Metaprogram
BIOSEFAIR

INRAE

Research actions supported by the metaprogram BIOSEFAIR 2021 -2023

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Metaprogram Biosefair

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Biodiversity is making the headlines these days, and has become a key issue on political agendas as its current and predicted decline has become a major challenge for humanity. The degradation of living organisms is relatively easy to perceive, and many symbols of it are widely used, such as the decline in the number of common birds. However, biodiversity remains a very complex concept to handle, and its preservation and restoration raise many and varied scientific and management issues. Many of the research projects carried out at INRAE deal, in one way or another, with biodiversity. However, it has been identified that there are blind spots in INRAE's scientific work on biodiversity, themes and questions that are not explored in sufficient depth in the usual work, marked by disciplinary orientations. In particular, this concerns the interfaces between environments and interactions between activities, the dynamics of biodiversity and ecosystem service networks in a context of global change and transitions, and global health as a challenge for the preservation of biodiversity.

The aim of the BIOSEFAIR metaprogram is to fill some of these gaps and to stimulate new research and interdisciplinary questions in INRAE laboratories that can usefully complement the overall understanding of biodiversity and its consequences for human activities.

To this end, Biosefair, following on from the Ecoserv metaprogram (2014-2019), is structuring a scientific community of nearly 300 people from INRAE laboratories who are interested in questions relating to biodiversity and its consequences for human activities (ecosystem services) through exchanges of information and knowledge, and methodological and thematic workshops. These people belong to virtually all INRAE's departments, providing a multi-disciplinary capacity for analysis. To go further, and encourage interdisciplinary practices, Biosefair supports scientific projects, ranging from conceptual productions and comparisons of points of view, to collaborative scientific projects on innovative, high-risk subjects, encouraging unprecedented interaction between laboratories. Two half-doctoral contracts (theses) per year complete this support scheme.

After 4 years, including 2 years with Covid, Biosefair brings together 7 consortia working to share knowledge and develop research guidelines, 17 2-year scientific projects and 10 ongoing theses. They are briefly presented in this document.

BIOSEFAIR is now entering a new phase in its work, as the projects it has supported will begin to produce results that will feed into strategic thinking on the future direction of biodiversity research. This will undoubtedly lead to the emergence of new lines of enquiry and concrete proposals that can be used by managers and decision-makers to take better account of biodiversity issues.

Consortia

BECO

Bees and consultation. Reconciling beekeeping, agriculture and biodiversity: floral resources seen as a common good to be managed collectively

CONSORTIUM

2021-2023

Contacts

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Thematics involved

Agroecology
Beekeeping
Landscape ecology
Human geography
Participatory action research

INRAE units involved

DYNAFOR Joint Research Unit - Agriforestry Landscape Dynamics and Ecology
ABEILLES ET ENVIRONNEMENT Joint Research Unit – Bees and environment

External partnership

ITSAP-Bee Institute
SENS Joint Research Unit - Knowledge, Environment and Societies
Parc National des Cévennes

Backgrounds and challenges

As a result of changes in farming practices, climate change and the increasing number of beekeepers and apiaries, tensions are emerging around floral resources, i.e. the nectar and pollen used by the bees. Long considered to be unlimited, these floral resources seem to be the object of a competition, both inter-specific between wild and domestic bees and intra-specific between domestic bees. This leads us to consider these floral resources as a common good to be managed collectively, involving not only beekeepers and biodiversity managers, but also the farmers who shape these landscapes and whose practices influence the availability of floral resources.

The BECO project aims to better understand the interactions between beekeeping, agriculture and the conservation of wild bees at landscape level, through the lens of floral resources, i.e. the nectar and pollen used by bees. The project is based on a mountainous case study, the Cévennes National Park, and will support a multi-stakeholder collaborative process on these issues.

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Objectives

To further understand these issues and the associated socio-ecological systems, the BECO project will develop a transdisciplinary approach combining (i) spatial ecology to measure and characterise competition between bees over floral resources, (ii) landscape ecology to assess the impact of agricultural practices on landscapes and floral resources, (iii) social sciences to understand and support social interactions around the management of this common good, and (iv) the involvement of key stakeholders (beekeepers, farmers, park managers) in a process of knowledge co-construction.

Resources

This consortium has three components. The first aims to further understand the local context, build the partnership with the National Park and foster co-construction : conducting interviews with beekeepers and farmers, organising discussion and co-construction meetings with the park's partners, running collective workshops bringing together local stakeholders (beekeepers, farmers, park staff) and scientists to build a shared diagnosis of the issues and needs in terms of knowledge and support. The second part aims to design an innovative conceptual framework for thinking of floral resources as a common good and to analyse the obstacles and levers to concerted management of these floral resources. The third part of the project will focus on networking between the scientists in the consortium, and with other researchers, in order to create a research community on these issues.

BEEDET

Identification des abeilles sauvages et domestiques par des méthodes moléculaires non destructives

CONSORTIUM

2021-2022

Contacts

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Thematics involved

Molecular and genomic biology
Landscape ecology

INRAE units involved

DYNAFOR Joint Research Unit - Agriforestry Landscape Dynamics and Ecology
GENPHYSE Joint Research Unit - Genetics, Physiology and Livestock Systems

Background and challenges

There are over 20,000 species of wild bees in the world and close to 1,000 in France. This great diversity of species, all differing in terms of morphology, mobility, phenology, nesting sites and more importantly floral preference, is essential for the pollination of a wide variety of wild and cultivated plants. The health of bee populations is threatened by many factors such as intensive agricultural practices and land management.

Lithurgus cornutus femelle

Objectives

In BEEDET, we proposed to develop a non-lethal protocol to identify wild bees from the traces they may have left when foraging on flowers (hair, saliva, faeces, etc.). The experimental design is based on strawberry plants, commonly used as a pollinometers to assess pollination service in different agroforestry landscapes. Three conditions were defined: a negative control consisting of enclosed strawberry plants in the absence of bee, a positive control consisting of enclosed strawberry plants in the presence of three wild bee species, and a test condition consisting of strawberry plants exposed to open air and local pollinator species. For each experimental condition, four strawberry plants were used and approximately ten flowers per plant were collected and stored at -20°C. DNA extraction was performed using the DNeasy *Blood & Tissue Kits* and PCR amplification was obtained by targeting a 220 bps fragment of the insect 16S minibarcode (Clarke et al., 2014). Illumina sequencing (Miseq) and bioinformatic analyses are underway.

CONTICOMIC

Assessment of the scientific challenges to better understand the role of the soil-water continuum in maintaining functional microbial biodiversity in agroecosystems

CONSORTIUM

2021-2022

Contacts

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Thematics involved

Aquatic and terrestrial microbial ecology and ecotoxicology
Molecular biology
Biostatistics
Biogeochemical cycles

INRAE units involved

RIVERLY Research Unit,
Interdisciplinarity Research Unit for the management and restoration of river systems and their catchments
AGROECOLOGY Joint Research Unit
CARRTEL Joint Research Unit - Alpine Center for research on trophic networks and limnic ecosystems
EMMAH Joint Research Unit - Mediterranean Environment and Modelling of Agroecosystems

External partnership

LECA CNRS

Background and challenges

Taking into consideration the environmental continuums, including the interface zones, to study and manage ecosystems is gradually gaining interest in both scientific and operational spheres. In this context, the role of the soil-water continuum in maintaining biodiversity and ecosystem functions and services is increasingly questioned. However, this role is still very little studied, especially because of the compartmentalization of research by type of environment (e.g. soil vs surface water vs sediment) as well as of conceptual and methodological scientific limitations (including in terms of experimental set-ups that integrate terrestrial and aquatic compartments).

Agroecosystems, which carry high socio-economic stakes, are ecosystems that illustrate the importance of the soil-aquatic continuum, due to the close links between watersheds and adjacent aquatic environments, particularly in headwater sections. While these links are relatively well studied in terms of chemical transfers (e.g. nitrates, phosphates and pesticides), little attention is paid to biological exchanges between soil and aquatic environments. In agroecosystems, microbial communities are present in all environmental compartments, where they contribute to various ecological processes that contribute to a wide range of ecosystem functions and services.

The functioning of agroecosystems and the interfaces between their various compartments is highly dependent on agronomic practices, which interact with various natural factors (e.g. climate, slope, soil impermeability, etc.) and which can be multiple and diverse at the watershed scale. Taking into account the diversity of these practices is therefore needed to better understand the role of the soil-water continuum in maintaining functional microbial biodiversity in agroecosystems.

In this context, it is necessary to identify the conceptual and technical levers to enable the development of more ambitious projects around the following question: "How do the interfaces between terrestrial and aquatic environments and the interactions between activities influence functional microbial biodiversity and the ecosystem services it supports in agroecosystems?". The aim of the CONTICOMIC project was therefore to promote the establishment of a scientific framework to help identify these levers and assess the related scientific challenges.

Resources

The CONTICOMIC project enabled a workshop to be organised, bringing together microbial ecologists and ecotoxicologists working in terrestrial and aquatic environments respectively, with the aim of leading a discussion using collective intelligence processes around :

1. The concepts of 'coalescence' and 'functional continuum' in agroecosystems,
2. Approaches/methods to be developed to explore these concepts based on the study of microbial biodiversity and certain services it supports.

AMPLI GAMMA

CONSORTIUM

2022-2023

Landscape planning and gamma multi-diversity

Contacts

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Thematics involved

Agroecology
Agroforestry
Conservation biology
Bryology
Ecoacoustics
Ecohydrology
Forest
Landscape
Plant and animal
Trophic
Aquatic ecology
Entomology
Landscape genomics
Forest management
Dispersal mechanisms
Modeling
Ornithology

INRAE units involved

LESSEM Research Unit - Mountain Ecosystems and Societies Laboratory
BAGAP Joint Research Unit - Biodiversity, Agroecology and Landscape Planning
DYNAFOR Joint Research Unit - Agriforestry Landscape Dynamics and Ecology
EFNO Research Unit - Forest Ecosystems
PSH Research Unit - Plants and Cropping Systems in Horticulture
ABSYS Joint Research Unit – Biodiversified Agrosystems
LISAH Joint Research Unit - Soil-Agrosystem-Hydrosystem interaction lab
EABX Research Unit – Aquatic Ecosystems and Global Change
UREP Grassland Ecosystem research
LISC Joint Research Unit - Complex Systems Lab
SAVE Joint Research Unit -Vineyard health and agroecology

External partnership

ECOBIO Rennes 1 University
Jyväskylä University (Finland)

Backgrounds and challenges

Our landscapes are continually being modified by changes in land use and management practices, leading to a redefinition of the relationship between biodiversity and management practices. However, the levers for action to conserve biodiversity are often conceived at a local scale (site or parcel) by looking for practices that better preserve local biodiversity. This local vision is not adapted to account for the dynamics of biotic and abiotic fluxes and the interactions between the elements of the landscape mosaic that are essential for ecosystem functioning. Despite recent conceptual advances in landscape ecology, the current challenge in terms of conservation is still to move from a "management" vision at the local scale to a "spatial planning" vision at the landscape scale.

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Objectives

How can landscapes be organised to better protect multi-taxonomic diversity?

In a global context of loss and fragmentation of natural habitats, changes in land use and management practices, the consortium will address the following two questions:

- What is the link between landscape compositional and configurational heterogeneity and multi-taxonomic specific and functional diversity at different spatial scales?
- How is multi-taxonomic gamma-specific diversity influenced by the configuration and composition of the landscape mosaic, and what are the relative contribution of different types of management (or ecosystem types resulting from management) to this gamma-specific diversity?

These questions are central to understand and analyse the role of management types on biodiversity in European anthropogenised landscapes, and to determine landscape organisation that would be more favourable to biodiversity.

Resources

These questions will be addressed through an empirical approach sampling different landscapes and biogeographical regions: predominantly forested landscapes, predominantly agricultural landscapes (including vineyards), aquatic landscapes and mixed landscapes, trying to cross-reference landscape types and biogeographical regions as much as possible.

The first task of the consortium will be to better formalise and refine the working hypotheses through an in-depth literature review on the link between landscape heterogeneity and biodiversity, in particular detailing the mechanisms that maintain gamma diversity in heterogeneous landscapes.

The second phase will focus on the sites and management gradients to sample, taking into account the current issues in forest management, agroecology and lakes, and the geospatial data available to characterise landscape composition and structure (satellite or aerial images, BDcarto®, Cesbio OSO layer, RPG).

A third focus will be on the sampling strategies to estimate multi-taxonomic gamma-specific diversity, as sampling gamma specific richness raises several methodological issues (species accumulation, detectability, etc.).

DIMIVEA

CONSORTIUM

2022-2023

Microbial and Plant Diversity in Multi-Species Agroecosystems - Modelling Relationships

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Thematics involved

Modelling
Microbial ecology
Plant-soil microorganism relationships

INRAE units involved

UREP Grassland Ecosystem research
IAM Joint Research Unit - Tree-Microorganism Interactions
AGROECOLOGY Joint Research Unit

External partnership

CREA Research Centre for Agriculture and Environment (Italy)
CNRS LIEC (Interdisciplinary Laboratory of Continental Environments)

Backgrounds and challenges

Biogeochemical modelling is used to assess the impact of agricultural activities and climate on carbon and nutrient cycles in ecosystems, as well as associated services or disservices such as biomass production, carbon emissions/storage and nutrient retention. In an agroecosystem perspective, DIMIVEA focuses on the physicochemical and biochemical characterisation of soils, functional diversity of plant and microbial communities, and the definition of indicators for ecosystem services to improve their simulation.

The project aims to model biodiversity dynamics in order to better simulate the provision of ecosystem services. Simulating multi-species systems (grasslands, forests, diversified cropping systems) allows for a detailed representation of coupled carbon-nitrogen cycles, but the models used remain simplified as they reduce biological diversity to simplistic interaction patterns with the environment. Creating simulators based on information provided by diversity attempts to go beyond the paradigm of condensing biological diversity into constant parameters. The results obtained enable exploring new research avenues to explain the synchrony between nutrient demand and supply by modelling certain levels of plant and microbial diversity.

By focusing on the characteristics of plant and microbial communities in mixed vegetation cover, the consortium aims to provide a conceptual framework to extend the potential of models for reliable estimation of ecological processes supporting ecosystem services provided by these covers. Advancing towards the creation of explicit, dynamic, and integrated simulators of microbial and plant diversity, DIMIVEA represents a new paradigm that acknowledges the interconnected aspects of biological diversity in agroecosystem modelling studies.

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Objectives

DIMIVEA integrates various experiments and knowledge to model the ecological organisations that allow natural ecosystems and certain agrosystems to be productive, multifunctional (contributing to carbon storage, water purification, soil quality improvement), and low-input. The ambition is also to identify ecological organisations to prioritise according to local pedo-climatic contexts and propose agricultural practices that could foster them in agrosystems.

For its reflections and conceptualisations, the consortium relies on aggregated microbial modelling (i.e. storing and depleting microbes in the SYMPHONY model of UREP) and experimental setups from the AGROECOseqC project of the European Joint Programme Cofund on Agricultural Soil Management (EJP SOIL). The partnership is committed to organising and facilitating dedicated workshops within scientific events such as international conferences and study days, and to progress towards the writing of a synthesis and position article, envisioned as the culmination of collective reflection in addition to prototype model production.

METAECOSERV

CONSORTIUM

2022-2023

The concept of metacommunities as a tool for understanding and managing ecosystem services in hydrosystems

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Thematics involved

Agroecology
Community and landscape ecology
Trophic ecology
Functional ecology
Ecohydrology
Eco-evolutionary dynamics
Continental hydrosystems, lakes, rivers, esturaries
Hyporheic zones
Macroecology
Biodiversity modeling

INRAE units involved

RIVERLY - Interdisciplinary Research Unit for the management and restoration of river systems and their catchements
HYCAR Research Unit - Anthropogenic continental hydrosystems: resources, risks, restoration
EABX Research Unit – Aquatic Ecosystems and Global Change
CARRTEL Joint Research Unit - Alpine Center for research on trophic networks and limnic ecosystems
LISC Joint Research Unit - Complex Systems Lab
LISAH Joint Research Unit - Soil-Agrosystem-Hydrosystem interaction lab
DECOD Research Unit - Dynamics and sustainability of ecosystems: from the source to the ocean

External partnership

IEES - Institute of ecology and environmental sciences of Paris - National Center for Scientific Research
MARBEC - Marine biodiversity exploitation and conservation - Montpellier University
CESCO - Center for Ecology and Conservation Sciences - National Museum of Natural History
SETE - Theoretical and Experimental Ecology Station - National Center for Scientific Research
Floride University

Backgrounds and challenges

Freshwater, biodiversity hotspots and major supports of ecosystem services, are among the most threatened ecosystems on Earth. Management measures for these ecosystems have traditionally been designed at local scales, without necessarily taking into account landscape variability in action plans, which has often limited the success of these measures. Today, our understanding of how biodiversity and ecosystem services are organized in these dynamic environments has progressed considerably, notably thanks to the emergence of the concepts of landscape ecology, metacommunities and the meta-systems paradigm, formalizing the processes and spatio-temporal dynamics of communities and ecosystems. These frameworks recognize that local (e.g. environmental filter, biotic interactions) and regional (e.g. dispersal, biogeographic context, material and energy flows) processes interact to determine the spatial organization of populations, communities and ecosystem processes in a given landscape. The meta-systemic framework has been conceptually applied for populations and communities and is beginning to be used for ecological processes and the conservation of biodiversity. However, the contribution of these concepts to the field of ecosystem services in aquatic environments has not yet been formalized, tested or translated into management tools.

Objectives

This consortium aims to determine, adapt and test the contribution of meta-systems theory and its corollaries in the understanding and management of ecosystem services supported by hydrosystems. It proposes to extend the concept of metacommunities to all ecosystem services in order to better understand the links between biodiversity and ecosystem services and their spatio-temporal organization in landscapes. This work will make it possible to identify relevant spatial scales for managing hydrosystems in a context of global change. Indeed, better integration of regional ecological processes involved in the spatio-temporal organization of biodiversity in management practices will make it possible to effectively conserve and restore biodiversity and associated ecosystem processes in a changing global environment, particularly in the face of extreme events. (floods, droughts, storms) which recurrently alter the physical and ecological connectivity of hydrosystems.

Resources

METAECOSERV will be based (i) on an in-depth bibliographic review detailing in particular the mechanisms underlying the maintenance of biodiversity in fragmented landscapes, (ii) on a conceptual synthesis. This reflection will include the different facets of biodiversity, from the local scale (alpha) to the regional scale (gamma). Two working seminars will also make it possible to progress in thinking. This will involve: (i) identifying and analyzing previous efforts aimed at including biodiversity aspects in understanding ecosystem services in hydrosystems; (ii) question the contribution of the concept of metacommunities in this context, by exploring its variation according to the capacities and modes of dispersal of organisms; (iii) synthesize knowledge around biodiversity-ecosystem functions (BEF) links and their applications in hydrosystems; (iv) address these questions within the different compartments of hydrosystems (watershed heads, lakes and bodies of water, riparian and hyporheic zones, rivers, estuaries) and at their interfaces.

REFUSE

CONSORTIUM

2022-2023

Ecological restoration, functionalities, uses and ecological services

Contacts

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Thematics involved

Geography
Political science
Economics
Aquatic and terrestrial ecology
Ecological restoration

Units involved

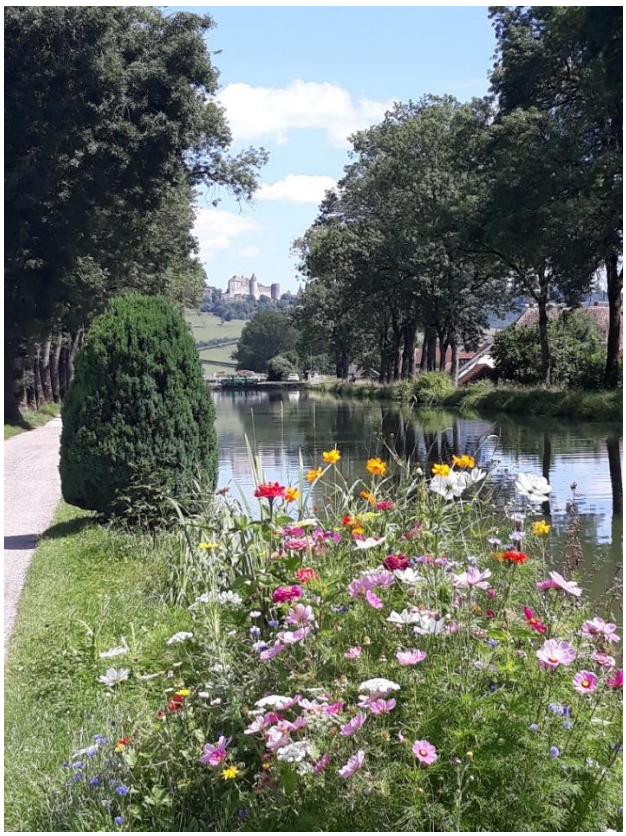
LISIS Joint Research Unit - interdisciplinary research laboratory and innovation in societies
RIVERLY Interdisciplinary Research Unit for the management and restoration of river systems and their catchements
GESTE - Joint Research Unit - territorial management of water and environment
EABX Research Unit – Aquatic Ecosystems and Global Change
BIOGECO Joint Research Unit - Biodiversity, genetic and communities
CESAER Joint Research Unit - center of economics and sociology applied to agriculture and rural areas
ETTIS Research Unit - Environment, territories in transition, infrastructures, societies

External partnership

OFB - French Biodiversity Agency

Backgrounds and challenges

The ecosystem services frame is often used as a reference to justify public actions or policies, or to assess their outcomes. However, its utilitarian approach, like that of nature-based solutions, raises questions and has limits.



Objectives

The REFUSE consortium aims at identifying relevant interdisciplinary research questions about the uses and limits of utilitarian and anthropocentric approaches (services, solutions) applied to landscapes and waterscapes restoration. What are the ecological functionalities poorly taken into account in the ecosystem services approach, what are the socio-political presuppositions this approach conveys, and with what kind of consequences? The REFUSE consortium also aims at better understanding how, in practice, the implementation of ecosystems restoration projects, when justified by the utilitarian ecosystem services approach, leads to excluding specific social groups or ecological functionalities. The main hypothesis is that, when facing situations of crisis (hydrological extremes, epizootic diseases, pollutions), the utilitarian approach is not enough to prevent or sanction practices that have significant negative impacts on ecosystems, and to design systems that are resilient or resistant to climate change or to significant changes in land or water uses.

Resources

The consortium has organized three meetings to discuss, based on empiric examples, how utilitarian approaches can lead managers, funding agencies and stakeholders to overlook certain ecological and socio-economic dimensions, and to design less resilient objectives for the management of ecosystems and their biodiversity. After clarifying various terms and concepts used when mobilizing the utilitarian approach, its blind spots and shortcomings have been highlighted, thanks to contributions from sociology and functional ecology. These blind spots were then debated in order to design new integrative frameworks able to overcome the limits of the utilitarian approach.

Pathfinder projects

ADORE

EXPLORATORY PROJECT

2021-2023

Tools for restoring biodiversity on farms: application of a results-based approach

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Thematics involved

Agroecology
Agronomy
Animal and plant ecology
Functional ecology
Water management
Ornithology
Design sciences
Zootechnics

INRAE units involved

DSLP Experimental Unit - Experimental domain of Saint-Laurent-de-la-Prée
SAD-APT Joint Research Unit - Science Action Development - Activities Products Territories
EABX Research Unit – Aquatic Ecosystems and Global Change
FERLus Experimental Unit - Fodder, Ruminants, Environment - Lusignan
AGRONOMY Joint Research Unit

External partnership

An ornithologist

Backgrounds and challenges

The issue of maintaining and restoring biodiversity in the agricultural environment is attracting growing support from many stakeholders. But what can be done to achieve ambitious biodiversity targets for the future?

Over the past twenty years, initiatives have been launched all over Europe to preserve and enhance biodiversity at the farm level. However, farmers very often find themselves in the position of observers or executors of advice rather than players in the management of biodiversity on their farms, as if they were subject to constraints in their practices without being involved in the objectives and ambitions of these action plans.

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Objectives

Preserving biodiversity on farms: thinking in terms of results

The aim is therefore to move from an approach based on the application of action plans (defined by non-farmers) to an approach based on the management of biodiversity on farms, characterised by:

1. The freedom given to groups of farmers in a given area to choose the actions they wish to develop in favour of biodiversity,
2. Action based on a "results rationale" with regard to the desired biodiversity, encouraging farmers who already have "good" results and supporting others in their search for solutions.

Providing farmers with tools enabling them to measure the effects of their practices on biodiversity is a fundamental issue in facilitating the transition of the agricultural world to agro-ecology. The adaptive management approach, which has already proved its worth in helping farmers to improve water quality at the level of a water catchment area, will be tested in ADORE to preserve biodiversity on farms. This adaptive management approach is participatory, as it is the farmers themselves who define which biodiversity elements they wish to test their practices on, with a view to achieving results.

Resources

The ADORE project involves testing the possible adaptation of an approach that has already been applied in the field of water quality to the issue of biodiversity management on a farm scale.

It involves the implementation of an activity designed by the farmer with a "results logic" in order to manage biodiversity with the levels to be achieved defined by the "beneficiaries". The agricultural and pastoral practices implemented are developed by the practitioners who carry out the work, with the support of "knowledgeable people" and a facilitator who supports the project's stakeholders and its governance.

The project will first be carried out on an INRAE experimental set-up, i.e. on two research farms, the Saint-Laurent de la Prée farm and the Ferlus farm, in order to identify the conditions for adapting the method to the issue of biodiversity, analyse any stumbling blocks that may be encountered and suggest measures to overcome them. All of this before the prospect of subsequent implementation on private farms.

BIOC@PT

EXPLORATORY PROJECT

2021-2023

Automatic Forest Biodiversity Sensors

Contacts

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Thematics involved

Forest biodiversity
Entomology
Artificial intelligence
Metabarcoding
Bryophyte taxonomy
Robotics

INRAE units involved

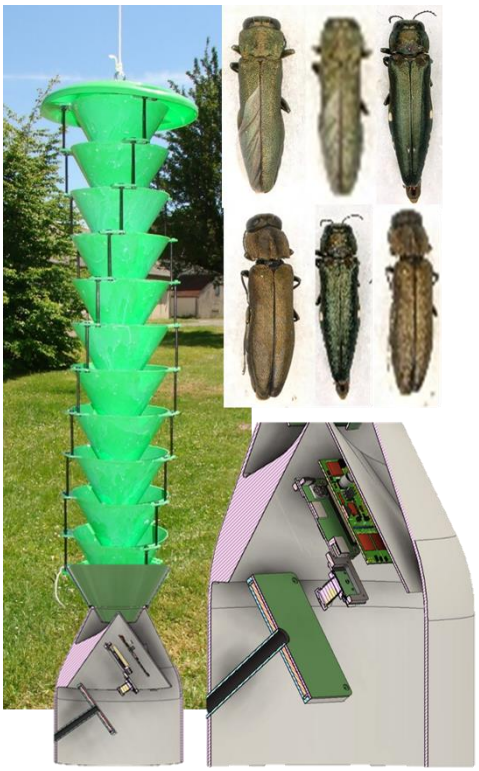
EFNO Research Unit - Forest Ecosystems
HERBIVORES Joint Research Unit
USC ECODIV – Rouen University - Study and Understanding of BioDiversity Laboratory
USC LBLGC Joint Research Unit - woody and field crop biology laboratory

External partnership

Laboratoire IRBI Joint Research Unit CNRS - Tours University - Institute of Research on Insect Biology

Backgrounds and challenges

The BIOC@PT project (Automatic Forest Biodiversity Sensors) is exploring new ways of acquiring biodiversity data that are faster and less costly than traditional morphological identification of species in the laboratory. It meets a triple aim of biovigilance, biodiversity monitoring and the study of spatiotemporal patterns of biodiversity. It involves automating field surveys (using sensors) and species determination (using artificial intelligence or metabarcoding techniques). Our exploratory approach concerns two important and relatively poorly known forest taxonomic groups (insects and bryophytes) and could be transferred to other groups. During the project, we are developing prototypes of insect sensors with automatic photographic traps, and testing their operation in forests. Automatic insect traps are selective (xylophagous *Agrilus*, flower-visiting insects) or generic (flying insects). During the project, we are also implementing a database of reference pictures (insects of the genus *Agrilus*, forest bryophyte spores), and we are developing neural networks designed to determine the species sampled by entomological sensors and airborne spore sensors (cyclone sampler). A metabarcoding feasibility test will be carried out on bryophyte spore samples, and the results compared with the visual recognition method using deep learning.



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Lindgren trap for forest beetle *Agrilus* with automatic optical sensor and classification algorithm

BIODILUTICK

Biodiversity, dilution effect and tick-borne diseases: analysis of the relationship between prevalence of pathogens, tick and host diversities along a landscape gradient

EXPLORATORY PROJECT

2021-2023

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Thematics involved

Agroecology
Population dynamics
Eco-epidemiology
Ecology and systematics of ticks
Community ecology
Landscape ecology
Spatial ecology
Epidemiology
Geomatics
Data management
Host-parasite interactions
Molecular methods
Dynamic modelling
Sociology

INRAE units involved

BIOEPAR Joint Research Unit - Biology, Epidemiology and Risk Analysis in animal health
USC CEBC - Résilience

Backgrounds and challenges

Numerous studies have demonstrated the role of landscape features on the biodiversity of agro-ecosystems and notably on tick abundance and Borrelia (the agent of Lyme disease) prevalence. The project explores the links between the ratio of wood, meadow, crop surfaces within each landscape window (considered as major environmental factors) and the biodiversity of host, vectors and pathogens.

Among investigations on the interlinkage between biodiversity and health, as for example in the case of tick-borne diseases, the dilution effect concept hold a central place but is still debated. Indeed, numerous vertebrates species contribute to tick-borne epidemiology either as pathogens reservoirs or/and as feeding hosts for ticks. The dilution effect suggest that a high diversity of vertebrates as tick hosts should reduce infection risk due to a lower prevalence of the bacteria being the etiological agent of Lyme disease (*Borrelia* spp.).

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Resources

To the left, satellite picture of the "Zone Atelier Plaine & Val de Sèvre" with 3 landscape windows illustrating different ratios of wood/meadow/crop surfaces. The 3 white stars show 3 sampling sites of ticks on the vegetation within each window.

To the right, representation of the interaction among the 3 communities involved in the patho-system : the hosts (here 3 small mammals species), the vectors (here 3 tick species) and pathogens (Borrelia spp.).

BIODILUTICK tests the hypothesis that the increase of specific diversity within host and tick communities produce a dilution of Borrelia spp. and thus a diminution of the likelihood of transmission of those bacteria to humans. The ticks are collected on the vegetation. Small mammals are captures to estimate their abundance and diversity, collect ticks attached to those animals and characterized pathogen prevalence in ticks and small mammals. Livestock (that are hosts of adult ticks) density in the sampled meadows is assessed with the help of the farmers. Finally, camera-traps are placed to determine the presence of middle size mammals (roe deer, small mammal predators such as red foxes, mustelids, feral cats…). The different pathogens (including Borrelia spp.) are looked for in the ticks collected on the vegetation and in the small mammals.

ISO SGDC

EXPLORATORY PROJECT

2021-2023

Relationship between taxonomic and genetic diversity of aquatic plants in lakes of the Atlantic coast

Contacts

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Thematics involved

Bioinformatics
Molecular biology
Community ecology
Population genetic
Taxonomy

INRAE units involved

EABX Research Unit - Aquatic Ecosystems and Global Change
BIOGECO Joint Research Unit - Biodiversity, genetic and communities

External partnership

National Botanical Conservatory South Atlantic
SIAEBVELG : management union of the Carcans-Hourtin and Lacanau lakes and Natura 2000 site coordinator
Community of Communes of the Great Lakes: Natura 2000 site coordinator
Black Pond National Nature Reserve: protected area manager
Landes Nature Association: Natura 2000 site coordinator

Backgrounds and challenges

Biodiversity is the baseline of all ecosystem services and thus represents an essential support-ing service. The lakes and ponds of the Aquitaine coastline are unique ecosystems at both the national and European levels. They host significant biological diversity, especially from a plant perspective, but are currently under severe threat. While the taxonomic diversity of these communities is well-known, the knowledge of their genetic diversity is currently non-existent. Improving this knowledge however appears essential for better management of these ecosys-tems, particularly for their endangered species.

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Objectives

In addition to propose concrete management directions, knowledge of the genetic diversity of these communities would allow studying its correlation with taxonomic diversity, referred in the literature as the 'SGDC' (species-genetic diversity correlations). The study of this relationship not only provides a better understanding of the functioning of the targeted communities and the processes patterning the assembly of their species but also enables to evaluate whether the taxonomic diversity typically used in conservation practices adequately considers the diversity at another biological scale. This is the objective of this research project jointly developed by two research units, each possessing strong expertise in one of the dimensions of this diversity.

PRABIES

EXPLORATORY PROJECT

2021-2023

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Thematics involved
Agroecology
Botany
Ecology of plant communities
Livestock economics
Zootechnics

INRAE units involved
ECOLOGIE PRAIRIALE Research Unit
Grassland Ecosystem
UMR HERBIVORE

External partnership
National Botanic Conservatory of the Massif Central

How livestock farming practices 'transform' grassland biodiversity into bundles of ecosystem services

Backgrounds and challenges

Understanding the link between biodiversity and the level of provision of ecosystem services is complex because their relationship is not linear or unidirectional. This is due in particular to the fact that biodiversity is often quantified by species richness than by functional diversity. Looking at biodiversity in terms of different metrics is a way of gaining a better understanding of this relationship.

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Objectives

The project will study how biodiversity, assessed under different metrics (specific richness, functional and equitability, rarity), is "transformed" into bundles of effective ecosystem services, via relevant agropastoral practices. For example, grasslands provide many ecosystem services such as the production of fodder, maintenance of habitat for pollinators, or provision of open and diverse landscapes. PRABIES will focus also on the 'climate adaptation service', assessed through the capability of ecosystems to adapt to climate change and variability, by analyzing how diverse grasslands can buffer the effects of climate hazards (drought, heatwaves) and reassemble to provide a range of relevant ecosystem services, under a new climate. It will make it possible to propose management practices to improve the delivery to these ecosystem services. Indeed, many conventional technical adaptation solutions are based on intensification to build up fodder stocks (use of irrigated maize silage, early mowing and systematic fertilization), which can in turn negatively affect biodiversity.

Resources

PRABIES will use and complete a database containing proxies of ecosystem services, botanical data, soil, fodder quality and practices of farmers. This database will be completed by the climate adaptation service in order to study how grassland plant communities can reassemble, to ensure a satisfactory level of forage production. PRABIES will analyze the progression in recent years of Mediterranean species in the Massif Central, taking into account practices and their impact on fodder production and its stability. The perceptions regarding this type of ecosystem service will be finally studied in order to assess the operational relevance of adapting to a new climate through grassland biodiversity.

SICCCUB

EXPLORATORY PROJECT

2021-2023

Contacts

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Thematics involved

Functional biodiversity of soils
Forest dynamics
Forest ecology
Landscape history
Forest management
Impacts of past and present uses
Soil organic matter
Pedology

INRAE units involved

LESSEM Research Unit - Mountain Ecosystems and Societies Laboratory
DYNAFOR Joint Research Unit - Agriforestry Landscape Dynamics and Ecology
EFNO Research Unit - Forest Ecosystems
ECO&SOLS Joint Research Unit - Functional Ecology and Biogeochemistry of Soils and Agrosystems

External partnership

LECA Joint Research Unit CNRS - Alpine Ecology Laboratory

Monitoring the impact of climate change and land use change on biodiversity and the functioning of mountain ecosystems

Backgrounds and challenges

Mountain areas are particularly sensitive to the combined effects of climate change and land use change. Indeed, the climate in mountain areas is warming faster than in other regions, and in Europe, mountains underwent significant reforestation at the beginning of the century. These changes have already led to significant reorganisation of biodiversity, with consequences for the functions and services provided by mountain ecosystems. Future climate change is likely to amplify these reorganisations.

Objectives

SICCCUB will deepen the description of current and past land use in Orchamp, the space-time observatory of biodiversity and the functioning of mountain socio-ecosystems (Orchamp). This will allow us monitor the dynamics of biodiversity and the functions of these ecosystems over the long term in function of climate change and land use change.

The SICCCUB project will study the relationships between:

- the history of practices and the landscape
- tree recruitment dynamics
- biodiversity and functions.

These functions underpin the production of ecosystem services in terms of wood supply and regulation, such as the regulation of soil quality, the reduction of greenhouse gases in the atmosphere and seed dispersal.

Resources

The Orchamp observatory is based on altitude gradients of around 1000 m with permanent plots (30 x 30 m) spaced at around each 200 m of elevation intervals. The observatory also has measurements at landscape and catchment scale, based on remote sensing data and current mapping data.

The SICCCUB project will provide a quantitative description of past and present uses of the plots. "Cartes d'état-major" (drawn up between 1818 and 1866) and the "cadastre napoléonien" (drawn up between 1807 and 1850) will be used to describe past uses around the plots. For more recent uses, old aerial photographs, use and habitat maps, forest management archives and pastoral surveys will be used.

Monitoring of tree recruitment, a key factor for changes in these ecosystems, and the dynamics of seed production will be analysed. Measurements of above-ground and below-ground biodiversity and of the ecosystem functions provided by soils will be carried out.

The presence of large and very large trees, the quantity and diversity of types of dead wood and the presence of dendro-microhabitats will be analysed in relation to diversity measurements for different groups (flora, fungi, bacteria and insects).

WATERSEED

EXPLORATORY PROJECT

2021-2023

The role of water in the spatial structuring of plant biodiversity in wine-growing agrosystems

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Thematics involved

Agronomy
Botany
Ecohydrology
Ecology
Spatial ecology
Hydraulics
Fluid mechanics
Pedology
Photogrammetry
Transfers in porous media

INRAE units involved

G-EAU Joint Research Unit - Water Management, Actors, Territories
LISAH Joint Research Unit - Soil-Agrosystem-Hydrosystem interaction lab
ABSYS Joint Research Unit – Biodiversified Agrosystems

External partnerships

Laboratoire CITERES Joint Research Unit - Tours University - Cities, Territories, Environment and Societies

Backgrounds and challenges

Agricultural intensification has degraded ecosystems, and it is now necessary to take greater account of the role of biodiversity in agrosystems and its importance for ecosystem services provision. For the past two decades, cultivators in vineyards have been improving their sustainable management practices, developing a vegetation cover inside inter-rows to limit soil erosion, and an extensive management of plot edges and networks of ditches. These practices support the development of a spontaneous vegetation cover, a source of numerous ecosystem services including for example runoff regulation, water erosion mitigation and organic pollutants retention.

This is a major challenge, particularly in Mediterranean vineyards, where climate change is likely to increase the frequency of intense rainfall.

© Faucher

Objectives

In order to limit the negative effects of agricultural intensification, it is necessary to rethink the interactions between ditches, inter-rows of perennial crops, headlands and agricultural plots. These elements host a spontaneous vegetation that provides numerous ecosystem services in terms of regulation and supply, and facilitates water circulation in the landscape. WATERSEED will analyse how water structures the distribution patterns of plant communities, the dispersal of seeds by water and the spatial structure of species according to soil moisture gradients.

Resources

This project will include

1. Characterisation of the plot and interstitial environment, using 3D reconstruction methods (photogrammetry) and a network of humidity sensors.
2. Measuring the composition of the seed bank in the environments mentioned earlier, thanks to spontaneous germination experiments.
3. Measuring seed flows between cultivated and interstitial environments using innovative monitoring methods.

The ecosystem services associated with plant biodiversity will be estimated using field samples: biomass, fraction of plant cover, chemical composition of the biomass and associated microbial communities, in relation to edaphic conditions. The species identified will be linked to ecosystem functions via databases (e.g. the TRY

database) to determine qualitative traits: nectariferous potential, competition with crops

IFOSSA

EXPLORATORY PROJECT

2022-2024

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Thematics involved

Agronomy,
Ecology of interaction networks
Microbial ecology
Invertebrate ecology
Tree ecophysiology
Soil functions
Microfauna
Macrofauna
Plant phenology

INRAE units involved

ECO&SOLS Joint Research Unit - Functional Ecology and Biogeochemistry of Soils and Agrosystems
DIASCOPE Experimental Unit – Experimental domain of Melgueil
DGIMI Joint Research Unit - Diversity, Genomes and Insects-Microorganisms Interactions
PHIM Joint Research Unit - Plant Health Institute of Montpellier

Distribution of interaction networks and functions in a spatially heterogeneous system, case of agroforestry

Backgrounds and challenges

Agroforestry, broadly defined as the presence of trees in agricultural landscapes, is an example of mixed farming that increases "planned biodiversity". Thanks to their perennial structures, these trees create a microclimate that varies over time, leading to changes in the associated biodiversity and the activity of organisms through habitat diversification. However, few studies have looked at the effects of agroforestry on soil organisms and the functions they perform. Trees in agricultural plots provide mosaics of specific habitats because of their perennial above- and below-ground structures. They have a strong impact on the heterogeneity of the plot microclimate, which varies from season to season depending on the phenology and morphology of the trees. As a result, they modify the associated biodiversity and the activity of other organisms. Finally, the presence of trees, and sometimes of associated herbaceous strips, leads to local concentrations of organic resources from the production of aerial and subterranean litter, and a local increase in soil organic carbon and nutrient levels. Soil structure and aggregate stability can be improved under tree lines, leading to spatial heterogeneity in soil microhabitat characteristics.

© INRAE - UMR Eco&Sols

Objectives

The general aim of this project is to highlight the response of networks of ecological interactions and functions to the spatial organisation of the environment following the establishment of trees and grass strips in arable crops. The main hypothesis of the project is that modifying the spatial organisation of plots by planting trees leads to an increase in the diversity and multifunctionality of agricultural plots. The operational objectives are (A) to characterise the changes in biodiversity within taxa and by trophic group, (B) to infer the interaction networks between the organisms studied, (C) to establish the relationships between the ecological interaction networks, the physicochemical functioning of the soils and plant growth in order to understand the multifunctionality of these plots.

Resources

This study will be carried out on the Instrumented Mediterranean Agroforestry System under water stress (DIAMs), South of Montpellier, France, on an INRAE experimental station (UE Diascope, Mauguio). This is a factorial experimental set-up covering 5 ha, divided into three blocks. In each block, 3 modalities were compared: forest plantation plots, an agroforestry system and field crop plots. Within the agroforestry system, we separated several habitats: (i) the line of trees and the grassy strip at their foot, and (ii) the cultivated alley. The crops are grown using conventional, low-input farming methods. The instrumented site is used to monitor radiation reaching the soil, soil temperature and humidity at different depths, root growth and nutrient levels in the soil solution.

The growth and yields of crops and the growth and resource allocation strategies of black locust trees will be monitored. Morphological or molecular identification will be used to characterise the communities of soil engineers, surface macro-arthropods, free-living and parasitic nematodes (phytophagous and entomopathogenic), fungi and bacteria (free-living in the soil and associated with parasitic nematodes) and weeds. Interaction networks will be reconstructed using field observations, either directly, such as bipartite interactions (e.g. symbiotic bacteria of entomopathogenic nematodes or pollinators on flowers), or inferred by combining taxon co-occurrence data with a knowledge graph of trophic interactions in soils (via databases).

The intensity of the response of the various taxonomic groups studied will be analysed by comparing the values obtained with those obtained in the agricultural control and the forest control. The response of the structure/composition of the reconstructed modules will be tested in relation to the spatial organisation of the agroforestry plots.

MICROBIOMIQ

EXPLORATORY PROJECT

2022-2024

Multiomic approach to characterize the link between the structural biodiversity and the microbial activity along the natural evolution of periphytic biofilm

Contacts

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Thematics involved

Algal composition analysis
Lipid analysis
Multi-omics statistical analyses
Physico-chemical measurements
Metabolomics
Metagenomics

INRAE units involved

EABX Research Unit – Aquatic Ecosystems and Global Change
BIOGECO Joint Research Unit - Biodiversity, genetic and communities

Backgrounds and challenges

Periphytic microbial communities are complex assemblages of micro-organisms (algea, bacteria, fundi, cyanobacteria, protozoa) that are attached to immerged substrates (inert or alive) in most of aquatic ecosystems. These communities play a tremendous role in ecosystems functions and associated services (e.g. primary production, biogeochemical cycles).

In the global change context, one major challenge for human and environmental health is to better understand the response of microbial communities to multiple stressors in terms of acclimation, adaptation and resilience in order to preserve ecosystem function and services. In particular, as regard chemical contamination of aquatic systems, one major goal is to characterize how the natural fluctuation of the structural biodiversity and microbial community functioning due to environmental changes might modulate their sensitivity to the chemical stress.

In this context, the omics methods and their combination pave the way to new perspectives in microbial eco(toxi)cology to tackle the knowledge gap. Among others, these omics encompass:

Metagenomic allowing to explore simultaneously the diversity of species within a microbial community and its functional potential (gene reservoir); Untargeted meta-metabolomic providing a comprehensive picture of the microbial activity in response to the environment by analyzing all the small molecules from biochemical reactions within the community.

© Motte

Objectives

MICROBIOMIQ aims to better understand the link between the microbial activity (i.e. metabolome), the structural biodiversity (diversity of species and genes) and the sensitivity to the chemical stress associated to natural fluctuation in the species composition and the functioning of periphytic communities due to changing environmental conditions along the year. Thus, through the combination of metagenomic and meta-metabolomic on periphyton, this project will focus on the modulation of the photosynthetic function that is strongly involved in primary production and overall biogeochemical cycles.
The outcomes of the project will allow to better understand the adaptive mechanisms (e.g. phenotypic plasticity) in the sensitivity of ecosystem functions (i.e. photosynthesis) to the chemical stress and their time sequence. The collected data would be further used to support the development of management tools in a water quality biomonitoring purpose.

Resources

MICROBIOMIQ will implement investigation on the field and in controlled conditions based on a multi-disciplinary approach coupling metagenomic, meta-metabolomic, photosynthetic yield assessment and physico-chemical characterization of the medium. The combination of these methods will allow an innovative and accurate way to characterize the relationship between the changing environmental conditions, the taxonomic diversity, the microbial activity and the photosynthetic function and their sensitivity to the chemical stress in natural and in controlled conditions through the implementation of bio-informatics tools.

PARMENIDE

EXPLORATORY PROJECT

2022-2024

Rural agricultural mosaic landscapes and novel indicators of ecoacoustic diversity

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Thematics involved

Agroecology
Biodiversity
Eco acoustic
Landscape ecology
Entomology
Geomatics
Ornithology

INRAE units involved

DYNAFOR Joint Research Unit - Agriforestry Landscape Dynamics and Ecology
BAGAP Joint Research Unit - Agroecology and Landscape Planning
ST LAURENT DE LA PRÉE Experimental Unit

External partnership

Laboratoire LADYSS CNRS
SETE Moulis CNRS Université de Toulouse
University of Stirling, United Kingdom, Scotland
ISPRA, Italy

Backgrounds and challenges

Temperate rural landscapes have undergone deep changes under the combined impacts of climate and land use changes. To better quantify the socio-ecological dynamics behind these changes, it is necessary to use integrative metrics that account for the complexity of the relationships between agricultural practices, landscape heterogeneity and biodiversity. The sound dimension of biodiversity has benefited from major conceptual and methodological advances with the emergence of landscape ecoacoustics and acoustic diversity indices making it possible to simultaneously quantify sounds from biological and anthropogenic origins. Here, we will test the hypothesis that the acoustic diversity of rural landscapes increases with the heterogeneity of composition and configuration of forest-farmland mosaics, while also being favoured by mixed crop-livestock systems tending towards extensification of management (organic farming and agro-ecological transition practices). In particular, we will analyze the effects of the amount and spatial distribution of permanent grasslands on the acoustic diversity of rural landscapes in a network of INRAE long-term study sites in France: ZA Pyrénées Garonne (Occitanie), Experimental Unit Saint Laurent de la Prée (Charente-Maritime) and ZA Armorique (Bretagne). All these sites also benefit from annual biodiversity monitoring, which will help to clarify the socio-ecological processes driving the acoustic diversity of rural landscapes.

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PASTOFUTUR

EXPLORATORY PROJECT

2022-2024

Analysing pastoral livestock farming through its multifunctionality and associated ecosystem services to strengthen public action

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Thematics involved
Ecology
Economics
Geomatics
Computer science
Pastoralism
Organizational sciences
Zootechnics

INRAE units involved
LESSEM Research Unit - Mountain Ecosystems and Societies Laboratory
MoÏSA Joint Research Unit - Montpellier Interdisciplinary center on Sustainable Agri-food systems
SELMET Joint Research Unit - Mediterranean and Tropical Livestock Systems

External partnership
Laboratoire Sens (Knowledge, Environment and Societies) CIRAD

Backgrounds and challenges

Pastoralism is subject of diverse societal expectations that combines the production of food and the control of ecological dynamics contributing to the sustainability of social-ecological systems in Mediterranean regions. However, pastoralism currently undergoes considerable pressure, raising the question of its future forms and relationships with other activities in the region, particularly in the context of territorial restructuring (shift towards a residential and tourist economy, forest expansion, climate change, etc.).

© Garcon

Objectives

The Pastofutur project aims to produce an interdisciplinary framework around the concepts of ecosystem services associated with pastoral areas and of multifunctionality of the pastoral activity. Through these conceptual lenses, the project will provide actionable knowledge around pastoral activities, with the objective to strengthen societal contributions in defining the future of this activity.
In the form of an action research project, it will study the ability to express synergies and trade-offs between the functions expected of livestock farming by linking them to the functioning of ecosystems and the services they produce. It will identify the ways in which the notion of ecosystem service is perceived and appropriated by stakeholders, and how it can constitute a boundary object facilitating the convergence of public actions.

Pastofutur aims to co-produce, with a diversity of stakeholders, a set of methods to support the redefinition of the role of pastoral activity in the future of the areas concerned. It will explore how knowledge on ecosystem services can be mobilised to support the adaptive capacity of the pastoral activity and its contribution to sustainable territorial development.

Resources

This project will be based firstly on an analysis of pastoral livestock farming activities from the point of view of their multifunctionality, i.e. considering its multiple contributions to the economic, social and environmental dynamics of rural areas. Secondly, the project will analyse the bundles of ecosystem services associated to agropastoral areas in terms of co-production processes and of synergies and trade-offs between their beneficiaries on a territorial scale.

To facilitate the expression of points of view on the various functions of livestock farming and on its contribution to the sustainable development of the region, the project will use the audiovisual mediation medium "Grazy!".

A conceptual model of multifunctionality and an associated simulation model will be adapted and parameterised on the basis of a characterisation of the ecosystem services associated with pastoral activity in the French situation.

A case study will be carried out on the territory of the Alpes-Provence-Verdon community of municipalities.

PRODIGE

EXPLORATORY PROJECT

2022-2024

Taking into account the needs of potential users and functional representations of landscape elements in the design of a biodiversity indicator for agricultural landscape

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Thematics involved

Agronomy
Landscape ecology
Political science
Human geography
Construction of indicators
Ergonomics

INRAE units involved

LAE Joint Research Unit Agronomy and Environment Laboratory
DYNAFOR Joint Research Unit - Agriforestry Landscape Dynamics and Ecology
SAD-APT Joint Research Unit - Science Action Development - Activities Products Territories

External partnership

IDEAS Initiative for Design in Agrifood Systems

Backgrounds and challenges

Numerous studies show the central role played by agricultural systems in the collapse of biodiversity. Assessing the performance of farming systems with respect to biodiversity conservation is an essential step in supporting their agro-ecological transition. However, predictive biodiversity indicators are scarce, particularly at landscape level. Yet the landscape is the most appropriate level of ecological organization for assessing the impact of agricultural systems on biodiversity.

© Weber

Objectives

In a first step, the needs of potential users of these biodiversity indicators will be analyzed. Then, PRODIGE will assess the extent to which taking account of landscape elements (crops, semi-natural habitats, etc.) in both quantitative (e.g. number of crops, percentage of semi-natural habitats) and qualitative terms, will enable us to design more accurate biodiversity indicators tailored to users' needs. The qualitative approach will be based on a functional approach integrating agricultural practices. This project will take up the major challenge of bridging the gap between levels of ecological organization and levels of social organization.

Resources

A characterization of the profiles of potential users, their approaches to biodiversity assessment in their activity and their needs and expectations with regard to such indicators will be carried out through diagnostics of usage situations. This will be carried out at both national and territorial level, using the usability analysis framework, which will be applied to the Vallées et Coteaux de Gascogne area, in the PYGAR Workshop Zone. The mobilization of ecological concepts and agronomic knowledge will make it possible to characterize the functional diversity of landscape elements and crops, and to measure their effect on biodiversity on the basis of a large pre-existing dataset. Finally, the integration of this knowledge into a predictive indicator of impacts on biodiversity will be tested.

SPABIO

EXPLORATORY PROJECT

2022-2024

Dynamic spatialized bioeconomy of biological invasions: proof of concept for the management of Ludwigia sp. in Brière

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Thematics involved

Biological invasions
Spatio-temporal heterogeneity
Modeling
Transferability
Uses and governance

INRAE units involved

DECOD Joint Research Unit - Dynamics and sustainability of ecosystems: from the source to the ocean
CEE-M Joint Research Unit – Center for Environmental Economics-Montpellier
PSAE Joint Research Unit – Paris-Saclay Applied Economics

External partnership

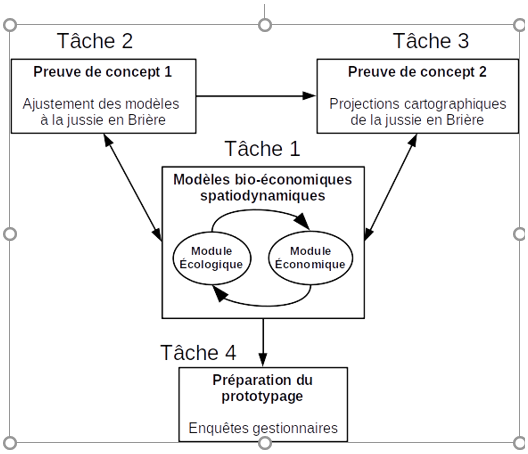
ECOBIO Joint Research Unit CNRS – Ecology, Biodiversity, Evolution
AMSE Joint Research Unit Aix-Marseille University – Aix Marseille School of Economics
Regional Natural Park Brière

Backgrounds and challenges

The management of invasive alien species (IAS) is a complex problem requiring interdisciplinary approaches that combine ecology and economics. Bio-economic decision-making tools are still underdeveloped. Existing models suffer from a lack of ecological realism, from a high level of complexity that makes them hardly usable for applied management problems, and from a relative disconnection from the needs of environmental managers. In other words, although these models have all the ingredients needed for becoming decision-making tools, they remain mainly restricted to the academic sphere and their results have little impact on management.

Resources

To fill this gap, SPABIO builds on a transdisciplinary collaboration between ecologists, economists and wildlife managers in order to (1) develop a new class of ecologically-realistic, bio-economic models that are directly applicable to IAS management on the field, (2) provide a proof of concept for these new tools using the case of water primrose in the Brière Regional Natural Park, and (3) prepare the application of the modelling framework to other IAS problems in various contexts. The experience gained in SPABIO will further strengthen our group for more successful application to larger calls.



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Ludwigia sp in Brière marsh.

TRAMETES 2

EXPLORATORY PROJECT

2022-2024

Contribution of the network of old-growth forest elements to the conservation of habitats and species

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Thematics involved

Forest biodiversity
Fungal communities
Eco-acoustics
Environmental metabarcoding
Statistics
Taxonomy of wild bees

INRAE units involved

LESSEM Research Unit - Mountain Ecosystems and Societies Laboratory
UEFM Experimental Unit - Entomology and Mediterranean Forest
USC ECODIV – Rouen University - Study and Understanding of BioDiversity Laboratory
PSH Research Unit - Plants and Cropping Systems in Horticulture

External partnership

Laboratoire EGCE IRD taxonomy of wild bees
Society Fold AI (Germany) Eco-acoustics

Backgrounds and challenges

Assessing the conservation state of forest habitats is mainly based on indirect methods. For species at stake, the contribution of forest structural elements to population remains poorly known, and, therefore, the link between natural habitat state of conservation and species is not evident.

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Objectives

The present project aim is both for knowledge and methodology:

- In terms of knowledge, we propose to test the links between to potential state of conservation indicators (black woodpecker cavities and forest structural maturity) and the diversity of species from habitat and species European directives (owls, woodpeckers, bats), and with other species not included in any directive but which have a high functional role (saproxylic fungi);
- In terms of methodology, we use different methods for assessing biodiversity: environmental DNA for fungi, ecoacoustics for birds and bats.

The Biosefair funding completes the one obtained from MNHN-OFB (TRAMETES 2021-2023) and allows a better representation of ecological gradients as well as deeper exploration of ecological links between species and ecosystem structure.

BIOFORDIV

EXPLORATORY PROJECT

2023-2025

Taxonomic, functional and phylogenetic diversity of forest biocenoses along a gradient of naturalness

Contacts

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Thematics involved

Entomology
Ornithology
Botany
Community ecology
Eco-acoustics
Molecular systematics
Forest management/biodiversity interactions

INRAE units involved

DYNAFOR Joint Research Unit - Agriforestry Landscape Dynamics and Ecology
RECOVER Joint Research Unit - Risks, ECO-systems, Vulnerability, Environment, Resilience
URFM Research Unit Ecology of Mediterranean Forests
URZF Forest Zoology Research Unit

External partnership

Conservatory of natural areas Occitanie
National Center for Forest Property (CRPF)

Backgrounds and challenges

The forest ecosystems of Occitanie (France) are located at a biogeographical crossroad between Atlantic and Mediterranean climatic influences, making them and their associated biodiversity particularly vulnerable to climate change and its functional consequences for biocenoses.

The conservation of biodiversity in natural ecosystems depends partly on the development of faster, less costly and non-lethal tools for monitoring and quantifying biodiversity. New monitoring tools can help to provide indicators of the resilience potential of forests to environmental change, which can be used to implement biodiversity-friendly forest management practices.

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Objectives

1. To describe and quantify the taxonomic, functional and phylogenetic diversity of birds, insects and vascular plants along a historical gradient of forest use in silver fir (Abies alba) stands in Occitanie,
2. To compare data from traditional (e.g. sampling and species identification by expert taxonomists) and innovative (e.g. metabarcoding, environmental DNA, ecoacoustics) inventory methods,
3. To investigate how biodiversity responds to the degree of naturalness of silver fir stands and to the history of their management.

BIOFORDIV will be based on the interdisciplinary OcciGen project (2021-2025), funded by the Occitanie Region and led by INRAE. OcciGen aims to develop genetic, ecophysiological and ecological indicators of resilience to climate change in old-growth forests with contrasting silvicultural management. The main expectation of OcciGen is to gain fundamental knowledge on the resilience of old-growth forests managed along management gradients, with many applications for rapid implementation by foresters and stakeholders.

Resources

BIOFORDIV will use an interdisciplinary, multi-taxonomic approach to measure biodiversity in silver fir stands in the mid-upper montane zone of the eastern and central French Pyrenees, France. These stands are located along a gradient of naturalness related to their historical management, i.e. old-growth forests with no trace of silvicultural exploitation (>100 years), formerly exploited (>50 years) and currently managed for timber exploitation.

Along with OcciGen, the contributions of BIOFORDIV will ultimately allow us to quantify the relationships between the evolutionary and response capacity of Silver fir stands to environmental stress and the associated taxonomic, functional and phylogenetic diversity of their biocenosis in contrasting forest management contexts.

iSERV

EXPLORATORY PROJECT

2023-2025

Contacts

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Thematics involved

Evolutionary and functional ecology
Population genetics
Metabolic theory of ecology
Economic evaluation
environmental chemistry
Fish management and ecology
Scalimetry

INRAE units involved

CARRTEL Joint Research Unit - Alpine Center for research on trophic networks and limnic ecosystems
DECOD Joint Research Unit - Dynamics and sustainability of ecosystems: from the source to the ocean
RECOVER Joint Research Unit - Risks, ECO-systems, Vulnerability, Environment, Resilience
BETA Joint Researche Unite - Theoretical and applied economics office

External partnership

SETE CNRS
Fishing federation Haute-Savoie
Approved Association for Fishing and the Protection of Aquatic Environments - Annecy

Relationship between intraspecific diversity and ecosystem services: role of fish stocking practices

Backgrounds and challenges

Intraspecific diversity is a major facet of biodiversity that is currently affected by human activities. Fish species are facing multiple pressures, such as climate changes, fishing and pollution. Fishes are supporting many ecosystem services for culture, hobbies and are subject to several management practices. Changes in their intraspecific diversity could therefore have impacts on aquatic ecosystems and associated services.

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Objectives

In large peri-alpine lakes, Arctic charr (Salvelinus alpinus) is an important species for recreational and commercial fishing, and for ecosystem functioning due to its trophic position (top predator). Therefore, Arctic charr displays important social and ecological values in these great lakes. Nevertheless, charrs numbers are declining and for several decades, supportive breeding programs have been used to support charr populations. For instance, Lake Annecy, supportive breeding management practices have evolved through time, and until recently fish from Lake Annecy and Lake Geneva were restocked. Although they have a common origin, charrs from these 2 lakes have undergone very different environmental constraints in the last century, for example Lake Geneva has undergone important eutrophication, which can cause individuals to diverge due to different trophic conditions. Genetic and phenotypic divergences are therefore expected and hybridizations between individuals of different origins can strongly modify the genetic and phenotypic structure of the population in Lake Annecy, modifying the services supported by this population. The main objective of this project will be to understand the role of captive breeding in Lake Annecy on intraspecific diversity (genetic and functional) and ecosystem services (biomass production and regulation of the nutrient cycle).

Resources

iServ is a three-parts project aiming to (1) link intraspecific diversity resulting from restocking to the nutrient cycle (regulating service) at individual and ecosystem scales with a mesocosm approach; (2) quantify in situ the effects of restocking on genetic diversity and fish biomass production (production service); (3) quantify local population (e.g., anglers) preference for Arctic charr conservation strategies.

To quantify functional differences between individuals of different origins (Annecy and Léman), we will measure several functional traits at the individual level such as metabolic rate, nutrient excretion rate, prey consumption and morphology. These different traits can indeed affect interactions in communities and can therefore be important factors to understand the links between intraspecific diversity and ecosystem services.

Then, the effects of functional differences on regulation and production services will be tested using a mesocosm approach. They will be inoculated with phytoplankton and benthic and pelagic invertebrates a few months before the introduction of fish from different origins (Annecy, Léman). For several months, surveys will be carried out to understand the effects on ecosystem services: (i) concentration of nitrogen, phosphorus and carbon (nutrient cycle); (ii) gas exchange (CO_2) with the atmosphere (carbon sequestration); (iii) invertebrate communities (food webs support).

From 2018 to 2020, larvae from Lake Geneva and Annecy have been marked (on the otoliths) before being restocked in the Lake Annecy. Through collaboration with anglers, the otoliths and scales were recovered from fish caught between 2021 and 2023. This will allow to investigate the effects of restocking on the genetic structure and biomass production of charr in Lake Annecy.

Finally, a socio-economic survey will be conducted to understand the preferences of the local population (e.g., anglers) for different conservation strategies influencing water quality, Arctic chare populations and genetic varieties, and to estimate the impacts on the contribution to economic well-being of recreational fishing.

METAGROFORESTRY

EXPLORATORY PROJECT

2023-2025

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Thematics involved

Theoretical ecology
Ecological modelling
Flow modelling
Mathematical modelling
Ecology of meta-ecosystems
Study of microfauna
Macrofauna and soil functions

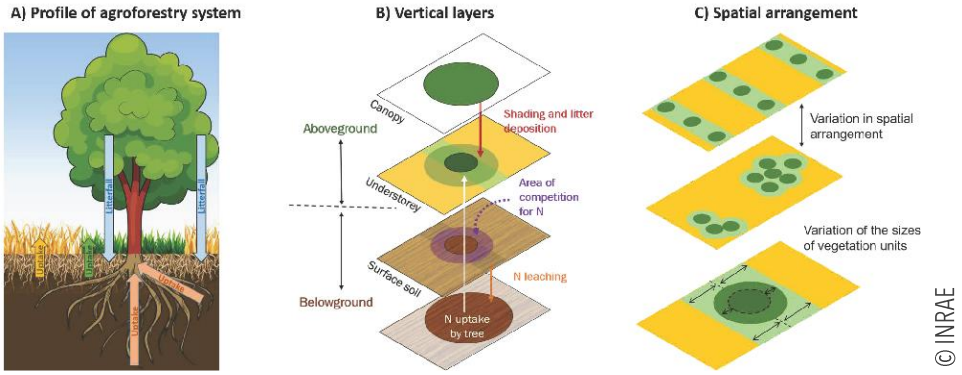
INRAE units involved

ECO&SOLS Joint Research Unit - Functional Ecology and Biogeochemistry of Soils and Agrosystems
MISTEA Joint Research Unit - Computer mathematics and statistics for the environment and agronomy
ABSYS Joint Research Unit – Biodiversified Agrosystems
IEES - Institute of ecology and environmental sciences of Paris - National Center for Scientific Research

Influence of the management and spatial arrangement of agroforestry systems on nitrogen recycling: a meta-ecosystem modeling approach

Backgrounds and challenges

Agroforestry systems (AFS) are complex, diverse and sustainable agricultural systems combining trees with crops and/or pastures to improve the provision of ecosystem services. They can increase agricultural production, reduce soil erosion, conserve biodiversity, improve carbon sequestration, mitigate greenhouse gas emissions, and improve soil fertility. The different types of SAF vary in their plant diversity and structure, in space or time and derive their benefits from ecological interactions between their different "subunits" (trees, annual crops, perennial crops, meadows, spontaneous vegetation...).



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Objectives

The spatial arrangement of SAF subunits, their plant composition and associated practices (ploughing, recycling of residues, etc...), determine the way in which they interact and affect ecological processes. Given the important role played by nitrogen in the productivity and sustainability of SAF, it is essential to be able to evaluate how the spatial arrangement of the subunits, their relative proportions, as well as the practices carried out there, can affect the recycling of this nutrient within SAF as well as the ecosystem services linked to it: plant production (fiber and food), and support (availability and conservation of nitrogen).
Since carrying out field experiments is costly in resources and requires long growth periods due to the perennial component of SAF, a meta-ecosystem model will be constructed. It will describe the flows and stocks of nitrogen within each of the subunits of a SAF as well as the flows connecting these subunits. It will take into account their spatial organization (arrangement, geometry and size), their plant composition and the agricultural practices carried out there. This model will enable the study of a particular SAF: the instrumented experimental alley-cropping site "DIAMS" (Mauguio, Hérault, Occitanie, France).

This multidisciplinary approach is innovative because it lies between ecological modeling and agronomic modeling. It allows us to focus on the roles of agricultural practices and spatial organization on the dynamics of nitrogen flows and stocks within the meta-ecosystem.

Resources

A synthesis of the literature will be realized to help define a typology of SAF in their greatest diversity in order to identify and characterize the subunits of the different types of SAF with a view to constructing a generic model: possible spatial configurations, plant compositions and their associated biodiversity, soil types and associated soil functions, agricultural practices.

This typology will allow the determination of compartments, flows, as well as their mathematical expressions in the model. Parameters related to the spatial arrangement of the SAF, such as the relative areas of the subunits, will make it possible to determine the overlapping surfaces between them.

New data acquired in situ on the DIAMs instrumented experimental site will complement those already available to configure the model. The biomasses and plant productions of the different subunits of the SAF, as well as the mineral and organic nitrogen contents of the soil will be measured at different depths. Nitrogen isotope tracing will make it possible to evaluate transfer fluxes between SAF subunits.

Cofunded thesis

ECOSYTEMIX

Mixing species to produce ecosystem services: co-design of an integration and knowledge sharing tool mobilizing the concepts of functional ecology

THESIS

2020-2023

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Additional Supervisors: Raphaël Paut (Agronomist, assessment/design of cropping systems, design of tools)

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Funding: Biosefair metaprogramme / Arvalis institut du végétal

Thematics involved

Agroecology
Agronomy
Functional ecology
Science of design

Backgrounds and challenges

Mixing species is an agroecological practice central to increasing the ecological functioning of agroecosystems (resilience to hazards, stability of performance, efficient use of resources, regulation of pests and diseases) in a context of global change (reduction of inputs, climate change). However, this practice comes with a complexity in the choice and management of crops and requires farmers to have knowledge and tools to help them implement it.

Current agriculture is mainly based on the use of fertilizers, plant protection products and monoculture in order to maintain high productivity. However, the use of synthetic fertilizers and plant protection products has a negative impact on the environment and has shown its limits in terms of sustainability of agro-ecosystems. One lever that can be mobilized is to promote ecosystem services through the mixing of cultivated species to promote biological regulation.

Objectives

However, little is known about how to mix species to promote these ecosystem services. Moreover, many combinations of species are possible to design crop mixtures.

Our aim is therefore to propose a generic method to design species mixtures based on a functional approach, which takes into account the functioning of mixtures in order to overcome the specificity of each species.

Resources

In order to understand these functioning, we will mobilize (i) scientific knowledge through the literature and experimentation and (ii) empirical knowledge gathered during design workshops with various stakeholders with expertise on the functioning of species mixtures. This approach will allow us to define the assemblage modes of the mixtures as well as the ecosystem services they can provide.

Expected results

The identification of important functions and traits will allow us to evaluate the level of service provided by a species mixture and to identify the species mixtures most likely to provide one or more services in a given agro-environmental context. This knowledge could make it possible to develop tools to help farmers and advisers in choosing species to make mixtures in agricultural plots.Disciplines impliquées.

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Experimental trial to compare sole and mixed crops. From left to right, you can see Flax (Linum usitatissimum) in pure crop, Pea (Pisum sativum) in pure crop and a Flax and Pea mixture crop.

PRAIRIES MC CC

THESIS

2021-2024

Functional response of grasslands in the Massif-Central to climate change: identifying the role of biodiversity in the short, medium and long term

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Funding: Biosefair metaprogramme / Clermont-Auvergne-Métropole

Thematics involved

Ecology
Agronomy

Objectives

Climate change is altering the way living beings function and pushing ecosystems towards their ecological limits, beyond which they will no longer be able to maintain their functioning and provide ecosystem services at current levels. Our current knowledge suggests that this will have dramatic consequences for life on Earth (erosion of biodiversity) and for human societies (living conditions). One of the challenges of this thesis is to analyse and evaluate how biodiversity, from both an ecological and functional perspective, can be a major lever for adapting livestock farming systems to climate change and supporting their transition. We will focus on managed agro-ecosystems that are rich in biodiversity, such as permanent grasslands. In particular, we will be seeking to better characterise and understand the spatio-temporal dynamics of plant communities in a context of climate change and their impact on ecosystem functioning and its capacity to deliver ecosystem services, in relation to a diversity of management practices.

The aim is to understand how the structure and functioning of grassland agro-ecosystems in upland areas (Massif-central, France) respond to climate change, and how this response depends on changes in practices and biodiversity over time and space.

First, we will analyse the relationships between the functional diversity of plants and the dynamics/stability of plant communities within grassland ecosystems. We propose to mobilise the most recent advances in ecology by studying the different forms of distribution of functional traits in plant communities subjected to contrasting management practices. To do this, we will use data from a long-term observation system (20 years) set up at an altitude of 900 m (ACBB-Anaee-F) on permanent grassland and manipulating the rates of disturbance (mowing, grazing) and fertilisation (N,P,K). By studying the shape of functional distributions, we will be able to highlight the dynamics of species assemblages in plant communities, which are not random but dependent on management practices.

Secondly, we will assess the consequences of farmers' management choices in response to climate change factors on grassland ecosystems within a contrasting geographical area. We will draw on a dataset acquired over 15 years (2008 - 2016 - 2022) on around sixty livestock farms spread across the Massif-central. Characterising changes in climate, biology, soil and management practices will be an important output of this study and will provide a better understanding of ecosystem responses to change and the resulting effects (in terms of vegetation dynamics and ecosystem services). To do this, we used the « space-for-time substitution hypothesis » at the scale of the Massif-Central area, which is topographically and pedologically contrasting. More specifically, the aim will be to compare the response of ecosystems over time and space and to gain a better understanding of the factors potentially involved in this equivalence. We hypothesise that by targeting global correlations between climatic, agronomic, pedological and biodiversity variables we will be able to approach predictions on the functioning of grassland ecosystems and in particular their carbon storage potential within the different pools of soil organic matter.

In addition to the cognitive contributions of this work, we also hope to be able to assess the possible effects of these multiple changes on the stability of grassland agroecosystems and their capacity to maintain ecosystem services at the level expected by farmers and/or society, by identifying and constructing potential scenarios combining climate change, management practices and community assembly.

SEINARIOS

THESIS

2021-2023

Prospects for biodiversity in the Seine drainage basin in the face of global change and connectivity constraints

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Funding: Biosefair metaprogramme / AESN (Seine-Normandie Water Management Agency)

Thematics involved

Aquatic ecology
Hydrology

Objectives

In the face of global change, one of the major challenges for contemporary societies will be the preservation of biodiversity. In this context, it is necessary to identify the most vulnerable areas, especially within drainage basins and their river networks, very sensitive to these pressures. In order to inform public policy and help prioritize decision-making, it has become essential to better understand the consequences of management decisions and climate change scenarios on future biodiversity, which necessitates the study of projections (i.e. simulations) based on species models.

To assess the resilience of biodiversity, especially fish communities, in the face of global change, past research has mainly focused on the role of climate change (e.g. temperature), or even land use (e.g. urbanization). However, a major challenge remains in the understanding of the role of connectivity (e.g. dams, low water levels) and of the landscape context (e.g. riparian vegetation, natural reserves) which will strongly condition movement, dispersion, and therefore the response of species to changes in their environment.

Thus, this PhD project aims at producing prospective forecasts of fish diversity in the near and further future based on scenarios of hydroclimatic change (e.g. flows), river network management (e.g. for navigation) and land use (e.g. agriculture) taking explicitly into account physical and ecological connectivity within watersheds.

This interdisciplinary work, combining predictive ecology and hydroclimatology, will allow policymakers to make educated management decisions while ensuring the consistency of relevant measures across the territory at the core of our study – the Seine Basin.

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SYNBIOTOX

Synchronisms and antagonisms in the relations between agricultural environment, biodiversity, and ecological functions in an agricultural constructed wetland

THESIS

2022-2025

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Thematics involved

Ecology
Ecotoxicology
Constructed wetlands
Pesticides
Amphibians
Aquatic invertebrates
Biomonitoring

Objectives

Some of the agricultural contaminants (pesticides, nitrogen) spread on cultivated soils reach the hydrosphere through agricultural drainage (1) with proven consequences on aquatic ecosystems and their functions. Constructed wetlands are designed to break down nitrates and certain pesticides through natural purification features. Nevertheless, they constitute potential reservoirs of contaminants likely to impact the wild species they shelter by acting as ecological traps. In this context, the Constructed Wetland of Rampillon (CWR, Seine-et-Marne) intercepts drainage and runoff water from an agricultural basin. The aquatic biocenosis that lives there is potentially exposed to the effects of agricultural pollution. A major challenge is, therefore, to determine whether the wetland is a shelter or, on the contrary, an ecological trap. To answer this question, the present study aims to evaluate the biological responses to exposure with contaminants through multi-taxa measurement and monitoring campaigns (amphibians, benthic macroinvertebrates) at different levels of organization (cell, individual, community), based on spatiotemporal comparisons. The selected comparison sites follow a gradient of contamination with agricultural pollutants. The following are evaluated: (i) biodiversity indices, (ii) a functional response of the benthic macroinvertebrate community via the study of the litter breakdown process, (iii) the ecotoxicological and functional effects of pesticides on an invertebrate (*Gammarus fossarum*) monitored in mesocosms, (iv) *in situ* effects of pesticides on the activity levels of several enzymes (in saliva) involved in neurotransmission (acetylcholinesterase) and enzymes involved in the processes of cellular detoxification or witnesses of cellular stress (peroxidase, glutathione-S-transferase, alkaline phosphatase, etc.) in the Common toad (*Bufo bufo*) and the Green frog (*Pelophylax sp.*). Our first results, from a census period from February to July 2023, indicate that the CWR is characterized by a high level of amphibian biodiversity compared to exposed and unexposed control sites. Litter breakdown is similar between the sites subjected to different pesticide pressures and the most contaminated site (upstream of the CWR) seems to be richer in pollution-resistant invertebrate taxa. This result could be linked to the harmful effects of pesticides on populations of sensitive species. The majority of the measured traits of *Gammarus fossarum* appear to respond to the cocktail of pesticides with a strong influence of environmental conditions. It was difficult to link toads enzymatic activities to the different levels of pesticide contamination, but a partially response was observed, highlighting an intermediate level of stress of toads in the CWR. This work provides a better understanding of the role of agricultural constructed wetlands for conservation of aquatic fauna in agricultural landscapes.

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An artificial wetland buffer zone

ISOÉTIDES

THESIS

2022-2025

Genetic and taxonomic diversity of isoetids communities of Aquitaine's coastal shallow lakes

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Funding: Biosefair metaprogramme / Région Nouvelle Aquitaine

Thematics involved

Population genetic and community Genetic
Community ecology

Objectives

Lakes and ponds of the Aquitaine Atlantic coast are unique natural ecosystems, not only at the national but also at the European scale. These systems host a high taxonomic diversity, especially for aquatic plants. Indeed, isoetid communities represent a set of species with high conservation value, also including one endemic species. These communities are however highly threatened, especially by anthropogenic activities, and most of the coastal Aquitaine's lakes have already experienced their extinction. Knowledge on these species is still however scarce, particularly concerning their genetic diversity. While conservation and restoration actions are emerging with the redaction of a National Plan for preserving these communities, understanding their genetic diversity, their relationships with taxonomic and functional diversity appear as a major issue. This doctoral project is based on 3 work packages. First, a comparative genetic diversity analysis of 9 species of the community will be initiated and should give information about the distinct effect of historical and environmental variables on species demography. Second, the relationship between genetic and taxonomic diversity will be investigated and should deliver crucial information on biological interactions and metacommunity functioning. Finally, results will be considered within a conservation perspective, examining genetic isolation of protected species to suggest adapted management for their conservation.

THESIS

2022-2025

Ecotoxicological effects and ecological consequences of microplastics on soil functioning

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Funding: Biosefair metaprogramme / ANR CE34 Contaminant, Environnement, Santé projet E-Dip « Environmental Dynamics and Impacts of contaminant cocktails originating from Plastics in soil ecosystems" 2022-2026

Thematics involved

Ecotoxicology
Microbial ecology
Plant ecophysiology
Functional ecology
Soil biogeochemistry

Backgrounds and challenges

The increasing use of various kinds of plastics leads to the accumulation and long-term storage of microplastics (MP) in soils. There is a growing scientific literature linking the presence of MP and the consequences for soil organisms that perform essential ecological functions. However, for the most part, these are ecotoxicological approaches through effects on certain organisms studied separately (microorganisms, micro-, macrofauna and plants), without addressing ecotoxicity issues. Moreover, in agricultural soils, the presence of MP may be due to inputs via amendments with organic matrices and their impact on the biological functioning of soils is then little documented.

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From the earthworm's point of view

Objectives

The objective of this thesis is to quantify the ecotoxicological effects and to understand the ecological consequences of MP on soil functioning, focusing on the relationships between processes in the soil, implemented by organisms belowground and aboveground. In particular, we will test the hypothesis that interactions between organisms in the soil exacerbate exposure to MP, while interactions in the presence of a plant mitigate MP exposure in each biological compartment. We will test the direct effects of MP on different model organisms and aim to assess the influence of trophic interactions on MP ecotoxicity via feedbacks from the different organisms studied. The general approach is based on experiments in controlled systems with an increasing complexity of exposure situations, and a modelling of the observed effects with regard to food webs. The expected results will provide new knowledge on the functional ecotoxicity of MP, with the aim of developing a conceptual model.

Integrated modelling of networks of activities, ecosystem services and biodiversity in the Camargue Island: which resilience in a context of global change and agro-ecological transition?

THESIS

2022-2025

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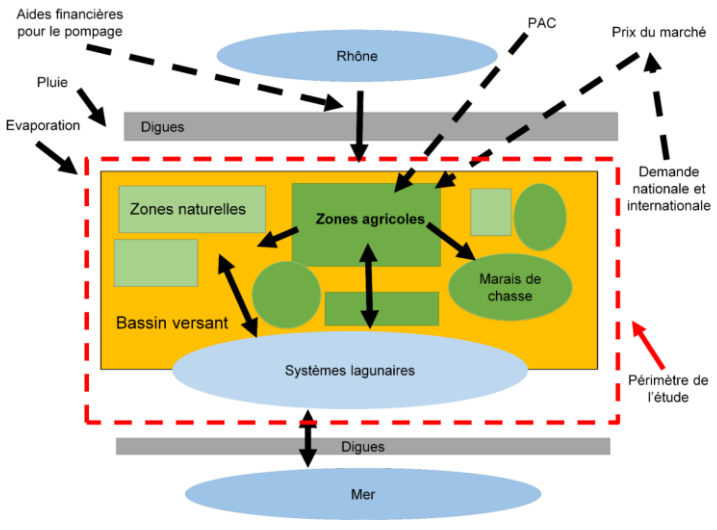
Funding: Biosefair metaprogramme / Tour du Valat - Research institute for the conservation of Mediterranean wetlands

Thematics involved

Modelisation
Hydrology
Agronomy
Ecology

Objectives

The Camargue (Rhône delta) is a complex social-ecosystem with important issues regarding biodiversity conservation and economic and cultural activities. In a context of global change, anthropogenic (water management in agricultural and natural areas, agricultural practices) and climatic (rainfall, evapotranspiration) drivers affect the hydro-saline balance. This hydro-saline functioning is a central element in the dynamics of the Camargue's habitats and species, and the associated networks of activities and services.
In order to develop an integrated representation of the functioning of the Camargue delta, this PhD aims to develop an integrated model simulating the dynamics and relationships between water management, agricultural activities, ecosystem services and emblematic biodiversity groups. This model will be used to perform an integrated assessment of scenarios of agricultural practices and in hydro-climatic drivers.
Studied goods and ecosystem services are: (1) agriculture, livestock and fishing productions; (2) flood regulation and water quality services, with a particular focus on the regulation of hydro-saline dynamics; and (3) cultural services, including habitats (rice fields) and species (e.g. flamingos) with a key symbolic significance for this area.
This model will therefore provide a better understanding of the response of deltaic social-ecosystems to various anthropogenic and climatic drivers. Ultimately, it is intended to be used as part of multi-stakeholder deliberative processes aimed at establishing a concerted allocation of water resources that enables the best possible compromises to be made between the various services expected in the context of agroecological transition and global change.



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DYNAGRASS

THESIS

2023-2026

Temporal dynamics of biodiversity and ecosystem services in French permanent grasslands in the context of global changes

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Funding: Biosefair metaprogramme / OFB

Thematics involved

Community ecology
Functional ecology
Landscape ecology
Remote sensing

Objectives

Permanent grasslands play an essential role in maintaining grass-fed livestock and providing key ecosystem services for the agro-ecological transition (pollination, pest control, soil fertility) and society (carbon storage, water purification, aesthetic value). In France, permanent grasslands are one of the most diversified ecosystems but also one of the most threatened at the national scale. Indeed, their surface has considerably decreased over the last decades, which hinders the functioning of agricultural landscapes as well as the conservation of a unique heritage biodiversity. Moreover, global changes are likely to influence the characteristics of the remaining grasslands. However, we lack knowledge on the temporal dynamics of biodiversity and ecosystem services of permanent grasslands at the French national scale, as well as on the underlying causes and consequences of these dynamics. Using a unique database compiled by the French National Botanical Conservatories, the thesis will characterize the temporal dynamics of taxonomic, phylogenetic and functional diversity of permanent grassland plants at different spatial scales (from plot to national territory) over the last decades. By combining these data with cartographic and statistical data, it will then assess the causes of these dynamics, particularly in terms of land use and climate changes. Finally, by mobilizing remote sensing data, it will assess their consequences from a functional point of view, particularly in terms of the resilience of grasslands to climatic hazards.

This thesis thus aims to address the major scientific challenge of understanding the temporal dynamics of biodiversity in response to multiple factors of global change and its consequences on the functioning of ecosystems. It also aims to provide actionable knowledge to improve the conservation of permanent grasslands and promote the agroecological transition of the livestock sector and its adaptation to climate change.

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Permanent grasslands in the Pyrenees National Park

SABEMAF

Structuring edaphic biological activity in relation to soil multifunctionality in agroforestry systems in Mediterranean and semi-arid tropical environments

THESIS

2023-2026

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Starting Date: autumn 2023
Research Unit: ECO&SOLS Joint Research Unit - Functional Ecology and Biogeochemistry of Soils and Agrosystems
INRAE Site: Occitanie Montpellier

PHD Director: Mickaël Hedde (ecologist)
Additional Supervisors: Christophe Jourdan (root ecophysiologist)

PhD Student: Emma Belaud
University and Doctoral School: GAIA Institut Agro Montpellier, ED 584

Funding: Biosefair metaprogramme / CIRAD programme TSARA

Thematics involved

Soil ecology
Ecophysiology
Quantitative ecology
Agroecology

Objectives

The project aims to understand the way in which the biological activity of agroforestry systems is structured, in time and space, in relation to the soil multifunctionality in Mediterranean and semi-arid tropical environments. The project will be divided into three lines of research. The first will focus on community structures and soil interaction networks according to different spatial and temporal heterogeneity gradients. The aim is to identify patterns of community assembly and interaction networks at different scales (i) spatial and (ii) temporal. (i) At the spatial level, the assembly of communities and soil interaction networks in two agroforestry sites (Mediterranean and tropical) under the plant communities that make up these sites (crops, trees, herbaceous strips) will be studied. (ii) The temporal dynamics of the identified assemblages will be compared according to daily and seasonal components. The second axis of the project will focus on the synchronicity between the phenology of the different soil organisms and the management of the agrosystem. The aim is to identify, at key phases of the crop cycle and agro-ecosystem management (interventions on the crop and between crops), the activity levels of the different soil organisms according to their functional group (chemical engineers, ecosystem engineers, biological regulators). The third phase of the project focused on the link between the levels of biological organization and the multifunctionality of agroforestry soils. The aim in this part is to identify structural parameters that correlate with indicators of soil functioning (infiltration, respiration, production, etc.). The study will be carried out on two agroforestry sites: one agroforestry site in a Mediterranean environment (located in Mauguio near Montpellier in France) and one tropical agroforestry site in a dry zone (located in Niakhar in Senegal). The monitoring of edaphic biological activity will be carried out by in-situ imaging, using buried scanners positioned in different areas and at different depths of the agroforestry sites.

REMIFO

What place do the actors of forest territories give to plants in their representations and collective practices? Investigation of the evolution of relations to forest in the Livradois-Forez Regional Natural Park

THESIS

2023-2026

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Date de démarrage : autumn 2023
Unité d'accueil : SILVA Joint Research Unit
Centre INRAE : Grand Est-Nancy

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Encadrement de la thèse : Marieke Blondet, AgroParisTech, UMR SILVA

Doctorant : Michaël Ricchetti
Université et école doctorale : Clermont Auvergne University (UCA), ED 370 – Letters and Human and Social Sciences

Financements : Biosefair metaprogramme / ADEME (The French Agency for Ecological Transition)

Disciplines impliquées
Anthropology
Ecology

Contexte

French forests suffer the combined effects of climatic, health and human disturbances, while at the same time being identified as one of the solutions to the ecological transition. As a result, controversy over the future of forests and associated ecosystem services intensifies. These debates could reflect, on the ground, more profound changes in the interactions between humans and these environments and be embodied in new modes of governance. Drawing on the theories of care, the ontological turn and ethnobotany, our research involves investigating the collective transformations underway in the Livradois-Forez Regional Nature Park.

Objectifs

Through a survey of collective transformations underway in the Livradois-Forez Regional Nature Park, our aim is to track changes in people's relationships with forests and, more broadly, with plants, in order to report on the transformations experienced by local actors, which could lead to the emergence of new modes of governance in forest areas. More specifically, the study will focus on:

1) Changes experienced by local players (including forest managers), i.e. the way in which individuals and groups experience the ecological and forestry crisis in their area. This involves questioning the players about the changes they are observing, the knowledge they are producing, and the practices they are adjusting and developing;
2) Changing relationships with forests: in a context where the management choices made in French forests are now being questioned by various members of civil society, our aim is to extend the debate on interactions between speciesandand to include interactions between humans and non-human living beings;
3) The link between different types of knowledge: we want to identify and connect scientific and local knowledge, in order to gain a better understanding of (1) how, and through what knowledge, stakeholders perceive changes in the forest, and (2) the extent to which they draw on and articulate this knowledge to develop individual and collective practices;
4) The potential emergence of new modes of governance in forest territories: How can the great uncertainties surrounding climate change prompt groups of stakeholders to commit and take action in order to protect ecosystems that are increasingly seen as 'new commons'? How the emergence of new stakeholders and new ways of thinking about forest ecosystems may have implications in terms of governance, by highlighting sometimes contradictory or conflicting interactions between various groups of stakeholders ?

Vieille forêt du Forez avec du gros bois mort sur pied et au sol

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