiversity' means, but mostly thought of plant species diversity; 2) individual plant species have a negative instrumental value for farmers due to their effect on fodder quantity; 3) higher biodiversity is linked with lower fodder quantity but higher quality, 4) farmers have a higher relational value for biodiversity more broadly; and 5) these contrasting values that biodiversity have are associated with co-existing roles that farmers have. This study should be seen as a contribution to a broader and more multifaceted understanding of biodiversity and towards designing a more nuanced pathway towards biodiversity conservation that moves away from the dichotomy spanning from an either/or approach to both conservation and marketoriented production. We mainly mean to reflect Alpine farmers' mental model of biodiversity and its influence on their grassland management decisions. This study could be followed by analogous research focusing on other stakeholder groups or, ideally, by participatory research methods bringing together various stakeholder groups to discuss how findings may be applied in practice.

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