Vital statistics

The long-term protection of natural resources we rely upon is of paramount concern for mankind. **Dr Sandra Lavorel** discusses VITAL, which explores how a change in land management can affect different ecosystem services in semi-natural grasslands; research which could help protect our natural resources

Firstly, could you outline the main objectives of the project?

We aim to understand how coupled changes in plant functional and soil microbial diversity in response to grassland management influence nitrogen cycling and other ecosystem processes that underlie ecosystem services. The main innovations of VITAL are:

- Soil microbial diversity is incorporated into the assessments of patterns and mechanisms of ecosystem service provision
- Ecosystem services that are quantified – and their trade-offs – are those of interest to local and regional stakeholders, as well as to European policies
- A wide range of ecosystem services are assessed along with two dimensions of biodiversity (plant and microbial)

How can management changes affect ecosystem services (ES)?

The abandonment of manuring, mowing and grazing, or conversely management intensification, can cause a reduction in plant species and functional diversity, soil microbial diversity and activities, soil nitrogen availability and nitrogen transformation processes. These changes have the potential to fundamentally shift the ecosystem services that these agro-ecosystems can provide, and thereby the livelihood and development potential for local economies.

Where is your research being conducted?

Research activities are spread across three carefully selected sites; one in the French Alps (Lautaret), one in Austria (Stubai Valley), and one in the UK (Colt Park, Yorkshire Dales). These sites represent the expected range of fertility conditions for semi-natural grasslands.

What methods are you using?

We quantify the potential for different plant species to influence soil microbial diversity by using single plants in controlled glasshouse conditions. We also use simplified ecosystems (mesocosms), in which we study species in varying mixes under semi-controlled conditions. The effects of coupled plant and soil microbial diversities (especially on components of the nitrogen and carbon cycles) are measured in the mesocosms and in the field. The measurements include above and belowground biomass production, leaching of different nitrogen forms, litter decomposition, carbon pools and fluxes. We use structural equation models to test for causal chains from plant diversity to ecosystem functioning and account for inter-site differences in climate or soil types.

How are you assessing the impact of agricultural practices?

Our sites cover a wide range of management intensities, from fairly intensive to abandonment. Within each of our three sites we consider grasslands under different levels of management intensity, especially in terms of fertilisation. Management effects on different measures of soil fertility are quantified and used as explanatory variables for plant and microbial diversity, and for ecosystem processes.

Who will benefit most directly from the research?

The primary beneficiaries will be local decision makers and potentially regional, national and European policy makers. Our research will also inform mountain farming communities about the advantages of multifunctional management. The research will reinforce links between nature conservation and agricultural sectors. The results will be valuable to marginal (or less favoured) agricultural areas, where current agricultural and sustainable development policies are targeting biodiversity conservation, restoration and multi-functionality.

How successful has the project been so far? Are there any highlights that you would like to draw attention to?

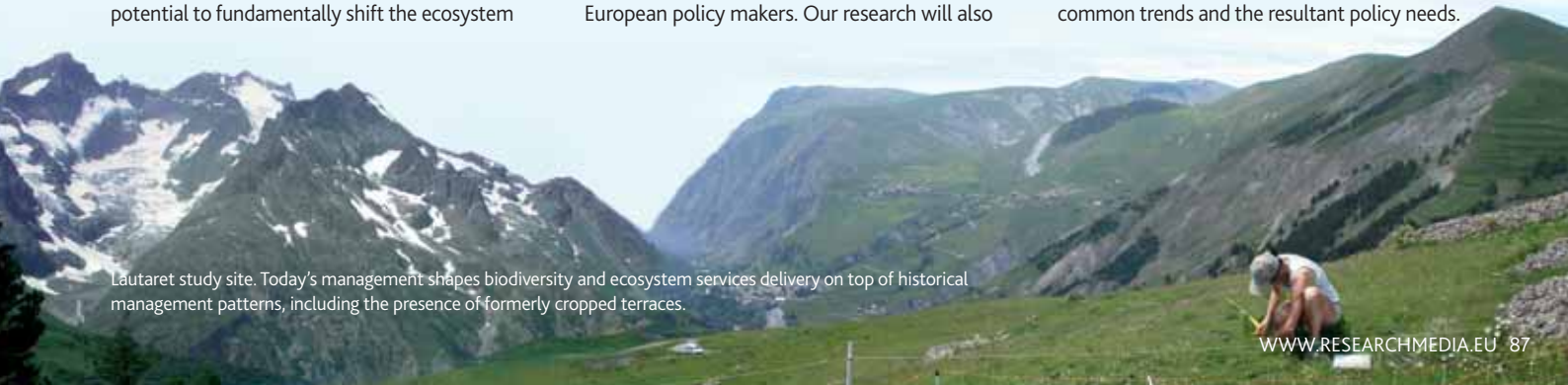
From a scientific point of view the project has been very successful. The preliminary results support our initial hypotheses on how plant traits affect microbial diversity, and in turn ecosystem functioning. We have also obtained ecosystem service models for the Lautaret site and generated maps for several relevant services. The engagement with stakeholders, in particular farmers, has also been a real success.

Will the dissemination of the results be directed at stakeholders or a wider audience?

Our results are available to stakeholders and end users (managers and policy makers) throughout the project. In the future we will enhance the relevance of the results through interactive workshops. This should result in an increased awareness of the importance of plant and microbial diversity in maintaining fertility and the opportunities for multifunctionality. We are also producing a toolkit for training students and managers. Our website will provide a popular version of the results, and project presentation leaflets have been produced at field sites. The Lautaret botanical garden, which is associated with the French research site, also offers an important public interface.

Finally, what does the future hold for your research?

We hope that our message will be received by national and European policy makers. A natural follow up would be to encourage similar assessments across other marginal agricultural regions, and to develop a network that can identify common trends and the resultant policy needs.



Lautaret study site. Today's management shapes biodiversity and ecosystem services delivery on top of historical management patterns, including the presence of formerly cropped terraces.

Novel research into grassland management

Spatially explicit understanding of ecosystem services is currently limited. To address this deficit, the BiodivERsa-funded **VITAL** project proposes an approach based on studies of plant traits and abiotic characteristics

THE CONCEPT OF ecosystem services has been developed over recent decades to aid understanding of the human use and management of natural resources. This method of framing the relationship between biodiversity, ecosystems and human wellbeing first gained strength in nature conservation during the 1990s. It has since spread through a range of scientific disciplines, and into policy and industry. In 2005, the Millennium Ecosystem Assessment (MA) report provided the most comprehensive assessment of the state of the global environment to date. This assessment classified ecosystem services under four areas: supporting, provisioning, regulating and cultural. The concept provides an anthropocentric justification for conserving species and ecosystems, based upon our dependence on the goods and services they provide.

The challenge for European agriculture is to provide ecosystem services (such as carbon storage and water quality protection) along with biodiversity conservation and economically viable production. However, while extensively managed or restored grasslands are key elements of European landscapes, basic understanding of ecological constraints and opportunities for multifunctionality is deficient. Policy management and land planning urgently require spatial analyses of multiple ecosystem services (ES) at global, continental and regional scales.

Rhizotron experiment growing individual species under two nutrient availability conditions in order to measure their functional traits and their impacts on soil microbial functional traits and diversity

Conceived to address this knowledge gap, VITAL is a Europe-wide BiodivERsa-funded project which explores the hypothesis that the delivery of multiple ecosystem services in semi-natural grasslands, and their vulnerability to changes in management, can be explained by the coupling in plant and soil microbial functional diversity and its impacts on carbon and nitrogen turnover. The core objective is to build a conceptual model of relationships among plant and microbial functional diversity and multiple ecosystem service delivery.

SITE STUDIES

Research is being conducted at three sites; the first is in the French Alps (Lautaret), the second is in Austria (Stubai Valley), and the third is in the UK (Colt Park, Yorkshire Dales). These sites provide a representative range of management and natural conditions, as Dr Sandra Lavorel, the project's coordinator explains: "Ecosystem services relevant to each of the three study sites were identified using interviews with regional experts (from agriculture, nature conservation and tourism) and with locals including farmers and non-farmers. The services we consider are those explicitly perceived as relevant and important at a regional to local level," she states.

The aim of the research is to understand how functional diversity in plants affects microbial diversity in soils along gradients of grassland management intensity. Furthermore, the project intends to better explain how these two dimensions of biodiversity then influence nitrogen cycling and other ecosystem processes. This understanding will make it possible to document how different ecosystem services (such as pasture production, soil fertility maintenance, soil carbon storage, soil water retention capacity, and grassland cultural value) are affected by changing management: "This will provide an improved knowledge of which combinations of services operate in synergy and which combinations trade off against each other," explains Lavorel.

The project sites were chosen specifically because they incorporate the full expected range of fertility conditions for semi-natural grasslands. All three sites are located in high altitudes as these areas are those set to suffer or benefit most from changes in land management approaches. However, each site also faces region-specific challenges.

At the Lautaret site, extensification of grassland management leads to modification in agricultural value, with a shift to poor quality forage, and

Yorkshire Dales study site. The landscape is a mosaic of improved, highly fertile grasslands with low biodiversity, and restored grasslands where fertility is lower and biodiversity has increased considerably since restoration.

especially to large decreases in plant and insect diversity, as well as cultural value (aesthetic, sense of stewardship by the farmers). This is mainly due to the dominance by large unpalatable grasses which block off other species and accumulate large amounts of dead material.

Professor Ulrike Tappeiner, the site leader for Stubai, explains the effect of changes to established land management techniques: "Traditionally managed areas can be seen as 'best practice' to optimise provisioning ES (ie. water storage capacity), regulating ES (ie. buffering natural hazards such as snow-gliding, landslides and surface runoff), habitat or supporting ES (ie. biodiversity – genetic diversity), and cultural ES (aesthetic, heterogeneity). Abandonment or intensification both decrease forage quality for instance. Vulnerability is thus expressed both with intensification at the valley bottom and abandonment on upper slopes," she explains.

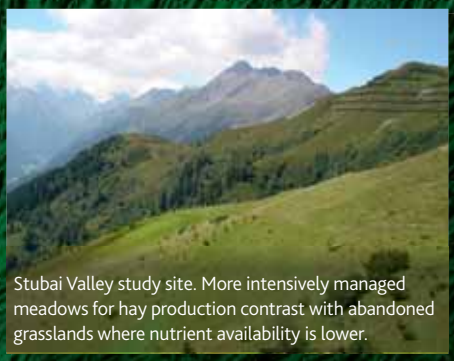
In the Yorkshire Dales, intensification of grassland farming – through the use of inorganic fertilisers and reseeding – has caused dramatic reductions in plant and invertebrate diversity. Professor Richard Bardgett, who coordinates the research activities of the UK team, highlights the significance of this loss: "Large areas of the landscape which were once species-rich, such as traditionally managed hay meadows, have been converted to species-poor, productive grassland. This is associated with a loss of several ecosystem services, including

declines in the amount of carbon in the surface soil, declines in soil structure, and loss of habitat heterogeneity and aesthetic appeal," he explains.

ECOSYSTEM SERVICES MODELLING

The VITAL team's approach relates ES to ecosystem properties (EP) according to indicators identified by stakeholders or experts. This approach, based on social evaluation of ES rather than on a top-down expert approach, makes it possible to quantify service provision as perceived by those who actually understand and benefit from the services directly. Although necessarily site-specific, such an approach reveals how ecosystems meet local stakeholders' expectations for services. In general, VITAL uses simple, rather than weighted, sums of EP to derive ES, because attribution of specific weights would require in-depth analyses of perception which is highly sensitive to both the stakeholder sample and context.

The project concludes next year, but the researchers' results are already yielding significant insights. For example, they are keen to highlight that findings on multiple services such as aggregate agronomic and cultural value – have demonstrated that it is possible to reach high values for both in lightly fertilised and mown grasslands as well as in summer pastures. The significance of the work could have lasting impact: "Sustainable management of species and functionally diverse grassland could simultaneously aim at conserving biodiversity and locally important ecosystem services by taking advantage of correlations and trade-offs among different plant functional traits," she explains. Furthermore, stakeholder engagement has been a real success and farmers are especially keen on the scenario approach which is beginning now: "They expect to learn more about the multifunctional management of their grasslands in the face of climatic variability and socioeconomic uncertainty," Lavorel elucidates. An evaluation of the project benefits by the farmers and other local stakeholders themselves is also planned.



Stubai Valley study site. More intensively managed meadows for hay production contrast with abandoned grasslands where nutrient availability is lower.

The general conceptual model will be applicable to mountain grassland systems, while extension to other low intensity grassland management systems in Europe will require further testing. The main beneficiaries of this research will be local decision makers, but it could have a wider-reaching effect, as Lavorel explains: "Our results will be of interest to decision makers and managers in terms of promoting multi-activity and multifunctional agriculture. It will also inform mountain farming communities about the opportunities they might derive from multifunctional management, and reinforce existing links between the nature conservation and agricultural sectors". By focusing on concept development and on sites that span a broad spectrum of ecological conditions and a diversity of socioeconomic contexts, VITAL is making real headway in its goal to provide robust knowledge of generic value across Europe.

> The research will provide an improved knowledge of which combinations of services operate in synergy and which combinations trade off against each other

Mesocosms experiment simulating the effects of mixtures of plant species with different functional traits on microbial functional and genetic diversity and on nitrogen cycling processes

INTELLIGENCE

VITAL

ECOSYSTEM SERVICE PROVISION FROM COUPLED PLANT AND MICROBIAL FUNCTIONAL DIVERSITY IN MANAGED GRASSLANDS

OBJECTIVES

To produce a conceptual model of relationships among plant and microbial functional diversity in grasslands, and multiple ecosystem service delivery.

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