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Localized Agri-Food Systems and Biodiversity

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Abstract: Interest in localized agri-food systems has grown significantly in recent years. They are associated with several benefits and are seen as important for rural development. An important share of the academic debate addresses the contribution of localized food systems to the current and/or future sustainability of agriculture. Sustainability is defined in several ways, but many scholars recognize that sustainability can only be achieved by a combination of socio-economic, cultural, and environmental aspects. However, the attributes and indicators used for sustainability analyses also differ. Biodiversity is, for instance, often not included in analyses of environmental sustainability even if biodiversity is of crucial importance for longer-term ecological sustainability. To contribute to the debate about the importance of localized food production for sustainability from the environmental point of view, specifically with regard to biodiversity, this is therefore discussed based on the results of several studies presented in this paper. The studies focus on Nordic low-intensity livestock systems related to species-rich semi-natural grasslands. All the studies show that low-intensive agriculture and use of semi-natural grasslands may play an important role in maintaining biodiversity on both small and large scales. They also show that milk and dairy products from free-ranging livestock in heterogeneous landscapes with semi-natural grasslands may have a unique quality associated with local grazing resources. Thus, producers can combine production of food of documented high nutritional and gastronomic value with maintenance of biodiversity, i.e., localized agri-food production based on low-intensive agriculture systems and semi-natural grasslands may be a win-win recipe for both farmers and the society.

Keywords: localized agri-food systems; biodiversity; semi-natural grasslands; low-intensive agriculture; summer farming

1. Introduction

Interest in short food chains [1,2], and localized agri-food systems has grown significantly in recent years [3–5]. Localized food systems (LFS) are associated with several benefits [4], such as high competitiveness, because their products are strongly linked to local assets (nature, knowhow, and tradition), which are highly valued by local consumers [6–10]. Local culture, tradition, place, and origin-based quality are important in the creation of values [8,11,12], and localized food systems may contribute to preserve heritage and traditions [13]. In addition, there are a number of studies that have accounted for the contribution of Geographical Indications and other immaterial rights to promote localized food systems and the creation of economic, cultural, and other values [14,15], including a more sustainable food production [16] through practices that help promote biodiversity [17]. The emergence of new and implicitly more inclusive and fair governance models based on specific characteristics and territorial features [18], the empowerment of local communities [19], and the contribution to the generation of income and social cohesion through collective action rather than just achieving simple economic agglomeration/cluster effects [6,20] are other benefits.

Local food systems can be based on a large area, produce a large amount of goods (with a semi-intensive method of exploitation), and generate quite well-known products that generate large revenue for the local community, such as Parmigiano-Reggiano, a local cheese produced in a well-delimited area between the cities of Parma Reggio nell'Emilia in Italy. However, local food systems can also be composed by very extensive production systems in small and isolated areas where the products are only known locally. The current article focuses on the latter.

The viability of localized food systems goes beyond the economic, cultural, and environmental aspects. An important characteristic of localized food systems is that these systems seem to address consumers fears in relation to industrial food by offering an insight to the production process, or by offering re-assurance through face-to-face meetings between producers and consumers [21–23]. By strengthening the economy of farmers, localized food systems may also counteract the demographic effects of agricultural modernization if young producers are aware that the history and method of food production are qualities for which consumers are willing to pay [24]. To sum up, previous research reinforces that localized food systems are vehicles of substantial benefits [1].

An important share of the academic debate addresses the contribution of localized food systems to the current and/or future sustainability of food production. The term "sustainability" is difficult to define and is described differently depending on the context of the publication [25]. Many scholars use a comprehensive definition of sustainable development as "systems of production and consumption that satisfy the needs of today without damaging and reducing availability of natural resources, e.g., by not endangering the needs of future generations" [26–28]. Some scholars concentrate on narrower definitions of sustainability, such as socio-economic sustainability [29] or environmental sustainability [19]. In this paper, we recognize that sustainability can only be achieved through the combination of socio-economic, cultural, and environmental aspects. The complexity of these human-environment interactions is, however, difficult to capture in economic and agricultural modelling [30,31], and the attributes and indicators used for sustainability analyses differ widely. Biodiversity is for instance not always captured by the indicators for ecological sustainability even if biodiversity may be of crucial importance for longer-term ecological sustainability/resilience of ecosystem functions and ecosystem services, as well as for productivity in natural and human-managed ecosystems [32,33]. Agricultural intensification is among the key threats to biodiversity in Europe [34]. On the other hand, low-intensive agriculture may maintain biodiversity [34], and farmer's local experiential knowledge may enhance resilient agriculture [35]. The purpose of this article is therefore to contribute to the debate about the contribution of localized food systems to sustainability from an environmental point of view, specifically regarding its contribution to the maintenance of biodiversity in semi-natural grasslands. Furthermore, new knowledge about connections between the quality of pasture-based localized food products and biodiversity is presented. The recent increase in the interest for localized food has been based on beliefs that localized food is more sustainable and healthier than industrial products [36]. However, good and healthier quality of localized food products is mostly claimed without scientific evidence. Based on the results from some Norwegian and Swedish studies, new evidence for this is therefore also presented and discussed.

2. Materials and Methods

This paper focuses on localized agri-food systems and their effects on biodiversity in Nordic cultural landscapes. More specifically, it focuses on low-intensity livestock systems related to species-rich semi-natural grasslands.

The sources of empirical information are the findings and experiences of previous research projects. These projects were carried out in Norway and Sweden, and include topics such as traditional land-use practices, localized food production, management activities, and their effects on biodiversity in rural areas. The studies presented here deal first and foremost with localized food production in mountainous summer farming landscapes, but experiences and study findings from the lowlands and the coastline are also included.

Literature reviews, databases, and historic archives have also been used in this paper. Databases from the Norwegian Environment Agency, the Norwegian Biodiversity Information Centre, the Swedish Species Information Centre, the Finnish Environment Institute, and the red list from Aarhus University, Denmark have been used to sum up Nordic trends for red-listed nature types and species.

3. Farming Practices Have an Immense Impact on Biodiversity

Agriculture was introduced in Europe about nine thousand years ago [37], and reached Scandinavia about six thousand years ago [38]. European agriculture was an integrated system of cultivation and grazing systems [39]. In Norway, and partly also in the other Nordic countries, agriculture has been based on an outlying land − infield farming system since the Iron Age until the 20th century. Arable land is scare in Norway but outlying land (Norwegian: *utmarka*) offered large areas for grazing, fodder harvesting, and production of timber, firewood, fence materials, charcoal, etc. This extensive use of outlying land resulted in varied and open landscapes with a variety of different semi-natural nature types, such as grazed forests, coastal heathlands, mown fens, and semi-natural pastures and hay meadows [40]. Today, all these semi-natural nature types are threatened or near-threatened in Norway [41], as well as in many other European countries [39].

3.1. Grasslands

Husbandry is a key factor for maintaining most of the semi-natural nature types. Grazing and mowing keep the landscape open and create grasslands. Grasslands still constitute about 45 percent of European arable land [42]. Most of them are cultivated or improved grasslands with low biodiversity, though natural and semi-natural grasslands still exist. Natural grasslands have long existed in Europe, probably since the Ice Age. During the glaciations, grasslands covered most of the terrestrial ice-free areas, while during the interglacials they broke up into small areas [43]. Natural grasslands occur where conditions are too wet, too cold, too instable, or otherwise too extreme to allow tree growth. The area of such grasslands in Europe is small [37,39].

Semi-natural grasslands have been developed in Europe by low-intensity land use since the beginning of the Neolithic period, the last stage of the Stone Age. Semi-natural grasslands are defined as grasslands with or without bushes and/or trees, are characterized by native species, and are not intensively managed, i.e., they have not been cultivated and sowed or agriculturally improved through regular applications of fertilizers. They are mostly characterized by high biodiversity, especially if they are open, semi-dry, and base-rich [37,39]. Long continuity also enhances biodiversity [44,45]. Some semi-natural grasslands have developed from natural grasslands and the borderline between natural and semi-natural grasslands are diffuse [46]. However, most of the European semi-natural grasslands were created where the natural vegetation is forest, and would become overgrown if grazing or mowing were to end [37,39].

3.2. The Effect of Grazing and Mowing on Biodiversity

Semi-natural grasslands are complex ecosystems in which the farmer and the livestock interact with other biotic and abiotic factors. Grazing and mowing influence vegetation in several ways. Removal of biomass by mowing and grazing suppresses regeneration of bushes and trees, i.e., maintains the open areas and the grassland flora. Grazing and mowing also result in quite low nutrient content in the soil. This reduces possibilities for nutrient-demanding plant competitors and creates better conditions for small, light-demanding species. Trampling both destroys plants and creates gaps in the vegetation that are suitable for seed germination. Deposition of dung and urine increases variation in the nutrient levels in the soil and thereby creates possibilities for several different species. Furthermore, dung and animals themselves are important for seed dispersal. Since livestock prefer certain species and vegetation types over others, mosaics of more or less grazed areas may be

created on both small and large scales. These and other processes contribute to the development and maintenance of species-rich semi-natural grasslands [47–50].

3.3. Red-Listed Nature Types and Species, Trends in the Nordic Countries

Semi-natural grasslands have played an important role in European agriculture, and to some extent still do. In Western Europe, however, these areas have diminished significantly, and many of those that remain are threatened either by intensified agricultural management, such as cultivation and fertilization, or by abandonment and reforestation [39]. This development has resulted in long red lists of threatened plant and animal species that depend on these habitats.

The Norwegian Red List for Ecosystems and Habitat Types 2011 [41] stated that land-use changes were the most important impact factor for all the red-listed habitat types. For semi-natural habitats such as grasslands, hay meadows, and coastal heathlands, encroachment by bushes and trees due to ceased agricultural management is the most important impact factor. Intensified agriculture, changed agricultural practices, and woodland planting are other important factors. About 24 percent of the red-listed species in Norway (including vascular plants, mushrooms, butterflies, beetles, and wasps) live in semi-natural areas [51] (Figure 1). Only forest habitats have more red-listed species than semi-natural areas in Norway. However, many forest areas have been utilized for extensive grazing. Grazed forests may be defined as semi-natural habitats [40,52,53] and some forest species that occur there are also favored by or dependent on traditional low-intensive agricultural management [54].

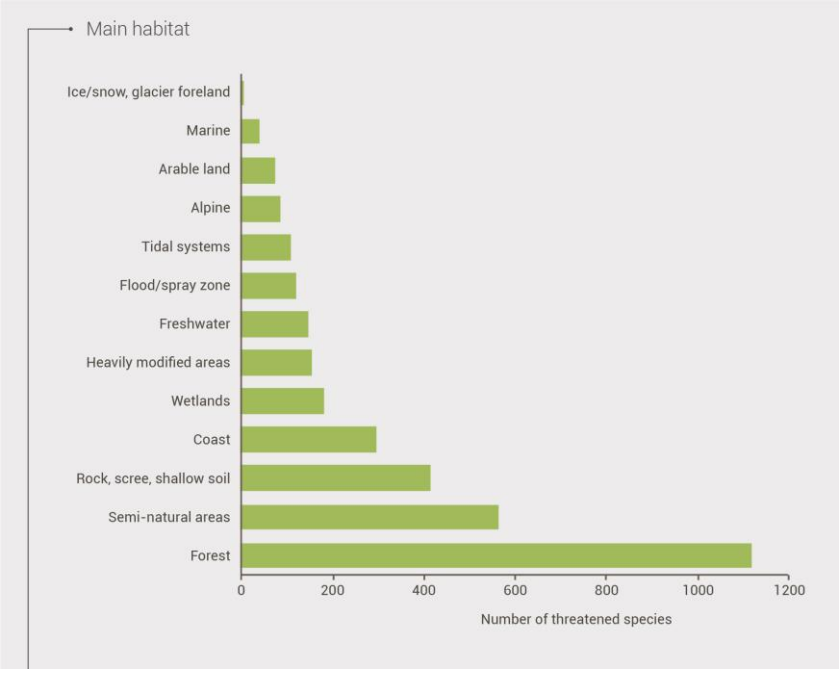

Figure 1. The distribution of threatened species in Norway 2015, classified by main habitats [51]. Norwegian Biodiversity Information Centre, CC BY 4.0.

Also in Sweden, encroachment by bushes and trees represents one of the greatest threats to the red-listed species today [55]. Several habitats such as meadows, pasture forests, and wetlands are overgrown due to cessation of hay cutting and grazing. Other red-listed species are threatened due to lack of natural disturbances such as fire and flooding, to land-use changes such as tree planting, fertilization, and ditching, or to nitrogen deposition and a warmer/drier climate [55]. In Finland, most of the threatened species also depend on forests (36.2 percent) or rural and semi-natural habitats (22.3 percent) [56]. In Denmark, 56 percent of the butterflies are now red-listed [57], and plants and animals are disappearing faster now than ever before [58]. More than 10 butterfly species have

become extinct, such as the wood white (*Leptidea sinapis*). (The wood white caterpillars use meadow plant species as food plants.) This accelerated disappearance of species is caused by the intensive exploitation of land areas and natural resources, i.e., intensified farming, forestry, urban development, infrastructure, and manufacturing [58].

These Nordic trends for threatened habitats and species show that semi-natural habitats, like grasslands (grazed forests, pastures, and hay meadows), must be maintained to prevent loss of biodiversity.

4. Results of Some Studies of Localized Food Production

In the present paper, some studies from Norway and Sweden are presented to highlight the importance of low-intensive farming for biodiversity (Figure 2). Three of these studies also demonstrate that grazing on semi-natural grasslands may result in high-quality food products (Table 1).

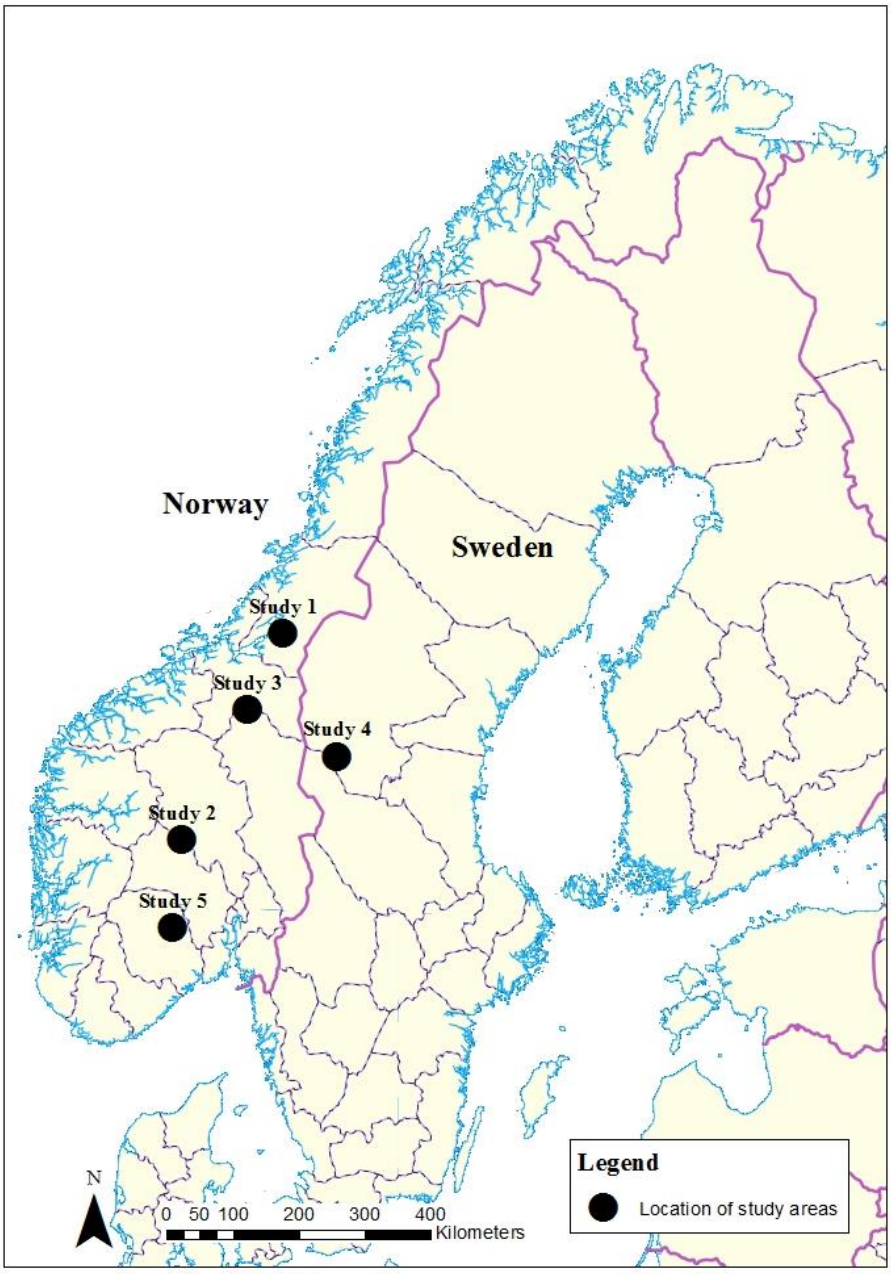

Figure 2. The study areas in Norway and Sweden. Source: Norge Digitalt.

Table 1. Main geographical characteristics of study areas, protected area status, land use practices, and effects on biological values and food products.

Study Number	Name on Area/Region	Vegetation Zone/m.a.s.l./mm Annual Precipitation	Protected Area Status	Traditional Land Use Practices	Management Practices Today	Effects on Biological Values	Effects on Food Products
Study 1	Rinnleiret/central Norway	Southern boreal zone/0–20 m.a.s.l./800–1000 mm	Nature Reserve/Ramsar site	Cattle, horse and sheep grazing together with, military activity. Grazing ended in 1970-ies and military activities in 2002.	Restoration by removal of bushes and trees, and sheep grazing started in 2004.	Restoration and introduction of grazing animals have had positive effects on vegetation structure, plant diversity and bird populations. High biodiversity at large and small scales.	Not investigated
Study 2	Hjartdal-Svartdal/ southern Norway	Boreo-nemoral-south -boreal zone/200-700 m.a.s.l./1050 mm	Selected agricultural landscape in Norway	Grazing, mowing, coppicing, pollarding in infields and on outlying land.	Grazing, mowing, pollarding	High number of semi-natural nature types (hay meadows, pastures, small road verges) and grassland species. High biodiversity at large and small scales.	Not investigated
Study 3	Budalen/central Norway	Northern boreal zone/600–900 m.a.s.l./500–800 mm	Landscape protection area/selected cultural landscape in Norway	Summer farming and grazing by herded cattle, horses, goats and sheep, mowing meadows and fens, harvesting of lichen, pollarding, coppicing.	Summer farming, grazing by free ranging cattle, sheep and goat, mowing of some meadows.	Mosaic of red-listed semi-natural nature types (hay fens, hay meadows, grazed forests, boreal heath) and red-listed species. High biodiversity at large and small scales.	Local products (sour cream, brown whey chees) show higher levels of beneficial fatty acids, β-carotene, and vitamin E (than corresponding industrial products).
Study 4	Östvallen/central Sweden	Northern boreal zone/810 m.a.s.l/500 mm		Summer farming and herded grazing livestock, mowing meadows.	Summer farming, free ranging grazing by cattle.	A mosaic of heavily grazed patches of pastures and more extensively grazed spruce forests and fens. High biodiversity at large and small scales.	Higher levels of favorable fatty acids, β-carotene and vitamin E in local cream (than in corresponding industrial product).
Study 5	Valdres and Hallingdal/eastern Norway	Northern boreal-low alpine zone /910–1040 m.a.s.l./500–800 mm		Summer farming and grazing by herded cattle, sheep, goats and horses. Mowing, coppicing and pollarding in infields and on outlying land.	Summer farming, free ranging grazing by cattle and sheep, grass production (infields).	A mosaic of semi-natural grasslands, heathlands, fens and different forest types. High biodiversity at large and small scales.	Levels of β-carotene in milk increased with higher proportions of herbs eaten; the milk was characterized by high levels of favorable fatty acids, low ratio omega-6: omega-3, high number of terpenes (compared to corresponding industrial milk).

4.1. Study 1. Grazing Effects in Semi-Natural Tidal Meadows, Central-Norway

Many semi-natural habitats have existed in the landscape for so long that people regard them as natural. This can be exemplified by sea shore tidal meadows. In Norway and Sweden, tidal meadows along the coastline have been used for grazing or hay cutting. In former times, before fertilizers were used, these semi-natural habitats were especially important for the farmers, since their nutrient content and production were maintained by daily floods/high tides. Agricultural modernization and discontinued use of tidal meadows have resulted in vegetation changes. In southern Norway, the species-rich tidal meadows are now largely replaced by dense zones of common reed (*Phragmites australis*) and tidal meadows have become near-threatened (NT) [41].

The tidal meadows are important for the diversity not only of plant species but also of birds and insects [59]. Many ornithologists have seen grazing livestock as a threat to nesting birds [60]. However, a study from Rinnleiret Nature Reserve in Trøndelag County shows that the opposite is the case.

Rinnleiret (2.4 km^2) is a subsite of a large wetland system along the Trondheim fjord. The area is a protected Ramsar site, which is of great importance to migratory birds. As many as 225 bird species have been observed in this area [59]. Rinnleiret has been used for military exercises, but also for grazing. About 200 farm animals (horses, cattle, and sheep) used to graze there. However, grazing ended in the 1970s and military activities ended in 2002. This resulted in a process of rapid overgrowing, vegetation changes, and a dramatically reduced number of nesting birds.

In 2004 a management plan was therefore developed [61], and management activities began. Trees were felled, invading, alien species such as Japanese rose, *Rosa rugosa*, were removed, and grazing animals (sheep) were once again turned out to restore and maintain landscape and biodiversity values.

In 2013, the management plan was revised and the effects of management activities evaluated [62]. Restoration and grazing (Figure 3) had produced positive results with regard to the semi-natural habitats, vegetation structure, and plant diversity, i.e., they had resulted in a development towards the old semi-natural vegetation types and cultural landscape. Bird populations had also developed positively, even though the conservation targets were not reached in 2012 [61,62].

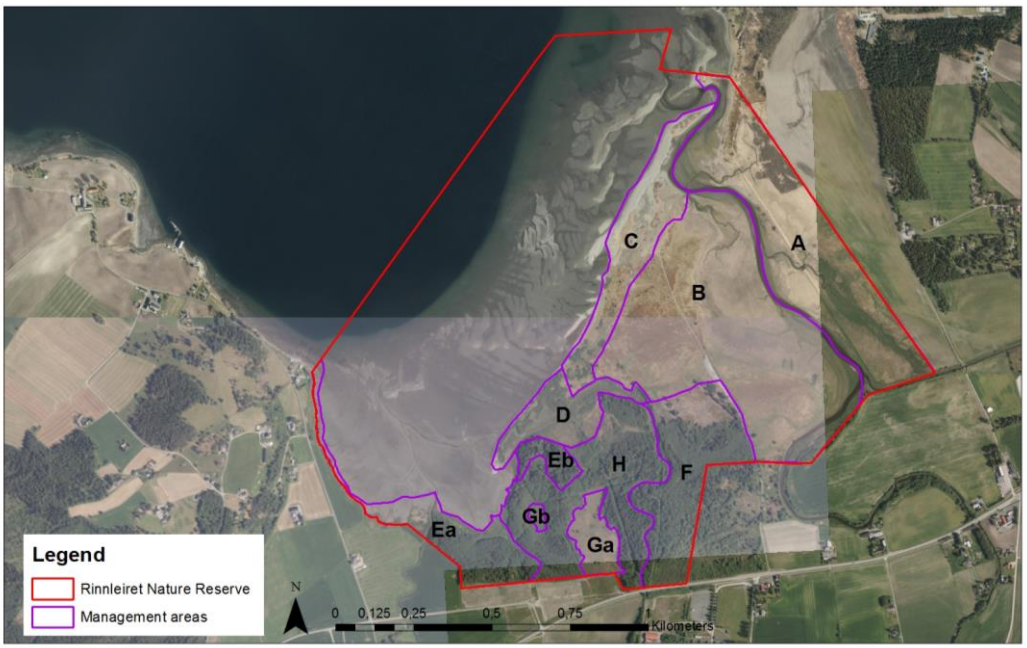

Figure 3. Management map for Rinnleiret Nature Reserve. In 2004 different management regimes for preserving biodiversity were introduced in different areas (marked with letters A–H) [62]. Source map: Norge digitalt.

This project shows that habitats, by many people seen as natural, may be semi-natural and thus depend on maintenance of traditional low-intensive agriculture to avoid loss of biodiversity at different scales.

4.2. Study 2. A Pastoral Mountain Landscape in Southern Norway

The importance of low-intensive agricultural management for biodiversity can be exemplified by a study of the Hjartdal–Svartdal area of Telemark County southern Norway. This area is situated 200–700 m above sea level and consists mainly of two river valleys surrounded by mountains. There are deciduous forests in the bottom of the valleys but in the rest of the study area the forests are partly mixed, partly coniferous. The main part of the area has long been used for grazing, fodder production, mowing, coppicing and pollarding, cereal and potato growing, etc. This has created a landscape with a mosaic of more or less human-influenced vegetation types with many cultural monuments, such as characteristic, old wooden buildings.

Vegetation analyses and a comparison between the biodiversity of the different grassland habitats in this area showed that the semi-natural hay meadows had the highest average number of plant species per subplot, and that they contained several species that did not occur in the other grassland habitats. Furthermore, many grassland species had their largest populations in the semi-natural hay meadows (Figure 4). The semi-natural pastures and verges along small gravel roads were also species-rich and contained characteristic grassland species, while the more modern hay meadows were less species-rich and contained common species and species characteristic of fertilized meadows [63].

Figure 4. Semi-natural grasslands are usually species-rich. Photo: Ann Norderhaug.

Even though agricultural modernization has also caused land-use changes in this area, both cultural monuments and old semi-natural hay meadows, pollarded trees, grazed forests, and semi-natural pastures are maintained. Important ecological landscape structures were mapped and the landscape heterogeneity examined by interpreting infrared aerial photos. The results showed that this rural area was a small-scaled, high complex landscape. In other words, it was a landscape with high biodiversity at both a large landscape scale and a small habitat scale [63].

The locals are proud of their cultural landscape, and use the landscape values in different ways for rural development. One of them is a mohair goat farmer, who is interested in the connections between farming, landscape, biodiversity, and product quality. Today, she has successfully developed a value-adding chain from semi-natural grasslands to wool products [64,65].

4.3. Study 3. Traditional Mountain Summer Farming, Central Norway

The main purpose of summer farming in Norway was to utilize grazing and winter fodder resources, as well as other natural resources in remote mountain and forest areas [66]. Summer farming was common all over the country. Many farmers had several summer farms at different altitudes and distances from the farm in order to utilize the best pastures during seasonal movements. Mountain summer farming was the most common form, though forest and island summer farming were also practiced [66]. Intense grazing in mountain areas in western Norway dates back to 500 BC, but extensive grazing probably originated even earlier [40]. In 1850 there were between 70,000–100,000 summer farms in Norway [67], but in the late nineteenth century summer farming began to decrease, due first and foremost to the agricultural revolution. Nonetheless, many summer farms were used until the Second World War. In 2015, however, the total number of summer farms with milk production numbered only about 900 [68].

Summer farming usually lasted for three to four months, and all the farm animals could stay on the summer farm. The cows and goats were milked twice daily. The milk was used to produce products such as cheese and butter, which were stored until they could be transported down to the farm. During the day, the livestock were herded to protect them from being attacked by carnivores. It was also important that herding made best possible use of the grazing resources within the area. Today only cows or goats are kept on summer farms, and they are not herded but allowed to roam free from morning milking until evening milking.

The summer farming valley Budalen is located at 600–900 m above sea level in Trøndelag County, central-Norway. Mountain pastures and meadows were created by traditional low-intensive farming practiced there since the eighteenth century [69]. The number of active summer farms in Budalen has halved since the 1990s, and 13 summer farms with milk production now operate in the area.

A mosaic of semi-natural vegetation types with high species diversity is characteristic for the Budalen area [70]. Grasslands, intermediate fens, birch woodlands, and heathlands represent important grazing resources (Figure 5). Several of the nature types are red-listed: semi-natural grasslands (VU, vulnerable), semi-natural hay meadows (EN, endangered), grazed forests (NT, near threatened), hay fens (EN, endangered; CR, critically endangered), and boreal heaths (DD, data deficit) [41]. There are also several red-listed species in this cultural landscape, such as white frog orchid, *Pseudorchis albida* (NT), and field gentian, *Gentianella campestris* ssp. *campestris* (NT) [51]. A GPS-study on resource use by modern and old dairy breeds in this summer farming landscape showed that the free-ranging cows still utilized large parts of the landscape for grazing [71]. The cows travelled maximum 7.6 km per day, taking different routes every day and utilizing pastures up to 880 m above sea level. Both breeds preferred grass and herb-dominated semi-natural pastures and meadows, but they also grazed on a wide range of other habitats, such as hay fens and birch forests. By making extensive use of the old summer farming landscape, the cows contributed to maintaining the mosaic of (red-listed) semi-natural habitats and red-listed species depending on these nature types. The old breeds had a higher frequency of bushes and trees in their diet, and may perhaps be better to keep the landscape open, i.e., be better "landscape managers" than modern breeds.

Figure 5. A heterogeneous landscape with high biodiversity in the Budalen summer farming valley, Norway. The landscape has been formed by herded livestock and is to a large extent maintained by free ranging cattle and sheep. Photo: Bolette Bele/NIBIO.

The study in Budalen also documented that the species-rich semi-natural grasslands represented valuable fodder resources for cows. An analysis was conducted of fodder samples and milk products from two summer farms in the area, and corresponding reference products were analyzed and compared to the localized food products. The results showed higher levels of beneficial fatty acids, β-carotene, and vitamin E in the summer farming products, which could be correlated and explained by the fodder quality [72–74].

4.4. Study 4. Traditional Forest Summer Farming, Central Sweden

In Sweden, development and establishment of summer farms began in the sixteenth century as part of an expanding use of marginal land. Forest grazing has been common in both southern and northern Sweden, but forest and mountain summer farming developed in the central part of Sweden and northwards, i.e., from Dalarna County to the southern part of Norrland (the northernmost five counties). Summer farming was an important part of the agriculture in this part of Sweden. However, due to the agricultural and industrial revolutions, the number of summer farms began to decline in the second half of the nineteenth century [75]. Today only a few summer farms still exist.

All types of forests have been used for grazing. Grazing reduces the content of bushes and keeps the field layer of grasses and herbs short. Grazed forests therefore often acquire a park-like appearance. Due to trampling and varied grazing intensity, grazed forests develop into mosaics of heavily, moderately, and not grazed areas. Patches that are intensively grazed develop a field vegetation with the same species composition as open semi-natural pastures [40,76].

The summer farm Östvallen in Jämtland County is situated 810 m above sea level, in a forested landscape of spruce (*Picea abies*), birch (*Betula pubescens*), and pine (*Pinus sylvestris*). Summer farming has been practiced in this part of the country since the sixteenth century. Jämtland County still has about 100 summer farms, but only 25 produce dairy products in the traditional way as at Östvallen [77].

The grazing area at Östvallen was mapped by photo interpretation and field studies [78]. The most common vegetation types in the area were bilberry forest and mixed forest (covering 61 percent of the total grazing area). Ten vegetation types were identified, several of which were classified as semi-natural. The studied summer farm herd (Figure 6) consisted of both the traditional breed Swedish Mountain Cattle and the modern breed Holstein [78].

Figure 6. The dairy cattle at Östvallen summer farm in Sweden. Photo: Bolette Bele/NIBIO.

Studies of grazing preferences and animal behavior showed that both breeds generally preferred the grass-dominated pastures and old hay meadows (even though they cover only 0.3 percent of the total grazing area). Common and valuable fodder species in these pastures and hay meadows were grasses such as common bent (*Agrostis capillaris*) and wavy hair-grass (*Deschampsia flexuosa*), and herbs such as alpine bistort (*Bistorta viviparum*), yarrow (*Achillea millefolium*), white clover (*Trifolium repens*), red campion (*Silene dioica*), autumn hawkbit (*Leontodon autumnalis*), and common sorrel (*Rumex acetosa*).

The most heavily grazed patches were found near the summer farm and along paths and trails in the landscape. This creates a diverse landscape and a gradient from the most intensively grazed patches close to the summer farm and the more extensively grazed areas in the surrounding forests and mires. Results from Östvallen show that overall the Swedish Mountain Cattle walked longer distances than the Holstein cows and grazed on more varied vegetation than Holstein [78], i.e., grazed on several different vegetation types. This traditional breed may therefore be more important for maintaining the cultural summer farming landscape than the modern breed, since they use more of the landscape and thereby contribute to maintaining several semi-natural habitats by grazing, trampling, and seed dispersal of pasture species.

Like the milk products from Budalen, analyses of milk products from Östvallen showed quality differences compared to industrial products (higher content of vitamin E, carotenoids, and favorable fatty acids) [73,74].

4.5. Study 5. Traditional Mountain Summer Farming, South Central Norway

In the Valdres and Hallingdal regions of eastern Norway, two dairy cattle herds (Norwegian Red) from two summer farms were studied during three grazing seasons [79]. Both study areas are situated at altitudes between 910 and 1040 m above sea level. Traditional summer farming by free ranging dairy cattle has been practiced there for centuries, but the grazing intensity has decreased. Many of the semi-natural grasslands are today in an overgrowing process and invaded by bushes such as juniper (*Juniperus communis* ssp. *alpine*), willow (*Salix* ssp.), and trees as mountain birch (*Betula pubescens* ssp. *czerepanovi*).

Vegetation maps for both areas were made by interpreting infrared aerial photos and supplementing with fieldwork [79]. GPS recordings were used to log the animals' behavior and use of the landscape. Results from this study show that the average daily walking distance was about 4.8 km [79]. The cows held together and used different routes every day, giving the habitats a chance to recover between grazing events (Figure 7). The cows preferred grass and herb-rich vegetation,

but in Valdres the cows also grazed in forests. Because of their preferences for open, grass, and herb-dominated habitats, the free-ranging cattle contribute to maintain semi-natural vegetation types.

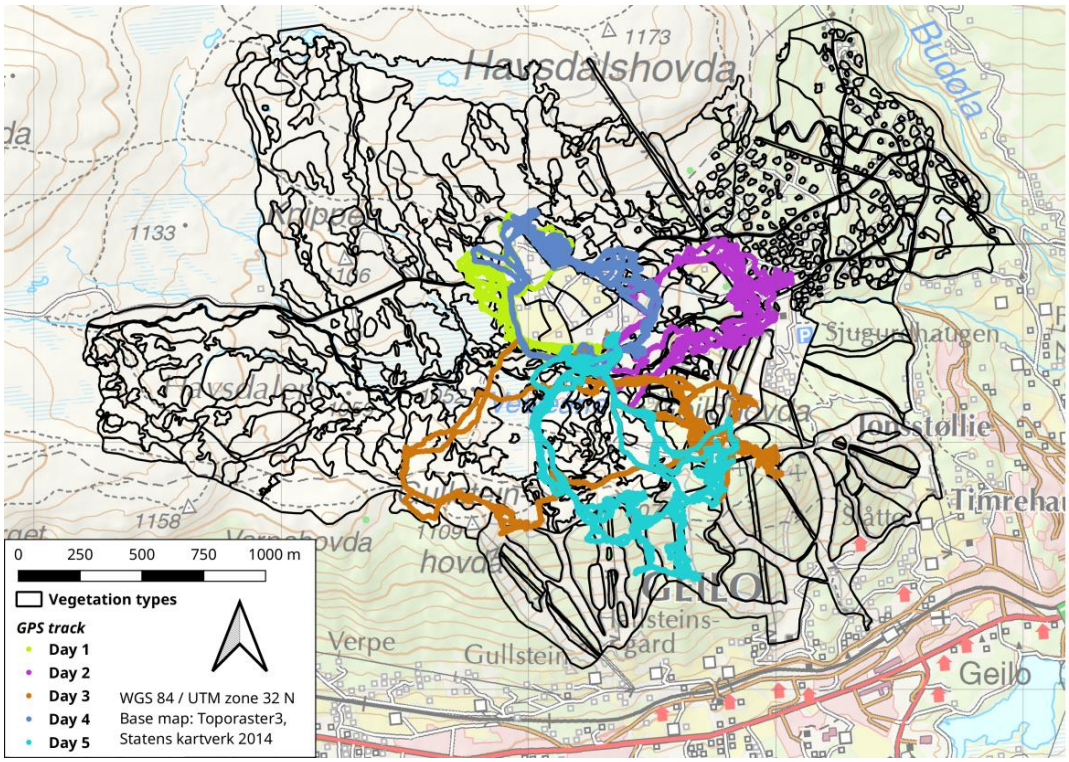

Figure 7. GPS tracking of the cattle herd in Hallingdal over 5 days in July 2009. The herd chose different routes every day. The cows thereby optimized their utilization of the grazing resources though they were no longer herded [79]. The black lines in the background is the vegetation map, i.e., the outlines of different vegetation types.

The animal diet was identified by field studies and microhistological analyses of faeces, and the content of fatty acids, carotenoids, and terpenes in the milk samples were analyzed [79,80]. In both study areas the connections between grazed plant species and milk quality was then examined. The results show that different plant groups on the rangelands were significantly related to the studied chemical components in the milk. For instance, the levels of β-carotene in the milk increased according to the higher proportions of herbs eaten. As a whole, the milk had low contents of unfavorable fatty acids, high levels of the favorable fatty acids, a low ratio omega-6: omega-3, and a relative high number of terpenes, i.e., a healthier composition than milk from grazing cows in Norway in general. Thus, summer farming can be said to produce unique milk products.

5. Discussion and Conclusions

The studies presented in this paper all show that low-intensive agriculture and the use of semi-natural grasslands may play an important role in maintaining biodiversity at both small and large scales, i.e., the maintenance of both the species richness of semi-natural habitats and the complexity and variation of the cultural landscapes. This is of crucial importance if biodiversity is to be maintained, since many (red-listed) species require such mosaic landscapes, i.e., landscapes comprising a mixture of at least two habitat types, such as forest edges and open grasslands [55,76]. Many studies have shown that promoting biodiversity requires enhancing heterogeneity on the landscape level, not just proper management of individual species rich habitats [81]. As seen in the case studies presented in this paper, low-intensive livestock farming may create such landscapes. Doyle [82] states that it is difficult to mimic the effects of livestock on the vegetation structure, as well as the soil structure,

since the animals do not act just as mowing machines but move around, rest some places, produce dung, etc., and thereby create conditions it would be impossible to establish in another way. OECD [83] also underlines that agricultural activity, beyond its primary function of supplying food and fiber, shapes the landscape and may provide environmental benefits such as the preservation of biodiversity.

Furthermore, studies 3–5 of summer farming landscapes show that milk and milk products from free-ranging livestock in these mountain cultural landscapes have a special quality associated with the local grazing resources. This finding tallies with several other studies documenting high nutritional and sensoric value in milk and meat produced on semi-natural grasslands compared to products based on cultivated pastures and/or concentrates [84–86]. For localized food producers, this documentation can be a competitive advantage over industrial products from high-intensive agriculture, giving local food a documented value, not just a "positive image". Provenza [87] states that we have broken the important links between plants, herbivores, and humans that our ancestors had. When domestic animals forage on heterogenous and phytochemically rich landscapes, they learn to find nourishing combinations of food, resulting in healthy products for humans. These links between humans and landscapes are weakened or destroyed by industrial farming and processed food production.

Some farmers say they do not want to be landscape managers, but rather food producers [88]. As our case studies show, the one need not preclude the other. By using semi-natural grasslands, localized food producers can combine production of food of high nutritional and gastronomic value and at the same time contribute to maintaining biodiversity. Norwegian and EU farmers can receive grants for promoting this threatened biodiversity and thereby strengthen their financial condition. The biodiversity of semi-natural grasslands includes both plant and animal species, such as, for instance, pollinators of high importance for agriculture and mankind [89–91].

Such low-intensive livestock grazing systems presented here, based on farmers' local experiential knowledge [35] promoting both biodiversity and production, may be a key factor for sustainable agriculture [92]. Semi-natural grasslands represent the sustainable use of nature resources and can often not be used for other agricultural purposes than grazing [39,40]. Due to climate change, the importance of such grasslands may increase instead of decrease, both because more food production is needed and because grasslands probably play a more important role in promoting climate changes than previously believed [93–95]. In addition, species-rich, semi-natural grasslands function as a kind of gene bank, i.e., as an in situ preservation of wild relatives of domesticated plants [89,90].

To conclude, localized agri-food production based on low-intensive agriculture systems and semi-natural grasslands may be a win-win recipe for both farmers and society.

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