NIBIO BOOK | Vol 4 no 11 2018

20th meeting of the FAO-CIHEAM Mountain Pasture Network
9th – 12th September 2018 in Ballstad, Lofoten, Norway

Adapting Innovation in Grassland Management

Book of abstracts

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Tjøtta – Norway 2018

Norsk Landbruksrådgiving

NIBIO
NORSK INSTITUTT FOR BIOØKONOMI

NORDLANDSFORSKNING
NORDLAND RESEARCH INSTITUTE

20th meeting of the FAO-CIHEAM Mountain Pasture Network
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Adapting Innovation in Grassland Management

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Organized within the framework of: Food and Agriculture Organization of the United Nations

This book of abstractes is published by:
NIBIO, Høgskolevegen 7, NO-1432 ÅS
post@nibio.no
Editor-in-chief: Research Director Per Stålnacke
NIBIO BOK Vol 4 nr 11 2018

ISBN-number: 978-82-17-02159-9
ISSN-nummer: 2464-1189
www.nibio.no

Frontpage: Views from Lofoten. Photo: Vibeke Lind (top) and og Finn-Arne Haugen (lower)

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FOREWORD

Welcome to the 20th Meeting of the FAO-CIHEAM Mountain Pasture Sub-Network in Lofoten.

This book of abstract should be regarded as a working document. This year, the organizing committee decided to change the structure of the contributions to be “extended abstracts” of one page per contribution. The invited speakers were allowed 10 pages for their contributions. Each contribution has a “take home message” also included in this book. There is room to take notes on each contribution.

The texts listed in this book have the merit to update knowledge and methodologies on how to adapt innovation in grassland management to farmers’ needs and societal and climatic changes. The geographical extent of the participants covers regions from all Europe, China, Israel, USA and the South-Mediterranean countries. Such a multiplicity of study areas reveal the richness of the network. The 20th meeting will set up an actual inventory of the research done at the field scale to better manage and preserve grasslands. Methods will be shared and common protocols established in a way to reinforce the scientific evidence of the mountain pastures contribution to agriculture and environment.

Technology has made its way also to farmers in the mountain areas. Virtual fences, GPS tracking of animals, estimation of stocking rate and planning grazing routines using technology is becoming daily life for more farmers. The new research findings can support management strategies and preserve or improve biodiversity and other ecosystem services.

The effects of climate changes in mountainous areas are forcing farmers to change management and adapt to new situations. At the same time, focus is on the agricultural sector to reduce greenhouse gas emissions of in particular CO_2 and CH_4. The outcome of the climate changes are both drought and floods. Plants must adapt to these changes and as a result also animals. Is it possible to predict the outcome of the climate changes?

The mountain agropastoral systems provide a large number of goods and services related to human activities. Tourism, biodiversity, use of native breeds, specificity of products and consumers perception are some examples. Possible conflicts and constraints affecting ecosystem services should be taken into account. Conflicts between domestic animals and wildlife is an ongoing topic in many mountainous areas with a focus on reducing these conflicts and at the same time taking care of both the wildlife and animal production and welfare.

The different sessions of the seminar will draw up a large panel of research activities on mountain grasslands. During the day trip, an organic goat farm producing local cheeses and a traditional sheep farm delivering premium lambs to Lofotlam will be visited. The visits illustrate some of the possibilities of a living in the mountains in the northern part of Norway.

On behalf of the organizers, we wish you a fruitful meeting and a lot of pleasure in exchanging knowledge on fascinating topics around mountain and hill farming.

Vibeke Lind

Leader organizing committee

Giampiero Lombardi

Coordinator of the Mountain Pastures Sub-Network

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Take home message

Karlsen and Haugen

Invited speakers

Lofotlam is produced at farms in Lofoten which are approved according to strict criteria (Lofotlam). The meat is considered tender and the sensory quality supreme due to the unique conditions at the pastures of Lofoten.

"Lofotlam" – from local specialty to brand

Gustav Karlsen[1], Finn-Arne Haugen[2]

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Introduction

During the past 40 years, the agricultural structure and farm sizes have changed dramatically in Northern Norway. The number of farms is reduced by 87 percent (from 26 000 to 3 300 units) and agricultural land use is decreased by 26 percent (from 1.2 million ha to 0.88 million ha). For livestock, the number of cattle is reduced by 19 percent, sheep by 20 percent and goats by 63 percent. The decrease of farm units is thus much higher than the decrease of land use for grazing and feed production. The consequences are bigger farms with a more intensive production for both livestock and land use, leaving other areas abandoned with no farms and extensive or no land use. The picture of Northern Norway is similar in Lofoten. However, the sheep production with its' long traditions is stronger than ever. Active sheep farmers have run a systematic breeding program and produced animals well adapted to exploit the extravagant resources and keep the unique landscape well groomed. The green mountains of Lofoten as they appear today is not a natural landscape but a cultural landscape because of generations' utilising the natural resources.

Every year, approximately 300,000 tourists visit Lofoten to experience the amazing archipelago far out in the sea. Here, we find the world's oldest mountain range (Lofoteruptivene), which builds on the characteristic Lofoten wall. In this unique landscape, the sheep have a central place. For millennia, these green mountainsides have developed a special flora, with nutritious herbs and rich pastures. The pastures are naturally salted with sea salt brought by wind and weather. This has an influence on the mineral content in the pastures and provide a large floral biodiversity.

Picture 1. Sheep at the Lofoten wall (photo: G. Karlsen)

The steep mountainsides and the cool growing season provide abundant access to young nutritious pastures throughout summer, for the sheep. Grazing from the top of the mountains to the seashore, also fresh seaweed from the North Sea is a natural part of the diet. Lofotlam is produced at farms in Lofoten, which are approved according to strict criteria. The lambs must be born and raised here, and in addition satisfy a variety of quality requirements. After approval at the slaughterhouse, the carcasses will be marked with our own brand of Lofotlam, before being shipped to the market.

The natural conditions for sheep production in Lofoten are good. There are few incidents with predators disturbing the sheep at pasture and the long light summer nights give lambs access to juicy pasture throughout the grazing season. The light is a major reason why Lofotlam has a greater muscle density, unique tenderness and distinctive aroma compared to lambs from more traditional mountain pastures in Norway.

Vegetation mapping

During the past six years, engineers in NIBIO have mapped the vegetation of approximately 290 km^2 of Lofoten. Focus is to document the quality and quantity of the pasture resources available for the sheep. A vegetation map contains information of botanical and ecological interest that can be used for several purposes. Utilization of nature resources, nature protection, and landscape management are some of them. A big part of the mountain areas in Lofoten lies below the climatic tree line. In Lofoten this is between 400 (at exposed areas to the west) and 500 (at areas protected against the weather) meters above sea level with an average of 450 meters. Studying the potential forest regrowth, regardless of climate change, shows that agriculture contribute to deforestation. The question of interest is how much forest will increase if we take the historical use of wood and the farmer and his grazing animals out of the equation.

Picture 2. Forest regrowth (Photo: F-A. Haugen)

Picture 3. Unstad (Photo: F-A. Haugen)

Today, approximately 15 percent of the land area in Vestvågøy municipality is forest. Another 40 percent is below the climatic tree line and could potentially grow into forest (Gjengroingsmodell, Skog og landskap 2012). Where regrowth and forestation happens, the cultural landscape changes dramatically. The only way to prevent the open mountain pastures to grow into forest is the use of livestock grazing. Grazing livestock, however, also changes the vegetation and species composition of plants. We find that grazing at productive soil types increase the proportion of Gramineae such as *Deschampsia cespitosa, Agrostis capillaris, Poa pratensis, Festuca rubra, Anthozanthum odoratum*. When grazing is limited, different species of ferns (e.g. *Athyrium filix-femina*, *Athyrium distentifolium*, *Dryopteris filix-mas, Dryopteris expansa*) will dominate the pastures. Ferns are not considered species of high grazing value. However, at pastures with a more moderate soil quality, the gramineae such as *Anthoxanthum odoratum* and *Agrostis capillaris* will increase while *Vaccinium myrtillus* and *Empetrum nigrum* dominates in abandoned areas.

Not all the consequences of the landscape forestation is negative. For the cultural landscape of Lofoten, however, there are some concerns which we will highlight in the following paragraph.

Picture 4. Fern encroachment (Photo: F-A. Haugen)

Reduced grazing quality. The first step of regrowth is often a dense layer of scrub that reduces the production of grass and herbs. Grasses and herbs are important species for the sheep, high in nutrients during the summer. The scrubs are covering grass and herbs from sunlight and uses water and nutrients from the soil. Dense scrub also reduces accessibility for grazing animals.

Reduced biodiversity. Regrowth of forest in the cultural landscape has a negative impact on 29 percent of the endangered species in Norway, and the number is increasing as the regrowth continues (E. Svalheim 2017). In general, the biodiversity will decrease with increased encroachment.

Fewer tourists. This is not a well-documented argument, but interview studies have shown that tourists react negatively on regrowth of forest at the degree that reduces the possibilities for viewing the landscape while hiking or driving by car (A.Bryn m.fl. 2013).

Locals' identity. The green mountains of Lofoten is probably a big part of locals' identity. They appreciate the fact that the landscape is created through generations who struggled to make a good life for themselves. Many of the locals express their concerns about the landscape change. The landscape created through a thousand years of activity could be changed dramatically during a few decades of inactivity and abandonment.

The green mountains in Lofoten is not a stabile landscape. It is a changing cultural landscape, which can only be preserved through management. The importance that grazing sheep have for preserving the Lofoten landscape is insufficiently communicated and may not even be fully understood.

Under these conditions, a group of people initiated the brand of Lofotlam; a product of high quality and sold all over Norway.

Picture 5. Nice day at work - vegetation mapping Unstad (Photo: F-A. Haugen)

Lofotlam named Norway`s best lamb

The general concept of food, changes with increasing living standards. Enough food for a growing population and health and balanced nutrition becomes important to us. This has led to increased interest in food safety, local and regional food specialties. Where the taste experience can be linked to special conditions at the production site, the product is in a special position, *Terroir*. Typical examples of *Terroir* from abroad are Roquefort and Parmasan products.

Several tests have confirmed that the sensory quality of Norwegian lamb is supreme. “The Meat and Vegetable Information Office” conducted a test in 1992 where Lofotlam competed with lamb from four other regions in Norway. Lofotlam became a winner on quality, and chefs across Norway have praised our lamb for its good meatiness, unique tenderness and distinctive aroma. Based on objective carcass classification of lambs’ provided by the abattoirs, Lofotlam is at the top of the national context.

Comparing average conformation and carcass qualities from lambs at a Norwegian level, for Northern Norway and Lofotlam, Table 1 shows that Lofotlam are heavier with a higher conformation score (EUROP) (Sauekontrollen).

Table 1. Average age at slaughter, carcass weight and fat score of lambs at the level of Norway, Northern Norway and Lofotlam. Distribution of the carcass conformation within the EUROP classification system.

	Norway	Northern Norway	Lofotlam
Age at slaughter, days	144	143	133
Carcass weight, kg	18.1	18.8	19.3
Fat score	5.8	5.8	5.7
Conformation score, %			
P	10.8	7.1	4.5
O	44.7	54.9	46.5
R	35.5	32.8	43.9
U	2.3	1.7	14.3
E	0	0.1	0.3

Norwegian lamb produced at mountain pastures is an approximate organic product. In order to clarify any differences in taste and quality of lambs that have grazed different pastures, NOFIMA performed an investigation between the diet of the animals and meat quality. In the survey, meat from 22 lambs from each of three mountain pastures (Baroniet in Rosendal in Hardanger, at Hallingdal and at Lofoten) was compared with meat from 22 lambs grazing a lowland pasture (Table 2). The survey conclude that meat from lambs grazing mountain pastures have a different carcass quality compared to meat from lambs grazing lowland pastures.

Table 2. Average age at slaughter, average carcass weight (kg) and number of lambs within the conformations scores O to R+ in the EUROP classification system (P- to E+).

	Hardanger	Lofoten	Hallingdal	Lowland pasture
Age at slaughter, days	144	133	131	143
Carcass weight, kg	18.7	21.0	22.1	17.9
Conformation score, %				
O	5	5		45
O+	55	25		35
R-	30	15	20	15
R	10	50	70	5
R+		5	10	

The survey put great emphasis on the flavor experience provided by the meat from the different areas. An important feature of lamb meat is that it is easy to bite through; it should be tender and juicy without tasting too much fat. Lamb from Lofoten made a positive impression in this ranking.

Picture 6. View from Lofoten wall (photo: G. Karlsen)

Lofotlam – Norway`s prè salè

Lofotlam has become a popular brand in the market. Chefs and food experts emphasize Lofotlam because of high quality and special characteristics. Access to high quality, naturally salted pastures from early spring until slaughter contribute to the unique flavor of the meat. This is Norway's prè salè: salted from nature's side.

The statistics show that Lofotlam has higher conformation score and less fat than lambs from Norway in average. Analyzes of the meat show that the fat is intramuscularly / marbled in the muscle and thus, Lofotlam become more tender and have a particularly good aroma. The marbled fat is related to the physical activity.

There is a positive relationship between taste / meat quality and fat content. Lean lamb (in fat grade 1) has poorer taste and meat quality than lamb in fat grade 2+ and 3 -. The survey showed that lambs with higher fat score also had higher carcass weight (Table 3).

Table 3. Correlation between fat group (EUROP fat scores 1- to 5+) and carcass weight (kg)

Fat Group	1	1+	2-	2	2+	3-	3
Carcass weight, kg	18.6	18.7	18.2	18.7	19.3	20.6	21.2

The success of Lofotlam is a combination of unique pastures and good management. The fact that Lofotlam has a contract with the grocer’s trade of REMA1000 is huge in itself. The meat is exposed to the big marked of Oslo, the capital of Norway.

Innovation in grassland management and monitoring

Take home message

Beltramo

Invited Keynote speaker

Mechanization and automatization of agriculture are considered as means that evolve thanks to the introduction of electronic and software innovations, and, today, with the connection to the Internet. IoT (Internet of Things) for agriculture and Scato18 are introduced.

Internet of Things and Agriculture. Proximal sensoring and Grass8 system for a sustainable management of pastures.

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Abstract
The paper starts introducing management systems in economic organizations. It continues drawing a parallel between the consequences of policies for sustainability that have involved manufacturing companies and the evolution of agriculture, till the point of precision agriculture.

Mechanization and automatization of agriculture are considered as means that evolve thanks to the introduction of electronic and software innovations, and, today, with the connection to the Internet. From Things to Connected Things and the Internet of Things.

The concepts and implications of the IoT for agriculture are discussed through examples, useful for estimating the potential of the IoT. Scatol8 is introduced to approach the design of Grass8, an ongoing project oriented towards sustainable management of pastures will be showed.

In the conclusion, strong and weak points of IoT applications will be discussed.

1 Background: Open systems and MMSS

My experience has seldom met agriculture, it is related to economic organizations, that's to say to open systems, and its objectives are the optimization of performances through implementation of tailor made integrated management systems.

These are management tools developed at the dawn of the debate on sustainable development, which have undergone improvements to transfer the contents of the evolution that the concept of sustainable development has lived, since 1987.

The search for sustainability, considered in a broad sense, gave life to guide-lines, thousands books and more or less creative tools available today for economic organizations. There are many tools available for those companies who trust in the application of sustainability principle; we refer to methods that allow companies to witness their engagement in CSR, today buzzword for sustainability.

A non-exhaustive list, but one that certainly considers the most important tools is the following:

- Life Cycle Thinking: Life Cycle Assessment, Social Life Cycle Assessment, Life Cycle Costing
- EU Eco-label
- Environmental Management & Audit System & ISO14001
- ISO 50001 - Energy Management System
- ISO 26000 - Social Responsability
- ISO 45001 - Occupational health and safety
- Global Reporting Initiative
- CSR, Non Financial reporting

These tools highlight common elements:

- all consider transformation processes;

- all foresee a succession of phases for the development: for some it is about providing answers to checklists, filling inventory tables, for others to elaborate indicators or to design management systems.
- all need evidences, to build upon.

An unavoidable condition for determining whether or not operations (or processes) are sustainable, is the availability of accurate data.

Management systems can be integrated, by merging attention to sectors that plays different role in the sustainable management of an economic organization. Integrated systems help company to behave properly under ordinary, abnormal and emergency conditions.

This is the starting point: the integration of Quality, Environment and Safety management systems allows an economic organization to define KPI and keep them under control, applying self-defined behavioral rules which consider and marry the requirements of the company and of the laws, adopting voluntarily and adapting a framework established by ISO or other bodies.

The company's requirements are defined by the market. They deal with the ability to respond efficiently and effectively to customer and stakeholders demand. Law constraints depend on time and place where the company is located. More and more laws are inspired and directly derive from documents defined at international level by supranational organizations. They aim to ensure conditions of safety for the health of employees and, in general, of human beings, of environmental protection, of the conservation of resources. International agreements also provide for a commitment to define and guarantee fair and widespread development conditions.

2 Agriculture

The construction of an integrated management system in agriculture may start from the diagram in Fig. 1

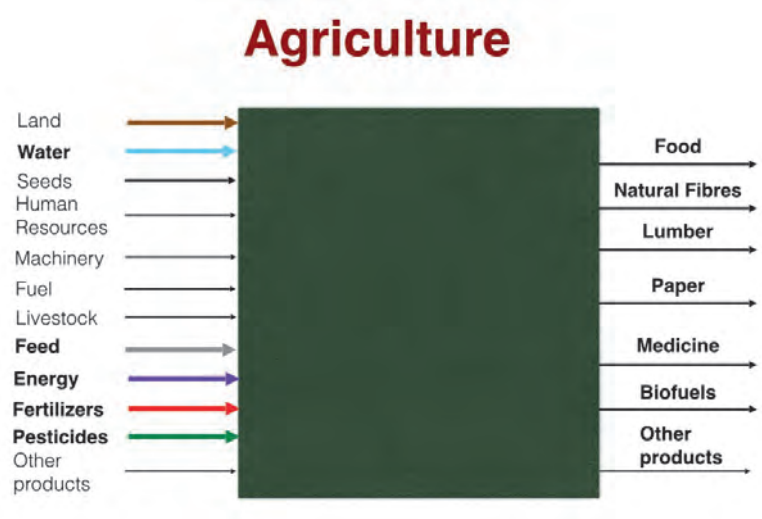

Figure 1. Construction of an integrated management system in agriculture

The fundamental and urgent theme, often referred to in the Food and Agricultural Organisation (FAO) documents that take us to the relation between agriculture and standardized management systems, is food security. A mono-thematic view, however, is weak: food security is a much broader and more ramified question, which draws nourishment from various fields of knowledge, which are combined to give life to a model of sustainable development.

FAO predicts that the global population will reach 8 billion people by 2025 and 9.6 billion people by 2050. In order to keep pace, food production must increase by 70 percent by 2050. If we consider the space-time horizon in which we live, the regulatory framework is shaped by the Agenda 2030:

"This Agenda is a plan of action for people, planet and prosperity. It also seeks to strengthen universal peace in larger freedom. We recognise that eradicating poverty in all its forms and dimensions, including extreme poverty, is the greatest global challenge and an indispensable requirement for sustainable development. All countries and all stakeholders, acting in collaborative partnership, will implement this plan. We are resolved to free the human race from the tyranny of poverty and want and to heal and secure our planet. We are determined to take the bold and transformative steps which are urgently needed to shift the world onto a sustainable and resilient path. As we embark on this collective journey, we pledge that no one will be left behind. The 17 Sustainable Development Goals and 169 targets which we are announcing today demonstrate the scale and ambition of this new universal Agenda."

Regarding the theme of this intervention, the most relevant objectives are:

- 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture
- 3: Ensure healthy lives and promote well-being for all at all ages
- 6: Ensure availability and sustainable management of water and sanitation for all
- 7: Ensure access to affordable, reliable, sustainable and modern energy for all 8: Decent work and economic growth
- 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
- 12: Ensure sustainable consumption and production patterns
- 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development
- 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.

However, it can be considered that other objectives also intersect the relations between agriculture and development. Eg: 1-End poverty in all its forms everywhere; 4-Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all; 11-Make cities and human settlements inclusive, safe, resilient and sustainable.

The 2030 Agenda formalizes objectives and operating procedures for the signatory countries, outlining useful programs and actions, also in virtue of objective 17: Partnership for the goals.

Reaching 17 goals is difficult in itself. But it is even more difficult if we reflect on the fact that interdependencies exist between the objectives, destined to "tangle" because of the actions that will be carried out to achieve the individual objectives.

Defeating hunger, and therefore acquiring food security, is a very complex topic. Interference is generated between technical, economic and political facts that are based on behavioural guidelines that are not always oriented in the same direction. The three areas called to act jointly are linked by relationships that determine contradictory behaviours with respect to the desire to achieve the declared goal. For instance, if a system of energy policies and economic incentives favours the start-up of energy crops, if the arable land is determined and not scalable, these will take away food crops. In short, from agricultural fields to photovoltaic fields. It will be possible to proceed towards Objective 7, but to the detriment of Objective 2.

A lower supply of products, at the same demand, leads to an increase in prices. The demand, however, is bound to increase (given the forecasts of population growth), so there is a well-founded fear that the increase in prices may be such as to further worsen the current situation.

The starting point, for all entrepreneurs, is to optimize the use of resources with positive results, planning and systematically doing the operations at best, sniffing the market trends and introducing innovations to improve performance over time.

2.1 Precision agriculture

This process has gradually led to the transformation of management logics matured in the manufacturing industry to agriculture, to reach today the concept of precision agriculture.

"Precision agriculture" is a specification that leads an inexperienced observer to believe that before the addition of this complement agriculture was inaccurate. But perhaps we want to understand an agriculture which is managed bearing in mind that the resources available are not infinite, they are not infinitely renewable.

If we consider environmental consequences of traditional agriculture, it is confirmed that environmental conservation has not been yet the top priority.

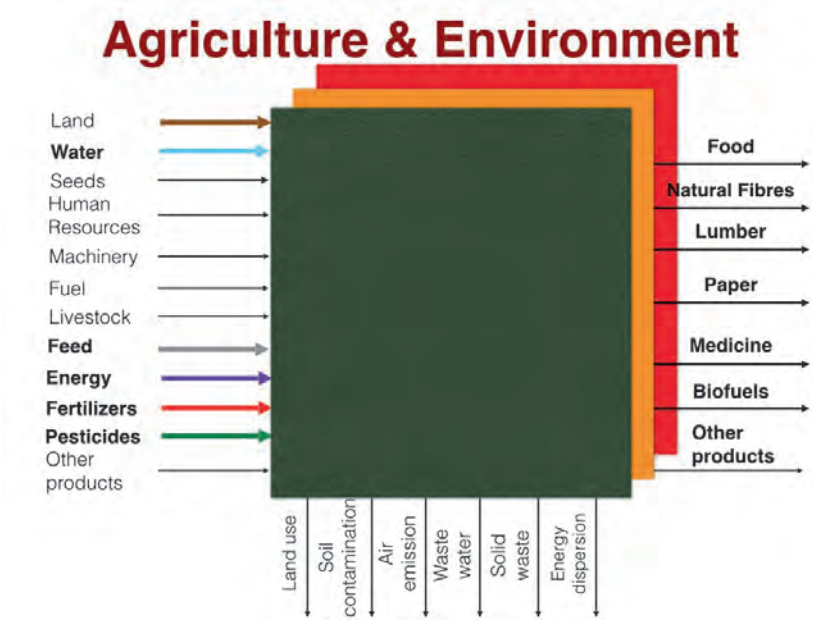

Figure 2. Construction of an integrated management system in agriculture and environment

Drivers:

- Environmental quality
- Land degradation
- Water use: "Farming accounts for around 70% of water used in the world today and also contributes to water pollution from excess nutrients, pesticides and other pollutants. But the competition for water is increasing and the costs of water pollution can be high"
- Soil contamination
- Air emission
- Energy: Paradigm shift
- Nutrition - Diet shift: "*By 2050, global population is projected to be 50% larger than at present and global grain demand is projected to double. This doubling will result from a projected 2.4fold increase in per capita real income and from dietary shifts towards a higher proportion of meat (much of it grain-fed) associated with higher income.*" [1]
- Conscious consumption: Food distribution involves the storage, processing, transport, packaging, and marketing of food. Food-chain infrastructure and storage technologies on farms can also affect the

[1] Nature 418, 671-677 (8 August 2002) | doi:10.1038/nature01014, Agricultural sustainability and intensive production practices, David Tilman, Kenneth G. Cassman, Pamela A. Matson, Rosamond Naylor & Stephen Polasky

amount of food wasted in the distribution process. Poor transport infrastructure can increase the price of supplying water and fertilizer as well as the price of moving food to national and global markets. Around the world, few individuals or households are continuously self-reliant for food. This creates the need for a bartering, exchange, or cash economy to acquire food.

- Climate change: Climate change could increase annual precipitation and make more fresh water available in some places. Rising temperatures, however, could increase the rate of evaporation from surface waters and reservoirs and lead to the loss of freshwater held in glaciers. Furthermore, increased rainfall might come in the form of storms that lead to flooding and damage thereby doing more harm than good. Climate change poses a series of risks to water supply and water management systems, although much uncertainty remains.

Several innovations have been introduced in agriculture to improve productivity. They have not always been accompanied by attention to environmental, economic and social impacts.

The introduction of mechanization, first, and automation, after, had been possible thanks to activities that favoured standardization: “production” (selection hybridization, etc.) of seeds with desired and steady characteristics, plant species with desired and constant characteristics, products with desired and constant characteristics. All this made it possible to considerably increase the quantity of production.

The increase in efficiency has occurred at the expense of diversity. The results were not negligible. For example, in the 1930s, the yields, in q / ha, of the so-called ancient grains were 20-25; the yields of the modern ones are 60-70. This happened thanks to precise processes of intervention on the seeds, to the improvement of crop alternations and cultivation techniques (ploughing, harrowing, sowing, threshing and transport, fertilizer, seed, weeding, possible treatments)

Interventions such as these, lead us to consider the processes that occur in agriculture as well as those that occur in the manufacturing industry.

How to optimize the management of a company? In the industrial field, deterministic theories have emerged: subdivision of processes into elementary operations, assessment of the contribution of elementary operations to the overall result, possible improvement of the methods of execution or equipment used for elementary operations, verification of the effectiveness of change also in relation to the execution of the subsequent elementary operation.

In a manufacturing company, the ability to control the variables that affect efficiency and effectiveness is not complete, but greater than that of Agriculture, a primary sector. Both sectors want to govern the logic of production and may encounter difficulties in forecasting the demand, but the agricultural sector must be able to govern the variability of nature: the physical characteristics of the soil, the type and amount of rainfall, the effects of climate change are totally or only minimally manageable.

In agriculture, standardized solutions are applicable where there are standard situations: climate, plains, large extensions, production volumes, and the adequate amount of money. The size and capital requirements often led to economic and social consequences: mergers of companies, but also the disappearance of small and micro farms.

The effects of this approach are better understood if we consider the entire **production chain**. The acquired awareness on the generation of waste along the entire supply chain, has led the legislator to consider and discipline not only on the production stages, but the entire chain of transformation, transport, consumption and post-consumption. These phases that contribute to the value chain are greatly responsible for waste production. Optimization of the entire cycle is pursued, also through the prevention, valorization and reduction of waste.

The ultimate goal of Precision agriculture is **Circular agriculture**.

A mix of tradition and innovation to increase the efficiency thanks to waste valorization. New production chains are activated: pharmaceutical, nutraceutical, cosmetics recover precious substances from waste and transform them into profitable products.

The term “waste valorization” refers to any industrial processing activities aimed at reusing, recycling, or composting from waste, useful products, or sources of energy. It usually takes the form of one of the following activities: processing of residue or by-products into raw materials, use of discarded finished or semi-finished products as raw materials or energy sources, use of waste materials in manufacturing process stages, and addition of waste materials to finished products.

The possibilities of exploitation of waste could increase considerably, if the corporate networks are configured and activated, following the principles of **industrial symbiosis**.

To sum up:

In Industry:
Determinism -> standardization = no variability -> raw materials std -> std components -> std production cycles -> std products

In Agriculture:
Determinism -> standardization = no variability -> std seeds -> std plants -> std food raw materials -> std production cycles -> std products

Standardization has proved successful for mass production, where competition is played on minimizing costs, achieved through a high volume of production. But as a result of increased wellbeing, consumers' wishes evolve and consumers become less satisfied by standardized solutions: every consumer feels unique and wants personalized products.

If industrialization looks for standardization, it is necessary to compare and balance this requirement with a new exigence, that of personalization. And here come into play the management theories that define the best rules for custom production (highly customizable) and mass, putting in the middle those of the make-to-order.

The industry has devised a production model to respond to this demand for uniqueness: lean manufacturing. In industry, the pervasive use of extremely sophisticated technologies, organizational techniques and intense training have allowed to innovate also in the creation of customized products, thus optimizing the logic of lean manufacturing. Unique products or in small batches, are realized and the time to market is drastically reduced, thanks to intelligent robotic systems, that manage warehouses, operations and transport.

This trend has also reverberated in the food industry which, starting from steady raw materials (controlled variability), invents products that respond to specific needs (quantity of product per package, precooked, frozen, etc) to meet the many and changing needs of the market. Even in the food industry, the content in terms of service tends to prevail over the intrinsic qualities of the product.

A competitive advantage is acquired and strengthened only if consumers' wishes are known and if the company is able to satisfy them before competitors. Knowledge of the market is an element to keep in mind, when we consider the potential of IoT.

To make the point:

1 - all human activities need material and energy resources;

2 - the ways in which resources are used in the transformation processes affect the conditions of sustainability of development;

3 - sustainable development conditions can only be assessed if data are available;

4 - some data can be measured using measuring instruments (others through interviews, others from financial statements);

5 - the industrial sector has developed organizational and management models to incorporate data, maintain - and possibly improve over time - its economic, environmental and social results; 6 - network of enterprises can increase the efficiency, applying the principles of industrial ecology; 7 - agriculture is called to make this transition to improve efficiency and effectiveness, to respect the Planet and to fight starvation,

How? The itinerary develops in three steps.

A. Things
B. Connected things
C. IoT

3 The transition from Things to Internet of Things (IoT)

3.1 THINGS

Let's consider the tractor: it is a means of transport, and it is also a versatile tool: it can perform various agricultural tasks, being easy to mate with various specific tools.

If these activities form the core of the tractor-thing, other features make up the tractor-service: tools for the detection of operating parameters, air-conditioned cabins, devices for maintenance scheduling, etc.

The pervasive presence of electronic devices in vehicles, made possible by the miniaturization of the components and costs lowering, has determined a massive presence of sensors. The introduction of sensors in vehicles has greatly amplified the range of information that can be collected and transformed into service. This has happened also in tractors.

The expansion of sensors in the field of motor vehicles has determined a trajectory that, at a certain point, has intersected that of tractors and, more in general, of the means for agriculture.

The sensors monitor vehicle fluids, components and equipment to suggest maintenance or warn in the event of malfunctions, but they may go further, for example to plan the route to be used in carrying out agricultural operations. All this apparatus makes the tractor a "Thing" for our purposes.

If the tractor is a classic example, in agriculture the Remote Control Vehicles see the significant presence of drones. These are used for monitoring activities and timely intervention. "Seeing" the conditions of a field with a speed greater than that to which a farmer could proceed is useful, but it cannot be all. Only if just as much speed and precision can characterize the intervention phase, then the increase in effectiveness and efficiency becomes real.

3.2 CONNECTED THINGS

A "thing" can "talk" with other things, assembled with micro-controllers, sensors and actuators, through various communication systems, and determine the creation of a local network. On the market you can find standardized solutions, proprietary technologies, with multiple features that are routed in a path of precision farming.

3.3 IoT

If these "Things" or networks of Things are able to connect to the Internet, access is gained to the privileges deriving from the presence in the Internet of Things. Things that collect, transmit, process and visualize data according to various objectives.

By Goldman Sachs, *"The Internet of Things, or IoT, is emerging as the next technology megatrend, with repercussions across the business spectrum. By connecting to the Internet billions of everyday devices … the IoT merges the physical and online worlds, opening up a host of new opportunities and challenges for companies, governments and consumers."*

Internet of Things (IoT) "considers pervasive presence in the environment of a variety of things/ objects that through wireless and wired connections and unique addressing schemes are able to interact with

each other and cooperate with other things/objects to create new applications/ services and reach common goals."

The Internet & Television Association - NCTA estimates that the number of connected devices will exceed 50 billion by 2020.

By International Telecommunication Union, the network architecture of IoT consists of the sensing layer, the access layer, the network layer, the middleware layer and application layers (Xian-Yi Chen, Zhi-Gang Jin, 2012; Tabassum Ara, Pritam Gajkumar Shah and M. Prabhakar, 2016):

- **Sensing layer**: the main features of this layer are to capture the interest information large-scaly by various types of sensors, identify intelligently, and share the captured information in the related units in the network.
- **Access layer**: this layer's main function is to transfer information from the sensing layer to the network layer through existing mobile networks, wireless networks, wireless LANs, satellite networks and other infrastructure.
- **Network layer**: this layer's main function is to integrate the information resources of the network into a large intelligence network with the Internet platform, and establish an efficient and reliable infrastructure platform for upper-class service management and large-scale industry applications.
- **Middleware layer**: this layer's main function is to management and control network information real-time, as well as providing a good user interface for upper layer application. It includes various business support platform, management platform, information processing platform, and intelligent computing platform.
- **Application layer**: this layer's main function is to integrate the function of the bottom system, and build the practical application of various industries, such as smart grids, smart logistics, intelligent transportation, precision agriculture, disaster monitoring and distance medical care. Industries 4.0 and Fourth Industrial Revolution

Such an amount of connected devices feeds the cloud with an unimaginable flow of data, giving rise to the Big Data phenomenon.

Big Data is often associated with what seems to announce the fourth industrial revolution: the Industrie 4.0 project. Promoted in 2010 by Germany. Industrie 4.0 is an industrial key -project in the high-tech strategy of the German government, which strongly has involved the professional industrial federations. The project intends to develop a new organization in Production that involves the whole value chain, after the first three industrial revolutions, marked by mechanization, electricity and information technology.

The introduction of the IoT and the CPS into the factory (Cyber-Physical Systems) acts as a catalyst for the fourth.

Six are the guidelines of the factory 4.0 [Kurt Salmon, 2015]:

- The factory is fully represented in a 3D simulation model for monitor processes, products and the production environment;
- Systems have the ability to interact and communicate with each other;
- Decisions are decentralized and the CPS can take decisions independently;
- Data analysis and decision making take place in real time;
- The factory is service-oriented, extending the IoT also to services;
- It is modular, adapting quickly to changes in the application. [2]

[2] R. BELTRAMO, S. MARGARITA, "Smart technologies per la gestione ambientale e paesaggistica: lo SCATOL8® della sostenibilità", Atti del Congresso Nazionale AICA, Torino, 15-17 novembre 2011

The key-point of the approach is the intercommunication between all the actors and the objects connected parties involved in the production line.

4 IoT and Agriculture

IoT makes it possible to integrate the data collected by the vehicle in motion with other data existing on the Internet, loaded by different subjects, with different purposes, but made available allowing unrestricted access and unrestricted reuse (Open Access).

It is possible to plan and monitor the progress of the activities, track the route taken by the vehicle, measure the time spent, fuel consumption, track the products administered and georefer to them and send them to a server on the Internet.

Since it is possible to find an economic value on most of these data, they are useful for the preparation of financial statements and automatically filling in the exercise books.

Maintenance, component supply, appointment, parts replacement: it is possible to monitor the warehouse and proceed automatically with the order of products from suppliers. But also to sending information to the supplier and schedule delivery times and methods, and connect to similar systems, installed in companies belonging to the same network.

The programming of the activities can be performed considering exogenous and endogenous variables, for example the weather forecast. This evolution has already be converted into marketed solutions that makes precision farming real.

4.1 Literature review

John Deere is using the IoT to connect each of its vehicles to a mobile online platform called JDLink, which gives farmers and their dealers remote access to see location, utilization and diagnostic data for each machine.

Its John Deere Operations Center offers comprehensive IoT solutions for farmers, including wireless data streaming of production data, mobile monitoring, and weather and crop reporting in real time.

Networked sensors and both historical and real-time data on weather, soil conditions and crop status help farmers enhance the value of their operations by ensuring equipment is operating reliably. They optimize each job by ensuring that crops are planted and harvested when and how they will produce the best yields, and achieving what John Deere calls “agronomic optimization” by engaging the trusted partners of the farmer to analyze data and recommend changes for future crop years. [3]

Not only new machines from John Deere can plow, sow and reap, but also collect a Farmer’s Almanac worth of data, including air and soil temperatures, moisture, wind speed, humidity, solar radiation and rainfall.

Smart watering systems sprinkle just enough water on the fields, in just the right places, and can detect leaks in water pipes—vital in dry and drought-affected regions like California (Alec Scott).

Precision Livestock Farming
Precision Livestock Farming is a subset of smart farming. Sensors are used for monitoring and early detection of reproduction events and health disorders in animals.

Typical monitored data are the body temperature, the animal activity, tissues resistivity, pulse and GPS position. SMS alerts can be sent to the breeder based on predefined events (Federico Guerrini, 2015).

Forestry management system

[3] IoT Case Studies: Companies Leading the Connected Economy,Part 2 in a Series Foreword by: Robert S Schimek, Executive Vice President and CEO, AIG Commercial
https://www.aig.de/content/dam/aig/emea/germany/documents/brochure/iot-case-studies-companies-leading-theconnected-economy-digital-report.pdf

In the forestry ”RFID can bring value by tracking timber through the whole logging operation, through shipment, monitoring for deliveries and such." In pilots and deployments worldwide, governments, research institutes, forestry and sawmill companies, and wood products manufacturers are employing RFID to optimize forest production and improve the quality of wood products, as well as to minimize environmental damage and enable companies to comply with U.S. and European rules barring import of illegal or endangered timber products.

But before RFID-tagging becomes common practice in the forestry industry, tag prices must come down and more solid business cases must be demonstrated. Meanwhile, RFID shows promise as a tool to help control wildfires.

Aquaculture management system

The first pilot of the IoT aquaculture management system is being tested on an eel farm in Gochang, South Korea. A set of sensors in dozens of 20-foot-wide eel tanks wirelessly transmit data on water temperature, pH and dissolved oxygen levels to a sensor hub, which in turn connects to SK Telecom’s LTE network using a machine-to-machine radio.

All these examples are proprietary solutions are tied to specific vendors and are expensive, closed and scarcely customizable. To react this situation, a great deal of start-ups were born. Some of them provides complete solutions, ready to use.

Libelium has developed a galaxy of application-oriented kits, which have been used by start-ups in order to improve management conditions in several fields:

- Smart irrigation systems
- Monitoring systems for Cocoa fields
- Monitoring systems fo Strawberries crops
- Monitoring greenhouse conditions to develop new products in the food industry
- Monitoring Horses and Equine Facility Management
- Preventing environmental impact in wastewater irrigation area

Innovation marks the proposal of the company, which is stimulated by the request of potential users. Recently, it has been developed and sold a new Smart Agriculture Xtreme Sensor Node which provides maximum accuracy for crop monitoring.

The next step is to build vehicles equipped with automatic driving systems, avoiding stress and fatigue of a human driver and increasing the number of working hours. An evolution of the Remote control vehicles that have been developed for spatial research and military missions. It is not tomorrow, it is today!

Figure 3. Prototype remote control vehicle,
https://www.youtube.com/watch?v=i8yChqU4mBE

Probably an autopilot capable of considering and linking together many parameters at the same time can lead the vehicle optimally, in relation to the work it will have to perform and the environmental conditions in which it will operate.

If we leave the tractor and consider the field, the sensors can be combined and connected to create networks with variable capillarity to collect data.

In relation to the variables detected, the data can be processed with appropriate algorithms to improve management -> Forecasting, RNA, Fuzzy, Simulation models.

Agricultural vehicles can carry out operations without a driver. They can work for different times and conditions, interacting with the variables detected by the sensors in the field. The interaction between sensors in the field and satellite data, present on the Internet, with data related to the operating conditions of the agricultural vehicle, processed by software, allow the carrying out of automatic processing, being energy the main constraint.

Sensors for soil moisture detection and weather forecast data can be processed to decide if, when and for how long to activate an irrigation system. This can be done remotely, even without the intervention of an operator (M2M), if the software combines the data of a forecast model with those of the network, in order to send a signal to the actuators.

Working in Abnormal and Emergency Conditions

In the introduction, we stated that management systems deal with defining behavioral rules suitable for running the business in ordinary, abnormal and emergency conditions.

Further on, we approached the agricultural sector and mentioned the limited ability to predict and contrast the natural phenomena that affect production results.

There is, in fact, another important chapter for agriculture, that of prediction and intervention in emergency conditions:

- floods;
- fires;
- earthquakes;
- landslides
- avalanches.

All of them are phenomena capable of structurally influencing the conditions of a farm. In fact, the effects of these phenomena influence agricultural activity in the short and medium term.

These phenomena often cause real natural disasters whose magnitude is measured, in the short term, in victims and damages to the ecosystem and to human, civil and productive settlements. The restoration to the initial conditions can take years.

Although the attention devoted to forecasting and managing the effects of these phenomena has increased over time, and investments in parallel, the achievements recorded have been few and show that the spaces for improvement exist, and are wide.

If the operation of a remote sensing network in the agricultural field, under normal operating conditions, determines additional needs with respect to the industrial context (electrical supply of devices in isolated sites, data transmission, ...), in emergency conditions the elements to consider are greater because the event itself could seriously alter the operating conditions. To be sure that the system works in severe conditions, redundancy of power supply, data processing and transmission systems is required.

Various actors are called to intervene in emergency conditions. Collected data must be translated into operational instructions for a coordinated intervention and sent to the right subjects, in the communication code most suited to them.

4.2 Limits - critical considerations

We presented some examples of current and future IoT applications to agriculture. Is everything so easily accessible? Who can afford them?

Proprietary solutions are so costly that are restricted to wealthy farmers, to big companies who work large agricultural surfaces. By Eurostat, the largest average size of agricultural holdings in any of the EU Member States in 2013 was the 133 hectares recorded for the Czech Republic, with the second highest average recorded in the United Kingdom at 94 hectares. Six Member States reported average sizes below 10.0 hectares, with the smallest averages in Romania, Cyprus and Malta.

Will IoT able to improve living conditions for small and micro enterprises?

IoT seems like a magic word, pronounced which you immediately get all the answers to every management problem, to improve efficiency and effectiveness of all economic sectors.

The growth expectations of the number of devices connected to the network reinforce this conviction. Those who have lived through the information technology revolution and today work in the field of IoTs, perceive that it is a phenomenon of even greater scope. Perhaps the predictions are influenced by the typical enthusiasm of a start-up phase, they are quite different from source to source, but all converge on relevant numbers. And since the numbers involved in the order of magnitude of the billions, even the differences are of this order.

The attractiveness of IoT has increased, thanks to the production of Open source microcontrollers. Arduino and Raspberry are the best known. They were very prolific microcontrollers, from 2005 to today they have given life to many models, with increasingly advanced features. Not only are they products, but also communities of makers and of enterprises that develop innovative solutions for agriculture, accessible and easy to implement.

Fascinating elements, also reinforcing, are the (apparently) low barriers to entry:

- Cheap prices of electronics components;
- Empirism - Makers & Hackers;
- Newsgroups: Massive amount of information available for those facing neophytes;
- Educations on Hardware & Software, tutorials;
- Kits;
- Success stories;

The micro-controllers have conquered the market, have met the needs of millions of fans of electronics and information technology because, along with them, there are low-price sensors and actuators on the market. Their combination makes it possible to realize circuits in a really easy way.

After the first enthusiasm, it turns out that the steps from the home experiment to prototyping and the industrialization of objects which constitute the network and software or, better, software that makes it functional to the objectives, require structured knowledge. The design and implementation of the elements that will be connected in the network require the collaboration of different professionals: engineers and informatics, but above all agronomists to define the rules that determine the intelligence of the system.

The product must be reliable, in all operating conditions, mechanically robust and waterproof to withstand bad weather and bumps: industrial designers, engineers and technologists are called to

contribute. The system must be accessible, easy to install, plug'n play configuration, and to use: that's a task for informatics engineers and communicators.

It has been noted that monitoring environmental factors is not enough and complete solution to improve the yield of the crops, as there are number of other factors that affect the productivity to great extent: attack of insects and pests which can be controlled by spraying the crop with proper insecticide and pesticides; attack of wild animals and birds when the crop grows up; possibility of thefts when crop is at the stage of harvesting. In order to provide solutions to all such problems, it is necessary to develop integrated system which will take care of all factors affecting the productivity in every stages like; cultivation, harvesting and post harvesting storage (Nikesh Gondchawar, Prof. Dr. R. S. Kawitkar, 2016).

A first solution has been envisaged since 2011, by Lance Donny, the CEO and founder of OnFarm. She identified a unique opportunity to leverage his extensive personal agricultural knowledge with connected applications to create and deliver a transformational suite of Internet of Things-based agricultural management services. On Farm delivers easy-to-use, smart, connected product applications that provide its customers with the ability to have a real-time big picture of the large and varying data points necessary for them to create optimal agricultural working and growing conditions.

If the numerical dimension of the objects that will connect to the Internet is difficult to imagine, it is even more difficult to have a perception of the amount of data that objects could bring together. The Walmart case is particularly significant, both because it illustrates well the meaning of the word Big in the expression Big Data. Wal-Mart Stores, Inc. (Walmart) is an American large-scale retail company in 1962, which has reached such a size that it has been in the past for several years' position for turnover in the Fortune Global 500 ranking. From the Walmart Annual Report 2016 [Walmart, 2016] you can get some indicators that illustrate reality of the company: it employs 2.3 million people, with a turnover (2016) of 482 billion dollars, more than 11,500 stores in 28 countries and 260 million customers. It is believed that Walmart is cited more than 300,000 times per week in social networks, and that has complete data on 150 million American citizens. Furthermore, the systems of analysis (analytics) of Walmart, which cover millions of products and hundreds of millions of consumers, analyze 100 million keywords every day to optimize their use in the purchase of advertising. In 2014, Walmart claimed to handle around 30 petabytes of information on the purchases of its customers (a petabyte is a million billion bytes).[4]

The high number of data is a necessary but not sufficient condition for the verification of sustainability. Significant indicators must be identified and incorporated into management systems. We need logics that verify the conditions of sustainability, measure the level of achievement of the objectives, the deviations. The system must monitor a single company as well as the whole supply chain. A simulation program written to develop alternative scenarios, respecting physical and economic constraints, must be instructed on the basis of appropriate instructions, to propose valid alternatives. We enter the field of artificial intelligence or the ability that the object or the network of objects takes in defining the most appropriate rules of behavior autonomously, depending on the circumstances. The construction of performing ANN Artificial Neural Networks is facilitated by the availability of many data, but the learning process must be oriented, and the ability of the network to recognize and act appropriately, given certain patterns, supervised.

5 Scatol8®

Scatol8® is a system designed to arouse awareness on the theme of sustainable development. Its mission: Spreading the culture of Sustainable Development. Its vision: To Each His Own Scatol8®

[4] R. BELTRAMO, S. MARGARITA, op.cit.

The idea sprung out on 2010, and after several experiences, it has become an academic spin-off company of the University of Torino, innovative start-up of Regione Piemonte.

Scatol8® system is composed of:

- a team of people (People First !)
- a Wireless Sensors Network (WSN) to detect environmental variables, regarding relations between an organization and the environment ;
- a Crusc8 (a dashboard) for displaying instantaneous intensity and the time series of the values of each variable;
- the e-book "Scatol8®: A Path To Sustainability", which contains "recipes" for the construction and use of the system.

Sensors measures environmental and landscape variables (i.e.: energy consumption, water consumption, air quality, water quality, humidity, temperature, amount of waste, images) and transmits them to a personal computer on which they are stored, processed and displayed via an interface, the Crusc8 (dashboard). It can thus realize a real-time monitoring of each variable detected, in addition to evaluation of trend, thanks to the display of time series.

In turn, the personal computer merges its data on a server on the Internet that collects and organizes them in a collective database. In this way, they are published and accessible information on PCs, Smart phones, but also on relevant configurations for management purposes (production lines, departments, etc).

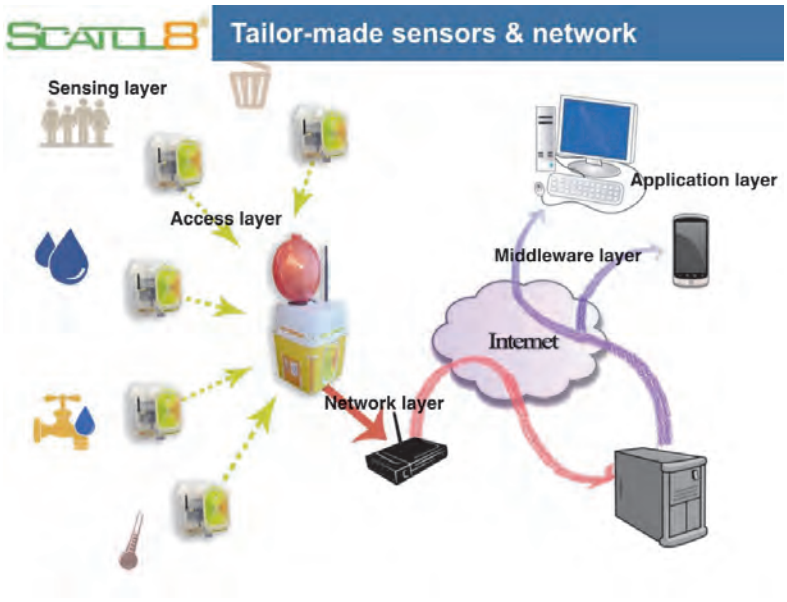

Figure 4. Scatol8® system

Guidelines of Scatol8®

Designed in the perspective of sustainability, Scatol8® is inspired in its creation and implementation to various criteria, such as:

- Accessibility. Hardware and software are fully based on open technologies and software (Open Source) in view of cost containment, openness and accessibility, even for training purposes. Scatol8® is not only a product, but also an initiative to spread knowledge, by Socials and in presence, which aims to involve young people in the creation of technology (and not only in its use), which is accompanied by information tools on the relationship between observed variables and sustainability and proposes the reuse of components through the concrete realization of the active systems.

- Modularity. The system is constituted from time to time, according to the requirements and specifications of each application.
- Environmental compatibility. All units and processing devices are placed in recycled containers, coming mainly from food and electronics industry, transformed and adapted to their new function, or in containers made of wood (a renewable resource), or even cardboard.

Communication plays a key-role in Scatol8®. It presents a number of problems because there are different subjects to which it is addressed (teachers, students, entrepreneurs of various productive sectors) and the means (website, social networks, brochures, research reports). A multilayer communication is carried out continuously, providing news updates to stimulate reflections and to keep the attention, to arouse curiosity in the potential of the system and to encourage involvement in the project proposals.

The System has been developed by Research projects, dealing with Integrated Management Systems, Life Cycle Analysis, Outdoor monitoring. Researches have had a fall out in Education activities in Primary and secondary School. In University Courses, within the School of Management and Economics, Scatol8® is an integral part of didactics. The e-book "Scatol8®: A Path To Sustainability", downloadable on http://scatol8.net, can be a useful support in different teaching methods and to different students. It is possible to prepare tailor-made releases of the book, combining parts of it in relation to teachers and students' needs.

6 Grass8

Grass8 is the proposal that Scatol8® is developing for the monitoring of pastures, in collaboration with the DISAFA Department of the University of Torino.

6.1 Previous experiences

The idea of dealing with agricultural systems has matured at the beginning as a preparation of a system for domestic plants. Temperature, humidity and brightness. Then evolved to S8 - Ecosystem and Scatol8 Smart Garden.

Each step has added functionality to the Scatol8, to meet the needs of different users: "green thumbs" home; Scatol8 Team interested in exploring the possibility of the system in terms of modularity and expandability; landscape architects, garden builders and green areas.

6.2 Characteristics of the system

Scatol8® will physically build the prototype of the networks and calibrate it in grassland contexts. This will imply extending the range of sensors available, which already determine for example: wind direction distance, snow height, gas (different kinds), light, mass (such as waste production), movement, Oxidation Reduction Potential, pH, rain, air pressure, solar radiation, ultraviolet radiation, soil temperature, air temperature, soil moisture, air humidity, leaf wetness and wind speed. Selection of variables, identification of indicators, choice of sensors and actuators will be done in collaboration with the DISAFA Department of the University of Torino.

Not only the progress in the performance to which we aspire concerns the performance of the network, but also the integration between open access data and those detected by Scatol8®; data processing and representation to feed management systems dedicated to various types of companies, through which to organize operations in the field and measure economic and environmental performance.

7 Conclusions and perspectives

IoT has all the requisites to make agriculture part of the Fourth Industrial Revolution.

IoT will add value if skills in data, Big Data elaboration are available. The IoT trend sends a clear message to the world of university education. It urges the design of new courses that prepare data scientists. The ability to extract useful information from the data, so called data-mining, requires the

establishment of multidisciplinary groups. The IoT network works if there is a network of knowledge, oriented towards a shared goal. First of all, users must be involved in a dialogue that makes needs emerge and that, at the same time, is useful to expose the potentialities that the new tools make available, so that we can reach truly useful solutions.

IoT is a business opportunity. The hardware costs are going down and this circumstance supports the predictions of an exponential increase of devices and networks. Software for network operation becomes more accessible. The crucial aspect, we reiterate, lies in the intelligence of the system.

Agriculture will become SMART, thanks to the IoT, when it will avoid man fatigue, when it will be able to close the game with world hunger, winning it, not standardizing production but multiplying the niches of biodiversity.

The challenge that today is possible to face thanks to the IoT is to realize accessible SMART technologies, systems that learn from the human, able to incorporate instructions but thanks to the knowledge distributed in the Internet, to which they can access, and to the new materials / devices improve efficiency and effectiveness of agricultural practices, with a dialogue that involves the entire supply chain.

The challenge of the IoT is not only to improve the efficiency of standardized productions, but to increase the efficiency of the niche markets, which carry forward the wealth deriving from the variety. By these ways we will have enough food for all and gourmand food for few.

There will be greater quantities of standardized mass products, next to which today niche products will be more accessible, deriving from food raw materials grown with less effort and greater productivity. The IoT leads to the growth of companies (micro and small enterprises) able to create customized systems, with a high knowledge content.


6

Take home message

Svels

As a substantial amount of pristine land is created by land-uplift the value is simultaneously changing. In Kvarken old traditions come to live with grazing provided by private farmers and authorities. The logic behind the use of the emergent land and the division of economic profit is not clear.

Governing emergent land, an expanding recreational resource in Kvarken Archipelago (Finland) and future pasture possibilities

Kristina Svels

Introduction: We explore governance structures of the recreational landscape of Kvarken Archipelago in Western Finland, an area where shore displacement occurs due to land rise and emergent (pristine) land is continuously created. The traditionally considered rather worthless, low-value agricultural production landscape, is now showing recreational value in the archipelago, and the area has become a popular second home destination. The traditional grazing areas, islets and emergent land areas are still in some cases used by farmers, but grazing is also pursued by the authorities adopting the policy of landscape care.

The emergent land thus makes up a common-pool resource system where private and collective usage rights overlap, and ownership structures govern decisions. In some instances, contention or conflicts arise among the multiple users of the resource system, and between part-owners and non-members of the commons. The aim is to understand the implications of this governance structure.

Methods: We have interviewed different local stakeholders such as municipality planners, representatives of commons, local communities, and with environmental and land survey authorities.

Results: The results show different logics of resource management locally in the studied commons and limited possibilities to influence the governance structure by users depending on their ownership status.

Conclusion: In conclusion, the commons in Kvarken Archipelago manage a growing natural resource system. The environmental changes occurring in the area are ongoing and have through time formed the commons' management regime. Originally, the management issue revolved around maintaining opportunities for meagre agriculture and fishing and hunting activities. The concentration of shares to a few large landholders who became local elites have during the commons' development path quite secured the operational structure. However, in the contemporary post-productive society, the part-owner communities are less cohesive, many part-owners are less interested and have a lower degree of knowledge about the commons' operational structure and the user rights they comprise. The changes which have recently occurred in society combined with the long-term changes in the landscape have in turn changed the commons' prerequisites to manage the resource.

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Take home message

Staudinger *et al*

Spatially precise estimates of browsing damage obtained using an efficient novel assessment method detected substantial differences between ruminant species and individuals.

Quantifying browsing damage on shrubs by grazing animals

Markus Staudinger, Tobias Zehnder, Manuel K. Schneider

Introduction: Shrub encroachment threatens the rich biodiversity of marginal pastures in many European mountain areas (Pornaro et al. 2013). Grazing with adapted breeds is a viable approach to maintain openness and ecosystem services of these pastures. Especially small ruminants are known to consume bark and leaves of woody plants and to actively counteract shrub encroachment. However, assessing the damage of grazing animals quantitatively remains challenging because most marginal pastures with shrubs are large, heterogeneous and difficult to penetrate.

Materials and methods: In a two-year experiment, multiple groups of Dexter cattle, Engadine sheep and mixed-breed goats grazed a steep pasture in the Eastern Swiss Alps. The site was strongly encroached by *Alnus viridis* (green alder) and to a lesser degree by *Sorbus aucuparia* (rowan) and other woody species. The main aim of the experiment was to explore the trade-offs between the maintenance of biodiversity and a viable meat production in mountain areas. This objective required the quantitative assessment of browsing damage in several hectares of shrub thickets, difficult to penetrate for animals as well as researchers.

We developed a novel assessment method with high spatial resolution, precise quantification and limited time consumption. Across the shrub thickets, the observer followed a predefined sampling grid of five meters using a hand-held DGPS device (Ashtec MobileMapper 120) as precisely as possible. Because straight movement was usually not possible, the detailed path was tracked by the DGPS device. Every 5 m, the surroundings were checked for signs of browsing and, if present, damaged and undamaged branches were counted in a circle of 5 m diameter. In order to save time, absence of browsing signs was not recorded but reconstructed along the path using an automated computer algorithm. The spatially explicit records of browsing damage were related to GPS tracking data of the animals and high-resolution surface models and orthophotos captured using a fixed-wing drone.

Results: The observed intensity and spatial arrangement of shrub damage was in line with recorded GPS tracks, which showed very targeted trajectories of goats into the thickets whereas sheep and cattle showed a more regular use of the area. Engadine sheep had been selected because of previous reports that this breed consumed the bark of *A. viridis* and increased its mortality. This behaviour was also detected in our experiment, especially at a high stocking rate, where on average 10% of all branches were barked. However, we found large differences between groups indicating that the intensity of barking depended on individual animals. This emphasizes the importance of individual adaptation and conditioning on foraging behaviour. Dexter cattle did not forage on alder bark but on leaves and opened the thickets by their movement activity. Goats, selected because of their known preference for browsing as intermediate-type feeders, also browsed on branches of *A. viridis* (1% barked on average) but to a far lesser extent than on *S. aucuparia* (69%). The preference of goats for *S. aucuparia*, which was usually taller than the more abundant *A. viridis*, was confirmed by analysing profiles of vegetation height obtained using the drone.

Conclusion: The developed method yielded spatially precise estimates over large areas of shrub thickets with a realistic investment of time. The optimisation of time consumption and aerial coverage was crucial, since other more precise methods would not be applicable on the several hectares of thickets to assess. The grazing experiment suggested substantial differences between ruminant species as well as individuals in their impact on shrubs. Since *S. aucuparia*, the shrub species preferred by goats, is an important species for forest regeneration, especially robust sheep breeds have a great potential in the restoration of pastures encroached by *A. viridis*.

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Take home message

Koczura *et al*

Independently from the breed, walk leads to a higher milk loss than truck transhumance, but these treatments have a similar effect on milk composition.

Effect of walking or truck transhumance on cows' performance

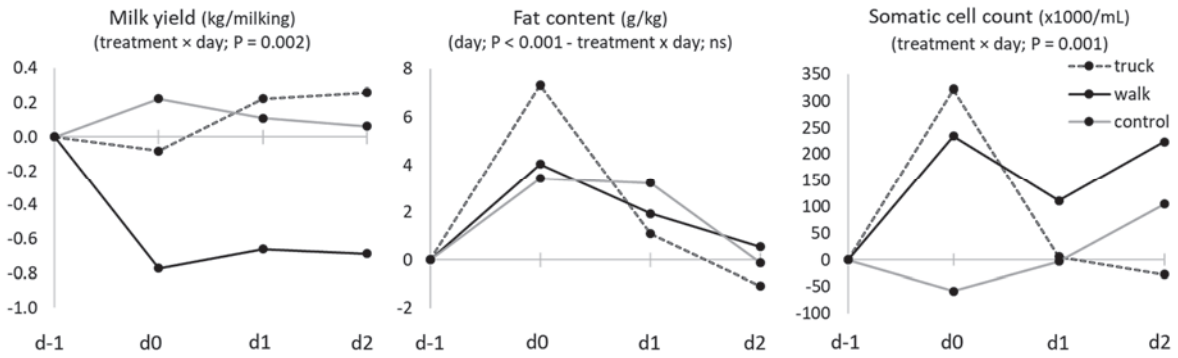
Madeline Koczura[1], Matthieu Bouchon[2], Germano Turille[3], Joël Bérard[1], Sarah Zurmühle[1], Michael Kreuzer[1], Bruno Martin[4]

Introduction: Summer transhumance is a traditional practice that allows valorisation of resources offered by mountain pastures. However, farmers experience milk losses and impaired cheese processing properties in the days following transhumance. Therefore, the effects of walking or truck transhumance on milk yield and composition were compared in three breeds of different milk yield potential.

Materials and methods: Three groups of 12 cows each composed of 4 Holstein (Ho, 245±35 days in milk (DIM)), 4 Montbeliarde (Mo, 220±23 DIM) and 4 Valdostana Red Pied (Va, a mountain breed originating from the Aosta Valley in the Italian Alps, 190±30 DIM) were formed. They were alternatively subjected to 1 h 45 min walk (6.5 km), 1 h truck transport or control (no transhumance) in a 3×3 Latin square design. Initial milk yield was 14.2±4.1, 14.9±4.6 and 10.5±3.0 kg/day for Ho, Mo and Va, respectively. The evening milk yield and gross composition were measured 16 h (d-1) before and 5 h (d0), 1day (d1) and 2 days (d2) after treatment. Blood was sampled 2 h before and 1 and 6 h after treatment for NEFA, urea, BHB and glucose analyses. A repeated mixed model including period, treatment, breed, day and interactions as fixed effects was used for data treatments.

Results: On average, cows lost 0.77 kg of milk during the milking right after walking, compared to only 0.08 kg after the truck transport ($P < 0.01$, Figure 1). The milk loss observed after walking remained constant until d2 and was similar for the three breeds (data not shown). Milk fat content increased in d0 in all treatments and returned to its initial level in d2 (Figure 1). The increase was higher for Mo and Ho cows in comparison to Va cows (+8.4, +5.7 and +0.7 for Mo, Ho and Va cows, respectively, $P<0.05$). The SCC transitorily increased by 321 000 and 233 000 cell /mL after the truck and walk treatment respectively. This increase was similar for the 3 breeds (data not shown).

Figure 1: Evolution of the evening milk yield and composition from d-1 to d2. Means reported are the adjusted means of the model centred on d-1.



A sharp but brief increase in plasma NEFA and urea concentrations was observed for both walking and truck transport 1 h after transhumance ($P < 0.01$), similar for the three breeds. Blood glucose and BHB levels were not affected.

Conclusion: Walking leads to a higher milk loss than truck transport, but treatments have a similar effect on milk composition. Most of the effects observed were independent from cow breed. This work was funded by the French government IDEX-ISITE initiative 16-IDEX-0001 (CAP 20-25).

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Take home message

Eftang and Bøe

The goats managed and understood the system with virtual fences, and the risk for reduced animal welfare was considered to be low.
Use of virtual fences will give increased access to rangeland, sustainable agriculture, better monitoring of grazing animals, as well as less cost and work with traditional fencing.

Virtual fences for goats

Silje Gunhild Eftang[1,2], Knut Egil Bøe[1]

Introduction: Virtual fences have been developed over many years, and already in 1973, Peck (1973) issued a patent in the United States on a system aimed at dogs and cats. Nofence AS is a Norwegian entrepreneurial business that has developed an electronic GPS-collar that is used to determine a grazing area, by creating a virtual fence, as an alternative to traditional fences. In 2017, the Nofence-collar was used on approximately 100 commercial goat farms in Norway including 1000 goats in total. Nofence`s system is based on GPS-technology, where a determined pasture defined by GPS-coordinates is transferred to the animals collars via the mobile network. When the goat approaches the virtual border the GPS instructs the collar to start playing a warning sound. If the goat ignores the sound and continues, a weak electric shock with a stored energy of 0.1 Joule is given. In comparison, the stored energy in an electric fence is 0.5 Joule. If the goat ignores three following warning sounds and electrical shocks it will be registered as escaped, and the system will be switched of, until the goat has turned back into the pasture.

The aim of the study was to collect data regarding numbers of warning sounds and electric shocks given, as well as escapes of goats on rangeland using virtual fences. The goats' reactions to the warning sound and electric shock were also observed.

Materials and methods: Ten farms and a total of 92 experienced goats (familiar with the virtual fence system), Kashmir and Boer breed, participated in the study. There were two studies; 1.Experienced goats on their regular rangeland, (10 groups, n=92), were recorded for 7 days, and 2. Experienced goats moved to new pasture or given new extended area, (4 groups, n=45), were recorded for 5 days. Some of the goats were involved in both studies.
Each goat was wearing a Nofence-collar, version Hardware C. Data on warning sounds, electric shocks and escapes were recorded. Both individual and group means were calculated, as well as maximum and minimum values.

Results: In study 1, goats at their regular rangeland, received an average of 10.6 warning sounds and 0.4 electric shocks per goat per day, and 0.009 escapes per goat per day were recorded. In study 2, goats given new pastures, received an average of 4.8 warning sounds and 0.5 electric shocks per goat per day, and 0.09 escapes per goat per day were recorded. This showed that the experienced goats understood the system very well. Some individuals even exploited the system by grazing in the virtual border zone and thus triggered many warning sounds but got very few electric shocks. These animals apparently had full control of the system. The reactions to the shock varied among individuals, but in general they were light. A few goats were lip smacking soon after, but there were not observed any vocalization. Most of the goats started grazing within ten seconds after receiving the shock.

Conclusion: The goats managed and understood the system with virtual fences, and the risk for reduced animal welfare was considered to be low.

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Take home message

Hvasshovd

An aircraft drone based system is more than capable to search and find sheep in most terrains.

New Methods for Retrieval of Free Range Sheep

Svein-Olaf Hvasshovd

Introduction: Retrieval of free range sheep is a laborious and time-consuming operation. Especially laborious is the retrieval of the very last sheep. Most sheep farmers report their frustration with spending days on end searching for their last sheep. We are developing a tool for efficient detection of free range sheep based on the application of drones and image analysis.

Materials and methods: Our system is based on the application of an aircraft drone with an operational flight time of approximately five hours, making it able to cover a flight distance of about 300 km per flight. The drone is equipped with a camera and image analysis equipment. The images will be scanned to detect sheep and will report in real-time its finds to the farmer. The drone will systematically check out a large area per flight.

Results: We have so far developed a test and experiment system based on student projects. We have focused on developing an efficient image analysis system and management of the drone's area tracking. The image analysis system detects animals based on their heath signature. We are currently so far not able to distinguish between animal species such as e.g. sheep and dog. The drone tracking system is automatically selecting the drone's route and analysing its energy reserve to make sure the drone is able to cover its entire intended route.

The system has already been used experimentally under constrained conditions.

Conclusion: Our developed system documents that an aircraft drone based system are more than capable to search and find sheep in most terrains. However, the permits required to operate such a system is rather demanding. It can therefore not be expected that this is a system owned and operated by an average farmer.

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Take home message

Grøva

Real-time information from temperature sensor in sheep can detect disease and behaviour on range pastures.

Can sensor technology and real-time communication detect tick-born fever in sheep on range pasture?

Lise Grøva

Introduction: More than two million sheep graze on unimproved, rough grazing land during the summer months each year in Norway. Free ranging sheep are perceived to experience high level of animal welfare through their opportunity to perform natural behaviour, but these benefits are compromised when sheep experience predator attacks, disease and accidents. Ensuring animal health and welfare in farming systems gets increased attention, and new policies and legislations are implemented. About 125 000 sheep (6-7%) are lost on such pastures every year. Tick-borne fever (TBF) is a disease considered to be a major challenge in sheep farming during the grazing season along the coast of south-western Norway. Clinical signs of TBF is often observed within 14 days of infection, starting with an abrupt rise in rectal temperature (often above 41o C). Being able to monitor farm animals on range pastures is increasingly important and implementing available technology for this purpose should be exploited. Implementation of sensor technology in rangeland sheep farming can monitor physiological parameters, such as body temperature (T) and heart rate (HR). Integrating sensors that communicate in a GPS tracking system may contribute to detect, locate and treat sick animals, as well as improve our knowledge of animal health in time and space in rangeland farming systems. Sensors for sheep that communicate with a GPS system is not commercially available today. The objective of the work presented here is to evaluate if temperature sensor information can be used for early detection of tick-borne fever (TBF).

Materials and methods: In 2016, temperature sensors (T) (CentiT Star Oddi, Iceland) were implanted in the abdomen of 20 lambs in a sheep flock in a TBF risk area (coastal herd) and in 20 lambs from one flock in a non-TBF risk area (inland heard) in Norway. The sensors were programmed to log temperature every 10 minutes, and were implanted in lambs in early June and collected in early September to retrieve data. The telemetry system (Telespor, Norway) was used on all lambs, and provided real-time positioning data that was used for continuous surveillance on range pasture. All lambs were monitored twice a day for clinical assessment for a one month period after they were turned out on pasture and weight was recorded at birth, spring and autumn. Remaining lambs in the coastal and inland flock were used as control for effect of sensor implantation on weight gain. Number of fever incidences and magnitude of fever was calculated by estimating area under curve (auc) for each temperature incidence for each lamb.

Results: In total 32 (80 %) of 40 implanted T sensors could be retrieved. From the coastal herd 17 of 20 T sensors could be retrieved and from the inland herd 15 of 20 Tb sensors could be retrieved. All 17 retrieved T sensors from the coastal herd and all 15 sensors of the inland herd worked as programmed. All lost sensor were not detected at retrieval as no lambs were missing. Temperature of all lambs in both herds ranged from 36.9 °C to 41.8 °C with a mean of 39.6°C (SD 0.35). Sensor implantation did not affect weight gain. There was a significant difference in fever incidences and magnitude of fever in lambs in the TBF risk area (coastal heard) compared to the lambs in the non-TBF risk area (inland herd).

Conclusion: The study shows that real-time temperature information in lambs has potential as a disease alarm.

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Take home message

Ravetto Enri *et al* [1]

Acer pseudoplatanus, Fraxinus excelsior, Salix caprea, and Sorbus aucuparia show remarkable foliage production, chemical composition, and digestibility for goat nutrition.

Evaluation of sycamore maple, common ash, goat willow, and rowan foliage for goat nutrition

Simone Ravetto Enri[1], Massimiliano Probo[2], Manuela Renna[1], Eleonora Caro[1], Carola Lussiana[1], Luca M. Battaglini[1], Giampiero Lombardi[1], Michele Lonati[1]

Introduction: Tree and shrub foliage is an important component of small ruminant diet in many parts of the world and plays an essential role for browsing animals. The importance of fodder tree species is particularly relevant during dry periods, when herbage quality decreases as a consequence of reduced water availability and/or the advancement of plant phenological stage, while in the meantime tree foliage maintains a higher nutrient quality. However, many tree and shrub species are underestimated fodder resources, especially in European temperate areas, due to insufficient knowledge about their potential feeding value. The objective of the present study was to characterize leaves of four widely common tree species as fodder resource for goat nutrition in different European mountain areas, by direct browsing.

Materials and methods: Four temperate tree species were selected: *Acer pseudoplatanus* (sycamore maple), *Fraxinus excelsior* (ash), *Sorbus aucuparia* (rowan), and *Salix caprea* (goat willow). In 2015, leaf length and biomass, main chemical components, fatty acid profile, phenolic composition, and *in vitro* true digestibility were determined along the vegetative season.

Results: The differences found among the species were remarkable (Table 1), even if weakly related to seasonal changes, especially when considering fatty acid and phenolic compositions. Ash sprouts were the most productive and its foliage showed the lowest phenolic contents, resulting in the highest digestibility. Rowan digestibility was similar, but its lower polyunsaturated fatty acid concentration could reduce the interest for this species as a feeding resource for goat dairy products with healthy properties. The lower digestibility found for goat willow and sycamore maple may be related to their high phenolic concentrations. Only sycamore maple was significantly affected by season advancement, with a digestibility decrease at the last sampling date. Previous research on Mediterranean evergreen species provided contrasting results, with a progressive decline of leaf digestibility with dry season advancement.

Table 1: main chemical features analysed for the four fodder tree species. Results are provided as means ± standard errors.

Fodder tree species	Dry matter (g/kg)	Crude protein (g/kgDM)	Neutral detergent fibre (g/kgDM)	Acid detergent fibre (g/kgDM)	Saturated fatty acids (g/kgDM)	Mono unsaturated fatty acids (g/kgDM)	Poly unsaturated fatty acids (g/kgDM)	Total extractable phenols (g/kgDM)	*In vitro* true digestibility (g/kgDM)
Rowan	609.91 ± 8.526	117.98 ± 3.500	408.30 ± 1.670	273.62 ± 13.325	3.21 ± 0.043	0.52 ± 0.024	6.23 ± 0.375	22.36 ± 1.789	572.55 ± 21.605
Goat willow	599.80 ± 24.923	140.45 ± 11.146	451.49 ± 2.968	353.58 ± 5.839	3.17 ± 0.095	0.44 ± 0.021	9.54 ± 0.462	47.25 ± 1.927	462.32 ± 16.657
Sycamore maple	520.69 ± 32.603	166.81 ± 8.694	411.62 ± 9.015	258.08 ± 12.665	3.39 ± 0.051	0.93 ± 0.045	8.48 ± 0.515	45.89 ± 5.502	432.58 ± 23.759
Ash	512.8 0 ± 25.994	140.31 ± 7.879	438.25 ± 10.854	203.21 ± 12.583	3.01 ± 0.080	1.40 ± 0.066	8.66 ± 0.556	11.24 ± 0.983	564.66 ± 20.137

Conclusion: The four species could represent a good quality feedstuff for goat nutrition, above all in the late summer when herbage quality decreases, particularly in terms of crude protein and fatty acid profile.

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Take home message

Lonati *et al*

Rotational grazing with stocking rates tuned on grassland carrying capacity changes the botanical composition and pastoral value of alpine grasslands.

Planning grazing management enhances plant alpha-diversity and pastoral value of alpine grasslands

Michele Lonati[1], Elisa Perotti[1], Massimiliano Probo[2], Marco Pittarello[3], Giampiero Lombardi[1]

Introduction: the goal of the research was to analyse the effects produced on botanical composition, plant diversity, Pastoral Value (PV), and soil nutrient content by a five-year implementation of a Grazing Management Plan (GMP) in an alpine summer pasture, previously managed under a continuous grazing system (CGS) with a lower stocking rate (- 24% on average). The GMP are a policy and management tool aimed at enhancing farm productivity, while preserving plant diversity, soil and landscape (Lombardi et al., 2011). In the western Italian Alps, they are based on rotational grazing systems (RGS) with animal stocking rate adjustments to keep it balanced with grassland carrying capacity (Probo et al., 2014). Once computed on the basis of vegetation composition and topographical and elevation conditions, the same stocking rate is applied without further changes for five consecutive years. It was hypothesized that GMP would enhance plant diversity and increase meso-eutrophic species number and cover. Furthermore, PV and soil nutrient content would increase and homogenize across vegetation communities.

Materials and methods: a total of 199 vegetation surveys was carried out in summer 2011 and reiterated in 2016. Vegetation ecological groups were identified by means of a Hierarchical Cluster Analysis and plant diversity indices were computed (alpha: species richness, Shannon diversity; beta: Whittaker index). In this context, beta-diversity reflects the spatial variation of species composition within the paddocks. The mean soil nutrient content was estimated through Landolt N indicator values (N index) for each transect. Paired-sample statistical tests were performed on the whole vegetation dataset, on vegetation ecological groups and considering functional pools of species. PERMANOVA analysis was performed in order to test multivariate vegetation changes.

Results: on the whole, mean species richness (2011-2016: 28.7 *vs*. 36.1; $p = < 0.001$), Shannon diversity (2011-2016: 3.3 *vs*. 3.5; $p < 0.001$), N index (2011-2016: 2.3 *vs*. 2.4; $p < 0.001$), and PV (2011-2016: 15.0 vs. 15.8; $p < 0.050$) increased, while beta-diversity remained stable (2011-2016: 6.66 vs. 6.62; $p = 0.871$ not significant). Species richness increased in almost all the ecological groups identified, with a peak in the mesotrophic one (+ 11.5 species, on average). A significant change in the botanical composition (PERMANOVA analysis) was recorded in oligotrophic ($p < 0.010$), mesotrophic ($p < 0.050$), and thermic groups ($p < 0.050$). The number and cover of nitrogen-poor high-elevation species increased in all groups, likely boosted by livestock seed transportation and improved connectivity amongst different communities. The meso-eutrophic species number and cover increased in thermic, mesotrophic, and pre-forest groups, suggesting a greater use of such areas by livestock after GMP implementation than under CGS. In addition, an increase of PV was detected in the pre-forest group (2011-2016: 10.6 *vs*. 13.0; $p < 0.050$).

Conclusion: GMP implementation, through RGS with stocking rates tuned on grassland carrying capacity, was an effective and a sustainable management tool to enhance the botanical composition and plant diversity of sub-alpine and alpine grasslands over five-year, and to improve their pastoral value as well.

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Take home message

Ravetto Enri *et al* [2]

Distance from night pens is an easy-measurable and effective proxy to predict sheep stocking density in mountain environments.

A new methodology to estimate stocking density of grazing sheep based on distance from night pens

Simone Ravetto Enri, Alessandra Gorlier, Ginevra Nota, Michele Lonati

Introduction: Grazing is a useful tool for the implementation of management strategies finalized to the restoration, improvement, or conservation of grassland vegetation. Many studies aiming at assessing the effectiveness of such strategies were based on indirect measures (proxies) of livestock stocking density such as distance from congregation areas (e.g. sheds, water sources), since stocking density is known to affect the consumption of plant species by animals. However, the suitability of these proxies have been rarely validated. In the Alps, sheep flocks are usually managed through lenient supervision by shepherds during day and sheltered in temporary night penning areas (TNPA).Given that TNPA are periodically moved over the pasture throughout the grazing season, the aim of our study was to implement a method using a GPS/GIS assessment to determine whether the distance from TNPA can be used as a reliable predictor of sheep stocking density at grazing.

Materials and methods: In 2015, a flock of 250 sheep grazed for one month over 45 ha of nutrient-poor dry grasslands in the Western Italian Alps and in that period it was fenced in 14 TNPA for 2-3 nights each. Ten sheep were tracked with GPS collars recording at 15-minute intervals. We assessed sheep stocking density as the number of GPS fixes within a 30 m-buffered zone around 65 randomly-generated points. We performed a linear regression analysis using stocking density within each buffered zone as response variable and the sum of inverse distances of each point from all the TNPA as explanatory variable.

Results: Our results highlighted a strong inverse correlation ($P < 0.001$, $R^2 = 0.83$) between the stocking density and the distance from TNPA.

Conclusion: This short-term experiment supported the use of the distance from congregation areas as an easy-measurable and effective proxy to predict sheep stocking density in mountain environments.

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Take home message

Bayr *et al*

Poster

Ground-based repeat photography is an effective way to monitor landscape changes and offer possibilities for both, qualitative and quantitative research.

Repeat photography as a method in landscape monitoring

Ulrike Bayr, Oskar Puschmann, Wenche Dramstad

Introduction: Repeat photography is a method where ground-based landscape photographs are taken from exactly the same location at different points in time. These "then and now" images are an effective way to communicate long-term landscape changes to a broad audience. Photographs are particularly useful for capturing gradual landscape changes. For instance, successive forest regrowth on pastureland is a challenge many mountainous areas are currently facing. In Norway, repeat photography has contributed considerably to raise awareness for this trend among politicians and the public. However, until now these photographs have only been used for a qualitative documentation of landscape changes. Our study provides a general overview of repeat photography as monitoring technique. Furthermore, we aim to examine the potential of repeat photography for quantitative research by testing different approaches based on machine learning and photogrammetry.

Materials and methods: For this study, we use a random selection of repeat photographs from the Norwegian Institute of Bioeconomy Research (NIBIO) photo archive, which contains around 3500 images. We test the performance of Convolutional Neural Networks (CNN) for the automatic recognition of woody vegetation in landscape photographs. From different class, image tiles with 50x50 pixels are extracted from the photographs and organized as visual codebook. The labeled samples are then used to train the CNN. Predictions are made for image pairs in order to quantify changes in image cover. In the second part of the study, we use information on camera position and angle to link ground-based photographs to geographical coordinates.

Results: As qualitative approach, repeat photography provides an ideal basis for documenting landscape changes in a way that is easy to interpret even by non-experts. For quantitative research, the automatic classification of woody vegetation in landscape photographs allow us to quantify changes in image cover between two dates. By assigning geographical information to ground-based photographs, we can combine them with other geodata such as maps and aerial images in order to perform spatial analyses.

Conclusion: Repeat photography provides valuable information on landscape change, which is useful for both, qualitative and quantitative research. Modern machine learning techniques are quite powerful in image recognition and may help to analyze ground-based photographs more efficiently. Finally, the implementation of photographs as additional quantitative data and their combination with other geodata can considerably contribute to improve landscape monitoring.

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Take home message

Meisser *et al*

Poster

Elevation and aspect are the main factors affecting the botanical composition of shrub-encroached alpine pastures.

Detecting the early stages of secondary succession of under-exploited alpine summer pastures

Marco Meisser, Virginie Dekumbis, Massimiliano Probo

Introduction: In the Alpine countries, many summer pastures have been under-exploited or abandoned, thus favouring the development of encroachment and secondary succession. These processes remain poorly documented, and the awareness of an ongoing evolution occurs often too late for reversing the process with simple management measures. The present work, which is the first part of a long-term survey, aims at describing the different types of early succession, with particular emphasis on plant species that could serve as indicators. We made two hypotheses: (i) the type of succession is strongly dependent on the ecological factors, especially aspect and soil depth, and (ii) the pastoral value of those early-successional vegetation types is low.

Materials and methods: The study was conducted on 17 summers pastures located in the western part of the Swiss Alps. Overall, we carried out 45 botanical surveys within 25 m^2 areas (i.e. two or three botanical surveys for each pasture) according to the method of Braun-Blanquet. Soil depth, slope, aspect, elevation, mean annual temperature and rainfall, type of soil (lithology) were determined. Based on species abundance, we calculated the mean values of Landolt ecological indices, Shannon-Weaver index, as well as pastoral values (calculated using the indices of specific quality of Cavallero *et al.*, 2007). A Redundancy Analysis was run in order to identify the ecological factors significantly associated to botanical composition. Finally, based on Jaccard/Ward clustering, we proposed a classification of the main vegetation types.

Results: In total, 268 species were recorded. Table 1 presents the classification in 5 vegetation types resulting from the clustering. As expected, we found different plant communities that primarily relate to environmental factors. The RDA analysis (data not shown) indicated that factors such as aspect, slope, elevation, and precipitation were significant, whereas depth of soil was not. Furthermore, pH (i.e. Landolt's Reaction value) strongly determined botanical composition. The pastoral values were low, in accordance with our hypothesis.

Table 1. Main vegetation types (± SD) encountered in the study.

	Type 1	**Type 2**	**Type 3**	**Type 4a**	**Type 4b**
	Calcareous pastures	Past. dominated by *Bromus erectus/Dactylis glomerata*	Past. with *Festuca rubra*	Acidic mesophilic past. dominated by *Nardus stricta*	Acidic oligotrophic past. dominated by *Nardus stricta*
Characteristic herbaceous species	*Sesleria caerulea, Carex sempervirens*	*B. erectus, Origanum vulgare*	*F. rubra, Agrostis capillaris, Alchemilla vulg.*	*Common to both types: N. stricta, Arnica montana, Vaccinium myrtillus, Plantago alpina*	
Characteristic shrub species	*Picea abies, Larix decidua*	*Crataegus laevigata, Prunus spinosa, Rosa sp.*	*Rhododendron ferrugineum, Vaccinium myrt.*	*Alnus viridis*	*Vaccinium gaultherioides*
Elevation (m)	1834 ±37	1447 ±233	1944 ±104	1842 ±96	1875 ±170
Landolt nitrogen	2.27 ±0.07	2.76 ±0.26	2.92 ±0.18	2.63 ±0.21	2.46 ±0.23
Landolt humidity	2.22 ±0.16	2.53 ±0.31	3.06 ±0.15	3.06 ±0.13	2.98 ±0.08
Landolt temperat.	2.01 ±0.28	2.92 ±0.23	2.30 ±0.18	2.38 ±0.13	2.35 ±0.24
Landolt reaction	3.43 ±0.01	3.13 ±0.25	2.79 ±0.18	2.47 ±0.22	2.45 ±0.24
Specific richness	38 ±15	52 ±7	40 ±5	47 ±8	42 ±8
Shannon-W.	3.32 ±0.90	4.86 ±0.26	4.09 ±0.46	4.40 ±0.36	4.30 ±0.27
Pastoral value	16 ±1	16 ±5	18 ±4	12 ±4	9 ±4

Conclusion: this study confirmed that the vegetation in the early successional stages is very diverse but of low pastoral value. In absence of precise data on the management, it is difficult to gain a complete understanding of the secondary succession processes. A second survey in a few years is planned, in order to link the different spatial and temporal scales and gain a better insight into the process

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Strategies to reduce the causes and mitigate the effects of climate changes on agropastoral systems

Take home message

McClaran

Invited Keynote speaker

Based on our drought planning process for cattle ranchers and federal land managers in Arizona, USA, I suggest the following three lessons to help planning for climate change: 1) design a process that supports hands-on learning, scenario-based problem solving activities, and action plans for implementing the solutions, 2) provide some estimates of the likelihood of change by using the recent extreme (low likelihood) trends in temperature or precipitation as the set of tangible climate change scenarios, and 3) build a realistic socio-ecological model for a scenario planning tool, and make that tool as interactive as possible to support the identification and assessment of many realistic scenarios and many different coping strategies.

Three Lessons from Drought Planning to Help Planning for Climate Change

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Abstract

Imagine Pequerel, Italy in 1711, when the citizens debated the merits of building a wall to protect against the future avalanches. We can speculate that the discussion included reference to an avalanche destroying the neighboring town only five years earlier. It may have referenced the increased frequency of avalanches in the preceding decades, during what we now call the Little Ice Age. It may also have referenced the skilled wall-building labor and engineering capacity brought to the region a decade earlier to construct fortifications during the Nine Years War. We do know, without speculation that the wall was completed in 1716, it is still standing, and so is the town of Pequerel.

This speculation is consistent with the factors that increase motivation to take protective action against threats, whether the threats are avalanches, other natural hazards such as drought, flood and fire, or threats to human health from treatable diseases. Those motivations typically include intimate experience with the threat (neighboring town destroyed), known frequency of threatening events (avalanche frequency in the preceding decades), and access, both conceptual and tangible, to a solution that protects against the threat (availability of skilled wall-building labor and engineering).

Remove any of these factors, and protective motivation declines, and so does protective action. Hence the difficult challenge of planning to increase protection against climate change must include the use tangible examples of future threats, likelihoods of climate change intensity, and examples of protective solution design and likelihood of success.

I explore that challenge by examining a planning process we applied to help cattle ranchers and federal land managers increase protection against drought in a period of increasing drought frequency. I specifically seek lessons about the planning process and increased frequency of threat that may transfer to planning for climate change. Returning to the Pequerel example, I am searching for lessons that may have motivated the neighboring town of Puy to build an avalanche wall before it was destroyed.

Drought v. Climate Change: Probability, Vulnerability Assessment, and Planning

Drought, like many natural hazards has a probability distribution associated with the intensity of the threat. For example, the Standardized Precipitation Index (SPI) represents the likelihood of drought intensity (departure from average divided by standard deviation), where SPI $\leq$-1.0 is expected 16% of the time, and SPI $\leq$ -2.0 is expected 2.5% of the time. These probabilities are based on the empirical record of precipitation. In contrast, predictions about the magnitude of climate change are not based on the empirical record, but based on modeled predictions of expected outcomes. The likelihood of those outcomes are often based on comparisons of different model-based predictions. However, the recent trend in climate conditions may provide a bridge between empirical probabilities of natural hazards and modeled probabilities of climate change. For example, increasing temperatures, increasing inter-annual variability of precipitation, and prolonged droughts all represent very unlikely probabilities in the empirical record, and as such, they could provide tangible examples of possible future conditions under a new climate regime.

Vulnerability assessments provide a useful framework for comparing planning for drought and planning for climate change. Vulnerability is a function of exposure to threats, the sensitivity to that level of exposure, and the adaptive capacity to resist, recover or transform after the impact of the threat. Vulnerability increases with increasing exposure and sensitivity, but vulnerability decreases with increasing adaptive capacity. Again, drought and climate change differ most in the empirical basis for estimating exposure, and given the novel conditions of climate change, there is less empirical basis for estimating sensitivity and adaptive capacity than for drought. Nonetheless, vulnerability assessment provides a useful framework for evaluating potential impacts and the associated adaptive responses for both drought and climate change.

Planning for increased protection is the logical next step after a vulnerability assessment for both drought and climate change. Again, planning to increase protection against drought has the advantage of empirical probabilities for exposure and sensitivity, and a history of adaptive responses such as flexible management and infrastructure to support flexibility as well as government investments to encourage preparation. Therefore, one might predict greater engagement and impactful outcomes if planning for climate change is built on recent trends toward climate extremes. For example, lessons learned from planning for drought at SPI -1 could be the starting point for climate change planning where SPI -1 is the new norm.

Drought Planning Framework

We adopted the Protection Motivation Theory and associated Health Action Planning Approach (PMT-HAPA) to structure the drought planning activities because it integrates experiential knowledge about known drought probabilities, threat assessment and coping assessments for drought conditions, and action plans to implement the coping strategy and recovery plans for when the strategy fails. PMT-HAPA emerged in the health profession to understand the psychological process of patients adopting a physician's directive, and applied that understanding to improve the delivery of those directives and the support mechanisms that increase the patient's ability to follow directives.

PMT-HAPA expands a typical vulnerability assessment by adding a planning and recovery component to help the patient, or in our cases land and cattle managers identify the steps needed to apply any promising solution. Specifically, the initial step of learning the critical probabilities of threats is analogous to understanding probabilities of exposure in a vulnerability assessment. Developing threat and coping assessments in PMT-HAPA, such as finding a treatment regime that is realistic for a patient is analogous to understanding sensitivity and adaptive capacity in a vulnerability assessment. However, there is no analog in vulnerability assessments for the HAPA activities of developing actions plans for implementing coping practices and recovery plans for when those initial plans fail.

Applying PMT-HAPA to Drought Planning in Arizona, USA

In 2014, we starting working with cattle ranchers and federal land managers to increase their preparation for drought. We used PMT-HAPA to structure the tools and activities. Our efforts increased their level of preparation for future drought compared to non-participants. Our web site http://cals.arizona.edu/droughtandgrazing provides access to the tools and planning guides as well as a dashboard of current drought indices.

In Arizona, like most of the western USA, privately owned cattle graze on federally owned rangeland and therefore private ranchers and public land managers will collaborate in efforts to increase preparation for drought. Those collaborations are not always successful, and in our study area there is still some animosity because the National Forest managers required the removal of all private cattle during the severe drought of 2002-2003. Hence, the participants have an intimate experience with drought impacts.

Given this setting, our first premise was to engage and integrate both groups in the drought planning process because they both contribute to and are affected by decisions. Integration is expected to improve communication and trust for future interactions. The second premise was based on principles of adult education, where hands-on tools and problems solving activities will generate the greatest engagement and positive learning outcomes.

We developed the SPI Explorer tool to support learning about drought probabilities and associated precipitation deficits in the empirical record since 1895. This provided a common language to discuss both the intensity and likelihood of recently experienced droughts as well as scenarios of future drought conditions. We developed the Drought Scenario Planning tool to support scenario planning exercises for a realistic, but hypothetical federal grazing allotment and associated cattle ranch in Tonto National Forest. We used the SPI Explorer to generate the values of precipitation associated with scenarios in the Drought Scenario Planning Tool. Together, these two tools supported the PMT elements of learning critical probabilities of threats, and developing threat and coping assessments.

The HAPA elements of developing action and recovery plans were supported by a Decision Table that reports the likelihood of the National Forest approving a practice and the length of time for that approval. The Decision Table was generated by the planning participants based on their experience with policy, regulations, and legal challenges. We then required participants to identify the likely actors in the decision process, the frequency and lines of communication during the process, and a "Plan B" or recovery plan to follow if the preferred coping practice was not approved by the National Forest.

The entire process is described in the *Guide to Co-Developing Drought Preparation Plans for Livestock Grazing on Southwest National Forests*. It includes worksheets for completing threat and coping assessments, and for prioritizing coping practices based on expected approval by the National Forest. Most importantly, we designed the *Guide* and worksheets to support collaboration between the private ranchers and the National Forest land managers.

Our end-of-project survey of participants and non-participants suggest that participants are more familiar and comfortable with drought information tools, have better working relations with the National Forest, are more prepared for future drought, and are more likely to pursue collaborative drought planning with the National Forest. Most interesting is that non-participants want to have better working relations with the National Forest as a way to increase preparation for drought.

Lessons Applied to Climate Change Planning

For drought planning, we found success using tools that support hands-on learning and scenario-based problem solving activites, but most critical were the action plans for implementing the solutions identified in the coping assessments. Therefore, one lesson is to pursue a planning structure like PMT-HAPA because it develops realistic action plans and recovery plans after failures, rather than stopping at the threat and coping assessment stages.

Uncertain probabilities for climate change may be the biggest challenge to a climate change planning process that results in realistic action plans. These probabilities are critical to assessing likelihood of exposure to new conditions. We observed that the empirical probabilities of drought in the SPI Explorer tool provided the credibility needed for participants to be committed to the scenario planning process. Therefore, a second lesson is to develop climate change scenarios that represent the recent extreme (low likelihood) trends in temperature or precipitation and use those to provide new, yet tangible stationary conditions for climate change scenarios. For example, we experienced more frequent SPI -1 conditions since 1996 than occurred between 1940 and 1996. Using SPI -1 as the new norm for climate change scenarios might provide the necessary link to empirical probabilities as well as the critical reference to conditions experienced by planning participants.

Lesson three is build a realistic socio-ecological model for a scenario planning tool, and make that tool as interactive as possible to support the identification and assessment of many realistic scenarios and many different coping strategies. Scenario planning should support the discovery of creative and realistic solutions that can be applied to real situations. Specifically, scenario planning should help users discover and solve the "bottlenecks" in the hypothetical situation, so that they can perform the same analysis for a real situation. Therefore, the socio-ecological model should not only represent the sensitivity of forage and drinking water to drought, but also must represent how adaptive capacity is dependent on social factors such as motivations, economics, law, and land tenure. For example, our tool represents the typical bio-physical sensitivities of drought-related declines in forage production and drinking water availability for each pasture and each growing season (winter and summer). It also supports changes to herd size and composition, and changes to the sequence of movement between pastures. Most importantly, it can also represent federal policies that might limit use of some pastures for various times of the year to accommodate endangered species, recent fires, or recreation use.

Return to Pequerel

Recall the Pequerel example, and this time imagine that the neighboring town of Puy had completed an avalanche planning process similar to the drought planning process, but no neighboring town had been destroyed. I am not optimistic that they would have been motivated to take protective action if the threat was based on entirely on a predicted increase in avalanche frequency without a tangible example of the threat. Instead, I predict that they would have focused on other more tangible threats such as the ongoing Nine Years War.

In contrast, I am more optimistic that they would have taken protective action if tangible evidence of increasing avalanche frequency was clearly described. That increased frequency of avalanches (threat assessment) and a feasible solution to build a wall (coping assessment and action plan) may have provided enough motivation in spite of the ongoing Nine Years War.

Take home message

Sturaro *et al*

The sustainability and the multifunctionality of dairy cattle systems in Eastern Italian Alps provide synergies and trade-offs between efficiency, ecological footprint and non-provisioning ecosystem services.

Climate footprint and ecosystems services in Alpine dairy cattle chains

Enrico Sturaro, Marco Berton, Luigi Gallo, Stefano Macolino, Cristina Pornaro, Maurizio Ramanzin

Introduction: The socio-economic evolution of mountain areas is challenging local productions, leading to the abandonment of traditional jobs and rural areas. The multifunctionality of mountain livestock systems can be addressed using the ecosystem services approach (Rodriguez Ortega et al., 2014), to ascribe values, and allocate resources, to products and services that contribute to human well-being and the attractiveness of mountain areas. In this study, we present the preliminary results of the project "TOP-VALUE, the Added Value of Mountain Products" (Interreg Italy-Austria ITAT2009). The project aims at empowering the added value (extrinsic quality) of "mountain products" by identifying and quantifying ecosystem services (e.g. biodiversity, landscape conservation, emissions' regulations) linked to the natural and cultural assets of the area. The specific aim of this contribution is to analyse synergies and trade-offs between efficiency, ecological footprint and non-provisioning ecosystem services in a sample of dairy cattle farms in Eastern Italian Alps.

Materials and methods: Eighteen dairy cattle farms conferring milk to 4 cooperative dairies were sampled in Eastern Italian Alps. Data on herd composition and management, milk production and quality, land use, and use of external input were collected to calculate the environmental footprint of these systems. A Life Cycle Assessment (LCA) approach was used to calculate: Global Warming Potential (GWP), Eutrophication (EP), Cumulative Energy Demand (CED) and Land Occupation (LO). Two functional units were used: 1 kg of Fat and Protein Corrected Milk (FPCM) and 1 m^2 of farming area. Milk vs meat biophysical allocation (IDF method) was used. Production efficiency was calculated as gross energy conversion ratio, considering also the diverting of human edible resources. Data on grasslands management of each farm were collected and the species richness of the different categories of land use was determined by recording all species found in three unit surface areas homogenous for management and representative of all vegetation types. In each unit, species were recorded during a walk along a linear path which intersects the area with the highest diversity. A hot-spot analysis of the impact categories was used to investigate the contribution of different practices/sources of emissions (herd and manure management, on-farm feedstuffs production, purchased feedstuffs and materials). Correlations among the different indicators were tested to analyse synergies and trade-offs between efficiency, environmental footprint and grassland biodiversity.

Results: The sample of dairy farms considered in this study is heterogeneous, as expected in mountain areas (Sturaro et al., 2013). The average herd size is 53±33 LU, the milk yield is 7837±1831 FPCM/cow per year and the agricultural area is 36±32 ha, mainly grassland, with a large variability of farm self-sufficiency (from 14 to 93 % of diet dry matter). The impact categories calculated with LCA approach are in line with literature (Salvador et al., 2016): GWP=1.26± 0.23 kg CO2-eq; EP=6.4±1.7 g PO_4-eq; CED=3.6±1.0 MJ; LO=1.94±0.64 m^2/y, 1 kg of FPCM as functional unit. The correlations between impact categories were positive and statistically significant with the same functional unit, but they were not correlated by comparing different functional unit. As higher was the production, as lower were the impact categories, but the use of external inputs, especially human edible concentrates, affects this result. Farms with high self-sufficiency can maintain grasslands with a good balance between production and species richness (data not shown).

Conclusion: The results from this study evidenced that the alpine dairy farming systems are able to produce high quality products by using local resources. A multi-indicator approach is recommended to analyse the sustainability and the efficiency of this system, taking into account the trade-offs between production and non-provisioning ecosystem services.

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Take home message

Baumgartner *et al*

Focussing on the assessment per kg milk, the environmental results for longer grazing showed a diverging picture with benefits for ecotoxicity and the use of P resources and drawbacks with respect to global warming potential (GWP). However, when the attention was turned to the environmental burden per ha farmland (UAA), dairy farms with a longer grazing duration performed significantly better, e.g. land competition or GWP, than those with shorter ones.

Does grazing duration in dairy farming have environmental benefits?

Daniel U. Baumgartner[1], Thomas Guggenberger[2], Silvia M.R.R. Marton[3]

Introduction: in today's Europe, two contradicting tendencies can be observed: On the one hand, pasture grazing is declining as high lactating cows are fed mainly indoors (Van den Pol et al., 2008). On the other hand, consumers' awareness of animal welfare issues is increasing, and numerous stakeholders consider grazing an important part of the inherent behaviour of dairy cows. The same consumer group is often also concerned about the environmental effects, e.g. on climate change, of products. The objective of this study was to assess how grazing duration affects the environmental performance of dairy production.

Materials and methods: twenty-two commercial Austrian dairy farms provided agricultural management data for the year 2014. In the long grazing duration group (n=10; average grazing duration per year: 3880 hours) on average grazing supplied 37%, dried or ensiled roughages 58%, and concentrates 5% of the feed intake (in dry matter). For the short grazing duration group (n=12; average grazing duration per year: 630 hours) the feed intake was on average 8% from grazing, 78% from dried or ensiled roughages, and 14% from concentrates, respectively. For the environmental assessment we used the FarmLife-methodology (Herndl et al., 2016), a life cycle assessment (LCA) approach at farm level.

Results: The "long grazing" group of farms had significantly lower values per ha farmland (UAA) and year for cumulative non-renewable energy demand (nrCED), global warming potential (GWP), both aquatic eutrophication N and P, terrestrial ecotoxicity, use of P and K resources, land competition, land use change, and water use. The lower stocking density in the "long grazing" group was one reason for these positive results. Another important reason was the use of far fewer concentrated feedstuffs compared to low grazing farms. In addition, the greater use of purchased concentrates explained the higher land competition for "short grazing" farms, as they needed more agricultural surfaces off-farm for the purchased feedstuffs. In a world with growing human population and increasing demand for food, this is a key-issue, as the competition for land will grow further.
Analysing the LCA results per kg milk showed a diverging picture. For several impact categories such as nrCED, aquatic eutrophication N and P, and water use, there was no difference between the dairy farms with high and low grazing duration. For other impact categories such as GWP, land competition, and land use change, the environmental impacts of the "long grazing" farms were significantly higher; for other categories such as terrestrial ecotoxicity or resource use of both P and K, the impacts were significantly lower than for the low grazing farms. One of the reasons for these trade-offs per kg produced milk was the milk yield (kg/cow*a) which on average was 28% lower on "long grazing" farms. For environmental impacts where the advantages of long grazing duration were limited, the reduced milk output resulted in a less favourable LCA result. Altogether there were few trade-offs, which is encouraging. However, need for action exists for reducing the GWP.

Conclusion: Producing milk with long grazing duration had significant or very significant environmental advantages regarding the effects per ha of farmland, i.e. the livelihood preservation function. At the same time, we observed for the "long grazing" farms some negative environmental effects with respect to the productive function, e.g. for GWP. These are encouraging results to promote grazing of dairy cows. However, the attention should be directed on how the discovered trade-offs could be reduced, namely GWP, e.g. with feed supplements, pasture quality improvement or adapted dairy cow genetics.

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Take home message

Marin

Pastoralist systems' adaptations need to be understood as a complex transformation that integrates social and environmental knowledge and concerns. This can be done more systematically by comparing across cases.

Socio-ecological transformations: how do pastoralists adapt to climate change in Norway and Mongolia?

Andrei Marin

Introduction: The paper presents comparatively environmental policy processes related to formalizing rights to land and other resources (water, migration routes) in two apparently different pastoralist systems: the Sámi reindeer management system in Finnmark, Norway, and the Mongolian pastoralist system in the desert-steppe ecotone in the central part of Mongolia. The goal is to tease out how large-scale socio-environmental changes (transformations) constrain or facilitate adaptation to climate change.

Materials and methods: The paper draws on long-term empirical research in both contexts. By applying an analytical approach common in political ecology and historical institutionalism, the paper illustrates how long-term and large-scale social and environmental processes influence adaptation. Particular attention is given to policy processes related to formalization of customary rules for managing natural resources and to local perceptions of environmental and climate change. The paper looks specifically and critically at the policy process: that is how science, technocracy and expertise are used and argued in the ongoing discourses. In addition, it shows how actor-oriented and practice-based approaches to policy-making and to adaptation studies can be combined in innovative ways.

Results: The results show a typology of adaptation options and how they are both constrained and facilitated by the socio-environmental contexts discussed. They also emphasize the importance of understanding the complex historical contexts in which adaptation options take place and how local pasture users conceive of their livelihoods in a way that integrates environmental and social concerns.

Conclusion: The study proposes a unifying conceptual framework for understanding adaptation in pastoralist systems as an element of larger socio-ecological transformations. The conclusion is that pastoralists do adapt to climate change but that their adaptations need to be understood as a complex transformation that integrates social and environmental knowledge and concerns.

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Take home message

Vagnoni *et al*

The use of a mass-based or land area functional unit in a LCA study to assess the environmental implications of dairy sheep system extensification leads to contrasting conclusions. The inclusion of soil C sequestration in the assessment of Global Warming Potential reveals an environmental advantage for grass-based sheep systems.

Climate change implications of sheep farming system extensification: A LCA case study

Enrico Vagnoni[1], Antonello Franca[2], Pasquale Arca[1], Claudio Porqueddu[2], Pierpaolo Duce[1]

Introduction: The evaluation of trade-offs between agri-food production and ecosystem services and the mitigation of greenhouse gases (GHG) emissions are among the main research priorities of the EU Scientific Research Agenda (Notarnicola, 2017). Regarding these themes, Mediterranean sheep farming systems can represent interesting case studies because of their recognized multifunctionality and key role in climate change mitigation strategies of livestock supply chains (Marino et al., 2016). The aim of this work was to evaluate the environmental effects of the transition from a semi-intensive (SI) to a semi-extensive (SE) management system in a dairy sheep farm, using a LCA approach. The study particularly focused on the influence of soil C sequestration (Cseq) and the role of different functional units (FU) on Global Warming Potential (GWP) performances.

Materials and methods: Data refer to two years, 2001 and 2011, when two different farming systems were implemented in a dairy sheep farm located in Osilo (40°45'11" N and 8°38'43" E), Northwestern Sardinia (Italy). In terms of flock size and total area, the farm is representative of about 65% and 47% of Sardinian dairy sheep farms, respectively. The LCA methodology followed the international standards ISO 14040–14044 (2006) and FAO (2010). Both 1 kg of Fat Protein Corrected Milk (FPCM) and 1 ha of Utilized Agricultural Area (UAA) were used as FU. The GWP was assessed using the IPCC (2013) evaluation method. Moreover, soil Cseq was estimated according to Petersen et al. (2013), taking into account C from manure and crop residues (above and belowground), and considering a 100-year time horizon.

Results: GWP and the contribution of each process to the total GHG emissions of SI and SE production systems, calculated including and excluding soil Cseq are presented in the following table:

	Semi-intensive		Semi-extensive	
	No Cseq	Cseq	No Cseq	Cseq
Global Warming Potential (kg CO_2-eq)				
per kg FPCM	2.95	2.73	3.34	2.63
per ha UAA	5,471	5,052	3,800	2,999
Processes contribution (%)				
Enteric CH_4 emissions	51	55	55	70
Purchased feeds	24	26	29	37
On-farm feeds	8	8	2	2
Energy	7	7	2	2
Transport (lorry and/or transoceanic freight ship)	4	4	5	7
Infrastructure	1	2	1	1
Tractor and agricultural machinery production	1	1	3	4
C sequestration	0	-8	0	-27
Remaining processes[a]	4	4	3	3

[a] Includes all the processes with a percentage contribution lower than 0.25%.

Conclusion: The transition from SI to SE system resulted in a clear environmental advantage when GWP was expressed per ha of UAA, while the mass-based FU led to contrasting results and less pronounced differences between the tested production systems. The positive effect of soil Cseq on GWP performances of a grass-based sheep system was confirmed. The LCA study highlighted the environmental hotspots that can be investigated and improved for the development of GHG mitigation strategies for the Mediterranean dairy sheep sector.

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Take home message

Hovelsrud *et al*

Farmers understand the concept of green transition in many different ways ranging from larger industrial agriculture to local food production. The majority position their existing activities within a green shift. While organizations, enterprises and individuals in the agricultural sector are sympathetic to the need to transform to lower emission, it is mainly incremental changes that are occurring and seen as acceptable.

How do Norwegian farmers and agricultural organizations understand their role in 'the green transition'?

Grete K. Hovelsrud, Marianne Karlsson, Halvor Dannevig

Introduction: There is increasing evidence that incremental changes will not lead to sufficient emission cuts to avoid dangerous consequences of climate change. The need for a more profound restructuring or transformation of society has therefore been argued as necessary to achieve a fossil free future. Globally and in Norway, agriculture plays a dual role in climate change discourses by being depicted as a substantial emitter of greenhouse gases and a driving force toward a new and more sustainable bio economy. The combination of pressing market conditions regulatory demands, climate variability and change play the sector at the forefront of adaptation, innovation and thereby potentially transformation. This paper examines how farmers and agricultural organizations understand, negotiate meaning and view their role in Norway's 'the green transition'

Materials and methods: The paper is based on 12 qualitative interviews with farmers, agricultural organizations and bureaucrats in four case areas: Sogn og Fjordane in Western Norway, Lofoten Islands in Nordland Northern Norway, the Hammerfest region Finnmark Northern Norway and the Jæren region, Rogaland South-Western Norway. The selected case areas represent different climatic, geographical and market conditions. We employed a common research framework and consistent methodology across the case areas, allowing for generalizations to be formulated with higher validity than if each case was treated in isolation (Flyvberg 2004).

Results: The findings show that our informants are in general sympathetic to the need to go toward a greener economy but they interpret the concept in various ways; from a strict focus on reducing carbon emissions within their activities to promoting local resource use and food production. Many farmers associate the green shift with opportunities in promoting their activities and products as part of the green shift. We found two main narratives that relate farming to the green transformation; one emphasizing large scale intensified agriculture and one emphasizing local resources and food production. The prevalence of the different narratives varies across case studies. For example, in Jæren, intensified agriculture is promoted as a climate solution whereas farmers in Lofoten tend to emphasize the importance of small-scale production and local resources. Several innovations including biogas facilities, experiments with new berries and fertilizers take place in all case studies. While some innovations contribute toward environmental and climate goals and thereby can play a role in a green transition, innovations are driven by the need to increase value generation or to comply with regulations.

Conclusion: We find that although most of our informants support a green transition they choose a definition that favour their existing business model and activities. This indicates that farmers and agricultural organization can accept smaller and incremental changes but not a profound transformation.

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Take home message

Short and Aglionby

Goods and services from commons including water quality and flood protection, biodiversity, cultural landscape, access, carbon storage and archaeology might be improved by addressing threats to traditional collaborative management in England.

Our Common Cause: Our Upland Commons – taking a multi- partner collaborative approach to resolving challenges on upland commons in England

Christopher John Short, Julia Aglionby

Introduction: This paper will introduce a new project looking at 4 areas of upland common in England (Dartmoor, Lake District, North York Moors and Shropshire Hills) that seeks to address threats to traditional collaborative management by using a collaborative and multi-partner approach to improving the goods and services from commons. These goods and services include water quality and flood protection, biodiversity, cultural landscape, access, carbon storage and archaeology. The project activities will increase understanding of the heritage of commons and their role in ecosystems service provision between visitors, local communities, policy makers and farmers. Overall the aim is to seek ways that support the contribution of commoners and commons to the delivery of public goods and services. It addresses the lack of understanding of commoning and commons amongst decision makers and other organisations who influence the management of the land.

Materials and methods: There are a number of significant threats facing commoners and commons which put the practice of commoning, and with it the natural and cultural heritage of commons, at considerable risk. The paper will consider three broad areas.

A) The most fundamental threat is that the role of commoners and commons is neither understood nor valued.
B) The increasing number of external pressures on commoners threatens to undermine the systems and cultural landscapes of commons.
C) The decline in commoning threatens the heritage of commons and the public goods and services they produce. It also diminishes the resilience of commons in the face of external pressures.

Results: A pilot project produced a set of 'attributes of successful management for multiple outcomes' and these are central to the Our Common Cause project. The co-production approach will be outlined regarding the best practice in the commoning community. Given the limited opportunities to build capacity and increase capability it is essential to promote and examine good case studies to ensure that knowledge and skills exchange is viable. The trans-regional approach is essential due to the fragmented nature of commons across England and justified by the themes that arose from the regions in the pilot. The richness of experience across the country will benefit commons, commoning communities and the range of organisations (public and private) that engage with them.

Conclusion: The pilot study revealed that there are common features across upland commons and that local action and activity is possible even where there is a lack of national incentive or interest. The new project will facilitate an exchange of knowledge between parties with an interest in upland commons, thereby improving understanding and mutual respect. The needs of upland commons and the related communities are severe and need to be tackled urgently.

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Take home message

Veland

Naturalization of Western Norwegian mountains places livelihoods, food production, and biodiversity at risk. Agricultural production efficiency indicators that go beyond 'litres and fat percent' to consider farmers' ecosystem services may slow or curb the trend.

Reasons for valuing smallholder farmers' ecosystem services in maintaining biodiversity and food productivity in Western Norway

Siri Veland

Introduction: Smallholder farms are under pressure across the world as specialization, intensification, and consolidation of farmlands challenge their economic and societal sustainability, even as climate changes alter conditions for growth and disease vectors. The drivers of intensification over recent decades are many and varied, including international trade, consumer preferences, and productivity indicators used by governments and industry. In 2015, the Norwegian Government could celebrate evidence of increasing productivity in Norwegian agriculture and describes this being a trend since at least the 1930s (Produktivitetskommisjonen 2015). Nevertheless, the commission points to the challenges associated with measuring productivity against purely economic measures, and to the many societal benefits of farms in maintaining communities in rural areas. The commission also points to the increasingly important role of maintaining food production under climate change and dynamics of global markets in the future post-petroleum world. This study attends to the performance of smallholder farmers to meet productivity standards, and highlights some unintended consequences. It considers the drivers of naturalization of Norwegian mountain pastures, and suggests a possible solution valuing farmers' ancestral and praxis-based knowledge.

Materials and methods: The research is part of a pilot study coordinated a survey across eight nations (Benin, China, Ghana, Madagascar, Nigeria, Norway, Peru, and Spain). The team of researchers interviewed smallholder farmers to elicit their innovations to climate change, with particular focus on which knowledge traditions contributed to their innovative adaptive measures. The survey involved questions concerning farm size and economy, experiences of climate change, the use of extension services, and reliance on innovations drawing on science, own experience, or inherited/indigenous knowledge systems. The fieldwork was carried out in 2016. This paper focuses on survey results from Sunnfjord in Western Norway.

Results: Results reveal a complex set of interacting factors leading to overgrowth and naturalization of mountain pastures, and long-term sensitivity of Western Norwegian food production to environmental change. First, farmers reported that agricultural productivity measured by 'milk volume' and 'percentage fat' had driven the breeding of cattle that are bigger and heavier, but with small hooves. These cattle produce higher quantities of milk, but their heavy weight over a small surface area causes them to trample the pastures. Given increasingly wet and mild climates, these pastures are becoming less capable of supporting grazing. Second, with decreasing profits from sheep farming, sheep are no longer maintaining the cultural landscapes and biodiversity of mountain pastures. One farmer reported returning to sheep production following the observation that the sheep 'prepared' the near-farm pastures for cattle yearlings. Third, they observed that with naturalization, the species composition of mountain pastures had changed markedly. They highlighted increasing risk of wildfires as naturalization progresses, and that old burning practices are becoming less frequent or known. The farmers express frustration at political disincentives that prevent valuing the practices of farmers in maintaining productive ecosystems. In ecosystem-based management, attention to the economic value contributed by ecosystem processes led to the recognition of 'ecosystem services'. Shifting the baseline of agricultural productivity to include 'farmers' ecosystem services' may maintain mountain ecosystems.

Conclusion: Current agricultural productivity measures induces farm animals maladapted to environmental conditions. Measuring productivity beyond 'litres and percentage fat' to valuing farmers' ecosystem services improves the resiliency of mountain pastures and food security in Western Norway.

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Take home message

Martinez *et al*

Tissue stoichiometry studies (N, P, K) under drought stress can have implications for climate-smart agricultural management strategies.

Tissue stoichiometry as a forage quality index in the context of climate change: drought-related productivity constraints and nutrient quality

Melissa Cristina Morcote Martínez[1], Johannes Ingrisch [1], Roland Hasibeder [1], Helene Solderer [1], Kevin Van Sundert[1], Sara Vicca [2], Michael Bahn [1]

Introduction: Marginal grasslands strongly rely on natural climatic conditions and require a close adaptation of agronomic practices to climate change. It has been suggested that in the coming decades severe drought periods will likely become more intense and more frequent (IPCC 2012), with potentially severe consequences for ecosystem functioning (Reichstein et al. 2013, *Nature*). Next to climatic changes, land-use changes have been prevalent in many mountain regions, and have frequently led to the abandonment of managed grasslands. While droughts and land-use changes have been observed to have significant impacts on the productivity of mountain grassland, their combined effects have rarely been tested. We performed a series of studies simulating extreme summer drought on managed and abandoned grassland in the Austrian Alps. We analysed drought effects on productivity and tissue nutrient concentrations.

Materials and methods: At the at the LTSER site Stubai Valley, Austria, rainout shelters were installed on managed and abandoned subalpine grassland. These grasslands have been traditionally used as pastures and for haymaking, for which they are cut once a year and lightly fertilized with liquid manure every few years. Some grasslands were abandoned in the 1980ies and were partly reforested. For replicated plots subjected to drought and for ambient control treatments, above-ground net primary productivity and yield were measured at peak biomass, which corresponded to the peak drought period, and at the end of the season, when plots had recovered from drought. To understand drought responses in more detail, also root biomass was sampled and analyzed for changes in root mass and length. Tissue nutrient concentrations are currently being measured, and include N, P, K, Mg, and Ca.

Results: The productivity of managed grassland was more strongly affected by drought and recovered faster than on the abandoned grassland (Ingrisch et al. 2018, *Ecosystems*) and reflected a trade-off in the components of resilience to drought (Ingrisch and Bahn 2018, *Trends in Ecology and Evolution*). During rewetting after drought nitrogen (N) was more strongly released by soil microbes on the managed as compared to the abandoned grassland, and was taken up by plants more rapidly, speeding up recovery from drought on managed grassland (Karlowsky et al. 2018, *Journal of Ecology*; Ingrisch et al. 2018, *Ecosystems*). Results for other nutrients are currently pending and will permit an analysis of whether the strong N dynamics during recovery from drought were also mirrored by other elements, and to what degree thus nutrient quality and overall forage quality were thus affected by drought.

Conclusion: Knowledge on nutritional allocation grassland plants communities under water scarcity can re-direct management strategies e.g. in terms of botanical composition, soil amendments, and fertilization. The obtained data have the potential to contribute to management strategies that closely adapt to climate change to secure the resilience of grasslands to climate exremes. Our study can have implications for climate-smart agricultural management strategies measuring stoichiometric traits in low-input grasslands, which strongly rely on natural climatic conditions. By learning from plant strategies in semi-natural grasslands, we can expect to combat better the impacts of drought on productivity and fodder quality under ongoing global changes.

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Take home message

Metawi

The north western coastal zone of Egypt is characterized by availability of different water sources with varied distribution between regions. This study aims to assess the effect of drought on livestock farming systems and Bedouins socio-economic vulnerability and to identify the most frequently adaptive process developed by Bedouins to reduce the negative impact of drought. The findings of the study indicate that profitability of livestock production in dry regions is affected by the presence of the proper strategies to decrease animal feeding costs.

The contribution of livestock species to reduce vulnerability in pastoral areas of Egypt

Helmy R. Metawi

Background: The North-western coastal region of Egypt extends about 500 kilometres along the Mediterranean coastline. The pastoral livestock production systems prevail in this area. The zone has witnessed major changes over the last 50 years; demographic growth, urbanization and degradation of rangelands. More recently, the zone has faced by drought that has become more frequent.

Objective: to assess the effect of drought on livestock farming systems and Bedouins socio-economic vulnerability and to identify the most frequently adaptive process developed by Bedouins to reduce the negative impact of drought.

Methodology: A semi-structured questionnaire was used for interviewing 162 randomly selected Bedouins. Based on water resources, the study area was divided into two agro ecological subzones': i) the rain-fed area (RA) in the west, ii) the dry area (DA) in the east.

Result: Analysis of data showed that drought produce a large number of impacts that affects Bedouins economical standard of living. The annual sheep and goat productivity declined by 18.03 and 8.33%, respectively. Furthermore, the returns on capital invested in sheep and goat production were significantly reduced by around 47 and 34%, respectively. The analyses showed a significant relationship exists between the Bedouins socioeconomic characteristics and the encountered challenges ($p < 0.05$). Breeders have developed different adaptive mechanisms against drought conditions such as decreasing flock size, supplementary feeding, changing herd composition ,early marketing of their lambs/kids and migration of family members to urban areas.

Conclusion: The contribution of livestock to household income increased from 50.34 % in RA to 74.3% in DA. Hence, more emphasis should be given to improving livestock productivity and proper utilization of Bedouins resources in the dry areas. It is important to take into consideration socio-economic factors that influence small ruminant development programs to enhance their success.

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Take home message

Peratoner *et al*

Poster

Potential evapotranspiration (PET) was shown to be the main driver for growth rate in extensively managed pastures at low altitude in the Alps. Forage quality was only partially affected, and to a lesser extent, by the weather conditions.

Effect of drought on growth rate and forage quality of different pasture types in a protected area

Giovanni Peratoner, Lorenzo Vitalone, Ulrich Figl, Andreas Kasal

Introduction: In protected areas, the conservation of valuable pasture vegetation types and the prevention of undesirable succession depend on an adequate stocking rate of the grazing livestock. As the forage production of lowland pastures at the southern margin of the Alps on shallow acidic soils has been shown to be highly variable depending on the weather conditions (Peratoner et al., 2009), the identification of the main weather drivers, also depending on the pasture type, represents a valuable tool to identify shortcomings in the forage production and suitable strategies to tackle them.

Materials and methods: The study was carried out at the biotope Castelfeder (about 300 m a.s.l., mean yearly temperature 12.4°C and precipitation sum 821 mm, Etsch Valley, South Tyrol, Italy). Three main pasture types (grazing season from mid-April to mid-November) were investigated: dry and semi-dry grassland (DG), extensively managed pastures with *Festuca rubra* (EP) and nutrient-rich pastures with *Festuca rubra* and *Agrostis tenuis* (RP) (Ruffini et al., 2005). In a four-year trial, growth rate and forage quality were determined according to the Corrall-Fenlon method (Corrall and Fenlon, 1978) with a six-week rotation. Meteorological data from the meteorological station of the Laimburg Research Centre (5 km distance from the experimental site) were used to compute for each regrowth period Growing Degree Days (GDD), Precipitation sums (PS), Potential Evapotranspiration (PET) according to Penman and Monteith (Allen et al., 1998) and a water balance (WB) as a difference between PS and PET. Statistical models were stepwise forward developed for each pasture type by means of mixed models accounting for the translation of the trial area every year within the vegetation type (random factor) and using the GDD, PS, PET and WB as covariates to build a polynomial regression and AIC as an indicator.

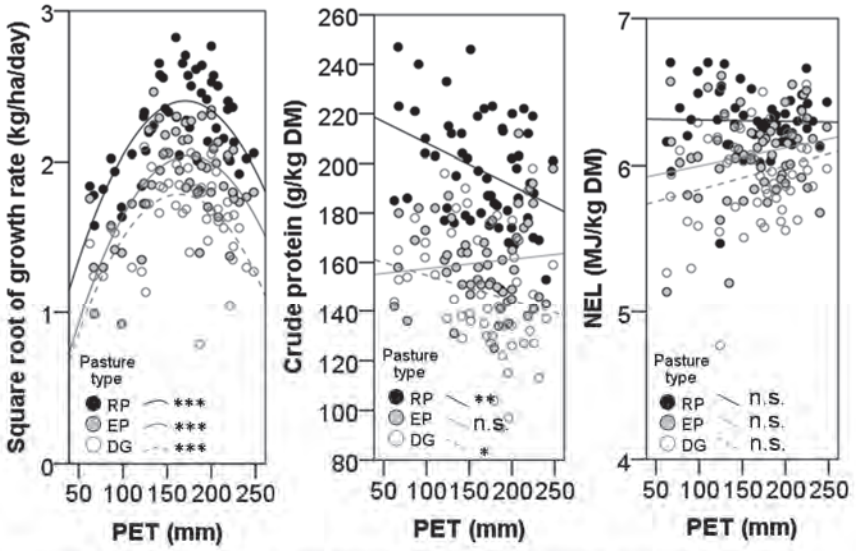

Figure 1. Effect of PET on forage yield and forage quality.

Results: Among all investigated meteorological variables, PET was the one affecting most the forage growth rate (quadratic polynomial), with PS ($P<0.001$) further improving the model and showing as expected a positive relationship with the growth rate. The growth rate was found to increase for all pasture types up to moderate values of PET and then to decrease. No effect of PET was detected on NEL, whilst less pronounced effects were found for crude protein, decreasing in tendency with increasing PET for RP and DG only. No other meteorological variable could further improve the statistical models.

Conclusion: Forage production was greater affected by weather conditions than forage quality. Real time computation of PET might be used as a proxy to identify shortcomings in the forage production during the growing season.

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Linking agropastoral sustainability with agricultural policies and human activities

Take home message

Hansen *et al*

Invited Keynote speaker

The reestablishment of large carnivores in Norway, but also worldwide, is a huge challenge for the most severely affected farmers resulting in high livestock losses. Reduced number of livestock in some areas will lead to changes in the cultural landscape and probably loss in biodiversity over time. The legitimacy of the carnivore management zoning strategy is disputed by the rural communities, escalating the political conflict over the entire carnivore conservation strategy.

Effects of Norwegian large carnivore policy on national grazing industry

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Introduction

The populations of large carnivores (brown bear (*Ursus arctos*), grey wolf (*Canis lupus*), Eurasian lynx (*Lynx lynx*) and wolverine (*Gulo gulo*), are currently recovering after 100 years of near extinction in many parts of Europe, due to conservation designations protecting large carnivores. Roughly one third of the continent is now host to at least one large carnivore species (Chapron et al. 2014). The return of the large carnivores may have a negative effect on farmers, potentially leading to a renewal of tension and conflicts (e.g. Cuicci & Boitani 1998, Mattiello et al. 2012, Meuret et al. 2017, Widman & Elofsson 2018). It is therefore judicious to follow the process closely and examine the impact of the reintroduction of large carnivores on the agricultural sector.

The near extinction and later revival of large carnivores has been the subject of numerous studies. Informative overviews are provided by, among others, Linnell et al. (2000), Ray et al. (2005) and Chapron et al. (2014). There is also a considerable literature based on studies of attitudes to carnivores (e.g. Kaltenborn & Bjerke 2002, Røskaft et al. 2007, Blekesaune & Rønningen 2010, Krange et al. 2011). These studies confirm that the conservation and reintroduction policies have broad public support, even in many rural areas. Most conflicts, however, are directly linked to carnivore predation on livestock. Mitigating efforts are therefore implemented to address these conflicts (e.g. Linnell et al. 1996, Linnell et al. 2001, Dorresteijn et al. 2013) accompanied by studies of the effects of the various efforts and strategies (e.g. Weaver et al. 1996, Skogen 2003, Ray et al. 2005, Pohja-Mykrä 2017). The bulk of mitigation efforts and related studies regarding human-carnivore conflicts seem to be addressing attitudes in general and fear of carnivores in particular. Studies addressing the effect of carnivores on agricultural systems, production and economy are rare.

Carnivore-livestock conflicts in Asia, Africa and South America

Studies from Asia, Africa and South America report average annual livestock losses due to carnivores between 0.2 % and 12 % of total livestock and economic losses up to 17 % of the annual income per household (e.g. Aryal et al. 2014, de Azevedo & Murray 2007, Palmeira et al. 2008, Lyamuya et al. 2014). The agricultural sector in these countries is less industrialized and a larger part of the population is directly affected when carnivores prey on livestock. Carnivores in Africa and Asia can also represent a direct threat to people in rural areas. In a South African study Thorn et al. (2015) found that 62 % of the respondents (commercial game and livestock farmers) believed carnivores to be financially damaging. Attitudes to carnivores were determined by a combination of cultural and land-use attributes more than by economic factors such as stock holdings or predation losses. A study of the human-lion conflict in the Ngorongoro conservation area showed that many local people felt that they had unfairly carried the cost of living with the Ngorongoro's wildlife, without deriving sufficient benefits. However, conservation incentive payments is a promising way to handle the situation that may also improve attitudes towards lions (Pekor et al. 2018). Soto-Shoender and Giuliano (2011) investigated conflicts in Guatemala and found that landscape structure around ranches provided the best explanation for the probability of predation on livestock there. Such knowledge is useful, because it can be used to adjust the pastoral activity in order to minimize carnivore impact.

Carnivore-livestock conflicts in Canada and North America

There are few studies in North America that specifically focus on analysing the impact of carnivores on livestock. Steele et al. (2013) showed that non-consumptive impacts of wolf presence in the US results in similar or higher levels of economic short-term loss than losses due to predation. A study by Howery & DeLiberto (2004) showed how harassment by predators in the US directly may cause weight loss in livestock due to increased energy expenditure associated with running and loss of sheep, but may also indirectly reduce the ability of ruminants to convert plant nutrients into weight gain due to decreased rumination time.

Several of the above mentioned studies, and additional studies that only assessed landscape features and their effect on predation risk, stated that the severity of impact depends on wild prey abundance and distance to specific landscape attributes such as water or forest. The effect of a specific landscape however also depends on the hunting mode of the carnivore that is involved (e.g. de Azevedo & Murray 2007, Aryal et al. 2014, Miller et al. 2015, see also Treves et al. 2004, Palmeira et al. 2008, Soto-Shoender & Giuliano 2011).

The North American carnivore management regime follows a "separation model", suggesting clear boundaries between realms of nature and those of human dominated landscapes. This model argues that the largest carnivores can only survive in protected areas or wilderness, thus the emphasis is on preservation rather than intervention (Chapron et al. 2014, Linnell et al. 2015).

Carnivore-livestock conflicts in Europe

Europe is succeeding in maintaining and restoring viable large carnivore populations on a continental scale (Table 1, Figure 1, Figure 2). All mainland European countries except for Belgium, the Netherlands and Luxembourg have a permanent and reproducing occurrence of at least one species of large carnivore. The area of occasional presence is expanding as the presence of solitary dispersing wolves was confirmed in Belgium and Denmark some years ago (Chapron et al. 2014), and in Denmark one reproducing wolf pack has now been established (Olsen & Sunde 2018). Fennoscandia is however the only region containing all four large carnivore species in Europe due to the limited northern distribution of the wolverine (Chapron et al. 2014). Wolves are the most successful in adapting to human-dominated landscapes (Figure 1). The figure shows that large carnivores are able to coexist with people on a continental scale, although there are inevitable conflicts (Chapron et al. 2014). This is called the "coexistence carnivore conservation model".

Ratification of the Bern Convention and the implementation of the EU Habitat Directive have contributed to increasing livestock-carnivore conflicts in many European countries since early 1990s. Meuret et al. (2017) found an increase in the number of livestock depredated or wounded by wolves in France from 0 in 1992 to 12 000 in 2017. Inskip & Zimmermann (2009) showed in their literature review that the Eurasian lynx was responsible for a loss of 31.478 US dollar and 2.6 million US dollar in Sweden and Norway respectively as a result of sheep predation in 2000 alone (calculated based on the compensation payments that were made). Rigg et al. (2011), in a case study of predation on livestock in Slovakia, found that economic damage was inconsequential on a national scale but locally important.

With regard to the management of large carnivores, the alternative view to the North American "separation model" is this European "coexistence model". Some carnivore ecologists/biologists and conservationists will argue that large carnivores' future in Europe depends on their continued persistence in modified landscapes because protected areas are too small to support many individuals (Linnell et al. 2015).

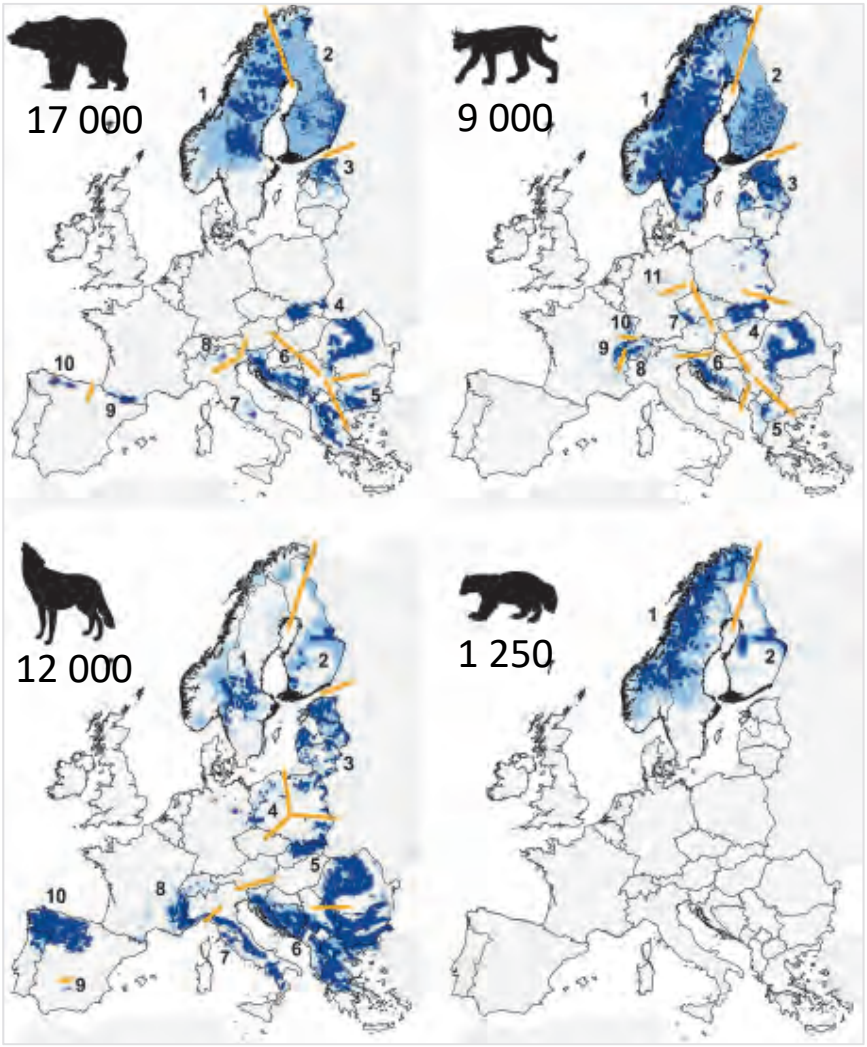

Figure 1. Numbers and distribution of large carnivores in Europe in 2011. Brown bears (top left). Eurasian lynx (top right), grey wolves (bottom left), and wolverines (bottom right). Dark blue cells indicate areas of permanent occurrence, and light blue cells indicate areas of sporadic occurrence. Small typed numbers refers to different genetic population. Orange lines indicate boundaries between populations (after Chapron et al. 2014).

Carnivore-livestock conflicts in Norway

Natural pasture utilization

Livestock production is important in Norwegian agriculture. Norway is located between 58 and 71 degrees latitude in the northern hemisphere. Only 3 % of the land is productive agricultural land and large parts can only be used for grass production. Increased Norwegian food production based on national roughage resources is a political goal and more extensive use of natural pastures is encouraged (Government white paper Mld.St. 9, 2012). According to Rekdal (2017), only 40% of the capacity of Norwegian rangeland pastures was utilized by grazing livestock in 2015.

The five large carnivore species appearing in Norway are brown bear, wolverine, grey wolf, lynx and golden eagle (*Aquila chrysaetos*). In the past years of absence of large carnivores, agriculture and rural land use adapted to a more or less carnivore free environment with lifestyles, livestock and economies dependent on a low degree of carnivore pressures. During the summer months, the livestock are left to roam the natural pastures and exploit these rangelands, in a production system that has been operative

for many centuries. The reintroduction and subsequent growth of large carnivore population has therefore inevitably also led to a revival of old human-carnivore conflicts, now as a political conflict with strong economic and societal connotations.

Losses of livestock due to large carnivores

The Norwegian Nature Inspectorate (NNI, Norwegian: "Statens naturoppsyn") does examine carcasses of grazing animals found and reported by the farmers in order to determine the cause of death. Only a fraction (< 10 %) of the animals lost and claimed are found and examined by NNI, but the cases reported by NNI can be considered as a valid sample of the animals actually killed by carnivores. The data are available in the database Rovbase (www.rovbase.no).

The livestock foraging on natural pasture pastures for part of the year consist of approximately 2.0 million sheep, 250 000 cattle, 58 000 goats and 8 800 horses (Landbruksdirektoratet 2017a). In addition, there are around 200 000 domesticated reindeer, mainly owned and managed by the samii population (Landbruksdirektoratet 2017b). The potential for conflict is clearly present. In 2017, compensations were paid for 18 350 ewes and lambs as taken by protected large carnivores. 17 374 semi-domestic reindeer were also compensated. Most sheep are depredated by wolverines and lynx (Figure 2 a), whereas wolverines, lynx and golden eagle kill the most reindeer (Figure 2 b).

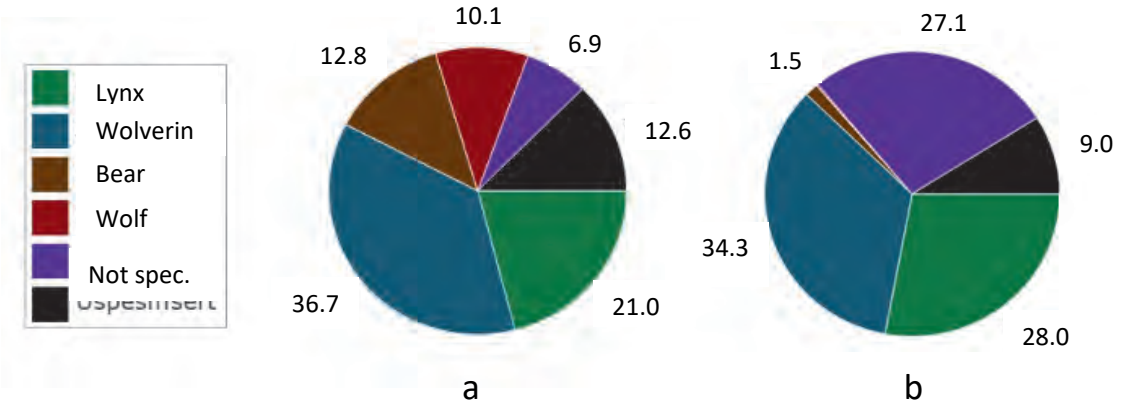

Figure 2. a) Distribution of carnivore species in per cent of total number of a) sheep compensated for as being killed by protected carnivores (www.rovbase.no, 2017) and b) reindeer compensated for as being killed by protected carnivores (www.rovbase.no, 2016/2017).

Norwegian large carnivore policy

Norwegian large carnivore policy has a two-folded goal: To ensure both viable carnivore populations and sustainable grazing industries. The method is a geographically differentiated management strategy. The solution is based on a political consensus formalized through parliamentary decision 687 (June 17th 2011) over proposal 163 S (2010–2011). The decision is known to the Norwegian public as the "Carnivore agreement of 2011". The government has outlined management goals for each of the five protected carnivore specie (https://lovdata.no/dokument/SF/forskrift/2005-03-18-242, Table 1). Management zones are delineated for each of the large carnivores, except golden eagle, based on their biological requirements and proposed population targets. The zones are delineated separately for each species and there is considerable spatial overlap between the zones. The remaining area (not allocated to one or more carnivore species) is considered as prioritized for livestock. Natural pastures can also be utilized inside the carnivore management zones, but only provided that sufficient and adequate means are taken to avoid conflicts with carnivores. Such means include fencing, shepherding or cultivated pasture pasturing.

Table 1. Management goals for each of the five protected carnivore species outlined by the Norwegian government (status and numbers 2017 collected from www.rovdata.no).

Species	Norwegian management goals	Status 2017	No (approx.)
Lynx	65 annual reproductions	55.5 reproductions	330
Wolverine	39 annual reproductions	40 reproductions	324
Wolf	4-6 annual reproductions, of which at least 3 reproductions should be fully Norwegian	7 reproductions, of which 4 fully Norwegian	105-112
Bear	13 annual reproductions	7 reproductions	125
Golden eagle	850-1200 nesting pairs	963 nesting pairs	

Effects of Norwegian large carnivore policy on national grazing industry

In 2016 Norwegian Institute of Bioeconomy Research (NIBIO) was commissioned by The Ministry of Food and Agriculture (LMD) to evaluate the effect of the large carnivore populations on Norwegian food industry based on Norwegian resources (Strand 2016). The objective of this study was to describe the current status regarding conflicts between livestock and carnivores in Norway. In particular, the study aimed to examine and explain the effect of the zonal management approach used in Norwegian carnivore management and discuss possible mitigation efforts to alleviate future conflicts in this domain. Results from this study are presented below:

Management zones offering protection for lynx, wolverine, bear and wolf now cover 55 % of the Norwegian mainland (Strand 2016, Figure 3). The management zone for Lynx constitutes the largest parts of this area (approximately 149 000 km^2), often intersecting management zones for other large carnivore species. The zones for wolverine, bear and wolf are smaller. The management zone for wolf covers approximately 18 000 km^2 in south-eastern Norway. This is, as a comparison, an area twice the size of Yellowstone national park in the US. 30 % of the sheep and 50 % of the Saami reindeer grazing areas are found inside these management areas. The utilization of the natural pasture grazing capacity is 59 % outside, but only 26 % inside the carnivore management zones. The lowest utilization of available grazing resources is found inside the management zones for wolves (12 %) and brown bear (6 %) (Strand 2016).

The loss of grazing livestock due to predation by large carnivores in Norway has decreased over the last years, also within carnivore management zones (www.rovbase.no). However, documented losses due to wolf and golden eagle are increasing. Sheep and reindeer farmers in regions falling within zones of more than two carnivore species at the same time are most prone to livestock damages. The situation is most severe in a region covering approximately 9 000 km^2 in Hedmark county where all the four large carnivore species are present and protected (Strand 2016, Figure 3).

Figure 4 shows the loss of sheep (percent lost) on natural pastures by year during the period 1970 to 2014 using data from Local Grazing Associations, a voluntary organization encompassing around 80% of the sheep grazing in the Norwegian outfields (https://www.landbruksdirektoratet.no/no/miljo-og-okologisk/regionalt-miljotilskudd/organisert-beitebruk#statistikk). The lines represent the national average and two selected counties: Hordaland and Hedmark (representing two different environments with respect to carnivores). The graph shows how loss rates were systematically reduced from 1970 to the early 1980s, when loss rates started increasing in Hedmark but not in Hordaland. The loss rates accelerated rapidly in Hedmark after 1990, but also increased somewhat in Hordaland in the mid 1990s. Loss rates have decreased in Hordaland since 2006, and sharply in Hedmark from 2014. The graph is raising a number of questions regarding the different phases and changes, and about the apparent differences between Hordaland and Hedmark. These questions will be addressed in the discussion below.

Findings of sheep killed or possibly killed by protected carnivores (documented by NNI) were used as an indicator of the range of carnivores. It was found that lynx is the only carnivore species where a majority of the killings of livestock (65 %) took place inside the management zone. Similar figures for the other three species are 31.7 % (wolverine), 25.1 % (bear) and 21.7 % (wolf) (Strand 2016). In carnivore management zones, mitigation measures that separate livestock and carnivores in time and/or space are implemented, e.g. electric fencing, cultivated pasture pasturing and early gathering. In areas with less carnivore pressure, sheep farming is increasing. Consequently, most of the sheep (and reindeer) losses due to carnivores are found as a spill-over effect in the border areas, 30 - 50 km outside the carnivore zones, where sheep are still grazing at open mountain and forest ranges. Furthermore, preying on sheep by wolves is increasing significantly outside the management zone as the Scandinavian wolf population is growing (Strand 2016). Thus, there is a need for more effective mitigation measures in the border areas around the management zones.

Although there is inadequate data on number of semi-domestic reindeer killed by large carnivores, there is concurrence between the presence of large carnivores and the most vulnerable periods for the reindeer, particularly during calving season and late winter when the grazing access is low.

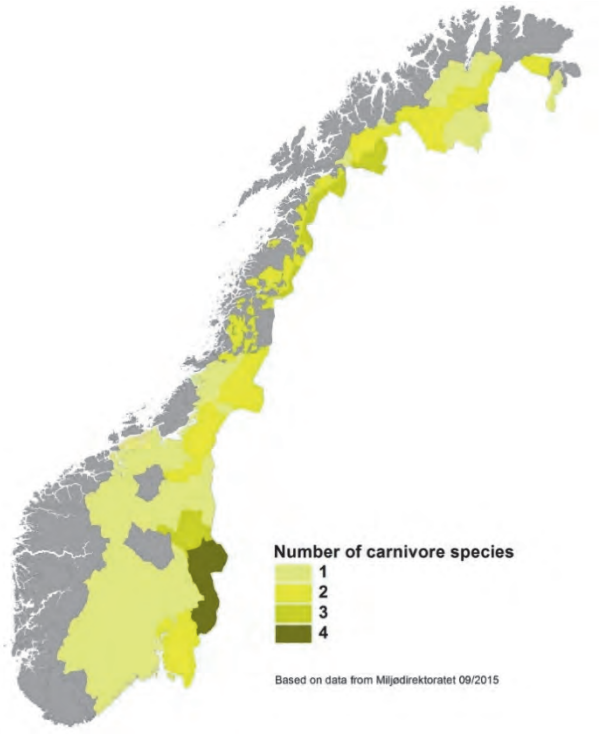

Figure 3. Management zones for carnivores in Norway. Management zones for different carnivore species are overlapping and the map shows the number of carnivore species found in each area. Areas with no carnivore species are prioritized for pasture (after Strand 2016).

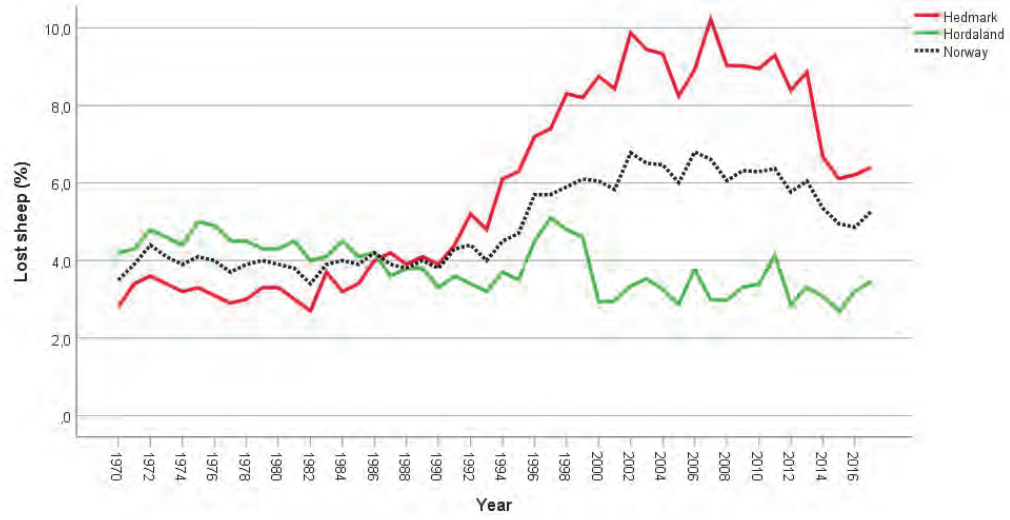

Figure 4. Percentage of sheep grazing on natural pastures that are lost during the summer months. In addition to national figures (Norway) the graph includes figures for two counties: Hordaland on the Atlantic coast (with few large carnivores) and Hedmark (in the eastern part of the country, bordering Sweden, and with growing carnivore populations since approximately 1990) (after Strand 2016).

Impacts for livestock farming in Norway

There have been considerable structural changes in the Norwegian agricultural sector after World War II towards fewer and bigger farms (Bye et al. 2014). This structural process is very similar inside and outside the management zones for large carnivores. However, the relative number (structural changes adjusted for) of sheep declined by 7.5 % in the management zones during the study period (1999-2014), whereas the numbers increased by 2.75 % outside the management zones (Strand 2016). The reduction in number of sheep in the management zones is balanced by a similar increase outside the management zones. Thus, the total production is maintained, but sheep farming is lost as a source of income for farmers inside the management zones. Mitigation measures that separate livestock and carnivores in time and space limit the utilization of natural pastures. The low number of livestock in some areas will inevitably also lead to changes in the cultural landscape and possibly have an influence on the biodiversity in these areas.

There is a need for more exact carnivore population monitoring to quantify the carnivore pressure, better documentation of reindeer losses and higher acceptance of mitigation measures amongst stakeholders. Furthermore, we suggest exclusion of lynx management zones from the best alpine sheep grazing areas and reindeer calving areas, more formalized border zones; and efficient management in the border zones; compensation for not being able to use natural pastures. Increased involvement of social sciences in order to understand the social impact of the carnivore management and develop relevant mitigation measures for affected communities.

Overall conclusion

The reestablishment of large carnivores in Norway, but also worldwide, is a huge challenge for the most severely affected farmers, resulting in high livestock losses and eventually closedown of livestock production. Although of little consequence for the total food production, the economic and social impact is serious for the individual farmers affected, their families and the local community. Reduced number of livestock in some areas will also lead to changes in the cultural landscape and probably loss in biodiversity over time. The legitimacy of the zoning strategy is disputed by the rural communities, escalating the political conflict over the entire carnivore conservation strategy.

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Take home message

Jørgensen *et al*

Native cattle breeds may utilize natural pastures to a different extent than modern cattle breeds. The herd of Vestlandsk fjord cattle investigated here, performed well on a grass-based diet. No indicators of poor animal welfare were found.

Utilizing natural pastures in Northern Norway with Vestlandsk fjord cattle

Grete H.M. Jørgensen[1], Nina Hovden Sæther[2], Kleopatra Delaveris[3]

Introduction: In Norway, there are currently six native breeds of cattle maintained by national preservation protocols. These native breeds are often smaller than the modern high yielding breeds. Farmers defend the native breeds and claim that they utilize mountainous and rangeland pastures to a better degree than the heavier breeds The general knowledge on average weight gain and the body condition changes according to season of such breeds is however scarce. The aim of this study was to investigate how a native Norwegian cattle breed is utilizing natural pastures and roughage feed for production.

Materials and methods: A herd of 36 Vestlandsk fjord cattle was weighed and assessed for body condition a total of 10 times over two years (2015 and 2016). In summer 2016, 20 cows were instrumented with GPS collars and their position in the rangeland pasture was automatically recorded four times per day. Vegetation mapping of the pasture area was also performed in summer 2016. Average daily gain and variations in body condition scoring and body weight over seasons and years was calculated from the gathered data.

Results: For each of the ten dates of animal data recording, a total of between 19 and 36 adult cows were assessed. Their body weight varied according to season and pregnancy state. Overall mean body weight (± STD) was 396.4 ± 30.6 kg, peaking both years in December during the winter feeding period. Cows gave birth during February and were lactating throughout the grazing season with the lowest body weight being observed around turnout in June. Bull calves had an average daily gain of 727 ± 0.07 grams over the 148 days on pasture.

Early in the pasture season (June), the cows kept closer to the barn and preferred areas with billberry birch forest, meadow birch forest and meadow spruce forest. In October, the cows spread more out looking for food, than in June (figure 1 a) and b)).

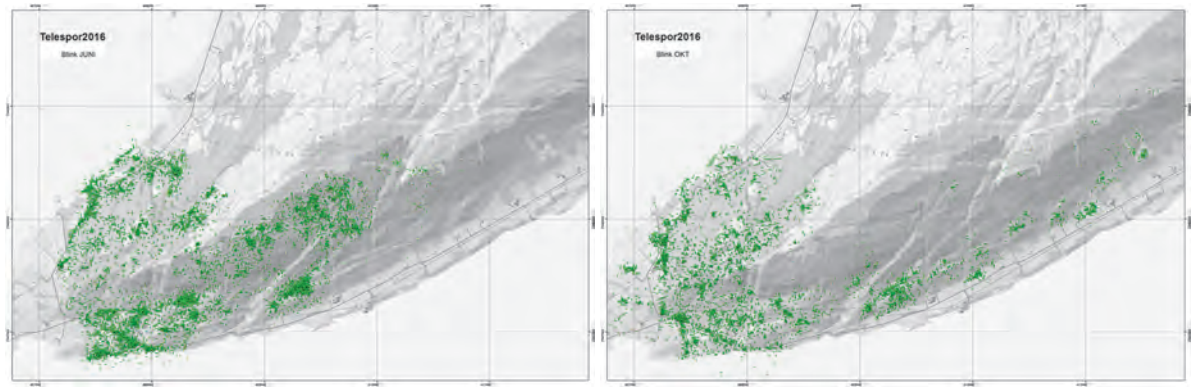

Figure 1 a) and b). Cow location and use of the rangeland pasture area according to early (June) and late (October) in the grazing season.

Body condition scores were maintained within an acceptable variation according to animal age and production stage (lactation, pregnancy or growth). Calves and young heifers had in general high body condition scores at all recording dates. Cows older than 10 years lost body fat over their back first.

Conclusion: The native cattle breed investigated here, performed well on a grass-based diet. No indicators of poor animal welfare were found, and utilizing natural pastures may be an effective, animal-friendly and sustainable way of producing high quality food for a growing human population.

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Take home message

Nucera *et al*

Plant diversity is higher in the Surfaces for the Promotion of Biodiversity among the permanent grasslands of the utilised agricultural area.

The Surfaces for the Promotion of Biodiversity as an effective political tool for plant diversity preservation in the southern Swiss Alps permanent grasslands

Emiliano Nucera[1], Michele Lonati[2], Simone Ravetto Enri[2], Pier Francesco Alberto[1], Massimiliano Probo[3]

Introduction: In the last years, the Swiss Agricultural Policy has incentivized the establishment of a minimum proportion of permanent grassland areas called 'Surfaces for the Promotion of Biodiversity' (SPB). The SPB give right to direct payments to farmers but they need to be managed extensively and according to specific rules (e.g. number of annual mowings, mowing or grazing after established dates). Based on a large dataset of meadows located in the Southern Alps (Canton Ticino), we compared plant diversity between grasslands that had been exploited for several years as SPB or conventionally managed grasslands (CMG), in order to evaluate if SPB have been effective in preserving permanent grassland biodiversity.

Materials and methods: We carried out 242 vegetation transects with the vertical point-quadrat method (Daget and Poissonet 1971), among which 64 on SPB and 178 on CMG. For each transect, species richness, Shannon diversity index, and the number of species belonging to different functional groups were assessed. Independent samples t-tests were carried out to detect significant differences between SPB and CMG. Vegetation transects were classified into vegetation communities by cluster analysis and a Pearson χ^2 was used to test if the proportion of SPB and CMG was similar in different vegetation communities. An indicator species analysis was run to identify specific plant species associated to SPB and CMG.

Results: A total of 389 plant species and six main vegetation communities were identified. Significant differences in the proportion of SPB and CMG within different vegetation communities were found, with a higher proportion of SPB associated to *Festuca* gr. *rubra* and *Brachypodium rupestre* dominated communities. On the whole, SPB were located at higher and steeper locations and hosted a higher plant diversity (both species richness and Shannon index). Moreover, a higher number of typical forest, fringe, high-elevation grassland, and dry grassland species was detected within SPB than in CMG. Conversely, the number of species typical of nutrient-rich and mesophile grasslands did not differ between SPB and CMG. The indicator species analysis identified 20 species significantly associated with transects on CMG and 112 with SPB, among which some rare species of the Swiss flora.

Conclusion: Based on our results, SPB proved to be an effective policy and management tool to preserve permanent grassland biodiversity. Indeed, they encouraged the active and sustainable management of the most marginal and rugged alpine areas, whose abandonment would instead lead to extensive woody species encroachment, with consequent loss of biodiversity. However, further research is needed to discriminate the relative effects produced on plant diversity by local environmental conditions and grassland management.

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Take home message

Coppa *et al*

The specificity of mountain milk is related to upland grasslands.

Does mountain origin give specifity to milk?

Mauro Coppa[1], Chantal Chassaing[1], Cecile Sibra[1], Odd Magne Harstad[2], Jože Verbič[3], Jaroslav Golecký[4], Anne Ferlay[1], Bruno Martin[1]*

Introduction: Several studies have shown the added value of mountain products, thanks to which specific labels and legislation were set up at European level to protect the mountain production systems. The aim of this research was to identify the causes of the added nutritional value of mountain milk in EU; milk origin *per se* or forage system linked to mountainous conditions?

Materials and methods: Tanker milk and related production conditions from 55 groups of farms in France, Slovakia and Slovenia were analysed. Farms of each group were geographically close, had similar production conditions and were selected to be representative of the typical maize silage- and grass- (fresh or conserved as hay or silage) based forage systems of each country. Within each forage system, the groups of farms were balanced according to their origin from lowland or upland areas (defined according to national rules), within a range of 40-1400 m a.s.l.. The tanker milk from the groups of farms was analysed twice in summer and three times in winter for carotenoids content and fatty acids composition (FA) according to Chassaing et al. (2016).

Results: As expected, C16:0 was lower and PUFA including C18:3n-3 and c9, t11 CLA were higher in grass-based forage systems (Table 1). In contrast, milk composition did not differ significantly according to origin; only C16:0 and c9, t11 CLA tended to be lower and higher respectively in mountain milks. Within the grass forage system, upland milk had lower β-carotene and SFA and higher MUFA contents than lowland milk. This could be due to the different composition and utilisation of upland pastures, which are richer in forbs and are usually grazed or harvested at a later phenological stage.

Table 1: Average diet composition at farm and related milk quality according to forage systems and origin

Forage system	Grass		Maize		SEM	Effects and significance[1]		
Origin	Lowland	Upland	Lowland	Upland		Forage system	Origin	Interaction
Diet composition (% of DM in diet)								
Pasture	39	39	11	16	1.8	***	ns	ns
Grass silage	11	17	18	19	0.8	ns	*	ns
Hay	24	18	10	12	1.0	***	ns	ns
Maize silage	8[c]	5[c]	36[a]	27[b]	1.0	***	***	*
Concentrate	17	19	23	25	0.5	**	ns	ns
Milk yield (kg/cow/day)	18.8	18.8	23.8	23.3	0.34	***	ns	ns
Milk composition (FA in g /100 g total FA)								
β-carotene (µg/kg fat)	3.62[a]	2.95[b]	2.38[c]	3.10[b]	0.162	*	ns	**
C16:0	29.5	28.3	30.8	30.5	0.16	***	†	ns
C18:3n-3	0.62	0.64	0.40	0.44	0.013	***	ns	ns
c9,t11 CLA	0.76	0.86	0.45	0.53	0.022	***	†	ns
SFA	68.6[a]	67.5[b]	69.1[a]	69.7[a]	0.17	**	ns	*
MUFA	26.7[b]	27.6[a]	27.0a	26.3[b]	0.13	†	ns	*
PUFA	3.96	4.12	3.34	3.44	0.048	***	ns	ns

[1]***: $P < 0.001$; **: $P < 0.01$; *: $P < 0.05$; †: $P < 0.1$; ns: not significant.

Conclusion: The specific composition of mountain milk often reported is mainly due to the specific mountain forage system. Protection of mountain products should include specifications related to forage system (i.e. minimum threshold of forages from natural grasslands or maximum threshold of maize silage) in order to guarantee the specific composition of mountain dairy products.

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Take home message

Pauler *et al*

Higher plant species richness and lower shrub cover in pastures grazed by Highland cattle as compared to production-oriented breeds demonstrate the potential of robust cattle breeds to sustain ecosystem services of marginal mountain pastures.

The impact of cattle breed on pasture vegetation

Caren Pauler[1,2,3], Johannes Isselstein[2], Thomas Braunbeck[3], Manuel K. Schneider[1]

Introduction: The past decades have seen an increase in the diversity of cattle breeds in the Alps. Especially robust cattle breeds, like Highland cattle, have spread beyond their countries of origin and have been used for new applications such as the conservation of ecosystem services in marginal pastures. They differ from production-oriented breeds in terms of robustness, growth rate and weight. Compared to the five popular breeds of Limousin, Simmental, Braunvieh, Angus and Charolais, cows of Highland cattle weigh 34% less. At birth, Highland calves are 40 % lighter, and their daily average weight gain is about 60% less (Swiss Suckler Cow Association, 2018). Moreover, Highland cattle have larger claws (Nuss et al. 2014) and likely also different movement and forage selection behaviours, which could impact vegetation composition. The study aims at identifying the level of breed-dependent impact on the composition of pasture vegetation. The initial hypothesis was that vegetation on Highland cattle pastures is less adapted to trampling and grazing, and, because of lower competitive exclusion, species-richer than pastures grazed by production-oriented breeds.

Materials and methods: In 2016, the vegetation composition was recorded in 50 paired pastures at 25 locations in mountain areas of Switzerland and in southern Germany grazed by either Highland cattle or a production-oriented cattle breed, such as Limousin, Braunvieh, Simmental breed, German Angus and Charolais. The two pastures in a pair needed to be (1) in close proximity of each other, (2) similar concerning elevation, inclination and the intensity of grazing (3) not been mown, manured or fertilised recently and (4) been grazed by the respective breed for at least 5 years. Plant species composition was assessed on a total of 150 plots. On each pasture, three plots were located in zones of different intensity of use. For all available species, indicator values were extracted from the Biolflor database (Klotz, Kühn, & Durka, 2002) as well as from Landolt (2010). Generalized mixed-effects models and multivariate methods were used for data analysis.

Results: Irrespective of site conditions, which were quite similar between the two paired pastures at each location, plants on pastures of production-oriented breeds showed higher indicator values for grazing ($p_{\chi^2} < 0.001$) and trampling tolerance ($p_{\chi^2} = 0.008$). There were more vegetation-free areas on pastures grazed by production-oriented breeds than by Highland cattle ($p_{\chi^2} = 0.02$). In line with the initial hypothesis, plant species richness was positively influenced by pasturing with Highland cattle ($p_{\chi^2} < 0.001$). The longer a pasture was grazed by Highland cattle, the clearer was the difference in plant species richness compared to pastures of production-oriented cattle ($p < 0.001$). Moreover, shrub cover was lower at Highland cattle pastures than at their respective counterparts ($p_{\chi^2} = 0.03$). This indicates differences in forage preference between cattle breeds.

Table: Effect of location variables on vegetation

	Grazing indicator value	Trampling indicator value	Plant species richness	Pielou's Eveness	Woody species cover
Breed	***	**	***	-	*
Elevation	-	*	**	***	***
Inclination	-	-	**	**	-
Phosphorus	-	-	***	***	-
Plot	***	***	-	-	**

Conclusion: Pastures grazed by Highland cattle and production-oriented breeds differ significantly in botanical composition. Higher plants species richness and lower shrub cover are important for landscape attractiveness and biodiversity. Robust cattle breeds have, therefore, the potential to sustain and develop ecosystem services of marginal mountain pastures.

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Take home message

Brunschwig

This paper presents a new way to look at the practices of the traditional farmers of the Andes, using the agroecological criteria. Thus, it seems that the mountain character of breeding systems is well associated with agroecology in less productive areas, but not in good potential areas.

An agroecological lecture of the Andean breeding systems

Gilles Brunschwig

Introduction: Traditional mountain breeding systems are often endowed with many ecological virtues, because of their ability to operate in difficult conditions and to maintain themselves durably in these areas despite the hazards. This paper aim to renew the look at traditional farming systems and more specifically Andean by reading them according to the principles of agroecology

Materials and methods: The characteristics and practices of several breeding systems (Brunschwig 1988, Tichit 1998, Aubron 2006, Valencia Chamba 2008, Charbonneau 2009), supplemented with observations spread over more than 20 years (Brunschwig et al., 2009), are mobilized to analyse this diversity of livestock systems and their evolution using the agroecology bases. The adaptation of agroecology to livestock is based on five principles jointly implemented: integrated management of animal health (P1), reduction of inputs using ecological processes (P2), closure of cycles to reduce pollution (P3), use agronomical diversity to increase resilience (P4), and preserve biodiversity (environmental and agronomical) by adapting practices (P5) (Tichit and Dumont, 2016).

Results: The ecological staging of the central Andes is at the origin of a wide range of agricultural and livestock production. Between 0 and 500 m asl, on the Pacific desert coast, dairy cattle breeding (S1 system) rubs the irrigated commercial crops from which it consumes residues. The animals produce up to 7000 L of milk per lactation, which is collected by industrial companies. Between 2000 and 4000 m asl, ruminant livestock farming (S2) is associated with cropping systems. Animals graze rangelands and crop residues. Cattle herds provide milk during the rainy season, as well as traction and meat. Sheep are used for wool, meat and manure for fertilizing crops. On this same ecological belt, a more intensive dairy farm (S3) uses fodder crops to complete the rangelands. Cows produce between 700 and 4000 L of milk per lactation which is processed into cheese. Above 4300m asl, shepherds guide multi-species herds (alpacas, llamas, sheep) (S4). The animals, breed for the production of wool and meat, graze the altitude steppe (puna) and wetlands. The wool is mainly destined for the international market. This relatively lucrative alpaca farm contributes to increasing population pressure in the southern puna of Peru. In the Amazonian piedmont, mixed dairy-meat cattle farming (S5) with low productivity are managed on tropical pasture established in Amazonian forest clearing). The S2, S3 and S4 systems can be qualified as agroecological. They use mainly local medicines (P1) and almost no external inputs (P2), the livestock effluents are valued on the rangelands or on the cultivated plots and the animals consume the crop residues (P3), herds are composed of several species and the grazed areas mainly consist of natural grasslands (P4), and these systems are part of sparsely populated areas with a relatively conserved biodiversity (P5). However, pollution mainly exists related to mining activities, but also to the waste of farmer's families. The S1 and S5 systems, on the other hand, are less virtuous, making easier use of veterinary drugs (P1), largely consuming concentrated feeds (P2), although the effluents are used to amend crops mainly intended for the production of exported foods or silage maize (P3). The S1 and S5 systems use herds composed of a single species or even a single breed and forage resources often consisting of a cultivated species (maize or few grass species) (P4) and implanted in colonized and largely modified spaces (irrigated deserts or Amazonian forests cleared for grassland) (P5).

Conclusion: This reading thus highlights a variety of situations, the agroecological nature of which is partly due to the interest of colonizing new areas with productive potential to develop commercial animal productions that are not respectful of agroecology (S1, S5) or the difficult conditions, the low availability of resources and the need to maintain traditional, relatively extensive and more agroecological livestock systems (S2, S3, S4). It therefore seems for breeding that the mountain character is well associated with agroecology in less productive areas, but not in good potential areas.

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Take home message

Mettler

The impact of the Swiss policy to improve biodiversity and the coexistence between husbandry animals and large carnivores shows that a new shepherd and flock management culture can reinforce the resilience of sheep alpine pastures and contribute to a sustainable pasture management under hard topographical and socio-economical conditions.

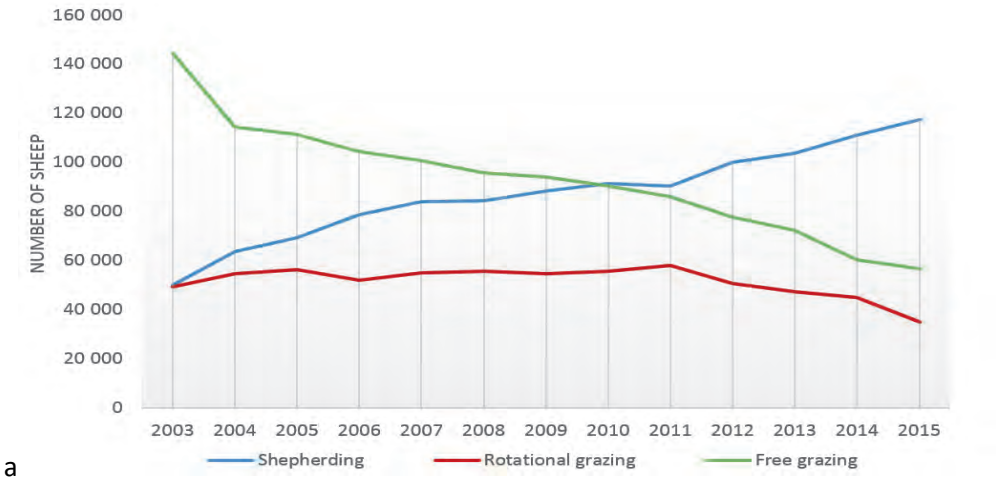
The Challenge of the large Carnivores: “Change Management” from free Grazing to flock management

Daniel Mettler

Introduction: The return of the wolf and his impact on sheep summer grazing is an actual example how change processes in the regional pasture practise can be analysed and influenced. It shows that this ”Change management” in agriculture is an interdisciplinary challenge for policy makers, scientists and advisory services. In regions where large predators were eradicated and, thanks to stricter European protective provisions, make a comeback, livestock owners are faced with major challenges changes. The project ”Summer grazing of sheep in the canton of Valais“ shows how extension and knowledge transfer can create long-term processes in a politically polarised environment. The national framework is formed by wolf-management and agricultural policy, which influence the practice of small-livestock farming.

Materials and methods: 155 units of alpine summer grazing farms have been analysed and registered in a data base. Quantitative and qualitative data have been collected by means of interviews of owners and farmers of alpine pastures. A management plan for the alpine pastures has been established for every individual farm. The next step was further planning on the collective level valley by valley with the communities and in the last step a master plan for the management of the sheep flocks was elaborated for the entire canton of Valais. For planning the investments and the coaching of the changes to improve flock management and flock protection, the responsibilities have been integrated in the local agricultural consultant network.

Results: Statistics from 2003-2017 confirm the national trend towards better control of the animals in summer grazing through shepherding and rotational grazing fields. The survey conducted in the context of the inspection and analysis of 155 alpine summer grazing units in the canton of Valais shows that in addition to political and socio-economic factors, psychological and ecological aspects should also be taken into account to facilitate the change of the pasture practise. So for example the role of property and the organisation form of the pasture units determine the decision making process on the local level.



a

Management evolution from 2003 to 2015: Free grazing, rotational grazing, shepherding (Source FOAG).

Conclusion: The results of the project “Summer grazing of sheep in the canton of Valais” demonstrate that the combination of extension and sound planning principles provide a confidence-building basis for developing and implementing strategies for dealing with the return and presence of wolves. Nevertheless it needs investments in infrastructure and human resources to face with the new challenge caused by the resettlement and presence of large carnivores.

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Take home message

Sărăţeanu *et al*

Extensive grassland management is demanded in low populated highland areas for preserving grassland resources and functionality.

Impact of organic fertilisation on agro-ecological features of *Trisetumflavescens* (L.) P. Beauv. grassland

Veronica Sărăţeanu, Carmen Claudia Durău, Otilia Cotuna, Dorin Rechiţean

Introduction: Most of the highland grasslands in Romanian mountains and hill areas are secondary as origin, they being created during centuries by the population from clear cutting of the forest for their cattle and sheep. The secondary grasslands represent a great resource of biodiversity and for feeding, they representing a great part from the total agricultural land of the country. The sustainability and balance of these grasslands totally depends by an extensive management. Highland area is characterised by depopulation, the consequence being land and grassland abandonment. This phenomenon represents a great threat for the high biodiversity of the secondary grasslands. Thus, the solutions for a sustainable extensive use need to be documented under different aspects, both ecological and agricultural. The aim of the study is to show the influence of manure fertilisation on Ellenberg's indicator values on aHigh Nature Value grassland dominated by *Trisetum flavescens* (L.) P. Beauv vegetation sward.

Materials and methods: The experimental plot were set in Maramures County (Northern Romania) at Viseul de Jos. Sheep manure was applied once in two years. The plots were 3m x 5m (15 m^{-2}), each applied three fertilisation manure variants (20, 40 and 60 t/ha) and one control non-fertilised. The vegetation data were collected by using the linear point quadrate method (Daget Poissonet, 1971) twice a year, in June and September. Floristic composition and pastoral value was analysed. The Ellenberg's indicator values, adapted by Kovacs (1979) for Romanian grasslands considered for analysis were: light, temperature, soil moisture, reaction and nitrogen, there being analysed the ecological spectres. Other aspects of the vegetation analysed under the influence of fertilisation were the spectres of the life forms and geographic origin of the species. Thus, there was analysed correlation among indicator values and pastoral value (VP) and floristic composition of the analysed variants.

Results: The application of manure on dominated by *Trisetumflavescens* leads to the increase of forb and legume species in the vegetation sward, and decrease the contribution of the grasses. Mean species richness was greater in control variant, in both analysed time periods, respectively June (S = 57) and September (S = 43). The mean VP obtained was higher in June (71.65 in non-fertilised variant; 75.68 in 20 t/ha variant; 81.46 in 40 t/ha variant; and 72.99 in 60 t/ha variant) in comparison with VP determined in September (63.01 in non-fertilised variant; 59.55 in 20 t/ha variant; 63.28 in 40 t/ha variant; and 62.86 in 60 t/ha variant). Low fertilisation dose has a positive influence on the VP. Correlation coefficients among the pastoral value and the floristic composition have the highest value in the case of grasses species number (r = 0.86), being followed by the correlation with legumes species number (r = 0.65) and forbs (r = 0.54) Those practices proved their adaptation that provides a proper and sustainable management of the manure and biomass in the area of winter settlements of the farmers. Due to this management, the swards are rich in species and have a great pastoral value. According with other researches, in permanent grassland, usually the valuable forage species contribution decreases with the increase of management intensity.

Conclusion: Manure fertilisation in small doses and at an interval of at least two years are able to keep a good condition of the grassland regarding biodiversity, feeding value and its ecological services.

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Take home message

Lombardi *et al*

The analysis of consumers' perception of grass-fed milk supports the spread of grass-fed milk business model, which provides an answer to new consumption needs and farmers' expectations.

Grass-fed milk consumers' perception: an explorative survey in Italy

Giampiero Lombardi[1], Giovanni Peira[2], Damiano Cortese[2], Luigi Bollani[3] Elena Salussoglia[2]

Introduction: As a reaction to globalization, there is a tendency in some food sectors to adopt alternative approaches to both food production and consumption. In fact, some consumers are choosing to consume goods with a special taste, healthy food, orientating towards cultures of the past, naturalness, local and regional food, animal welfare and sustainability (Botelho et al, 2017). Grass fed sector is one of those that are starting to have some interest in stakeholders. Particularly grass-fed milk has a different chemical, nutritional and nutraceutical composition than does grain-fed one. Moreover, it has organoleptic features that consumers are likely to appreciate and will most probably be willing to pay a higher price for than non-premium milk products. Nowadays, milk in Europe is obtained predominantly from intensive breeding systems, whilst small farmers (rearing 30-50 cows) are orientated towards developing extensive breeding systems also to meet the increase in grass-fed milk demand. Large farms generally use mainly crops as feed, while smaller farms are mostly located in the mountains and rely on permanent/temporary meadows and pastures to feed less productive breeds. Grass-fed milk could represent a sustainable system because of its lower environmental impact compared to the more conventional one, more extensive production methods, its orientation to animal welfare, and the ability to generate positive economic and social repercussions (Galloway et al. 2018). This study aimed at analyzing the consumers' perception of grass-fed milk so as to understand if a more sustainable business model could provide an answer to new consumption needs and mountain dairy farmers' expectation towards this production.

Methodology: To investigate milk consumption habits, a questionnaire was proposed to 15% of Slow Food members who regularly take part in initiatives such as taste workshops and could represent target consumers. We collected information on personal data, on milk habits, e.g. the type of milk bought, where it was bought and what influenced choices, on how much consumers knew about "grass-fed milk", and how much they would be willing to pay. A total of 750 replies was analyzed using Principal Component Analysis (PCA) to group quantitative variables into "dimensions", which were used as input of multivariate statistics (HCA, Hierarchical Cluster Analysis and MCA, Multiple Correspondence Analyses) to define consumer profiles.

Results: The consumers were grouped into four clusters, corresponding to four profiles: Careful Buyer (26% out of the sample), i.e. interested in price, price/quality ratio, quite interested in brand and with low interest in the local supply chain and/or traceability; Observer (24%), whose decisions are based on price, price/quality ratio and also on the local supply chain and traceability; Nutrition conscious (19%), interested in nutrients, fats and storage data; Sustainable (31%), very interested in the local supply chain and traceability, and quite interested in the brand, but not in price and/or the price/quality ratio. The last cluster had a higher inclination to spend up to 30% more for grass-fed milk than the other clusters. The data from our study are in line with those reported, not only on foodstuff, but also on the general trends adopted by today's consumer. That is, sustainability is now part and parcel of choosing what to buy and who to buy from (Vermeir and Verbeke 2006). Indeed, not only the sustainable cluster members are interested in the socioeconomic aspects and the environment, but also the other clusters are slowly, but surely creeping in this direction.

Conclusions: Our data confirm an interest in grass-fed milk consumption. Indeed, nowadays, consumers are more oriented towards quality, local supply chains and traceability and are characterized by a higher propensity to spend more for it. Grass-fed milk may well represent a new competitive model of sustainable and replicable business, as it has low environmental impact, it responds to the ethical needs of both producers and consumers alike, it can generate a positive social impact by assuring employment for those destined to disappear from the work scene, or even create new positions, and it may activate a potential for other related businesses, such as food tourism. Such new business model often responds to farmers and societal expectations in the Italian Alps.

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Take home message

Duglio and Lombardi

Binding agricultural and tourism supply chains for developing mountain rural areas in an eco-management framework.

Eco-management for the agriculture and tourism chains in marginal mountain areas

Stefano Duglio[1], Giampiero Lombardi[2]

Introduction: The need of integrating agriculture and tourism under the umbrella of the eco-management at territorial scale is based on the assumption that the economic activities in mountain marginal areas are characterized by fragmentation, small business size and lack of communication among tourism and food chain actors, local administrators and other stakeholders. This situation limits the competitiveness of both agricultural and tourism holdings, being the former unable to promote their high-quality products (Bonadonna et al., 2015) and find an appropriate placement on markets, and being the latter unable to propose an offer tightly tied to territories, limiting the attractiveness of the area itself. An eco-management at territorial scale based on the cultural and environmental heritage, is intended to boost the benefit deriving by the adoption of a systemic approach (Beltramo et al., 2011; Beltramo et al., 2014). This contribute aims at presenting the methodological approach adopted in the EMERITUS Project (Eco-ManagemEnt for agRI-Tourism in moUntain areaS) with the economic support of the Compagnia di San Paolo of Torino in the Soana Valley, within the Gran Paradiso National Park area (Regione Piemonte, North-West of the Italian Alps).

Materials and methods: The development of an eco-management system for integrating the agriculture and tourism chains relies on the main tool used to plan an EMS, the ISO 14001:2015 International Standard. In particular, the new ISO 14001:2015 adopts the context analysis scheme as a step to take into account the environmental and the risk dimensions of the organizations' activities, in the drafting of the environmental preliminary analysis (EPA). For implementing the different sections of the context analysis, we are working at two levels, using a mixed methodology. At micro level (the operator's perspective) we are carrying out direct interviews in order to i) analyse the food productions, the tourism services and their interactions and ii) converge the operators' opinions to a set of common options (modified Dephi method), using a multi actor participatory approach (Forum of operators). A total of 20 farmers, which represent all the farmers operating in this mountain valley, have been interviewed. Together with farmers, all the local administrators (3) and tourism operators (14) have been involved through direct interviews. At territorial level, we are adopting a quantitative approach of the Weaver model, consisting of calculating indicators related to tourism and regulatory issues, in order to verify whether the Soana Valley may be considered a sustainable or not sustainable tourism destination. Contextually, a survey focused on tourists using a devoted questionnaire (research goal: 200 questionnaires) is intended to examine the tourist's perception on the service quality, the knowledge on the role of the local food products and compare them with expectations.

Results: As far as the tourism sector is concerned, some provisional results clearly show how the municipalities of the Soana Valley may be considered as a niche-sustainable tourism destinations, mainly thanks to the presence of Gran Paradiso National Park. At the meantime, both tourism operators and farmers converge on the need to rely on the natural and cultural heritage for promoting the quality of food productions and tourism. The flow analysis between the two chains (work in progress) shows that the local food product can play a fundamental role in promoting tourism activities in the Valley. Nevertheless, when considering quantity and quality of the food production, some aspects need further investigations.

Conclusion: In marginal mountain areas, highly characterized by fragmentation of the economic activities, small business size companies and lack of communication among the local players, inverting the community desertification would be possible only if the two main pillars of local economies (tourism and agriculture) are considered by local governments with a more systematic approach. An eco-management tool gives local administrators the conceptual framework for addressing the public policy at local level.

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Take home message

Häggblom

Poster

During the past five years, instruments and views of animal husbandry have changed drastically on Åland. In addition, the Åland government has adopted a Development and Sustainability Agenda. This study considers the development against the different dimensions of sustainability: the social, the economic and the ecological.
One conclusion is that farmers need to be able to reach sufficient profitability in order to maintain a versatile pasture use with sustained biodiversity in the long run.

Is the development of the use of natural pastures sustainable in Åland (a self-governed part of Finland)? Thoughts on instruments and rural development

Maija Häggblom

Introduction: Just a few decades ago, agriculture still was a very important part of the Åland economic base. Afterwards this share has steadily declined and the trend towards marginalization has remained steady in recent government periods, reinforced by austerity in both agricultural subsidies and the reform of the locum tenens service for farmers. Farmers often find it difficult to influence their life situation for the better. Farmers' experience can be seen against the theoretical framework of Karlsson et al. (2013).

The idea of sustainability lays on three dimensions: the economic, the social and the environmental. For sustainable development all three must be considered in policy decisions. After the elections in 2015 the goal is a sustainable society until year 2051The current government has a strong focus on sustainability at all levels. Certainly, a sustainability project was initiated during the previous government's term of office, but some focusing seems to have taken place. The sustainability project is ongoing and has currently produced a Sustainable Åland Agenda (Sustainability 2016). As a result of this project, a number of the most current and decision-making issues will be more versatile highlighted; partly because the changes in farm farming and the management of the economy have been subject to major changes, especially during the last ten years, partly because farm farming is considered to be one of the most traditionally bound areas, and the Åland conditions in many respects differ from other areas. Developments in this group are important for future development in Åland at the same time. Because of these reasons, the purpose is to collect and produce material and evidence for future development work and decision making. I focus on the survival of active production on farm use, considering the three dimensions of sustainable development.

Materials and methods: The method is qualitative research where material collected through previous questionnaires will be discussed, as well as received submissions in the form of referral, submitters and other submitted factual documents will be treated against the theoretical framework. Three different surveys have been made during the process. The analysis of these has been done in the form of qualitative content analysis and highlights the development of farmers 'ways of practically resolving the exchange situation, and giving an indication of the farmers' experience of the situation over time. Submitters in connection with the substitution question and agricultural reforms in the local newspapers have been collected in 2010-2017. These will be analyzed in terms of the questionnaire and to provide more diverse support for the interview work. In addition, the provincial government has received any contributions from producer

Results: There is a strong connection between the economic reality, the social context and a sustainable development of biodiversity.

Conclusion: The trend towards big units and a poor economy are not highly supporting the sustainable development of biodiversity. Many pastures are not in use or they became too highly used. There should be better methods to give economic support to people actively working with old pasturing methods and keeping farm animals on a way supporting more biodiversity.

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Journal of Mountain Science: an important platform for publishing mountain research achievements.

Dunlian Qiu

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Journal of Mountain Science (JMS) founded in 2004, is an international English journal. JMS is sponsored by Institute of Mountain Hazards and Environment, Chinese Academy of Sciences, published by Springer. JMS is one of the five SCI-indexed journals specially on reporting mountain research. In the oral presentation, I'll briefly introduce the five SCI-indexed journals on mountain science and introduce the history of JMS and its future development strategy.

Meeting Program

20th FAO CIHEAM Mountain Pasture Network
9 - 12 September 2018

Sunday, 9 September BOAT TRIP	
15:00	Departure Hurtigruten boat trip Bodø – Stamsund (Lofoten)
	Registration Hurtigrute kay Bodø
17:30	Welcome dinner
19:00	Arrival Stamsund bus to Ballstad
	Accommodation at Ballstad
Monday, 10 September MEETING DAY	
08:30 – 09:00	Registration Kraemmervika Havn
09:00 – 10:10	**Opening session** Chairperson: *Grete M. Jørgensen*
09:00	Opening address *Alain Peeters, Giampiero Lombardi, Vibeke Lind*
09:15	Welcome by Remi Solberg, Mayor of Vestvågøy municipality
09:25	Bioeconomy in Norway – role of the land-based sectors including mountain pasture *Per Stålnacke, Director Research NIBIO*
09:45	Lofotlam – from local speciality to brand *Gustav Karlsen, NLR Northern Norway, Finn-Arne Haugen, NIBIO*
10:15 – 13:00	**Innovation in grassland management and monitoring** *Chairperson: Giampiero Lombardi*
10:15 – 10:55	Internet of things and agriculture. Proximal sensoring and Grass8 system for a sustainable management of pastures *Riccardo Beltramo, University of Torino*
10:55	Governing emergent land, an expanding recreational resource in Kvarken Archipolago (Finland) and future pasture possibilities *Kristina Svels*
11:10	Quantifying browsing damage on shrubs by grazing animals *Markus Staudinger, Tobias Zehnder, Manuel K. Schneider*
11:25	Coffee break
11:45	Effect of walking or truck transhumance on cows' performance *Madeline Koczura, Matthieu Bouchon, Germano Turille, Joël Bérard, Sarah Zurmühle, Michael Kreuzer, Bruno Martin*
12:00	Virtual fences for goats *Silje Gunhild Eftang, Knut Egil Bøe*

12:15	New methods for retrieval of free range sheep *Svein-Olaf Hvasshovd*
12:30	Can sensor technology and real-time communication detect tick-born fever in sheep on range pasture? *Lise Grøva*
12:45	Evaluation of sycamore maple, common ash, goat willow, and rowan foliage for goat nutrition *Simone Ravetto Enri, Massimiliano Probo, Manuela Renna, Eleonora Caro, Carola Lussiana, Luca M. Battaglini, Giampiero Lombardi, Michele Lonati* Planning grazing management enhances plant alpha-diversity and pastoral value of alpine grasslands *Michele Lonati, Elisa Perotti, Massimiliano Probo, Marco Pittarello, Giampiero Lombardi* A new methodology to estimate stocking density of grazing sheep based on distance from night pens *Simone Ravetto Enri, Alessandra Gorlier, Ginevra Nota, Michele Lonati*
13:00	Lunch and poster session
14:30 – 17:30	**Strategies to reduce the causes and mitigate the effects of climate changes on agropastoral systems** Chairperson: *Grete Hovelsrud*
14:30	Three lessons from Drought Planning to help planning for climate change *Mitchel McClaran, Arizona University*
15:10	Climate footprint and ecosystems services in Alpine dairy cattle chains *Enrico Sturaro, Marco Berton, Luigi Gallo, Stefano Macolino, Cristina Pornaro, Maurizio Ramanzin*
15:25	Does grazing duration in dairy farming have environmental benefits? *Daniel U. Baumgartner, Thomas Guggenberger, Silvia M.R.R. Marton*
15:40	Socio-ecological transformations: how do pastoralists adapt to climate change in Norway and Mongolia? *Andrei Marin*
15:55	Coffee break
16:20	Climate change implications of sheep farming system extensification: a LCA case study *Enrico Vagnoni, Antonello Franca, Pasquale Arca, Claudio Porqueddu, Pierpaolo Duce*

16:35	How do Norwegian farmers and agricultural organizations understand their role in 'the green transition'? *Grete K. Hovelsrud, Marianne Karlsson, Halvor Dannevig*
16:50	Our common cause: Our Upland Commons – taking a multi- partner collaborative approach to resolving challenges on upland commons in England *Christopher John Short, Julia Aglionby*
17:05	Reasons for valuing smallholder farmers' ecosystem services in maintaining biodiversity and food productivity in Western Norway *Siri Veland* Tissue stoichiometry as a forage quality index in the context of climate change: drought-related productivity constraints and nutrient quality *Melissa Cristina Morcote Martínez, Johannes Ingrisch, Roland Hasibeder, Helene Solderer, Kevin Van Sundert, Sara Vicca, Michael Bahn* The contribution of livestock species to reduce vulnerability in pastoral areas of Egypt *Helmy R. Metawi*
19:30	Dinner Kraemmervika Havn
Tuesday, 11 September DAYTRIP	
08:30 - 21:30 DAYTRIP	Stockfish in Lofoten The blacksmith in Sund Farm cheese factory with goats including lunch Sheep farmer delivering to Lofotlam Viking museum at Borg including dinner with the chieftain
Wednesday, 12 September MEETING DAY	
09:00 – 12:35	**Linking agropastoral sustainability with agricultural policies and human activities** Chairperson: *Per Stålnacke*
09:00	Livestock – carnivore conflicts; the impact of production *Inger Hansen, NIBIO;* *Geir-Harald Strand, Auvikki Ilmarar Bjerka de Boo, Camilla Sandström*
09:40	Utilizing natural pastures in Northern Norway with Vestlandsk fjord cattle *Grete H.M. Jørgensen, Nina H. Sæther, Kleopatra Delaveris*

09:55	The surfaces for the promotion of biodiversity as an effective political tool for plant diversity preservation in the southern Swiss Alps permanent grasslands *Emiliano Nucera, Michele Lonati, Simone Ravetto Enri, Pier Francesco Alberto, Massimiliano Probo*
10:10	Does mountain origin give specifity to milk? *Mauro Coppa, Chantal Chassaing, Cecile Sibra, Odd Magne Harstad, Jože Verbič, Jaroslav Golecký, Anne Ferlay, Bruno Martin*
10:25	The impact of cattle breed on pasture vegetation *Caren Pauler, Johannes Isselstein, Thomas Braunbeck, Manuel K. Schneider*
10:40	Coffee break
11:05	An agroecological lecture of the Andean breeding systems *Gilles Brunschwig*
11:20	The challenge of the large carnivores: “Change Management” from free grazing to flock management *Daniel Mettler*
11:35	Impact of organic fertilisation on agro-ecological features of *Trisetum flavescens* (L.) P. Beauv. grassland *Veronica Sărăţeanu, Carmen Claudia Durău, Otilia Cotuna, Dorin Rechiţean*
11:50	Grass-fed milk consumers’ perception: an explorative survey in Italy *Giampiero Lombardi, Giovanni Peira, Damiano Cortese, Luigi Bollani, Elena Salussoglia*
12:05	Eco-management for the agriculture and tourism chains in marginal mountain areas *Stefano Duglio, Giampiero Lombardi*
12:20	Journal of Mountain Science: an important platform for publishing mountain research achievements *Qiu Dunlian, Executive Editor-in-Chief Journal of Mountain Science*
12:35	Administrative information
12:45	Closing ceremony
13:00	Lunch
14:00	Bus departure to Leknes airport

Program daytrip

20th FAO CIHEAM Mountain Pasture Network
Tuesday 11 September 2018
Ballstad – Sund – Bøstad - Unstad – Borg - Ballstad

08:30	Departure Ballstad

We will drive a short distance to visit "Stockfish from Lofoten" where Helge Haug, CEO of Nic Haug AS will be our host. Stockfish from Lofoten is dried and matured Arctic cod, wild caught just outside the Lofoten islands. The artisan product contains no additives or preservatives and is a result of a long, natural drying and maturation process – just as the Vikings did 1,000 years ago (https://www.torrfiskfralofoten.no/en/)

10:00	Departure to Sund

Going south along the narrow main road of Lofoten, E10, we will arrive Sund after approximately 1 hour. Here we will visit the blacksmith (http://smedenisund.no/index.html, Norwegian page). In the smithy, we will meet the blacksmith, Tor-Vegard, who is a magician with his tools. His primary production is sculptures of the cormorant (*Phalacrocorax carbo)* in all shapes and sizes. The smithy is warm in both temperature and hospitality.


The comorant

12:15	Departure for Lofoten Gårdsysteri https://www.lofoten-gardsysteri.no/

We will continue back north along the same road, E10, going through the main city of the region, Leknes. We continue to Bøstad where we will meet Marielle and Hugo. They originate from the Netherlands but found their home in Lofoten.


They are running an organic goat farm producing cheeses from the animals. They also use the meat from the kids to produce sausages. They use seaweed as an interesting ingredient in their

feeding. Marielle and Hugo will serve us lunch and we will hear about their farm and production system.

13:15	Lunch Lofoten gårdsysteri

14:15	Visit Lofoten gårdsysteri


15:45	Departure for Unstad

At Unstad we will visit the sheep farmer Harry Martinsen. He has a flock of approximately 200 ewes of the Norwegian common breed – Norwegian White Sheep. He produces lamb for Lofotlam and is one of the many farmers in Lofoten produce prime quality lamb meat. In addition to being a farmer, Harry Martinsen is also contractor employing three staff for preparing the groundwork at new building sites, break masses and plough the roads during winter.


17:30	Departure for Lofotr Museum http://www.lofotr.no/index.asp

We have just a short drive from Harry Martinsen to Lofotr Vikingmuseum at Borg. Here we will meet the Vikings, smell the tar, taste the food and feel the history. The Vikings have been awaiting you for more than 1000 years.

In the early iron age (Norwegian 500 - 1030 A.D.) Borg had already been a powerful centre for hundreds of years. The oldest version of the Chieftain´s house was built around 500 AD, and became part of a centre of social and religious status that already had existed for long times and was to last for several centuries.

The archaeological finds at Borg are bearing witness of a rich chieftain who had a position in the Scandinavian upper class. Several finds are proof that the chieftain at Borg had extensive contact with the world far away from Borg.

18:00	Guiding and Dinner at Lofotr vikingmuseum

21:00	Return to Ballstad

Wish you all a pleasant day
Grete, *Gustav* and *Vibeke*


Bøstad
Lofotr Vikingmuseum
Tangstad
Vestvågøy
E10
Myrland
Leknes
Napp
Vareid
Flakstad
Ramberg
Flakstadøya
Nusfjord
Sund
Gravdal
Sennesvik
Ballstad
Stamsund
815
817
818
Stamsund
Arrival
Hurtigruten
Venue
Stockfish from Lofoten