

ABSTRACTS BOOK



12th SERE CONFERENCE
7th – 10th SEP 2021
online



A NEW GREEN DEAL FOR EUROPE'S NATURE

Science and political action towards socio-ecological restoration

Dear colleagues.

The organizing committee and the University of Alicante welcome you to the 12th European Conference on Ecological Restoration SERE2021.

Between September 7 and 10 2021, we will discuss challenges facing ecological restoration in post-2020 Europe, and particularly, how can ecological restoration promote the recovery of damaged, degraded and destroyed socio-ecological systems in these critical times.

Ecological restoration is increasingly present in our lives. UN Declaration of 2021-2030 as the Decade of Ecological Restoration clearly responds to social concerns and illustrates commitment towards using ecological restoration to fight major environmental problems. Yet, international high-level initiatives should scale down and translate into concrete actions.

The advance of ecological restoration in Europe has been slow for reasons that are political and socio-economical, rather than ecological. Because of the onset of the UN Decade, and ongoing discussions on the EU Biodiversity Strategy for 2030, the Farm-to-Fork Strategy, and the Action Plan for Disaster Risk Reduction (2015-2030), 2021 should be the turning point to develop ambitious European legislative and funding frameworks for ecological restoration that will help Member States respond to current environmental crises.

In parallel, our societies are undergoing profound changes. The diversity of policies concerning nature and environmental protection in EU Member States clearly illustrates the search for new ways to understand growth and re-define human role in the Biosphere, and the tensions behind them. Europeans look astonished at the magnitude of the global challenge and must find ways to establish a healthier relation between culture and nature before it is too late.

In SERE, we know about this, and the way ecological restoration can sustain the new deal. For almost 30 years, our Society has helped to bridge the gap between humans and nature, and we know firsthand that ecological restoration can contribute to adapt and mitigate climate change, halt species extinction and combat desertification, while contributing to reduce poverty and inequality.

For some late-summer days, academics and practitioners from Europe and beyond will meet to discuss these topics and advance the theory and practice of socio-ecological restoration in Europe. This book summarizes the contributions of more than 300 experts from a wide range of geographic contexts and sectors. Abstracts refer to video-recorded presentations that will soon be freely available on the web, to promote knowledge exchange and upscale ecological restoration in Europe.

JORDI CORTINA-SEGARRA
Chair SER Europe
University of Alicante



Jordi Cortina-Segarra
Departament d'Ecologia
i IMEM. Universitat
d'Alacant
Spain



Berit Köhler
Norwegian Institute for
Nature Research (NINA)
Norway



Kris Decler
Research Institute for
Nature and Forest
Belgium



Anne Tolvanen
Natural Resources
Institute Finland, Oulu Unit
Finland



Aveliina Helm
Institute of Ecology and
Earth Sciences, University
of Tartu
Estonia



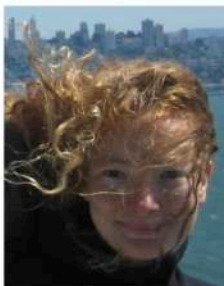
Johannes Kollmann
Technische Universität
München, Dept.
Ökologie und
Ökosystemmanagement
Lehrstuhl für
Renaturierungsökologie
Germany



Melinda Halassy
Institute of Ecology
and Botany, Centre for
Ecological Research
Hungary



Sabine Tischew
Hochschule Anhalt (FH),
Fachbereich 1
Germany



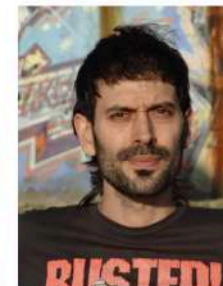
Elise Buisson
IUT de l'Université
d'Avignon / IMBE – UMR
CNRS IRD
France



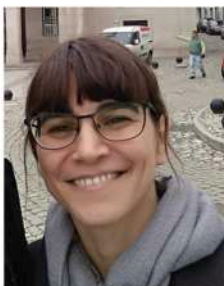
Klára Řehounková
Department of Botany,
Faculty of Science,
University of Ceske
Budejovice
Czechia



Agata Klimkowska
Eco-Recover, Ecosystem
Restoration Advice
The Netherlands



Josu Alday
Dep. of Vegetal Production
and Forestry Science,
Universitat de Lleida
Spain



Alice Nunes
Centre for Ecology,
Evolution and
Environmental Changes.
Faculdade de Ciências,
Universidade de Lisboa
Portugal



Jonathan Mitchley
School of Biological
Sciences, University of
Reading
United Kingdom



Thorunn Pétursdóttir
Soil Conservation Service
of Iceland (SCSI)
Island



Jordi Cortina Segarra
Department of Ecology, University of Alicante



Adrian Maturano Ruiz
Department of Ecology, University of Alicante



Alberto Vilagrosa Carmona
CEAM Foundation / Department of Ecology, University of Alicante



Alejandro Valdecantos Dema
CEAM Foundation / Department of Ecology, University of Alicante



Ana M. Sabater Blasco
CEAM Foundation / Department of Ecology, University of Alicante



Andreu Bonet Jornet
Department of Ecology, University of Alicante



Antonio Aledo Tur
Department of Sociology I, University of Alicante



Aymen Moghli
Department of Ecology, University of Alicante



Carlos Sanz Lázaro
Department of Ecology, University of Alicante



César Bordehore Fontanet
Department of Ecology, University of Alicante



David Fuentes Delgado
Ecodroneoks / Department of Ecology, University of Alicante



Dora Cabrera Avellà
CEAM Foundation



Elysa Silva Morales
Department of Ecology, University of Alicante



Emilio Climent Gil
Department of Sociology I, University of Alicante



Fernando T. Maestre Gil
Department of Ecology, University of Alicante



Guadalupe Ortiz
Department of Sociology I, University of Alicante



Paula Lopezosa
Department of Ecology, University of Alicante



Ramón Vallejo Calzada
CEAM Foundation



Hassane Moutahir
Department of Ecology, University of Alicante



Jaime Baeza Berna
Department of Ecology, University of Alicante



José Antonio Alloza Millán
CEAM Foundation



Luna Morcillo Julià
Department of Ecology, University of Alicante



Santiago Soliveres Codina
Department of Ecology, University of Alicante



Susana Bautista Aguilar
Department of Ecology, University of Alicante



Susana Silvestre Carbonell
Department of Ecology, University of Alicante



Victor M. Santana Pastor
CEAM Foundation / Department of Ecology, University of Alicante



Victoriano Peiró Clavell
Department of Ecology, University of Alicante



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*keynote
speakers*

PROGRAM

SEPTEMBER
7TH

SEPTEMBER
8TH

SEPTEMBER
9TH

SEPTEMBER
10TH

posters

Keynote Speakers



The EU Restoration Law: A New Hope

An Cliquet

Rethinking the role of people in efforts to protect and restore the environment

Lindsay C. Stringer

United Nations Decade on Ecosystem Restoration

Wilkie, Mette

Building Capacity for the UN Decade of Ecosystem Restoration. SER as Global Partner

Bethanie Walder

Understanding the ecology and biogeography of global drylands to promote their effective restoration

Fernando Maestre

Terraforming drylands with synthetic biology

Ricard Solé

Restoration of agricultural soils in Russia after the collective farming collapse: opportunities and benefits for environment

Irina Kurganova

Challenges in marine ecosystem restoration

Simonetta Fraschetti



The EU Restoration Law: A New Hope

Author(s): An Cliquet

Affiliation(s): Ghent University

The EU Biodiversity Strategy 2030, adopted in May 2020, aims to strengthen the EU legal framework for nature restoration, including the development of a new EU restoration law in 2021, with legally binding EU nature restoration targets. In this presentation we discuss the various elements that we consider to be important for the new law. The issues discussed include the following: do we really need yet another law; what is the existing legal framework on restoration; what can or should be the relationship between existing and new legislation; how can restoration be defined in the law; what can be the targets, the geographical scope, the ambition level; which baseline should be used; how will states prioritize restoration activities; what are the legal tools to achieve the restoration targets; should the law include performance standards on restoration; how will the efforts be monitored? As the law will be under development at the time of the conference, no definitive answers on many of these issues can be given. But this presentation aims at clarifying the legal issues and challenges, as well as pointing to the relevance and role for restoration scientists in the development and implementation of the law.



Rethinking the role of people in efforts to protect and restore the environment

Author(s): Lindsay C. Stringer

Affiliation(s): University of York

Policy and research into human-environment interactions tends to treat people as separate from, rather than part of nature, even when applying a socio-ecological systems lens. This conceptualisation has important implications in terms of how we do research, what we reveal through science-policy assessments such as those undertaken for the Intergovernmental science-policy Platform on Biodiversity and Ecosystem Services, and how we monitor and evaluate progress towards international sustainability aspirations such as the Sustainable Development Goals (SDGs). It also affects how we consider issues of fairness and equity. This presentation argues that current approaches can miss opportunities to improve human wellbeing and equity while simultaneously reducing and reversing degradation. It draws on recent work in Kenya involving restoration of areas affected by invasive cactus *Opuntia stricta*, which explicitly focused on understanding equity and viewed humans as part of rather than external to the system. Rethinking the role of people in efforts to protect and restore the environment is vital in informing science and political action towards socio-ecological restoration if outcomes are to support both environmental and socio-economic improvement.



United Nations Decade on Ecosystem Restoration

Author(s): Wilkie, Mette

Affiliation(s): Director, Forestry Division. FAO

It is estimated that one-third of the world's farmland is degraded; one third of commercial fish stocks are over-exploited and in the last 30 years we have lost 420 million hectares of forests – that's an area the size of India and Nigeria combined. The United Nations Decade on Ecosystem Restoration 2021-2030 aims to address these and similar issues with a global call to prevent, halt and reverse the degradation of ecosystems worldwide. The strategy prepared for the implementation of the Decade envisions a world where — for the health & wellbeing of all life on Earth and that of future generations —the relationship between humans and nature has been restored, where the area of healthy ecosystems is increasing and where ecosystem loss, fragmentation and degradation has been ended. Three interlinked pathways will help achieve this goal: the generation of a global movement; political will; and technical capacity. This presentation provides an update on the plans for the UN Decade and suggestions for how you can become part of #GenerationRestoration.



Building Capacity for the UN Decade of Ecosystem Restoration. SER as Global Partner

Author(s): Bethanie Walder

Affiliation(s): SER Executive Director - Society for Ecological Restoration

Since the announcement of the UN Decade, SER has been engaging with UNEP, FAO and other international organizations under the Global Forum on Ecological Restoration to promote the vision and goals of the Decade. As one of the original global partners, SER has supported the development of the strategy, participated in several Task Forces, and partnered to create the recently released guiding principles for the Decade. SER is also working to ensure that ecological restoration is recognized as a key tool for implementing the Decade, with an especially vital role in addressing the dual challenges of climate change and biodiversity loss. The presentation will introduce SER, its partnership with the Decade, the new UN Decade guiding principles, the importance of ecological restoration in the context of the Decade, and other associated activities that SER is undertaking to support the Decade. It will tackle topics as the ecological restoration continuum, the systems to certify professionals (CERP) and projects (SER standards), discuss the excellent results of the Make a Difference Week 2021 and the plan to hold it annually, and finally invite attendees to SER by means of the Membership for All program.



Understanding the ecology and biogeography of global drylands to promote their effective restoration



Author(s): Fernando Maestre

Affiliation(s): University of Alicante

Substantial research efforts are being devoted in the last decades to understand the ecology of major biomes and ecosystem types across large spatial scales and to use this knowledge to improve restoration actions. However, large-scale field studies have largely been carried out in ecosystems other than drylands, which cover ~45% and host over 40% of the global population. In this lecture I will illustrate with examples from our research how advances on our understanding of the ecology and biogeography of drylands at the global scale can inform restoration efforts carried out in these ecosystems, something key to halt land degradation in these areas, mitigate climate change impacts and guarantee the supply of essential ecosystem services to more than 2 billion people in a rapidly changing world.



Terraforming drylands with synthetic biology



Author(s): Ricard Solé

Affiliation(s): Universitat Pompeu Fabra

Semiarid ecosystems are threatened by global warming due to longer dehydration times and increasing soil degradation. Mounting evidence indicates that, given the current trends, drylands are likely to expand while crossing several aridity thresholds, including catastrophic shifts from vegetated to desert states. Here, I present a recent suggestion based on the concept of ecosystem terraformation, where a synthetic organism is used to counterbalance some of the nonlinear effects causing the presence of such tipping points. Using models incorporating facilitation and considering a simplification, we investigate how engineered microorganisms can shape the fate of these ecosystems. We show that small modifications enhancing cooperative loops can effectively protect drylands from experiencing critical transitions. Additionally, we will discuss the concept of "ecological firewalls" as a community-level containment phenomenon that can act as an effective limit to the spread of the synthetic microbial strain and about future prospects for experimental implementations of this bioengineering approach.



Restoration of agricultural soils in Russia after the collective farming collapse: opportunities and benefits for environment



Author(s): Irina Kurganova

Affiliation(s): Russian Academy of Sciences

Abandonment of croplands is happening on 220 million ha worldwide and ca. 1/4 of this area is located in Russia. The most massive cropland abandonment in Russian Federation was caused by the collapse of the farming system in the early 1990s. The cessation of cropland cultivation leads to the natural vegetation recovery and contributes strongly to soil restoration by improvement of degraded properties and medium- and long-term carbon (C) sequestration in post-agricultural ecosystems. Succession of natural vegetation and processes of soil recovery after cropland abandonment specific for the local climate. We investigated how the abandonment of arable soils in various bio-climatic regions of Russia affects (i) accumulation of SOC, its composition, stability, and turnover, (ii) soil structure, (iii) microbial and enzymatic activity during the postagricultural restoration of soils.

We concluded that the soil type as well as intrinsic pedogenic processes and time since abandonment determine the C sequestration dynamics and the SOC properties. The pattern of SOC sequestration and its stability during post-agricultural restoration are governed by initial SOC stocks in former arable soils, the biochemical composition of above-/belowground inputs, the chemical properties of soils, and the environmental conditions, mainly by aridity. The succession of natural vegetation on the abandoned agricultural lands was accompanied by a clear trend of increasing activity and diversity of microbial functioning and by the specialization of enzymes for the broader chemical composition of C input into the soil as leaf litter. Therefore, the cropland abandonment provides undeniable environmental benefits which include improvement of soil health, increase in plant biodiversity, and climate change mitigation owing to the intensive process of C sequestration in former agricultural lands.



Challenges in marine ecosystem restoration



Author(s): Simonetta Fraschetti

Affiliation(s): University of Naples and Anton Dohrn Zoological Station of Naples

Global change and direct anthropogenic impacts increasingly affect most marine habitats at planetary scale. In most cases, conservation and management are largely insufficient to maintain the health of marine habitats. Despite marine restoration is a relatively young scientific discipline, restoration interventions are increasingly considered key actions when changes of degraded ecosystems are beyond the potential of natural recovery. As a consequence, despite the evaluation of restoration results is still a complex task, success stories are becoming increasingly evident across marine habitats and geographical areas. In my talk, I will synthesize recent knowledge in marine habitat restoration showing the main outcomes from coordinated experiments to individuate determinants of restoration success, under the umbrella of international projects. Then, I will describe the challenges to support restoration upscaling, stressing the need for multidisciplinary, systemic approaches including the full involvement of industry and human society. I will also discuss the need for setting realistic restoration targets to empower the potential of marine ecosystems to recover their structures and functions, including the consideration of the services they provide that should be fully considered in the evaluations of a restoration intervention. Finally, I will discuss the importance of developing guidelines for integrating conservation planning and prioritization of sites for restoration within a Maritime Spatial Planning perspective to improve the resilience of conservation/restoration plans to cumulative human impacts and climate change.

PROGRAM



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September 7th, 2021

September 7th, 2021 – Main Room

Opening Ceremony

- 9:00 Salutation. **Jordi Cortina-Segarra**, Chair of SER Europe.
- 9:05 Welcome address. **Mireia Mollà**, Consellera d'Agricultura, Desenvolupament Rural, Emergència Climàtica i Transició Ecològica de la Generalitat Valenciana (Secretary of Agriculture, Rural Development, Climate Emergency and Ecological Transition of the Regional Government of Valencia).
- 9:15 Welcome address. **Hugo Morán Fernández**, Secretario de Estado de Medio Ambiente del Ministerio para la Transición Ecológica y el Reto Demográfico del Gobierno de España (Secretary of State for the Environment, Ministry for the Ecological Transition and the Demographic Challenge, Government of Spain).
- 9:25 Welcome address. **Joanna Drake** (Deputy Director-General in charge of Coordination of Resource-efficiency policies and instruments in D.G. Environment, Oceans and Fisheries).
- 9:35 Official inauguration. **Jordi Cortina-Segarra**, Chair of SER Europe.

9:40-10:20 Plenary Session. The EU Restoration Law: A New Hope. An Cliquet

Professor in International and European Environmental Law. Ghent University (Flanders).

Session Chair(s): Jordi Cortina

Technical Assistant: Elysa Silva

10:30-12:30. S1. Hot topics in ecological restoration I

Session Chair(s): Kris Decler

Technical Assistant: Elysa Silva

EU restoration strategy. Jacub Wejchert

SER standards and principles for ecological restoration: the reference for successful and cost-effective restoration in the EU. Kris Decler

Standards for the certification of forest ecosystems restoration projects: pilot application. Diana Colomina

A rewilding theory of change. Sally Ann Hawkins

Passive restoration in the context of macro-ecological parameters at the global scale. Karel Prach

Gender bias in Ecosystem Restoration: from Science to Practice. Verónica Cruz-Alonso

12:30 - 13:20. Break

13:20- 14:00 Plenary session. Rethinking the role of people in efforts to protect and restore the environment. Lindsay Stringer

University of York

Session Chair(s): Susana Bautista

Technical Assistant: Elysa Silva

14:40 - 16:10 W5. Natural capital restoration: enriched toolkit for decision makers.

Session Chair(s): Sandra Magro Ruiz

Technical Assistant: Elysa Silva

Natural capital valuation to improve restoration actions in the private sector.

Sandra Magro Ruiz

Valentín Alfaya

Elena Blanco

Jorge Pina

16:20 - 18:20 W1. YOUNG#ER - Education and Training of YOUNG PROFESSIONALS TOWARDS socio-ecological restoration.

Session Chair(s): Patricia María Rodríguez-González, Agustín Merino, Melinda Halassy, Jordi Pietx, Mark Nason, Jordi Cortina

Technical Assistant: Elysa Silva

Introduction. Agustín Merino, Melinda Halassy, Jordi Pietx, Mark Nason, Jordi Cortina, Elysa Silva

Empowering #GenerationRestoration Professionals – Knowledge Transfer for Employability. Mark Nason

Empowering future generations for climate action through the Life Terra project (LIFE19 CCM/NL/001200, lifeterra.eu). Aroa Gregori Montaner

When necessity meets opportunity: using Service-Learning projects to train new generations in Ecological Restoration. Pablo Souza-Alonso

Students on the road for a better environment. Patricia María Rodríguez-González

September 7th, 2021 – **Room 2**

10:30 -12:30. S5. EU LIFE programme and socio-ecological restoration - chances, challenges and prospects

Session chair(s): Jan Sliva, Ana Nava Tazo

Technical Assistant: Victor M. Santana

Bringing nature back through LIFE: Actions, science and policy implications for social-ecological restoration. Ben Delbaere

LIFE: Ecological restoration and mitigating biodiversity loss. Bent Jepsen

LIFE: Ecological Restoration of European freshwater habitats. Lynne Barratt

LIFE: Ecological restoration and climate change mitigation. Hannah Wilson

LIFE: Ecological restoration and sustainable land use. Jan Sliva

Q&A session: Live discussion with the audience. Session chairs, presenters and experts from the NEEMO Coordination Team, Brussels

12:30 - 13:20. Break

14:10 - 15:30 S6.1 IX International Meeting FuegoRED2020: Post-fire restoration in a changing world: vulnerability and resilience of forest ecosystems to fire

Session chair(s): Daniel Moya, Jorge de las Heras, Manuel Esteban Lucas-Borja, Victor M. Santana

Technical Assistant: Victor M. Santana

Adaptive management of highly flammable Mediterranean ecosystems by combining fuel reduction and post-fire restoration. Victor M. Santana

Effects of post-fire mulching on moss biocrust functionality after a wildfire. Minerva García-Carmona

FacingFIRE: a Service-Learning approach to improve the training on restoration in wildfire affected lands, the experience in Spain. Agustin Merino

Impact of post-fire regeneration activities on soil organic matter quality. Nicasio T. Jiménez-Morillo

15:40 - 17:00 S6.2 IX International Meeting FuegoRED2020: Post-fire restoration in a changing world: vulnerability and resilience of forest ecosystems to fire

Session chair(s): Daniel Moya, Jorge de las Heras, Manuel Esteban Lucas-Borja, Victor M. Santana

Technical Assistant: Victor M. Santana

Prescribed burning in British peat moorlands as tool to maximize carbon sequestration while minimizing emissions. Josu Alday

Burn severity: dealing with this fire regime parameter in the framework of post-fire restoration. Leonor Calvo

Reducing future fire risk through preventive restoration of fire-prone lands: results from Proyecto Mosaico. Fernando Pulido

Can we recover ecosystem services with ecological restoration? An experience with Mediterranean fire prone communities. Adrián Maturano Ruiz

Is the process of post fire emergency stabilization in Portugal heading in the right direction?. Luís Filipe Lopes

September 7th, 2021 – **Room 3**

10:30 - 12:30 S3. Restoring Mediterranean wetlands from Science to Management.

Session Chair(s): Brigitte Poulin, François Mesleard, Lisa Ernoul

Technical Assistant: Ana Sabater

Reference ecosystems: How can we quantify the success of wetland restoration?. Hugo Fontes

Management and restoration actions in a context of global changes: assessing the water needs of a wetland for today and tomorrow. Gaëtan Lefebvre

Vulnerable species as a lever to orient and monitor wetland restoration actions. Philippe Lambret

Manipulating priority effects to control invasive plant species in a restoration context. Manon Hess

Restoration of the former salt works of Camargue: Results from 10 years of a coastal wetland renaturalisation process. Brigitte Poulin

12:30 - 13:20 Break

14:10 - 15:40 S2.1 Restoring European grasslands.

Session Chair(s): Sabine Tischew, Kati Török, Melinda Halassy

Technical Assistant: Ana Sabater

One step from science to policy: amending restoration seed transfer regulation. Katalin Török

The effectiveness of grassland restoration A systematic literature review. Alvaro Roel Bellot

Establishment of *Rhynanthus* in a fertile grassland: the importance of seed quality and reduction of competition. Solvita Rusina

Phosphorus puts a mortgage on grassland restoration. Stephanie Schelfhout

Restoration of sand grasslands to replace invasive black locust plantation: effects of long-term mowing. Bruna Paolinelli Reis

15:50 - 17:20 S2.2 Restoring European grasslands

Session Chair(s): Sabine Tischew, Kati Török, Melinda Halassy

Technical Assistant: Ana Sabater

Relaxing management intensity in mountain grasslands restores plant species richness but not community structure in the mid term: lessons from a controlled experiment. Ségolène Humann-Guilleminot

Restoration of grasslands for butterflies and other pollinators. Sue Collins

Restoration of orchid-rich dry calcareous grasslands by rotational goat pasturing. Martina Köhler

Seed trait variability and seed transfer zones: lack of correspondence in sand grassland species. David Cevallos

Relative effectiveness of seeding methods for restoring or re-creating species rich grasslands: a systematic review. Daniel Slodowicz

Suppressing an invasive native species in wet grasslands – effects of designed mixtures and management. Leonardo H. Teixeira

September 7th, 2021 – Networking Area

14:30 – 16:00 AEET ecological restoration working group meeting

Session Chair(s): Josu Alday, Carolina Martinez

Technical Assistant: Jordi Cortina

18:30 – 19:30 Virtual YOUNG#ER café

Session Chair(s): Victor Méndez Vales, Robin Spencer Payne, Maria Nolan, Bruna Reis

Technical Assistant: Paula Lopezosa

Note : The time zone is CEST.

September 8th, 2021

September 8th, 2021 – Main Room

9:00 - 9:40 Plenary session. United Nations Decade on Ecosystem Restoration. Mette Wilkie

Director, Forestry Division. FAO

Session Chair(s): Elise Buisson

Technical Assistant: Victor Santana

9:50 - 11:10 S8.1 Near-natural restoration of urban green infrastructure.

Session Chair(s): Lena Neuenkamp, Leonie Fischer

Technical Assistant: Victor Santana

Connectivity of urban green and blue infrastructures: living veins for microbial diversity?.

Lena Neuenkamp

Designing an effective urban green infrastructure for the city of Bilbao (Basque Country, Northern Spain). Leire Mendez-Fernandez

Supporting regional biodiversity by native species introduction on extensive green roofs in Northwestern Germany. Franziska Päscher

Biotic resistance of plant communities and alien propagule pressure predict invasion during urban grassland restoration. Johannes Kollmann

11:10 - 12:30 S8.2 Near-natural restoration of urban green infrastructure.

Session Chair(s): Lena Neuenkamp, Leonie Fischer

Technical Assistant: Victor Santana

People's preferences for the invasive tree *Ailanthus altissima* and its management in cities.

Leonie K Fischer

The Urban Ecology Imperative: Bringing it All Back Home. Richard Scott

Alien species in vegetation succession: participation, temporal trends and determining factors in various central-European series. Miguel Ballesteros

12:30 - 13:20. Break

13:20- 14:00 Plenary session. Bethanie Walder

Session Chair(s): Klara Rehounková

Technical Assistant: Victor Santana

14:10 - 16:10 S22. Increasing the ecological value of forests.

Session Chair(s): Alberto Vilagrosa, Victor Santana

Technical Assistant: Victor Santana

PRIMED Restoration, management and valorisation of PRIority habitats of MEDiterranean coastal areas. Roberto Valenti

Maternal effect of decay on alder regeneration in its Southern limit: prospects for passive restoration. Cristina Vieites Blanco

Introducing Acacia mangium in the forest plantations of the Congolese coastal plains: A new ecological screen?. Lydie-Stella KOUTIKA

Innovative production of a wide variety of forest seedlings enhancing regeneration and biodiversity (VERENIKE). Kalliopi Radoglou

Effects of the nitrogen form on plant quality of quercines and on Tuber spp. Mycorrhization. Mercedes Uscola

16:20 - 18:20 SER Europe General Membership Meeting

Technical Assistant: Jordi Pietx

September 8th, 2021 – **Room 2**

9:50 - 11:10 S12.1 The Global Dryland Ecosystem Program and beyond.

Session Chair(s): Hongwei Zeng, Bojie Fu, Bingfang Wu

Technical Assistant: Aymen Moghli

Global Dryland Ecosystem Programme (Global-DEP): Background, Conceptual Framework, and Research Highlights. Bojie Fu

A Brief Introduction to the Global Dryland Ecosystem Programme (Global-DEP). Chao Fu

Soil erosion assessment driven by a novel RUSLE-GEE framework. Abdelrazek Elnashar

An approach to separate natural and anthropogenic evapotranspiration. Hongwei Zeng

Alternative biome states of African terrestrial vegetation and the potential drivers: a continental-scale study. Nan Lu

11:10 - 12:30 S12.2 The Global Dryland Ecosystem Program and beyond.

Session Chair(s): Hongwei Zeng, Bojie Fu, Bingfang Wu

Technical Assistant: Aymen Moghli

Ecosystem services change and driving forces in dryland region of the Chinese Loess. Plateau. Yihe Lyu

Comparative study of plant dynamics in prickly pear plantations in the region of Sidi Ifni and the region of Marrakech-Safi (Morocco). Fatima Zahra Yous

Ecological assessment of green dam plantations in Algeria. Sarmoum Mohamed

Habitat restoration for the conservation of a threatened steppe bird, the Dupont lark (*Chersophilus duponti*). Ana Santos

12:30 - 13:20. Break

14:10 - 16:10 S13. Ecological restoration to reverse desertification.

Session Chair(s): Santiago Soliveres Codina

Technical Assistant: Aymen Moghli

Non-linear changes in drylands' restorability in response to aridity. Santiago Soliveres Codina

More is not necessarily better: The role of cover and spatial organization of resource sinks in the restoration of patchy drylands. Paul Berghuis

Morphoecological characteristics of forage grasses of potential use in the restoration of degraded African drylands. Kevin Mganga

Restoration and Rehabilitation of Steppic Ecosystems: An Overview of the Algerian Experience. AMGHAR Fateh

September 8th, 2021 –Room 3

9:50 - 11:10 S20.1 Restoring wetlands

Session Chair(s): Sébastien Gallet

Technical Assistant: José Antonio Alloza

Global Dryland Ecosystem Programme (Global-DEP): Background, Conceptual Framework, and Research Highlights. Bojie Fu

Action plan for the naturalisation of wastewater treatment plants in the Balearic Islands. Carlota Viada

Biodiversity restoration of formerly mined raised bogs – vegetation succession and recovery of other trophic groups. Kamila Vítovcová

The restoration of small diked salt marshes, challenges and potentialities. A transversal approach. (The PEPPS program). Sébastien Gallet

Marshland restoration nearby Doñana National Park. Beltrán Ceballos

NDVI explaining the growing season CO₂ fluxes in alkaline fen. Raimo Pajula

11:10 - 12:30 S20.2 Restoring wetlands

Session Chair(s): Sébastien Gallet

Technical Assistant: José Antonio Alloza

Restoration of a coastal wetland in Mallorca, an example of participatory process and citizen science. Pere Tomàs

Restoration of small salt marshes: when social representations of nature and those of the lived space clash and decline. Gourlay Florence

Comparative values of plants and arthropods as indicators of salt-marsh restoration (PEPPS program). Manuel Salgueiro Simon

LIFE Peat Restore Reduction of CO₂ emissions by restoring degraded peatlands in Northern European Lowland. Letícia Jurema

Long-term response of vegetation on the water level drop-down on a large calcareous fen (NW Estonia). Laimdota Truus

12:30 - 13:20. Break

14:10 – 15:25 S14. Social science aspects of river restoration.

Session Chair(s): Berit Kohler, Matthias Buchecker

Technical Assistant: José Antonio Alloza

Challenges in the planning, implementation and success evaluation of river restorations from a social perspective. Berit Kohler

Evaluating river restoration measures through cultural ecosystem services. Daniel Hayes

Integrated river basin management – a promising approach to implementing river restoration projects?. Matthias Buchecker

Integrating instrumental and deliberative participatory mapping methods to co-design nature based solution in river landscapes. Sarah Gottwald

September 8th, 2021 – **Networking area**

14:00 – 16:00 Ecological restoration networking in Eastern Europe and Russia

Session Chair(s): Ekaterina Trosman

Technical Assistant: Jordi Cortina

Speakers: Elena Shelyagina, Vasiliy Yablokov, Jordi Cortina, Jordi Pietx

Note : The time zone is CEST.

September 9th, 2021

September 9th, 2021 – Main Room

9:00 - 9:40 Plenary session. Understanding the ecology and biogeography of global drylands to promote their effective restoration.

Fernando Tomás Maestre Gil

Distinguished researcher and full professor in dryland ecology. University of Alicante.

Session chair: Santiago Soliveres

Technical Assistant: Aymen Moghli

9:50 - 11:10 S19.1 Understanding the impacts of global environmental change and desertification in global drylands through international collaboration.

Session chair(s): Fernando Tomás Maestre Gil, Yanfen Wang

Technical Assistant: Aymen Moghli

Understanding global change and desertification impacts through international collaboration: The BIODESERT project. Fernando Tomás Maestre Gil

The Regional Impact of Ecological Restoration in the Arid Steppe on Dust Reduction over the Metropolitan Area in Northeastern China. Xiaoming Feng

Sustainable development in global drylands. Yali Liu

Interaction and synergism management of Water and Ecosystem in Aral Sea basin. Chen Xi

Framework of remote sensing-based grassland degradation monitoring on Qinghai-Tibet Plateau. Yanfen Wang

11:10 - 12:30 S19.2 Understanding the impacts of global environmental change and desertification in global drylands through international collaboration.

Session chair(s): Fernando Tomás Maestre Gil, Yanfen Wang

Technical Assistant: Aymen Moghli

Essential dryland ecosystem variables. Bingfang Wu

Dryland forests and future restoration potential driven by climatic legacies. Emilio Guirado

Desertification in Spain: an accurate diagnosis without effective solutions. Jaime MartínezValderrama

Croppedland dynamic change and spatial variations from 2010-2020 in Mediterranean Regions. Hongwei Zeng

12:30 - 13:20. Break

13:20- 14:00 Plenary session. Terraforming drylands with synthetic biology

Ricard Solé.

ICREA Professor and specialist in complex systems and ecological theory. Universitat Pompeu Fabra

Session chair(s): Fernando Tomás Maestre Gil

Technical Assistant: Aymen Moghli

14:10 - 16:10 S11. Restoring continuity and barriers removal in rivers: complexity of managing Ecological Restoration projects.

Session chair(s): Simon Dufour, Ivan Bernez, Patricia María Rodríguez – González

Technical Assistant: Aymen Moghli

An innovative technology to decrease the environmental impact caused by polluting effluents from abandoned mines in rivers. Meritxell Abril

Improvement of Natura 2000 statuses with renaturation of Stržen's riverbed on intermittent Cerknica Lake. Irena Likar

Plants under hydropeaking: morphological and physiological responses. Alejandro Baladrón

Toward more effective stream restoration: a demonstration sites network to assess efficiency. Evelyne Tales

16:20 - 18:20 W4. Socio-ecological restoration of riparian vegetation by integrating biotic and abiotic pressures.

Session chair(s): Patricia Rodríguez González, Simon Dufour, Inês Marques, Cristina Vieites Blanco

Technical Assistant: Aymen Moghli

Ecological rehabilitation of riparian vegetation in regulated rivers: assessing ecosystem costs and benefits. Roland Jansson

Emerging Biotic (pest and diseases) pressures on riparian ecosystems: challenges and needs for their socio-ecological restoration. Jonas Oliva

Riparian plant invasions: causes, consequences and management. Eduardo Gonzalez Sargas

Socio-ecological restoration of riparian forests, what do we mean by "socio-" ?. Simon Dufour

September 9th, 2021 – **Room 2**

9:50 - 11:10 S17. Tools for planning ecological restoration I

Session Chair(s): Elysa Silva, Andreu Bonet, Jordi Cortina-Segarra, Mchich Derak, Antonio Aledo

Technical Assistant: Elysa Silva

Tools for planning ecological restoration. Jordi Cortina-Segarra

Supporting future restoration efforts by measuring past restoration over space and time. Louise Willemen

Modelling landscape management scenarios for equitable and sustainable futures in rural areas based on ecosystem services. María Felipe-Lucia

Social barriers for Mediterranean restoration: a multicausal network analysis. José Javier Mañas

11:10 - 12:30 S17. Tools for planning ecological restoration I

Session Chair(s): Elysa Silva, Antonio Aledo, Andreu Bonet, Mchich Derak, Jordi Cortina-Segarra

Technical Assistant: Elysa Silva

Social learning on forest restoration in semiarid areas of North Africa. Mchich Derak

The Global Restore Project: Knowledge Sharing for Shared Success. Emma Ladouceur

4 Returns Framework for Business-driven Landscape Restoration. Simon Moolenaar

Codes of conduct as tool in large-scale landscape restoration, applied in two Norwegian restoration projects. Dagmar Hagen

12:30 - 13:20. Break

14:10 - 15:30 S18.1 Tools for planning ecological restoration II

Session Chair(s): Elysa Silva, Andreu Bonet, Jordi Cortina-Segarra, Mchich Derak, Antonio Aledo

Technical Assistant: Elysa Silva

Comparing prioritization methods for ecological restoration in Mediterranean landscapes. Elysa Silva

Prioritizing sites for ecological restoration based on ecosystem services. María Felipe-Lucia

Social and experts approaches in landscape restoration – Meeting points and conflicts. Alejandro Valdecantos

Restoring landscapes from a socio-ecological approach. Alexis Heinz

WePlan – Forests: A decision support platform for spatial planning of forest ecosystem restoration. Brooke Williams

15:40 - 17:00 S18.2 Tools for planning ecological restoration II

Session Chair(s): Elysa Silva, Andreu Bonet, Jordi Cortina-Segarra, Mchich Derak, Antonio Aledo

Technical Assistant: Elysa Silva

Alternatives for climate change adaptation and socio-economic recovery in mid-mountain areas (La Rioja, Aragon, Catalonia). Diana Pascual Sanchez

Deforestation and climate change threaten headwaters in Central-South Chile: priorities to restore. Adriana Rendon-Funes

Design of Ecological Restoration's interventions according to stakeholders' perception after an environmental disaster: a case-study. Tiago Lima

Development of the strategic framework for the restoration of degraded ecosystems and landscapes for the state of Austria. Florian Danzinger

September 9th, 2021 – **Room 3**

9:50 - 12:30 W2. Restoring Mediterranean wetlands: challenges for practitioners and lessons learned

Session Chair(s): Teresa Gil Gil, Brigitte Poulin

Technical Assistant: Paula Lopezosa

Strengthening the restoration of Mediterranean Wetlands for nature and people. Teresa Gil, Brigitte Poulin

The need of wetland restoration and the legacy of MAVA. Luis Costa

Criteria to prioritize restoration sites selection. Carlota Viada

Case study Estany des Ponts, Mallorca, Spain. Pere Tomàs

Case study Santa Giulia, Corsica, France. Eva Tankovic

Case study Laguna di Nora, Sardinia, Italy. Mauro Fois

Case study "Saline di Priolo", Sicily, Italy. Pietro Minissale, Fabio Ciléa

Case study Sakarun, Dugi Otok, Croatia. Boris Laus

Case study Lady's Mile, Cyprus. Stathis Theofilou, Lefkios Sergides

Case study Gökçeada Lagoon, Turkey. Derya Yildirim

Case study Ghar el Melh wetland complex, Tunisia. Imen Rais

Case study Azraq Wetland Reserve, Jordan Hazem Khreisha

Case study Guadalquivir Estuary, Spain. Rafael Seiz

12:30 - 13:20. Break

14:10 - 15:10 Meet the Editor

Session Chair(s): Aveliina Helm

Technical Assistant: Paula Lopezosa

Restoration Ecology. Stephen Murphy and Valter Amaral

Ecology and Management/Trees, Forests and People. Dan Binkley

Communications Biology/Scientific Reports. Caitlin Karniski

Frontiers in Conservation Science. Emma Phipps

15:20 - 16:50 S16.1 The role of soil organisms in restoring degraded land

Session Chair(s): Miriam Muñoz Rojas, Sonia Chamizo

Technical Assistant: Paula Lopezosa

Reconnecting above and belowground biodiversity with microbially assisted restoration. Miriam Muñoz Rojas

Beneficial heterotrophs enhance the effectiveness of cyanobacteria-based biocrust restoration in drylands. Corey Nelson

Cyanobacteria inoculation to restore dryland degraded soils: optimizing their growth through application of habitat ameliorating techniques. Sonia Chamizo

Development and Application of Microbial Inoculum for Biological Soil Crust Restoration in Drylands. Corey Nelson

Non-destructive measurements for assessing biocrusts recovery. Jose Raul Roman

17:00 - 18:20 S16.2 The role of soil organisms in restoring degraded land

Session Chair(s): Miriam Muñoz Rojas, Sonia Chamizo

Technical Assistant: Paula Lopezosa

Rising from the ashes: The effects of soil burn severity on fire-moss growth and establishment. Juliana Monteiro

Metabolites from native biocrust cyanobacteria: applications for promoting germination and growth of plants used in restoration. Nathali Machado de Lima

Fungal perspective of pine and oak colonization in Mediterranean mined areas. Irene Adamo

Inputs of sheep droppings increase arthropod abundance. Emulation of sheep grazing on natural steppes. Margarita Reverter Cid

September 10th, 2021

September 10th, 2021 – Main Room

9:00 - 9:40 Plenary session: Restoration of agricultural soils in Russia after the collective farming collapse: opportunities and benefits for environment.

Irina Kurganova

Dr. Hab. (Ecology and Soil science), leading researcher of the Institute of Physicochemical and Biological Problems in Soil Science. Russian Academy of Sciences

Session Chair(s): Ramon Vallejo

Technical Assistant: Adrián Maturano

9:50 - 11:10 S9.1 Restoration strategies in mining areas

Session Chair(s): Carolina Martinez-Ruiz, Josu Alday, Beatriz Olmo Gilabert, Cristina Gil Monteso
Technical Assistant: Adrián Maturano

Woody colonization in reclaimed coal mines in Northern Spain: insights for forest expansion.
Carolina Martinez-Ruiz

Can native shrubs and grazing exclusion affect soil properties in reclaimed open-cast coal mines?. Elena Muñoz-Cerro

Monitoring opencast mine restoration using drones. Vicenç Carabassa

Restoration strategy and techniques for recovering degraded landscapes after mining activity under Mediterranean conditions. Diana Turrión Cerrejón

Aquatic succession in various post mining sites in Central Europe. Anna Müllerová

11:10 - 12:30 S9.2 Restoration strategies in mining areas

Session Chair(s): Carolina Martinez-Ruiz, Josu Alday, Beatriz Olmo Gilabert, Cristina Gil Monteso

Technical Assistant: Adrián Maturano

Biomass accumulation in forest floor and litterfall in Robinia pseudoacacia restoration plantations. Giorgos Xanthopoulos

Evaluating quarry ecological restoration success with field and remote sensing approaches (Arrábida Natural Park, Portugal). Cláudia Mendes

Evaluating the provision of pollination services by insects in actively and spontaneously restored quarries. Carolina Carvalho

Land reclamation activities for the restoration of the agrochemical properties of arsenic-contaminated soils. Petar Petrov

Seed dispersal services provided by birds in a 40-year-old revegetated quarry are depleted when compared with neighbouring areas. Ana Sampaio

12:30 - 13:20. Break

13:20- 14:00 Plenary session: Challenges in marine ecosystem restoration

Simonetta Fraschetti

Professor in Ecology at the University of Naples Federico II and Research Fellow at the Anton Dohrn Zoological Station of Naples

Session Chair(s): Cristina Gambi

Technical Assistant: Adrián Maturano

14:10 - 16:10 W3. What can we learn from eLTER on long-term monitoring and evaluation of restoration interventions?

Session Chair(s): Melinda Halassy, Kati Török

Technical Assistant: Adrián Maturano

Keynote speaker. TBD

Ten-year progress in the restoration of dry grasslands on arable land using a regional seed mixture. Klara Rehoukova

Restoration peatland eLTER, case of France. Gogo Sébastien

Long-term monitoring and evaluation of restoration experiments in Kiskun LTER, Hungary. Melinda Halassy

Limiting factors of plant establishment in restored grasslands of White Carpathian Mts. Ondrej Mudrák

Restoration of Mediterranean forests after major disturbances: The Lanjarón fire over 15 years of succession. Alexandro B. Leverkus

Long-term monitoring of a quarry site restoration based on vegetation structure and functional diversity. Alice Nunes

Q&A

17:30 - 18:30 Closing ceremony

Session Chair(s): Jordi Cortina-Segarra, Kris Decler, Jordi Pietx

Technical Assistant: Jordi Pietx

September 10th, 2021 – **Room 2**

9:50 - 11:35 S10 Restoring biodiversity and ecosystem services in European agricultural landscapes.

Session Chair(s): José M. Rey Benayas

Technical Assistant: José Antonio Alloza

Assisting natural regeneration in Mediterranean old fields by planting woodland islets and hedgerows. José M. Rey Benayas

Contributions of hedgerows to people – a global meta-analysis. David García de León

Challenges and opportunities for biodiversity conservation and restoration in olive groves. Jose Manuel Herrera

Environmental Enhancement of European Agricultural Landscapes by Agroforestry. Sonja Kay

Wetland restoration in Mediterranean agricultural landscapes. Eugenio de las Heras Martín

Selection of grapevine varieties according to their heat tolerance: a new approach using whole plants. Lara Río Moreno

11:40 – 12:40 S4 Large scale analysis of biomass and Carbon accumulation in abandoned agricultural lands: possibilities for Southern Europe

Session Chair(s): Eduardo Velázquez

Technical Assistant: José Antonio Alloza

Limited effect of forest expansion in abandoned agricultural lands to offset regional C emissions under Mediterranean-continental climate. Eduardo Velázquez

Aboveground biomass estimation in natural and plantation forest areas in Greece using satellite data. Giorgos Mallinis

Long-term abandonment of agro-ecosystems in Mediterranean mid-mountain areas: environmental consequences Estela Nadal-Romero

Carbon sequestration on abandoned agricultural lands in Russia: A review. Florian Schierhorn

12:40 - 13:20. Break

14:10 - 15:40 S7.1 Marine Ecosystem Restoration in changing oceans

Session Chair(s): Silvia Bianchelli, Simonetta Frascetti, Nadia Papadopoulou

Technical Assistant: Carlos Sanz-Lazaro

Restoration of *Cymodocea nodosa* seagrass meadows: efficiency and ecological implications. Cristina Gambi

Ecophysiological responses of two fucalean seaweeds to key environmental factors to identify restoration priorities. Sotiris Orfanidis

The first steps of ecological restoration in marine ecosystems: results and future challenges. Silvia Bianchelli

Stakeholder expectations from marine restoration projects: AFRIMED and algal forest restoration in the Mediterranean. Konstantia Papadopoulou

Habitat and functional recovery after the restoration of a canopy-forming algae forest. Cristina Galobart Vilamitjana

Nature-based-Solutions foster seagrass *Zostera noltei* resilience and restoration success: guidelines for practitioners and upscaling activities. Ana Sousa

15:50 - 17:10 S7.2 Marine Ecosystem Restoration in changing oceans

Session Chair(s): Silvia Bianchelli, Simonetta Frascetti, Nadia Papadopoulou

Technical Assistant: Carlos Sanz-Lazaro

Posidonia oceanica marine forest: epifaunal community response to plant restoration. Ines Castejon

The role of scale in seagrass restoration and biodiversity: a functional trait approach. Karine Gagnon

Understanding the ecological effects of extreme events in rocky shores to be applied in restoration. Iraide Saez-Zamacona

Zostera noltei as a rehabilitation tool for degraded estuarine ecosystems (Ria de Aveiro, Portugal). Vitor Oliveira

Zostera noltei response to transplantation into contaminated sediments (A mesocosm experience). Beatriz Fonte

September 10th, 2021 – **Room 3**

9:50 - 11:10 S15.1 Soil and Water Bioengineering as a tool for ecological restoration

Session Chair(s): Paola Sangalli, Rosemarie Stangl, Daniel Arizpe Ochoa, Albert Sorolla Edo
Technical Assistant: Hassane Moutahir

Soil and Water Bioengineering in European context for Ecological restoration. Concrete examples. Paola Sangalli

Greening measures for sustainable ecosystem restoration – decision making approaches and management strategies. Michael Obriejetan

Methods of process-orientated urban river development using Soil and Water Bioengineering . Henning Günther

Requalification of the coastline using bioengineering techniques. Case study: Caldeirão dune - Northern Portugal. Carla Rolo Antunes

SWB plantation tools to combact desertification in Mediterranean Europe. Gianluigi Pirrera

11:10 - 12:30 S15.2 Soil and Water Bioengineering as a tool for ecological restoration

Session Chair(s): Paola Sangalli, Rosemarie Stangl, Daniel Arizpe Ochoa, Albert Sorolla Edo
Technical Assistant: Hassane Moutahir

Best practice – Is natural revegetation sufficient to achieve mitigation goals in road construction?. Anne C. Mehlhoop

Ecological Engineering for transitional water restoration: Life Lagoon Refresh case study. Alessandra Feola

Restoration of drove roads to enhance biodiversity and connectivity of Natura 2000 sites in Spain. Violeta Hevia

Lessons learned from a fluvial bioengineering work for improving water course connectivity and river biodiversity. Txarrota dam rehabilitation. Paola Sangalli

12:30 - 13:20 Break

14:10 - 15:25 S21. Soil restoration in dry environments: from farms to mines

Session Chair(s): Pilar Andrés, Montserrat Jorba, Eduardo Arellano

Technical Assistant: Hassane Moutahir

Soil restoration in Mediterranean woody crops: best practices and best indicators. Pilar Andrés

Edaphic materials used in quarry restoration: effects on vegetation in the medium-long term. Montse Jorba

A Quorum Moment: Bridging the Practices of Ecological Restoration and Regenerative Agriculture. Darren J. Doherty

The role of soil amendments and conditioners in restoring seasonally dry forests. Eduardo Arellano

Responses of non-mutualistic diazotrophic microorganisms to fire occurrence in Mediterranean native forest soils. Claudia Rojas Alvarado

15:30 - 17:30 W6. Ecological Restoration contributions to Disaster Risk Reduction, Preparedness and Mitigation

Session Chair(s): Alfred De Jager, Sara Pelaez

Technical Assistant: Hassane Moutahir

Disaster Risk Reduction and Ecological Restoration. Alfred De Jager

The potential of ecological restoration for disaster risk management (DRM). Sara Pelaez

Dryland restoration, the forgotten option. Alfred De Jager

Natural assurance schemes: socio-ecological approaches to NBs for ecosystem based adaptation and ECO-DRR. Elena López Gunn

Floods and river restoration. Diego García de Jalón

Ecological restoration improves and becomes self-reinforcing for human health. James Aronson

September 10th, 2021 – **Networking Area**

14:10 - 15:10 Meet the restorer

Session Chair(s): Session Chair: Aveliina Helm

Technical Assistant: Jordi Cortina

Speakers: Patricia Rodriguez, Karel Prach, Sara Pelaez, James Aronson, Annely Esko, Aveliina Helm

15:20 - 16:20 Meet the SERE

Session Chair(s): Jordi Cortina, Kris Decler, Berit Köhler, Anne Tolvanen, Alice Nunes, Sabine Tischew, Melinda Halassy, Klara Rehounková, Johannes Kollmann, Josu Alday, Aveliina Helm, Elise Buisson, Agata Klimkowska, Jonathan Mitchley, Kristin Svavarsdottir, Richard Scott

Technical Assistant: Jordi Pietx

16:20-17:20 Virtual Terrace

Session Chair(s): Richard Scott, Jordi Pietx

Technical Assistant: Jordi Cortina

Note : The time zone is CEST.



SEPTEMBER
7TH

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S1 – Hot topics in ecological restoration I

SER's standards and principles for ecological restoration: the reference for successful and cost-effective restoration in the EU

Author(s): [Decler, Kris](#)

Affiliation(s): *Research Institute for Nature and Forest*

ABSTRACT

We present an overview of the most important principles and standards for ecological restoration, published by Gann et al (2019) on behalf of the Society for Ecological Restoration, and discuss their value for successful implementation of the restoration obligations in the EU.

Standards for the certification of forest ecosystems restoration projects: pilot application

Author(s): Colomina, Diana.¹; García, Ramón.²; Melero, María.³
Affiliation(s): ¹WWF España, Spain; ²VAERSA, Spain; ³WWF España, Spain
E-mail: dcolomina@wwf.es

ABSTRACT

WWF Spain has coordinated, since 2010, the development of standards for the certification of forest ecosystem restoration projects. Its main objective is to be able to determine, through a common and standardized methodology, when a restoration project can be qualified as certified, based on criteria of good restoration practices.

In recent years, WWF is working on the alignment with the Second Edition of the SER Standards and on the other hand, its application is being evaluated through pilot projects. In this sense, in 2020, an independent audit of the project "Actions to restore habitats of community interest in the ZEC Muela de Cortes and El Caroig (Valencia)" was carried out, in collaboration with the Generalitat Valenciana and VAERSA. In this case, the principles of the standards that refer to the project design were evaluated. Currently, we are launching the application of the standards in the execution, maintenance and monitoring phase, together with the Generalitat, VAERSA and TRAGSA.

The audit in the design phase and the one planned now for the execution, maintenance and monitoring of the project, will provide new information that will allow to obtain some conclusions of its application on the ground and provide feedback on the proposed standards, in a process of continuous improvement. In addition, the experience generated with a specific example represents an opportunity for other entities to learn about the strengths and weaknesses of this tool and to adopt it in other forest ecosystem restoration projects.

Keywords: Forests; Restoration strategy/planning; Standards; Evaluation and monitoring.

Fig. 1 ZEC Muela de Cortes and El Caroig (Valencia)



A Rewilding Theory of Change

Author(s): [Sally Ann Hawkins](#)^{1,2}, Ian Convery^{1,2}, Darrell Smith^{1,2}

Affiliation(s): ¹ *Department of Science, Natural Resources and Outdoor Studies, University of Cumbria, United Kingdom* ² *The Lifescape Project, United Kingdom*

ABSTRACT

Rewilding has the potential to create transformational change in social-ecological systems, with long-term goals of restoring complete, self-sustaining ecosystems and ecocentric societal values. Since the emergence of the concept in North America in the 1990s, the concept of rewilding has evolved and grown in complexity, becoming more difficult to define, apply and evaluate. As a result, the IUCN Commission on Ecosystem Management commissioned a Rewilding Task Force (now the Rewilding Thematic Group) to establish a globally recognized definition and principles for rewilding (Carver, Convery, Hawkins et al., forthcoming). To inform this work, we surveyed 60 international rewilding “pioneers” to trace the evolution of the concept and establish the common intentions of rewilding in research and practice. This oral presentation presents the results of this survey, giving a brief history of the concept, and proposes a rewilding theory of change based on the results. While this theory of change establishes that rewilding intentions are shared, it allows for adaptability and complexity in social-ecological systems, recognizing that the most effective rewilding interventions will differ across systems based on the current social-ecological conditions. Rewilding requires and promotes transformational ecological and social change, the application of rewilding therefore requires innovative and interdisciplinary approaches. By creating this theory of change we hope to provide a focus for remaining debates and a framework for planning, monitoring and evaluating rewilding, enabling researchers and practitioners to affect vital change.

Passive restoration in the context of macro-ecological parameters at the global scale

Author(s): Prach, K.¹; Janečková, P.¹; Walker, L. R.³...

Affiliation(s): ¹Faculty of Science USB, Czech Republic - EU; ²University of Nevada, USA

E-mail: prach@prf.jcu.cz

ABSTRACT

We evaluated the success of passive restoration, i.e. the spontaneous development of successional vegetation to a desired target, using simple categories: (i) successful – the target was reached, or expected to be reached, within 100 years; (ii) partly successful – the target was only partially reached; (iii) unsuccessful – the target was not reached. We selected 530 studies for our evaluation. Then, we related the success to the following global environmental characteristics: latitude, mean annual temperature, temperature seasonality, temperature annual range, annual precipitation, and precipitation seasonality in 1 km² grids, and the corresponding potential evapotranspiration, aridity index, and growing degree days. We further used published data on plant species richness and number of alien species. The success of passive restoration was significantly positively related to the latitude as a proxy of many climatic variables and negatively to species richness. We carried out a conditional random forest analysis that found the type of successional series to be of the highest importance. The most successful series were those after fire and glacier retreat, while the most unsuccessful represented succession on abandoned fields and after volcanic eruptions. These global relationships should provide a useful framework for site-specific restoration projects.

Keywords: global scale, restoration success, vegetation

Gender bias in Ecosystem Restoration: from Science to Practice

Author(s): Cruz-Alonso, V.^{1,2}; Marqués, L.³; Martínez-Baroja, L.⁴, Monteagudo, N.⁴, Rodríguez-Uña, A.⁵, Rohrer, Z.⁶, Velado, E.⁷

Affiliation(s): ¹Graduate School of Design, Harvard University, USA; ²Fundación Internacional para la Restauración de Ecosistemas, Spain; ³Department of Environmental Systems Science, Swiss Federal Institute of Technology (ETH Zürich), Switzerland; ⁴Universidad de Alcalá, Forest Ecology and Restoration Group, Spain; ⁵Basque Centre for Climate Change-BC3, Spain; ⁶Cinclus Soluciones S.A., Spain; ⁷Departamento de Ecología Integrativa, Estación Biológica de Doñana-CSIC, Spain

E-mail: veronica.cral@gmail.com

ABSTRACT

The declaration of the United Nations Decade on Ecosystem Restoration 2020-2030 has attracted special attention to this discipline. Gender is discussed and included in stakeholder participation in restoration projects, but scant attention has been devoted to gender bias of academic publication authorship and project leadership in ecosystem restoration. The main objective of our research is to analyze gender bias in ecosystem restoration from science to practice including three dimensions: the academy, outreach, and project implementation. First, we study the differences in academic productivity considering the gender of first and last authors in journals specialized in ecosystem restoration (i.e. Restoration Ecology, Ecological Restoration, Ecological Management and Restoration) using Web of Science. Second, we identify gender bias in the communication of scientific publications regarding ecosystem restoration in different Web media (e.g., blogs, Twitter), by analyzing the gender of the scientific paper's author and, when possible, the gender of the person sharing the article. Finally, we assess gender bias in the leadership of restoration projects using the restoration project database compiled by the Society for Ecological Restoration. We classified the projects into different categories (e.g., by type of restored ecosystem) to connect scientific publications and restoration projects by topic and to compare the rates of representation for men and women within each topic. Men led a higher proportion of publications (either as first or last author) and projects than women. An evolution through equity is observed over time in both dimensions. Preliminary results also show a dominance of male as outreach authors. The conclusions of this project can help to improve the equity in the transfer of scientific restoration knowledge into practice, a goal directly aligned with the objectives of Sustainable Development Goal 5 about gender equality.

Keywords: Communication / participation, Ecological restoration: Concepts and theory, Sustainable Development Goals (SDGs), Education and training, History and tradition

W5 – YOUNG#ER - Education and Training of young professionals towards socio-ecological restoration

Empowering #GenerationRestoration Professionals – Knowledge Transfer for Employability

Author(s): Nason, M.¹

Affiliation(s): ¹Eden Project Learning, UK

E-mail: mark.nason@cornwall.ac.uk

ABSTRACT

The global imperative to restore ecosystems provides a powerful and motivating antidote to ecological despair. To succeed, we must attract, nurture, and empower students of ecological restoration to create competent and reflective practitioners. We should raise expectations to deliver educational programmes that meet them and provide impactful opportunities to learn from, evaluate and improve best practices. A transdisciplinary approach is needed to engage employers, practitioners and researchers as partners with students in education – failure to do so diminishes the experience for students and damages their wellbeing. We should not underestimate the feelings of impotence and helplessness resulting from poor training, characterised by limited opportunities for students to make a difference by contributing evidence to underpin best practice or put theory into action. What competencies, knowledge and behaviours must #GenerationRestoration acquire to support their journey from optimistic amateurs, to skilled professionals? How should this training be delivered for maximum impact, enjoyment and accessibility? Who, and where are the educators and how can they break with tradition and outmoded practice to assess students with authenticity whilst maintaining academic rigour?

Reflecting critically on my experience of developing new educational programmes, I will share learning from the introduction in 2019 of a taught MSc in Land and Ecological Restoration in the UK region of lowest participation in Higher Education. Illustrated with feedback from students and employers I identify areas most likely to fall short of student and sector needs and present suggestions for improvement. I will explain how the introduction this year of the UK's first work-based apprenticeship in ecological restoration provides an alternative to traditional models, helping to widen participation and contract employer-practitioners, academics and students as partners in learning.

Keywords: education and training, ecological restoration, knowledge exchange, employability, restoration strategy / planning

Fig. 1 MSc Land and Ecological Restoration students at the Eden Project, UK



Empowering future generations for climate action through the Life Terra project (LIFE19 CCM/NL/001200, lifeterra.eu)

Authors: [Gregori-Montaner, A.](#)¹; [Sabaté, S.](#)^{2,5}; [Devasirvatham, P.](#)¹; [Sauras-Yera, T.](#)²; [Borràs, N.](#)¹; [Geluk, K.](#)³; [Stassen, S.](#)³; [Klomps, S.](#)³; [van Borne, W.](#)³; [Billon, N.](#)⁴; [Gras-Velazquez, A.](#)⁴; [Bajorinaite, M.](#)⁴; [Molina, M.](#)⁴; [Allasia, S.](#)²; [Kallen, S.](#)¹.

Affiliations: ¹*Volterra Ecosystems, Spain*; ²*University of Barcelona, Spain*; ³*Gynzy, The Netherlands*; ⁴*European Schoolnet, Belgium*; ⁵*CREAF, Spain*.

E-mail: education@lifeterra.eu

ABSTRACT

Life Terra is a European initiative that seeks to bring people together to plant 500 million trees, one for each European citizen. The project's strategy is to provide knowledge, technology and skills which will enable citizens to take urgent action to tackle the climate crisis. In this way, Life Terra plans to engage and connect a record number of volunteers in collaboration with existing initiatives to spark a citizen tree-planting movement.

Education is Life Terra's most valuable long-term investment. We have developed different strategies to raise environmental awareness among all ages, with a focus on children and youth. We empower citizens to become part of the climate solution and be future stewards of our planet:

- **Plant with communities.** Over 60 events in its first year, some involving families and schoolchildren.
 - Participants learn about local ecosystems, ecological functions of trees, and how to plant them correctly.
 - Supported by our monitoring platform to "tag" every tree planted.
- **Train the trainers.** A hands-on training programme for +18 volunteers -Terra Leaders- interested in taking the lead in our tree-planting events.
- **Educate future generations.** An environmental education programme for students ages 8-14 based on STEM and the best available science.
 - Our [online course](#) -Terra Mission- covers 8 sustainability themes (climate change, energy transition, circular economy, etc.) with a problem-solving approach. It includes teacher guides, answer keys, worksheets, outdoor activities, and extra exercises, films and games.
 - Our [pilot test](#) has demonstrated a high positive impact on both students' and teachers' knowledge and attitudes towards the environment.
 - Our [contests](#) and [exchange programme](#) will give voice to the youngest and exchange ideas for climate solutions through EU-level experience-sharing and knowledge-transfer.

These multiple strategies of both technical and practical education, inside and outside classrooms, are being implemented to facilitate climate action and restore our connection with the Earth.

Keywords: education, training, climate action, sustainability, tree-planting.

When necessity meets opportunity: using Service-Learning projects to train new generations in Ecological Restoration

Author(s): Souza-Alonso, P.¹; Omil, B.¹; García-Romero, D.²; Otero-Urtaza, U.²; Lorenzo Moledo, M.²; Rodríguez García X.C.³; Merino, A.¹

Affiliation(s): ¹*Department of Soil Science and Agricultural Chemistry. Higher Polytechnic School. University of Santiago de Compostela 27002, Lugo, Spain;* ²*Department of Pedagogy and Didactics, Faculty of Communication Sciences. University of Santiago de Compostela. 15782, Santiago de Compostela, Spain;* ³*Secondary School "Lucus Augusti", Lugo, Spain.*

E-mail: pablo.souza@usc.es

ABSTRACT

Key strategy for ecosystem recovery, Ecological Restoration (ER) is gaining momentum in the environmental and political debate worldwide. Aimed to restore natural capital and ecosystem services, transforming degraded areas into functional ecosystems benefits society and future generations. Different analyses show that the reinforcement of training capacities is needed to overcome technical, social and economic limitations of ER. In a world facing a progressive and accelerated degradation, society is increasingly motivated to participate in environmental actions, including restoration. Aspects related to education and communication -preferentially focusing the youngest- are essential.

Since limitations are numerous, new approaches can increase the capacity and sensibility of the society to meet these challenges. Service-Learning (S-L) represents an experiential and education methodology combining learning and community service in a single project with a civic and academic base. S-L projects bring together students, academia and stakeholders whereby all become teaching resources, problem solvers and partners. Here, students learn, identifying and acting to solve real-world necessities, obtaining academic credit, and integrating community service into the curriculum. Regardless the outcome of the objective (service), S-L represents an end by itself since projects assure a direct benefit (learning) to those involved.

Here is where necessity (*environmental, social*) **meets** opportunity (*S-L projects*), bringing together social and environmental demands with science, encouraging community engagement in environmental protection. Starting from a local initiative (Plantando Cara o Lume, 2016), the project “Plantando Cara al Fuego” (Spanish National project; FECYT-2020) and its European counterpart “Facing Fire” (Erasmus+, 2020) are based on independent S-L projects designed to prevent, protect, and restore areas affected by forest fires in Southern Europe (Spain, Portugal, Italy, Greece). S-L projects allow future managers, ecologists, practitioners, and students from different disciplines to gain experience in environmental activities (including restoration), learning, training, and developing competences and beneficial skills for their futures.

Keywords: Service-Learning, student training, fire management, participative projects, community engagement.

Fig. 1 Representation of main characteristics of Ecological Restoration (ER, left) and Service-Learning (S-L, right). In the middle, those characteristics aligning wither principles shared by both ER and S-L projects. TEK (traditional ecological knowledge), LEK (local ecological knowledge).



Students on the road for a better environment

Author(s): Méndez-Vales, V.¹; Nolan, M.²; Paolinelli Reis, B.³; Payne, R.⁴

Affiliation(s): ¹University of Santiago de Compostela, Spain; ²Eden Project Learning, UK; ³Eötvös Loránd University, Hungary; ⁴Instituto Superior de Agronomia, Universidade de Lisboa, Portugal;

E-mail: victor.mendez.vales@rai.usc.es; maria.c.t.nolan@gmail.com; brunapaolinelli@gmail.com; robin.payne@hotmail.co.uk

ABSTRACT

At present there is in-depth knowledge about the major degradation processes that we will have to face in the coming decades. In many cases, we have enough knowledge and technology to recover at least part of these ecosystems. However, the successful application to restoration will depend to a large extent on this knowledge transfer to future generations of professionals and on formulas to apply this technology in an economically viable way. Previous analyses shows that curricula can be reinforced by offering a good practices program and involving students in real restoration cases in their areas. On the one hand, this strategy makes easier the knowledge transfer to future professionals, and at the same time generates the necessary society awareness about land degradation.

In this overview, undergraduate and master students from different European countries show and discuss case studies in which they are involved, focused on ecological restoration of the main environmental challenges in their countries. In Spain, examples are shown of how students have been involved in the restoration of areas affected by fires. In the UK, a study managing complex and protected island sites illustrates the potential for carbon storage. In Hungary students are involved in long-term evaluation of grassland restoration efforts, with focus on monitoring and evaluation. Finally, in Portugal, understanding challenges and needs faced by managers on riparian ecosystems is essential to fight the multiple social barriers and minimize the environmental threats (biotic and abiotic) for their restoration.

Keywords: education and training, restoration planning, restoration strategy

Fig. 1 Students carrying out practices on ecological restoration:

a) Soil protection on recently burnt areas in Spain, b) Sampling in protected island sites for carbon storage in United Kingdom, c) Monitoring of restoration efforts on abandoned fields in the Kiskunság, Hungary and d) Assessment of the riparian forest biodiversity in Portugal



S6.1 – IX International Meeting

FuegoRED2020: Post-fire restoration in a changing world: vulnerability and resilience of forest ecosystems to fire



Adaptive management of highly flammable Mediterranean ecosystems by combining fuel reduction and post-fire restoration

Author(s): [Santana, V. M.](#)¹; Baudena, M.²; Baeza, M. J.³; Moghli, A.³; Valdecantos, A.¹; Vallejo, V. R.¹.

Affiliation(s): ¹*Mediterranean Center for Environmental Studies (CEAM), Spain;* ² *National Research Council of Italy, Institute of Atmospheric Sciences and Climate, CNR-ISAC, Italy;* ³*Ecology Department, University of Alicante, Spain.*

E-mail: vm.santana@ua.es

ABSTRACT

Forest fires and extreme droughts will continue to be main disturbances in Mediterranean ecosystems, given the ongoing and predicted climatic changes. In fact, an exacerbation of some aspects of their regime is expected. Within this perspective, it is fundamental to design adaptive management strategies to both reduce the impact of disturbances and increase ecosystem resilience. To achieve this, it is important to develop an integrated management, able to select the best combination of restoration actions for different scenarios. Here, we first address the effectiveness of the combination of several actions related to fuel reduction and restoration after fire in the medium term (i.e., 13 years after treatments). Fuel reduction treatments include the application of shrub clearing at different intensities and frequencies. Restoration actions comprise the plantation of several resprouting species, aiming to increase ecosystem resilience. These actions were preferentially performed in fire prone Mediterranean ecosystems, such as dense *Ulex parviflorus* gorse shrubland, regenerated after fires. Secondly, we assess which is the best selection of management actions in the long term to increase the presence of resprouting species and mitigate fire occurrence. for different climate change scenarios. For this we used a published model, specifically developed for Mediterranean ecosystems and including species competition and post-fire responses, which we calibrated using the recorded vegetation response to treatments. Our results point out that, if we look for more resilient ecosystems in the next decades, we will need an intensification of fuel reduction treatments, while resprouting species should be introduced in the ecosystem. However, the success of this actions will be variable depending on the climate scenario.

Keywords: Adaptive management, climate change, modelling, resilience, wildfire.

Effects of post-fire mulching on moss biocrust functionality after a wildfire

Author(s): *García-Carmona, M.*¹; *Arcenegui, V.*¹; *García-Orenes, F.*¹ *Mataix-Solera, J.*¹

Affiliation(s): ¹*GEA-Environmental Soil Science Group, Universidad Miguel Hernández, Department of Agrochemistry and Environment, Elche, Spain.*

E-mail: minerva.garcia@umh.es

ABSTRACT

After wildfires in Mediterranean forests, mosses have been described as faster colonizers in early successional stages when soil surface is vulnerable and exposed to rainfall events. As pioneer species, mosses exhibit high resilience to fires and post-fire environments thus revealing important roles especially related to soil erosion mitigation. Despite the relevant functions described for the soil biological crusts, information about their implication in the recovery of recently fire-disturbed soils and the interaction with post-fire management strategies are rather limited. With this aim, we studied the effects of the application of one of the most common post-fire strategies designed to protect the soil and reduce erosion rates, mulch based on wood debris, on the moss-dominated biocrust performance in soils. The study area, located in "Sierra de Beneixama" (E Spain), was affected by a wildfire in August 2019 that burned 862 ha, followed by salvage logging management that triggered soil erosion processes. Seven months after the wildfire, two doses of mulch were assayed, achieving a mulch cover of 75% and 100% respectively. Results were compared to non-amended control soils and to the unburned area. After one year since mulch application, the percentage of moss cover and the physicochemical and biological soil properties were measured in soils beneath the moss crust and in soils lacking crust development. The preliminary results showed moss cover mitigated the soil water repellency after the wildfire. The establishment of mosses enabled soil humidity retention thus enhancing the microbial abundance. However, the higher dose of mulch negatively affected the moss biocrust development, resulting in a decrease of 25% of cover compared to the lighter dose. Although a high dose of mulch would reduce efficiently the runoff response, it could hamper the ecosystem functionality restoration, of special concern in semi-arid areas highly vulnerable to land degradation under high severity wildfires.

Keywords: biocrust, dryland, moss, mulch, soil.

FacingFIRE: a Service-Learning approach to improve the training on restoration in wildfire affected lands, the experience in Spain

Author(s): Merino, A.¹; Moya, D.²; Rodríguez y Silva, F.³; Madrigal, J.⁴; Rodríguez-García, J.C.⁵; Omil, B.¹; Souza, P.¹; Reyes, O.¹

Affiliation(s): ¹University of Santiago de Compostela, Spain; ²University of Castilla la Mancha, Spain; ³University of Córdoba, Spain; ⁴INIA, Spain; ⁵IES Lucus Augusti, Spain

E-mail: agustin.merino@usc.es

ABSTRACT

Forest fires are a complex problem in Europe, especially in Southern countries, where it seriously impacts the environment, rural development and economy. Although research and substantial technical advances have been made in recent years, no practice of restoration is adopted in most of these burnt areas. Introducing innovative approaches in the training might contribute to overcoming the shortage of skilled workers.

The FacingFIRE project introduces the Service-Learning (S-L) approach to develop training projects in areas impacted by wildfires. The training is boosted by hands-on practices, in which multiple interactions between educators, researchers, forest companies/ NGOs and decision-makers are planned.

The consortium comprises different partners from the most fire-prone regions in Spain. The Universities, Research Centres, VET centres have recognized expertise Forest Management and teaching innovation, whereas multiple professional partners (Forest Associations, Decision-makers, NGOs, Councils, Companies, Primary schools) played a key role in identifying the main training needs, complementing the students training and enhancing the impact of the outcomes.

In this pilot phase, more than 100 students from different studies (forestry, education, biology, journalism) and more than 20 stakeholders (secondary schools, forest administration, forest communities) have participated in more than 15 projects carried out in 4 regions (Andalucía, Castilla la Mancha, Madrid, and Galicia). Some examples are: participative restorations of recently burnt areas, awareness activities with secondary schools, protection on endangered plant and fauna species, prevention activities on forests, awareness activities in urban area, audio-visual materials, educational interviews, surveys to students and managers.

At the individual level, the impacts included improvement of technical employability skills. At the organizational level, the stakeholders benefited from access innovative educational tools, state-of-the-art methods and a greater supply of skilled workers.

A network on wildfire training is proposed at national level under the umbrella of FUEGORED, which will open multiple possibilities for future cooperation.



1 Participative restoration in a recently burnt area

Keywords: education and training, restoration, service-learning, awareness.

Impact of post-fire regeneration activities on soil organic matter quality

Author(s): Jiménez-Morillo, N.T.¹; González-Pérez, J.A.²

Affiliation(s): ¹Universidade de Évora, Instituto Mediterrâneo para a Agricultura, Ambiente e Desenvolvimento (MED), Portugal; ²Instituto de Recursos Naturales y Agrobiología de Sevilla (IRNAS-CSIC), Spain.

E-mail: ntjm@uevora.pt

ABSTRACT

Post-fire soil recovery strategies (e.g., tillage, tree logging and reforestation) may modify the quality of soil organic matter (SOM) at molecular level. The aim of this research was to assess the molecular alteration of SOM produced by anthropogenic post-fire restoration activities. The effect of fire and restoration on SOM was analysed in bulk samples and sieved soil fractions (coarse, "CF", and fine, "FF") from burned pines forest areas, located in Doñana National Park (SW, Spain), before and after restored activities. The analytical pyrolysis was applied to evaluate the molecular alteration of SOM. The molecular characterization of the burnt soil displayed a remarkable depletion in lignin-like compounds, but an enrichment in unspecific aromatics (UA) and polycyclic aromatic hydrocarbons (PAHs). Concerning soil fractions, burnt CF consisted mainly of lignocellulose-like compounds and fatty acids, while FF was dominated by lipid compounds. In addition, high contribution of UA compounds and PAHs was observed in burnt FF. However, in post-fire restored samples, there was a significant proportion of fresh biomass, which may be due to soil mixing during rehabilitation actions. The van Krevelen diagram allowed determining the chemical mechanisms induced by fire and/or restoration activities. The fire triggered a defunctionalisation of lignin compounds and the formation of pyrogenic material. However, restoration activities increased the aromaticity of burnt soil by the accumulation of lignin and PAHs. This suggests additional inputs from charred lignocellulosic biomass, including black carbon, that was incorporated into the soil during rehabilitation practices.

Keywords: Soil, Post-fire restoration, Organic Matter, Wildfire, Chemometrics

S6.2 – IX International Meeting

FuegoRED2020: Post-fire restoration in a changing world: vulnerability and resilience of forest ecosystems to fire



Prescribed burning in British peat moorlands as tool to maximize carbon sequestration while minimizing emissions

Author(s): Alday, Josu^{1,2}; Marrs, R.H³., Allen, K.A³., Lee, H.^{3,4} & Santana, V.M^{5,6}

Affiliation(s): ¹Joint Research Unit CTFC – AGROTECNIO Lleida, Spain; ²Dep. Crop and Forest Sciences University of Lleida, Spain; ³School of Environmental Sciences, University of Liverpool, Liverpool L69 3GP, UK; ⁴National Institute of Ecology, Seocheon-gun, Republic of Korea; ⁵Mediterranean Center for Environmental Studies (CEAM), Spain; ⁶Ecology Department, University of Alicante, Spain.

E-mail: josu.alday@udl.cat

ABSTRACT

One of the most important challenges for fire ecology is the optimization of ecosystem management and restoration techniques that maximize ecosystem services while minimizing carbon emissions and fire risk. This is especially true for peat moorlands of the boreal region, which harbour 30% of the global soil carbon stores, and in which prescribed burning is a contentious management strategy. Here, we combined two approaches; first we modelled the effects of different prescribed-burning rotation intervals and wildfires on present and future carbon emissions, and second, we quantified the effects of prescribed burning on peat and recent carbon accumulation rates using stratigraphical techniques within an experiment with known burn frequencies; 0, 1, 3 and 6 managed burns since around 1923. The aim was to identify the prescribed burning rotation intervals that minimised carbon emissions while maximizing peat forming and C sequestration. Our models showed that colder and wetter sites accumulated lower amounts of litter with time than southern sites (hotter and drier), whilst the accumulation of live vegetation dominated by *Calluna vulgaris* was more site-dependent. The optimal prescribed-burning rotation interval for minimizing annual carbon emissions averaged between 30 and 50 years. The peat and carbon accumulation rates in soil were only reduced significantly in the 6-burn treatment. However, although prescribed burn did not prevent peat and C accumulation rates in all treatments, each additional burn reduced the accumulation rates by 4.9 g m⁻² yr⁻¹ (peat) and 1.9 g C m⁻² yr⁻¹. Our data showed that appropriate prescribed burning intervals may mitigate wildfire risk and C emissions, whilst peat maintaining positive C accumulation rates. These results challenge the widely held perception that cessation of burning is essential for peat formation.

Keywords: Fire ecology, peat, C emissions, C sequestration, *Calluna vulgaris*.

Burn severity: dealing with this fire regime parameter in the framework of post-fire restoration

Author(s): Calvo, L.^{1,2}; Fernández-Guisuraga, J.M.¹; Fernández- García, V.¹; Huerga, S.¹; Beltrán, D.¹; Marcos, E.¹; Tárrega, R.¹; Valbuena, L.¹; Ansola, G.¹; Sáenz de Miera, L.¹; Taboada, A.^{1,2}; Suárez-Seoane, S.³

Affiliation(s): ¹Area of Ecology, Department of Biodiversity and Environmental Management, Faculty of Biological and Environmental Sciences, University of León, 24071 León, Spain; ²Institute of Environmental Research (IMA), University of León, E-24007 León, Spain; ³University of Oviedo, Department of Organisms and Systems Biology (BOS; Ecology Unit) and Research Unit of Biodiversity (UMIB; UO-CSIC-PA), Oviedo, Mieres (Spain).

E-mail: leonor.calvo@unileon.es

ABSTRACT

Burn severity, denoted as the total amount of biomass consumed, is one of the most important factors determining the ecological effects of fire on ecosystems, conditioning their regeneration capacity. Monitoring the burn severity impact on fire prone ecosystems is crucial for developing adaptive management strategies that promote ecosystem resilience. The impact produced by severe wildfire on ecosystems makes it necessary to implement restoration measures to recover their natural value. The aim of this study is to evaluate the effect of straw mulch restoration on soil quality and vegetation regeneration in the short term after wildfire. The study was conducted in the Sierra de la Cabrera range (NW Spain), within the perimeter of a mixed severity mega-fire that occurred in August 2017 and affected 9,940 hectares of shrubland and tree forest ecosystems. The restoration process, carried out by the Regional Administrative Board (Junta de Castilla y León), was focused on the burned heathlands affected by different severity. We monitored the regeneration of the vegetation and the changes on chemical and biochemical soil properties, comparing the control (burned heathlands without restoration) and the restored plots. The results showed that the restoration with straw favoured the recovery of herbaceous species, and increased the microbial carbon and enzymatic activities of the soil. However, the effect of mulch application did not show significant positive effects on the regeneration of woody species, due to the high capacity of *Erica australis* to resprout in these ecosystems.

Keywords: Wildfire, burn severity, restoration, heathlands, vegetation regeneration, soil characteristics.

Fig. 1. Mulch restoration in heathlands in the Cabrera wildfire



Reducing future fire risk through preventive restoration of fire-prone lands: results from Proyecto Mosaico

Author(s): Pulido, F.¹

Affiliation(s): ¹*Instituto de Investigación de la Dehesa, Universidad de Extremadura, Spain.*

E-mail: nando@unex.es

ABSTRACT

After large fires occur, post-fire restoration practices must guarantee soil conservation and vegetation recovery especially in the most sensitive areas. However, these catastrophic fire events often affect forest lands with inadequate management leading to excessive fuel continuity. Simply restoring the same fire-prone forest landscape may result in subsequent fires and further land degradation. Here I present a new concept, preventive restoration, which may help to design smart fire landscapes with reduced fire risk. In this approach, open areas in between forest tracts are designed to reduce fuel continuity and managed as “productive fuel breaks” maintained through economic practices such as woody crops, livestock husbandry or harvesting of tree biomass and resin. The model is illustrated with results from Proyecto Mosaico, an initiative starting in 2016 after a large fire in Sierra de Gata, Cáceres, Spain. Mosaico has created a network of ca. 300 initiatives proposed by local farmers, municipalities, associations and companies. These actions have the capacity to reduce fuel loads in strategic areas in a cost-effective way, and they can be seen as measures complementing conventional fire infrastructures. The area covered by local land users to date is ca. 12000 ha, as compared to 1200 ha occupied by conventional firebreaks. The implementation of this scheme is already lowering fire risk by altering fuel abundance and distribution while helping local inhabitants and attracting neorurals engaged in a highly participative process.

Keywords: ecological engineering, ecological restoration, landscape architecture, participation, rural development.

Figure 1. Productive fuel break planted with chestnut within fire- prone pine forest.



Can we recover ecosystem services with ecological restoration? An experience with Mediterranean fire prone communities

Author(s): Maturano, A.¹; Baeza, M.J.¹; Bautista, S.¹, Vallejo, V.R.², Valdecantos, A.^{1,2}.

Affiliation(s): ¹University of Alicante, Spain; ²CEAM Foundation, Spain

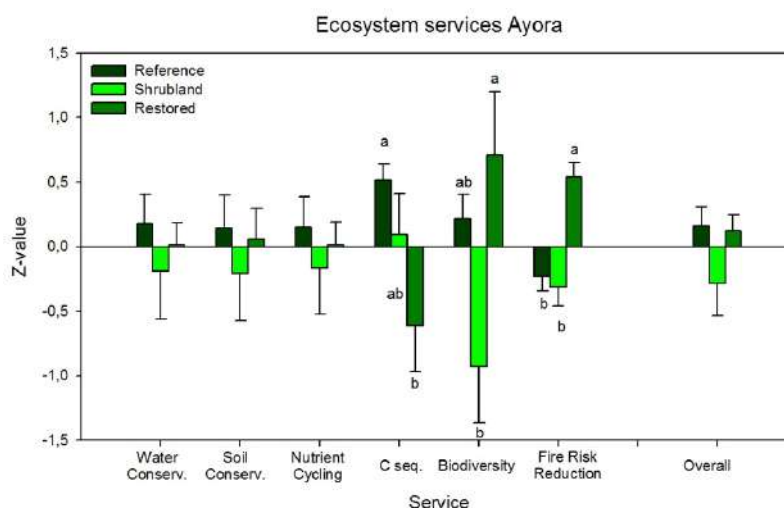
E-mail: a.maturano@ua.es

ABSTRACT

Degradation implies losses of ecosystem functioning and diversity that may compromise the provision of ecosystem services. An evaluation approach based on the ecosystem services concept appears therefore to be the right framework to assess the achievements of restoration actions. In this study, we assess ecosystem properties and a selection of derived ecosystem services for three ecosystem states of a maritime pine forest in relation to fire: an unburned mature pine forest (Reference), a mature secondary shrubland 34 years after the fire (Shrubland), and the latter managed to reduce fire risk and increase resilience (Restored). The Shrubland state reached similar functionality than the Reference pine woodlands, although the community structure and composition significantly changed, becoming more homogeneous and impoverished biodiversity ecosystems. The main landscape change due to wildfire was the tree layer loss, which entailed a great loss of biomass, which reduced C sequestration but not fire risk. The restoration approach conducted on the Shrubland reduced fire risk but at expense of a reduction of C sequestration. In addition, biodiversity was enhanced by restoration beyond the pre-fire reference levels. These changes found in ecosystem processes, properties, and services point to the mature post-fire shrubland as an alternative stable state, where successional dynamics was arrested or slowed down. The restoration actions assessed allowed the progression of succession, reduced fire risk, and improved community diversity and ecosystem resilience to further disturbances.

Keywords: Biodiversity, Ecosystem processes, Ecosystem services, Forests/woodlands, Restoration strategies.

Fig. 1 Net balance of ecosystem services assessed in the three alternative states of maritime pine forest (Reference, Shrubland and Restored) in Ayora (SE Spain). For each ecosystem service, different letters denote significant differences between ecosystem states ($p < 0.05$; $n = 3$).



Is the process of post fire emergency stabilization in Portugal heading in the right direction?

Author(s): Lopes, L. F.¹; Acácio, V.¹

Affiliation(s): ¹*Centro de Ecologia Aplicada “Prof. Baeta Neves”, Instituto Superior de Agronomia, Universidade de Lisboa, Portugal;*

E-mail: l.lopes@edu.ulisboa.pt

ABSTRACT

Policies for restoration of burned areas in Europe are heterogenous across countries, responding to the variability of wildfires and inherent perceived level of threat. Within Europe, the EUMED5 (the five European countries most affected by wildfires, namely Italy, Greece, France, Portugal and Spain) present the most thorough legislation in terms of post-fire management. However, despite this broad legislation, its enforcement is a major challenge, and the implementation of post-fire measures is mostly executed by the property owners/managers with public subsidies.

In Portugal, post-fire restoration incentives have gradually gained visibility on the political agenda, beyond the historical reforestation of burned areas, especially in the beginning of the 21st century. Since 2007, public subsidies for the restoration of forest ecosystems affected by fires started including emergency stabilization, which have been provided by Portuguese Rural Development Programs.

The speed of decision-making and execution is critical for the efficiency of postfire emergency stabilization, in order to mitigate the potential negative impacts of fire and support ecosystem recovery. However, the financial support for postfire emergency stabilization tends to be available belatedly, with the beneficiaries often facing lengthy procedures, in most cases overcoming the critical period of action (the first months after fire). Consequently, the efficiency of postfire emergency interventions is compromised.

In this perspective, we analysed the process of implementation of public funding in 2009-2018 for postfire emergency stabilization using data from: (i) emergency stabilization reports (147), (ii) open calls resulting from those reports (12), and (iii) execution projects subsidized by the calls (517). Main results were compared with other approaches (i.e. BAER in USA and SEAGA in Galicia, Spain), and discussed in light of recent changes in Portuguese public policies, such as the National Plan for Integrated Rural Fire Management in 2020, which may improve the efficiency of post fire emergency stabilization interventions in Portugal.

Keywords: Governance and Policy; Restoration strategy/planning; Evaluation and monitoring; Forests/woodlands; Landscape

S3 – Restoring Mediterranean wetlands from Science to Management

Reference ecosystems: How can we quantify the success of wetland restoration?

Author(s): Fontès, H.^{1,2}, Marquis, C.¹, Torre, F.², Grillas, P.¹, Dutoit, T.², Mesléard, F.^{1,2}

Affiliation(s):¹Tour du Valat Research Institute, Le Sambuc, 13200 Arles, France;²Aix Marseille Université, Avignon Université, CNRS, IRD, IMBE, France

ABSTRACT

Reference ecosystem is a key element for the evaluation of wetland restoration projects. There is much debate around this concept, but few concrete methodological proposals have been developed to address this issue. Here we propose a methodological and statistical approach allowing considering the variability of ecosystems with multiple references sites when evaluating the success of the restoration or creation of ecosystems. For this, we used, as a study model, the plant communities of Mediterranean temporary ponds which are characterized by a strong variability in the expression of their vegetation in time and in space.

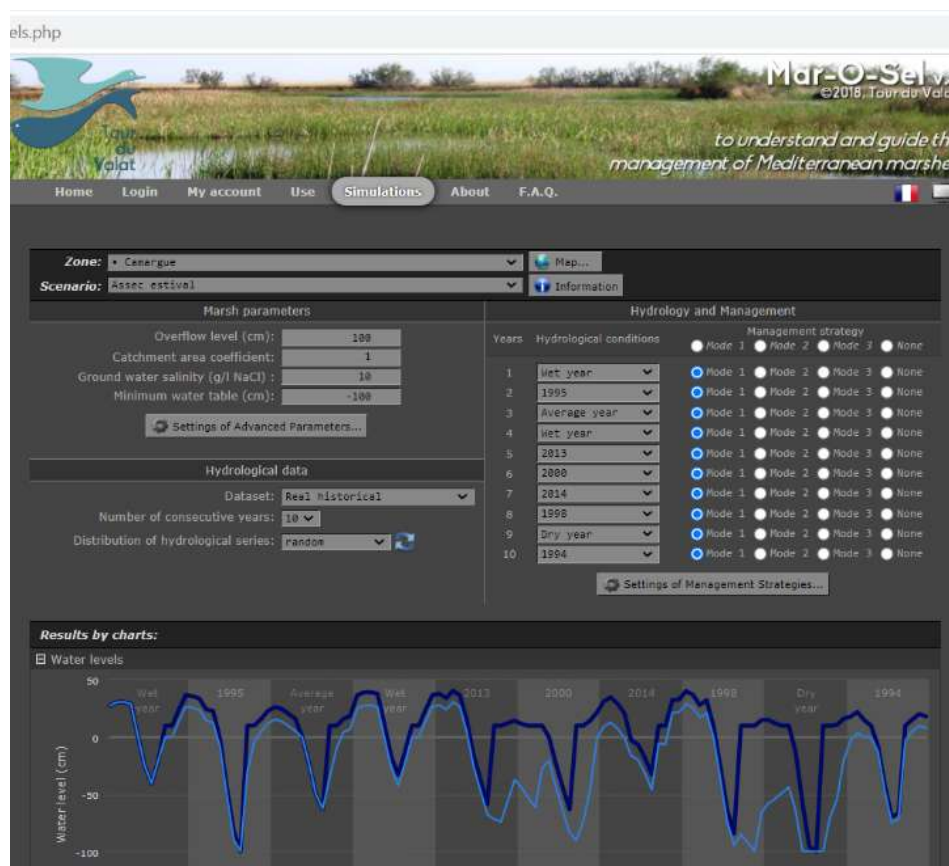
Management and restoration actions in a context of global changes: assessing the water needs of a wetland for today and tomorrow

Author(s): Lefebvre, G., Poulin, B.

Affiliation: Tour du Valat Research Institute, Le Sambuc, 13200 Arles, France.

ABSTRACT

Wetland catchment areas are shrinking as a result of agricultural and urban development. As a result, an increasing number of Mediterranean marshes are requiring artificial water input to maintain their functions, with climate change adding further pressure in terms of water stress. How can we estimate the amount of water needed to restore and maintain a wetland in the long term? To better appraise the consequence of increased water deficit on wetland management and restoration, an interactive web tool combining meteorological data and hydrological modelling has been created (Mar-O-Sel.net) for the whole Mediterranean climate zone. In addition to historical meteorological data, Mar-O-Sel integrates climate projections at the 2050 and 2100 horizon based on a scenario of stabilisation (RCP4.5) or steady increase (RCP8.5) in greenhouse gas emissions. This user-friendly interface can be used for a rational management of any wetland today or for testing options of water management in the future. A few applications are given as examples to encourage a better integration of hydrology in wetland restoration planning.



Vulnerable species as a lever to orient and monitor wetland restoration actions

Author(s): Lambret, P.^{1,2}, Fontès, H.^{1,3}, Stoks, R.², Mesléard, F.^{1,3}

Affiliation: ¹Tour du Valat Research Institute, Le Sambuc, 13200 Arles, France

²Laboratory of Aquatic Ecology, Evolution and Conservation, KU Leuven, Deberiotstraat 32, 3000 Leuven, Belgium ³Aix Marseille Univ, Avignon Université, CNRS, IRD, IMBE, France

ABSTRACT

Wetlands are biodiversity hotspots as they support 10% of species while occupying less than 1% of the world's surface. Meanwhile, their loss follows a continuously increasing trend due to human activities, making their restoration a high priority. Among Mediterranean wetlands, temporary and brackish waters have faced one of the most severe declines over the past decades. These waters, typically estuaries and littoral ponds and marshes, are often inhabited by *Lestes macrostigma*, a damselfly threatened at the European scale. To use this species as a flagship for wetland management, restoration and creation, its ecological requirements have been intensively studied. We found that *L. macrostigma* can lay eggs in several plant species, but prefers the seaclub rush *Bolboschoenus maritimus* as this increases adult fitness through a higher oviposition rate, but also that of their progeny through a higher hatching success. An earlier flooding of eggs after the dry season increases egg survival. Yet, a too early flooding in autumn allows other dragonfly species to lay eggs, which may increase predation and competition during the next spring, when *L. macrostigma* larvae grow. Although *L. macrostigma* prefers brackish waters, higher salinity levels have sublethal negative effects. Therefore, salinity levels should not exceed 6-8 g/L at the beginning of larval development, being from mid-March, and 10-12 g/L at the end of adult emergence phase, in late May. Hence, we recommend conservation managers to install a flooding period from November to May using active water management when possible. When creating new ponds, this should be taken into account by modelling their shape, size and watershed using rainfall and topographic data. In addition, habitat engineering should focus on active vegetation restoration by sowing or transferring *B. maritimus* propagules. Effectiveness of these conservation measures should be quantified by yearly monitoring of the reproductive success of this insect species.



Figure 1. *Lestes macrostigma* mating wheel among its preferred oviposition plant *Bolboschoenus maritimus*

Keywords: Flagship species, Ecological requirements, *Lestes macrostigma*, Management and engineering.

Manipulating priority effects to control invasive plant species in a restoration context

Author(s): [Manon Hess](#), Elise Buisson, François Mesléard
E-mail: manon.hess@hotmail.fr

ABSTRACT

Active restoration of invasion-resistant plant communities is increasingly recognized as a relevant strategy to combat invasive plant colonization in disturbed areas, but results are often unsatisfying. Historical effects, referred as “priority effects” (i.e. the effects generated by the order in which species arrive at a local site), can play a major role in community assembly and local invasion success because they involve early colonists altering the performance of later colonists. Considering these priority effects in restoration projects is emerging as a relevant way to improve native species restoration success and prevent future invasions. Two strategies emerged to achieve the classic restoration goal “more native, less invasives”. The first strategy relies on tackling priority effects of invasive plants using different management options. The second strategy is to bring about situations in which the restored native species are more likely to exert strong priority effects, then decreasing invasion success. This includes increasing time advance given to native species or manipulating restored community composition and diversity. Priority effects emerge as a powerful tool to enhance restoration success, while further research is needed to investigate the influence of environmental conditions as well as the cost-effectiveness of priority effect-based strategies.

Keywords: invasions; grassland restoration; active restoration; revegetation; plant community ecology; competition

Restoration of the former salt works of Camargue: Results from 10 years of a coastal wetland renaturalisation process

Author(s): Poulin, B., Thibault, M.

Affiliation: *Tour du Valat Research Institute, Le Sambuc, 13200 Arles, France*

E-mail: poulin@tourduvalat.org

ABSTRACT

Located in the Rhône delta (France), the former saltworks (5000 ha) are made of lagoons, salt marshes and dunes particularly exposed to coastal dynamics and sea level rise. The site was acquired by the French Coastal Conservancy after 50 years of salt production, resulting in the containment of lagoons and circulation of pumped seawater to favor salt pre-concentration. Since 2011, the site is managed by the Camargue regional nature park with the Tour du Valat Research Institute and the National Society for Nature Protection. A major orientation defined by the management plan (based on hydrology, biodiversity, and socio-economic studies) consists in depoldering the site in order to enable hydrobiological connectivity among lagoons, the sea and the peripheral sub-catchments. In response to coastal erosion, a more flexible management of the coastline has been favored. The costly maintenance work of sea-front defense structures has been stopped and is being replaced by a natural strip of sand (lido) that is more durable and better suited to the shore profile. Pumping stations have been dismantled and hydraulic structures have been created or abandoned to restore gravity water flows and Mediterranean water cycles. Various studies were initiated to monitor and orient the rapid evolution of the site, relying on a two-dimensional hydrodynamic model used to calculate water levels, flows and salinities according to different civil works and sluice management options. Sea-shore line and vegetation were monitored using remote-sensing tools. Fish populations were sampled at various stations to assess connectivity for migratory species. Monitoring of breeding and wintering bird population was continued and extended to new species groups (passerines, ducks) benefitting from site restoration. This example shows how rising sea level can provide an opportunity to rethink the management of coastal areas, by giving more room to the natural functioning of coastal wetlands.



S2.1 – Restoring European grasslands

One step from science to policy: amending restoration seed transfer regulation

Author(s): Török, K.¹; Cevallos, D.^{1,2}; Kövendi-Jakó, A.¹; Szitár, K.¹; Halassy, M.¹; Bede-Fazekas, Á.^{1,3}

Affiliation(s):¹ Centre for Ecological Research, Institute of Ecology and Botany, Vácrátót, Hungary; ² Department of Plant Systematics, Ecology and Theoretical Biology, Eötvös Loránd University, Budapest, Hungary; ³ Centre for Ecological Research, GINOP Sustainable Ecosystems Group, Tihany, Hungary

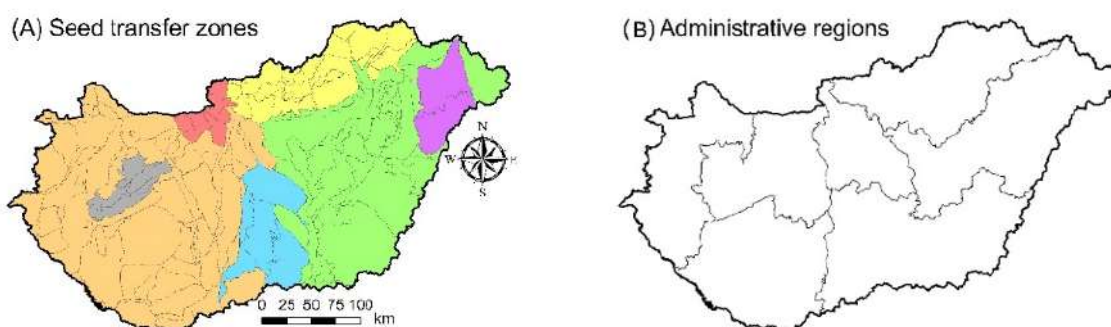
E-mail: torok.katalin@okologia.mta.hu

ABSTRACT

Restoration activities are often based on reintroducing seeds of native species. To avoid the use of maladapted germplasm, seed transfer zones regulate seed provenance. In EU countries a common policy for fodder species exists that was applied by using the seven administrative-territorial units in Hungary. We launched a study to find scientific evidence to change this policy. A base map, drawn by using three biogeographic maps, was filled with predictions of the Multiple Potential Natural Vegetation model. A spatially restricted clustering was performed on the filled polygons of the base map to form contiguous clusters, resulting in the Seed Transfer Zone (STZ) map. An independent systematic grid ('quadrats') was used to estimate the uncertainty of the seven STZs and also that of the seven administrative regions. The comparison discovered the advantage of the STZ map with a much larger area (about 76% of the country) where the zones overlap with the clusters of quadrats as opposed to the administrative regions. The number of tested STZs was adjusted to the seven administrative territories, but the optimal number of zones can be different. Therefore, we used the same methods to test lower and higher number of STZs. Four and seven units provided the best agreement with the independent clusters. It is suggested to change the present Hungarian regulation from administrative units to evidence based STZs. As other studies criticise the EU regulation (EC 2010/60) to limit seed markets, thus hinder large scale restoration, it would be beneficial to join forces to adjust Europe wide and national regulations to the increasing demand of restorative actions for the New Green Deal for Europe's nature.

Keywords: large-scale restoration, local adaptation, native seed propagation, potential natural vegetation, seed transfer regulation

Fig. 1 Maps of the seven evidence based Seed Transfer Zones (A) and the administrative-territorial units (B) that serve as the current regulation in Hungary



The effectiveness of grassland restoration: A systematic literature review

Author(s): Roel Bellot, Alvaro¹; Mills, Morena²; Arlidge, William N.S.³

Affiliation(s): ^{1,2} Centre for Environmental Policy, Imperial College London, London UK; ³IGB Leibniz-Institute of Freshwater Ecology and Inland Fisheries, Berlin, Germany

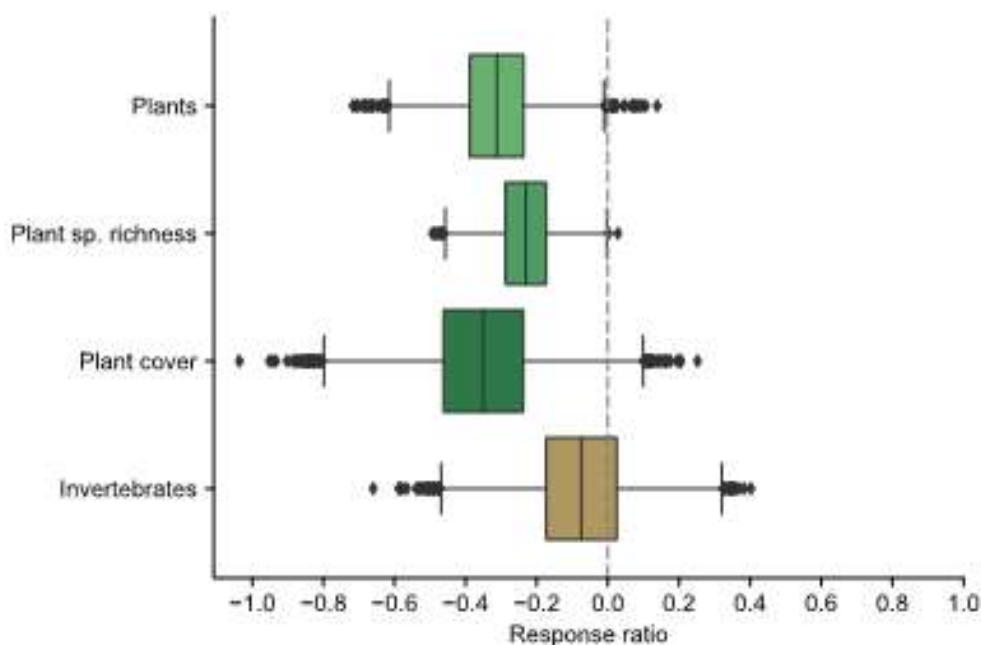
E-mail: alvaro.roel-bellot16@imperial.ac.uk

ABSTRACT

Grassland biomes are some of the biggest, most threatened and degraded in the world. Restoration is our way to recover degraded grasslands. We carried a systematic literature review and meta-analysis on the effectiveness of grassland restoration aiming to improve evidence-based prioritisation between different conservation actions. Restoration proved capable of promoting the recovery of degraded grasslands, but not to the level of natural remnants, highlighting that protection should be prioritised over restoration. Grassland restoration actions are diverse, species propagation and disturbance control their main focus. The literature reviewed shows a clear bias towards North America and Europe, highlighting a gap in the research of threatened tropical grasslands. Few articles reported the monetary cost of interventions hindering decision-makers' ability to consider cost-effectiveness. If effective safeguarding of earth's largest terrestrial biome is to be achieved, further research on the cost-effectiveness of restoration actions and other factors affecting restoration outcomes will be crucial.

Keywords: Grasslands, Strategy/planning, meta-analysis, response ratios, effectiveness.

Figure 1: Bootstrapped response ratios of invertebrates (n=8 (398)), plant species richness (n=22 (438)), plant cover (n=22 (715)) and plants (n=34(1291)) for restored systems compared to reference systems. The 0 line indicates no difference to reference systems. "n" is the number of studies and in parenthesis is the number of observations used in the resampling.



Establishment of *Rhinanthus* in a fertile grassland: importance of seed quality and reduction of competition

Author(s): Rūsiņa, S.¹; Dzedule, L.²; Rābante, L.²; Bikova, J.¹; Krūzmane, M.²; Strazdiņa, B.³; Viti, M.M.⁴

Affiliation(s): ¹University of Latvia, Faculty of Geography and Earth Sciences, Jelgavas iela 1, Rīga, LV-1004, Latvia; ²Institute of Agricultural Resources and Economics, Latvia; ³Latvian Fund for Nature, Latvia; ⁴University of Bologna, Department of Biological, Geological and Environmental Sciences, Italy

E-mail: solvita.rusina@gmail.com

ABSTRACT

Rhinanthus species are well known for their ability to suppress competitive grasses, and they are widely used for grassland restoration. However, in many European countries, *Rhinanthus* seeds of native origin are not available on market, and the alternative would be to collect seeds in nearby donor grasslands. There is limited knowledge about the number of plants that should be collected in order to obtain a sufficient number of mature and viable seeds. Thus, one aim of our study was to assess *Rhinanthus* seed resources and quality in a typical semi-natural grassland. Another issue that we addressed was that while *Rhinanthus* establishes mainly in moderately productive grasslands, the restoration efforts in Europe normally target fertile grasslands. Initial competition amongst vegetation is the main obstacle to a successful establishment of *Rhinanthus*. To overcome this problem, we tested the influence of weeding of sown plots, to facilitate the establishment process. We collected seeds in two separate populations per species. We counted the abundance of individuals and number of seeds. We performed seed germination test and viability test in laboratory.

Sowing experiment was done in a randomized block design in three replicates in six 0.5x2 m plots per species. Germination tests showed that *R. serotinus* performed significantly better than *R. minor* with germination rate 12.0±8.9% and 3.8±2.3%, respectively. The influence of weeding in mid-May was positive and more than 50% of seedlings survived and developed into adult plants by June. We recommend to use the ratio of area 1.2 : 1 (donor site : recipient site) for collecting *Rhinanthus* seeds in order to get at least 100 adult plants per m² that is the recommended number of adult plants for a successful establishment in fertile grasslands.

The study was supported by the GrassLIFE project No: LIFE16NAT/LV/000262.

Keywords: yellow rattle, restoration, post-agricultural, sowing experiment.

Habitat creation for species-rich grassland, heathland and woodland utilising topsoil inversion

Author(s): Putwain, P.¹; Scott, R.²; Lewis, S.³;

Affiliation(s): ¹The University of Liverpool, UK; ²The Eden Project, UK ³Butterfly Conservation, UK.

E-mail: philp@liverpool.ac.uk; rscott@Edenproject.com; phwarden@sky.com

ABSTRACT

Habitat creation on former agricultural soils and are frequently compromised by relatively high soil fertility, a seed bank containing a large population of annual, biennial and perennial 'weed' species and no local source of potential native colonising plants.

There is clear evidence that topsoil inversion, ploughing to a depth of up to 90-100 cm, will reduce surface soil fertility in many UK soils. Reduction in soil phosphorus is a key outcome. The main constraint of this niche approach to habitat creation is the potential existence of archaeological artifacts in the target area. This will necessitate an archaeological investigation before soil inversion is undertaken.

We present several case studies that involved topsoil inversion and describe (a) the creation of plant species-rich mesotrophic grassland from existing vegetation dominated by a few grass species; (b) the creation of lowland heath on former arable farmland and (c) the creation of new woodland with associated forb flora on existing pasture.

An area of species rich meadow (1.5ha) was created at Ness Botanic Gardens, Cheshire (UK), with initial topsoil inversion undertaken in 2008. Monitoring of plant species assembly, soils and pollinators has been undertaken until 2021. At Prees Heath Reserve located in Shropshire (UK), lowland heathland was created (21ha) on existing agricultural land where deep ploughing was implemented in 2007. This was specifically to safeguard a population of the rare silver-studded blue butterfly. Development of heathland vegetation, the butterfly population and soils has been monitored until 2021. Amenity woodland (7ha) was established at Wheeldon Copse, Cheshire (UK) and Lunt, Merseyside (UK) following soil inversion in 2003. Subsequent tree growth and forb layer floristics were monitored and soil data will be presented.

Keywords: Evaluation and monitoring, Grasslands, Heathland, Soils

Phosphorus puts a mortgage on grassland restoration

Author(s): Schelfhout, S.¹; Goossens, E.P.²; De Schrijver, A.³; Vanhellefont, M.³; Verheyen, K.¹; Mertens, J.¹

Affiliation(s): ¹Forest & Nature Lab, Department of Environment, Faculty of Bioscience Engineering, Ghent University, Belgium; ²Plant Biology and Nature Management, Vrije Universiteit Brussel, Belgium; ³Research Centre AgroFoodNature, HOGENT University of Applied Sciences and Arts, Belgium

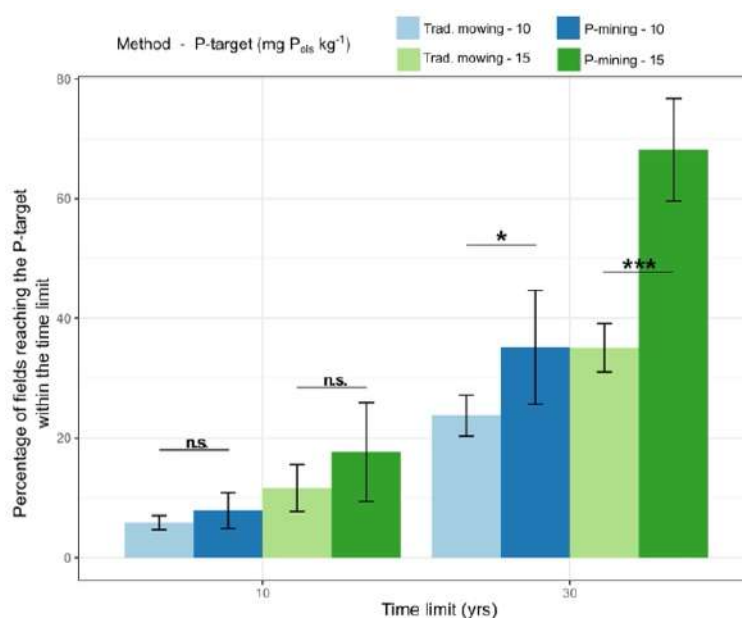
E-mail: stephanie.schelfhout@ugent.be

ABSTRACT

Restoration of species-rich grassland requires time for restoring both abiotic conditions, e.g. low soil phosphorus concentrations, and biotic conditions, e.g. re-introduction of missing target species. We calculated the time needed for restoring phosphorus-poor soil in 507 grasslands in Special Areas of Conservation in northern Belgium. Eleven percent of the grasslands met the strictest soil phosphorus target of 10 mg/kg for target vegetation *Nardus* grassland (H6230*). Mowing management may enable reaching the soil phosphorus target by 2050 in less than 25% of the grasslands with phosphorus-rich soil, whereas P-mining, a more intensive technique involving fertilization with nitrogen and potassium, could help achieve the phosphorus target in about 30% of the grasslands. To reach the ambitious P target, 65% of the phosphorus-rich grasslands would require alternatives such as topsoil removal; choosing a different, less ambitious grassland target might be a better option at several sites. Our calculations do not include the time needed for biotic restoration. We show grassland restoration is a long-term process, hence, we advocate better protection of still existing species-rich grasslands.

Keywords: Ecological restoration, Grasslands, Biodiversity, Restoration strategy/planning, Soils

Fig. 1 The proportion of grasslands (n=452 for 10 mg P_{dis} kg⁻¹ and 416 for 15 mg P_{dis} kg⁻¹) that reach the two P-targets (in blue: strict target, 10 mg P_{dis} kg⁻¹; in green: less strict target, 15 mg P_{dis} kg⁻¹) after P-removal by mowing (light colors) or by P-mining (full colors) for 10 and 30 years. Calculations are based upon removing P from the top 20 cm soil layer. 95% confidence intervals are indicated for our calculated results by flags. Significant differences between mowing and P-mining are indicated with asterisks. Significance levels: n.s. P > 0.05; * 0.01 < P ≤ 0.05; ** 0.001 < P ≤ 0.01; *** P < 0.001.*** (Goossens et al. under review at Restoration Ecology)



Restoration of sand grasslands to replace invasive black locust plantation: effects of long-term mowing

Author(s): Bruna Paolinelli Reis¹ Anna Kövendi-Jakó², Katalin Szitár², Katalin Török², Melinda Halassy²

Affiliation(s): ¹ Eötvös Loránd University, Department of Plant Taxonomy, Ecology and Theoretical Biology Pázmány P. stny. 1/C, 117, Budapest, Hungary

² Centre for Ecological Research, Institute of Ecology and Botany Alkotmány u. 2-4, 2163 Vácrátót, Hungary

E-mail: brunapaolinelli@gmail.com

ABSTRACT

Biological invasion is considered one of the major threats to grassland biodiversity and to self-rehabilitation of natural vegetation. Therefore, nature conservation managers seek the best methods to eliminate invasive species to restore natural habitats. We studied the long-term effect of mowing on the restoration of Pannonian sand grassland at clear-cut black locust (*Robinia pseudoacacia*) plantation in Hungary, Europe. Three *R. pseudoacacia* stands of ca. 1 ha were clear-cut in the winter of 1994-1995 followed by chemical (GARLON 4E) application on tree trunks in the Kiskunság National Park. The three stands were chosen in different landscape matrices; closed forest (Bugac), grassland-forest mosaic (Fülöpháza) and predominantly open grassland area (Izsák). We applied mowing with hay removal twice a year (June, September) as a management to assist open sand grassland recovery between 1995-2001 in six 10 m by 10 m parcels. Success was compared to unmown control and semi-natural grassland reference. Vegetation cover was estimated in 2 m x 2 m plots in June and August each year between 1995 and 1999. Afterwards, we re-sampled Izsák and Fülöpháza six times until 2017 and Bugac once in 2019. Chemical treatment successfully repressed *R. pseudoacacia* in stands surrounded by mostly open landscapes and with repeated mowing for seven years also in closed forest. Significant woody cover developed in unmowed plots, but *R. pseudoacacia* re-established only in Bugac. According to vegetation composition trajectory analyses, vegetation of mowed plots approximated the reference grasslands in sites with nearby open sand grasslands. In these sites, mowing resulted in higher cover of target species compared to unmowed plots, but it still significantly lower than in the reference, as mowed plots were susceptible to secondary invasion. The long-term monitoring demonstrated that initial mowing assisted the restoration of Pannonian sand grassland, but for complete recovery, other interventions are needed.

Keywords: Invasive species, Grasslands, Evaluation and monitoring, Landscape

Fig. 1. Scheme to summarize the methods and objectives of the restoration study



S2.2 – Restoring European grasslands



Relaxing management intensity in mountain grasslands restores plant species richness but not community structure in the mid term: lessons from a controlled experiment.

Author(s): Humann-Guillemainot, S.¹, Boch S.², Lessard-Therrien M.¹, Hayoz-Andrey A.¹, Serres-Hänni A.¹, Humbert J-Y.¹, Arlettaz R.¹

Affiliation(s): ¹Division of Conservation Biology, Institute of Ecology and Evolution, University of Bern, Bern, Switzerland, ²WSL Swiss Federal Research Institute, Zürcherstrasse eleven1, 8903, Birmensdorf, Switzerland

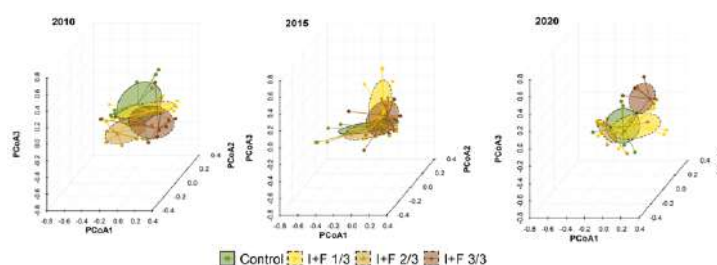
E-mail: segolene.humann@iee.unibe.ch

ABSTRACT

In montane areas around the globe, extensive farming management is currently facing a shift towards agricultural intensification. However, fertilization, irrigation and the increase in grazing/mowing frequency has severe implications on grassland biodiversity. We experimentally investigated the passive restoration capacity of montane and subalpine hay meadows that had been submitted to six years of management intensification, with different levels of fertilization and irrigation, followed by five years of total release of intensification, i.e. extensification. Our randomized block-design experiment started with a first period (2010-2015) during which we exposed four 20-meter diameter plots within eleven extensively managed hay meadows to three intensification regimes (low, medium and high inputs of fertilization and irrigation) or to a control, extensive regime. In a second period (2015-2020), intensification was halted, and all the meadows were extensified. We monitored species richness and diversity (Simpson diversity index), the cover and species richness of three functional groups (legumes, forbs and grasses), indicator species associated with each treatment and the composition and variability of the plant communities based on Bray-Curtis dissimilarities distances. If total species richness was significantly diminished in the most intensified plots after six years of intensification, all plots retrieved their initial species richness after five years of extensification. Additionally, we found no differences in plants diversity (Simpson diversity index) among treatment levels in any of the years. Species richness of forbs was affected by intensification in 2015 but was restored to its initial values after five years of extensification. In contrast, intensification led to different plant communities compared to the extensive, control plots, and this remained the case after five years of extensification, thus inducing a legacy effect. We discuss these results in the context of mountain agro-ecosystems, which offer a species-rich matrix that may favour passive restoration processes.

Keywords: Grassland, Biodiversity, Ecological restoration, Restoration strategy

Figure 1. PCoA ordination plot of the first three axes based on Bray-Curtis dissimilarities of plants community variabilities among the three levels of combined irrigation and fertilization (I+F, with 1/3, 2/3 and 3/3 corresponding to low-, medium- and high-intensity management, respectively) in 2010, 2015 and 2020.



Restoration of grasslands for butterflies and other pollinators

Author(s): Collins, S.¹; Ellis, S.^{1,2}; Sevilleja, C.G.^{1,3}; Foulds, T¹ and van Swaay, C.^{1,3}.

Affiliation(s): ¹Butterfly Conservation Europe, The Netherlands; ²Butterfly Conservation, United Kingdom; ³Dutch Butterfly Conservation, The Netherlands.

E-mail: sue.collins@bc-europe.eu

ABSTRACT

Evidence shows that declines in insects, including pollinators, are serious and continuing. Their loss undermines essential pollination services, valuable to agricultural and horticultural production and to wildflowers. Many pollinator habitats, especially natural and semi-natural grasslands, have lost extent and quality and are still declining. Habitats that depend on agricultural management and that are sensitive to eutrophication are seriously threatened. There is abundant evidence of the state of grasslands and their characteristic biodiversity and the threats to them. BCE analysis of EU Member State's Article 17 Reports underline the poor conservation status of butterflies of European importance and the grassland habitats of insect pollinators; the pressures and threats to them; and the management measures required for their recovery and restoration. Reversing abandonment and reducing agricultural intensification pressures is vital.

To achieve the recovery of pollinators (a target in the EUBDS 2030), measures to protect, sustainably manage and restore their remaining habitats, with connections across the landscape, are essential. Butterflies are considered good indicators and a proxy for the state of insect pollinators because of their quick response to change, sensitivity to their environment and relative ease of identification. Butterflies have been extensively monitored in the field over the last few decades and the grassland butterfly indicator charts declines. The EU ABLE Project "Assessing Butterflies in Europe" added 10 eBMS schemes to a total of 21 active schemes in EU Member States and developed additional butterfly indicators and tools, including the Butterfly Count App. The EU PPA SPRING Project, will test implementation of the EU Pollinator Monitoring framework and complete the eBMS network right across the EU. Sound data is vital for development and evaluation of effective conservation and restoration actions.

Keywords: Pollination, Grasslands, Biodiversity, Landscape, Restoration planning

Restoration of orchid-rich dry calcareous grasslands by rotational goat pasturing

Author(s): Köhler, M.; Tischew, S.

Affiliation(s): Anhalt University of Applied Sciences, Germany

E-mail: martina.koehler@hs-anhalt.de

ABSTRACT

Dry calcareous grasslands are one of the most species-rich habitats in the cultural landscape of Central Europe. Due to large-scale abandonment driven by socio-economic changes during the last century, shrub encroachment is one of the main threats to many orchid-rich calcareous grasslands. Goat pasture has been reported to efficiently restore highly shrub encroached habitats. However, positive effects may be opposed by negative effects on target species, in particular, orchids, but long time data on goat-restored orchid sites is still rare. Over 10 years, we studied the development of large-scale woody plant cover and plant species on 12 permanent 25-m² plots in a spring, summer and autumn goat paddock and three ungrazed control slopes. In the summer paddock and an adjacent ungrazed site, where the largest population of the main orchid target species *Ophrys sphegodes* occurred, individual number, leaf index, number of blossoms and seed capsules, annual recruitment, mortality, and vegetative dormancy were observed on seven 1-m² plots. Woody plant cover was significantly reduced in all paddocks with best results in the spring and summer paddock, whereas the ungrazed control showed a significant increase. The number and cover of characteristic dry calcareous grassland species increased or remained stable in grazed sites, whereas they finally declined in ungrazed sites. *O. sphegodes* individual number significantly increased in the summer paddock and ungrazed plots. Grazing promoted a higher recruitment probably due to enhanced light availability and the creation of open soil. We conclude, that goat pasturing is suitable to restore shrub encroached dry calcareous grasslands with a higher efficiency in spring and summer. Generally, the high year-to-year variations of orchid species call for a long-term scientific monitoring to evaluate the restoration outcomes.

Keywords: open landscape conservation, target plant species, woody plant encroachment, *Ophrys sphegodes*, *Trinio-Caricetum humilis*

Fig. 1 Goat browsing on woody plants significantly reduced woody plant cover on formerly heavily encroached dry calcareous grasslands.



Seed trait variability and seed transfer zones: lack of correspondence in sand grassland species

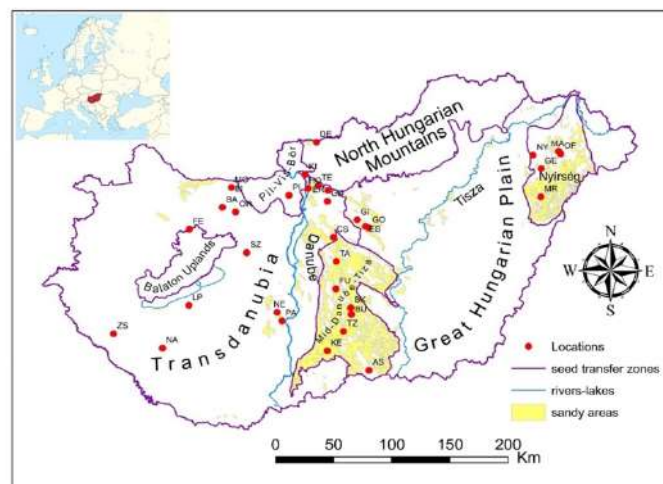
Author(s): David Cevallos^{1,2}, Katalin Szitár^{2,3}, Melinda Halassy², Anna Kövendi-Jakó², Katalin Török²

Affiliation(s): ¹ Department of Plant Systematics, Ecology and Theoretical Biology, Eötvös Loránd University, Budapest, Hungary ² Centre for Ecological Research, Institute of Ecology and Botany, Restoration Ecology Research Group, Vácrátót, Hungary ³ Centre for Ecological Research, Institute of Ecology and Botany, Lendület Landscape and Conservation Ecology Research Group, Vácrátót, Hungary

E-mail: david_cevallos@hotmail.com

ABSTRACT

Using maladapted populations can produce a failure on restoration projects when seeds are transferred to non-local habitats. Seed transfer zones (STZs) can guide restoration practice to avoid this failure. Based on biogeographic maps and potential natural vegetation models, we previously delineated STZs for Hungary. The goal of this study was to use seed traits from sandy grassland populations to compare the pattern of their variability to the zones. Seeds from two dominant grasses (*Festuca vaginata* and *Stipa borysthenica*) and two accompanying forbs (*Dianthus serotinus* and *Centaurea arenaria*) were collected from 34 different sand grassland habitats within Hungary. We evaluated the influence of localities, different types of distances, e.g., geographical (Euclidean), ecological (related to STZ), and environmental (related to aridity) among different sites using three distinct traits (seed mass, germination and emergence) using a common garden. Seed trait differences between populations of the studied species were identified in search of a signal of local adaptation or phenotypic plasticity. Except for the emergence of *C. arenaria*, geographic distance had no impact on seed trait variability. Except for the seed mass of *C. arenaria*, ecological distance expressed in STZ delineation did not explain seed trait heterogeneity in the studied species. The two forbs were affected by aridity, but not the grasses, in terms of germination or emergence. We do not recommend restricting seed transfer among populations of the studied species over the sampled area based on our findings. More genetic research and measurements of other species characteristics from different habitat types may complement these findings and lead to more general conclusions.



Keywords: aridity, germination, ecological distance, geographical distance, local provenance, emergence, Pannonian region, thousand seed weight.

Fig 1: This map displays the 34 different localities within sandy regions in Hungary (Pásztor et al. 2018) with the seed transfer zone borders (Cevallos et al. 2020), where the seeds from the studied species were collected. Location codes and coordinates can be found in Table S1. The Pilis-Visegrád-Börzsöny region is abbreviated as Pil-Vis-Bör.

Relative effectiveness of seeding methods for restoring or re-creating species rich grasslands: a systematic review

Author(s): Slodowicz, D.¹; Durbecq, A.^{2,3}; Ladouceur, E.^{4,5,6}; Eschen, R.⁷; Arlettaz, R.¹; Humbert, J-Y.¹

Affiliation(s): ¹Division of Conservation Biology, Institute of Ecology and Evolution, University of Bern, Switzerland; ²Mediterranean Institute of Biodiversity and Ecology (IMBE), Avignon University, CNRS, IRD, Aix-Marseille-University, Avignon, France; ³Engineering consulting ECO-MED, Marseille, France; ⁴German Centre for Integrative Biodiversity Research (iDiv), Halle-Jena-Leipzig, Germany; ⁵Department of Computer Sciences, Martin Luther University, Halle-Wittenberg, Germany; ⁶Department of Physiological Diversity, Helmholtz Centre for Environmental Research – UFZ, Leipzig, Germany; ⁷CABI, Delémont, Switzerland

E-mail: daniel.slodowicz@iee.unibe.ch

ABSTRACT

Extensively managed grasslands in temperate regions can harbour a variety of plant and invertebrate species. Yet, they have suffered from habitat loss and degradation in the past decades, mainly due to agricultural intensification. Grassland restoration and re-creation through active seed addition has gained in importance in the recent years. Restoration measures including hay transfer (Fig. 1), seeding of a species rich seed mixture, and soil preparation such as ploughing, or power harrowing may help to improve biodiversity. However, the relative effectiveness of these measures remains poorly known. Here, we ask what the relative effectiveness of these restoration methods is on plant and invertebrate biodiversity. We conducted a systematic review to scrutinize the peer-reviewed and grey literature dealing with at least one of the above-mentioned seed addition methods. We included only studies which were carried out in temperate Europe, with a study duration of three years or more. We then conducted a meta-analysis with studies having a low risk of bias and a qualitative analysis with studies having a medium risk of bias using descriptive statistics.

Preliminary results suggest that a robust comparison of restoration methods is hardly possible. In addition, very few studies focused on the effect of grassland restoration on invertebrates. The focus was almost exclusively on plants. We propose a standardized way to report results in restoration studies and to put more study effort into understudied groups, such as invertebrates or soil biota.



Keywords: Grasslands, Biodiversity, Species reintroduction

Fig. 1 Hay transfer on a ploughed meadow in Pfaffnau (Switzerland) in June 2019.

Fig. 2 Distribution of grassland restoration sites in temperate Europe. Each dot represents one site. Several dots may be part of a single study. Green dots are study sites that were included in the meta-analysis. Red dots are study site that could not be included in the meta-analysis.

Suppressing an invasive native species in wet grasslands – effects of designed mixtures and management

Author(s): Teixeira, L.H.¹; Möhrle, K.¹; Krieger, M.T.¹; Kollmann, J.¹

Affiliation(s): ¹Chair of Restoration Ecology, TUM, Germany

E-mail: leonardo.teixeira@tum.de

ABSTRACT

Invasive plants can be both cause and consequence of environmental degradation in natural ecosystems. The poisonous hemi-cryptophyte *Jacobaea aquatica* is an example of such a challenge. Although being a native species to Central Europe, it became an invasive plant in wet grasslands due to intensified or reduced management, which affects species distribution and composition of grassland communities. Therefore, the species is both a response to changes in management and a factor of declining environmental quality of wet grasslands. Here, we present the results of a series of projects on the suppression of this native invasive plant.

To develop and to test control methods for *J. aquatica*, we conducted greenhouse and field experiments on the effects of seed mixtures specifically designed to match the functional trait space of *J. aquatica*. We also studied the effects of changed mowing and fertilization on frequency, biomass, vegetative and generative growth of this species. We observed that manipulating plant traits of specifically designed seed mixtures can be an effective technique for suppression of *J. aquatica*, when including species with high values in leaf area and producing many seeds. Increasing shade within the grasslands is a promising technique for controlling vegetative growth of *J. aquatica*. However, this might imply reduced mowing of wet grasslands, which compromises fodder quality. Thus, a combination of sowing with specifically designed seed mixtures and increasing stand density should produce better results than applying only one of these approaches.

Keywords: design of seed mixtures, grassland management, shading effects, trait-based restoration, weed control



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S8.1 – Near-natural restoration of urban green infrastructure

Connectivity of urban green and blue infrastructures: living veins for microbial diversity?

Author(s): Neuenkamp, Lena¹; Alos-Orti, Marta²; Hallikma, Tiit²; Öpik, Maarja³; Laanisto, Lauri²
Affiliation(s): ¹Bern University, Switzerland, ²Tartu Applied Science University, Estonia, ³Tartu University, Estonia
E-mail: lena-neuenkamp@web.de

ABSTRACT

Nature is the lifeblood of urban environments. Parks bring urban residents clean air, cooler temperatures, beauty and wellbeing. Parks act as corridors for many animals, plants, and other living things that need nesting spots, food, and ways across the city. The presented research is part of the Biodiversa project <Bioveins>, which investigates how cities can care for nature while nature cares for cities. These investigations include many organism groups such as plants, insects, birds, spiders and soil microbes in seven European cities along a North-South gradient, focussing on the role of habitat structure and connectivity across parks within each city for the diversity of the studied organism groups. While drivers of plant, insect and bird diversity in urban greenspace have been in the focus a while already, we know far less about microbial diversity, despite the important links between e.g. soil bacteria and fungi on plant diversity, biomass production and other ecosystem functions. Does microbial diversity differ between urban and natural habitats? How well do microbial taxa distribute among parks within and across cities? Based on molecular data of soil bacteria and fungi collected from all seven Bioveins cities, our preliminary results indicate substantial variation in microbial diversity and composition among cities. Variation between cities was stronger for fungal than bacterial diversity with the tendency of the former to decrease towards South-located cities. Park size and soil properties were additional drivers of fungal and bacterial diversity and composition, respectively. These results suggest dispersal limitation or habitat filtering by soil and climatic conditions as potential factors shaping microbial communities in urban parks. Our results will shed light on the peculiarities of microbial communities in urban compare natural habitats, regarding its diversity, composition, functioning and finally the need of considering soil microbial communities in the restoration and management of urban habitats.

Keywords: Urban and periruban environments (invited by the organisers of the session "Near-natural restoration of urban green infrastructure", V. Klaus, myself and others)

Figure 1: Sampling sites and sampling equipment in the parks of Zürich (CH), summer 2019). Picture taken by L. Neuenkamp.



Designing an effective urban green infrastructure for the city of Bilbao (Basque Country, Northern Spain)

Authors: *Méndez-Fernández, L.*¹; *Fernández de Manuel, B.*¹ *Peña, L.*¹; *Ametzaga-Arregi, I.*¹

Affiliation(s): ¹*UNESCO Chair on Sustainable Development and Environmental Education, Department of Plant Biology and Ecology, University of the Basque Country (UPV/EHU), P.O. Box 644, Bilbao 48080, Spain*

E-mail: leire.mendez@ehu.eus; beatriz.fernandezd@ehu.eus; lorena.pena@ehu.eus; ibone.ametzaga@ehu.eus

ABSTRACT

In recent years, the contribution of urban green infrastructure (UGI) to the mitigation of climate change and to the human well-being has been demonstrated in numerous studies. A method to evaluate such contributions is to measure the ecosystem services (ES) provided by the vegetation or water bodies present in urban green and blue spaces (UGBS) that constitute the UGI. The objective of this study is to map and evaluate ES supply and demand in the different urban neighbourhoods of the city of Bilbao (Basque Country, Northern Spain) to analyse the mismatch or coincidence in four ES: run-off retention, air purification, cooling and carbon sequestration. Demand was evaluated based on indices from the literature and i-Tree software, while the ES demand was quantified using the percentage of inhabitants in each urban neighborhood, except for run-off retention. A total 30120 urban tree individuals were quantified with GIS, belonging to 248 species. The most common species were *Tilia cordata* (9.3%), *Ligustrum japonicum* (7.8%), *Betula pendula* (6.4%) and *Platanus hybrida* (6.3%). The results indicated that there was a clear mismatch between ES supply and demand in the study area, where in the 35% of the neighborhoods the actual UGBS do not satisfy the demand for ES. Hence, those areas lacking ES supply spaces should be a priority when planning new green areas (parks, tree lines, urban gardens) within the municipality. This could be done by selecting the type of urban green structure planned, and improving the net efficiency of the urban green infrastructure.

Keywords: Ecosystem services, Urban and periurban environments, Biodiversity, Rewilding, Restoration strategy/planning.

Supporting regional biodiversity by native species introduction on extensive green roofs in northwestern Germany

Author(s): Päscher, F.¹; Jeschke, D.¹; Schröder, R.²; Kiehl, K.¹

Affiliation(s): ¹ Osnabrück University of Applied Sciences, Germany

² German Federal Environmental Foundation (Deutsche Bundesstiftung Umwelt DBU), Germany

E-mail: f.paesch@hs-osnabrueck.de

ABSTRACT

In many cities the spatial extent of urban green infrastructure is declining due to ongoing urbanization. This results in a loss of important ecosystem functions like water retention, temperature regulation and habitat function for biodiversity. Green roofs can reduce or mitigate negative environmental effects of urban densification to some extent, but conventional green roofs are mostly species poor and often contain non-native plant species (incl. cultivated varieties of *Sedum* and *Phedimus* species). We studied the suitability of plant species of sandy dry grasslands (Koelerio-Corynophoretea) for extensive roof greening in northwestern Germany. In our experiments we use species-rich mixtures of native plant species of regional origin to enhance the habitat function of extensive green roofs (EGR) for regionally typical insect species. We tested the effects of different measures of species introduction (seeding, transfer of raked material), the effects of substrate and layering on vegetation establishment and persistence on green roofs of 500 m² to 10000 m² area. Establishment rates of the sown native plant species ranged from 88.4 to 90.7 % in the first and from 67.4 to 76.7 % in the second vegetation period after start of the experiment. 61 vascular plant species were introduced by raked material out of which 42 were also found in the second year. In 2020 we started to investigate the suitability of the established EGR vegetation for flower-visiting insects. In this talk we will present key results of our ongoing experiments and give recommendations for successful roof greening intended to support regional native biodiversity.

Keywords: roof greening, native plant, insects, vegetation, dry grassland

Fig.1: Extensive green roof in Osnabrück, northwestern Germany



Invasive species as challenge for ecological restoration. Biotic resistance of plant communities and alien propagule pressure predict invasion during urban grassland restoration

Main coordinator: Halassy, Melinda

Main coordinator affiliation: *Institute of Ecology and Botany, Centre for Ecological Research, Vácrátót, Hungary*

Main coordinator E-mail: halassy.melinda@okologia.mta.hu

Author(s): Kollmann, Johannes¹, Rojas Botero, Sandra Liana¹, Teixeira, Leonardo H.¹

Affiliation(s):¹ *Chair of Restoration Ecology, Technical University of Munich*

ABSTRACT

Invasive alien plants challenge restoration of many ecosystems. Thus, understanding the factors that determine the establishment of invasive plants is crucial to improve restoration outcomes. While some drivers of invasibility of plant communities have been studied, the results are inconsistent, and potentially interacting effects have not been addressed. Here, we investigate the contribution of three drivers of invasion success during early phases of restoration of urban grasslands, i.e. biotic resistance, invasive propagule pressure and environmental fluctuations. We compared the contribution of these drivers in a series of mesocosms experiments using designed urban grasslands as a model system, and *Solidago gigantea* as invasive species. Two communities were prepared according to competitive trait hierarchies with different sowing patterns, reflecting variation in biotic resistance. We then manipulated invader propagule pressure and applied different scenarios of environmental fluctuation, i.e. flood, heat and fertilization. Alien biomass was considered as proxy for invasion success, while native biomass represented restoration success. There were consistent effects of biotic resistance to *S. gigantea* invasion via competitive trait hierarchies in the three experiments. Communities dominated by species with high-competition traits were more resistant regardless of environmental fluctuation. Clumped seeding of the native community reduced invasibility, whereas larger invasive propagule size increased invasion success. The effects of environmental fluctuation were context-dependent and played a secondary role when compared to biological drivers of invasion. Thus, restoration initiatives on urban grasslands potentially impacted by invasive plants should consider biotic resistance as a key driver for reducing establishment of invasive species during community assembly.

S8.2 – Near-natural restoration of urban green infrastructure

People's preferences for the invasive tree *Ailanthus altissima* and its management in cities

Author(s): Leonie K. Fischer^{1,2,3*}; Tanja M. Straka^{2,3}; Mario Lehmann²; Rafael Studnitzky²; Kowarik, Ingo^{2,3}

Affiliation(s): ¹University of Stuttgart, Institute of Landscape Planning and Ecology, Keplerstraße 11, D-70174 Stuttgart, Germany; ²Technische Universität Berlin, Institute of Ecology, Rothenburgstr. 12, D-12165 Berlin, Germany; ³Berlin-Brandenburg Institute of Advanced Biodiversity Research (BBIB), D-14195 Berlin, Germany

E-mail: leonie.fischer@ilpoe.uni-stuttgart.de

ABSTRACT

Urban areas are becoming denser, more artificial and extremer habitats from an ecological viewpoint. Yet, there are species that thrive, and that often establish under such hard conditions. In some contexts, such a “rewilding” and spontaneous growth is included as site-specific natural elements – both in people’s everyday uses, and into landscaping approaches. Berlin, Germany, is one of the cities where tree species such as *Ailanthus altissima* (tree of heaven) are abundant and find their way into transformative open space approaches. Nevertheless, looking through the lenses of restoration and biodiversity experts, the backsides may be revealed: management measures need to be established due to the EU-Regulation on Invasive Alien Species that since 2019 also includes *Ailanthus*. Still, for achieving broad acceptance of management measures, the perspectives of diverse actors within cities need to be combined. Therefore, we assessed people’s preferences for the invasive tree *Ailanthus altissima* and its management in the model city of Berlin, Germany. With reference to four different urban contexts, we asked both practitioners and laypeople in which urban settings they like or dislike *Ailanthus*, and what management strategy (choice of three) they would accept. With a data set of nearly 200 respondents, our findings show very clearly that the picture is not a black-and-white one; that people actually liked *Ailanthus* in park-like situations but had less clear preferences for *Ailanthus* in informal situations. Generally, people supported the removal of *Ailanthus* in problematic cases, and supported to leave situations as they are otherwise. With regard to people’s sociocultural and expert background, some distinctions in preferences were revealed. In sum, integrating people’s views on invasive species and their management could support novel management strategies for urban contexts that include social, cultural and ecological matters.

Keywords: Communication / participation; Invasive species; Landscape architecture; Restoration strategy/planning; Urban and periruban environments

Fig. 1 The non-native tree *Ailanthus altissima* (tree of heaven) is abundant in many cities nowadays, and often forms nature elements in both formal as well as informal greenspace settings. Yet, it is unknown, how people like or dislike the species and how they would accept possible management approaches. Photo credit L. Fischer.





Alien species in vegetation succession: participation, temporal trends and determining factors in various central-European series

Author(s): Ballesteros, M.¹, Vítovcová, K.¹, Řehouňková, K.¹, Müllerová, A.¹, Janečková, P.¹, Pospíšilová, P.¹ and Prach, K.^{1,2}

Affiliation(s): ¹ *Department of Botany, University of South Bohemia, Branišovská 1760, CZ-37005 České Budějovice, Czech Republic;* ² *Institute of Botany, Czech Academy of Sciences, Dukelská 135, CZ-37981 Třeboň, Czech Republic.*

E-mail: miguelballesterosjimenez@gmail.com

ABSTRACT

A systematic analysis of vegetation successions following disturbance can outline general invasion patterns and contribute to the management of disturbed and natural ecosystems. Here the participation of alien plant species, with special regard to neophytes, was compared in 20 types of successional series in the Czech Republic, central Europe, to detect possible trends and factors supporting their occurrence. Based on 3,473 samples of spontaneously established vegetation, we used linear mixed models and multivariate analyses to assess how alien species were influenced by successional age, average annual temperature and precipitation, altitude, geological substrate, and surrounding land-cover. Out of 1,035 plant taxa recorded, 839 were natives, 129 archaeophytes and 67 neophytes. The primary or secondary status of series may influence the participation of neophytes but was not determinative. The most invaded successional series were those in deforested landscapes at lower altitudes. Altitude plus climate, substrate and degree of urbanisation shaped the general vegetation pattern and occurrence of aliens. Neophytes were additionally benefited by density of roads and railways and extent of arable land in the surrounding landscape, confirming that these land uses are relevant invasion pathways and should be targeted in prevention strategies. Alien participation is low and mostly declines in later stages, with few neophytes becoming locally dominant over time. This supports spontaneous succession as a suitable restoration option and places the focus on an early detection of potentially problematic species. These findings may contribute to guiding decisions in landscape restoration and the management of disturbed sites under central European conditions.

Keywords: biodiversity, ecological restoration, invasive species, landscape, succession.

S22 - Increasing the ecological value of forests



Restoration, management and valorisation of PRiority habitats of MEDiterranean coastal areas

Author(s): Valenti Roberto¹, Cambria Vito Emanuele²; Georgiadis Christos³, Attorre Fabio¹

Affiliation(s): ¹Sapienza University of Rome, Department of Environmental Biology, Italy, ²University of Padova, Italy, ³Hellenic Protection Society of Nature, Greece

E-mail: roberto.valenti@uniroma1.it

ABSTRACT

In the summer of 2003, 40% of the floodplain coastal forest of Palo Laziale, 38 km far from Rome (Italy), collapsed in an area where many EU priority habitats are currently widespread.

In 2008 the site owners entrusted the Sapienza University of Rome to identify the primary causes that caused this dramatic case of forest dieback. A multidisciplinary study hypothesized a series of triggers, including an increase in drought due to climate change, an accumulation of salts in the soil due to excessive evapotranspiration of water, increasing competition for resources between plants due to the abandonment of the coppice.

The combination of these factors has probably caused strong stress conditions and allowed a weakness parasite, *Biscogniauxia mediterranea* fungus, to progress to a strongly pathogenic phase, causing the death of a great number of trees.

In 2018, with the approval of the project LIFE PRIMED (LIFE17 NAT/GR/000511), the study carried out in the 2008 was upgraded to fill the 10-year gap with the latest methods of investigation.

As regards the soil analysis, the latest findings suggest that the highly heterogeneity of the soil texture could have played a key role in the forest dieback.

This jeopardized variability, with some areas with high presence of clay (17 out of 23 pits have clay values greater than 30%) and sand (20 out of 16 above 35%), might have indeed exacerbate the magnitude of the drought stress undergone by the adult individuals of oak trees.

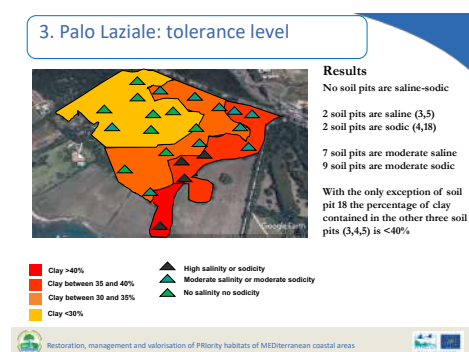
On the contrary, the contribution in salinity/sodicity of the soil seems to be not so significant, and in any case no relief is contextually saline/sodium..

Newly emerged indications like these, along with the others, will help orienting the next project stages and to adjust the ongoing LIFE PRIMED's restoration solutions to the ecological needs of Palo Laziale.



Fig. 1: Picture of one of the many temporary ponds

Fig 2: Map of "Tolerance level" of the area



Maternal effect of decay on alder regeneration in its Southern limit: prospects for passive restoration

Author(s): Vieites-Blanco, C.¹; Gomes Marques, I.¹; Cupertino, A.¹; Caperta, A.D.²; Rodrigues, A.P.¹; Rodríguez-González, P.M.¹

Affiliation(s): ¹*Centro de Estudos Florestais, Instituto Superior de Agronomia, Universidade de Lisboa, Lisboa, Portugal;* ²*Linking Landscape, Environment, Agriculture and Food (LEAF), Instituto Superior de Agronomia, Universidade de Lisboa, Lisboa, Portugal*

E-mail: cristinavieites@isa.ulisboa.pt

ABSTRACT

Alder riparian forests are key to maintain ecosystem services such as water quality, flood mitigation and biodiversity. However, alders are suffering massive decline and mortality in Europe due to the emerging invasive pathogen *Phytophthora xalni*, which is now spreading in Portugal and where it adds to other historic threats to the species (e.g. alterations to fluvial systems, climate change). There is still a lack of information on the effects of maternal infection and geographical provenances in the germination and establishment of the progeny. Understanding the effect of alder decay on its recruitment is crucial for forecasting the success of passive restoration and for the maintenance of essential ecosystem services, prioritized by the Sustainable Development Goals.

In four hydrographic basins across Portugal's latitudinal range (41°-37° N), mature cones were sampled from asymptomatic (i.e. no clear decay symptoms) and symptomatic alders (i.e. decay symptoms such as stem necrosis) (8 per basin). Seeds were germinated in controlled conditions of temperature and light, evaluating germination each two days for 21 days. Then, seedlings were maintained in a peat:sand mixture and under controlled temperature and light conditions for 7 months, regularly monitoring survival, growth and number of leaves.

Our results showed that alder decline affects the next generation. Germination was higher in seeds from symptomatic mothers than from asymptomatic mothers, observing the highest germination rates in seeds from symptomatic mothers from the Northern basins. However, early growth was similar for seedlings from symptomatic and asymptomatic mothers. Further studies are needed that envisage other possible effects on the progeny (e.g. physiological, currently under study) and larger temporal spans.

Keywords: Forests/woodlands, Invasive species, Rivers

Introducing *Acacia mangium* in the forest plantations of the Congolese coastal plains: A new ecological screen?

Author(s): Koutika L-S.¹, Merino A.²

Affiliation(s): ¹Research Centre on the Durability and the Productivity of Industrial Plantations (CRDPI), Av. Ma Loango Moe Poaty BP 1291, Pointe-Noire, Republic of the Congo. ²University of Santiago de Compostela, Spain, Department of Soil Science and Agricultural Chemistry, 2702 Lugo, Spain.

E-mail: ls_koutika@yahoo.com, agustin.merino@usc.es

ABSTRACT

Research conducted in the native tropical savannas in the Congolese coastal plains has regional importance. Afforestation of native savannas of Congolese coastal plains using eucalyptus started in the 1950s to prevent natural forest ecosystems, provide wood for the pulp industry and fuel energy for the rural population, and, currently, to mitigate climate change. Inherently poor status of the soils beneath plantation has been worsened by both nutrient depletion at harvest and lack of fertilizers due to their high cost. *Acacia mangium* have been introduced in the 1990's to sustain forest plantations, replenish the soil's chemical, physical and biological fertility, and to enhance climate change mitigation through C sequestration in both soil and biomass. Changes have been also reported at ecological scale through a higher microbial activity in the forest floor of mixed-species plantations. This reveals a lower thermal recalcitrance and aromaticity (NMR spectroscopy), i.e., a faster decomposition/humification rate along with a higher extractable P concentrations and more organic P preventing their loss relative to pure plantations. Therefore introducing *A. mangium* in these forest plantation might have brought not only a new ecological screen owing to a mechanism able to improve soil fertility and sustain forest productivity, e.g., ensure the P requirement in this P-poor ecosystem, but it also could potentially benefit the C sequestration and climate change mitigation. However, the balance of some potential environmental risks due to its invasiveness i.e., major negative impacts to biodiversity and ecosystem functioning and the benefits for development i.e., improving soil fertility in forestry, agroforestry and agriculture and restoring degraded lands, must always be considered.

Keywords: Climate change, coastal, forests, invasive species, soils.

Innovative production of wide variety forest seedlings enhancing regeneration and biodiversity (VERENIKE)

Author(s): Radoglou, K.^{1,2}, Spyroglou, G.², Iakovoglou, V.², Kiourtsis, F.³, Maslarinou, O.⁴, Karaisaridis, S.⁴, Giannakos, S.⁴, Margheriti, E.⁵ and Giannissi, S.⁵

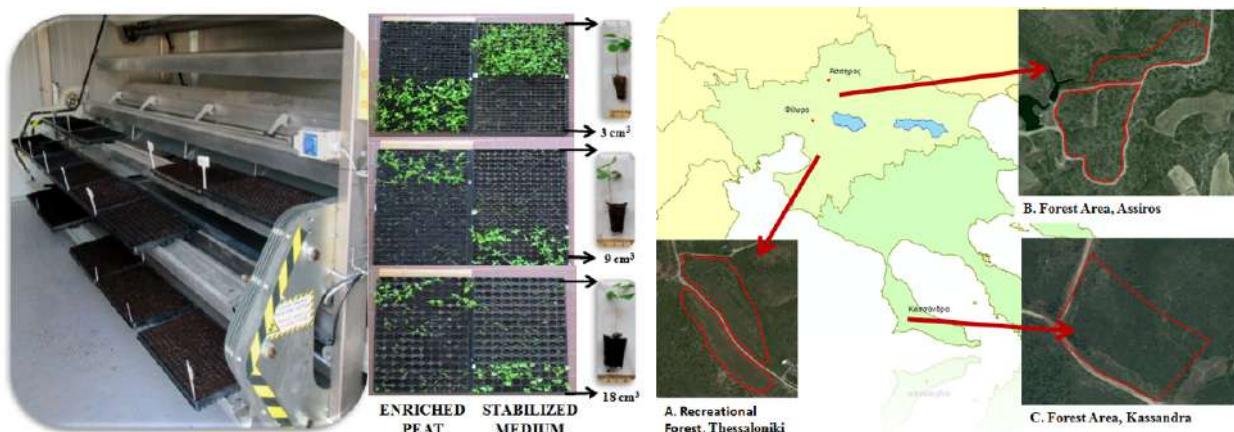
Affiliation(s): ¹ Department of Forestry and Management of the Environment and Natural Resources, Democritus University of Thrace, Greece, ² Forest Research Institute, Hellenic Agricultural Organization Dimitra, Thessaloniki, Greece ³ Decentralized Administration of Macedonia & Trace-Directorate for Coordination and Supervision of Forests, Greece ⁴ Decentralized Administration of Macedonia & Trace-Directorate for Reforestation in Central Macedonia, Greece, ⁵ Vivai Torsanlorenzo, Italy

E-mail: kradoglo@fmenr.duth.gr, radoglou@fri.gr

ABSTRACT

VERENIKE LIFE09 NAT /GR/000326 project efforts in maintaining high biodiversity levels in reforestation. This task is even harder when trying to regenerate disturbed ecosystems, especially under harsh dry summer conditions that is usually the case for Mediterranean ecosystems. Verenike project attempted to enhance biodiversity and regeneration success by engaging innovative new technology, traditional seedling production techniques, and scientific knowledge. The project was comprised of actions that facilitated the steps, starting from the beginning of the project's actions such as "seed collection", the intermediate steps to help with the completion, through the successful ending step of the project, like evaluating the project regenerated seedlings. Twenty-six (26) Mediterranean forest species (shrubs and trees) were used to complete all the steps. For the species, seed collections were completed, and germination protocols were created for all of them. Growth protocols were developed to achieve better seedling quality. Also, seedlings were grown through the innovative use of the "prototype unit", an automated controlled growth conditions machine that enabled the vast production of seedlings through mini-plugs. All the seedlings, including those grown under the standard nursery methods, were produced and planted at three regenerated sites of Northern Greece, Assiro, Filyro and Kassandra. Results indicate that the characteristics of the regenerated sites and the species that are aimed to be planted are crucial and determine the success of the regeneration effort. The seedling survival indicated that Kassandra had the highest regeneration success that was followed by Assiros and Filyro.

Keywords: reforestation, regeneration success, semi-arid ecosystems, survival, forest nurseries.



Effects of the nitrogen form on plant quality of quercines and on *Tuber* spp. mycorrhization

Author(s): Uscola, M.¹; Rio, L.¹; Lei, X.²; Oliet-Palá, J.³; Benito Matías, L.⁴; Álvarez-Lafuente, A.⁵.

Affiliation(s): ¹Dpto de Ciencias de la Vida, Universidad Alcalá, Spain; ²Key Laboratory for Silviculture and Conservation, Beijing Forestry University, China; ³ Dpto de Sistemas y Recursos Naturales.

Universidad Politécnica Madrid, Spain ⁴INIA - Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria, Spain; ⁵TRAGSA CNRGF “El Serranillo”, Spain.

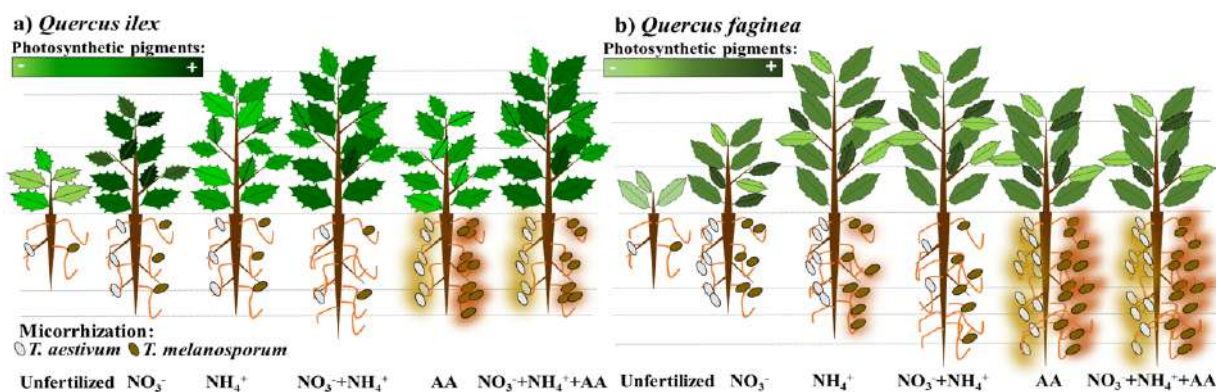
E-mail: mercedes.uscola@uah.es

ABSTRACT

Truffle plantations are a potential reforestation tool, with the benefit of the high economic value of truffles. In the nursery production of seedlings mycorrhized with *Tuber* spp., seedlings are rarely fertilized or they are fertilized at very low doses to avoid negative effects on the mycorrhizae. However, low fertilization hinder plant quality. To optimize the success of seedling establishment and early years performance of truffle plantations, it is necessary to reconcile both practices, fertilization and mycorrhization, increasing plant quality and maximizing mycorrhizal colonization. The nitrogen (N) form in the fertilizer has remarkable morphophysiological effects on plants, but its effect on truffle species and its colonization of roots is unknown. Specifically, organic N, given its lower metabolic cost and its carbon content, would benefit both, plant and mycorrhizal partner. We evaluated the effect of N forms individually or in mixtures on plant quality of two quercines (*Quercus ilex* and *Q. faginea*) and on the mycorrhization with *Tuber melanosporum* and *T. aestivum*. Unfertilized seedlings showed low development and low *Tuber* spp. Mycorrhization. In general, both quercines showed highest development when fertilized with ammonium or inorganic N mixtures, intermediate with organic N or mixtures of all N forms and lowest with nitrate. Mycorrhization with both species of *Tuber* increased with fertilization, although the effect depended on the N form. Organic N, alone or in mixture, was the N form that maximized mycorrhization for both species of *Tuber*. These results show that the fertilizer formulation and, specifically, the choice of the N form, is key to maximizing both, plant quality and mycorrhization.

Keywords: ammonium, amino acids, nitrate, photosynthetic pigments.

Fig. 1 Organ mas (indicated by the size of the organ), photosynthetic pigments (green intensity of leaves) and mycorrhizal colonization by each *Tuber* species (number of symbols) in both *Quercus*.



S12.1 – The Global Dryland Ecosystem Program and beyond



12th SERE CONFERENCE
7th – 10th SEP 2021
online



Global Dryland Ecosystem Programme (Global-DEP): Background, Conceptual Framework, and Research Highlights

Author(s): Fu, B.^{1,2}; Stafford-Smith, M.³

Affiliation(s): ¹State Key Laboratory of Urban and Regional Ecology, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085, China; ²Affiliation, Country University of Chinese Academy of Sciences, Beijing 100049, China; ³CSIRO Land and Water, Canberra, ACT 2601, Australia

E-mail: bfu@rcees.ac.cn

ABSTRACT

Given the increasing speed and intensity of ongoing climate change and human interventions, more systematic research is needed to realize the Sustainable Development Goals (SDGs) in drylands. In 2017, the Global Dryland Ecosystem Programme (Global-DEP) was proposed by a joint research team from different countries committed to address the challenges faced by the diverse and fragile dryland social-ecological systems (SESs). As a synthesis of previous studies on dryland SESs and insights from various regional consultations, we developed the conceptual framework of Global-DEP with SESs as the core, driving forces, impacts, feedback and scale as the key elements. We identified four key themes (1) dryland SES dynamics and driving forces, (2) dryland SES structure and functions, (3) dryland ecosystem services and human well-being, and (4) ecosystem management and sustainable livelihoods in drylands. The themes and their linkages were then analysed to outline 12 research priorities. The conceptual framework and research priorities were the basis for the Global-DEP science plan, which is intended to facilitate actionable interdisciplinary research on dryland SESs and help achieve the SDGs in drylands in ways that are regionally and culturally appropriate. Several case studies were highlighted to show that this framework could be useful to strengthen dryland research and meet the needs of land practitioners and policymakers in drylands.

Keywords: Global-DEP, drylands, social-ecological systems, drivers, structure and functions, ecosystem services, ecosystem management, livelihoods

A Brief Introduction to the Global Dryland Ecosystem Programme (Global-DEP)

Author(s): Fu, C^{1,2}

Affiliation(s): ¹*Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing 100101, China;* ²*United Nations Environment Programme-International Ecosystem Management Partnership (UNEP-IEMP), Beijing 100101, China*

E-mail: chao.fu@unep-iemp.org

ABSTRACT

Drylands cover 41% of the global land surface and support ~40% of the global population. Given the speed and intensity of climate change and socioeconomic development, both of which risk aggravating issues such as land degradation, poverty, food and water insecurity in drylands, systematic research on both social and ecological processes as well as their interactions in dryland regions is essential to achieving the Sustainable Development Goals in many countries. In 2017, the Global Dryland Ecosystem Programme (Global-DEP) was initiated by the Chinese Academy of Sciences as a key international cooperation project with the aim to develop an actionable research plan to address the challenges facing diverse and fragile dryland social-ecological systems (SESs). The Global-DEP Scientific Committee was set up to coordinate the development of its Science Plan, with a Secretariat to provide technical support. Four thematic work groups and five regional work groups were also established between principal investigators from the Chinese Academy of Sciences and their counterparts from the United States, Spain, Senegal, Australia, etc. So far, the conceptual framework and research priorities on dryland SESs, which serve as the basis for the Global-DEP Science Plan, have been developed through major consultations during the Scientific Committee meetings and regional workshops held in China, Australia, and Africa. Special issues on international journals have been published to disseminate the concepts, data and cases of Global-DEP. The Global Dryland SES working group has been also set up under the Global Land Programme to link with the broader land system science community. Overall, these major achievements lay a solid foundation to launch the Global-DEP Science Plan by the end of 2021 and contribute to strengthening global research collaboration on dryland SESs from a long-term perspective.

Keywords: drylands, social-ecological systems, sustainable development goals, conceptual framework, Global-DEP

Soil erosion assessment driven by a novel RUSLE-GEE framework

Author(s): Elnashar, A.^{1,2,3}, Zeng H.^{1,2}, Wu B.^{1,2}

Affiliation(s): ¹State Key Laboratory of Remote Sensing Science, Aerospace Information Research Institute, Chinese Academy of Sciences, Beijing 100094, China; ²College of Resources and Environment, University of Chinese Academy of Sciences, Beijing 100049, Chin; ³Department of Natural Resources, Faculty of African Postgraduate Studies, Cairo University, Giza 12613, Egypt

E-mail: abdelrazek@aircas.ac.cn, zenghw@aircas.ac.cn, wubf@aircas.ac.cn

ABSTRACT

Soil erosion is an essential contributor to environmental and socioeconomic problems worldwide. Assessment of soil loss and understanding its major drivers are essential to implement targeted management interventions. Understanding soil erosion rate (spatially, quantitatively, and qualitatively) is critical for combating land degradation, restoring eroded soil, and reducing the risks of eroded materials entering the ecosystem. All of which contribute to soil-related sustainable development goals (SDGs) and mainly dependent on the model and input data used. The Revised Universal Soil Loss Equation (RUSLE) provides a reasonable solution between accuracy, ease of application, and moderate data demand; thus, it is in the top 25 most applied soil erosion prediction models worldwide. The Google Earth Engine (GEE), a cloud computing platform, has been used worldwide for retrieving and processing many earth observation data, which nowadays cover all geospatial data needed to build the RUSLE model in a comprehensive and robust cloud-based environment. In terms of soil erosion assessment, RUSLE-GEE can provide rapid characterization of soil loss rates that could be used to prioritize erosion mitigation plans to support sustainable land resources and tackle land degradation in the dryland ecosystem.

Keywords: Soil loss severity analysis, Revised Universal Soil Loss Equation, Google Earth Engine, Cloud computing

An approach to separate natural and anthropogenic evapotranspiration

Author(s): Zeng, N.¹; Abdelrazek, E.²; Bingfang, W.³

Affiliation(s): ¹State Key Laboratory of Remote Sensing Science, Aerospace Information Research Institute, Chinese Academy of Sciences, Beijing, 100101, China; ²College of Resources and Environment, University of Chinese Academy of Sciences, Beijing 100049, China; ³Department of Natural Resources, Faculty of African Postgraduate Studies, Cairo University, Giza, 12613, Egypt

E-mail: zenghw@radi.ac.cn

ABSTRACT

Distinguishing the contribution of natural process and human activities to evapotranspiration (ET) and quantifying the amount of ET due to human activities are key to controlling water consumption in basins and achieving sustainable water use in arid and semi-arid regions. This study proposed a method coupling data-driven and Random Forest Regressor (RFR) for natural and anthropogenic ET separation. The steps of the method include: (1) monitoring total water consumption (ET_t) at the basin scale using remotely sensed ET; (2) classifying land cover into natural land cover, and human-managed land cover types, and (3) then developing a natural ET prediction model with ET of natural land cover types and the corresponding meteorological, topographical and geographic factors; (4) predicting natural ET (ET_n) of human-managed land cover types, and (5) deriving the anthropogenic ET (ET_h) by deducting the natural ET from the total ET of human-managed land cover. This approach was used to separate natural and anthropogenic contributions to ET in the Colorado River, Blue Nile, and Heihe River in 2017, respectively with R² and NSE above 0.93 and RB within 1% for natural ET prediction. The study quantified the amount of ET disturbance by anthropogenic forces and natural forces in rain-fed agriculture, irrigated agriculture, mosaic agriculture, and urban construction in Colorado, Blue Nile, and Heihe River Basins. The approach can provide strong support for the disturbance of water resources by different human activities at the basin scale and the accurate estimation of the impact of human activities.

Keywords: Natural ET, Anthropogenic ET, Separation, Machine Learning, Dryland

Alternative biome states of African terrestrial vegetation and the potential drivers: a continental-scale study

Author(s): Nan Lu^{1,2*}, Linhai Cheng^{1,2,3}, Mengyu Wang^{1,2}, Bojie Fu^{1,2}, Zhihong Xu³

Affiliation(s): ¹*State Key Laboratory of Urban and Regional Ecology, Research Center for Eco Environmental Sciences, Chinese Academy of Sciences, Beijing 100085, China.*

²*University of Chinese Academy of Sciences, Beijing, China*

³*Environmental Futures Research Institute, School of Environment and Science, Griffith University, Nathan, QLD 4111, Australia*

E-mail: nanlv@rcees.ac.cn

ABSTRACT

The alternative stable state (ASS) theory provides a plausible framework to explain the spatial distribution of biomes and their dynamics. Existing studies to test the alternative biome states (ABSs) mainly focused on tree-dominated biomes. It is still uncertain whether ABSs are present in a wide range of terrestrial biomes. This study was to examine the ABSs in the terrestrial vegetated areas of Africa and the maintaining factors. The potential landscapes were reconstructed separately for forest, grassland and shrubland using the MODIS VCF data along the gradients of temperature, precipitation and aridity index (AI). The differences of soil organic carbon density (SOC_D), fire count and grazing intensity were compared to test the feedback hypothesis to maintain the ABSs. The results showed that AI was the best climate indicator to detect the ABSs at the continental scale. Forest (at the wetter end) and shrubland (at the drier end) were well separated along the AI axis. Forest had three stable states (i.e. closed forest, woody savanna, and savanna) and shrubland had two stable states (i.e. closed shrubland and open shrubland). Grassland had two stable states (i.e. dense grassland and sparse grassland) distributing in a large AI range. The stable states that shared a specific AI range were regarded as the ABSs. Climate aridity greatly determined the distribution of the ABSs but the positive feedbacks between vegetation and SOC_D, fire count, and livestock density played potential roles in driving the shifts between the ABSs. Our study indicated that the ABSs commonly existed in varied biomes in the African continent, which provided an enlarged picture of the ABSs of the terrestrial biomes. The findings contribute to a deeper understanding of large scale vegetation patterns and their dynamics and facilitate to macro management of the terrestrial ecosystems in facing the possible regime shifts of the biomes.

Keywords: alternative biome state, climate gradient, potential landscape, threshold, positive feedbacks

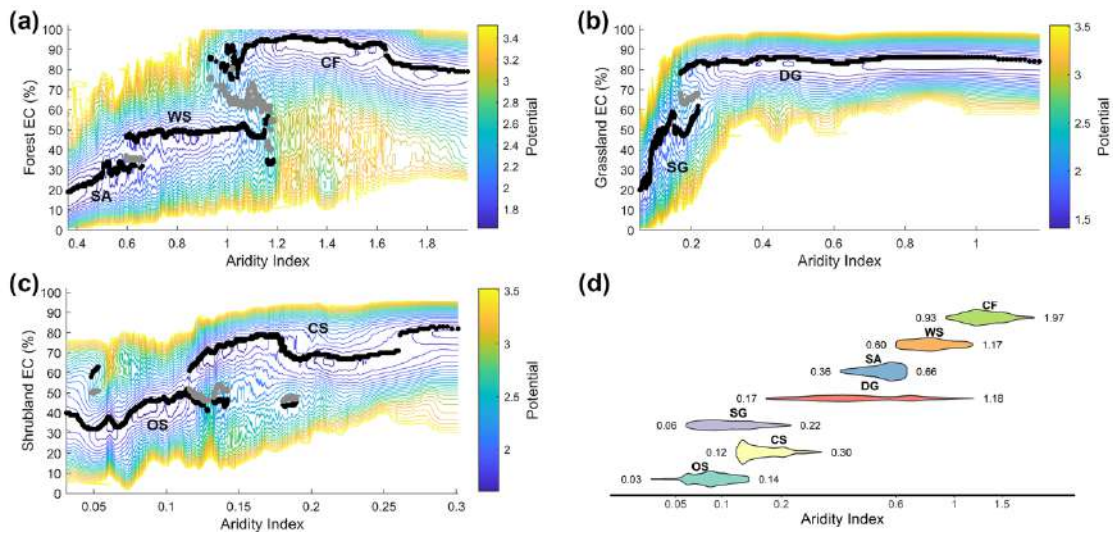


Fig. 1 Distribution of the biome states along the Aridity Index (AI) gradient. Potential landscapes of forest (a), grassland (b) and shrubland (c). Colored lines represent the contour lines of potential energy in the two-dimensional potential landscape based on Eigen-coverage (EC) and AI values. The potential value is illustrated by the color bar on the right. The discontinuous black lines represent the local minima (or “basins”) of the potential landscape reflecting stable biome states. The gray lines represent the local maxima (or ridges) indicating structural thresholds (unstable states) that separate ABSs. Graph (d): distribution of all detected stable states within the aridity gradient (log-transformed). The width of each violin plot represents the frequency density of each state changing with the AI. The minimum and maximum AI values of each state are presented. Biome states are abbreviated by the following acronyms: CF, Closed Forest; WS, Woody Savanna; SA, Savanna; DG, Dense Grassland; SG, Sparse Grassland; CS, Closed Shrubland; OS, Open Shrubland.

S12.2 - The Global Dryland Ecosystem Program and beyond



Ecosystem services change and driving forces in dryland region of the Chinese Loess Plateau

Author(s): [Lyu, Y.](#)¹; Li, T.²; Liu, Y.³

Affiliation(s): ¹Research Center for Eco-Environmental Sciences, Chinese Academy of Science, China; ²Xi'an University of Science and Technology, China; ³Capital Normal University, China

E-mail: lyh@rcees.ac.cn

ABSTRACT

The concept of Ecosystem Service (ES) has provided an underpinning framework for ecological restoration research and applications. Ecological restoration is a corrective intervention that aims to reverse land degradation and to contribute to the 2030 Global Sustainable Development goal of Land Degradation Neutrality. It is critical to investigate the long-term effects of ecological restoration and land use change on ESs and ES interactions (synergies or trade-offs) to better understand the mechanisms supporting this goal. Therefore, we analyzed land use and ESs (food provisioning, soil retention, hydrological regulation, carbon sequestration, water purification and habitat provisioning for biodiversity) using historical data for a typical watershed in Chinese Loess Plateau, which has experienced series of restoration activities since the 1950s. The interactions between ESs were evaluated by correlation analysis. The results show that soil retention, carbon sequestration, water purification and habitat provisioning for biodiversity increased significantly across different land use types over several decades except hydrological regulation. Grassland was found to maintain greater water yield than woodland with high values of other ESs and trade-offs between ESs can be mitigated by adjusting the proportion of some important land use types (such as woodland and grassland). We further analysed the ES bundles across the whole Loess Plateau to explore changes in ES spatial distributions, bundle types and multiple ES interactions in a period of rapid vegetation restoration between 2000 and 2015. We found that (1) most of the ESs were improved, especially provisioning services and carbon sequestration. (2) Changes in the bundling patterns between 2000 and 2015 revealed heightened gaps among ESs due to the upsurge of carbon sequestration and deterioration of the baseflow regulation. This research provides a new perspective for understanding the interactions between multiple ESs with regional vegetation restoration activities at different spatiotemporal scales.

Keywords: vegetation restoration, land use, trade-off, synergy, ecosystem service

Comparative study of plant dynamics in prickly pear plantations in the region of Sidi Ifni and the region of Marrakech-Safi (Morocco)

Author(s): Yous, F.Z.¹, Alifriqui, M.¹ and Ouhammou, A.¹

Affiliation(s): ¹Laboratory of Microbial Biotechnologies, Agrosciences and Environment (BioMAGe), Department of Biology, Faculty of Sciences Semlalia, Cadi Ayyad University, Marrakech, BP2390, 40000 Morocco.

E-mail: yousfatimazahra@gmail.com

ABSTRACT

The prickly pear (*Opuntia ficus-indica* (L.) Mill.) is a plant that is subspontaneous found in Morocco. Currently, several programs are conducted for the fight against erosion, for the restoration of degraded soils and specially to support the emerging sector of production of fruit and other products of the prickly pear. In these different operations, we witness a dynamic environment, materialized by a significant biological rise, accompanied by changes and improvement of soil fertility characteristics.

The objective of this work is to evaluate this ecological process accompanying the restoration of soils and the conservation of the richness of biodiversity. It is also to evaluate the speed of reinstallation of climatic species, often disappeared in the very degraded zones, before the introduction of the prickly pear.

Our study focuses on the evaluation of the effects of prickly pear with different ages: old (> 25 years), medium (10-25 years) and younger (<10 years) on the dynamic's vegetation. In addition, the impact on edaphic characteristics was evaluated. These plantations are located along of coastal transect to continental in a Pre-Saharan region of Central-Western Morocco: Sidi Ifni region and in the region of Marrakech-Safi.

In each area, we have recorded a phyto-ecological data in plots of different ages of prickly pear. So we made the soil sampling at each area and three plots of different ages by selecting 3 plant of prickly pear with 3 samples per depending on the distance from the plant of prickly pear for object to made a physicochemical analyses, like the particle size, pH, organic matter, assimilable phosphorus, Kjeldahl nitrogen, etc...)

The results showed that the phyto-biodiversity increased with the age of prickly pear plots in all zones, so that the area factor and age of prickly pear plantations had statistically significant effects on some soil parameters, while the distance from the plant of cactus has no significant effect.

Keywords: *Opuntia ficus-indica*, Morocco, vegetation dynamics, phyto-ecological record, edaphic characteristics, restoration.

Ecological assessment of green dam plantations in Algeria

Author(s): SARMOUM Mohamed ¹

Affiliation(s): ¹University of Tiaret Algeria

E-mail: Sarmoum.med82@gmail.com

ABSTRACT

Algeria, a vast Mediterranean country (over 2.3 million km²) is dominated by an arid climate (Sahara) and a semi-arid climate (highlands and Tell). This situation combined with a very high anthropozoic action led to an alarming degradation of the plant cover and the soil. Desertification threatens nearly 20 million hectares today. To fight against desertification, Algeria launched in the early 1970s a vast planting program called: the green dam.

Our study aims to carry out an ecological assessment of the plantations carried out within the framework of this project by a dendrometric (total height, DBH, basal area) and dendroecological (evolution of radial growth) approach at the level of 09 Aleppo pine populations.

The results obtained show that the growth of Aleppo pine varies from one station to another depending on the altitude, the slope. Sloping land and / or in northern exposure offer the best growing conditions. On the other hand, in flat terrain growth is very weak.

These results obtained made it possible to identify a certain number of elements of answers as for the current state of the stands and their adaptation with the conditions of the environment. These results can be used by managers for future reforestation projects.

Keywords: Algeria, restoration, desertification, green dam, Aleppo pin, growth.



Fig. 1 Aleppo pine plantations as part of the green dam project in Algeria

Habitat restoration for the conservation of a threatened steppe bird, the Dupont lark (*Chersophilus duponti*)

Author(s): Santos-Torres, A.¹; Reverter, M.^{1,2}; Pérez-Granados, C.^{1,3}; Zurdo, J.^{1,2}; Barrero, A.^{1,2}; Gómez-Catasús, J.^{1,2}; Bustillo-de la Rosa, D.^{1,2}; Traba, J.^{1,2}

Affiliation(s): ¹ Terrestrial Ecology Group, Department of Ecology (TEG-UAM) Universidad Autónoma de Madrid. C/ Darwin, 2. 28049. Madrid. Spain; ² Centro de Investigación en Biodiversidad y Cambio Global (CIBC-UAM), Spain; ³ Ecology Department, Universidad de Alicante, 03690 Alicante. Spain

E-mail: ana.santos@usal.es

ABSTRACT

Mediterranean natural steppes have drastically changed in the last few decades due to land abandonment, agricultural intensification and land use changes, such as tree afforestations. These factors have caused large declines in steppe bird populations, one of the most threatened bird groups in Europe. Conservation of steppe birds may require active land restoration actions, but little is known about their effects on bird habitat quality. We focus on Dupont's lark (*Chersophilus duponti*), a threatened insectivorous steppe bird with dramatic population and habitat reduction in the last years. LIFE Ricotí project carried out actions to improve Dupont's lark habitat quality by cutting 50ha of pine afforestations and tree-clearing in 250ha, mainly oaks (*Quercus ilex*). We tested the efficiency of these actions by measuring arthropod biomass as an indicative of habitat quality and by recording vocal activity of the species as a surrogate of bird abundance in control and restored areas, in a BACI design. We used pitfall traps and sweep nets (six times per year, N=23 sampling stations) to sample epigeous, hypogeous and coprophagous arthropods in both action and control areas before (2017) and after (2018-2019) the treatments. Autonomous sound recorders were used to register vocal activity during the breeding season of the first and second year after the treatment (N=6 locations). After fitting GLMM, we found a significantly higher epigeous arthropods biomass in 2018 and a lower *Diptera* biomass in 2019 after removing pine afforestations, while no significant results were found for the other groups. Vocal activity was higher after the actions in both areas, but that difference was enhanced in the tree clearing area. These results suggest an improvement in the space use by Dupont's lark on the restored areas and that both treatments had almost no negative impact on arthropod abundance, the main prey diet of the species.

Keywords: Acoustic monitoring, biodiversity, birds, food availability, habitat restoration.

S13 - Ecological restoration to reverse desertification

Non-linear changes in drylands' restorability in response to aridity

Author(s): Santiago Soliveres^{1,2}, Francisco Romero Fornés

Affiliation(s): ¹*Department of Ecology, University of Alicante*

²*Multidisciplinary Institute for Environmental Studies "Ramón Margalef", University of Alicante*

E-mail: santiago.soliveres@ua.es

ABSTRACT

Many studies have addressed restoration success in dryland ecosystems'. However, these are generally performed using contrasting response attributes (e.g., plant species composition vs soil carbon) and under contrasting environmental conditions, hindering the development of generalities regarding their success and context-dependency. Here we present preliminary results of a meta-analysis evaluating restoration success (log response ratio of restored/control plots) in Mediterranean dryland ecosystems, summarizing 62 studies and 1044 response variables. We analysed this data according to recently shown non-linear responses of dryland ecosystems to aridity, in which three thresholds (the first associated to productivity declines at aridity levels [1- FAO's aridity index] ≥ 0.54 , the second associated to disrupted plant-soil interactions at aridity levels ≥ 0.69 , and the third associated to sharp plant cover and richness declines at aridity levels ≥ 0.83), and considering ecosystem attribute- and restoration tool- specific responses. Generally speaking, soil and leaf nutrients and soil microbial composition showed stronger and more positive responses to restoration, whereas plant composition, growth and litter build-up proved more difficult to restore and took a longer time to recover. The most efficient restoration techniques were watering and organic amendment, which rendered more positive effect sizes than afforestation, reduction of erosion or combined treatments. Ecosystem-attribute and restoration tool-dependent responses showed significant interactions with aridity, showing that restoration success is directly linked to the three different aridity thresholds. Restoration success was maximal before any of those thresholds was crossed, showing sharp declines afterwards. This decline in restoration success was particularly evident when considering only those response variables related to each one of the thresholds previously observed in drylands. For example, plant-productivity related variables were harder to restore once aridity levels were above 0.56, and attributes related to plant-soil interactions responded more weakly to restoration under aridity levels beyond 0.69.

The role of cover and spatial organization of resource sinks in the restoration of patchy drylands

Author(s): Berghuis, P.M.J.¹; Mayor, A.G.¹; Rietkerk, M.¹; Baudena, M.²

Affiliation(s): ¹*Copernicus Institute of Sustainable Development, Utrecht University, PO Box 80115, 3508 TC Utrecht, the Netherlands* ²*National Research Council of Italy, Institute of Atmospheric Sciences and Climate (CNR-ISAC), Corso Fiume 4 10133, Turin, Italy*

E-mail: p.m.j.berghuis@uu.nl

ABSTRACT

A low-cost restoration in patchy drylands aiming at recovering the ability of the ecosystem to capture and store water and nutrients is the installation of obstructions to break runoff pathways and retain these resources (hereafter, resource sinks). Field works in drylands worldwide have studied how the effectiveness of this action depends on the materials used to build the obstructions. However, the spatial pattern attributes of the resource sinks can also affect the effectiveness of the restoration and has not yet been investigated. In this work, we cover this knowledge gap by using a well-known dryland model to investigate how different initial amounts of cover and spatial distribution of installed resource sinks (i.e., random vs. regular) affects the recovery of the system. In agreement with field-work studies, our model results confirm that the installation of resource sinks can restore degraded drylands that are not able to recover naturally. More importantly, we found that a very small cover of resource sinks was sufficient to trigger the recovery of vegetation, while a high cover could lead to a complete failure of vegetation recovery. This was found for both random and regular distributions of resource sinks. However, a distribution similar to that of vegetation in the reference healthy system (i.e., regular distribution in our study system) was more effective: higher plant densities were reached for a given initial cover of resource sinks. Given the high efficiency of low covers of resource sinks suggested by our work, combined with the low-cost materials needed, the installation of resource sinks in severely degraded drylands has the potential to be a key contributor to the large restoration efforts needed to achieve land-degradation neutrality in the coming decades, particularly in developing countries.

Keywords: Dryland degradation, restoration, resource sinks, spatial organization, dynamical modelling

Morphoecological characteristics of forage grasses of potential use in the restoration of degraded African drylands

Author(s): Mganga, K.Z.^{1,2}, Kaindi, E.¹, Ndathi, A.J.N.¹, Bosma, L.³, Kioko, T.³, Kadenyi, N.³, Wambua, S.¹, van Steenberg F.³, Musimba N.K.R.¹

Affiliation(s): ¹South Eastern Kenya University, Kenya; ²University of Helsinki, Finland; ³MetaMeta Research, Netherlands

E-mails: kmganga@seku.ac.ke and kevin.mganga@helsinki.fi

ABSTRACT

Perennial grasses have been identified as a viable option for restoration of degraded African drylands and increased pasture production. Indigenous African grasses *Cenchrus ciliaris* L. (African foxtail grass), *Eragrostis superba* Peyr. (Maasai love grass), *Enteropogon macrostachyus* (Hochst. Ex A. Rich.) Monro ex Benth. (Bush rye grass), *Chloris roxburghiana* Schult. (Horsetail grass) and *Chloris gayana* Kunth. cv Boma (Rhodes grass) were established in a semi-arid dryland in Kenya to compare their morphoecological characteristics. Dry matter biomass yields were estimated at the early reproductive stage. Stem and leaf biomass fractions were separated to estimate stem-to-leaf ratios. Plant densities (plants m⁻²), tiller densities per plant species, seed production, plant height (the tip of the top leaf), percentage basal cover and plant frequency were determined. Statistical analyses were performed using Software STATISTICA 10.0, StatSoft Inc. One-way ANOVA was used to test for significant differences between treatments. Fischer's LSD *post hoc* test was used to separate significant differences between treatments. *Chloris gayana* cv Boma and *E. superba* produced significantly higher leafy biomass per individual plant. *Chloris roxburghiana* displayed a significantly higher leaf:stem ratio. These characteristics demonstrate their suitability for forage. Total biomass yield per individual plants of *E. macrostachyus*, *C. ciliaris* and *C. roxburghiana* were comparable. *Enteropogon macrostachyus* and *C. ciliaris* displayed significantly higher values for rehabilitation indices. In conclusion, desirable outcomes of increased forage production and rehabilitation of African drylands can best be achieved through a multiple species approach to capitalise on the unique strengths of different grass species.

Keywords: Drylands, Restoration, Perennial Grasses, Reseeding, Indigenous Species

Restoration and Rehabilitation of Steppic Ecosystems: An Overview of the Algerian Experience

Author(s): Amghar E.¹ & Margerie P.²

Affiliation(s): ¹ Biodiversity, Biotechnology, Environment and Sustainable Development Laboratory, Faculty of Sciences, M'Hamed Bougara University of Boumerdès. 35000 Avenue de l'Indépendance, Boumerdès (Algeria). E-mail: amgharfateh@univ-boumerdes.dz.

² Normandie University, Rouen, Laboratory ECODIV URA IRSTEA / EA 1293, FR CNRS 3730 SCALE. Place Émile Blondel. F-76000 Rouen

E-mail : pierre.margerie@univ-rouen.fr

ABSTRACT

The last four decades have been marked by the fight against desertification and the development of steppic ecosystems, which has become a national priority. In this context, several management techniques have been tested to cope with the advance of the desert.

The purpose of this study is to highlight the effect of two management techniques (fencing and *Atriplex canescens* planting) on (i) floristic diversity, (ii) pastoral value, (iii) some physical and chemical soil parameters and (iv) the condition of its surface at the level of nine pastorals and agro-pastoral departments. 312 phyto-ecological and soil surveys were conducted on a mixed sampling basis, combining systematics and randomness, and processed numerically by univariate and multivariate analyses under R version 3.6.1.

The results showed that floristic richness, plant cover and pastoral value are clearly superior in protected areas. The chemical parameters of the surface horizons show a trend in favor of protected areas especially for the levels of total nitrogen and organic carbon. In addition, this study shows that the two management techniques allow in a relatively short time (4 years), a biological lift and an improvement of the physical properties-soil chemicals with contrasting results for some parameters.

Key words: Desertification, restoration, rehabilitation, Algeria, *Atriplex canescens*.

S20.1 – Restoring westlands

Action plan for the naturalisation of wastewater treatment plants in the Balearic Islands

Author(s): Viada, C.¹; Calvo-Cubero, J²; Sánchez-Mateos, P.³; Gil, T⁴. & Vicens, P⁵.

Affiliation(s): ^{1,5} *Consultant WWF, Spain*; ⁴ *WWF-Spain*; ^{2,3} *Agencia Balear del Agua, Spain*

E-mail: cviada@wwf.es

ABSTRACT

An action plan for the improvement of biodiversity in wastewater treatment plants in the Balearic Islands was prepared by WWF Spain in 28 of the 79 wastewater treatment plants (WWTP) managed by the Balearic Water Agency in the Balearic Islands. It was launched in May 2021. Its main objective is to conserve and promote biodiversity in the treatment plants and focuses mainly on the wetlands created for the evaporation and infiltration of treated water in the 28 selected facilities. 21 of them in Mallorca; four in Menorca; and three in Ibiza. The wetlands selected to implement the Plan cover a total surface area of 350,000 m², and represent freshwater oasis of particular relevance in the inland of the archipelago. Three of the six largest freshwater wetlands in Mallorca are associated with WWTP managed by the Balearic Water Agency (Playas de Muro, Felanitx and Binissalem). The Son Navata lagoons (Felanitx WWTP) stand out as the fourth most important wetland area in Mallorca in terms of the number of water birds, with around a thousand wintering birds of 18 different species.

The main objectives of the proposed measures are related to the enhancement of biodiversity in the aquatic environment, but also in the terrestrial one where the WWTPs are located. The measures range from the creation or extension of the wetlands associated with each WWTP to the creation of floating islands for breeding waterfowl, or the installation of insect hotels and nesting boxes for breeding birds. It is also planned to plant autumn fruiting shrubs to provide food for migratory birds and to install bird-watching facilities. The hides will be open to the general public and educational activities will be promoted. Other relevant objectives also relate to promoting governance and management measures and the monitoring of both biodiversity and other aspects such as governance and the dissemination of this action plan. Initiatives such as this one are a great example for the improvement of biodiversity, easily replicable in other autonomous communities and Mediterranean countries.

Keywords: Biodiversity, restoration strategy, rewilding, urban and periurban environments.

Fig. 1 Son Navata lagoons -associated to the Felanitx Wastewater treatment plant- stand out as the fourth most important wetland in Mallorca in terms of the number of wintering water birds.



Biodiversity restoration of formerly mined raised bogs – vegetation succession and recovery of other trophic groups.

Author(s): Kamila Vítovcová¹, Jana Lipárová², Alžběta Manukjanová¹, Martina Vašutová¹, Pavel Vrba², and Karel Prach^{1,3}

Affiliation(s): ¹ Faculty of Science, Department of Botany, University of South Bohemia, České Budějovice, Czech Republic, ² Institute of Entomology, Biology Centre CAS, České Budějovice, Czech Republic, ³ Institute of Botany, Academy of Sciences of the Czech Republic, Třeboň, Czech Republic

E-mail: Lencova.kamila@seznam.cz; lencok00@prf.jcu.cz

ABSTRACT

Central European raised bogs are unique and fragile ecosystems inhabited by specialists from higher plants, fungi, and insects. Many of these ecosystems have suffered and still are suffering from peat harvesting and drainage. The respective specialists, so-called tyrphobionts, and their abundances can serve as good indicators of restoration processes after the disturbance, however, the various taxonomic groups might differ in their responses. This study shows successional trends at two disturbed raised bogs and their trajectories towards the adjoining reference undisturbed raised bogs regarding vascular plants, mosses, fungi, butterflies, and moths. Generally, after three decades of spontaneous succession, the species composition of any taxonomic groups of organisms did not reach the reference site. Instead, an alternative, near natural woodland developed. The different groups of organisms exhibited very similar trends in species richness and participation of tyrphobionts. About half of these specialists, occurring in the reference sites, were able to colonize, at least in some quantity, the disturbed sites. It appeared, habitat limitations played a more important role than dispersal limitations in this restoration process. More successful restoration could be probably possible with a substantial increase of water table in the disturbed localities.

Keywords: Biodiversity, peatlands, succession, multi-taxa approach.

The restoration of small diked salt marshes, challenges and potentialities. A transversal approach. (The PEPPS program)

Authors: Gallet S.¹, Gélinaud G.², Le Quillec R.³, Dauvergne X.¹, Pétilion J.⁴, Carpentier A.⁵, Dèbre, C.⁶.

Affiliation(s): 1. EA 7462- *Géoarchitecture. Territoires, Urbanisation, Biodiversité, Environnement. Université de Bretagne occidentale (Brest).*

2. *Réserve Naturelle Nationale de Séné*

3. *Agence de l'eau Loire-Bretagne*

4. *UMR 6553 Ecobio- Université de Rennes 1*

5. *UMR BOREA – Université de Rennes 1*

6. EA 7462- *Géoarchitecture. Territoires, Urbanisation, Biodiversité, Environnement. Université de Bretagne Sud (Lorient).*

Email: Sebastien.Gallet@univ-brest.fr

ABSTRACT

Present at the land-sea interface, salt marshes present major challenges in terms of biodiversity, functioning of coastal ecosystems or of protection of the coastline. After a long time under strong pressure or degradation, particularly linked to polderisation, the restoration of these environments has recently become a subject of concern especially in response to societal expectations for conservation (coastal green and blue frames) but especially to prevent the effects of global change (Nature based solution against- marine submersion).^o

Given the complexity of implementing restoration actions on large salt marshes, there is significant potential for “small” marsh systems. Nevertheless, their restoration requires a good knowledge of their functioning and of the processes of restoration but also to consider the local context and the social representations of the marshes and of their transformations during the restoration process.

The PEPPS research program (2018-2021), financed mainly by the Loire-Bretagne Water Agency, analyses and crosses both the ecological and the social dynamics on four formerly polderised sites of the Armorican Coastline (western France), which had been restored over the past decades, two in estuary settings and two in salt marshes. Its objective is thus to identify the key factors of the restoration, its success and its acceptance.

This communication aims to present the programme and the main results obtained in both social and ecological dynamics. It also aims to show the interest and the stakes of building a multidisciplinary and partnership approach around ecological restoration issues and experiences.

Marshland restoration nearby Doñana National Park

Authors: Ceballos, B.¹; Gallardo, J.¹; Fuentelsaz, F.²; Carmona, J.²; Bernal, A.²; Gil, T.²

Affiliation(s): ¹Plegadis S.L, Spain; ²WWF-España, Spain.

E-mail: tgil@wwf.es

ABSTRACT

WWF-Spain in cooperation with “Fundación Coca Cola” has restored 6 ha of marshland in the “Adventus” Marsh, Trebujena (Cádiz) in the framework of the project 'Misión Posible'.

The project focuses on wetlands rehabilitation, water management, public use and biodiversity conservation. The marshes on the left-hand bank of the mouth of the Guadalquivir Estuary are one of the last Marbled Teal (*Marmaronetta angustirostris*) breeding areas in the Iberian peninsula. Marbled Teal is the most endangered Europe's duck. Additionally, the “Adventus” Marsh is a strategic breeding area for ducks, waders and others waterbirds during winter. Therefore the regeneration of the halophytic vegetation and macrophytes is essential as they provide resting and feeding areas for vertebrates and invertebrates both aquatic and terrestrial.

The ecosystem services (services provided by nature for society) generated at the “Adventus” Marshes ensure high levels of natural capital. The demand for shrimp (*Palaemonete varians*) in the national and international market is much higher than the offer. The new wetland is managed with the support of a local aquaculture company dedicated to the exploitation of these crustaceans. In addition a public bird observatory, footpaths, and a timber-made observation tower have been built to foster public use and eco-tourism activities.

The earthmoving works, mainly of clay, required to restore this wetland to build and shape islands, walls, ringes and other areas of the marsh reached approximately 30.000 m³. The fact that three different administrations have competency in the territory - national, regional and local- has made the procedure of obtaining the urban planning licenses complicated and slow.

Since the project restoration finished follow up and monitoring works show a remarkable improvement of the wildlife and the natural environment resulting in the settlement of three pairs of Marbled Teal in this new wetland and the breeding of several waterbirds species.

Keywords: Restoration strategy/planning, Coastal/marine environments, Biodiversity, Sustainable tourism/outdoor recreation, Wetlands.

Fig. 1 “Adventus” Marsh, Trebujena (Cádiz) after the restoration



NDVI explaining the growing season CO₂ fluxes in alkaline fen

Authors: Raimo Pajula¹, Anna-Helena Purre²

Affiliation(s): ¹*Institute of Ecology, Tallinn University, Tallinn, Estonia* ²*STEIGER Engineering LLC, Tallinn, Estonia*

E-mail: raimo.pajula@tlu.ee

ABSTRACT

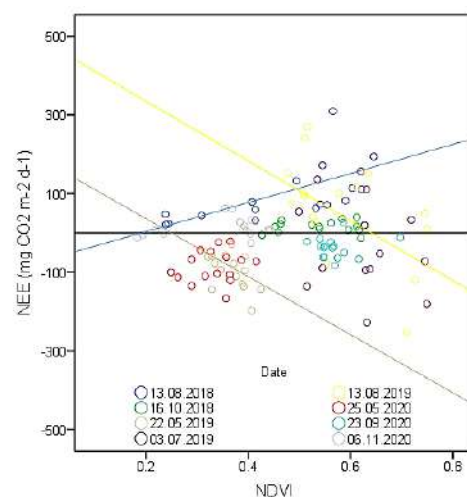
Normalized Difference Vegetation Index (NDVI) is a widely used multispectral vegetation index to estimate vegetation health and its abundance. NDVI is based on the ratio of the red light and near infrared light that is reflected from the surface, so reflecting the density and “greenness” of vegetation. We aimed at relating CO₂ fluxes and NDVI measured by drone to investigate possibilities to upscale CO₂ fluxes larger areas cost-efficiently.

In Estonia, the project “Life Peat Restore” aims at restoring natural water regime and carbon sequestration on large Läänemaa Suursoo mire. During the project, automated drone SenseFly eBee applied with Parrot Sequoia multispectral sensor was used for NDVI mapping of the study area and manual transparent chambers method was used for CO₂ measurements. The NDVI and CO₂ flux measurements were done simultaneously in eight measurement campaigns between 2018 and 2020 on the monitoring transect located on alkaline fen.

NDVI maps reflect pattern of mire plant communities - higher NDVI values reflect higher cover of vascular vegetation, and low values sparser vascular vegetation and higher litter or brown moss cover. Both NDVI and CO₂ balance had seasonal pattern during the growing season with highest index values and carbon binding in mid-summer. Generally, no significant relation was found between NDVI and measured net ecosystem exchange (NEE) and photosynthesis at ambient light conditions. Whereas during sunny and warm monitoring days the NDVI explained over 30% of the variation in NEE (Fig. 1). The relationship was stronger for reconstructed NEE and NDVI, where higher NDVI was related with lower NEE due to higher ecosystem respiration on those plots. NDVI was generally positively correlated with ecosystem respiration ($r = 0.44$, $p < 0.01$). NDVI is useful indicator for analysing mires vegetation parameters but relations with CO₂ fluxes needs further investigations in different peatland ecosystems and conditions.

Keywords: alkaline fen, boreal peatland, NDVI, carbon dioxide, NEE

Fig. 1. Relation between net ecosystem exchange (NEE) and NDVI. Solid lines indicate the linear regression on dates when NDVI explained at least 30 % variation in NE



S20.2 – Restoring wetlands

Restoration of a coastal wetland in Mallorca, an example of participatory process and citizen science

Author(s): Tomàs, P.¹; Gil, T.²; Seiz, R.² and Viada, C.¹

Affiliation(s): ¹Consultants to WWF-Spain; ²WWF-Spain.

E-mail: tgil@wwf.es

ABSTRACT

WWF-Spain is promoting the restoration of the “Estany des Ponts”, a Mediterranean coastal wetland in the north of Mallorca. The project includes the ecological and landscape restoration as well as appropriate management actions given its high potential for education, recreation and tourism. One of the strengths of the project is the involvement of the local community through a participatory process. The Alcudia City Council, the Balearic Islands Tourist Board and the hotel sector are involved, as well as several local experts and the school community through citizen science activities.

The “Estany des Ponts” is a large lagoon that once was part of the Alcudia Bay wetland complex that included the existing s’Albufera marshes. With the development of mass tourism in the 1960s, uncontrolled urban development caused the degradation of the lagoon environment. Concrete banks were built around the lagoon; the surrounding marshes and part of the lagoon itself were used as a dumping ground for industrial waste coming from the nearby power station with the intention of creating new urban land. Fortunately, the project area was not developed and the land was abandoned. The site has since been used as an illegal landfill for building and garden waste, causing the spread of certain invasive alien species.

Over the years, a Mediterranean scrub vegetation has developed with lentisk and wild olive trees, scattered pines, a few temporary ponds and even a small reed fringe on the banks. This, together with the open waters, represents a diversity of habitats that has favoured the establishment of an interesting flora and fauna, particularly birds. The Natural Resources Management Plan for the nearby s’Albufera Natural Park identifies the “Estany des Ponts” as an ecological corridor between the park itself and the Albufereta Natural Reserve, thus recognizing its important connection role between the two protected wetlands.

Keywords: Restoration, Wetlands, Sustainable tourism, Outdoor recreation, Periurban environment



Restoration of small salt marshes: when social representations of nature and those of the lived space clash and decline.

Author(s): Debre, C.¹; Bourhis, M.²; Ledouble G.³, Gourlay, F.⁴

Affiliation(s):¹ *Laboratoire Géoarchitecture, France;* ²*Laboratoire Géoarchitecture, France;* ³ *Laboratoire Géoarchitecture, France;* ⁴

E-mail: celia.debre@uni-ubs.fr

ABSTRACT

In this area, you must write the summary of your contribution, in a maximum of one DIN A4 page, 300 words. The summary must allow checking the scientific/technical interest of the presentation and should clearly describe the data you will present. [Arial 11, single space]

For centuries the development of coastal areas has been dominated by the construction of structures separating land from the sea, in particular to protect populations from marine submersions. In these coastal marshes, such structures have most often removed land or basins from the influence of the tide to develop agricultural activities. However, this "gain" on the sea is increasingly questioned for economic and environmental reasons. Flood these polders allow them to be reconnected to the sea and respond to contemporary coastal management objectives both for restoration of natural areas and fighting against flooding risks (Goeldner-Gianella, 2013).

As part of the multidisciplinary research program "Environmental relevance of the restoration of small marshes or salt meadows" on the Armorican coast, we studied the social practices and representations of small coastal marshes that had been the object of depolderisation. This field survey, conducted between November 2018 and November 2020, includes 131 interviews with people involved and/or interested into one of the four sites studied (responsible for the management of natural spaces, elected officials, economic stakeholders, NGO's, residents, users). This paper gives an account, on the one hand, of the representations of the sites studied and their transformations linked to their restoration. These latter renew the frontality between transformations fed by scientific knowledge and those more empirical, which come from discourses on the lived space. On the other hand, this investigation reveals the variation of these representations according to the characteristics of the sites and the operations carried out.

Keywords: restoration strategy/planning – governance Policy - wetlands

Comparative values of plants and arthropods as indicators of salt-marsh restoration (PEPPS program)

Authors: Salgueiro Simon M.¹, Gallet S.¹, Devogel P.^{1,2}, Lafage D.², Dauvergne X.¹, Hacala A.², Pétilion J.².

Affiliation(s): 1 EA 7462- *Geoarchitecture. Territories, Urbanization, Biodiversity, Environment. University of Western Brittany (Brest), France.*

2 UMR 6553 CNRS - *Ecobio. Ecosystems, Biodiversity, Evolution. University of Rennes 1 (Rennes), France*

ABSTRACT

Located at the interface between land and sea, salt marshes host a specialized biodiversity, mostly adapted to stress factors induced by both flooding and salinity. Salt marshes have been reclaimed for a while to establish activities that locally stopped nowadays, especially in small polders. With the objective of restoring biodiversity, but also of adapting to global changes, several restoration projects of small systems are currently undertaken, some with a monitoring of the recovery dynamics of biodiversity as well as emerging structural and functional proprieties of the new habitat.

A complete ecological evaluation of a restoration process implies combining different attributes that have been described in the SER International Standard. The present study, included in a pluridisciplinary research program so-called "PEPPS", is based on the analysis of de-embanked marshes in Western France that have been voluntarily or accidentally renatured by dam breaches. Our main objective is to evaluate their renaturation by comparing these systems with nearby reference marshes (natural marshes) and to develop a standardized, multidisciplinary, monitoring for future national salt-marsh restorations. Several parameters are being monitored in the research program, and in this presentation we are presenting a comparison of the value plants vs arthropods (spiders and ground beetles) to evaluate salt-marsh restoration success through a comparison with reference systems. Both taxa are compared in terms of species composition and spatial organization, and the first results highlight the complementary of plants vs arthropods, confirming the few comparative studies previously done in salt marshes and other coastal systems.

Keywords: Depolderization, Ground beetles, Spiders, Saltmarshes, Vegetation.

LIFE Peat Restore

Reduction of CO₂ emissions by restoring degraded peatlands in Northern European Lowland

Author(s): Jurema, L.¹; Etzold, J.²; Herrmann, A.³ et al

Affiliation(s): ¹ NABU, Germany; ² NABU, Germany; ³ NABU, Germany

E-mail: Leticia.Jurema@NABU.de

ABSTRACT

The EU-LIFE project Peat Restore is reducing GHG emissions by restoring 5,300ha of degraded peatlands across 10 project sites in Estonia, Latvia, Lithuania, Germany and Poland. To estimate the climate effect of the restoration measures the project uses the GEST approach (Greenhouse Gas Emission Site Type) and the direct measurement technique.

Through workshops, panel discussions and targeted informational material, including policy recommendations; Peat Restore addresses key stakeholders to convey the message that protection and restoration of peatlands is essential to achieve the emission targets of the Paris Agreement.

GHG monitoring measures:

GEST-types show different emission characteristics depending on the water table and vegetation composition.

Manual Chamber Method with transparent and opaque chambers equipped with a cooling system; Automated in-situ CO₂-measurements; Manual and automatic sampling for CH₄ and N₂O analysis.

Restoration measures:

Measures began in 2018 and will be completed in 2021. Dams were built on ditches to block the water runoff and raise the water table. Trees and shrubs established in severely drained sites were removed. Further measures include Sphagnum spreading on a post-extraction site (Lithuania) and the testing of artificial floating islands (Poland); both for the purpose of re-establishing peat forming vegetation.

Outcomes from workshops and implementation of restoration and monitoring measures are highlighted in various publications. The project identified GESTs, which were already published as well as GESTs, with a probable different emission character. Our first GEST-GHG calculations suggest a significant reduction of the global warming potential by ca.25% compared to the current situation. These results are still preliminary and need further evaluation, but they show a relative positive mitigation trend. Based on preliminary modelling results from direct GHG measurements, a clear “global” relationship with the water table could not be found yet, but it seems that the water table fluctuations play a more important role.

Keywords: Climate change, Restoration strategy/planning, Peatlands/wetlands, Policy, Evaluation and monitoring.

Long-term response of vegetation on the water level drop-down on a large calcareous fen (NW Estonia)

Author(s): Truus, Laimdota ; Ilomets, Mati; Pajula, Raimo; Sepp, Kairi; Lode, Elve

Affiliation(s): *Tallinn University*

E-mail: laimdota.truus@tlu.ee

ABSTRACT

Most of the minerotrophic fens are drained because of human interest to manage them for agricultural purposes. The restoration of managed fen remnants is complicated task because of peculiar hydrodynamics and nutrient regime. We investigated plant cover, hydrology, peat and water properties on a Suursoo-Leidissoo *Carex-Schoenus* earlier alkaline fen (ca 3400 ha) in NW-Estonia sparsely drained in the end of 19th century. The site was selected for rising up the water level with long-term perspective to restore alkaline fen vegetation on disturbed parts of the earlier alkaline fen. The ill-fated amelioration resulted in the development of peatland with patterned plant cover from still open fen to *Sphagnum* dominated transitional fen and drained forested peatland communities.

Our hypothesis is that the patterned vegetation development is driven not only by hydrodynamics water level (WL) seasonal fluctuations, minimum and maximum WL and its standard deviation but also by pore water nutrient regime.

Transect method with nested-plot design was used for vegetation survey - 3 subplots by 2x2 m divided into four 1x1 m squares were nested into 10x10 plot. Species composition was identified in every subplot, *pH* and electric conductivity (*EC*) of pore water was measured close to every plot. Divers were used for WL fluctuation measurement, samples of topmost peat were taken for their later bulk density and ash content analyses.

We identified about 120 vascular plant species and some 85 moss species (12 *Sphagnum* and 53 fen moss species). On the plot level nine plant assemblages were distinguished.

We demonstrate that in communities of near-natural part of the site the WL and pore water *pH* are the main abiotic drives. In the drained parts of the site the species composition in the field layer responds to pore water *pH* and *EC*, topsoil ash content and the coverage of the tree layer.

Keywords: drainage-induced successions, fen, hydrology, vegetation

S14 - Social science aspects of river restoration

Challenges in the planning, implementation and success evaluation of river restorations from a social perspective

Author(s): Junker-Köhler, B.¹, Hagen, D.¹

Affiliation(s): ¹*Norwegian Institute for Nature Research*

E-mail: berit.kohler@nina.no

ABSTRACT

Ecological restoration encounters in its practice a diversity of social, economic, cultural and political aspects that can be decisive for project efficiency and success. All restoration activity takes place in a larger socio-economic political context, constituting for example drivers and barriers for its realization. Using an encompassing social-ecological systems (SES) perspective has been suggested in order to improve restoration planning and implementation, and to promote ecosystem and community resilience. However, taking such a SES perspective can add up to a very complex picture with a high level of uncertainty about which aspects to include on the “social” side of this framework, and when to give them ample consideration in the restoration process.

We will build on different kinds of quantitative and qualitative data to shed more light on these questions: 1) data from a national online survey of all restoration activities (in all habitats) in Norway since the year 2000; 2) case studies on river restoration projects in Switzerland, and 3) a national survey on river restoration in Switzerland. Based on the findings, we will arrive at recommendations on how challenges in the planning, implementation and success evaluation of river restorations from a social perspective can be addressed in a best possible way.

Keywords: public preferences, stakeholder acceptance, conflicts, values, success evaluation, participation

Evaluating river restoration measures through cultural ecosystem services

Author(s): Hayes, Daniel S.¹; Becsi, R.¹; Scheikl, S.¹; Böck, K.¹; Grüner, B.¹; Muhar, S.¹

Affiliation: ¹*Institute of Hydrobiology and Aquatic Ecosystem Management, University of Natural Resources and Life Sciences, Vienna, Austria*

E-mail: daniel.hayes @boku.ac.at

ABSTRACT

River restoration contributes to the improvement of hydro-morphological and ecological conditions of the aquatic environment. At the same time, restored sites as well as near-natural rivers are increasingly associated with socio-cultural values as such river landscapes provide a wide range of functions and services to many different users. In detail, such rivers may offer cultural ecosystem services such as recreational opportunities, the experience of nature, knowledge transfer, or spirituality. However, a methodological framework is needed to identify and evaluate this added value.

This study, therefore, aims to develop a spatially explicit, practicable, and replicable method to quantify the potentially available cultural ecosystem services of rivers before and after restoration activities. This approach includes the identification of significant criteria and indicators, and the further development of non-monetary assessments.

We based the assessment framework on a literature review, expert interviews, and standardized surveys of river users. The hierarchically organized method allows us to evaluate eight categories of cultural ecosystem services (hiking and running, bicycling, bathing, boating, angling, nature experience and tranquillity, education, landscape beauty and scenery) through a diverse indicator portfolio. Here, we demonstrate the method's applicability in five Austrian case studies.

The results show that river restoration measures improve cultural ecosystem service availability, particularly for water-based activities and for passive benefits such as nature experience. Overall, the method is deemed suitable for evaluating the success of river restoration measures, thereby adding a cost-effective approach to the hydro-morphological and ecological evaluation framework. Follow-up studies will continue testing and validating the method in further case studies to include the method in future standardized monitoring programs of river restoration projects.

Keywords: rivers, restoration strategy and planning, ecosystem services, status assessment, monitoring

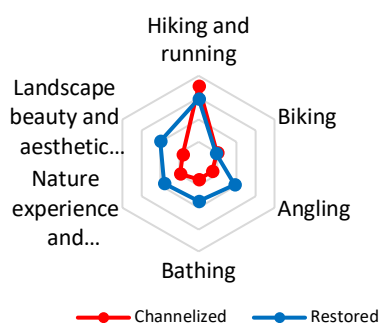


Fig. 1 Overall assessment of the case study 'Liesingbach': comparison of the mean cell value of six different cultural ecosystem services.

Integrated river basin management – a promising approach to implementing river restoration projects

Author(s): Buchecker, Matthias ; Gaus, Raphael; Fankhauser, Marius

Affiliation: *Swiss Federal Research Institute WSL; Swiss Federal Research Institute WSL; Swiss Federal Research Institute WS*

E-mail: matthias.buchecker@wsl.ch

ABSTRACT

Since two decades European policies have called for ecological enhancement of rivers - with limited success. This has to do with conflicting interest-based perspectives of relevant stakeholder groups that complicate finding shared solutions. Recent literature on social learning suggests that interactive involvement of relevant stakeholders in the management of regional river basin would allow for a convergence of stakeholders perspectives and thus increasing the shared solutions space. As robust evidence for the expected effects of this approach are scarce, We therefore designed a project with the goal to systematically evaluate the social learning effects of an integrated river basin management. The study was conducted in the river basin of the Hasli Aare in the Central Swiss Alps, where an actor platform was initiated by a cantonal agency in which the future development of the rivers within the basin should be determined. To evaluate the participatory process, we combined a quasi-experimental intervention research design with a mixed method approach including a repeated measurement of involved and not involved members of relevant actor groups as well as a process observation. The analysis of the qualitative and quantitative data confirmed and narrowed down the expectations. Before the participatory process the involved actor groups were found to held very specific interest-focused perspectives of the issue of regional river management, but also some shared interests, in particular in terms of the future flood management. During the process, a substantial convergence of actors perspectives could be determined, which became manifest in actors' agreement on a number of integrated river management projects. Notably, they included river restorations that had little acceptance before the participatory process. The implications of the findings for future river management will be discussed.

Integrating instrumental and deliberative participatory mapping methods to co-design nature based solution in river landscapes

Author(s): [Gottwald, Sarah](#)¹; Schröter, Barbara.^{2,3}; Gottwald, Eva.¹, Castro- Arce, Karina⁴

Affiliation(s): ¹*Ruhr University Bochum, Germany*; ²*Leibniz-Centre for Agricultural Landscape Research (ZALF), Germany*; ³*Lund University Center for Sustainability Studies (LUCSUS), Sweden*;
⁴ *University of Costa Rica, Costa Rica*

E-mail: Sarah.Gottwald@ruhr-uni-bochum.de

ABSTRACT

The concept of Nature-based solutions (NBS) has recently gained increasing attention in science and policy. NBS comprise actions to alleviate societal challenges by harnessing ecological processes. Although the integration of diverse stakeholders has been identified as a key requirement for successfully planning and implementing NBS, its implementation in practice remains challenging and underexplored. The Tárcoles river in Costa Rica is one of the country`s most polluted rivers, and is under intense pressure due to illegal garbage disposal, unregulated constructions upon its banks, and sealed surfaces of the surrounding environment. To assess the existing range of problems and co-design appropriate solutions, the varied stakeholder interests and their perceived challenges have to be considered. Currently, there are gaps in knowledge about the spatial location of social-ecological challenges, which NBS could help alleviate those challenges, and how NBS can be designed in a participatory manner. We focus on how participatory planning with NBS could be facilitated by remote collaboration of design teams, stakeholders, facilitators and scientists. The aim is to co-design, in collaboration with diverse stakeholders, an alternative future to the current reality that incorporates NBS that address perceived social-ecological problems related to the river. Specifically, we seek to answer the following research questions: 1) where do local stakeholders locate perceived problems?, 2) Which spatial patterns of implementing NBS could help addressing the problems?, and 3) which co-benefits and trade-offs might the proposed pattern of NBS yield? Our research study design integrates instrumental and deliberative spatial participatory methods integrating stakeholders in efforts to design and evaluate a spatial plan in consideration of NBS. The results include spatially explicit assessments of problems, plans for river development incorporating NBS, and an evaluation of potential impacts. We conclude with reflections on this methodological integration and discuss its suitability for the application in other river landscapes.

Keywords: PPGIS, Geodesign, river landscapes



SEPTEMBER
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S19.1 – Understanding the impacts of global environmental change and desertification in global drylands through international collaboration



Understanding global change and desertification impacts through international collaboration: The BIODESERT project

Author(s): Maestre, F.T.^{1,2}

Affiliation(s): ¹*Instituto Multidisciplinar para el Estudio del Medio 'Ramón Margalef', Universidad de Alicante, Alicante, Spain;* ²*Departamento de Ecología, Universidad de Alicante, Alicante, Spain*

E-mail: ft.maestre@ua.es

ABSTRACT

Changes in climate and land use (e.g., increased grazing pressure), are two main global change components that also act as major desertification drivers. Understanding how drylands will respond to these drivers is crucial because they occupy 41% of the terrestrial surface and are home to over 38% of the world's human population. Land degradation already affects ~250 million people in the developing world, which rely upon the provision of many ecosystem processes and services (multifunctionality). To better understand the joint effects of climate change on drylands, we have conducted a global field survey (the BIODESERT survey), involving more than 130 scientists working in over 30 countries from all continents except Antarctica, aiming to assess how simultaneous changes in climate and grazing pressure affect both biotic attributes and multifunctionality in drylands worldwide. In this communication, I will present the main characteristics of the BIODESERT survey, and some preliminary data regarding the location and environmental characteristics of the sites surveyed so far. By studying multiple grazing levels at each site and conducting a global study encompassing all aridity conditions found in drylands, the data gathered with this survey will provide key information to characterize the likely impacts of land degradation due to grazing on ecosystem structure and multifunctionality under climate change in drylands worldwide.

Keywords: Desertification, climate change, biodiversity, ecosystem services, global environmental change.

The Regional Impact of Ecological Restoration in the Arid Steppe on Dust Reduction over the Metropolitan Area in Northeastern China

Author(s): [Feng, Xiaoming](#) ; Zhou, Chaowei; Lv, Yihe; Fu, Bojie

Affiliation(s): *Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences; Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences; Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences; Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences*

E-mail: fengxm@rcees.ac.cn

ABSTRACT

Humans have begun to actively protect, manage, or restore ecosystems to adapt to and mitigate climate change effects, such as Nature-based Solutions (NbS). The nature-based solution shares the central theme that ecosystems, typically when in good condition, can sustain people's efforts to regulate risks from climate change and natural hazards. This concept focuses on societal welfare rather than on conservation for nature's own sake and has thus received increasing attention, including a recent emphasis in the Intergovernmental Panel on Climate Change (IPCC) Special Report¹ and the Paris Agreement on climate change.

In northern China, a reduction of dust was synchronous with the increase in vegetation growth after ecological restoration. Ecological restoration mainly reduced the sand emission in steppe area by improving the soil conditions of the underlying surface, and hence contributed 15% of the reduction of dust events in the Beijing-Tianjin-Hebei metropolitan area through dust transmission ($p = 0.002$). The impact of the increase in vegetation on local wind speed ($p = 0.30$) was easily covered by environmental climate change. Thus, the ecological restoration in the northern steppe in China can be further optimized with the view of regional impact of ecological restoration in the arid steppe on dust reduction over the metropolitan area.

Sustainable development in global drylands

Author(s): Liu Y.¹; Du J.¹; Zhu J.²; Yang Y.²; Wang Y.¹

Affiliation(s): ¹College of Resources and Environment, University Chinese Academy of Sciences, Beijing 100049, China; ²Sino-Danish College, University Chinese Academy of Sciences, Beijing 101408, China

E-mail: yfwang@ucas.ac.cn

ABSTRACT

Drylands occupy ~41% of the terrestrial surface and house ~2.5 billion people. These regions are especially sensitive and vulnerable to human activities and climate change. Restricted by the harsh environment, the development in drylands is generally unbalanced and might be challenging towards a holistic achievement of sustainable development goals (SDGs); however, its current status and problems have rarely been investigated globally. Here, we have systematically evaluated the progress towards SDGs in global drylands by integrating development evenness among goals. Our results suggest: (1) drylands have the lowest average performance of 17 goals and also the most uneven performance towards SDGs; (2) the interactions among goals tend to weaken from slightly arid to extremely arid countries; (3) SDGs regarding the essential human needs (e.g., water, food, health, and energy) are the most challenging aspects for sustainable development in drylands. As water resource is a major limiting factor in drylands' development, we further explore the correlations between water-related factors and other aspects of dryland's sustainable development. Finally, taking the typical drylands in northern China as a case, we find that the strict water management regulations have promoted the synergy between economic development and ecological conservation.

Keywords: drylands, sustainable development, evenness, index correlation, water resources management

Interaction and synergism management of Water and Ecosystem in Aral Sea basin

Author(s): Chen, Xi.¹; Liu Tie.¹;

Affiliation(s): ¹*Xinjiang institute of ecology and geography, Chinese academy of sciences, China*

E-mail: chenxi@ms.xjb.ac.cn

ABSTRACT

The Aral Sea began to shrink on a large scale from 67000 km² in 1960 to 3000 km² in 2020. The lake ecosystem was seriously damaged. Salt dust storms occurred in the exposed dry lake basin, which affected the health of millions of people in the basin. Our research shows that the Aral Sea change is divided into three stages, 1940-1960 stable period, 1960-1990 rapid decline period, 1990-2020 slow decline period. The ecological status of the Aral Sea is closely related to water resources management among Central Asian countries. The atmospheric remote sensing and ground observation data of salt dust were used to analyse relationship between salt dust storm and dry seabed, the results showed the main source of salt dust storm was in the dry eastern region. If the salt dust source area of 8000-10000 km² in the East is covered with water or vegetation or other materials, the salt dust storm will be reduced by 70%, that is, it will return to the status of the Aral Sea in 2005. According to land use change from 1960 to 2015, the cultivated land increased rapidly from 1960 to 1990, and the Aral Sea decreased by 50%. From 1990 to 2015, the cultivated land in most regions decreased, but the Aral Sea also decreased by 45%, the area of reservoir, wetland and groundwater level increased 2-3 times. So The reason for the Aral Sea drying up in the last 30 years is problem of synergism management on water , ecosystem. This paper provides a pilot demonstration of water-ecosystem monitoring system, fully promote water-saving irrigation technology, and water and ecosystem management.

Keywords: Aral Sea, Salt Dust, Water and Ecosystems, Water Saving Irrigation, Management Systems.

Framework of remote sensing-based grassland degradation monitoring on Qinghai-Tibet Plateau

Author(s): Wang, Y.11, Liu W.22, Hao Y.33, Xue K.41

Affiliation(s): ¹ College of Resources and Environment, University Chinese Academy of Sciences, Beijing 100049, China, ² Yunnan University, Kunming 650091, China, ³ College of Life Sciences, University Chinese Academy of Sciences, Beijing 100049, China

ABSTRACT

Alpine grassland is the major ecosystem in the Qinghai-Tibet Plateau (QTP), accounting for 60% area of QTP. Due to climate change and anthropogenic activities, diverse forms and differing intensities of grassland degradation have been reported in several regions of the Plateau, explicit monitoring is crucial to analysis the temporal and spatial variations of grassland degradation for both researchers and policy makers. In this study, a framework of remote sensing-based grassland degradation monitoring relevant to community function and structure change of grassland on Tibet Plateau was established. We developed a novel grassland degradation estimation model by using the regression tree algorithm (CART), combined with a series of representative remote sensing based ecological indicator including net primary productivity (NPP) ratio, fractional vegetation coverage (FVC), community diversity, nutrition content (crude protein) and surface roughness. The results showed that the grassland degradation on QTP was still serious. In 2019, the none and light degradation grassland accounted for only 10% and 13% of the total grassland area, while the proportion of moderate and heavy degradation grassland was 32% and 44%, respectively. Statistical analysis for grassland degradation area in three main provinces of QTP showed that degradation in Tibet was the most serious, 53% grassland suffered heavy degradation, which in Qinghai and Sichuan were 32% and 14%, respectively. There were only 10% grassland are none or light degradation in Tibet, which accounted for 38% and 75% in Qinghai and Sichuan province, respectively.

Keywords: QTP, grassland degradation, remote sensing, CART

S19.2 – Understanding the impacts of global environmental change and desertification in global drylands through international collaboration.

Essential dryland ecosystem variables

Author(s): Wu, B.^{1,2}; Zeng, H.^{1,2}; Lv, N.^{3,2}; Wang, Y.²; Fu, B.^{3,2}; Xu, Z.⁴.

Affiliation(s): ¹State Key Laboratory of Remote Sensing Science, Aerospace Information Research Institute, Chinese Academy of Sciences, China; ²University of Chinese Academy of Sciences, China; ³State Key Laboratory of Urban and Regional Ecology, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, China; ⁴Environmental Futures Research Institute and School of Environment and Science, Griffith University, Australia

E-mail: wubf@radi.ac.cn

ABSTRACT

Long-term and high-quality data are needed to assess the status, variability, change and drivers of dryland ecosystems, but these data are often lacking because dryland ecosystems are less studied without a consistent and systematic indicator framework. Moreover, these data are difficult to derive due to the highly fragmented spatial heterogeneity and temporal variability, which undermines our understanding of dryland ecosystems. This paper reviews the gaps in the existing essential variables of dryland ecosystems and proposes four criteria to identify essential dryland ecosystem variables (EDVs). The preliminary proposed EDVs have 6 dimensions and include 15 variables, which highlights the gaps in the current essential variables of thematic domains and focuses on the traits of dryland ecosystems. This study is only a first attempt, and a long-term process is required to establish the final EDVs and reach a consensus in the global dryland research community.

Keywords: Dryland Ecosystem; Essential Variables; Criteria; SES monitoring frameworks

Dryland forests and future restoration potential driven by climatic legacies

Author(s): Guirado, E.¹; Delgado-Baquerizo, M.², Martínez-Valderrama, J.¹; Tabik, S.³; Alcaraz-Segura, D.⁴; Maestre, F.T.^{1,5}

Affiliation(s): ¹*Instituto Multidisciplinar para el Estudio del Medio 'Ramón Margalef', Universidad de Alicante, Alicante, Spain;* ²*Departamento de Sistemas Físicos, Químicos y Naturales, Universidad Pablo de Olavide, Sevilla, Spain;* ³*Department of Computer Science and Artificial Intelligence, University of Granada, Granada, Spain;* ⁴*Department of Botany, Faculty of Science, University of Granada, Granada, Spain;* ⁵*Departamento de Ecología, Universidad de Alicante, Alicante, Spain*

E-mail: emilio.guirado@ua.es

ABSTRACT

Water availability is one of the main factors limiting the distribution of forests in drylands. However, the importance of climatic legacies and groundwater resources as drivers of the current distribution of forests in drylands has been neglected. Here we show that consideration of past mid-Holocene climates and aquifer trends is essential to explain the extent and distribution of dryland forests worldwide, especially in semi-arid climate zones. Our work updates the global extent of dryland forests to 1283 Mha and identifies an estimated 130 Mha of dryland forests whose current distribution is misplaced when past climatic conditions and aquifer trends are not considered. In particular, forest areas along the Sahel in Africa and northern Australia have been underestimated and in areas of South Africa overestimated in previous assessments. These findings highlight the importance of a wetter past and well-conserved aquifers in explaining the establishment of today's dryland forests, and can guide restoration actions by avoiding unsuitable areas for tree establishment in a drier world .

Keywords: Climate change, drylands and desertification, forest, restoration strategy

Desertification in Spain: an accurate diagnosis without effective solutions

Author(s): Martínez-Valderrama, J.¹; Del Barrio, G.²; Sanjuán, M.E.²; Guirado, E.¹; Maestre, F.T.^{1,3}

Affiliation(s): ¹*Instituto Multidisciplinar para el Estudio del Medio 'Ramón Margalef', Universidad de Alicante, Alicante, Spain;* ²*Estación Experimental Zonas Áridas, CSIC, Almería, Spain;* ³*Departamento de Ecología, Universidad de Alicante, Alicante, Spain*

E-mail: jaime.mv@ua.es

ABSTRACT

The World Atlas of desertification proposes the Convergence of Evidence to detect emerging desertification problems. By doing so, it forgoes mapping desertification and relies on cross-referencing the increasingly abundant and detailed spatial information to analyze where biophysical and socio-economic drivers (so-called Global Change Issues) converge. In addition, it stresses the enormous importance of the political, social and cultural context (as well as local and regional information) of each area in assessing the potential of these threats and, therefore, in being able to redirect the problem.

In Spain this type of procedure was applied twenty years ago. With less information available and less powerful geographical information systems than the current ones, five desertification landscapes related to agricultural activity or its abandonment were established. That pioneering vision of desertification by the National Action Plan against Desertification (PAND) was followed by other state-of-the-art developments, but stagnated when it came to implementing solutions. Here we review the current status of desertification landscapes proposed by the PAND, introduce new ones developed over the last two decades and discuss actions that should be implemented to combat land degradation and desertification in Spain.

Keywords: Desertification, drivers, socioeconomic, agriculture, solutions

Croppedland dynamic change and spatial variations from 2010-2020 in Mediterranean Regions

Author(s): Zeng, H.^{1,2}; Wu, B.^{1,2}; Zhang, M.^{1,2}, Elnashar Abdelrazek^{1,2,3}

Affiliation(s): ¹State Key Laboratory of Remote Sensing Science, Aerospace Information Research Institute, Chinese Academy of Sciences, China; ²University of Chinese Academy of Sciences, China; ³Department of Natural Resources, Faculty of African Postgraduate Studies, Cairo University, Egypt

E-mail: zenghw@radi.ac.cn

ABSTRACT

The ability to provide food is an important function of dryland ecosystems, and one that is becoming increasingly urgent as populations increase. The Mediterranean region is a typical dryland region, with arid areas covering 85.98% of the Mediterranean area, of which 48.76%, 13.44%, 18.75% and 5.03% are hyper-arid, arid, semi-arid and semi-humid drylands respectively. The African and Asian parts of the Mediterranean area have experienced rapid population growth and warming trends in the last decades, and the population and warming pressures have led to significant changes in the distribution of croppedland, and generated the significant impact on the sustainable use of water resources and food supply services in the region. This study mapped the distribution of croppedland in 18 countries of the Mediterranean region in 2010 and 2020 using all available Landsat imagery, using a random forest classifier (500 trees). In order to increase the classification accuracy of the feature classes, a total of 21 Landsat spectral bands, remote sensing indices and topographic features were used in this study to participate in the remote sensing classification of croppedland. Between 2010 and 2020, the area of arable lands in 18 countries in the Mediterranean region decreased from 1,243,200 ha to 1,180,000 ha, a decrease of 5.06%. Countries with significant increases in croppedland include Jordan, Libya, Syria, Tunisia, Egypt and Lebanon, while countries with significant decreases include Morocco, Algeria and France. The countries with significant increases in croppedland are mostly located in North Africa and West Asia, which are the regions with the driest climate, the most scarce water resources and the fastest population growth rates in the Mediterranean region, and the significant increase in croppedland will further increase the water stress in the region and affect the sustainable development of the region.

Keywords: Mediterranean region; croppedland; dynamic change; remote sensing.

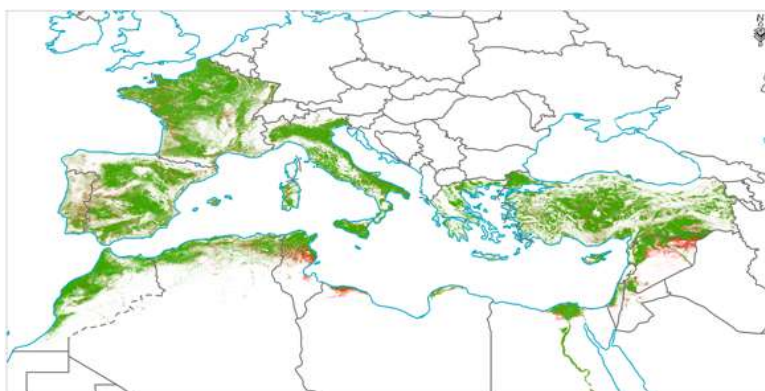


Fig. 1 Croppedland change from 2010 to 2020 (green colour is croppedland in 2010, and red colour is croppedland in 2020)

S11 – Restoring continuity and barriers removal in rivers: complexity of managing Ecological Restoration projects

An innovative technology to decrease the environmental impact caused by polluting effluents from abandoned mines in rivers

Author(s): Abril, M.¹; Vendrell-Puigmitjà, L.¹; Oatley-Radcliffe, D.²; Colón, J.¹; Peña, N.¹; Duarte, T.³; Bostock, R.³; Bostock, J.³; Sommer, T.⁴; Seemann, A.⁴; Alvarez, P.L.⁵, Llenas, L.¹

Affiliation(s): ¹ BETA Technological Center, TECNIO Network, University of Vic-Central University of Catalonia, Vic, Spain; Country; ²Energy Safety Research Institute (ESRI), Swansea University, Bay Campus, Fabian Way, Swansea, UK; ³ELENTEC Ltd, Dwyran, Llanfairpwll, UK; ⁴Dresden Groundwater Research Center, Dresden, Germany; ⁵Government of Principality of Asturias, Oviedo, Spain.

E-mail: meritxell.abril@uvic.cat

ABSTRACT

Abandoned mines cause serious environmental damage to their surroundings, with considerable impacts on waterbodies. These impacts occur mainly through the uncontrolled discharge of polluting effluents, which may contain high concentrations of heavy metals or salts, depending on the type of mine. Currently, no real solution exists for this significant environmental problem, leaving a legacy of global pollution that also hinders mining restoration activities. In this context, the LIFE DEMINE project has developed an innovative treatment technology that combines membrane and electrocoagulation processes, with the final aim of obtaining a non-polluting effluent that could be discharged in rivers without any risk and being in line with the current water legislation framework. In this regard, the results obtained when treating effluents from abandoned metal mines, shows a high-performance efficiency of the DEMINE technology, with a metal removal of 98%. To perform an evaluation of the environmental benefits that the implementation of this technology would have in freshwater ecosystems, the potential in reducing the ecological impact caused by polluting effluents in rivers has been demonstrated in different experiments using the aquatic biofilm as ecological indicator. While metal polluting effluents inhibited the photosynthetic processes and caused a shift in the algal community of the biofilm, the application of the DEMINE technology drastically reduced this ecological impact. Moreover, in order to assess the replication potential of the LIFE DEMINE technology, a mining effluent database containing the composition of 5618 mining effluents from 90 European mining sites has been created. The results obtained until the date indicate the potential of the LIFE DEMINE technology as an efficient tool to be implemented in restoration projects to improve the quality and biodiversity of the waterbodies affected by polluting effluents from abandoned mines.

Keywords: abandoned mines, river, treatment technology, ecological impact

Improvement of Natura 2000 statuses with renaturation of Stržen's riverbed on intermittent Cerknica Lake

Author(s): Likar, I.¹; Gabrejna Fajdiga, A.²

Affiliation(s): ¹Notranjska Regional Park, Slovenia; ² Notranjska Regional Park, Slovenia

E-mail: irena.likar@notranjski-park.si

ABSTRACT

With project LIFE Stržen activities, we are improving the conservation status of priority habitat type Turloughs (HT 3180*) and priority species Bittern (*Botaurus stellaris*) at Cerknica Lake.

In the 20th century, several watercourses of Cerknica Lake were redirected into straight channels. These regulations caused harmful changes in natural processes and drastically changed the ecosystem of the intermittent lake. Living conditions of species inhabiting aquatic and riparian habitat types have declined. Some species disappeared from the area entirely. Biodiversity and ecosystem stability were significantly reduced.

Stržen is the biggest watercourse on Cerknica Lake. Its restoration significantly alleviates this threat. The watercourse has been extended by 1.5 km. Consequently, water remains in this area for a longer period of time, which improves chances of survival of water-related species during dry season. We have restored the former double meander in the area Ključiči with a total length of 2.1 km. Due to weather conditions and water regime of the lake we adjusted the process of the restoration to those difficult conditions. The vicinity of the restoration area is one of the only Slovenian nesting sites for Bittern. This area has been designated as a quiet zone where fishing is forbidden. Visitors have been redirected from lake's most sensitive parts with the establishment of guiding infrastructure and activities such as active communication with visitors and locals and active awareness raising. Consequentially, uncontrolled visits to the area have been reduced significantly. The restoration of Stržen will result in longer water-retention times during the dry season and prolonged saturation of soil with water in the broader area along the riverbed. This improves the conditions for fish, invertebrates, birds and mammals, as it increases the amount of available food and access to the area. Conditions for growth of characteristics HT plant species have improved as well.

Keywords: Biodiversity, ecosystem functioning, wetlands, restoration, rivers.

Fig. 1 Aerial view of the restored double meander and artificial straight channel of Stržen



Plants under hydropeaking: morphological and physiological responses

Author(s): Baladrón, A.^{1,2}, Bejarano, M.D.²; Sarneel, J.³, Boavida, I.¹

Affiliation(s): ¹*Universidade de Lisboa, Portugal*; ²*Universidad Politécnica de Madrid, España*, ³*Umeå University, Sweden*

E-mail: mariadolores.bejarano@upm.es

ABSTRACT

Our goal was to evaluate the effects of hydropower production through the phenomenon of hydropeaking on riparian vegetation. Hydropeaking involves frequent and rapid variation in flow over a short period of time, usually sub-daily, altering hydraulic parameters which are key for plants. Specifically, we wondered whether plants' germination and establishment varies depending on the hydropeaking scheme and plant species, in order to identify the least impacting operating scheme and the most tolerant species to hydropeaking. For this aim we measured morphological and physiological attributes (i.e., germination, survival, above- and below-ground dry biomass, and leaves' total content of C, N and $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$) of a selection of species commonly found along riparian areas and which represent a variation in traits. Species were subject to different hydropeaking scenarios during three months (vegetative period) in the field and in a greenhouse. In the field hydropeaking scenarios corresponded to those derived from nearby hydropower plants, whereas in the greenhouse they corresponded to watering treatments which simulated different depths, durations and frequencies of inundation events. Significant differences were found in germination success, survival, leaves C/N balance, and biomass among species. These differences were linked to depths, durations and frequencies of inundation events both in the field and the greenhouse. In addition, differences were more evident at sites with the most intense hydropeaking disturbance. This finding points to particular plant traits in playing a role in species capacity to cope with hydropeaking. This study helps paving the way for identifying the boundaries beyond which riparian species cannot germinate, grow or survive under hydropeaking, which are key to diagnose the impact of hydropeaking in rivers and restore riparian areas. Additionally, measurements of function (i.e: morphological and physiological processes driving plants survival, growth and metabolic activity) contribute to better understand hydropeaking effects on the river's services.

Keywords: Greenhouse, Hydropower, Plant traits, Riparian areas restoration, Riparian vegetation

Toward more effective stream restoration: a demonstration sites network to assess efficiency.

Author(s): Tales, Evelyne¹; Vivier Anne²

Affiliation(s): ¹University Paris Saclay, INRAE, Research Unit Hydrosystems under changes, France

²OFB, Office for Biodiversity, France

E-mail: evelyne.tales@inrae.fr

ABSTRACT

Hydromorphological river restoration has been encouraged since the publication of the Water Framework Directive all over Europe in 2000, in order to improve the ecological status of running waters. Thus, numerous restoration operations have been conducted with various objectives: restoring ecological continuity, increasing river habitat heterogeneity, etc. However, it is often impossible to conclude on their efficiency as many of these operations lacked suitable monitoring or had flaws in their design.

European projects concerning water bodies (e.g. Reform ERC, Walphy Life Environment) attempted to resolve this matter by analysing restoration outcomes of selected case studies. They provided a set of good practices to ensure more effective restoration. At the same time, it is also necessary to better plan restoration projects from conception to implementation, to improve monitoring and thus understanding of the processes sustaining successful restoration.

Since 2010 in France, such an approach is realised as part of the Demonstration Sites Network. Coordinated by the French Office for Biodiversity (OFB), it results from a collaboration involving practitioners, stakeholders and researchers. It currently includes about 40 sites, which are subject to restoration works. The methodological framework developed for this network comprises several key elements to allow for a robust assessment of restoration efficiency. On these sites, a scientific long-term monitoring is conducted following a BACI (Before After Control Impact) design and using standardised protocols for data collection. Guidance documents concerning monitoring have been published to support restoration approach at a site scale. A guiding procedure for the restoration project evaluation is currently being developed. Finally, this network is also a tool to promote adaptative management.

Keywords: Rivers, restoration strategy/planning, evaluation and monitoring

W4 – Socio-ecological restoration of riparian vegetation by integrating biotic and abiotic pressures

Ecological rehabilitation of riparian vegetation in regulated rivers: assessing ecosystem costs and benefits

Author(s): [Roland Jansson](#), Birgitta Malm Renöfält, Åsa Widén

Affiliation(s): *Department of Ecology and Environmental Science, Umeå, Sweden*

E-mail: Roland.jansson@umu.se

ABSTRACT

Riparian zones form a transition zone between terrestrial and riverine ecosystems, and are characterized by high geomorphic and biological diversity. A large proportion of river systems worldwide are degraded by damming and flow regulation, also affecting riparian vegetation. In regulated river systems of northern Sweden, riparian plant communities have been reduced to a fraction of its former area, with concomitant losses in species richness, as a result of changes in the magnitude, timing, frequency and duration of flow. We review efforts to enhance establishment of riparian vegetation and increase its area in regulated water-bodies, using methods that allow for continued hydropower production, since this is an important source of renewable electricity. The methods imply changing aspects of flow or water-level variation to meet niche requirements of riparian plants, and include: (1) re-introducing more natural water-level variation in run-of-river impoundments, (2) implementing seasonal variation in minimum discharge to by-passed reaches, (3) re-introducing spring flood events, and (4) protection of riparian zones from erosion caused by hydropeaking by placing boulders in near-shore areas. Some of the environmental flow options are already implemented and need to be monitored, whereas others require further experiments or scaling up. The costs of implementing the rehabilitation measures in terms of losses in hydropower production were assessed by using model simulation software used for planning of hydropower operation, in which we modified the hydropower operational rules to reflect environmental flow options. We conclude that it is possible to implement environmental flow measures that provide critical ecosystem benefits, increasing the diversity and extent of riparian vegetation, that allow for continued hydropower production.

Emerging biotic (pest and diseases) pressures on riparian ecosystems: challenges and needs for their socio-ecological restoration

Author(s): [Oliva, J.](#)^{1,2}

Affiliation(s): ¹ Department of Crop and Forest Sciences, University of Lleida, Lleida, Spain; ² Joint Research Unit CTFC-AGROTECNIO, Lleida, Spain

E-mail: jonas.oliva@udl.cat

ABSTRACT

Global change has brought riparian trees in contact with new pathogens and new conditions that threaten their health and affect their ecosystem functioning. In this talk, I will review some of the research carried out in alder stands (*Alnus glutinosa* and *Alnus incana*) affected by the *Phytophthora alni* species complex in Sweden. The different species of pathogens and their impact in future climatic conditions will be discussed. Also, the potential impacts of invasive pathogens affecting the food web in freshwater ecosystems will be outlined. The results of a genetic resistance trial against two pathogens will be used to show the challenges we may face when attempting the restoration of affected stands using resistant material.

Keywords: invasive species, climate change, riparian forests, alder

Riparian plant invasions: causes, consequences and management

Author: González, E¹

Affiliation: ¹*Department of Biology, Colorado State University, United States of America*

E-mail: eduglez@colostate.edu / edusargas@hotmail.com

ABSTRACT

Plant invasions occur when the population of one species that has colonized a new habitat develops rapidly and becomes dominant. Invaders are very frequently (but now always) non-native species introduced in the system by humans.

Successful plant invasions are caused by a combination of high propagule pressure, environmental filters that favour certain traits and characteristics of the invader, and a low or impaired biotic resistance of resident communities. Riparian corridors are prone to plant invasions because fluxes of water and sediment facilitate propagule dispersal. Alterations of the natural flooding regime, climate, and land use lead to changes in environmental filters driving the equilibrium of disturbance and stress forces which ultimately determine riparian plant composition. More taxonomically and functionally diverse communities are more resistant to invasions.

Plant invasions have the reputation of producing multiple negative effects on ecosystems, such as displacing biodiversity, impoverishing wildlife habitat, and altering nutrient cycling. However, very often it is not clear whether invasions are drivers or passengers of ecosystem change. Negative perceptions of invasive species have dominated management historically, but eradication approaches have progressively been replaced with early detection, population control and acceptance of their integration in the system for maximizing ecosystem functions and services.

I will illustrate the causes, consequences and management of riparian plant invasions with the case study of non-native *Tamarix* shrubs (saltcedar/tamarisk) in western North America. This is arguably one of the most dramatic riparian plant invasions in the world. Millions of dollars have been spent for their active removal. Paradoxically, as soon as a cost-effective method of control was established: biocontrol with a defoliating beetle, stakeholder perceptions changed. Today, ecosystem functions and services provided by tamarisks are acknowledged, and management practices are changing accordingly. New strategies to control plant invasions in European riparian systems might be inspired by this example.

Keywords: invasive plant species, ecosystem change, saltcedar, tamarisk

Socio-ecological restoration of riparian forests, what do we mean by "socio-" !

Author: Simon Dufour

Affiliation: *Université Rennes / CNRS*

E-mail: simon.dufour@univ-rennes2.fr

ABSTRACT

This presentation aimed to illustrate why the human dimensions of riparian vegetation are crucial although neglected by scientists. We notably discuss how riparian management actions are driven by human factors. Indeed, in addition to the direct anthropic impacts, the cultural, social and political characteristics modulate indirectly the outcomes of riparian vegetation management practices. We also highlight the great complexity of human dimensions within socio-ecological systems (e.g. number and diversity of different stakeholders and of interactions among them). We argue that this diversity of the human dimensions has been poorly studied in riparian systems, when compared to other scientific topics in the last decades. If we want to find ways to better include stakeholders in decision-making process in the future, and thus to enhance the success of the restoration, we need to promote uncovered topics in riparian management research (i.e. push riparian vegetation as a scientific subject for social sciences).

S17 - Tools for planning ecological restoration I

Tools for planning ecological restoration

Author(s): Cortina-Segarra, Jordi.¹; Silva, E.¹, Bonet, A.¹

Affiliation(s): ¹Department of Ecology and IMEM-University of Alicante, Spain;

E-mail: jordi@ua.es

ABSTRACT

Ecological restoration activities will increase with the implementation of the UN decade of ecological restoration and the European biodiversity strategy for 2030. Restoration projects should tap on existing knowledge and develop new approaches to meet the challenges on 21st century restoration. These include optimizing actions at a landscape level, integrating multiple criteria in decision-making, and finding operational ways to engage society in restoration projects. We will present tools to increase the effectiveness of ecological restoration planning in degraded lands and discuss strategies for increasing their uptake and discuss them together with other participants in this session.

Research supported by the Ministry of Science and Innovation, Spanish Government, and European Regional Development Funds (project COSTERA, RTI2018-095954-B-I00).

Keywords: restoration strategy/planning, co-creation, social participation, land use planning, landscape-scale restoration



Fig. 1 Tools for planning ecological restoration: nature, people, and plans.

Supporting future restoration efforts by measuring past restoration over space and time

Authors (s): Willemen, L.¹; Del Rio-Mena, T.¹; Vrieling, A.¹; Nelson A.¹

Affiliation(s): ¹*Faculty of Geoinformation Science and Earth Observation (ITC) University of Twente, Netherlands;*

E-mail: l.l.willemen@utwente.nl

ABSTRACT

Restoration interventions typically aim to address multiple objectives to improve living conditions for people and nature. To support restoration efforts, the 2018 IPBES assessment report on Land Degradation and Restoration stated the need for *“Effective monitoring strategies, verification systems and adequate baseline data—on both socioeconomic and biophysical variables—provide critical information on how to accelerate efforts to avoid, reduce and reverse land degradation and conserve biodiversity”*. The concept of ecosystem services, defined as the contributions of nature to humans, links the social with the ecological system and could therefore be used as a holistic entry point for evaluating landscape restoration. With spatial data availability and quality is increasing rapidly, the question arises how, when and for what can spatial data be used to measure the effect and steer of restoration activities over time?

We provide an example of an ex-post evaluation based on remote sensing and GIS information to visualize and assess changing landscape conditions in the Baviaanskloof Hartland Conservancy, South Africa. Since 1990, several interventions have been implemented in this dryland to overcome decades of small livestock farming which has led to extensive land degradation and loss in income. Together with the project leads from LivingLand we selected six ecosystem services linked to the interventions objectives. Using field observations, we calibrated Sentinel-2 and Landsat vegetation indices combined with GIS data, to map and monitor the selected ecosystem services. This approach allowed us 1) to compare intervened and non-intervened sites within and between years, 2) capture within-intervention site variation, 3) distil factors that are associated with intervention impact, 4) design a work-flow for continued monitoring. Learning from past and ongoing restoration, can support smart allocation of new resources and represents an opportunity for improved decision-making and adaptive management based on critical reflection on lessons learnt.

Keywords: Ecosystem services, Landscape, Drylands and desertification, Evaluation and monitoring, Restoration strategy/planning

Modelling landscape management scenarios for equitable and sustainable futures in rural areas based on ecosystem services

Author(s): Felipe-Lucia, M.R.^{1,2}; de Frutos, A.³; Comín, F.A.⁴

Affiliation(s): ¹Helmholtz Centre for Environmental Research - UFZ, Leipzig, Germany; ²German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Germany; ³Department of Education and Specific Didactics, Faculty of Humanities and Social Sciences, Universitat Jaume I, Castellón, Spain; ⁴Instituto Pirenaico de Ecología-CSIC, Zaragoza-Jaca (Huesca), Spain

E-mail: maria.felipe-lucia@idiv.de

ABSTRACT

Scenario analysis is a useful technique to inform landscape planning of social-ecological systems by modelling future trends in ecosystem service supply and distribution. This is especially critical in floodplain agroecosystems of rural areas, which are constantly threatened with the disappearance of riparian forest corridors for increasing agricultural production or by rural abandonment. However, few studies investigating the effects of land management combine social and ecological modelling in scenario analyses. We estimated the supply of 16 ecosystem services under five alternative scenarios based on the combination of two gradients: agricultural intensification and ecological restoration of the riparian forest. We used redundancy analyses to detect ecosystem services bundles and interviews to identify societal gains and losses associated with each management scenario. Our results show how land management influences both the supply and distribution of ecosystem services. Scenarios promoting ecological restoration supplied more services and benefit a larger range of societal sectors than those scenarios focused on provisioning services. We also found two consistent bundles across scenarios, one related to less intensive food supply and another one related to outdoors activities. Interestingly, additional services were included in these bundles in the different scenarios, reflecting land management effects. Landscape scale management promoting both the conservation of ecosystem functioning and the sustainable use of provisioning services could supply a more balanced set of ecosystem services and benefit a larger number of societal sectors, contributing to more equitable and sustainable futures in rural areas.

Keywords: Ecological restoration: Concepts and theory; Ecosystem services; Restoration strategy/planning; Rivers; Rural development.

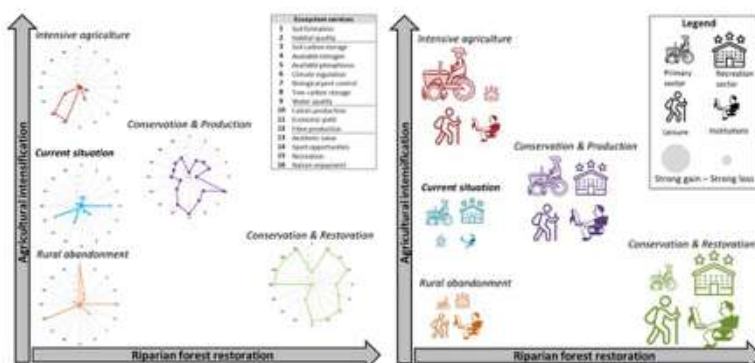


Fig. 1 Effects of alternative land management scenarios on 16 proxies of ecosystem services supply (left) and the four main stakeholder groups (right). Scenarios are depicted across a gradient of riparian forest restoration versus a gradient of agricultural intensification. Scenario 0: Current situation (bold); Scenario 1: Conservation & Restoration; Scenario 2: Agricultural intensification; Scenario 3: Conservation & Production; Scenario 4: Rural abandonment. On the right panel, the relative effect is proportional to the size of the icon representing each stakeholder group.

Social barriers for Mediterranean restoration: a multicausal network analysis

Author(s): Mañas-Navarro, José Javier; Aledo, Antonio; Ortiz, Guadalupe; Cortina-Segarra, Jordi.

Affiliation(s): ¹²³*Department of Sociology I, University of Alicante, Spain;* ⁴*Department of Ecology and IMEM, University of Alicante, Spain.*

E-mail: josejaviermanyasnavarro@gmail.com

ABSTRACT

The classical approach to ecological restoration has been predominantly positivist, based on empiricism and technical protocols. This praxis has worked in controlled environments, without the uncertainty and conflicts of a social environment. In contrast, ecological restoration works in environments with multiple actors, technical and non-technical backgrounds, who relate to and engage with restoration processes. Recognizing that ecological restoration is part of this social environment, a holistic perspective encompassing the whole complexity (environmental, social, economic, political, and cultural aspects) becomes necessary.

Faced with this problem, a constructivist diagnosis has been applied with the aim of identifying ecological restoration barriers and their causes, in the Valencian Community. Based on the identification of ecological restoration barriers, this diagnosis has allowed the design of effective management strategies appropriate to its socio-environmental context.

A methodology centered on endogenous knowledge and of a markedly iterative nature has been applied to carry out the diagnosis. The insights of 30 stakeholders representing the decision-making chain in the ecological restoration have been collective through semi-structured interviews. The participants indicated the most relevant barriers to ecological restoration and established cause-effect relationships for the different problems.

The analysis of data consisted of the creation of Collaborative Causal Attribution Maps that were analyzed with Multicausal Network Analysis, supported by Atlas.ti and Gephi. The stakeholders' reflective process and their multi-faceted vision made it possible to identify the main barriers and to unveil strategic windows for action in ecological restoration.

Keywords: collaborative causal maps, qualitative methods, multi-causal attribution network analysis, barriers and drivers.

S17.2 - Tools for planning ecological restoration I

Social learning on forest restoration in semiarid areas of North Africa

Author(s): DERAK Mchich⁽¹⁾, CORTINA Jordi⁽²⁾ & TAIQUI Lahcen⁽³⁾

Affiliation(s): ⁽¹⁾ Regional Forest Department. Tétouan, Morocco. ⁽²⁾ University of Alicante, Spain.

⁽³⁾ University of Abdelmalek Essaadi, Teétouan, Morocco

Email: mchich78@hotmail.com

ABSTRACT

Forest restoration is a suitable tool to mitigate land degradation and to enhance the supply a variety of vital goods and services. Being a long process, forest restoration requires a continuous effort from restorationists to follow the restoration progress and to bring corrective measures within a learning process that also seeks prolonged social acceptance and support. We adopted a social learning-based approach and assessed a nine-year demonstrative project aiming at participatory forest restoration in Beni Boufrah valley, a semiarid area located in North Morocco. We performed individual interviews and organized a workshop to check for changes in beliefs and attitudes among a variety of stakeholders. Learning was also described using monitoring measurements, field observations, and stakeholder recommendations. Our results revealed that *relational change* was barely achieved as conflict and mistrust continued to be the dominant feature of the relationship that link forest Administration with farmers and some local inhabitants. A considerable number of stakeholders showed a promising *cognitive change*, reflected by a transformation of beliefs on the inappropriateness of current behaviors and practices and recognition that forest restoration is a task of all the community. *Change in skills and experience* was relevant as stakeholders acquired theoretical and practical concepts on forest restoration. Monitoring and observation tasks showed a high impact of drought on seedling survival and growth along with a decrease in stakeholder engagement over time. We applied a series of practical improvements, namely (i) replacement of dead seedlings through participatory planting, (ii) fencing the restored site, (iii) establishment of a local monitoring committee, and (iv) maintaining continuity in the raising awareness effort. We believe that the present approach could be better tested and validated through larger experimental projects based on integrated interventions that address the whole landscape and enclose more innovative mechanisms to keep stakeholders motivated and engaged.

Keywords: Long-term engagement, awareness rising, stakeholders, landuse planning,

The Global Restore Project: Knowledge Sharing for Shared Success

Author(s): [Emma Ladouceur](#)¹, Nancy Shackelford²

Affiliation(s): ¹ *Biodiversity Synthesis & Physiological Diversity, German Centre for Integrative Biodiversity Research (iDiv) Halle-Leipzig-Jena*

² *School of Environmental Studies, University of Victoria*

E-mail: emma.ladouceur@idiv.de

ABSTRACT

The Global Restore Project (GRP) aims to bring together restoration researchers globally to pool existing data and knowledge for a deeper understanding of restoration science. Since our launch in 2019, we have partnered with the Global Arid Zone Project (GAZP), to bring together restoration data across global aridity gradients. We are collecting vegetation community monitoring data from actively restored (where seeding or planting treatments have been applied), passively restored and undisturbed remnant reference habitats for a rich, flexible, comparative framework to assess success. We are bringing together fragmented datasets collected over time by different teams, connecting references with local restoration and are developing tools for practitioners to be able to use. We envision that identifying spatial and temporal patterns of restoration success and failure has the power to inform predictive restoration science, to improve outcomes and reduce risk in restoration projects, and inform practical applications and policy. We will make these data completely open access and available to the community wherever possible, and intend to continue to grow these resources and tools over time. Here, we give an update on progress made, on our current status and invite interested people to reach out to us to chat about the many opportunities to get involved.

4 Returns Framework for Business-driven Landscape Restoration

Author(s): Moolenaar, Simon Willem¹

Affiliation(s): ¹Director Knowledge, Education & Innovation at Commonland Foundation

E-mail: simon.moolenaar@commonland.com

ABSTRACT

The 4 Returns Framework for landscape restoration is a system-change framework that can be used by diverse stakeholders who want to undertake a landscape approach and build a landscape partnership together. It connects ecology, community values and long-term economic sustainability at landscape level. The 4 Returns Framework allows governments, businesses and communities to co-create and deliver a common vision for a resilient landscape.

It is a conceptual and practical framework to help stakeholders achieve impact at scale through 4 Returns: return of inspiration and returns of social capital, natural capital and financial capital. The 4 Returns Framework follows the 5 elements of Integrated Landscape Management: 1. developing a landscape partnership; 2. building shared understanding; 3. forging a vision and strategy with spatially-targeted action plans; 4. coordinating actions, developing and financing an integrated landscape investment portfolio; 5. measuring landscape impacts, capturing lessons learned, and using them to adjust the landscape strategy and action plan. It encourages to take a multifunctional landscape perspective characterized by 3 zones: natural, combined and economic zones. Also, it stresses the importance of a long-term view to allow for ecological and social transformation and regeneration: a minimum of 20 years.

Business models ask and answer the question how to create, deliver and capture value. Business Model Innovation for landscape restoration aims at enhancing both organizational and social-ecological resilience by creating and regenerating natural, social and financial capital through restoring ecosystem functions and services. The benefits of this multiple value creation should be distributed to relevant stakeholders.

The 4 Returns Framework for Landscape Restoration will be explained and will be illustrated with an application of the “ESP Guidelines to analyse and capture the costs and benefits of nature conservation, landscape restoration and sustainable land management” (<https://www.es-partnership.org/esp-guidelines/>).

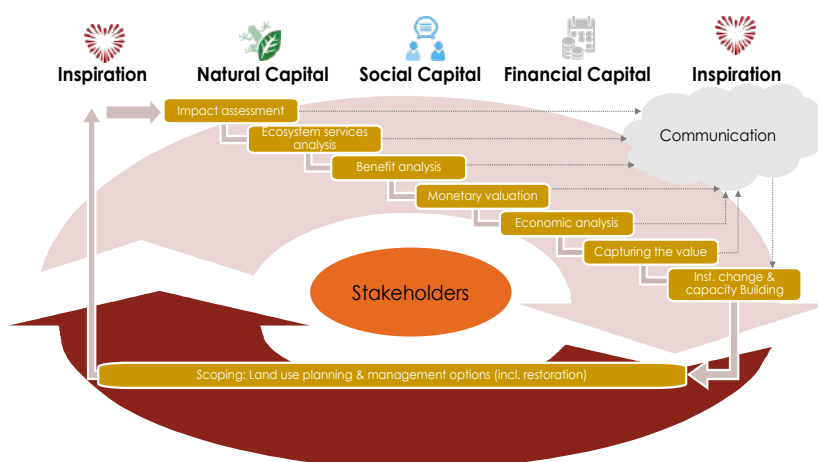


Fig. 1 ESP Guidelines to analyse and capture the costs and benefits of nature conservation, landscape restoration and sustainable land management

Codes of conduct as tool in large-scale landscape restoration, applied in two Norwegian restoration projects

Author(s): Hagen, D.¹, Solli, S.², Saether, A.L.³ Erikstad, L.¹

Affiliation(s): ¹Norwegian Institute for Nature Research, Norway, ²Norwegian Defence Estate Agency, Norway, ³Asplan Viak / Store Norske Spitsbergen Grubekompani AS, Norway

E-mail: dagmar.hagen@nina.no

ABSTRACT

In light of the IPBES and IPCC reports, the need for large scale restoration of degraded land has been stated as part of the solution to mitigate effects of climate change and protect biodiversity. This is subsequently reflected in the UN decade on Ecosystem Restoration (2021-2030). This global commitment call for the development of strategic tools for implementation of large scale projects, and to integrate scientific and experience based knowledge.

We present five principles developed and applied as codes of conduct in two iconic Norwegian landscape restoration projects; the restoration of a 165 km² military training area into National Park (during 1999 – 2020, 55 mill euro budget), and restoring a coal mining settlement in high arctic Svalbard (during 2017 – 2024, 200 mill euro budget). 1. Acknowledge ecological processes, 2. avoid new disturbance during the implementation, 3. no use of introduced species, 4. time scale – consider both short and long term effects, 5. spatial scale (integrate small and large scale perspectives). This approach has allowed for cooperation across sciences, policy, planning, and economy. The principles are particularly relevant to keep focus, reduce conflict level and make priorities within complex projects. The lessons learned in these projects are relevant for future restorations to meet the needed transformative change of global land-use.

Keywords: Communication / participation, High latitude ecosystems, Landscape, Restoration strategy/planning.

Fig. 1. Five principles for restoration have been successfully implemented in the restoration of a alpine military area (left) and a high arctic coal mine community (right) back to wilderness.



S18.1 – Tools for planning ecological restoration II



Comparing prioritization methods for ecological restoration in Mediterranean landscapes

Author(s): [Silva E](#)¹, Bonet A¹ & Cortina J¹.

Affiliation(s): ¹*University of Alicante and IMEM, Alicante (Spain)*

E-mail: sylvia

ABSTRACT

Mediterranean landscapes show a high risk of desertification due to intensive use and extraction of natural resources. Planning and prioritization are urgently needed to increase the effectiveness of ecological restoration. Different approaches have been proposed to prioritize areas and actions, but they seldom have been compared in terms of their effectiveness to increase the supply of ecosystem services. Here, we compare five different approaches to map priority areas for restoration in terms of their potential for increasing the supply of ecosystem services: prioritization based on (i) supply of ecosystem services, (ii) degradation state, (iii) prioritization criteria defined by the stakeholders, (iv) financial costs, and (v) cost-effectiveness. We found strong differences in the definition of priority areas for restoration depending on the criteria selected. Prioritization based on stakeholders' criteria and financial costs was relatively ineffective, compared to other approaches, as restoration of almost 60% of the land was needed to achieve a 50% increase in the supply of ecosystem services. Conversely, only 30% of the land should be restored to achieve the same target if prioritization was based on degradation state, cost-effectiveness, and the supply of ecosystem services. Our results show that different approaches are complementary and can be integrated to make informed and transparent collective decisions concerning restoration prioritization strategies.

Research supported by the Ministry of Science and Innovation, Spanish Government, and European Regional Development Funds (project COSTERA, RTI2018-095954-B-I00).

Prioritizing sites for ecological restoration based on ecosystem services

Authors: Francisco A. Comín^{1*}, Beatriz Miranda², Ricardo Sorando³, María R. Felipe-Lucia⁴, Juan J. Jiménez⁵, Enrique Navarro¹

Affiliations: ¹*Instituto Pirenaico de Ecología, Spanish National Research Council (IPE-CSIC), Zaragoza, Spain.* ²*Emgesa, Bogotá, Colombia.* ³*Aiseco, Zaragoza, Spain.* ⁴*Institut of Plant Sciences, University of Bern, Switzerland. Current affiliation: Helmholtz Centre for Environmental Research – UFZ and German Center for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Germany.* ⁵*Instituto Pirenaico de Ecología, Spanish National Research Council (IPE-CSIC), Jaca, Spain.*

Email: maria.felipe.lucia@gmail.com

ABSTRACT

Restoration ecology that maximizes ecosystem services (ES) requires planning at large spatial scales, which are often the most meaningful for ecosystem functioning and ES supply. As economic resources to undertake ecological restoration at large scales are scarce, prioritizing sites to enhance multiple ES supply is critical. We present the Relative Aggregated Value of Ecosystem Services (RAVES) index, to prioritize sites for ecological restoration based on the assessment of multiple ES. We tested the spatial heterogeneity of ES to identify the relevant scale to managing ES and to applying the RAVES index using a local case study. We also used the RAVES index to compare three alternative restoration scenarios to enhance ES based on the availability of socio-economic resources. The highest RAVES values were found in areas with natural vegetation and in gorges with riparian forests. The lowest values were found in crop fields, steep slopes, and river stretches without riparian forest. Most ES showed significant heterogeneity at broad (20–30 km) and very broad (40–50 km) scales. The optimal socio-economic conditions to enhance ES supply were met when both private and public land, together with economic funds were available to implement ecological restoration. As most areas with low RAVES were in private lands, even with limited funds restoration of private lands would result in a large increase of RAVES. The RAVES index is a practical tool to hierarchically prioritize sites for ecological restoration across large spatial scales. The RAVES index integrates both ecological information with societal values by weighting ES via a multicriteria analysis and can be used in scenario analysis to identify optimal management scenarios. We highlight the importance of analysing the spatial heterogeneity of ES to identify the most relevant scale to applying the RAVES index and to managing ES via ecological restoration.

Keywords: catchment scale; Mediterranean ecosystems; semi-arid landscape restoration; large spatial scales; multiple ecosystem services index

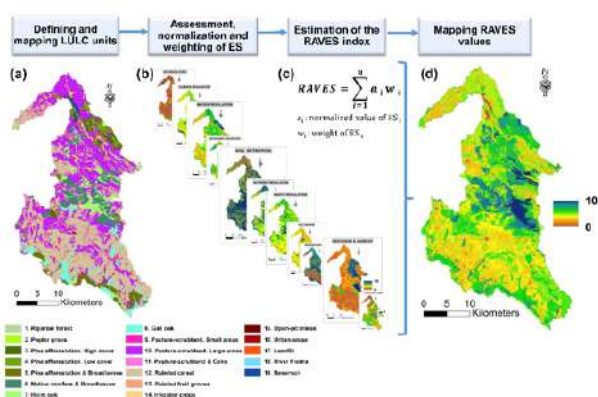


Fig. 1 Main steps to estimate the RAVES index. (a) Distribution of the LULC types identified at the River Piedra watershed. (b) Assessment, normalization and weighting of ES. (c) Estimation of the Relative Aggregated Value of Ecosystem services (RAVES). (d) Distribution of the RAVES index across the River Piedra watershed. All ES and RAVES maps are depicted using a classification of values into 10 categories where the lowest value is in red (0) and the highest value is in blue (10).

Societal and experts approaches in landscape restoration – meeting points and conflicts

Author(s): ; Valdecantos, A.^{1,2}; Disante, K.B.¹Alloza, J.A.²; Cortina, J.¹

Affiliation(s): ¹*Department of Ecology, University of Alicante, Alicante, Spain;* ²*CEAM Foundation, Paterna, Valencia, Spain*

E-mail: a.valdecantos@ua.es

ABSTRACT

Restoration projects in drylands have been often undertaken using top-down and manager-led approaches. Yet, the benefits of stakeholder engagement in restoration projects are multiple and aims at finding common interests to building consensus. Differences in the outcomes of both approaches are presumably significant but have been seldom assessed. We have compared both strategies in a fire-prone Mediterranean landscape in Easter Spain (Enguera Forest District; EFD). The goals of the study are: (a) to map priority areas for restoration based on manager advice, (b) to map priority areas based on the criteria of a stakeholder platform, and (c) to assess the impact of both approaches on the supply of ecosystem services (ES). Almost 85% of the study area showed a restoration priority lower than 0.5 (on a 0-1 scale) based on stakeholder's perception, high priority areas (>0.75) representing 0.3% of the EFD. ES supply could increase in 80% and 85% of the total potential intervention areas following expert and stakeholder criteria, respectively. Areas of high priority identified by managers largely agree with areas identified by the stakeholder platform, with less than 6% of the potential intervention sites corresponding to areas with stakeholder's priority below 0.25. In the presentation, we will discuss factors explaining the different outcomes of both strategies.

Research supported by the Ministry of Science and Innovation, Spanish Government, and European Regional Development Funds (project COSTERA, RTI2018-095954-B-I00).

Keywords: Bottom-up approach; Ecosystem services; Priority criteria; Stakeholders platform

Restoring landscapes from a socio-ecological approach

Author(s): [Heinz](#), Alexis K.

Affiliation(s): *Anagram ECO*

E-mail: akheinz@umich.edu

ABSTRACT

Landscape restoration is ecological restoration from a broad perspective. A theoretical understanding of ecology, landscape ecology, landscape architecture, ecological engineering, and conservation produces the foundation for this research project. The literature review includes topics of landscape, river, and upland restoration in addition to relevant cultural values. Natural experiments, planned experiments, and case studies are included as sources of data pertaining to landscape restoration.

After determining site locations from information on land cover, configuration, likelihood of sensitive species, nearness to rare habitats, and other parameters, social scientists interview landowners about values significant to restoration. Ecological specialists then survey the site for abiotic factors and biotic communities in multiple trophic levels that are most important to the restoration of healthy ecological functioning. The comprehensive socio-ecological information both informs future restoration decisions and evidences metrics that indicate restoration goals, progress, and success.

This oral presentation discusses the results of the literature review and site evaluation prior to restoration implementation.

WePlan – Forests: A decision support platform for spatial planning of forest ecosystem restoration

Author(s): Williams, Brooke

Affiliation(s): *IIS-AU*

Email: b.williams@iis-au.org

ABSTRACT

Forests are home to 80% of the world's biodiversity and stock high amounts of carbon relative to other ecosystems. However, substantial areas of forest have been cleared and, of the remaining forests, as much as 82% are now degraded to some extent as a result of human actions such as industrial logging, urbanization, agriculture and infrastructure. Tropical forest restoration has the potential to counteract some of these negative impacts and deliver multiple benefits, such as climate change mitigation, biodiversity conservation, and provide sustainable livelihoods for people. In response to the need thus identified, the "WePlan – Forests" was developed.

WePlan – Forests is a decision support platform for spatial optimisation planning of forest ecosystem restoration that can significantly enhance the outcomes of policies, programs and projects for biodiversity conservation, sustainable development, and climate change mitigation. The platform consists of a web-based interface that automates the technical and computing requirements of complex spatial analyses and allows users without GIS and spatial modelling know-how to explore a broad range of results and scenarios. The WePlan - Forests platform can help to plan and implement forest restoration to cost-effectively achieve biodiversity conservation and climate change mitigation benefits. WePlan – Forests also enables users to explore the potential of certain areas to sustain natural forest regrowth, a restoration intervention that is often the most cost-effective and provides substantial benefits for biodiversity and climate.

Here present the WePlan - Forests methodology, underlying data, and near future advancements. This project was developed by the International Institute for Sustainability Australia and International Institute for Sustainability Rio, in partnership with the Convention on Biological Diversity (CBD) Secretariat as part of the implementation of the Forest Ecosystem Restoration Initiative with the financial assistance of the Korea Forest Service of the Government of the Republic of Korea and the European Union.

S18.2 - Tools for planning ecological restoration II

Alternatives for climate change adaptation and socio-economic recovery in mid-mountain areas (La Rioja, Aragon, Catalonia)

Author(s): Pascual, D.¹; Pla, E.¹; Zabalza, J.²; Nadal-Romero, E.²; Lasanta, T.²; Aranda, X.³; de Herralde, F.³; Borrás, G.; Cantos, G.⁴; Retana, J.^{1,5}; Barrantes, O.⁶; Reiné, R.⁶; Lana-Renault, N.⁷; Ruiz, P.⁷; García-Balaguer, E.⁸.

Affiliation(s): ¹CREAF, Spain; ²IPE-CSIC, Spain; ³IRTA, Spain; ⁴OCCC-Generalitat de Catalunya, Spain; ⁵UAB, Spain; ⁶University of Zaragoza, Spain; ⁷University of La Rioja, Spain; ⁸CTP-OPCC, Spain.

E-mail: d.pascual@creaf.uab.es

ABSTRACT

Mountain areas in southern Europe are considered highly sensitive to climate change impacts due to, among others, the decrease in available water, the drought duration and severity and the increased in the frequency of fires. In addition, these areas have suffered in the last decade's rural abandonment, ecosystem degradation and reduction of socio-economic activities, causing a progressive loss of the mosaic landscape and a revegetation of the mountain slopes. These processes have reduced the environmental services provided by mountain areas, such as the provision of water to the lower parts of the basins, biodiversity, as well as the sustainability of agrarian and forestry systems and their economic income.

In this context, the project LIFE MIDMACC was created to promote the recuperation of the agro-silvo-pastoral mosaic to reverse these processes and adapt mid-mountain areas to climate change impacts. Through the implementation and monitoring of landscape management measures in La Rioja, Aragon and Catalonia (Spain), the project evaluates their socio-economic and ecological effectiveness in improving resilience to climate change, while promoting the recuperation and restoration of traditional landscapes. The measures implemented are: the recovery of pastures through scrubland clearing and introduction of extensive livestock farming; forest management for fire prevention and drought resilience and maintenance with extensive livestock farming; and the introduction or optimization of vineyards in mid-mountain areas. Preliminary results of such actions in previous research point to an improvement in carbon sequestration, fire resistance, forest productivity, erosion prevention and water retention capacity in managed areas. LIFE MIDMACC will provide results on these and other variables of interest in a spatially and temporally extensive manner along project duration (2019-2024). Acknowledgements LIFE18 CCA/ES/001099 LIFE MIDMACC project).

Keywords: Climate change, rural development, resilience (social and ecological), landscape, ecosystem services.

Deforestation and climate change threaten headwaters in Central-South Chile: priorities to restore

Author(s): Alaniz, A.^{1,2*}; Rendón-Funes A.^{3,4,5}, Fuentes N.⁶, Vergara P.⁷, Smith-Ramírez C.^{8,4,9}

Affiliation(s): ¹Departamento de Ingeniería Geográfica, Facultad de Ingeniería, Universidad de Santiago de Chile, Chile; ²Facultad de Ciencias Biológicas, Pontificia Universidad Católica de Chile, Chile; ³Áreas Prioritarias para la Investigación (API) Universidad de Los Lagos, Osorno, Chile; ⁴Instituto de Ecología y Biodiversidad (IEB), Santiago, Chile; ⁵Area de Ecología, Museo de Historia Natural Alcide d'Orbigny, Cochabamba, Bolivia; ⁶Laboratorio de Limnología, Departamento de Acuicultura y Recursos Agroalimentarios, Universidad de Los Lagos, Osorno, Chile; ⁷Departamento de Gestión Agraria, Facultad Tecnológica, Universidad de Santiago de Chile, Chile; ⁸Departamento de Ciencias Básicas y Biodiversidad, Universidad de Los Lagos, Osorno, Chile; ⁹Instituto de Conservación, Biodiversidad y Territorio, Universidad Austral, Valdivia, Chile.

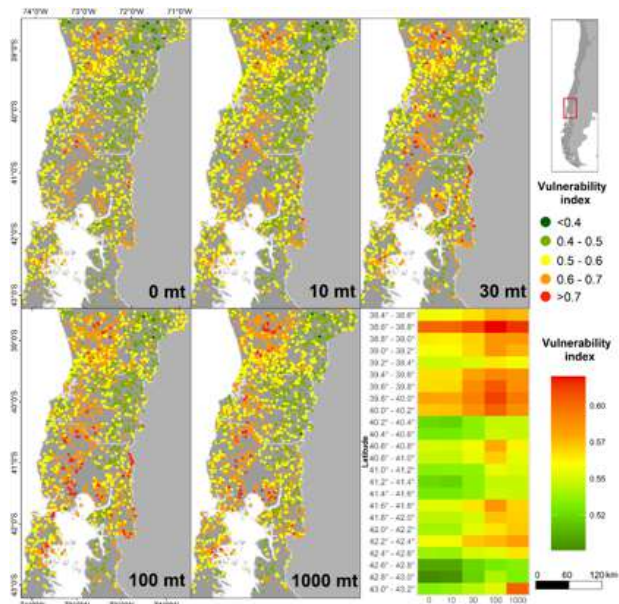
E-mail: Adriana20041@hotmail.com

ABSTRACT

We determine vegetation cover around headwaters in central-south Chile to prioritize its restoring. Each headwater was identified using governmental data and audited to ensure the fit of the shapefile with headwaters by a photointerpretation of high-resolution satellite images from 2016 to 2019. 2292 headwaters were identified and characterized, considering around them 5 radius buffer of cover per headwater. We characterized the vulnerability of headwaters estimating 12 parameters and indices of land use and cover change, potential water demand and climate change. The variables of principal components analysis with highest contribution to affect headwaters were the change of drought, the current drought, human modification index (HMI), anthropogenic land covers, latitude and the index of vulnerability. The HMI, current population density and the anthropogenic land cover were positively correlated between them, while were negatively associated with elevation. HMI and anthropogenic land covers were also negatively associated with slope, canopy cover and biomass. The longitude and latitude were positively associated with the change of drought and the current drought. 180 headwaters have very high vulnerability (>0.7) which represents the 7.9% of all the analysed units, 23 are the most vulnerable in relation with all variables. 79.1% of all headwater have a vulnerability >0.5, they are concentrated in central valley in Araucanía Region, as well as in north Los Lagos Region. We recommend restoring original forest cover to protect and recover water services starting with La Araucania region which is related higher ecosystem services.

Keywords: restoration planning, landscape ecology, ecosystem services, climate change

Fig. 1 Maps of vulnerability index in each headwater per scale. Lower-right panel shows the average vulnerability index in headwaters per latitude and scale.



Design of Ecological Restoration's interventions according to stakeholders' perception after an environmental disaster: a case-study

Author(s): Lima, T.; Rodríguez-González, P.M.; Soares, P.

Affiliation(s): Centro de Estudos Florestais, Instituto Superior de Agronomia, Universidade de Lisboa, Portugal

E-mail: isa125226@isa.ulisboa.pt

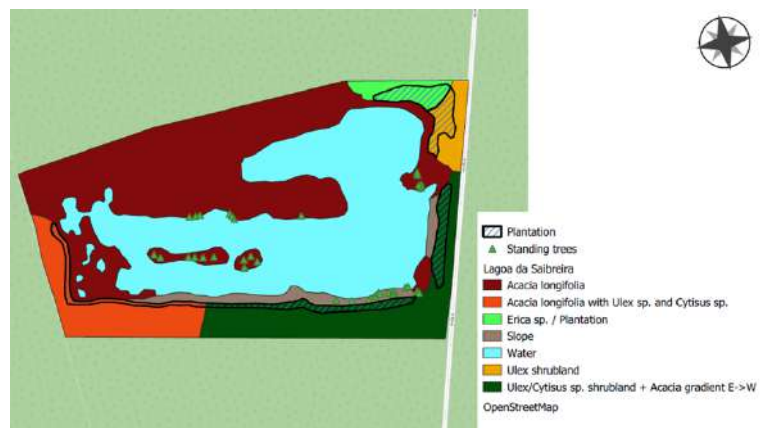
ABSTRACT

Finding balance between restoration and population's perception in the design of interventions, with the intention of improved public tendering.

On the 15th October 2017, a mega-fire burned 85% of the historical state *Pinus pinaster* Ait. forest from Portugal, Mata Nacional de Leiria (total area of 11.062 ha). One of the consequences was the invasion by *Acacia longifolia* on Lagoa da Saibreira, a lagoon of 2 ha located on the NE of this forest and originated by a sand pit in 1953. This study, developed in the context of a MSc Thesis, proposes a Restoration Plan to enhance biodiversity and ecological function in an artificial wetland, by considering stakeholders' expectations and their perception changes after a massive environmental disaster (mega-fire).

The SER's guidelines for Restoration were followed, including cartography, field work to identify flora richness, bioclimatic future analysis, and identification of relevant stakeholders. For the social component, a questionnaire was prepared and shared among the stakeholders through channels like local Associations (e.g. nature observers and hunters) and parishes in order to evaluate said perceptions

and restoration suggestions. The result is a structured plan that details the work process, with the intention that it serves as an example for more restoration projects in Portugal. The main degradation issues identified include *Acacia longifolia* presence in the entire area (and dominating half the study area), presence of trash disposed around and inside the Lagoon, presence of Louisiana Crayfish *Procambarus clarkii* (threat to local amphibians) and low cover of native tree species. To improve ecological values, a proposal to reduce pressures, and promote wetland native plant species was designed relating bioclimatic indexes with Natura 2000 habitats. The analysis of questionnaires allowed to understand multiple perceptions on identified stakeholder groups, highlighting the need of effective communication and stakeholder engagement to improve success of ecological restoration efforts.



Keywords: Restoration strategy/planning; Forests/woodlands; Invasive species; Stakeholder engagement.

Fig. 1 Status of Lagoa da Saibreira's polygons on first monitoring (2021)

Development of the strategic framework for the restoration of degraded ecosystems and landscapes for Austria

Author(s): Danzinger, F.¹; Paternoster, D.²; Koukal, T.⁴; Kudrnovsky, H.²; Lackner, S.³; Berger, A.⁴; Schadauer, K.⁴; Wrбка, T.¹; Stejskal-Tiefenbach, M.²; Ellmauer, T.²

Affiliation(s): ¹Affiliation, Country; ²Affiliation, Country; ³Affiliation, Country¹University of Vienna, Department of Botany and Biodiversity Research, Austria; ²Environment Agency Austria, Team Biodiversity & Conservation, Austria; ³Environment Agency Austria, Team Soil & land management; ⁴Federal Research and Training Centre for Forests, Natural Hazards and Landscape (BFW), Department Forest Inventory, Austria

E-mail: florian.danzinger@univie.ac.at

ABSTRACT

In 2011, the European Union published an EU Biodiversity Strategy for the period 2011-2020. The goals and measures of this strategy are based on the so-called Aichi Targets.

Target 2 of the EU Biodiversity Strategy calls for the restoration of at least 15% of degraded ecosystems by 2020. This target and the corresponding action are also included in the "Biodiversity Strategy Austria 2020+".

In the course of the present study, a strategic framework was developed as a preparatory measure (Action 6a according to the EU Biodiversity Strategy) to set priorities for the restoration of degraded ecosystems and landscapes in order to achieve the 15% target. This also included the identification of individual landscape areas that are to be prioritised for restoration.

A geographically explicit map of biotope types at national level served as the main basis for the development of the strategic framework.

Since the planning of restoration measures, along with the setting of restoration priorities, requires knowledge of the state of the ecosystems, the next step was to assess their current state and to perform a classification into four levels of degradation. The intrinsic characteristics of ecosystems, but in particular the heterogeneity of available and relevant basic data, made different methodological approaches necessary.

The costs necessary to achieve the 15% target were calculated separately for each of the ecosystems: forests, surface waters and open land. The resulting costs depend heavily on the target. Different scenarios were therefore calculated.

The implementation of the 15% target is assumed to be achieved within the 2020-2050 timeframe. The estimated costs of the implementation of restoration measures to achieve the 15% target in Austria are approximately 10.7 billion euros for all ecosystems and ecosystem groups, excluding urban ecosystems and those characterised by settlement.

Keywords: Biodiversity, Evaluation and monitoring, Governance and Policy, Landscape, Restoration strategy/planning.



Fig. 1 Ecological state of Austria's cultural landscapes dominated by arable farming

W2 - Restoring Mediterranean wetlands: challenges for practitioners and lessons learned

W2 – Restoring Mediterranean wetlands: challenges for practitioners and lessons learned

Organized by Teresa Gil Gil (WWF-Spain) and Brigitte Poulin (Tour du Valat Research Institute), organized within the frame of the MAVA Restoration Strategy implemented across the Mediterranean Basin.

What do we need for restoring wetlands?

First, we need time for gathering: (1) expertise for a comprehensive understanding of the ecosystem (eg. wetland dynamics, hydrological processes) to take the right action at the appropriate scale; (2) guidance to overcome bureaucracy obstacles at various steps of the process; and (3) human resources and funds to fully implement the Project.

Second, we need to involve all key stakeholders directly or indirectly affected by the restoration project (eg. local councils, national/regional environmental authorities, private sector, local experts and users or their representatives), as well as all relevant political levels early in the process to ensure a good integration of the restoration project in territorial planning and promote synergies with other initiatives.

Third, we need to secure land ownership to develop sustainable projects that will benefit to nature and people through adaptive management in the long term.

What do we need for scaling up restoration initiatives?

We need to allocate funds for the incubation phase of the restoration project with uncertain costs to permit high-quality diagnostic studies addressing biological, hydrological and socio-economic aspects related to the wetland restoration that will be used for defining goals in a collaborative manner with stakeholders.

We need to develop mechanisms (institutional frameworks) to aid coordination between actors and levels, to facilitate governance, financing, and alignment of public/private interests.

We need to embrace a biocultural view of conservation, by defining restoration goals based on a shared future scenario rather than a reference ecosystem of the past in highly anthropogenic landscapes where the restoration of ecosystem services is a primary goal.

S16.1 – The role of soil organisms in restoring degraded land

Reconnecting above and belowground biodiversity with microbially assisted restoration

Author(s): Muñoz-Rojas, Miriam

Affiliation(s): *UNSW Sydney, Australia*

E-mail: m.munoz-rojas@unsw.edu.au

ABSTRACT

Global environmental changes such as drought, intense fire and land degradation are rapidly transforming the structure and functioning of ecosystems worldwide. These changes are leading to a severe loss of above and belowground biodiversity and increased soil degradation. Soil microorganisms control important ecosystem functions such as nutrient cycling, plant productivity and climate regulation. Thus, microbially assisted conservation and restoration has the potential to reconnect above and belowground dynamics, creating functional ecosystems that are more resilient to climate change impacts. In this research, we (i) assessed the responses of soil microbial communities to disturbance, e.g. severe fire, and extractive activities such as mining, and (ii) developed bioinoculants composed of locally sourced soil bacteria from the rhizosphere and biocrust cyanobacteria, to promote plant growth and soil fertility and enhance ecosystem capacity for global change adaptation. This presentation will showcase some key findings of these studies that include the benefits of combining diverse native plant species and using indigenous microbes for promoting soil and ecosystem functions. We will also discuss the potential applicability of these approaches in landscape-scale conservation and restoration programs.

Beneficial heterotrophs enhance the effectiveness of cyanobacteria-based biocrust restoration in drylands

Author(s): Nelson, C. and Garcia-Pichel, F.

Affiliation(s): *Center for Fundamental and Applied Microbiomics and School of Life Sciences, Arizona State University, Tempe, Arizona, United States of America*

E-mail: ferran@asu.edu

ABSTRACT

Biological soil crusts (biocrusts) are communities of microbes that inhabit the surface of arid soils and provide essential services to dryland ecosystems. While resistant to extreme environmental conditions, biocrusts are susceptible to anthropogenic disturbances that can deprive ecosystems of these valuable services for decades. Until recently, many culture-based efforts to produce inoculum for cyanobacterial biocrust restoration in the Southwestern US focused on producing and inoculating the most abundant primary producers and biocrust pioneers, *Microcoleus vaginatus* and *M. steenstrupii* complex. The discovery that a unique microbial community characterized by diazotrophs and phosphate-solubilizing bacteria is intimately associated with *M. vaginatus*, known as the “cyanosphere”, suggests a symbiotic division of labor in which nutrients are traded between phototroph and heterotrophs. To explore the role and potential of the cyanosphere community for development of biocrust, we performed targeted isolation of cyanosphere inhabitants and used co-cultivation with *M. vaginatus* and other pioneer cyanobacteria under nutrient poor conditions, in both laboratory and field conditions, to test for beneficial interactions. We found co-inoculation of soil substrates with cyanosphere constituents resulted in more rapid development of cyanobacterial biocrusts over inoculation with the cyanobacterium alone. Further, we found that adding only beneficial heterotrophs to moderately to highly disturbed native soils facilitated the formation of a cohesive biocrust from remnant biocrust communities, without need of additional phototrophic biomass. Our findings highlight the hitherto unknown role of beneficial heterotrophic bacteria in the establishment and growth of biocrusts and allow us to make recommendations of biocrust restoration efforts based on presence of remnant biocrust communities in disturbed areas. Future biocrust restoration efforts should consider cyanobacteria *and* their beneficial community to be the true pioneers. Therefore, the inclusion of cyanobacteria and their beneficial community is instrumental for rapid establishment of incipient biocrust, thus rapidly restoring ecosystem services.

Keywords: Drylands and desertification, ecosystem services, soils

Cyanobacteria inoculation to restore dryland degraded soils: optimizing their growth through application of habitat ameliorating techniques

Author(s): Chamizo, S.¹; Alameda, A.¹; Maggioli, L.¹; Román, J.R.¹; Pagli, C.², Cantón, Y.¹

Affiliation(s): ¹Agronomy department, University of Almeria, Spain; ²University of Florence, Italy

E-mail: scd394@ual.es

ABSTRACT

Land use intensification and impacts of climate change are accelerating land degradation processes, being of special concern in drylands, where water scarcity and poor soil development increase vulnerability to impacts by anthropogenic disturbances. In this context, restoration of drylands becomes a priority to maintain their functionality and capacity to provide key ecosystem services to society. Traditional restoration usually fails in drylands due to common environmental stresses that constrain plant survival and growth and thus, the search for other cost-effective strategies is necessary. Biocrusts are poikilohydric organisms that inhabit most interplant spaces in drylands and that are successfully adapted to the extreme conditions that characterize these regions. Biocrusts play key roles in soil water availability and soil stability and fertility. Different studies show the viability of using biocrusts or single biocrust components as soil inoculants to induce biocrust formation and accelerate soil recovery following a disturbance. However, inoculum growth can be constrained in the field due to soil erosion and physiological stresses. To improve inoculum performance, habitat amelioration treatments can be applied. In this study, we used native biocrust-forming cyanobacteria to restore degraded soils from semiarid areas of SE Spain and compared the effects of cyanobacteria inoculation alone and combined with ameliorating strategies based on organic meshes and soil fixers. Treatments efficiency was first evaluated at outdoor conditions, and then, in small plots under field conditions. Cyanobacterial growth was assessed by means of chlorophyll *a* content and surface spectral features such as albedo and absorption peaks by photosynthetic pigments. Effect of the induced cyanobacterial biocrust on soil stability was also examined. Our results indicate the suitability of using ameliorating strategies to optimize cyanobacterial growth and soil stability, especially in the first stages of soil restoration. However, further research is necessary for the successful implementation of these techniques on large scales.

Keywords: biocrust, soil degradation, soil fixer, *Machrochloa tenacissima* mesh, soil stability.

Development and Application of Microbial Inoculum for Biological Soil Crust Restoration in Drylands

Author(s): [Ana Giraldo-Silva](#)^{1,2}, Corey Nelson^{1,2}, Julie Bethany^{1,2}, Sergio Velasco Ayuso¹, Nichole N. Barger, N. Nichole³, and Ferran Garcia-Pichel^{1,2}

Affiliation(s): ¹*School of Life Sciences and* ²*Center for Fundamental and Applied Microbiomics, Arizona State University, Tempe, Arizona, United States of America,* ³*Department of Ecology and Evolutionary Biology, University of Colorado, Boulder, CO 80309, USA*

E-mail: amgiraldo@asu.edu

ABSTRACT

Biological soil crusts (biocrusts) play important roles in improving soil fertility and promoting erosion resistance of arid lands. A variety of human disturbances such as vehicle and foot traffic can quickly damage biocrust communities and natural recovery can take decades. Attempting to enhance recovery rates, we developed a “biocrust microbial nursery” to supply inoculum for restoration. Four locations from different climatic and edaphic origins from the Southwestern US were selected as restoration sites, and two restoration strategies were pursued: whole-community and mixed-isolate approaches. Regardless of the approach, our studies indicate that working towards obtaining optimal inoculum is a complex endeavour. We will review these two methods as well as recent advances in strategies for biocrust restoration. Advances include inoculum conditioning to increase biomass viability in the field, seasonality of seeding, inoculum recycling, the development of a unified approach to growing field-acclimated mixed-community and mixed isolate inoculum on native substrates, water delivery approaches, and landscape-scale production of inoculum by operating a “mobile microbial nursery”. This nursery operates as a self-sufficient field research station and can be transported to different sites, allowing the production of quality-controlled, pedigreed, drought-acclimated and *in situ* acclimated inoculum of both whole community and cultured isolates.

Keywords: Drylands and desertification, ecosystem services, soils

Non- destructive measurements for assessing biocrusts recovery

Author(s): Román, J.R.¹, Rodríguez-Caballero, E.^{1,2}, Rodríguez-Lozano, B.¹, Roncero-Ramos, B.³, Gassó, M.A.¹, Cantón, Y.^{1,2}

Affiliation(s): ¹*Agronomy Department, University of Almeria, Spain;* ²*Centro de Investigación de Colecciones Científicas de la Universidad de Almería (CECOUAL), University of Almería, Spain;* ³*InBios-Center for Protein Engineering, University of Liège, Belgium.*

E-mail: jrf979@ual.es

ABSTRACT

Biological soil crusts (biocrusts) are widespread components in drylands where they are known to play key roles in numerous ecosystem processes. However, though well-adapted to live in extreme environments, biocrusts are very sensitive to climate change and easily disturbed by human activities. In the last decades, several innovative techniques are being developed to assist in the recovery of disturbed biocrust or to induce the formation of new ones, thereby reinstating their capacity to provide ecosystem services. In order to identify a biocrust disturbance or to assess the restoration success, a continuous monitoring of the induced biocrust is necessary. However, the techniques employed to assess biocrust dynamics and developmental stage usually implies the destruction of the studied biocrusts for laboratory procedures. Here, we evaluated the usefulness of non-destructive measurements to monitor biocrust health and recovery, by measuring key functional traits. Specifically, the potential of soil surface reflectance measurements, image classification and soil surface roughness for the estimation of biocrust development were studied. We found a high correlation between some variables obtained from the biocrust spectra, such as the value of continuum removal and first derivative of reflectance at the chlorophyll absorption region, and chlorophyll *a* content, which is the most common indicator of biocrust development and photosynthetic capacity. Furthermore, a high correlation between biocrust coverage and total organic carbon and total nitrogen of inoculated cyanobacterial biocrusts was found ($R^2 = 0.76$ and $R^2 = 0.45$, respectively). In addition, soil surface roughness was successfully employed to monitor sudden erosive episodes potentially affecting biocrust health. In summary, our study highlights those non-destructive measurements can provide reliable information of general biocrust development that could be incorporated into monitoring programs.

Keywords: biocrusts, monitoring, spectral response, biocrust cover, soil surface roughness

S16.2 - The role of soil organisms in restoring degraded land

Rising from the ashes: The effects of soil burn severity on fire-moss growth and establishment

Author(s): Monteiro, J.¹; Grover, H.²; Bowker, M.²; Antoninka, A.²; Loehman, R.³; Gibson, K.²; Sloan, M.²; Branquinho, C.¹

Affiliation(s): ¹ Centre for Ecology, Evolution and Environmental Changes (cE3c), Faculdade de Ciências, Universidade de Lisboa, 1749-016 Lisboa, Portugal; ² School of Forestry, Northern Arizona University, 200 East Pine Knoll Drive, Flagstaff, AZ 86011, U.S.A; ³ US Geological Survey, Alaska Science Center, 333 Broadway SE Suite 115, Albuquerque, NM 87102, USA

E-mail: jmmonteiro@fc.ul.pt

ABSTRACT

Increasing trends in wildfire frequency and severity have been reported worldwide. Since wildfires represent an important agent of land degradation, with short- to long-term impacts on soils and plant communities, the development of effective strategies to reduce soil loss and promote ecosystem recovery is critical. Post-fire colonizing mosses (collectively known as fire mosses), such as *Bryum argenteum* and *Ceratodon purpureus*, provide important ecosystem services in disturbed landscapes, including soil protection and erosion control. In recent years, moss-dominated biological soil crusts have emerged as potential tools in post-fire restoration. Here, we investigated the effects of soil burn severity and inoculum type on fire moss growth. In a full-factorial greenhouse experiment, three types of *B. argenteum* and *C. purpureus* inoculum (field-collected in 2017 and greenhouse-cultivated in 2017, both stored for approximately two years, and field-collected in 2019) were cultivated in soils burned at low, moderate, and high severity in a prescribed fire. In 60 days, high fire moss cover was achieved, with an average cover of 74% across treatments. During this experimental period, we observed different rates of growth among the stored inoculum types. *C. purpureus* cover was significantly higher in the stored field-collected inoculum, while higher *B. argenteum* cover was observed for the greenhouse-cultivated inoculum. Results of a structural equation model indicate a strong effect of inoculum type on *B. argenteum* and *C. purpureus* final cover. In contrast, soil burn severity was not an important predictor of fire moss cover. These results suggest that despite differences among species, stored inoculum retained viability. Moreover, fire mosses were successfully cultivated in a range of soil burn severity levels. Our findings highlight the potential use of fire mosses as bioinoculants to recover soil and ecosystem functions in post-fire environments.

Keywords: Soils, Restoration strategy/planning, Landscape.

Metabolites from native biocrust cyanobacteria: applications for promoting germination and growth of plants used in restoration

Author(s): Nathali Maria Machado de Lima¹, James Charlesworth¹, Jana Stewart¹, and Miriam Muñoz-Rojas^{1,2}

Affiliation(s): ¹ Centre for Ecosystem Science, School of Biological, Earth & Environmental Sciences, UNSW Sydney, NSW, Australia (m.munoz-rojas@unsw.edu.au) ²School of Biological Sciences, University of Western Australia, Crawley, ^{WA, Australia}

E-mail: n.machadodelima@unsw.edu.au

ABSTRACT

Cyanobacteria are primary components of biological soil crusts that perform essential ecological roles and thrive under high temperatures, intense UV radiation, and depletion of water. These abilities have led to their exploitation in the context of ecological restoration. Considered as “Plant Growth Promoter Bacteria (PGPB)”, they directly influence plant growth and health, with the production of longer radicals and increased seedling dry weight. Cyanobacterial inoculants have been tested as seed bioprimers for a range of Australian native plant species and the responses appear to be species-specific. Even though the positive effects are associated with hormonal production, the specific bio-active biological compounds produced by cyanobacterial inoculants used as bioprimers are still largely unknown. Therefore, this work aimed to identify the metabolites involved in the germination and growth of four Australian native species that are used broadly for dryland restoration. Two consortia, one composed by *Nostoc* and another by a mixed-cyanobacterial culture (*Leptolyngbya* and *Nostoc*) were used for seed biopriming and analysed for metabolites with a Focus DSQII GC-MS (Thermo Fisher Scientific, GER). Metabolomic analysis through GC-MS putatively identified the common plant hormone indole-3-acetic acid (IAA) and another potential phytohormone, such as salicylic acid. Plant-cyanobacteria relation varied across plant species and doses, showing that the production of the hormone per se does not implicate a positive effect on plant germination and growth. While *Triodia epactia* and *Grevillea wickhamii* presented longer roots when treated with the inoculant, *Triodia wiseana* presented an opposite response. Our results showed that the hormonal concentration could either improve, inhibit, or have a neutral effect depending on each plant species and their own ontogeny.

Keywords: auxins, biopriming, PGHs, salicylic acid, seed enhancement

Fungal perspective of pine and oak colonization in Mediterranean mined areas

Author(s): Adamo, I.^{1,2}; Dashevskaya, S.²; Castaño, C.^{1,3}; Bonet, J.A.^{1,2}; Alday, J.G.^{1,2}

Affiliation(s): ¹Joint Research Unit CTFC - AGROTECNIO, Av. Alcalde Rovira Roure 191, E25198 Lleida, Spain. ²Dept. Crop and Forest Sciences, University of Lleida, Av. Alcalde Rovira Roure 191, E25198 Lleida, Spain ³Swedish University of Agricultural Sciences, Department of Forest Mycology and Plant Pathology, SE-75007 Uppsala, Sweden.

E-mail: irene.adamo@udl.cat

ABSTRACT

Forest restoration has become one of the most important challenges for restoration ecology in the recent years. The reestablishment of trees has been mainly focused on the identification of suitable microsites and mechanisms that facilitate the tree seedling establishment and growth. Soil fungi are fundamental drivers of forest ecosystem processes, with significant implications for plant growth and survival. However, the effect of anthropogenic disturbances on below-ground fungal communities has been rarely assessed. **In this study, we performed ergosterol extractions, PacBio and Illumina sequencing of internal transcribed spacer 2 amplicons** across soil layers in *P. sylvestris*, *Q. robur* and *Q. ilex* forests and naturally revegetated mined sites. Our aim was to describe biomass and compositional differences of soil fungi in forests and mined systems and assess the use of soil/litter inoculum as an enhancer of tree seedlings establishment success and growth, while maximizing the reforestation investments. In pine forests, saprotroph and mycorrhizal biomass was significantly higher in litter and humus with the mycorrhizal genera *Tomentella*, *Inocybe* and *Tricholoma* dominating. Conversely, in oak forests the most abundant mycorrhizal genera were *Tomentella*, *Cortinari* and *Sebacina*. However, in oaks there was greater saprotrophs biomass in the litter layer compared to mycorrhizal with the genus *Preussia* being the most abundant. In the mined sites, mycorrhizal fungi dominated the humus and mineral layers in the revegetated plain with the mycorrhizal genus *Oidiodendron* being dominant. In contrast, in holm oak forests saprotrophs dominated both soil humus and mineral layers, with *Alternaria*, *Bovista* and *Mycena* dominating the soil humus forest layer, while the genus *Mycena* only dominated in the revegetated plain. The clear differences in soil fungi between habitats suggest that describing soil-plant-microbial interactions of different tree species might help to increase the effectiveness of tree restoration strategies in Mediterranean degraded sites by using soil/litter inoculum in planting/seeding.

Keywords: Forest restoration, mines, soil/litter, fungal communities, plant-soil feedback

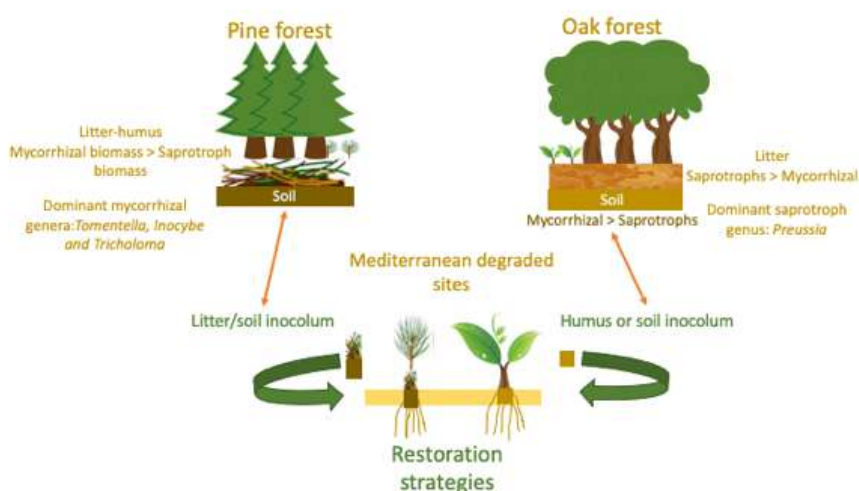


Fig. 1. Summary of the differences in soil fungal biomass and composition between pine and oak forest considering across litter, humus and mineral layers. The difference found might help to increase the effectiveness of tree restoration strategies in Mediterranean degraded sites by using soil/litter

Inputs of sheep droppings increase arthropod abundance. Emulation of sheep grazing on natural steppes.

Author(s): Reverter, M.^{1,2}; Santos, A.¹; Zurdo, J.^{1,2}; Barrero, A.^{1,2}; Gómez-Catasús, J.^{1,2}; Bustillo-de la Rosa, D.^{1,2}; Pérez-Granados, C.^{1,3}; Traba, J.^{1,2}

Affiliation(s): ¹ Terrestrial Ecology Group, Department of Ecology (TEG-UAM) Universidad Autónoma de Madrid. C/ Darwin, 2. 28049. Madrid. Spain; ² Centro de Investigación en Biodiversidad y Cambio Global (CIBC-UAM), Spain; ³ National Institute for Science and Technology in Wetlands (INAU), Federal University of Mato Grosso (UFMT), Computational Bioacoustics Research Unit (CO.BRA), Cuiabá, Mato Grosso, Brazil.

E-mail: margarita.reverter@uam.es

ABSTRACT

Variation in sheep grazing intensity can modify plant structure and composition, but also it may drastically alter arthropod abundance, directly or via dung deposition, thus affecting higher trophic levels, such as insectivorous birds. As part of the LIFE Ricotí project, we tested the effect of experimental dung deposition (low density, 0.25 kg ha⁻¹ and high density, 0.50 kg ha⁻¹; 10 ha per treatment) on the arthropod community of a typical Mediterranean natural steppe in central Spain (Soria province). Along 2017 (before), and 2018-2019 (after the treatment) we sampled epigeous, hypogeous and coprophagous arthropods via pitfall traps and sweep nets (six times per year). First, we evaluated annual differences in arthropod biomass just in control areas before and after treatment. No significant differences in epigeous and coprophagous arthropods among years were found, but a higher biomass of hypogeous arthropods was registered after the treatment. Secondly, after fitting GLMM, epigeous biomass was significantly higher in low dung input treatment only during the first year after the treatment (2018), decaying later. Coprophagous of the families *Scarabaeidae* and *Brachycera*, flying and epigeous Coleoptera families *Curculionidae*, *Cerambycidae*, *Tenebrionidae*, and the Order *Lepidoptera* showed significantly higher biomass in 2018 in both dung input treatments, while *Blattodea*, *Opiliones*, *Orthoptera*, *Hemiptera* and *Archaeognatha* were significantly lower in 2018 and significantly higher in 2019 in both treatment areas. Our results support the prediction that in areas where sheep grazing is decreasing, experimental inputs of sheep droppings can increase the biomass of some groups of arthropods, especially coprophagous, in the short and middle term. However, other arthropod groups may be adversely affected. Future research efforts examining long-term effects of dung deposition in arthropod communities could help to provide a precise tool-kit for the use of this technique for insect conservation and restoration of areas affected by low grazing pressures.

Keywords: Biodiversity, drylands, restoration strategy/planning.



SEPTEMBER
10TH

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S9.1 – Restoration strategies in mining areas

Woody colonization in reclaimed coal mines in Northern Spain: insights for forest expansion

Authors: Martínez-Ruiz, C.^{1,2}; Zaldívar, P.¹; López-Marcos, D.¹; Muñoz-Cerro, E.¹; Fernández-Santos, B.³; Alday, J.G.^{4,5}

Affiliations: ¹Department of Agroforestry Sciences, University of Valladolid, Spain; ²Sustainable Forest Management Research Institute, University of Valladolid & INIA, Spain; ³Ecology Area, University of Salamanca, Spain; ⁴Joint Research Unit CTFC-AGROTECNIO-CERCA, Spain; ⁵Department of Crop and Forest Sciences-AGROTECNIO Center, Universitat de Lleida, Spain

E-mail: carolina.martinez.ruiz@uva.es

ABSTRACT

In northern Spain, as in other areas in the world, opencast coal mining plays an important role in the dynamics of landscape fragmentation. In the reclaimed mines herbaceous species are usually employed to favor soil stabilization since often there is a lack of soil seed bank in the topsoil. The result is a patch of grassland in a forest matrix for grazing post-mining land use. Grassland is then colonized by woody species from the adjacent forest or dispersed by wind or animals from surrounding areas. This process is strongly affected by interactions between the forest matrix and the grassland patch and is influenced by the geometry of the patch and the hillside topography, common in mines in the mountains. The structure of the new plant community varies not only in time but also in space. The forest matrix, as a seed source, partly determines the species composition of woody colonizers. Grazing can directly limit the recruitment of woody species, and indirectly by specifically affecting the few seeds dispersed to the high-quality microsites. Native shrubs that colonize these mines (*Genista florida* and *Cytisus scoparius*) facilitate the establishment of native oaks (*Quercus pyrenaica* y *Q. petraea*) and thus the natural forest expansion. One of the mechanisms driving this facilitation shrub-tree process is the soil improvement mediated by native shrubs and its mechanical defence against herbivores. To improve decision-making during restoration management, it is necessary to be based on the knowledge of the mechanisms that condition the establishment of vegetation and the underlying succession processes. The long-term monitoring of existing experimental devices and their extension to other areas and restoration objectives are essential to establish a protocol of performance to adjust decisions to the circumstances of each area to be restored and, thus, reconcile environmental restoration with the economic activity of the area.

Keywords: coal mines, suitable microsites, nurse shrubs, oak establishment, sub-Mediterranean climate

Can native shrubs and grazing exclusion affect soil properties in reclaimed open-cast coal mines?

Author(s): Muñoz-Cerro, E.^{1,2}; López-Marcos, D.^{1,2}; Martínez-Ruiz, C.^{1,2}

Affiliation(s): ¹Department of Agroforestry Science, UVa. E.T.S.II.AA., Palencia, Spain

²Sustainable Forest Management Research Institute UVa-INIA. E.T.S.II.AA. Palencia, Spain

E-mail: elena.munoz.cerro@uva.es

ABSTRACT

Native shrubs have a nurse effect on oak seedlings' establishment in stressful and degraded environments such as open-cast coal mines in Northern Spain. Our hypothesis was that nurse shrubs can promote soil fertility (direct facilitation) and reduce herbivory pressure (indirect facilitation). Therefore, we assessed the combined effect of native shrubs and grazing exclusion on soil properties to identify some of the most important shrub-tree facilitation mechanisms in the study area. The highest pH was related to the independent effects of shrub and grazing exclusion, whereas, the highest electrical conductivity, cation exchange capacity, K⁺, and C/N were just related with the shrub effect. A shrub x fence interaction effect was found on the remainder chemical soil parameters: base saturation was significantly higher out of shrubs in the fenced plots whereas total nitrogen and carbon, available phosphorous, and organic matter were significantly higher under shrubs in the no-fenced plots. Among physical properties, bulk density and porosity were just affected by grazing exclusion (negatively and positively, respectively), whereas sand, clay, water holding capacity, and available water responded to a significant shrub x fence interaction. The sand was significantly higher under shrubs in the no-fenced plots, whereas clay showed the opposite trend. Water holding capacity and available water were the highest out of shrubs in the fenced plots. In summary, our results showed a clear influence of native shrubs on soil chemical properties, whereas grazing exclusion further affected the physical properties. These findings suggested that guidelines concerning grazing exclusion and shrub cover will need to follow in the reclaimed coal mines to facilitate seedling establishment by improving soil properties.

Keywords: shrub cover, herbivory pressure, Sub-Mediterranean climate, soil improvement, coal wastes.

Monitoring opencast mine restoration using drones

Author(s): Carabassa, V.^{1,2}; Montero, P.¹; Padró, C.²; Alcañiz, J.M.^{1,2}

Affiliation(s): ¹CREAF, E08193 Bellaterra (Cerdanyola del Vallès), Catalonia, Spain; ²Universitat Autònoma de Barcelona, E08193 Bellaterra (Cerdanyola del Vallès), Catalonia, Spain

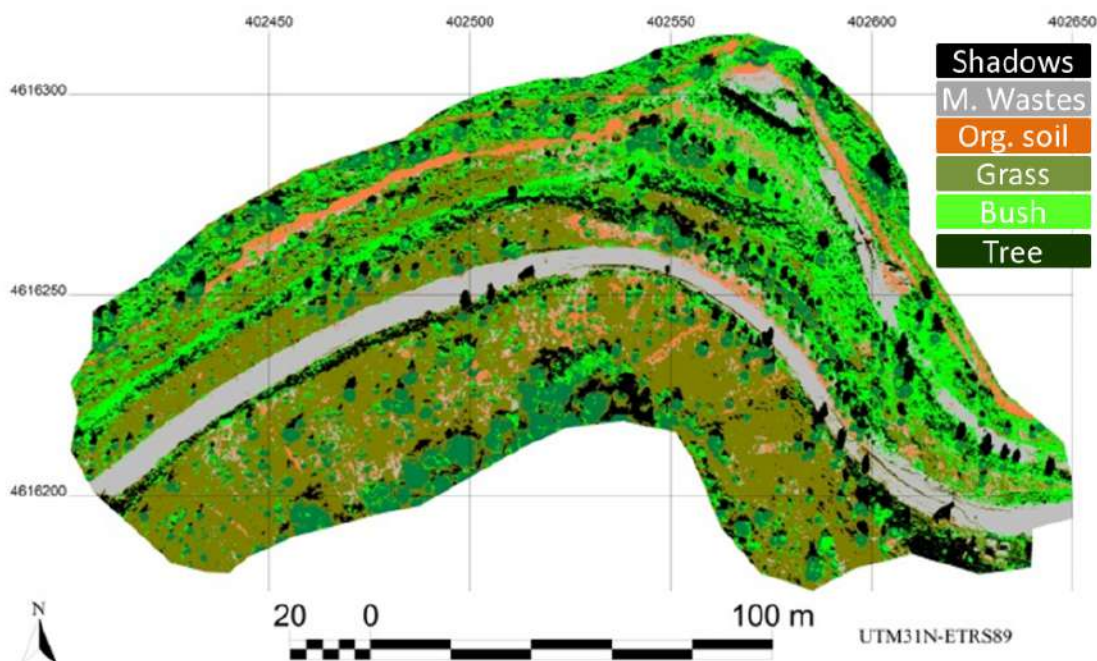
E-mail: v.carabassa@creaf.uab.cat

ABSTRACT

A protocol for the use of multispectral sensors onboard of a low-weight multicopter is introduced. It allows to determine land cover typologies in restored areas (such as grass, scrubs, trees, topsoil and mine spoils) by applying remote sensing and GIS techniques. We assess the capability of digital terrain models (Digital Elevation Model, Digital Surface Model, Digital Slope Model) derived from photogrammetric techniques. These provide useful and fast topographic and morphometric information for the proper assessment of open-pit mine exploitation and restoration. By applying these techniques, we present a cost-effective workflow adequate to monitor land cover types and dynamics in restored areas, but also for volumetric changes in stockpiles, waste dumps and extraction faces, dust related affections, among others. This combined approach, supporting both environmental and industrial needs, allows a rapid evaluation of the areas in operation and restoration, as well as their evolution by temporal comparing images and models.

Keywords: mines, evaluation and monitoring, standards, UAS, biodiversity

Fig. 1. Automated land cover classification using the monitoring protocol in a restored section of a quarry.



Restoration strategy and techniques for recovering degraded landscapes after mining activity under Mediterranean conditions.

Author(s): [Turrión, Diana](#)¹; Morcillo, Luna¹; Vilagrosa, Alberto^{1,2}

Affiliation(s): ¹ *Mediterranean Center for Environmental Studies (CEAM Foundation). Joint Research Unit University of Alicante-CEAM, University of Alicante, 03690, Alicante, Spain.* ² *Department of Ecology, University of Alicante, 03690, Alicante, Spain.*

E-mail: diana.turrion@ua.es

ABSTRACT

Considerable research efforts in quarry restoration strategies have been made, however, failures are still common. In drylands, as in the Mediterranean Basin, successful actions may depend on features related to proper species selection and restoration techniques that may substantially contribute to provide substrate stability and facilitate the regeneration of the main ecological processes. In this context, we developed the LIFE TECMINE project aimed to demonstrate the feasibility and suitability of innovative restoration practices applied to the clay-mine reclamation under limiting conditions. The restoration strategy was designed at the landscape level by applying geomorphological land remodeling by the Geofluv™ method. Afterwards, a combination of several field restoration techniques and a thorough species selection were implemented to restore plant communities, soil quality and ecosystem functioning. These techniques involved: i) Identification of Restoration Units according to abiotic factors (slope, soil characteristics, etc.), ii) accurate species selection according to surrounding reference habitats and limitations of the mine area ii) nursery seedling growth and control high-quality protocols, iii) field techniques to enhance resources availability as water runoff, soil fertility and amelioration of abiotic conditions, iv) a monitoring plan to evaluate restoration success across time which also warned about critical thresholds where intervene to avoid seedling mortality. Three years after restoration, the results showed the success of the implemented restoration strategy and techniques. Survival rates resulted by 80% and seedling growth showed mean values ranged from three up to seven times the initial seedling size. Plant cover promoted by sowing native species exceeded 60% and in general, new colonizing species incremented biodiversity indexes throughout all Restoration Units. Overall, the LIFE TECMINE project demonstrates that a proper restoration approach, a carefully species selection and suitable field techniques can enhance restoration success and initiate ecosystem functioning. This project represents a step forward in mine reclamation under Mediterranean climate.

Keywords: ecological restoration, ecosystem functioning, quarry reclamation, Geofluv™, LIFE TECMINE project.

Aquatic succession in various post mining sites in Central Europe

Author(s): Müllerová, A.¹

Affiliation(s): ¹*Department of Botany, Faculty of Science, University of South Bohemia, Branišovská 1760, 370 05 České Budějovice, Czech Republic*

E-mail: polarni.badatel@seznam.cz

ABSTRACT

Vegetation succession in aquatic and littoral environments has deserved much less attention compared to terrestrial habitats. We sampled differently aged successional stages in sandpits (261 plots), stone quarries (56 plots), china clay quarries (39 plots) and brown coal spoil heaps (76 plots) across the Czech Republic, Central Europe. They ranged in age since abandonment from 1 to 89 years. The chronosequence approach was adopted. Besides species identity itself, basic life-history species characteristics were considered to describe the succession. Alongside the vegetation data, several environmental variables were recorded: age, water depth, substratum type (i.e. proportion of sand, clay, gravel and organic material), pH, conductivity, elevation and additional disturbances. Based on the location (elevation) of plots, two geographical regions were delimited based on temperature and precipitation. Altogether 253 vascular plant species and 5 *Chara* species were recorded. Successional seres in aquatic and littoral habitats differed in the direction and the the speed of succession between the individual mining types. As generally expected, water table was the main driving factors alongside elevation, age, and water conductivity. Moreover, the vegetation pattern was significantly affected by substrate composition. At aquatic sites, the species composition was probably mainly driven, besides the water depth, by accumulation of organic material, and hydrophytes dominated throughout the sites. In littoral sites of all mining types, several distinct groups of life forms could be distinguished along the successional gradient. The young sites typically included stress-tolerant therophytes and hemicryptophytes. With the age, woody species started to dominate at higher elevations, while perennial graminoids dominated at lowland sites. Spontaneous succession at aquatic and littoral sites leads to valuable seminatural stages and can be generally recommended as a passive restoration option in disused mining sites.

Keywords: mines; succession; vegetation; wetland; aquatic

S9.2 – Restoration strategies in mining areas

Biomass accumulation in forest floor and litterfall in *Robinia pseudoacacia* restoration plantations

Author(s): Xanthopoulos, G¹; Radoglou, K¹; Spyroglou, G²; Fotelli, M.N²

Affiliation(s): ¹Department of Forestry and Management of Environment and Natural Resources, Democritus University of Thrace, N. Orestiada, Greece

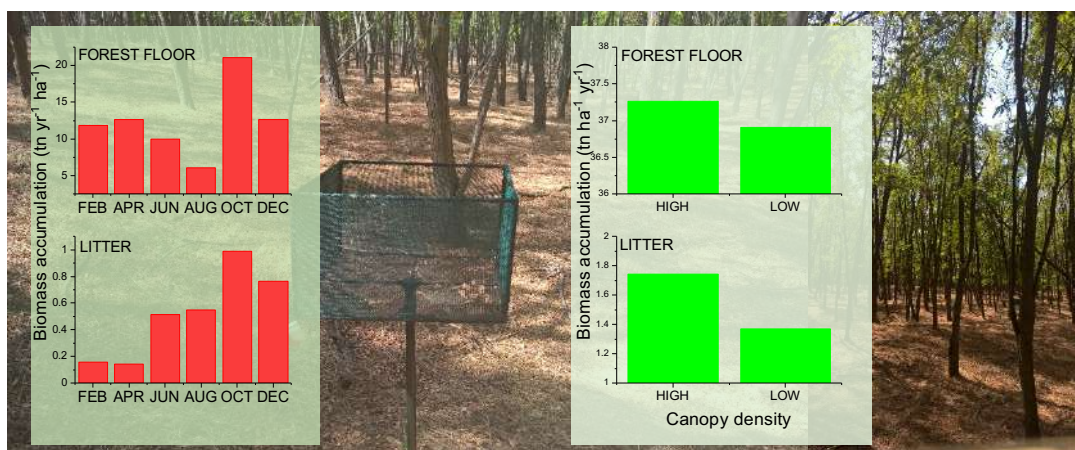
²Forest Research Institute, Hellenic Agricultural Organization Dimitra, Vasilika, 57006 Thessaloniki, Greece

Email: georxant9@fmenr.duth.gr

ABSTRACT

Post-mining restoration of degraded soils with forest plantations enhances climate change mitigation through carbon storage. At the Lignite Center of the Public Power Corporation in Western Greece c. 2,200 ha of land are planted for this purpose with black locust (*Robinia pseudoacacia*), as it is a fast-growing, drought tolerant species, characterized by its N-fixing ability and high carbon sequestration potential. This study was conducted within the COFORMIT project and aimed at estimating the pools of litterfall and forest floor in these plantations and at assessing their seasonal fluctuation and the effect of varying canopy density. Sampling was performed bimonthly for a year, at 18 plots, covering the range of tree DBH (diameter at breast height) of the plantations. In each plot, litterfall and forest floor were sampled at two locations of different canopy density (high: 96.0% vs low: 90.5%). The dry biomass of both pools peaked during senescence, from October till December 2020. However, the seasonal pattern of biomass accumulation of the two pools differed in the preceding period. Litterfall was low till April, when leaf expansion began, and increased gradually till autumn, while forest floor biomass gradually decreased from the beginning of the year till August and then substantially increased in autumn – winter. Litterfall accumulation was greater in higher vs lower canopy density (1.74 vs 1.37 tn ha⁻¹ yr⁻¹). A similar but less pronounced effect was observed in forest floor biomass accumulation (37.26 vs 36.91 tn ha⁻¹ yr⁻¹ in higher and lower canopy density stands, respectively), probably due to the effect of understorey herbaceous vegetation on forest floor accumulation. In the next steps, these results will be combined with the biomass determination in all ecosystem pools to estimate the carbon footprint of these restoration plantations.

Keywords: Climate change, Ecological restoration, Mines, Restoration strategy/planning, Carbon sequestration.



Evaluating quarry ecological restoration success with field and remote sensing approaches (Arrábida Natural Park, Portugal)

Author(s): Mendes, C.¹, Serafim, J.¹, Oliveira, A.¹, Nunes, A.¹, Branquinho, C.¹

Affiliation(s): ¹Centre for Ecology, Evolution and Environmental Changes, Faculdade de Ciências, Universidade de Lisboa, Campo Grande, C2, Piso 5, 1749-016 Lisboa, Portugal

E-mail: claudia.ar.mendes@gmail.com

ABSTRACT

Anthropogenic activities such as quarrying decrease biodiversity by destroying vegetation cover and causing the loss of beneficial ecosystem functions and services that maintain ecosystem integrity and sustain life on Earth. Restoration practices are necessary to reverse the negative impacts of quarrying and recover essential functions and services, for example, through the reintroduction of native plant species. Ecosystem monitoring is essential to confirm the desired outcomes of restoration actions and therefore, local and field measurements are needed. However, the recovery of ecosystem functionality and services occurs at the landscape scale, so complementing field data with remote sensing data can allow extrapolating changes in the ecosystem to various spatial and temporal scales. The objective of this work was to evaluate the ecological restoration success of a quarry in the Arrábida Natural Park (Portugal) based on field data resulting from sampling the plant community, and from remote sensing. In the quarry, restored benches range from 4 to 37 years old, which allows for a chronosequence to be studied. Indices of vegetation diversity and similarity with the reference natural vegetation were calculated and remotely sensed vegetation indices such as NDVI were extracted and correlated with field, climatic and topographical data to assess the success of the landscape-wide restoration.

Keywords: Ecosystem services, Ecological restoration, Species reintroduction, Evaluating and monitoring, Biodiversity

Evaluating the provision of pollination services by insects in actively and spontaneously restored quarries

Author(s): Carvalho, C.¹; Oliveira, A.,^{1,2,3}; Caeiro, E.^{2,4}; Miralto, O.^{1,2,3}; Parrinha, M.; Sampaio, A.^{1,2,3}; Silva, C.^{1,2,3}; Mira, A.^{1,2,3}; Salgueiro, P.A.^{1,2,3}

Affiliation(s): ¹UBC – Conservation Biology Lab; ²MED – Mediterranean Institute for Agriculture, Environment and Development, Institute for Advanced Studies and Research, University of Évora. Mitra, 7002-554 – Évora, Portugal; ³Department of Biology, University of Évora. Mitra, 7002-554 – Évora, Portugal; ⁴SPAIC - Portuguese Society of Allergology and Clinical Immunology, Lisbon, Portugal

E-mail: carolina_maria_carvalho@protonmail.com

ABSTRACT

Ecological restoration allows for an accelerated recovery of a degraded ecosystem's biodiversity, function, and ability to provide ecosystem services. However, the issues of when active restoration is necessary and how restoration effectiveness should be measured are still subject to considerable debate. Here we evaluate plant-pollinator networks in actively and passively restored quarries, comparing both composition and function of the pollinator community to a natural area representing the reference ecosystem. Overall, we aim at determining which restoration approach holds higher effectiveness on the rehabilitation of this ecological process. We found that while both approaches allowed for the restoration of pollination function, active restoration allowed for a faster recovery: pollination network structure is more similar to reference after 20-30 years of assisted restoration, than 40 years of natural succession in spontaneously restored areas. Nevertheless, the distinct strategies generated key structural vegetation differences, which influenced distinct pollinator communities providing the service in different areas. For example, a richer herbaceous layer of ruderal species from early successional stages in spontaneously restored areas allowed to buffer against the shortage of resources at critical periods. These results support the idea that restoration might be attained by distinct biological communities, and that both composition and function should be taken into account when evaluating restoration outcomes. Nevertheless, assisted restoration strategies, though effective, should enclose practices that behold wild bee communities such as the use of "bridging" plants that flower in different periods, and shelter provision for ground- and cavity-nesting wild bees.

Keywords: Pollination; Ecosystem services; Ecosystem processes/Ecosystem functioning; Restoration strategy/planning

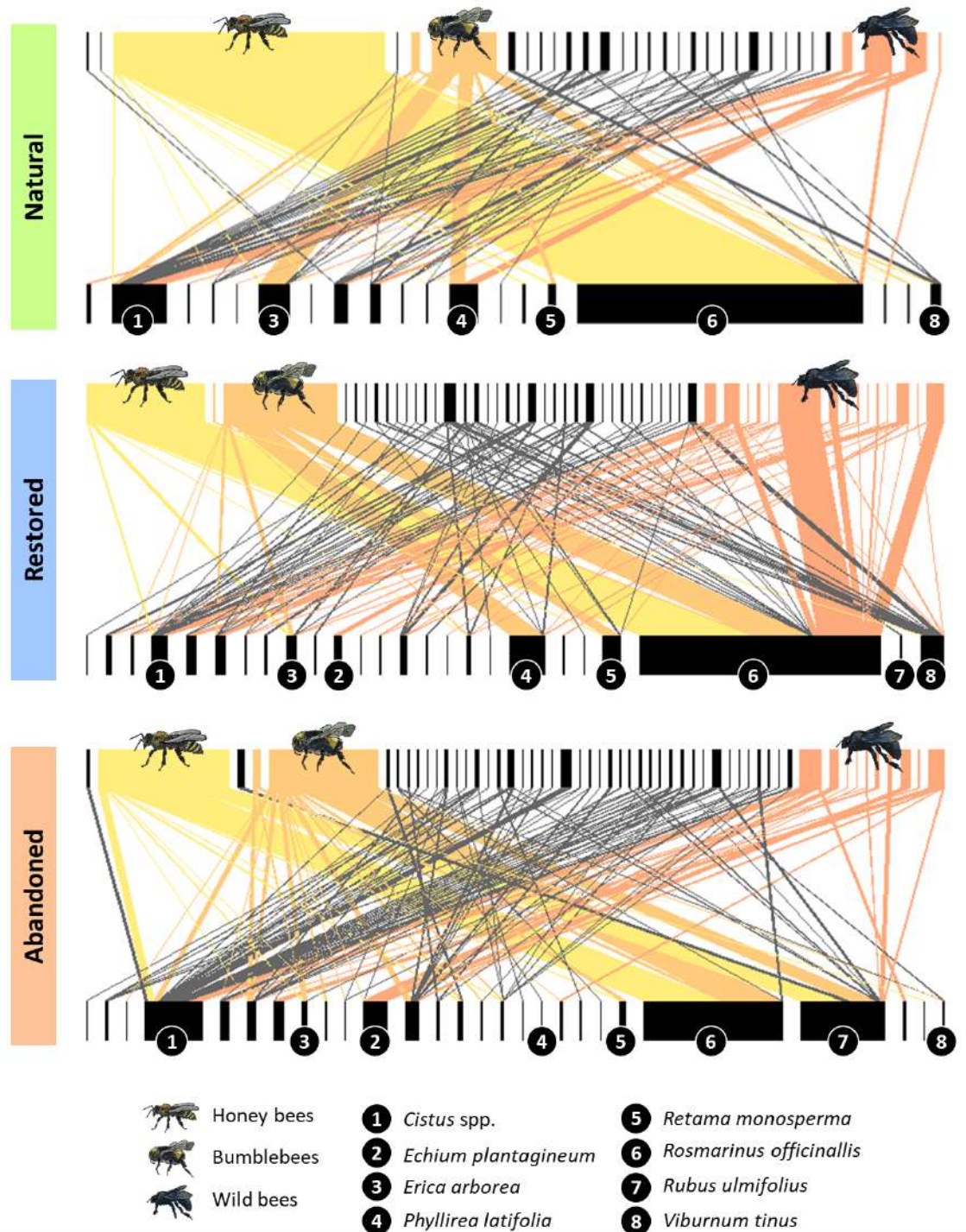


Fig. 1- Overall pollination networks pooling all pollen transport data collected for each area (all months and sites). Line width represent the strength of interactions, and bar width represents total amount of pollen grains carried by each pollinator group (upper level) and total amount of pollen transported for each plant species (lower level).

Land reclamation activities for the restoration of the agrochemical properties of arsenic-contaminated soils

Author(s): Veneta Stefanova¹, Petar Petrov¹

Affiliation(s): ¹University of Forestry, 10 Kl. Ohridski Blvd., Sofia 1797, Bulgaria

E-mail: venistefanova3@gmail.com

ABSTRACT

The present study examines the possibility for restoration of the agrochemical properties of arsenic-contaminated soils resulting from the extraction of copper through various amelioration-technical measures. The study investigated the effect and effectiveness of some ameliorants on the mobility of the arsenic as well as soils fertility and other soils properties. The content of nutrients, organics, heavy metals, arsenic, calcium, sulfur and pH were analyzed. As a result, the migration rate of arsenic from soils to plants was analyzed and the effect of different ameliorants was assessed.

Key words: land reclamation, arsenic, mine

Seed dispersal services provided by birds in a 40-year-old revegetated quarry are depleted when compared with neighbouring areas

Author(s): [Sampaio, Ana](#) ; Pereira, Pedro; Nunes, Alice; Clemente, Adelaide; Salgueiro, Vânia; Silva, Carmo; Mira, António; Branquinho, Cristina; Salgueiro, Pedro

Affiliation(s): *University of Évora; University of Évora; University of Lisbon, Faculty of Sciences; University of Lisbon, Faculty of Sciences; University of Évora; University of Évora; University of Évora; University of Lisbon, Faculty of Sciences; University of Évora*

E-mail: anadsampaio@gmail.com

ABSTRACT

Quarries cause modifications on native ecosystems' structure and composition inducing biodiversity loss and the depletion of ecosystem services. Ecological restoration stands as the solution to minimize such effects. However, as most approaches rely on species composition and community structure, evidence on how ecological functioning is responding to restoration is still limited.

Our aim was to assess ecological restoration effectiveness in a 40-year-old restored quarry area where native Mediterranean vegetation and the non-native Aleppo pine *Pinus halepensis* have been planted. We assessed seed dispersal services by birds in the restored quarry by comparing it with neighbouring natural (shrubland) and semi-natural areas (oak-pine mixed open and Aleppo pine forest). We analysed seed dispersal networks by collecting faecal samples of mist-netted birds, while also exploring bird community composition from point counts. Additionally, we measured vegetation structure to unveil its effects on species composition and functional traits.

Our results showed that bird abundance in the restored quarry was lower and, in most cases, compositionally different from the other areas. Seed-dispersing birds were the most affected group at the restored area, being these differences mostly driven by vegetation characteristics, such as native vegetation cover, lower fruit richness and higher Aleppo pine cover. Concomitantly, seed dispersal networks in the restored quarry were less complex than in other areas, and likely driven by the lower abundances of seed-dispersing birds. The causes affecting this group's lower abundance can relate to early revegetation measures favouring Aleppo pine, combined with the soil's poor quality and shallow depth, resulting in a weak development of the native vegetation.

Our study supports the existence of cascading effects related to the use of non-native species in restoration, which constrain the development of native habitats and, ultimately, the ecological processes mediated by animals.

W3 – What can we learn from eLTER on long-term monitoring and evaluation of restoration interventions?

Ten-year progress in the restoration of dry grasslands on arable land using a regional seed mixture: still on the way or on the home stretch?

Author(s): Řehouňková Klára¹, Jongepierová Ivana¹, Prach Karel¹

Affiliation: ¹ *Department of Botany, University of South Bohemia, Branišovská 1760, CZ-37005 České Budějovice, Czech Republic;* ² *Institute of Botany, Czech Academy of Sciences, Dukelská 135, CZ-37981 Třeboň, Czech Republic*

E-mail: klara.rehouňkova@gmail.com

ABSTRACT

Since 1999, large-scale restoration of species-rich dry grasslands has been conducted using species-rich regional seed mixtures in the White Carpathians Protected Landscape Area, Czech Republic, Central Europe. After sowing, the grasslands were regularly mown. Vegetation was analysed in 2009 at 35 sites restored 1–11 years before, and resampled after five (2014) and ten (2019) years. At each site, three plots 5 m × 5 m were established, in which species cover was estimated. We also sampled adjacent ancient species-rich grasslands as reference sites. We asked if the trajectory of sown grasslands approached the reference grasslands, particularly in species composition. The data were processed using multivariate statistics. The development of sites restored with regional seed mixtures led to an establishment of target dry (Bromion) or mesic vegetation (Arrhenatherion). The results show that it took only about 20 years for the species composition of sown grasslands to approach the reference sites, as is evident from the oldest restored grasslands. A properly designed regional seed mixtures is a very effective method in the restoration of species-rich dry grasslands, especially in a landscape with still existing ancient grasslands. These can serve as a donor sites for the spontaneous establishment of unsown target species at the restored sites.

Restoration peatland eLTER, case of France

Author(s): Gogo, S.¹; Gilbert, D.²; Magnon, G.³; André, L.⁴; Bertrand, G.²; Jacotot, A.¹; Laggoun-Défarge, F.⁴

Affiliation(s): ¹ Université d'Orléans, CNRS, BRGM, ISTO, UMR 7327, 45071 Orléans, France; ² Université de Franche-Comté, CNRS UMR 6249 Chrono-Environnement, Besançon, France.; ³ EPAGE Hauts Doubs Loue Communauté de Commune Frasne Drugeon, France; ⁴ BRGM, Water, Environment, Process Development and Analysis Division, 3 av. Claude-Guillemin - BP 36009 - 45060 ORLÉANS Cedex 2

E-mail: sebastien.gogo@univ-orleans.fr

ABSTRACT

Peatlands cover 3% of the continent and contain 25% to 33% of the world soil carbon (C). Hence, they are key systems in the climate regulation and contain a unique biodiversity adapted to the harsh conditions. However, local and global human activities may modify the biodiversity and decrease sink functioning of peatlands. Many drained sites are becoming net sources of C, potentially triggering a positive feedback on climate change. Therefore, there is a need for their conservation and restoration.

For a long time, peatland restoration was motivated by the conservation of endangered endemic species, inducing a focus on sites that were slightly disturbed. Currently there is a change of focus towards heavily disturbed sites that sometimes are no longer considered as peatlands. These sites are strong carbon emitters due to microbial activity and vegetation installed in these places. However, applying inexpensive restoration actions in these systems can lead to keep large amount of C away from the atmosphere. Thus, peatland restoration is probably one of the most cost-effective ways to limit global warming. Such actions can be integrated in economic models within the emerging C economy. Incentive actions to store C in peat systems should be promoted.

In this context, long-term studies are valuable, because such strategies need to be evaluated. Assessing restoration actions in representative sites through long-term monitoring of water table variations, vegetation diversity, C stock and fluxes, coupled with models of greenhouse gas fluxes is the most relevant way to make quantifiable the effects of incentive actions. We present restoration experiments and projects that work in this perspective. In the Care-Peat Interrreg project, pilot sites are promoting long-term restoration action that store C. We also present a potential future platform in eLTER (project in construction and pending acceptance), in the French Jura mountains, within which peatland restoration is one of the key concern both in terms of science and societal impact.

Keywords: Peatlands, Ecosystems functioning, Ecological engineering, Ecosystem services, Climate change

Long-term monitoring of restoration experiments in Kiskun LTER, Hungary

Author(s): Halassy, M.¹; Török, K.¹

Affiliation(s): ¹Centre for Ecological Research, Institute of Ecology and Botany, Hungary

E-mail: halassy.melinda@ecolres.hu

ABSTRACT

To help upscale ecological restoration of degraded lands longer time scales should be considered when assessing restoration efforts. Long-term ecological research sites offer an infrastructural background for restoration experiment that help long-term evaluation. KISKUN LTER was established in 1995 in the Kiskunság Sand Ridge and its periphery. Our first restoration experiment started in the same year and based the development of Kiskun Restoration Experiments site. The restoration experiments focus on two major types of degradation in the region deriving from human land use: arable cultivation and plantations of alien tree species. The target community is open sand grassland, once dominant in the driest parts of the inland sand dunes. Restoration interventions included mowing, carbon amendment and seeding. We evaluated long-term restoration trajectories with the help of multivariate analysis (PCoA and PRC) and direct comparison to reference based on the relative cover of target and alien invasive species for each experiment separately. We used linear mixed effects models to evaluate the role of treatments and time. Based on long-term evaluation, seeding was the best method in restoring sand grasslands favouring target species and controlling the spread of invasive alien species. Mowing created establishment windows that could be occupied by both target and invasive species. Carbon amendment had some minor positive impact on target species, but was neutral to invasives. Our result support that long-term monitoring is crucial in evaluating ecological restoration.

Keywords: biodiversity, evaluation and monitoring, grasslands

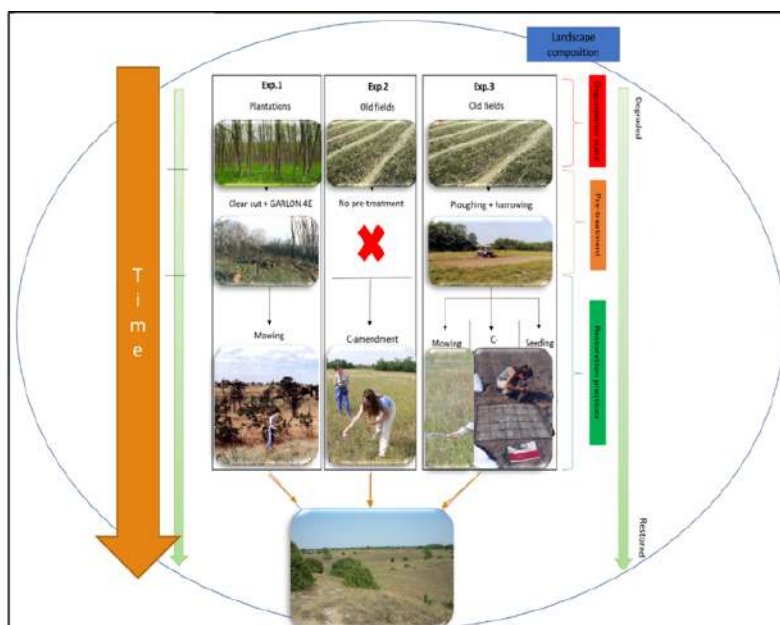


Fig. 1. Kiskun LTER Restoration Experiments

Limiting factors of plant establishment in restored grasslands of White Carpathian Mts.

Author(s): Mudrak, O.¹

Affiliation(s): ¹*Institute of Botany of the Czech Academy of Sciences, Dukelska 135, CZ 379 01 Trebon, Czech Republic*

E-mail: ondrej.mudrak@ibot.cas.cz

ABSTRACT

Meadows of the White Carpathians (SE of the Czech Republic, Central Europe) belongs to the most species rich grasslands of the world. In the second half of the 20th century their large area has been ploughed and converted to the arable land. The tremendous loss of biodiversity together with later socioeconomic changes led in their large-scale restoration. From the year 2000, over 700 ha of those grasslands have been restored by sowing regionally specific species rich seed mixture. Although rather diverse communities (~40 species per 25 m²) were restored, many typical grassland species are not able to colonize it, despite they have abundant seed sources in the close vicinity. The factors limiting the plant establishment are unclear. The commonly observed elevated productivity caused by high amount of residual soil nutrients and resulting into too intense competition for light (which suppresses uncompetitive rare species) does not seem to be the case. We found that plant biomass of restored grasslands is generally lower and that species rich restored communities have higher vegetation cover. The reduced productivity of restored grasslands can be attributed to the altered soil conditions of formerly tilled soil, namely to the lower soil organic matter content and lower nitrogen content. In the restored grasslands are generally missing the broad-leaved species with high specific leaf area and small stature. Our results indicate that those species are likely troubled to establish due to altered nutrient supply, altered soil watered regime or probably also due to modified soil biota in the formerly tilled soil. Although it is not clear yet, which of those parameters is crucial, the altered soil conditions seem to be the main reason for reduced diversity of restored grasslands.

Keywords: Grassland, Succession, Colonization, Tillage, Former arable land

Restoration of Mediterranean forests after major disturbances: The Lanjarón fire over 15 years of succession

Author(s): [Alexandro B. Leverkus](#)^{1,2}, Jorge Castro¹

Affiliation(s): ¹ *Departamento de Ecología, Universidad de Granada;* ² *Laboratorio de Ecología (iEcolab), Instituto Interuniversitario de Investigación del Sistema Tierra en Andalucía (IISTA), Universidad de Granada, 18006, Granada*

E-mail: Leverkus@ugr.es

ABSTRACT

Whereas disturbances such as wildfire constitute natural processes that shape ecological dynamics, ongoing shifts in disturbance regimes demand assessing both the effectiveness and the side-effects of common post-disturbance restoration techniques. After the 2005 Lanjarón fire in a pine stand in Sierra Nevada (Spain), we established a replicated, blocked experiment to test the effects of three management alternatives: (i) no intervention; (ii) salvage logging, a widespread technique consisting of the cutting and removal of burnt biomass usually aiming to recover wood value and to *restore* disturbance-affected areas; and (iii) partial cut, consisting of the felling of 90% of trees, which were delimited and cut in pieces but left scattered on the ground. Along 1.5 decades, we have measured several components of biodiversity and ecosystem processes, as well as economic implications through cost assessments and the valuation of ecosystem services. Overall, the remaining dead wood in the non-intervention and partial cut treatments promoted natural regeneration through modulating biotic and abiotic processes such as seed dispersal and predation, herbivory, fertilization through the gradual decomposition of dead wood, and microclimatic amelioration. The diversity of the bird, vascular plant, and soil insect communities responded to management too, although key responses were in terms of community composition rather than alpha diversity. Ultimately, these processes translated into effects on the functions of the ecosystem (such as soil respiration and C sequestration) and its capacity to provide benefits to human society (such as through natural regeneration). New sampling funded by LifeWatch shall help expand on the long-term dynamics of this system and help ascertain the temporality of the ecological impacts and side-effects of the common *restoration* technique of salvage logging.

Keywords: wildfire; ecosystem services; biodiversity; silviculture; biological legacy

Long-term monitoring of a quarry site restoration based on vegetation structure and functional diversity

Author(s): Nunes, A.¹; Mendes, C.¹; Serafim, J.¹, Oliveira, A.¹, Oliveira G.¹, Clemente A.¹, Correia O.¹, Branquinho C.¹

Affiliation(s): ¹*Centre for Ecology, Evolution and Environmental Changes, Faculdade de Ciências, Universidade de Lisboa, Campo Grande, C2, Piso 5, 1749-016 Lisboa, Portugal*

E-mail: amanunes@fc.ul.pt

ABSTRACT

Reversing the degradation of ecosystems as a result of human activities is one of the greatest challenges facing humanity, as the only way to guarantee human livelihoods and well-being. The exploitation of quarries, in particular, has several negative impacts on ecosystems, involving the removal of soil and the destruction of vegetation cover. To reverse this situation, many restoration actions start with the reintroduction of plants as a first step to recover biological communities and ecosystem functioning, assuming that natural succession processes will follow. However, to assess whether the system has in fact evolved in the desired direction, it is necessary to monitor it in the long-term, based on indicators of ecosystem self-sustainability and resilience. In this work we assessed vegetation structural metrics and alpha and beta functional diversity over space and time, in a quarry site whose restoration process was initiated over 30 years ago. We compared areas with different post-restoration ages (from 30 to a few years ago) over space, and also over time, using a monitoring database with more than ten years. Our findings allowed to assess the successional trajectory of restored areas resulting from the restoration actions implemented and to evaluate its resilience, as well as identifying potential limiting factors, in order to recommend adaptive management measures to improve its success.

Keywords: ecological restoration, Mediterranean vegetation, plant functional traits, resilience

S10 – Restoring biodiversity and ecosystem services in European agricultural landscapes

Assisting natural regeneration in Mediterranean old fields by planting woodland islets and hedgerows

Author(s): Rey Benayas, J.M.^{1,2}; García de León, D.¹; Martínez-Baroja, L. ¹; Pérez-Camacho, L. ¹; Villar-Salvador, P. ^{1,2}.

Affiliation(s): ¹University of Alcalá, Spain; ²Fundación Internacional para la Restauración de Ecosistemas, Spain.

E-mail: josem.rey@uah.es

ABSTRACT

The EU Biodiversity Strategy for 2030 aims to convert 10% of farmland into high-rich biodiversity elements, including woodland islets and hedgerows. These elements provide a wide range of ecosystem services in agricultural landscapes, particularly habitat and propagule dispersion. We have been investigating natural regeneration of abandoned fields after planting holm oak *Quercus ilex* woodland islets and species-rich hedgerows in central Spain since 1993. Seedling emergence from acorns produced by woodland islets averaged 446 individuals ha⁻¹ yr⁻¹, but only 15.5% survived by the end of the second summer. Despite their small size, planted islets affected survival of oak juveniles depending on the orientation and distance relative to the islets. The balance between facilitation (namely microclimate amelioration) and competition (namely water extraction) processes around the tree islets affected oak seedling emergence and survival and herb community development. Oak juveniles established at a rate of 5.7 plants ha⁻¹ yr⁻¹ around the woodland islets due to acorn and seedling predation, and it depended on interannual weather variation. Some 600, 3000, and 200 plants per hedgerow ha⁻¹ yr⁻¹ emerged from seeds produced by the hedgerows, resprouted, or from seeds arriving from outside the planted hedgerows, respectively. In the hedgerows, establishment averaged 94 plants ha⁻¹ yr⁻¹, being herbivory (particularly by rabbits) the major limiting factor. We conclude that assisted natural regeneration by planting woodland islets and hedgerows in Mediterranean old fields is slow despite seed supply because seeds and emerged seedlings must overcome numerous limiting factors, particularly seed predation, herbivory, and water stress. However, planting these woody elements provide seeds for forest restoration in sites where seed sources are absent, such as abandoned fields, leading to effective natural regeneration.

Keywords: cropland, ecosystem services, forests/woodlands, landscape.

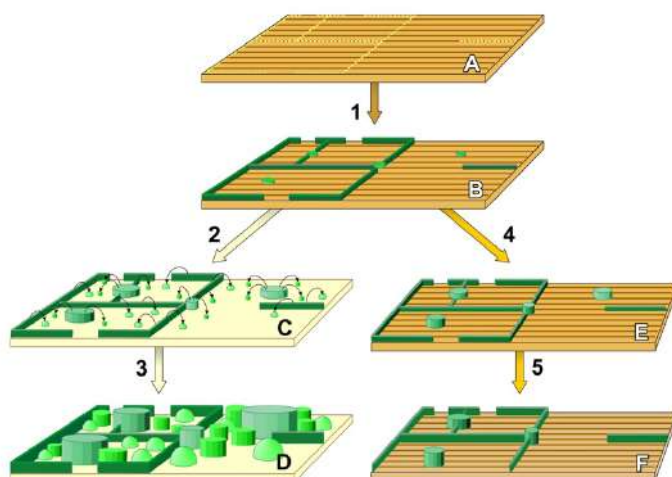


Fig. 1. The “woodland islets and coasts (hedgerows) in agricultural seas” model to assist natural regeneration.

Contributions of hedgerows to people – a global meta-analysis

Author(s): García de León, D.¹, Rey Benayas, J.M.^{1,2}

Affiliation(s): ¹University of Alcalá, Spain; ²Fundación Internacional para la Restauración de Ecosistemas, Spain.

E-mail: david.garcialh@uah.es

ABSTRACT

Hedgerows are linear landscape elements of woody vegetation usually located around agricultural fields. An increasing number of studies have addressed the effects of hedgerows on biodiversity and ecosystem services. This study aims to synthesize these effects at a global level. We hypothesized that (1) fields with hedgerows enhance contributions of nature to people as compared to fields without hedgerows and (2) hedgerows represent an intermediate between farmland and forests. After a search on Web of Science, a database was built out of 981 hit studies and analyzed following standard methodology in meta-analyses. Data selection retained 1387 samples from 178 primary studies, of which 626 samples and 96 studies were from European countries. Our results provided partial support for both hypotheses. Crops with hedgerows exhibited higher levels of biodiversity (vegetation cover, organism abundance, species richness) and of regulation (soil, climate) and supporting services (habitat, nitrogen cycling) than crops without hedgerows. Forests provided higher levels of water regulation than crops with hedgerows. Agricultural landscapes need to restore forest patches to provide substantial levels of some services such as water regulation. Overall, the effects of hedgerows on biodiversity and ecosystem services depended on specific taxa, control ecosystems (hedgerow-less cropland or forest), climate type (temperate or tropical), and spatial scale (field or landscape). Hedgerows and forest patches contribute to carbon sequestration and stocks in herbaceous crops and provide habitat for many wildlife species. In conclusion, conservation and restoration of hedgerows contribute to people in several ways by enhancing functionality in agricultural landscapes.

Keywords: Biodiversity, Croplands, Ecosystem Services, Forest/woodlands

Fig. 1 A planted *Rosa canina* at a hedgerow with a barley crop field behind.



Picture author: Maite Artero-Morales

Challenges and opportunities for biodiversity conservation and restoration in olive groves

Author(s): Herrera, J.M.

Affiliation(s): *Mediterranean Institute for Agriculture, Environment and Development and University of Évora, Casa Cordovil, 2nd Floor, R. Dom Augusto Eduardo Nunes 7, 7000 – 651 Évora (Portugal)*

E-mail: jmherrera@uevora.pt

ABSTRACT

Biocontrol services are increasingly recognized to provide ecological and economic incentives for the conservation of biodiversity in Mediterranean agroecosystems, particularly those provided by flying vertebrates such as birds and bats. Paradoxically, the decline of both taxonomic groups in agroecosystems is associated to landscape modification for agricultural purposes and the intensification of farming practices. Using olive (*Olea europaea* subsp. *europaea*) groves as study system, I will report the impact of management intensification and landscape simplification on both insectivorous birds and bats. Moreover, I will demonstrate how this impact concomitantly affects vertebrate-mediated biocontrol services, leading to significant ecological and economic impacts for olive economy. Finally, I will provide some restoration strategies for conserving and restoring biodiversity within olive groves and, in turn, biodiversity-mediated pest control services.

Keywords: Biodiversity, Economy, Ecosystem services, Olive groves, Restoration planning

Environmental Enhancement of European Agricultural Landscapes by Agroforestry

Author(s): [Kay, S.](#)¹; Burgess, P.²; Herzog, F.¹

Affiliation(s): ¹*Agroscope, Agricultural Landscapes and Biodiversity, Switzerland;* ²*Cranfield University, United Kingdom*

E-mail: sonja.kay@agroscope.admin.ch

ABSTRACT

Dehesas in Mediterranean areas, traditional fruit orchards in central Europe, bocage in coastal regions – all these agroforestry systems are well-established farming practices that combine trees or woody elements with agriculture on the same land. While these systems produce food and fodder, they also deliver timber and/or fruits. Additionally, they provide ecosystem services (ES) that improve micro-climatic conditions, soil water-holding capacity, habitat diversity, and carbon storage. Hence, they are labour, management, and cost intensive. These facts led us to the questions: Does the provision of ES differ in landscapes with agroforestry compared to landscapes dominated by agriculture? How do these services and dis-services reflect in economic terms?

An ES-toolbox for modelling biomass production, groundwater recharge, nutrient and soil loss, carbon sequestration, and biodiversity of European agricultural landscapes was developed and applied in eleven contrasting regions across Europe. In each region, we compared agroforestry and agricultural landscapes. We found that agroforestry landscapes – irrespectively of type, region, or composition – contribute to biodiversity, soil, climate, and water enhancement, whereas the annual biomass production and groundwater recharge were higher in agricultural dominated landscapes.

For the economic assessment, we evaluated the annual biomass production as marketable outcome and groundwater recharge, nutrient and soil loss, carbon storage, and pollination deficits as non-marketable outcomes, but to which financial values were also attributed. Market outputs tended to be lower in agroforestry landscapes (except for Mediterranean areas). Adding financial benefits or avoided costs by non-marketable ES, the relative profitability of agroforestry landscapes increased due to reduced nutrient and soil losses and additional carbon storage benefits.

We conclude that including the financial value of both marketable and non-marketable outcomes for a broad range of ES will engender multifunctional and sustainable land use and farming practices. In any case, valuing climate change mitigation and carbon storage becomes crucial within recent political debates.

Keywords: Ecosystem services, Landscape, Resilience (social and ecological), Biodiversity, Climate change

Wetland restoration in Mediterranean agricultural landscapes

Author(s): Miguélez, D.¹; Guillem, A.¹; de las Heras-Martín, E.¹

Affiliation(s): ¹Fundación Global Nature, Spain

E-mail: dmiguel@fundacionglobalnature.org; antonioguilem@fundacionglobalnature.org; eugenio.heras@fundacionglobalnature.org;

ABSTRACT

Fundación Global Nature has been working on wetland restoration in agricultural environments in Spain since 1990. Our experience includes more than 20 projects funded by the EU in more than 14,000 hectares of 110 wetlands, including La Nava lagoon. The biodiversity indicators analysed, such as richness and abundance of populations of endangered and/or emblematic flora and fauna such as Flowering Rush *Butomus umbellatus* or Greylag Goose *Anser anser*, allow to conclude that these restorations are successful.

The restoration and conservation of Iberian wetlands benefits exclusive migrant species such as the globally threatened Aquatic Warbler *Acrocephalus paludicola*, which replenishes fat reserves, vital to successfully complete its migrations, in these wetlands. Paludicola LIFE project aims at halting the populations decline of this species. For that, it is restoring the prenuptial and postnuptial migration habitat consisting of nine coastal and inland wetlands located in a highly transformed agricultural landscape.

Conservation and restorative actions have focused on (1) controlling marsh vegetation through the recovery of traditional grazing with five agreements between managers and farmers and the purchase of livestock (2,000 sheep and 80 cows graze 300 ha today); (2) the removal of vegetation by mechanical mowing (85 ha mowed with amphibious machines and 288 ha with tractors); (3) the removal of topsoil and sediments (5 ha); and (4) plantations to restore mown, burnt or disturbed areas that harbor 11,973 endangered aquatic plants.

Other actions are controlling the invasive exotic species American Mink *Neovison vison*; purchasing 13.7 ha of agricultural fields in the lagoon area; and specific hydraulic works to improve flooding and water management. GIS data collection and monitoring of aquatic flora and marshland birds are providing information on the wetland improvement after the application of these management tools. We have also developed a scientific-technical basis and a draft conservation strategy for the Aquatic Warbler in Spain.

Keywords: wetlands, biodiversity, evaluation and monitoring, restoration strategy/planning, landscape.

Selection of grapevine varieties according to their heat tolerance: a new approach using whole plants

Author(s): Río Moreno, L.¹; Morales-Castilla, I.¹; Uscola Fernández, M.¹

Affiliation(s): ¹ *Departamento de Ciencias de la Vida, Universidad de Alcalá, Spain*

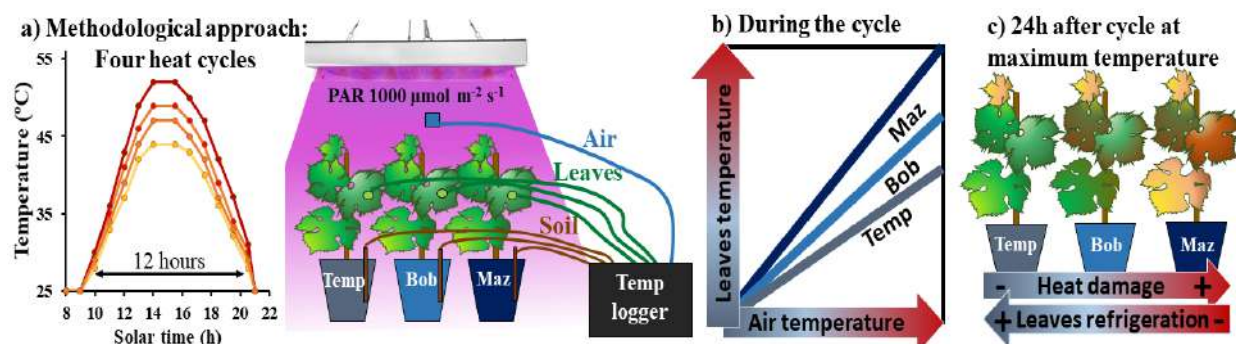
E-mail: lara.rio@edu.uah.es

ABSTRACT

Increased summer temperatures due to climate change is a major threat to crops as it can lead to yield reductions and mortality. Consequently, many crops would require adaptive strategies at risk of becoming unprofitable. Varietal selection is often considered an efficient adaptation strategy but there is little quantitative support informing which varieties are most adequate under specific climate scenarios. Grapevine, an important crop in Spain and Europe, is suited to study varietal selection due to its high intra-specific diversity and its economic importance. We analyzed summer heat tolerance of three widely distributed Spanish grapevine varieties: *Tempranillo*, *Mazuelo* and *Bobal*. While standard heat tolerance tests are performed on tissues, we implemented a more realistic assessment using a new whole plant approach. Plants were subjected to a 12 hour heat cycle that simulated the hourly temperatures during a day. Four heat cycles were performed with different mid-day maximum temperatures (from 44 to 55°C, Fig.1a). Heat damage was measured as Fv/Fm reduction 24 hours after the cycle. Heat damage began at the same temperature in all varieties. However, it increased faster in Mazuelo, intermediate in Bobal and the slowest in Tempranillo (60, 40 and 21% damage at maximum temperature, respectively, Fig 1c). Heat tolerance strongly correlated to the leaves refrigeration capacity of each variety: the higher refrigeration capacity of the leaves, the lesser heat damage (Fig 1b). These results confirm the potential of varietal selection to adapt agriculture to climate change. Knowing the tolerance to stress factors, such as heat waves or spring frost, of a large number of varieties will be key to determine the adequate varieties under specific climate scenarios.

Keywords: grapevine, climate change, varietal selection, leaf refrigeration

Fig. 1 Graphical abstract with the methodological approach (a), leaves temperature during the cycle (b) and damage after 24h of the heat cycle at maximum temperature.



S4 - Large scale analysis of biomass and Carbon accumulation in abandoned agricultural lands: possibilities for Southern Europe

Limited effect of forest expansion in abandoned agricultural lands to offset regional C emissions under Mediterranean-continental climate

Author(s): Velázquez, E.*^{1,2}, Martínez-Jaraíz³, C.; Wheeler⁴, C.; Mitchard, E.⁴; Bravo, F.^{1,2} * Presenter
Affiliation(s): ¹ Sustainable Forest Management Research Institute, Universidad de Valladolid & INIA, Palencia, Spain ² School of Agricultural Engineering, University of Valladolid, Palencia, Spain ³ Stipa & Azeral, Environmental Services S.L., Cuenca, Spain ⁴ School of Geosciences, University of Edinburgh, Edinburgh, United Kingdom

ABSTRACT

It is widely accepted that forest expansion in abandoned agricultural lands is contributing to the land C sink trend detected in the Northern Hemisphere. However, in areas of Mediterranean-continental climate, where natural regeneration in abandoned land is common, the amount of CO₂ that has been sequestered is poorly understood. We assessed the area affected by forest expansion in abandoned agricultural lands, and estimated the mean above- and below-ground carbon (AGC and BGC) densities and total stocks generated by this process, over the period 1977-2017, in a vast area (9.4 million ha) of Mediterranean-continental environment of the Central-North Iberian Peninsula. We achieved this objective through obtaining AGC and BGC estimations based on direct field measurements taken in 30 plots (25 m × 25 m), and extrapolating to the landscape using Synthetic Aperture Radar (SAR) satellite data from 2018. Using aerial photographs we found that 145,193 ha of agricultural land in 1957 (1.54 % of the study regions' total area) has since then regenerated naturally to forests, woodlands or other wooded lands, with many areas showing relatively large mean AGC (18.04 Mg C·ha⁻¹) and BGC (6.78 Mg C·ha⁻¹) densities. The BGC stock was also very large, representing 37.3 % of the total C stock (10 Tg) accumulated. However, we detected a mean annual C sink of 0.16 Tg C·yr⁻¹ which barely offset 1.22 % of the total regional CO₂ emissions. Our findings point to a smaller sequestration potential under Mediterranean than under temperate-cold conditions. Nonetheless, the area affected by this process could be larger than detected and many of the new wooded lands might have not still reached their C uptake peak. If such lands are to be used for carbon sequestration, we strongly advocate for the application of active forest management measures to increase their CO₂ sequestration potential.



Image: Quercus faginea forest developed on an abandoned agricultural land in Covaleda (Burgos, Spain).

Aboveground biomass estimation in natural and plantation forest areas in Greece using satellite data

Author(s): [Mallinis, G.](#)¹;

Affiliation(s): ¹Laboratory of Photogrammetry and Remote Sensing Unit (PERS Lab), School of Rural and Surveying Engineering, The Aristotle University of Thessaloniki, Greece,

E-mail: gmallin@topo.auth.gr

ABSTRACT

Forest biomass an important measure of ecosystem productivity, is an essential indicator for the quantification and monitoring of forests' role of in the carbon cycle, the potential for energy production, and the carbon stock estimation for climate change modelling. The ecosystem services of carbon sequestration is provided not only by primary and secondary natural forests, but also from forest plantations introduced on land without previous forest cover, as on agricultural, pastures or marginal and restored land. Information related to sequestered carbon in forest areas, is important not only for climate change modelling and environmental reporting, but also for their silvicultural management and health monitoring, prioritization of biomass harvesting and energy planning among others. Nowadays, satellite remote sensing sensors can regularly provide such spatially explicit information to forest managers, at a wide range of spatial and temporal scales.

This study presents the experimental findings related to the use of freely available medium-high spatial resolution data for modelling aboveground biomass (AGB) in natural and plantation forest areas in Northern Greece. The first study case is focused on a heterogeneous Mediterranean forest. Imagery from Landsat-8 and Sentinel-2 is used for modeling the relationship between the spectral information inherent in both sensors and AGB.

In the second study, the synergistic use of Sentinel-2 and Sentinel-1 sensors is explored for modelling AGB in black locust plantations in Northeast Greece. Random Forests (RF) models were developed originally upon monthly Sentinel-2 spectral indices while progressively monthly Sentinel-1 bands were incorporated in the statistical analysis.

In both cases moderate accuracy is attained using the optical remote sensing data (R^2 up to 0.50). Data from the dry-season period provided the best overall models. The inclusion of the Sentinel-1 bands in the optical-only models had a negligible effect in the accuracy, especially during the leaf-on period.

Keywords: Restoration strategy/planning, Forests/woodlands, Ecosystem services

Long-term abandonment of agro-ecosystems in Mediterranean mid-mountain areas: environmental consequences

Author(s): Nadal-Romero, E.¹; Khorchani, M.; Cortijos-López, M.; Sánchez-Navarrete, P., Errea, P., Lasanta, T.

Affiliation(s): ¹*Instituto Pirenaico de Ecología (IPE-CSIC), Spain;*

E-mail: estelanr@ipe.csic.es

ABSTRACT

European Mediterranean mountains suffered throughout the 20th century, depopulation and abandonment of traditional activities: decrease in livestock censuses, massive abandonment of agriculture and under-exploitation of the forests. As a consequence, there are dramatic landscape changes, including an intense process of natural revegetation (colonization by shrubs and forests) and afforestation (mainly with conifers). The result is a homogeneous landscape dominated by shrubs and pine forests, different from the traditional mosaic landscape. These processes have a variety of environmental consequences, as well as, consequences from the perspective of land management and public awareness. The massive revegetation of the territory has negative effects on some ecosystem services such as: (i) the homogenization of the landscape and loss of biodiversity, (ii) the increase in forest fires, (iii) the decrease in water resources, (iv) changes in soil properties, soil quality and soil organic carbon (SOC), and (v) the reduction of agropastoral resources. Also, some positive effects can be discussed, such as: (i) greater rewilding of landscapes and recovery of forest ecosystems, (ii) aesthetic benefits for urban tourism (iii) more CO₂ fixation, and (iv) less soil erosion. The objective of this presentation is to examine the environmental consequences of long-term abandonment of agro-ecosystems in Mediterranean mid-mountain areas, and briefly highlight some experiences in the Iberian Range and Central Pyrenees (Northern Spain), as an example.

Acknowledgments: This research was supported by the MANMOUNT (PID2019-105983RB-100/AEI/10.13039/501100011033) project funded by the MICINN-FEDER.

Keywords: cropland abandonment, Mediterranean mountains, rewilding, afforestation, ecosystem services.

Carbon sequestration on abandoned agricultural lands in Russia: A review

Author(s): Schierhorn, F.¹; Rolinski, S.²; Müller, D.^{1,3}

Affiliation(s): ¹Leibniz Institute of Agricultural Development in Transition Economies (IAMO), Theodor-Lieser-Str. 2, 06120 Halle (Saale), Germany. ²Potsdam Institute for Climate Impact Research, Member of the Leibniz Association, PO Box 60 12 03, 14412 Potsdam, Germany. ³Geography Department and Integrative Research Institute on Transformations of Human-Environment Systems (IRI THESys), Humboldt-Universität zu Berlin, Unter den Linden 6, 10099 Berlin, Germany.

E-mail: schierhorn@iamo.de

ABSTRACT

The abandonment of croplands in Russia after the collapse of socialism was one of the most drastic episodes of land-use change in the 20th century in the northern hemisphere. Approximately 37 million hectares of cropland were abandoned from 1990 to 2020, mainly because fodder crop cultivation declined in response to the contraction of the livestock sector. The regrowing on the abandoned croplands removed atmospheric carbon dioxide and sequestered carbon in soils and vegetation. However, estimated carbon accumulation rates due to cropland abandonment in Russia vary widely, due to differences in the calculation methods (e.g. processed-based modelling versus soil sampling) and in the land-use data. Our review of carbon sequestration on abandoned croplands in Russia suggests that carbon accumulation for the first 20 years after abandonment range between 0.47 and 1.04 Mg C ha⁻¹ year⁻¹ likely represents the largest human-induced carbon sink induced by land use change globally. Most studies agree that carbon sequestration was slow in the early years after abandonment, mainly due to time lags in vegetation development, but carbon uptake substantially increased after approximately ten years. Other factors, such as initial soil organic carbon stock, climate (change) and soil type condition the observed carbon stock changes in Russia. Russia's abandoned cropland have tremendous additional potential for carbon sequestration, particularly through reforestation, but this has received little attention in the literature. It is urgent that future land management strategies on the abandoned lands in Russia can achieve important benefits for climate change mitigation, biodiversity conservation, and food security.

Keywords: Croplands, Soils, Rewilding, Ecosystem Services

S7.1 – Marine Ecosystem Restoration in changing oceans

Restoration of *Cymodocea nodosa* seagrass meadows: efficiency and ecological implications

Author(s): Cristina Gambi¹, Zaira Da Ros¹, Cinzia Corinaldesi², Antonio Dell'Anno, Fabrizio Torsani¹, Roberto Danovaro^{1,3}

Affiliation(s): ¹ *Dipartimento di Scienze della Vita e dell'Ambiente, Università Politecnica delle Marche, Via Brecce Bianche, Ancona, Italy;* ² *Dipartimento di Scienze e Ingegneria della Materia, dell'Ambiente ed Urbanistica, Università Politecnica delle Marche, Via Brecce Bianche, Ancona, Italy;* ³ *Stazione Zoologica Anton Dohrn, Villa Comunale, Naples, Italy.*

E-mail: c.gambi@univpm.it

ABSTRACT

Seagrass meadows play a key role in the provisioning of ecosystem goods and services. These systems are extremely vulnerable to multiple anthropogenic impacts. Therefore, there is an urgent need to develop new techniques to efficiently restore degraded seagrass meadows. Here we tested the efficacy and efficiency of a new technique of seagrass transplant (*Cymodocea nodosa*) using biodegradable containers. We investigated the effects of this transplant technique in the Adriatic Sea comparing the transplanted seagrass meadows with adjacent donor seagrass meadows and bare sediments, used as control. We assessed the recovery rates and the ecological implications of this transplant on key-ecosystems functions, including the biomass and detritus provision to local biological communities, and the effects on the biodiversity of the associated benthic fauna. Our results show that this restoration technique was successful, enabling the seagrass survival (ca. 30%) even in high-energy conditions occurring in Winter. The sediments hosting the transplanted seagrasses showed an increase of trophic availability and of rates of organic matter cycling. Despite this, one year after the transplant, the abundance and biodiversity of meiofaunal assemblages in the restored seagrasses were still lower than in donor seagrass meadows. These results indicate that the restoration process of seagrass meadows can take a long time, and that a multi-level approach (including the analysis of biodiversity and of the sedimentary processes and biogeochemical cycles) is needed to assess the success of restoration actions in these habitats.

Keywords: seagrass restoration, transplant technique, biodegradable containers, meiofauna biodiversity, ecosystem functioning

Ecophysiological responses of two fucalean seaweeds to key environmental factors to identify restoration priorities

Author(s): Orfanidis S.; Nakou, K.; Papadimitriou, A.; Malea, L.

Affiliation: Fisheries Research Institute (ELGO-DIMITRA), Kavala, Greece

E-mail: sorfanid@inale.gr

ABSTRACT

The highlights of different replicated factorial laboratory experiments on the effects of temperature, irradiance, nutrients, and season on photosynthetic efficiency and growth of two fucalean seaweeds [*Ericaria barbatula* (Kützting) Molinari & Guiry, *Cystoseira compressa* (Esper) Gerloff & Nizamuddin] having different life-cycles and growth strategies are presented. Heat stress affected *E. barbatula* more seriously than the semi-perennial species *C. compressa*, especially in autumn, which survives summer and autumn months in the form of holdfasts. The reproduction only of *E. barbatula* were induced under short-day and low temperatures conditions (winter-spring) to secure germlings growth in the field in spring with high nutrients, ample light, and moderate temperatures. *Ericaria barbatula* and *C. compressa* growth was differentiated under different nutrient concentrations, with higher relative growth rates (RGR) of the first species measured under low nitrogen seawater concentrations ($N-NO_3=0.6 \mu M$) and of the second species under low to moderate ($N-NH_4=0.6$ to $30 \mu M$) ammonium and phosphorus ($P-PO_4=0.02$ to $1 \mu M$) concentrations. *Ericaria barbatula* was more tolerant than *C. compressa* at higher ammonium seawater concentrations ($N-NH_4=60$ to $90 \mu M$) as evidenced by higher effective quantum yield (Φ_{PSII}), low non-photochemical quenching (NPQ) and higher RGR values. TR_0/RC represents the maximal rate by which an exciton is trapped by the reaction center (RC), resulting in Q_A reduction increased under high ammonium treatments only for *C. compressa* confirming photodamage rather than a photoacclimation of the RC complexes. Understanding the interplay between species photosynthesis, growth, and environmental adversity is critical to understanding physiology and predicting fitness in species distribution and restoration actions.

Keywords: Marine botany, stress, brown algae, JIP-test, relative growth rate

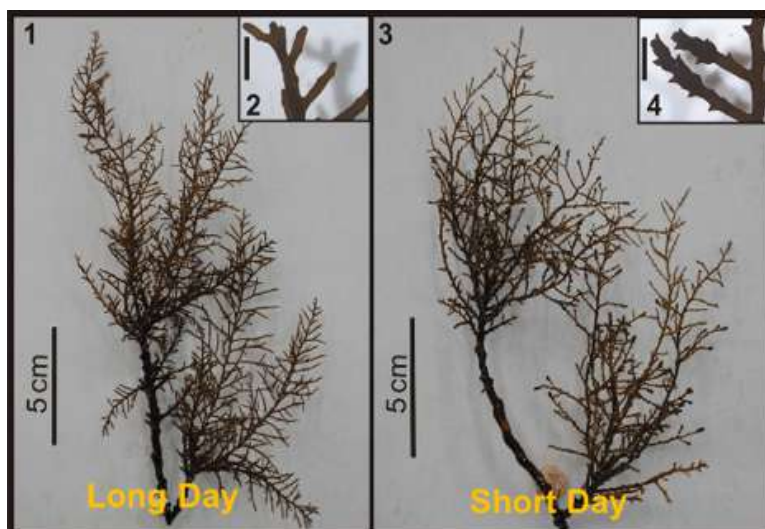


Figure 1. *Ericaria barbatula* thalli cultivated under long and short-day conditions.

The first steps of ecosystem restoration in marine ecosystems: results and new challenges

Author(s): [Bianchelli, S.](#)¹; Gambi, C.¹; Frascchetti, S.²; Papadopoulou, N.³, Danovaro, R.^{1,4}

Affiliation(s): ¹*Polytechnic University of Marche, Italy;* ²*University of Naples, Italy;* ³ *Hellenic Center for Marine Research, Greece;* ⁴*Stazione Zoologica Anton Dohrn di Napoli, Italy*

E-mail: silvia.bianchelli@univpm.it

ABSTRACT

Deterioration of marine ecosystems destroys their biodiversity and services they can provide, thus leading to the collapse of the Natural Capital. Major evidence of habitat loss has been observed at planetary scale and concern is rising for the European Seas and, particularly, for the Mediterranean Sea, a recognised hot spot of biodiversity. Restoration has been identified as a key action in the Aichi Biodiversity Target and in the UN Sustainable Development Goal: “*conserve and sustainably use the oceans, seas and marine resources for sustainable development*”. In 2021 we entered into the UN Decade of Restoration Ecology and Ocean Science for Sustainable Development, moreover, the EU launched the Green Deal, the Biodiversity Strategy 2030 and the EU Nature Restoration Plan to recover damaged ecosystems and ensure their sustainable management. Restoration in marine ecosystems has taken its first steps 5 years ago, within MERCES (Marine Ecosystem restoration in Changing European Seas), the first EU project dedicated to the restoration of marine ecosystems from coastal bottoms to the deep sea, and within the on-going AFRIMED (Algal Forest Restoration in MEDiterranean sea) project. Today, scientific results and technologies are available, but a concerted effort is required to scale up the restoration on wide geographical areas at basin scale, across marine ecosystems. It is now widely recognized that active restoration is essential to halt further decline, also beyond European boundaries. Here we discuss the urgent need for integrated environmental management actions for the preservation and restoration of habitats and key species based on the best scientific knowledge. Also, we show that increasing social awareness can support restoration upscaling, promoting and putting in place economically and ecologically sustainable initiatives allowing the recovery of marine ecosystems. Business innovations and building government-private and civil society partnerships enhance the restoration upscale implementation potential for European marine ecosystems.

Keywords: Biodiversity, ecosystem functioning, ecosystem engineers, marine environments

Stakeholder expectations from marine restoration projects: AFRIMED and algal forest restoration in the Mediterranean

Authors: Papadopoulou, N.¹; Mangialajo, L.²; Monserrat, M.², Cottalorda, J.M.²; Smith C.J.¹, Bianchelli S³

Affiliations: ¹Hellenic Centre for Marine Research, Crete, Greece; ² Université Côte d'Azur, CNRS, Nice, France; ³ Polytechnic University of Marche (UNIVPM), Ancona, Italy

E-mail: nadiapap@hcmr.gr; luisa.mangialajo@unice.fr; mmonserratb@outlook.com; cottalor@unice.fr; csmith@hcmr.gr; silvia.bianchelli@staff.univpm.it

ABSTRACT

Examples from the terrestrial world clearly emphasize the necessity, the feasibility and the socio-economic benefits of investing in, and restoring, nature. With the exception of some specific coastal and shallow reef habitats, marine restoration is generally less well developed and not well implemented, even though it has been specifically targeted in numerous regional and EU policies. Increased awareness of the importance of reversing habitat loss and regaining ecosystem services, fosters interactions between scientists (providing the knowledge base), decision-makers and managers (looking for policy implementation in their regions/countries, investing and prioritising their measures) and the private sector (that can provide the tools for large scale actions). In order to firmly interconnect science, management and business in the framework of the restoration of marine forests, AFRIMED is engaging with stakeholders, creating a Business Club and organising dedicated products and events. The development of a shared vision of the management of marine forests will help implement relevant strategies/initiatives, create acceptance and a sense of ownership from local communities, and develop partnerships to implement new targets and future investments in marine coastal restoration.

As a first action in this framework, an anonymous survey was designed, aiming to identify the expectations of stakeholders, including AFRIMED partners (<https://forms.gle/8QVTfMQYntCsYoGp7>). Additional information collected concerned demographics, stakeholder type and specific role or expertise. Preliminary results showed a high participation of scientists, followed by consultants, NGOs and national/local government. Such contributions highlighted the importance of producing new knowledge on restoration techniques, prioritization, development and transfer of best practices, and supporting EU policies and initiatives in line with global objectives and the EU Biodiversity Strategy and Green Deal. Networking and participation in future restoration actions is also considered very important by the stakeholders which will further support sustainable use of the oceans.

Keywords: Marine forests, Cystoseira, stakeholders, policy, Mediterranean

Habitat and functional recovery after the restoration of a canopy-forming algae forest

Author(s): Galobart, C.¹; Vergés, A.²; Golo, R.²; Ballesteros, E.¹; Cefali, ME.³; Gran, A.³; Cebrian, E.²

Affiliation(s): ¹*Centre d'Estudis Avançats de Blanes (CEAB-CSIC), Spain;* ²*Universitat de Girona (UdG), Spain;* ³*Estació d'Investigació Jaume Ferrer (IEO), Spain.*

E-mail: cgalobart@ceab.csic.es

ABSTRACT

Macroalgal forests represent one of the most productive habitats in coastal ecosystems, host relevant biodiversity and provide ecosystem services of global importance (i.e. acting as marine carbon sinks and natural buffers against coastal erosion). However, these habitats are currently declining, and active, large-scale intervention is required to halt the loss of these valuable ecosystems. Although restoration actions have risen during the past decades, marine initiatives are very scarce and still face several challenges. Even though canopy-forming macroalgae species display several features that may promote their restoration, there are few available examples on the literature. In these studies, restoration techniques are limited to transplantation of adults and enhancement of recruits, with results generally reported one or few years after the action. The restoration success is mainly defined by the density of the recruits or the number of individuals and there is hardly any study considering the recovery of the community assemblages. Here, we will take advantage of a unique canopy-forming algae restoration dating more than 10 years, which can provide information on the community restoration in the mid-long term. This study focuses on both the recovery of species composition and the ecosystem functionality by comparing non-restored, restored and reference habitats. A major finding is that biodiversity and functionality greatly increases in restored sites, which become similar to reference habitats. This study shows that the restoration of a canopy-forming macroalgal population leads to a true community restoration emphasizing that the recovery of the three-dimensional structure has important effects not only on the species diversity, but also on the functionality of the ecosystem.

Keywords: Biodiversity, Coastal / marine environments, Ecosystem processes / ecosystem functioning.

Funding: This project has been financially supported by the Horizon 2020 EU Research and Innovation Program under grant agreement No. 689518 (MERCES) and European Union's EMFF programme under grant agreement EASME/EMFF/2017/1.2.1.12/S4/ 01/SI2.789059 (AFRIMED). CG has been funded by Fundación Tatiana Pérez de Guzmán el Bueno predoctoral fellowship.

Nature-based-Solutions foster seagrass *Zostera noltei* resilience and restoration success: guidelines for practitioners and upscaling activities

Authors: Sousa, A.I.¹; Lopes, M.¹; Flindt, M.R.²; Costa, V.^{1,3}; Raínha, P.¹; Coelho, J.P.¹; Lillebø, A.I.¹

Affiliation(s): ¹ CESAM - Centre for Environmental and Marine Studies, Dpt of Biology, University of Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal; ² Dpt of Biology, University of Southern Denmark (SDU), Campusvej 55, dk-5230 Odense M, Denmark, ³ Current address: SZN, Dpt Integrative Marine Ecology, 90149, Palermo, Italy

E-mail: anaisousa@ua.pt

ABSTRACT

Seagrass meadows, which provide relevant ecosystem services, are worldwide influenced by natural and human induced stressors. In the frame of the UN Decade for Ecosystem Restoration (2021-2030) and UN Sustainable Development Goals, we propose a decision-making approach to enhance seagrass resilience against an invasive-alien-species (*Arenicola* spp., lugworm) bioturbation and provide guidelines to improve seagrass restoration by ecological restoration practitioners, using Nature-based Solutions (NbS). In a Portuguese coastal lagoon (Ria de Aveiro), used as a show-case, we tested (since 2018) *Zostera noltei* transplant and restoration methodologies *in situ* (from individual transplants - with different anchoring methods - to sods) and the effectiveness of two natural membranes (NbS) to mitigate the *Arenicola* spp. disturbance in these meadows. Results showed the sod is the best transplanting method, since the *Z. noltei* self-facilitation process is enhanced and it was the least invasive method to the donor meadow. The use of a natural membrane significantly decreased the bioturbation impacts caused by *Arenicola* spp. We then defined a stepwise approach to improve the resilience of *Z. noltei* and maximise the success of restoration, consisting of 1) Characterization of the donor population, 2) Identification of the constraints and implementation of measures, and 3) Scale-up the restoration plan. *Z. noltei* restoration upscaling was then started in July 2020 at three sites in the lagoon, and monthly monitoring of the seagrass coverage area and lugworm density (to evaluate the NbS membrane effectiveness) have been performed. Restoration success rates vary among sites. To sum up, the application of the proposed decision-making approach and guidelines for practitioners in intertidal coastal systems' management will facilitate the success of seagrass restoration plans. This work was funded by the project [BioPradaRia](#) (MAR-01.04.02-FEAMP-0020) - PO MAR2020, EMFF, EU, Portugal2020.

Keywords: Coastal/marine environments, Ecological engineering, Evaluation and monitoring, Restoration strategy/planning



Fig. 1 - *Zostera noltei* meadow disturbed by *Arenicola* spp. (faecal casts visible) (left); Restoration upscaling *Z. noltei* sods transplantation and natural membrane (NbS) applied (right).

S7.2 – Marine Ecosystem Restoration in changing oceans

Posidonia oceanica marine forest: epifaunal community response to plant restoration.

Author(s): [Castejón-Silvo, I.](#)¹; Burgos, E.¹; Gómez-Pons, M.; Terrados, J.¹

Affiliation(s): ¹*Mediterranean Institute for Advanced Studies, Spain;*

E-mail: icastejon@imedea.uib-csic.es

ABSTRACT

Seagrass meadows loss is being reported all over the world. Coastal ecosystem restoration presents technical challenges that frequently drive to low resources for the monitoring of community development after replanting. *Posidonia oceanica* replanting deals with the scarce and irregular flowering events and the consequent lack of seeds which hinders large/medium scale projects with propagules. The *Posidonia oceanica* Marine Forest is the first medium size restoration project in which two hectares of a damaged *P. oceanica* meadow in the North of Majorca have been replanted (12800 fragments of adult plant) and the monitoring of the associated community (e.g. epifauna, macrophytes, fishes) is being examined. Here we present the results of the early stage recovery, after replanting, of epifauna community in a gradient of habitat complexity, exemplified by: non replanted area, replanted area, natural meadow edge, inside natural meadow. We evaluate the abundance and diversity of motile invertebrates collected with non-destructive methods (i.e. light traps) and habitat complexity, as covariate, in terms of macrophyte density and biomass. Preliminary results show seasonality of faunal community during the first year after plantation. The highest abundance was found in natural meadows followed by non-replanted meadow and replanted area. This trend changed in the following months when abundances equalled in natural meadow, plantation area and non-replanted meadow. This result indicates seasonal variability in the natural meadow and no changes in the plantation area and non-replanted meadow. The epifaunal community was not recovered in response to the increase of habitat complexity after one year of replantation, and thus long-term monitoring of *P. oceanica* replanting projects should be done for a proper assessment of ecosystem functioning recovery.

Keywords: Coastal environment, Biodiversity, Ecosystem processes, Evaluation and Monitoring.

The role of scale in seagrass restoration and biodiversity: a functional trait approach

Author(s): Gagnon, K.¹; Bocoum, EH.²; Chen, CY.³; Baden, S.³; Moksnes, PO.⁴; Infantes, E.^{4,5}

Affiliation(s): ¹Environmental and Marine Biology, Åbo Akademi University, Finland; ²OSUR - Observatoire des sciences de l'Université de Rennes, University of Rennes 1, Rennes, France; ³Department of Biology and Environmental Sciences, University of Gothenburg, Gothenburg, Sweden; ⁴Department of Marine Sciences, University of Gothenburg, Gothenburg, Sweden; ⁵NIVA - Norwegian Institute for Water Research, Oslo, Norway

E-mail: karine.gagnon@abo.fi

ABSTRACT

Anthropogenic stressors have reduced seagrass cover around the world. Restoration can reverse these declines, but seagrass restoration success has been low. Large-scale planting is known to increase restoration success by assuring scale-dependent interactions and feedback mechanisms, but also increases pressure on donor populations and associated monetary costs. Here, we tested the role of patch size and configuration in a large-scale eelgrass (*Zostera marina*) restoration project in the Swedish Skagerrak (North Sea). We planted four large (25 x 25 m) plots with different configurations and patch sizes (one continuous plot, three plots with large, medium, and small patches). We measured seagrass shoot density and associated invertebrate (epifauna and infauna) biodiversity and functional diversity, in comparison to a healthy control meadow after one and two growing seasons. Eelgrass survival was very high and shoot density in the plots increased over time, though after two growing seasons it had not yet reached the density of the meadow. Epifaunal and infaunal invertebrates quickly colonised the plots and densities were similar to the meadow after only one growing season, but plot size-density relationships were not linear in most cases. There was little overlap in the community composition and functional diversity between the meadow and plots after one growing season, but higher overlap after two growing seasons, indicating that communities were becoming more similar. Overall, our results show that large-scale restored seagrass plots are quickly colonised by diverse invertebrate communities, but that plot size can drive the resulting community structure and functional traits, and that it can take several years for the restored communities to resemble natural communities in terms of both community composition and functional traits. Several more years of monitoring will be necessary to fully understand how restoration scale affects biodiversity and ecosystem functioning, and to determine optimal restoration configuration.

Keywords: coastal/marine environments, seagrass, biodiversity, functional traits, spatial scale.

Understanding the ecological effects of extreme events in rocky shores to be applied in restoration

Author(s): [Saez-Zamacona, I.](#)¹; Casado-Coy, N.²; Terradas-Fernández, M, N.³; Erazo, K.¹; Saiz, H.⁴, Sanz-Lázaro, C^{1,2}

Affiliation(s): ¹*Department of Ecology, University of Alicante, PO Box 99, E-03080 Alicante, Spain.*

²*Multidisciplinary Institute for Environmental Studies (MIES), Universidad de Alicante, P.O. Box 99, E-03080 Alicante, Spain.* ³*Department of Marine Science and Applied Biology, University of Alicante, PO Box 99, E-03080 Alicante, Spain.* ⁴*Institute of Plant Sciences, University of Bern, Bern, Switzerland.*

E-mail: iraide.25@gmail.com, carsanz@ua.es

ABSTRACT

Disturbances modulate the structure of biological communities, being extreme events among the most important ones. Climate change is modifying the disturbance regime by increasing the occurrence of extreme events. Restoration actions must take into account the consequences of climate change to maximise their effectiveness, making them as sustainable as possible to have a lasting impact. Our study focuses on the rocky shore habitat in the intertidal and subtidal zones of the coast of Alicante (SE Spain). Through manipulative experiments, we simulate storms and low tides as extreme events that occur in this habitat in two areas with contrasting levels of anthropogenic pressures. We inversely manipulated the intensity and frequency of the events, to have the same overall intensity in all treatments. The community structure was analyzed by means of diversity indices, multivariate and ecological network analyses. Our results show that a single extreme storm affects the structure of the biological community to a greater extent than several low intensity storms, especially under a high anthropic pressure scenario, where the recovery time of the community was also longer. Low tides reduced the species richness of the community when the community was already suffering other anthropogenic pressures. However, low tides similarly affected the nestedness and modularity of the communities independently of their level of anthropogenic pressure. Our results suggest that the effects of extreme events in biological communities could be reinforced when coexisting with other pressures. These results provide relevant information for environmental managers to design restoration strategies aiming to be sustainable and suitable for current climate crisis.

Keywords: Biodiversity, climate change, coastal environments, community assembly, extreme events

Fig. 1. A rocky shore of the study



Zostera noltei as a rehabilitation tool for degraded estuarine ecosystems (Ria de Aveiro, Portugal)

Author(s): Oliveira, V.H.¹; Sousa, A.I.¹; Fonte, B.A.¹; Lillebø, A.I.¹; Dias, J.M.²; Vaz, N.²; Díez, S.³; Dolbeth, M.⁴; Coelho, J.P.¹

Affiliation(s): ¹ Biology Department, CESAM - Centre for Environmental and Marine Studies, University of Aveiro, Campus de Santiago, 3810-193 Aveiro, Portugal; ² Physics Department, CESAM - Centre for Environmental and Marine Studies, University of Aveiro, Campus de Santiago, 3810-193 Aveiro, Portugal; ³ Environmental Chemistry Department, Institute of Environmental Assessment and Water Research, IDAEA-CSIC, E-08034 Barcelona, Spain; ⁴ CIIMAR - Interdisciplinary Centre of Marine and Environmental Research, Novo Edifício Do Terminal de Cruzeiros Do Porto de Leixões, Avenida General Norton de Matos S/N, 4450-208, Matosinhos, Portugal;

E-mail: vitor.hugo.oliveira@ua.pt

ABSTRACT

With the recent declaration of the 2021-2030 UN Decade on Ecosystem Restoration, seagrass restoration efforts are in the spotlight, given the ecosystem functions that support the vital services they provide (e.g., carbon and nutrient sinks, biodiversity enhancement and coastal erosion prevention). Within this framework, seagrass re-colonization is currently being tested as a blue-green infrastructure for restoring historically contaminated ecosystems. The overarching goal of this work is to evaluate the use of *Zostera noltei* as a remediation tool in the Ria de Aveiro (Portugal). The project encompasses an interdisciplinary approach assessing the effect of *Z. noltei* on contaminant biogeochemistry and sequestration, associated biodiversity, food web structure and contaminant biomagnification processes. The optimal transplantation site was chosen based on hydrodynamic modelling (Delft3D), taking into account the maximum time of immersion, current intensity, maximum depth, and turbidity. The transplanting strategy consisted of patches ($\pm 20 \times 30$ cm) collected from a donor *Z. noltei* meadow (3 km downstream) transplanted to a focal area with historical contamination. Patches were transplanted 40 cm apart to allow colonization of gaps in all directions, in a total area of circa 20 m² (7 x 3 m). After six months, regular monitoring indicates an approximate 70% increase in the plant cover of the transplanted area. Expansion of the transplanted area is scheduled for the next year. Ongoing work is being developed to evaluate the effect of *Z. noltei* presence in the contaminated area: 1) the evolution of sediment contaminant depth profiles using DGT (diffusive gradients in thin films); 2) colonization by the associated macrofauna (e.g., composition, structure and production); and, finally, 3) the effect of the transplantation experiment on the bioaccumulation of contaminants and trophic transfer. This work was partially funded by projects RemediGrass (PTDC/CTA-AMB/29647/2017) and ReMoliço (16-01-04-FMP-0019).

Keywords: Restoration strategy/planning; Biodiversity; Coastal/marine environments; Evaluation and monitoring

Fig. 1 – Evolution of transplant experiment: A) transplant day; B) transplant after 6 months; C) Evolution of coverage area



Zostera noltei response to transplantation into contaminated sediments. (A mesocosm experience)

Author(s): Fonte, B.A.¹; Oliveira, V.H.¹; Sousa, A.I.¹; Lopes, C.B.²; Henriques, B.³; Pereira, E.³; Calado, R.¹, Lillebø, A.I.¹; Coelho, J.P.¹

Affiliation(s): ¹CESAM - Centre for Environmental and Marine Studies, ECOMARE and Biology Department, University of Aveiro, Campus de Santiago, 3810-193 Aveiro, Portugal; ²CICECO, Department of Chemistry, University of Aveiro, Campus de Santiago, 3810-193 Aveiro, Portugal; ³LAQV-REQUIMTE- Associated Laboratory for Green Chemistry of the Network of Chemistry and Technology, Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal

E-mail: beatrizfonte@ua.pt

ABSTRACT

The importance of restoring historically degraded ecosystems has been highlighted within the scope of the UN Decade on Ecosystem Restoration (2021-2030). This work aims to assess the effectiveness of seagrass re-colonization as a nature-based solution for the recovery of a historically mercury contaminated coastal system (Ria de Aveiro, Portugal). A mesocosm experiment was conducted to evaluate the resistance of *Zostera noltei* to transplantation into sediments with increasing Hg concentrations. The experiment was performed in a life-support system with tidal simulation, and the design consisted of two controls (one experimental and one transplant) (<0.5 mg/kg Hg) and three experimental sediments from the target transplantation area (with contamination levels ranging from 1 to 10 mg/kg Hg). Tanks were filled with ≈2 L of sediment, a 150 mm diameter *Z. noltei* sod and filled with ≈3 L of natural water (previously adjusted to the water column salinity at the donor meadow) every 12 hours, which was pumped out after 6 hours (to simulate low tide, flow-through water circulation regime). The experiment was performed outdoors, under natural sunlight and temperature regimes. At each sampling moment (2 weeks, 1, 2, 4 and 7 months after the beginning of the experiment), 5 replicates were harvested per treatment and several relevant parameters were assessed to determine the resistance of transplanted *Z. noltei*: growth parameters (biomass and percentage of coverage area); photosynthetic activity; elemental composition of plants and sediment; oxidative stress metabolites.

While relevant differences were observed among treatments and sampling moments in some of the parameters, all seagrass transplants survived until the end of the experiment. Moreover, seed production was recorded both in control and experimental tanks, suggesting that re-colonization with *Z. noltei* can therefore be a viable restoration strategy for historically contaminated coastal systems.

This work was partially funded by projects RemediGrass (PTDC/CTA-AMB/29647/2017) and ReMoliço (16-01-04-FMP-0019).

Keywords: Restoration strategy; Coastal environments; Evaluation and monitoring

S15.1 – Soil and Water

Bioengineering as a tool for ecological restoration

Soil and Water Bioengineering in European context for Ecological restoration. Concrete examples

Author(s): ¹Sangalli P.

Affiliation(s): *President European Federation of Soil and Water Bioengineering*

E-mail: efibioengineering@gmail.com

ABSTRACT

Soil and Water Bioengineering (SWB) is a discipline based in Nature-SWB with the use of native plants as a building material, offers sustainable solutions face to the challenges of mitigation and adaptation to climate change.

The development, although not homogeneous in all European countries, is proceeding rapidly thanks to the introduction of the Green Infrastructure as a planning concept and to the NBS as constructive solutions. We therefore find ourselves in Europe at a favourable time for the expansion of our discipline.

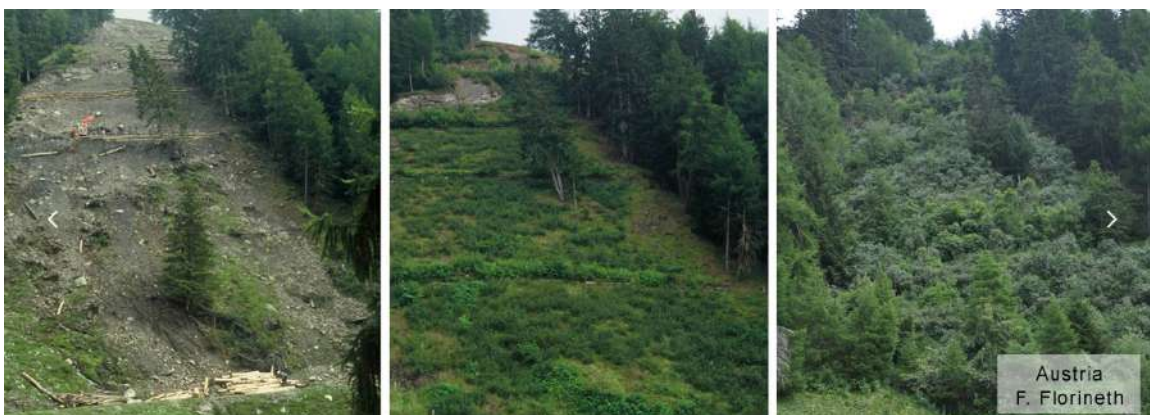
SWB as an applied discipline, was born in Central Europe (Germany, Switzerland, Austria) at the beginning of the last century, mainly in the field of hydraulic-forestry arrangements integrated with civil engineering techniques. Subsequently, in the forties, it will begin its development in other fields (coastal area, mining, linear infrastructures). In Mediterranean countries, the application was later, starting in the eighties, starting from Italy and then continuing in Spain, France and Portugal, with the decisive role of the Associations through numerous courses, conferences and publications, from the eighties.

This development resulted in the creation the European Federation for Soil and Water Bioengineering (E.F.B.I) founded in Vienna in 1996 . The Federation's objective is to promote this construction discipline through its aims: ecological (soil consolidation and protection) technical (restoration of ecosystems and development of its services), landscape integration (restoration and insertion of infrastructure works) and socio-economic objectives (zero-kilometer works and as a source of handwork) EFIB is currently organizing itself into four open working groups: **the communication group**, to disseminate and promote the discipline, **the training group**, to organize meetings, courses, excursions ..., **the research group** to promote applied research, and the **SWB without Borders group**, , to carry out training activities in Africa and Latin America.

In the presentation we want to present several examples of ecological restoration using SWB

Keywords: Ecological engineering; Restoration strategy/planning, rivers, soils, resilience

Fig. 1 Example of stabilisation an reintroduction of the forest in a landslide using SWB. Florin Florineth



Greening measures for sustainable ecosystem restoration – decision making approaches and management strategies

Author(s): Obriejetan, Michael¹; Stangl, Rosemarie¹

Affiliation(s): ¹ *Institute of Soil Bioengineering and Landscape Construction, University of Natural Resources and Life Sciences, Vienna, Austria*

E-mail: michael.obriejetan@boku.ac.at

ABSTRACT

The use of plants and plant communities to protect land, soil and infrastructures and at the same time contribute to landscape development are the key aspects in the field of soil and water bioengineering. In addition to technical functionality and safety functions, ecological and economic aspects are increasingly playing a role in the creation, restoration and management of ecosystems. Sustainable decisions require the development of cost-effective and efficient solutions, while still providing the greatest possible benefit in terms of ecosystem service (ESS) supply capacity. In order to be able to control these complex processes, decision-making tools are required that can link the strategic level with practical executions and can also be flexibly adapted to future requirements.

The right choice of greening material and technique, the use of gentle mowing techniques and careful vegetation monitoring, especially in the critical initial growth phase, can have a significant influence on the greening quality and its long-term success. The development and application of management systems is likely to become increasingly important in the coming years. Applicable tools in this sense act as valuable part of green space control systems that present decisions transparently and take into account the development of green spaces over their life cycle (planning, construction, maintenance). At the conference, strategic options, assessment approaches and implementation examples will be shown to position greening measures as an important discipline in the fight against species extinction and biodiversity loss.

Keywords: Ecological restoration, greening concepts and theory, restoration strategy planning, ecosystem services, evaluation and monitoring

Methods of process-orientated urban river development using Soil and Water Bioengineering

Author(s): Günther, H.¹; Zeumer, R.¹; Harre, K.¹

Affiliation(s): ¹HTW Dresden, Faculty of Agriculture/ Environment/Chemistry, Germany

E-mail: henning.guenther@htw-dresden.de

ABSTRACT

Floating vegetation stands are suitable as near-natural habitat structures for improving the ecological status of water bodies.

Their floating nature allows them to respond flexibly to water level fluctuations without limiting their functions, as is the case with land- and water-bottom-based structures.

The plants' roots, floating in the water, also provide large growing surfaces for water-purifying microorganisms, so that these systems are suitable for water purification.

Furthermore, they provide a semi-natural habitat for a large number of diverse species and can ecologically enhance paved bank sections, particularly in navigable waterways.

A qualitative improvement of the ecological status in the watercourse can be expected using large-scale applications that extend into adjacent areas, which are not restored.

The structures suitable for this application must have near-natural properties in terms of material and buoyancy so that they themselves do not contribute to the input of pollutants, like e.g. plastics or other non-decomposable, persistent and/or toxic materials and the associated negative effects on aquatic ecosystems. In the initial phase, this material serves as a plant carrier and has the properties of natural vegetation islands with vegetation and floating vegetation with regard to buoyancy. In the course of vegetative development, this material decomposes, is overgrown by the plants and a near-natural organic and overgrown root-rhizome body develops, which floats independently on the water surface.

Within this project, a planted green material made of biobased and biodegradable materials is to be tested with regard to its gas storage and degradation capacity. The obtained results will contribute to the development of sustainable solutions for the restoration of river banks.

Keywords: Ecological engineering, Ecosystem processes, Restoration strategy/planning, Rivers

Requalification of the coastline using bioengineering techniques.

Case study: Caldeirão dune - Northern Portugal

Author(s): Rolo Antunes, Carla ; Azevedo Coutinho, Miguel

Affiliation(s): *University of Algarve; University of Lisbon, Técnico*

ABSTRACT

It's desirable, from an integrated management perspective, to requalify the coastline and rehabilitated watercourses, through interventions compatible with planning instruments and based on principles, which focus on preserving and enhancing natural resources, biodiversity, natural heritage; environmental services, promoting the resilience of the territory, preventing, managing and monitoring threats.

The risks associated with the dynamics of the coastal zone, in the medium and long term, and the identification of risk areas for protection people and property are key topics in territorial planning and management process. In this framework, and context of the risks related with coastal erosion, the interventions suggested in the field of bioengineering are presented as a case study, meant at the requalification, stabilization and valorisation of "Caldeirão Dune". This dune, at the mouth of the Âncora River, is located in northern Portugal, close to an urban area. From the recognized dynamic of the mouth of this river, as well as the dune, it was observed, in recent decades, relevant changes.

According the dynamics of the system and need to promote protection and equilibrium of the dune, different types of intervention were considered, among which the consolidation of the left bank of the river (rock roll and bio roll layers), near the dune, artificial feeding of sand, from the dredging of the mouth, concerning the reconstruction / reinforcement of the dune, a solution of combined interventions with reinforcement works in the core of the dune, the placement of palisades and a buried sill (consisting of three geotubes, implanted parallel to the dune axis, with a front georoll); also, It was planned to vegetate the dune.

The proposed interventions consider the strong dynamics of the system, the actions that promote enhance, stimulate and accelerate the protection of the dune, the assurance of success and the cost of the works.

SWB plantation tools to combat desertification in Mediterranean Europe

Author(s): Pirrera, G.¹; Ferrara, L.M²
Affiliation(s): ¹AIPIN, Italy; ²BIOCITY, Italy
E-mail: jl.mine@libero.it

ABSTRACT

The role of vegetation in combating desertification is essential. However, the planting of plants requires water and soil for rooting. A correct choice of species is not enough: SWB as NbS techniques must adapt to extreme situations.

To retain the soil, techniques have already been used to recover plant material from the sea (*Posidonia oceanica* beached with the hydromulching technique) and from the earth (vine and olive agricultural shoots with biorollers, today technically evolved with the patent of the round bales now testing).

For some time in Sicily in lands poor in soil, "forced rooting" techniques have been adopted, which consist of placing peat, organic fiber, fertilizers, compost, biostimulants, mycorrhizae, etc, inside a deep hole in order to facilitate plant rooting

Even earlier, also following practices spread by the American soldiers during the Second World War, the cladodes of prickly pears (*Opuntia ficus-indica*) were exploited, broken up and / or whole inside the pit, which are able to yield gradually moisture to the soil, dehydrating and adding organic substance. The technology then intervened with plastic and biodegradable fiber supports to provide the plants with a slow-release water reserve. A Life project in this sense, in which the authors participated as a tester, has already concluded while a second in progress has also compared other techniques.

The paper reports application experiences for different species and in different contexts: water reserve systems are preferable for agronomic purposes while the best remedies in the naturalistic bioengineering are those that allow the recovery of plant material on site. In fact, they make it possible to apply circular economy principles and, at the same time, to recover materials that, otherwise, would be organic waste to be disposed of and therefore a cost, both in economic and resource terms, for the planet Earth and Climate Change.

Keywords: Desertification. SWB as Nature Base Solutions. Forced Rooting. Cladodes of *Opuntia ficus indica*. Circular Economy and Climate Change.

Fig. 1 Use of prickly pear cladodes



Fig. 2 Planting with Cocoon for the planting of *Chamerops humilis*



S15.2 – Soil and Water

Bioengineering as a tool for ecological restoration

Best practice – Is natural revegetation sufficient to achieve mitigation goals in road construction?

Author(s): Mehlhoop, A.^{1,2}, Brekke Skrindo, A.¹, Evju, M.¹, Hagen, D.¹

Affiliation(s): ¹Norwegian Institute for Nature Research, Norway; ²Norwegian University of Science and Technology, Norway

E-mail: amehlhoop@nina.no

ABSTRACT

In road construction projects, the area influenced by construction work is large, and measures are routinely carried out to re-establish vegetation in the disturbed area to reduce impacts on biodiversity and habitat use. The Norwegian Public Roads Administration has the national responsibility for road constructions and the accompanying mitigation measures, and they define the intact vegetation adjacent to the construction site as reference vegetation for the mitigation. However, the real value for biodiversity and landscape of these measures is not clear, and the cost-benefit from these actions should be evaluated for both biodiversity- and economic reasons. In this study, we assessed the effects of different revegetation measures (natural recovery, seeding, and planting) on vegetation development along large roads and on wildlife crossings built in different years in south-east Norway. We collected data on vascular plant species, vegetation cover and height, soil grain size and -organic matter content, and slope, and compared the species richness and composition of the restored sites with reference plots in the adjacent target vegetation (mature forest). We expected that natural recovery will facilitate species richness and -diversity sufficiently, compared to the other methods, but also expected a high dissimilarity between the restored sites and the reference vegetation over time. Our results show a significant higher richness and diversity for restored plots, but no advantage of natural recovery. It is therefore not realistic that the defined target vegetation will develop on the restored sites. It will be useful to define a realistic and achievable target vegetation for each road construction project in relation to land-use, adjacent vegetation type and successional stage, as e.g. forest edge instead of forest. This might mean more effort for the management but also a higher mitigation success.

Keywords: Roadsides, Evaluation and monitoring, Biodiversity, Urban/ periurban environments.

Ecological Engineering for transitional water restoration: Life Lagoon Refresh case study

Author(s): Feola A.¹; Bonometto A.¹, Ponis E.¹, Cacciatore F.¹, Matticchio B.², Canesso D.², Lizier M.³, Volpe V.⁴, Sfriso A.⁵, Ferla M.¹, Boscolo R.¹

Affiliation(s): ¹ ISPRRA - Italian National Institute for Environmental Protection and Research ² IPROS - Environmental Engineering s.r.l. ³ Veneto Region-Environmental Department. ⁴ OOPP - Interregional Superintendency for Public Works in Veneto, Trentino Alto Adige, Friuli Venezia Giulia. ⁵ UNIVE - University Cà Foscari of Venice - Department of Environmental Sciences, Informatics and Statistics

E-mail: alessandra.feola@isprambiente.it

ABSTRACT

Ecological Engineering has been increasingly used to re-create and restore ecosystems degraded by previous human activities, restoring natural processes by recovering suitable conditions for habitats and species of high conservation value, introducing ecosystem functions and services evaluation in water resources management.

In this framework, the LIFE LAGOON REFRESH project (www.lifelagoonrefresh.eu), started on September 2017, foresees the restoration of the ecotonal environment in the northern Venice Lagoon, SCI IT3250031, characterized by marked salt gradient and large intertidal areas vegetated by reedbeds (mainly *Phragmites australis*), whose presence has been greatly reduced by historical human environmental modifications.

The project actions involve: diversion of a freshwater flow from the Sile River into the lagoon for the recreation of the typical salt gradient; implementation of intertidal biodegradable structures to slow down the freshwater dispersion; transplanting (on the structures and on saltmarsh margins) of *P. australis* to accelerate their natural development and their related self-purification ecosystem functions. Fishermen and hunters are involved in the transplant actions.

Numerical modelling was performed to investigate the circulation pattern and to define the most suitable project configuration. In particular, hydrodynamic models were used to optimize the freshwater flow and the morphological configuration, in terms of salinity diffusion and hydraulic effects. Numerical modelling is applied to evaluate scenarios of increasing fresh water input (from 0 to 1000 l/s), useful for the hydraulic structure management.

The overall strategy of the project, the updated state of realization of conservation actions, the results of monitoring activities and numerical modelling will be presented as a case study to discuss the role of Ecological Engineering in the framework of transitional water restoration.

Keywords: Restoration strategy, Coastal environments, Ecological engineering, Ecosystem services, Wetlands

Restoration of drove roads to enhance biodiversity and connectivity of Natura 2000 sites in Spain

Author(s): Hevia, V.^{1,2}; Solascasas, P.¹; González, J.A.^{1,2}; Alcorlo, P.^{1,2}; López-Santiago, C.^{1,2}; Malo, J.E.^{2,3}; Mata, C.^{2,3}; Azcárate, F.M.^{2,3}

Affiliation(s): ¹ Social-ecological Systems Laboratory, Department of Ecology, Universidad Autónoma de Madrid, Darwin 2, 28049 Madrid, Spain ² Centro de Investigación en Biodiversidad y Cambio Global (CIBC-UAM), Universidad Autónoma de Madrid, Madrid, Spain ³ Terrestrial Ecology Group, Department of Ecology, Universidad Autónoma de Madrid, Darwin 2, 28049 Madrid, Spain

E-mail: violeta.hevia@uam.es

ABSTRACT

Drove roads (DRs) are the traditional routes used by herders and livestock for their seasonal movements in search of the most productive pastures. Shaped by traditional grazing and protected against ploughing for centuries, DRs combine grasslands with woody patches, hedgerows and other original vegetation types.

DRs exert important ecological effects at different spatial scales. These effects are critically linked to the maintenance of livestock movements. The progressive abandonment of transhumance has fostered invasions of DRs with crops, human built infrastructures, etc. Landscape fragmentation and isolation of Natura 2000 sites has been recognized as a major issue for conservation in Europe, and is threatening the relevant role of DRs as ecological corridors.

The general goal of LIFE CAÑADAS project is to build the scientific and practical steps to enhance the role of the Spanish network of drove roads that provides connectivity between Natura 2000 sites, by means of improving their conservation status and their associated ecosystem services, restoring their multi-functionality and assuring their adequate and sustainable management. The project will be developed at two spatial scales (Fig. 1). At the larger, national scale, we will focus on the “Cañada Real Conquense” a 75m-wide corridor that stretches along 410 km from the Sierra Morena (Jaén), to the Montes Universales (Teruel and Cuenca). At the regional scale we will focus on the network of the Autonomous Community of Madrid, which comprise 4,200km of DRs.

In this contribution, we present the LIFE CAÑADAS plan to restore the connectivity and functionality of selected DRs to enhance their role as biodiversity reservoirs and ecological corridors within and between Natura 2000 sites. Further, we propose to recover the traditional extensive livestock grazing of the DRs, preferably through transhumant flocks, in those areas where herbivore management is critical for maintaining the DR biodiversity and functionality.

Keywords: Biodiversity, Ecosystem functioning, Ecosystem services, Landscape, Restoration strategy/planning.

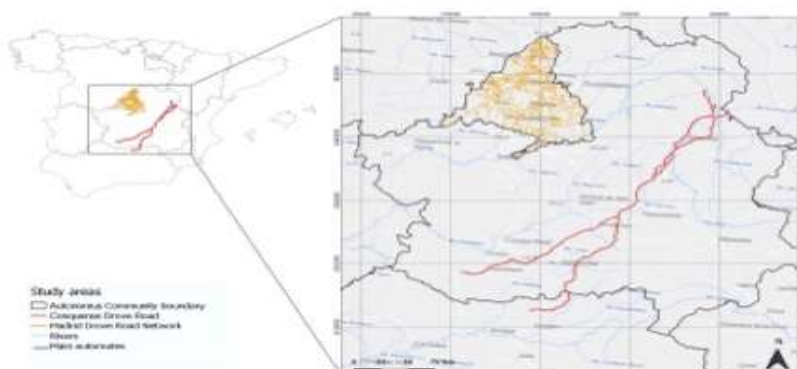


Fig. 1 Location of the study areas of the LIFE CAÑADAS project.

Lessons learned from a fluvial bioengineering work for improving water course connectivity and river biodiversity. Txarrota dam rehabilitation

Author(s): ¹Sangalli P.; ²Jugo J.; ¹Tardío G.

Affiliation(s): ¹Sangalli Coronel y Asociados S.L., Spain; ²Ikerlur S.L, Spain

E-mail: sangalli@sangallipaisaje.com

ABSTRACT

The “Txarrota” reservoir is located in the municipality of Zarátamo (Vizcaya) on the Txarrota stream, which flows into the Ibaizabal river. Txarrota is a gravity dam with a triangular profile with dimensions are 15 m high 72.5 meters length. The dam was built in the 60s to supply the neighbourhood. This dam, both in terms of its dimensions and its danger of flooding, in an eventual break, belongs to the highest category in terms of danger-(A). Currently, is no longer used for water supply and in March 2014 the dam loses almost all the water due to a break in its bottom valves.

Our team carried out an analysis of the possibilities and risks involved in the demolition, both from an environmental and a safety point of view. From recovery the river functionality, the total demolition of the dam was a priori the solution. However the characteristics of the small basin, the seasonality and circumstances of this stream (buried in most of its route) indicate that the environmental benefits should be very low, compared with the environmental cost that such demolition provokes in terms of rubble, elimination of accumulated sludge, acoustic pollution ..

We concluded that, from an environmental and safety point of view, the most convenient option was to maintain the wall of the dam, and our team present a proposal that guarantees safety, creates the smallest possible inconvenient and improves the environmental and landscape aspects making of the area an important point for biodiversity and for the approach to nature by the inhabitants of Zarátamo

The project was elaborated in 2015, the administrative authorizations in 2016 and the work finished mars 2017. We continue the work promoting the restoration of the basin and the change of a production forestry into a permanent forest.

Keywords: Ecological engineering; Rivers; Landscape architecture; Urban and periruban environments, Resilience

Fig. 1 Txarrota dam during the works and after six months



S21 - Soil restoration in dry environments: from farms to mines

Soil restoration in Mediterranean woody crops: best practices and best indicators

Author(s): Pilar Andrés¹, Enrique Doblas-Miranda¹, Stefania Mattana² Francesc Font³
Affiliation(s): ¹CREAF, Spain ²PLECO, Belgium ³AGROASSESSOR, Spain
E-mail: pilar.andres@creaf.uab.es

ABSTRACT

Most European agricultural soils are degraded (eroded, compacted, with low carbon and biodiversity levels) due to long-lasting intensive exploitation. Degradation must be counteracted to offset carbon emissions from agricultural landscapes and to maximize soil biological resilience to climate change. Sensitive indicators must be identified to quantify short-term progress towards recovery.

We have intensively sampled the soils of three vineyards (in Catalonia, Spain) that have been managed under contrasting strategies (intensive, regenerative and minimal intensity agriculture) during the last 4 years. We have processed our samples to assess 34 indicators. Some of these indicators were obtained from field or lab analyses (physical and chemical, microbiological and microfaunal indicators), while other were obtained by incubation of tea bags in field (mineralization capacity of the soil) or were simulated from the measured carbon biomass of every functional group of the soil food web (nitrogen mineralization, CO₂ emission from soil, C flow through mainly fungal or bacterial soil energetic pathways). These indicators show important difference in expertise requirement, economic cost, sensitivity and responsiveness to agricultural management.

Practically all our indicators showed the worst values under intensive management compared with regenerative or minimal impact management, which proves the high potential of these alternative agricultural strategies for soil restoration in Mediterranean woody crops.

Responsiveness to agricultural management was by far higher for the biological than for the physical and chemical indicators. Since biological indicators also are the most demanding in expertise, the most time-demanding and the most expensive, we propose here an effort-benefit framework to correctly assess soil restoration success.

Keywords: soils, croplands, biodiversity, indicators

Edaphic materials used in quarry restoration: effects on vegetation in the medium-long term

Author(s): Montse Jorba¹, Mercedes Medina¹, Antonio Edo¹

Affiliation(s): ¹BEECA, University of Barcelona, Spain

Email: montsejorba@ub.edu

ABSTRACT

The exploitation of mineral resources generates very altered spaces that must be restored according to the existing regulations.

The natural soil is stripped before exploitation but it is usually insufficient for the entire final surface to be restored. Spoils and earth from external excavations are used as "soils".

Spoils from the same quarry are used and have a high stoniness, a limited water reserve, with dominant macroporosity. Materials from external excavations are highly variable but may have a higher proportion of fine fractions, with dominant microporosity. These "edaphic materials" can determine the type of vegetation.

In February 2005, the same herbaceous species were sown in five limestone quarries, each one having a different "soil". Each "soil" had different physical and chemical characteristics. The pilot experiences were carried out on slopes (16-35°). In autumn 2005, the same woody species were planted in all the quarries.

Twelve years later, the vegetation developed is very different depending on the edaphic material used. In stony materials, a dense woody layer with little herbaceous cover has developed. In slightly stony materials, the herbaceous stratum dominates and the density of woody species is low.

However, the goal of the restoration programs of all these quarries is to obtain the same type of vegetation.

Keywords: soils, quarries restoration, vegetation

A Quorum Moment: Bridging the Practices of Ecological Restoration and Regenerative Agriculture

Author(s): Darren J. Doherty^{1,2}

Affiliation(s): ¹CPAg (AIA) ²Regrarians Ltd., Victoria, Australia

Email: djd@regrarians.org

ABSTRACT

A quorum of signals are being produced by all manner of biota with an appeal that they be sensed in order to restore and regenerate the biosphere's ecosystem process. With the diminution and isolation of disciplines, along with the rise and celebration of the 'human egosystem', the biosphere and its species are being deeply affected. The upside is largely running outside of orthodoxy with the 'integrationalists' and 'generalists' of the world now being sought out as the dilemma of ecological rationalisation is beginning to be feared as terminal. Integrating practices that have been separated as an outcome of rationalist thinking are emerging as a matter of course—reasoning at last that the solutions for biospheric restoration and regeneration are ecological and not reductive

Keywords: regenerative agriculture, soil restoration

The role of soil amendments and conditioners in restoring seasonally dry forests

Author(s): Arellano, E.^{1,3}; Talamilla, M.^{1,2}; Nouveou, M.^{1,2}; Rojas, N.^{1,2}

Affiliation(s): ¹Center of Applied Ecology and Sustainability, Chile; ²Facultad de Agronomía e Ingeniería Forestal, Pontificia Universidad Católica de Chile, Chile

E-mail: eduardoarellano@uc.cl

ABSTRACT

The Mediterranean Forest region of Central Chile are being seriously affected by severe drought and degradation. The use of organic amendment and conditioners in ecosystem restoration is an effective technique to recover vegetation and soil regeneration processes in degraded areas. Several cost-effective soil conditioning techniques that can decrease post-transplant stress have been proposed. The objective of this field study was to compare the effects of applying different conditioning techniques on physiological performance and survival of selected tree species and soil recovery. Three native coexistent Mediterranean tree species were selected: *Schinus polygamus*, *Lithraea caustic*, and *Quillaja saponaria*. These species were established under four treatments: control with no conditioning; soil mix from the area with a pile of stones that are placed on a PVC column, which is buried as a dry well; composted cattle manure; and SolidRain® 2 L superabsorbent hydrogel. Plant traits and soil physical, chemical and biological parameters were measured at the end of each growing season. At the end of second growing season, the three species had a significantly greater survival level in the hydrogel treatment group than in the other treatments. Soil organic matter, salinity and microbial activity was significantly greater in the composted cattle manure. In the short term, the addition of hydrogel can reduce plant water stress during the initial phase and contribute to improved survival of the species in degraded dry systems. However, in the long term the effectivity of soil amendment and conditioners on restoration process will depend on the capacity of the soil to recover its functionality.

Keywords: Mediterranean forest; Chile; soil indicators; soil amendments; drought

Responses of non-mutualistic diazotrophic microorganisms to fire occurrence in Mediterranean native forest soils

Author(s): Rojas, C.^{1,2}; Aponte, H.^{1,2}

Affiliation(s): ¹ *Laboratory of Soil Microbial Ecology and Biogeochemistry, Institute of Agri-food, Animal and Environmental Sciences (ICA3). Universidad de O'Higgins, 3070000 San Fernando. Chile;* ² *Center of Applied Ecology and Sustainability (CAPES). Chile*

E-mail: Claudia.rojas@uoh.cl

ABSTRACT

Fires have historically played an important role in the composition and distribution of terrestrial ecosystems. However, these events have also represented an important pressure that have induced land degradation worldwide, especially in regions with Mediterranean climates with dry summers and elevated temperatures. The negative effect of fires on soil properties is well recognized globally, and the greater sensitivity of soil biological properties to disturbances (compared to abiotic factors) is also established. Thus, understanding how microbial community structure and functioning recover after land burning is central to better comprehend ecological restoration processes and resilience of these fire-prompt ecosystems. This study aimed to evaluate prokaryotic community structure and diazotrophic populations in rhizosphere samples of herbaceous species and bulk soils from two fire-affected sclerophyll forests (one 33 and the other, 17 months after fire occurrences) in the Mediterranean climate zone of central Chile.

Molecular analyses based on qPCR and Illumina MiSeq of 16S rRNA coding genes reflected a legacy of fire occurrence regardless of time elapsed after land burning. This was evidenced by a reduction of gene copy numbers, a decrease in alpha diversity indexes, and alterations of relative abundance of several prokaryote taxa in burned soils when compared to their unburned counterparts. The latter comprised N-fixation related taxa, including *Rhizobiales*. Thus, current analyses based on molecular analyses and culture-based techniques focusing on diazotrophic microorganisms are being conducted to further understand the effect of forest fires in members of this functional group. These findings will allow to better understand microbial states over ecological succession following fires and potential resilience of prokaryote communities and diazotrophic populations at fire-prone ecosystems of central Chile.

Keywords: rhizosphere, N-fixing bacteria, sclerophyll forest, wildfires.

Fig. 1 Research sites consisting of sclerophyll forests located within the Mediterranean climate zone of Central Chile, in the Left, site affected in January of 2017, right site affected in May of 2018



W6 – Ecological Restoration

contributions to Disaster Risk Reduction,
Preparedness and Mitigation

Ecological Restoration contributions to Disaster Risk Reduction, Preparedness and Mitigation

Coordinator(s): Alfred de Jager (*European Commission, Joint Research Centre, JRC*)
Sara Pelaez Sanchez (*University of Limerick*),
Nina Nikolic (*University of Belgrade*)

ABSTRACT

We will focus on Ecological Restoration projects to reduce the risk of impact of extreme events such as riverine flooding, flash floods, mass movement of soils, droughts, forest fires and heatwaves.

We will first address various aspects and terminology of Disaster Risk Reduction in relation to climate heating, excessive agricultural production practices and adaptation to a hotter climate.

After setting this scope, we will focus on examples of historic disasters and measures to reduce the risk of impact based on typical grey or green interventions. Focus will be given on the complexity of disasters for example with disasters related to the mining industry or the various droughts that stroke Europe in the last ten years. Examples and lessons learned from projects financed by European funds will be given.

In order to activate governments or investors especially related to the insurance industry we will present and discuss various methods to quantify the economic costs of malfunctioning ecosystem services. We aim to have at least six presenters followed by a discussion panel comprising executive services of the European Commission.



posters



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(SEPTEMBER 7TH - 10TH 2021)

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A narrative of virtual and augmented reality in the forest sector

Author(s): [Laura Peedosaar](#)

Affiliation(s): *Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, Tartu, Estonia*

E-mail: laura.peedosaar@student.emu.ee

ABSTRACT

With the rapid development in data acquisition and presentation, there is a growing interest in virtual forests and computer visualization tools. Forest owners have become more aware about their property and are interested in applying different forest management methods and silvicultural techniques. The tools are also applicable in assessment of the changes to the landscape as a result of natural and anthropogenic disturbances. Virtual reality offers a good opportunity to test and compare different management options before implementing decisions which can lead to irreversible consequences. Advances in spatial and temporal data collection enable new and practical solutions for analysis and visualization of long-term natural processes with new forestry applications. In the near future, forest owners and managers will have the possibility to make management decisions without the direct need to exit the office. Furthermore, the learning process is more enthralling and also more profound through augmented reality, helping to foster better working practices even before starting a job in the forest sector.

Key words: computer simulations, virtual environment, data visualization, forestry.

Assessing drivers of plant mortality under extreme drought: a study case in the Mediterranean shrubland of south east Spain

Author(s): Samantha Ruiz-Yanetti*^{1,2}, Adrián Maturano¹, Àngela Manrique-Alba^{3,6}, Esteban Chirino⁴, Hassane Moutahir^{1,3}, Juan F. Bellot^{1,3}, and Alberto Vilagrosa^{1,5}

Affiliation(s): ¹ *University of Alicante, Department of Ecology, Apdo. 99, 03080 Alicante, Spain.*

² *Instituto de Ciencias Ambientales y Ecológicas (ICAE), Universidad de Los Andes, 05101, Mérida-Venezuela.*

³ *IMEM "Ramon Margalef", University of Alicante, Apdo. 99, 03080 Alicante, Spain.*

⁴ *Facultad de Ciencias Agropecuarias. Universidad Laica "Eloy Alfaro" de Manabí. Av. Circunvalación s/n.*

Manta. Manabí. Ecuador. ⁵ *Mediterranean Center for Environmental Studies (Foundation CEAM). Joint Research Unit University of Alicante – CEAM, Univ. Alicante, PO Box 99, 03080 Alicante, Spain*

⁶ *Estación Experimental Aula Dei (EEAD-CSIC), Zaragoza, Spain.*

Email: samanthayanetti@hotmail.com

ABSTRACT

The knowledge of how drought induces plant mortality is a key point for lead to successful ecological-restoration management, especially in water limited ecosystems, as Mediterranean drylands. Furthermore, global warming will decrease the incoming rainfall in the Mediterranean basin, leading to more, and more intense droughts in a region yet appointed as a climate change hot-spot. Patched spatial arrangement and heterogeneous composition are distinctive features of Mediterranean shrublands, the main vegetation community in transition areas from sub-humid to semiarid in Mediterranean drylands. In this study we assess the changes in structure and composition of four Mediterranean shrublands along a climatic gradient in SE Spain, after 2014's extreme drought. Our objectives were focused on analyzing differences in plant mortality among shrublands, and identifying the main drivers behind them. At each shrubland we sampled a pool of plant structure properties with vertical-stratified point intercept transects before and after 2014's drought, distinguishing dead plant tissues in the second sampling. We also measured soil properties, and monitored microclimate and soil moisture during two hydrological years (2013 and 2014). Results showed that vegetation cover reduction and dead load, derived from plant mortality, differed between sites and plant biotypes, with higher plant affectation in subshrubs of drier sites. Vegetation structure explained resistance to drought while soil properties and climatic conditions explained mortality under extreme drought conditions. More than 25% of shrubland cover reduction and more than 30% of dead load was found in dry-semiarid areas . These results point out the relevance of structure of vegetation in drylands under climatic adverse conditions and the needed of taking account criteria related with spatial arrangement and composition of vegetation, and soil surface properties for successful adaptative management and ecological restoration actions in water limited ecosystems.

Assessment of post-fire Erosion Barriers on vegetation recovery using RPAS and Time-Series NDVI Sentinel-2 Data

Author(s): Pérez-Cabello, F.¹; Baroja-Sáenz, C.¹; Montorio Llovería, R.¹; Angás Pajas, J.²

Affiliation(s): ¹Department of Geography and Spatial Management-Environmental Sciences Institute (IUCA), University of Zaragoza, Spain; ²School of Land Surveying, Geodesy and Mapping Engineering, Polytechnic University of Madrid, Spain

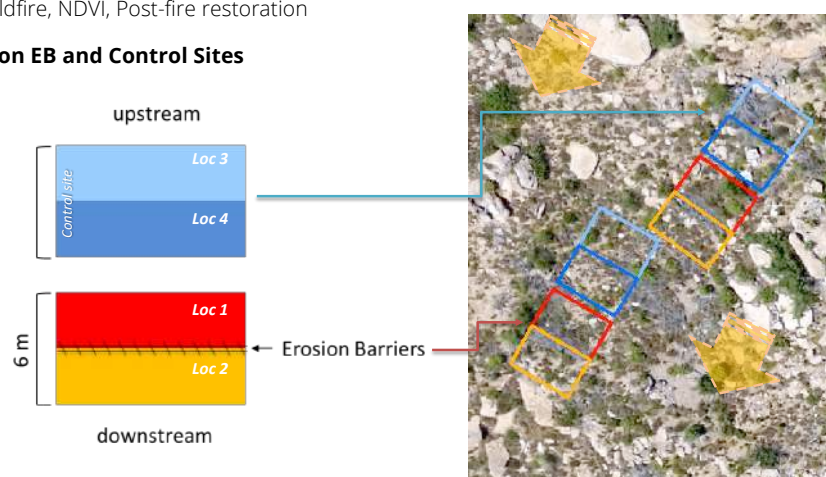
E-mail: fcabello@unizar.es

ABSTRACT

One of the most widely hydrological-forest restoration techniques applied in burned areas is the erosion barriers (EB). They constitute a type of post-fire action aimed to reduce erosion and sediments run-off into streams, rivers, etc., promoting vegetation recovery. However, in many cases, there is no precise spatial information on the effectiveness of such actions, so it seems necessary to verify, through operational methodologies, their effects on recovery. Unlike the extensive and labour-intensive field campaigns, remote sensing techniques are a time- and cost-effective way to monitor post-fire treatments. The objective of this work is to evaluate the effect of EB on post-fire vegetation recovery at two different temporal and spatial resolutions by means of (1) Remotely-Piloted Aircraft System platforms (RPAS) using imagery from a MicaSense RedEdge-MX camera and an RGB optical sensor for aerial photogrammetry (SODA) to achieve the NDVI and the height of the vegetation from a digital surface model (DSM), and (2) satellite imagery using time-series NDVI Sentinel-2 data (ESA) for monitoring four years after the wildfire. The study area corresponds to the Luna fire (Zaragoza -Spain) that took place in July 2015 and where EB were subsequently installed. A random sampling of paired observations is proposed in different plots: upstream and under burnt wood stacks, and in control sites, collecting NDVI values and height of vegetation. Regarding Sentinel imagery, 672 points per treatment (EB and No intervened areas -NI) were randomly selected. Upstream from EB, we found slightly higher NDVI values (0.45), and vegetation height averages lower than those collected in the control sites (~8 cm lower). Regarding the Sentinel-2 imagery, although NDVI distributions of the two treatments were different (p-value < 0.05), both shown very similar averages (~0.32) and positive trends over the 4 years.

Keywords: Evaluation and monitoring, wildfire, NDVI, Post-fire restoration

Fig. Scheme for measuring recovery on EB and Control Sites



Contribution of planted fields at a Lignite Center to climate change mitigation and atmospheric quality

Author(s): Radoglou K.¹, Markos N.¹, Kitikidou K.¹, Orfanoudakis M.¹, Milios E.¹, Xanthopoulos G.¹, Fotelli M.², Spyroglou G.², Papadopoulos C.³, Andreadou S.³, Sachanidis Ch.³, Manolopoulos D.³, Tziaferidis S. R.⁴

Affiliation(s): ¹ Department of Forestry and Management of Environment and Natural Resources, Democritus University of Thrace, N. Orestiada, Greece

² Forest Research Institute, Hellenic Agricultural Organization Dimitra, Thessaloniki, Greece

³ Public Power Corporation, Environmental Department, Greece

⁴ ena Investment Management, Xanthi, Greece

E-mail: kradoglo@fmenr.duth.gr

ABSTRACT

The COFORMIT research project assesses the contribution of tree plantations at restored areas to the mitigation of climate change and to the improvement of air quality. Forests and plantations, through photosynthesis, absorb and store CO₂, which is the main greenhouse gas in the atmosphere. Carbon is stored in the above and below-ground biomass, the dead wood, the litter and the soil. Furthermore, restoration plantations capture particulate matter (PM) produced by anthropogenic activities and, thus, contribute to the reduction of atmospheric pollution. The studied plantations were established after the end of the mining activity at the Lignite Center of Western Macedonia, at an area of about 2,000 hectares. The aims of the COFORMIT project are the estimation of (a) the carbon dioxide assimilation and storage from the plantations of this Lignite Center, both in long term and dynamic time periods and (b) the amount of PM particles that can be retained by these plantations. To this direction, a holistic approach is used that includes the estimation of the five carbon pools, the use of remote sensing (with the use of a field phenology camera and satellite images), eddy covariance and soil respiration methods, micrometeorological and analytical measurements for the estimation of canopy and soil CO₂ and H₂O fluxes, as well as of the retention of PM by the restoration plantations. This research has been co-financed by the European Union and Greek national funds through the Operational Program Competitiveness, Entrepreneurship, and Innovation, under the call RESEARCH- CREATE-INNOVATE (project: COFORMIT. T1EDK-02521).

Key words: Forest biomass, Carbon sequestration, *Robinia pseudoacacia*, Eddy covariance, PM pollution,



Challenges and successes of a private ecological restoration project in a degraded area of Chilean Patagonia

Author(s): Whitelaw, John¹; Sobakina, Elena.².

Affiliation(s): ¹PPA Pichimahuida, Chile/Australia; ²PPA Pichimahuida, Chile/Switzerland.

E-mail: elena@pichimahuida.info ; whitelaw.leones@gmail.com

ABSTRACT

Native ecosystems of Region XI of Chile were destroyed in the first half of XX century by deliberate fires and subsequent agriculture and mismanagement - a silenced massive ecological disaster. The loss of forest cover resulted in massive soil loss and ecosystem degradation.

Approx. 1800 ha of this destroyed land were assigned the status of a private protected area in 2006. A restoration project was initiated by managers who had experience of work in various environmental organisations.

The main focus and success is the native forest restoration. To date more than 250,000 native trees have been planted, with average certified survival rates of 85-90%. Nature based planting protocols have proven highly successful in re-establishing native tree species. Other achievements: successful erosion control, good natural regrowth, restoration of wetlands and return of wildlife and birdlife.

The challenges include, with regard to reforestation, shortage in or high price of appropriate native planting material. In order to solve this problem a seed reproduction facility is been set up. Other challenges are: protection from unsustainable tourism; control of invasive species; ingress of cattle; promotion of the understanding of the state of the degradation of the ecosystems of the region, etc. The funding of the project consists only of private funds, with the exception of a limited subsidy for reforestation.

Some resentment to land restoration is palpable in the culture of the settlers from the XX century. However, the success of the project has led to increasing interest among new landowners who see an urgent need to change the paradigm towards a restorative land management in order to prevent further ecological crises.

Legal science is commonly absent from the socio-political debate. The project is developing a legal scheme for securing long-term protection of the restored ecosystem, essential for private projects, and ensuring the recognition of the personhood of the ecosystem and its rights.

Fig. 1 Memory sign at the entrance of the Project



Development of soil microflora in reclaimed lands disturbed by copper mining

Author(s): Stefanova, V.¹, Petrov. P.¹

Affiliation(s): ¹*Universiti of forestry, Sofia, Bulgaria*

E-mail: venistefanova3@gmail.com

ABSTRACT

The amount and composition of the microflora was studied in 8 „humus-free“reclaimed sites disturbed as a result of copper mining in Bulgaria. The composition of the microflora is poor, with non-spore-forming bacteria predominating, which is a sign of the initial stages of formation of the microflora in the studied sites. The study shows that the depth of the studied layer, the type of vegetation and the materials used in the reclamation of the disturbed lands have a leading role in the composition and amount of the microflora.

Keywords: land reclamation, microflora, copper mining

Drained rae bog – forest experimental area in north Estonia

Author(s): *Katri Ots*

Affiliation(s): *Chair of Silviculture and Forest Ecology, Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, Tartu Estonia*

E-mail: *katri.ots@emu.ee*

ABSTRACT

The establishment of Rae experimental plantations (4.7 ha) was started in 1953, the main purpose of which was to find possibilities for afforestation of treeless bogs around Tallinn (capital city, North Estonia). The experimental area was drained in 1950. The thickness of the oligotrophic peat layer in the western part of Rae bog reached 6.8 m (the average is 5–6 m). Some of the experimental plots were fertilized in 1962–1973 repeatedly with NP-fertilizers; K-fertilizer was added on some plots and oil shale ash was used before afforestation (5–30 t ha⁻¹).

Cultivated tree species were Scots pine, Silver birch and Norway spruce. The purpose of establishing the experimental plots was to study factors that influence bog afforestation, such as the optimum distance between and depth of drainage ditches, proper methods of soil scarification, suitable main tree species and planting methods, initial plantation density and the effect of fertilization on tree growth, vegetation and on the process of soil formation.

Fertilization has the strongest effect on the growth of birches, a fairly strong effect on the growth of spruces and a weaker effect on the growth of pine trees. The combination of oil shale ash 20 t ha⁻¹ and NPK-fertilizer has a very good effect on the height growth of birches. The height growth of planted pines and spruces was better than the height growth of seeded trees. The application of oil shale ash 30 tons per hectare has a positive effect on the height growth of pines only for a short period.

The Environmental Investment Centre will be financing (Project No 16363) repeated measurements of the total network of experimental areas after 25 years. The objective of the project will be to evaluate the condition of planted tree species, stand productivity etc. based on data gathered during fieldwork.

Keywords: bog, afforestation, *Betula pendula*, *Pinus sylvestris*, *Picea abies*.

Effect of fire severity on the vertical structure of two forest ecosystems in Galicia

Author(s): Reyes, O.¹; Riveiro, S. F.¹; Cruz, O.¹

Affiliation(s): ¹Grupo BIOAPLIC. Área de Ecología. Departamento de Biología Funcional. Facultad de Biología. Universidad de Santiago de Compostela. 15782, Santiago de Compostela. España

E-mail: otilia.reyes@usc.es

ABSTRACT

Forest fires are one of the most serious and recurrent environmental problems in forest ecosystems on the planet. Fire has been present in the Mediterranean Basin since prehistoric times and, within this, the Northwest of the Iberian Peninsula is a hot fire zone.

The severity of the fire can make important differences in the ability of vegetation to regenerate naturally and is also an important factor to take into account when designing post-fire restoration actions. Vegetation recovery can be measured through different variables, with coverage being one of the most widely used. Changes in vertical coverage give us a quick and accurate picture of the impact of fire on the structure and functioning of ecosystems.

In this work we have analyzed and compared the effect of fire severity on the vertical structure of native forests dominated by *Quercus robur* L. and of *Eucalyptus globulus* Labill. plantations in an area affected by a large fire (around 10,000 ha burned) occurred in the province of Pontevedra in 2017.

We have detected large differences in the coverage of the different strata one year after the fire and we have also found large differences between the two ecosystems studied.

A general trend was observed towards the reduction of the highest strata and an increase in the lowest ones as the level of severity was higher and a greater reduction of the crown strata was also found in the eucalyptus forests than in the oaklands.

Funding: FIRESEVES (AGL2017-86075-C2-2-R) and WUIFIRECYL (LE005P20) projects and the Competitive Reference BIOAPLIC (ED431C2019/07) and the Strategic Researcher Cluster BioReDeS (ED431E 2018/09).

Keywords: cover, *Eucalyptus globulus*, fire severity, *Quercus robur*, vertical structure.

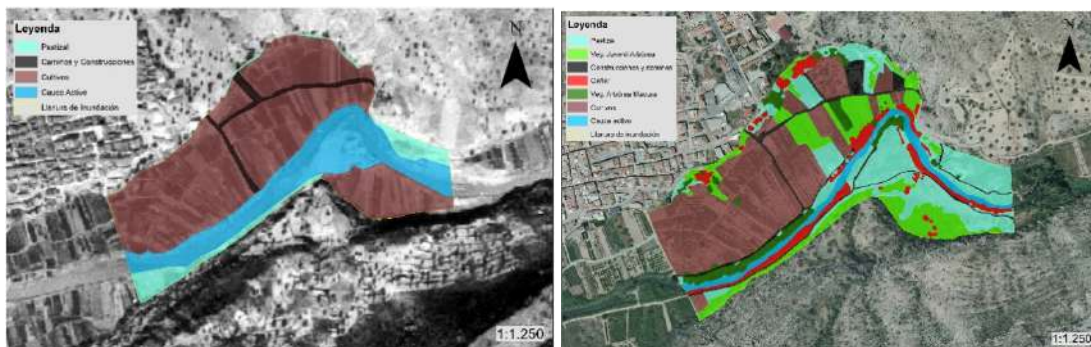
Evolution of the helophite and woody vegetation in two reaches of the Turia River

Author(s): Sánchez Murciano, María ; García de Jalón Lastra, Diego

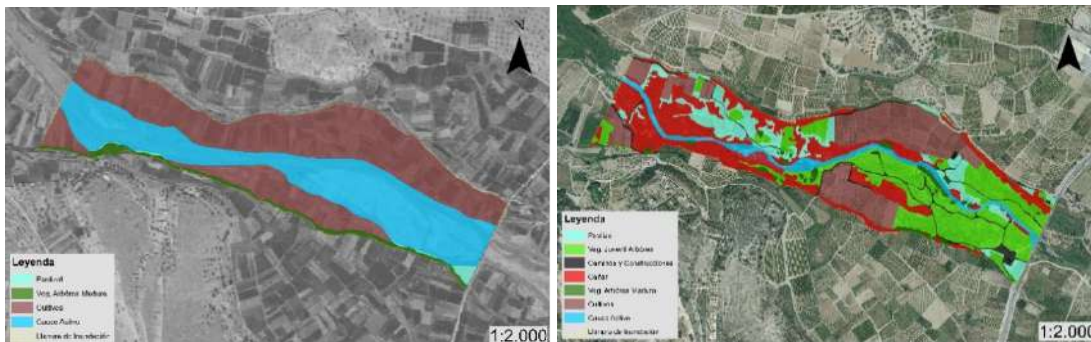
Affiliation(s): *Universidad Politécnica de Madrid; Universidad Politécnica de Madrid*

ABSTRACT

Arundo donax, river ecosystem, riparian forest, invasive alien species



Images 1 and 2: land cover maps of Bugarra site in the 1945 and 2015.



Images 3 and 4: land cover maps of Vilamarxant site in the 1945 and 2015.

Maps legend:

- Light blue: Grassland
- Dark blue: Riverbed
- Brown: Crops
- Black: Roads and Buildings
- Light green: Juvenile Tree Vegetation
- Dark green: Mature Tree Vegetation
- Red: Reed Bed

Fire severity and natural regeneration in *Quercus robur* woodlands versus *Eucalyptus globulus* plantations

Author(s): Cruz, O.¹; Riveiro, S. F.¹; Reyes, O.¹

Affiliation(s): ¹Grupo BIOAPLIC. Área de Ecología. Departamento de Biología Funcional. Facultad de Biología. Universidad de Santiago de Compostela. 15782, Santiago de Compostela. España

E-mail: oscar.cruz@usc.es

ABSTRACT

The effects that forest fires produce on plant communities largely depend on the level of severity reached by the fire and the type of plant community that burns. In the northwest of the Iberian Peninsula one of the most extensive climatic communities are the forests dominated by *Quercus robur* L., also called carballeiras, and among the most extensive productive forest systems are the *Eucalyptus globulus* Labill plantations. Also, in the northwest of the Iberian Peninsula the largest number of fires in Spain is concentrated and it is one of the regions of Europe with the highest incidence.

The objective of this work has been to evaluate the effect of the severity of the fire on the vegetal regeneration of carballeiras and eucalyptus forests through the cover values one year after fire.

For this, forest areas affected with different degrees of severity were delimited in the Pontecaldelas big fire of 2017. In both ecosystems, a distinction was made between zero severity (unburned parcels), low severity, medium severity and high severity. The selection of these areas was made based on satellite data. The cover of the soil variables (bare soil, litter, standing necromass and living vegetation) was measured at ground level and of the understory vegetation up to 2 m in height, recording the coverage of each of the woody species separately and the herbaceous as a whole.

We detected significant differences between the two ecosystems studied at the level of soil variables. The variable in which the greatest differences were observed is the bare soil. Undergrowth cover also varied depending on the level of severity; in general, cover tended to decrease with increasing severity.

Funding: FIRESEVES (AGL2017-86075-C2-2-R) and WUIFIRECYL (LE005P20) projects and the Competitive Reference BIOAPLIC (ED431C2019/07) and the Strategic Researcher Cluster BioReDeS (ED431E 2018/09).

Keywords: *Eucalyptus globulus*, fire severity, natural regeneration, *Quercus robur*, vegetation cover.

Habitat preferences of diurnal raptors in exotic Eucalyptus plantations under smallholder forestry

Author(s): Monteagudo, N.¹; Rebollo, S.^{1,2}; Higuera-Herrero, M.¹; Pataro, L.³; Fernández-Pereira, J. M.⁴; Pérez-Camacho, L.¹, and Rey-Benayas, J. M.^{1,2}

Affiliation(s): ¹Universidad de Alcalá, Forest Ecology and Restoration Group, Spain; ²Fundación Internacional para la Restauración de Ecosistemas, Spain; ³Universidad Autónoma de Madrid, Departamento de Botánica, Spain; ⁴Independent Assistant, Spain

E-mail: navilamonteagudo@gmail.com

ABSTRACT

The study of habitat preferences of a top predator guild can help analyse whether forest exploitation and biodiversity conservation are compatible, because top predators act as indicators of biodiversity. Moreover, this might allow to establish biological control strategies that use top predators as agents for pest regulation. The aim of this study is to determine nesting habitat preferences of three forest-dwelling diurnal raptors (northern goshawk *Accipiter gentilis*, Eurasian sparrowhawk *A. nisus* and common buzzard *Buteo buteo*) in *Eucalyptus* tree plantations in north-western Spain. We carried out a systematic sampling to characterize the surroundings of raptor nests and random points at different spatial scales. Habitat preferences associated to vegetation structure were detected mainly at the smallest scales (nest tree, nest site and nest stand). Spatial preferences were strongly affected by intraspecific competition and to a lesser extent by interspecific relationships. All species selected nest sites and nest stands with high *Eucalyptus* density, tree species richness, tree canopy cover and tree height. The studied plantations, with a unique forest management based on smallholder forestry (Fig 1), seem to provide suitable habitat for reproduction of these diurnal forest raptors and ultimately their preys. This smallholder management system makes possible to reconcile forest logging with the reproduction of avian top predators with conservation interest. Additionally, to enhance ecosystem services provided by raptors, it is necessary to consider the preferred nesting habitats of these beneficial species at a landscape scale.

Keywords: Forest, landscape, biodiversity, history and tradition, ecosystem services

Fig 1. Landscape in the study area (Morrazo Peninsula, north-western Spain). Forests are located in the higher areas while farmlands and urban centers are located in the lower areas.



Identifying in-stream habitat restoration hotspots in the Gilort River Natura 2000 site, Romania

Author(s): Tetelea, Cristian.¹; Giurea, Alexandru.¹;

Affiliation(s): ¹Invisible Nature, Romania

E-mail: cristiantetelea@invisiblenature.ro

ABSTRACT

A hierarchical geomorphic assessment of Gilort River was applied to identify potential restoration sites with the greatest benefits to improve a variety of habitats necessary to ensure a favourable conservation status for rheophilic fish species of European Union importance (*Eudontomyzon mariae*, *Barbus meridionalis*, *Gobio albipinnatus*, *Sabanejewia aurata*).

We performed a multi-scale field analysis of Gilort River in the Natura 2000 site as part of a Life Nature project ("Fish for Life" LIFE16NAT/RO/000778) aiming at improving hydromorphological conditions of the river and habitat heterogeneity for rheophilic fish species.

We assessed patterns and diversity (character and behaviour) of reach types found along 26 km of river in Natura 2000 site focusing on natural processes as driving force for the occurrence and maintenance of in-stream habitats. Longitudinal profile plots and total stream power were calculated for each 100 m river segments to understand the downstream patterns of the river and the controls that dictate the form and function of each river reach. River hydrology was determined especially concerning the magnitude and frequency important for creating and maintaining channel morphology and the type and distribution of in-stream habitats.

We evaluated the geomorphic condition for 14 river reaches and defined their fish habitat recovery potential. Geomorphic field mapping (e.g. in-channel and floodplain habitats) and data collection of a host of geomorphic information (e.g. cross-section survey, bed material texture, channel planform and geometry, pool spacing, large woody debris, bank erosion hazard, morphological quality indexes) was analysed in conjunction with riparian forest types and continuity, fish species richness and distribution, macroinvertebrate and water quality indices.

We synthesize the above into a prioritization of reaches styles with the identification of in-stream habitat that result in hotspots for multiple restoration benefits (species and natural processes). We rendered detailed site validation maps of in-stream habitats to depict details of restoration hotspots and use for communicating among stakeholders.

Keywords: rivers, restoration planning, biodiversity, ecosystem processes



Improving herbaceous species selection for restoration: multifactorial habitat modelling based on the plant database Anthos

Author(s): Aroca-Fernández M.J.¹; García-Centenera G.¹; Gastón A.¹; García-Viñas J.I.¹

Affiliation(s): ¹*ECOGESFOR, Universidad Politécnica de Madrid, Spain*

E-mail: pepa.aroca@gmail.com

ABSTRACT

Decision-support tools for the selection of species for restoration are much less developed for herbaceous species than for woody species. Further progress is still needed in order to provide objective methods that allow us to expand the list of herbaceous species commonly considered in restoration as well as to refine the selection of taxa compatible with the environment to be restored. The aim of this work was to propose a methodology for the development of habitat models for herbaceous species from easily accessible data. The starting data for the models were proposed to be: 1) species occurrence data in 10x10 km grids provided for Spain by the Anthos database (all cells without occurrence were considered pseudo-absences); 2) mean values of the main climatic variables for 1x1km pixel from WorldClim 2.1 database; 3) soil data provided by the European soil Data Centre. Models were constructed by penalized logistic regression for a total of 40 herbaceous species from different geographical areas and functional profiles. The results obtained indicated that: 1) more than 90% of the fitted models obtained a corrected AUC (Harrell, 2001) higher than 0.7 and more than 60% higher than 0.8; among them the best fits were for the species with the smallest distribution range in the Iberian Peninsula (stenoecious species), although hygrophilous species and microtherms also obtained models with a significantly higher discriminant capacity than the rest of the species. 2) the incorporation of the edaphic variables obtained from large-scale data into the models increased the mean AUC by only 0.023 points (3%). However, this contribution was significant in the models of the calcium carbonate tolerant species. The results obtained indicate that the proposed methodology can contribute to improve the information available for the selection of herbaceous species for restoration.

Keywords: restoration planning, ecological restoration, ecological engineering, biodiversity, art.

Isolation and characterization of plant growth promoting bacteria in the rhizosphere of *Pinus sylvestris* L.

Author(s): De Lara del Rey, I.A.; Pérez Fernández, M.

Affiliation(s): Área de Ecología, Facultad de Ciencias Experimentales, Universidad Pablo de Olavide, 41013 Seville, Spain

E-mail: iadedel@alu.upo.es

ABSTRACT

There is evidence that microbial activity affects ecosystems. The objective of this study was to isolate, identify and characterize edaphic bacteria from three different forest areas of *Pinus sylvestris* L. in Sierra Nevada. We chose three areas characterized by a pristine area; hollows produced by natural decay of adult individuals of *P. sylvestris*; and a regenerated area. Soil samples from the rhizosphere of plants of *P. sylvestris* collected in the three areas were analysed for their microbial content. Soil borne microorganisms were cultured in three selective growing media and then genetically identified. After DNA extraction and PCR amplification. The ability of the strains as plant growth promoters (PGPB) were identified in terms of production of indoleacetic acid, NH₃ and tolerance to variation in pH, (PGPB). A total of 667 strains were obtained and classified according to their growth time, colour and shape. 224 strains were collected in the pristine zone, 136 strains from zone with hollows and 317 from the regenerated area. Results indicated that in total, there were 96 different strains in five genera of PGPB (*Rhizobium*, *Anabaena*, *Bradyrhizobium*, *Fischerella*, *Stenotrophomonas*). Only 12 out of the 96 strains produce indole acetic acid in a concentration range of 0.46 to 0.5 µg IAA / µl of solution. Of these strains, 7 came from the pristine zone. Regarding the production of NH₃, there was 24% strains that produced it that came from the undisturbed area, 21% from restored soil and 15% produced by bacteria from the area with holes. The soils from the rhizosphere of *P. sylvestris* plants from the pristine zone showed greater richness, diversity and heterogeneity than the soils in which decay of this species is observed, what can be taken as indicator of the quality of the soil and the balanced relationships between plants and soil bacteria.

Keywords: Indoleacetic acid, Ammonia, Microorganisms, Bacteria, pH, PGPB.

LIFE *Nardus* & *Limosa*: Combining phosphorus removal with maintaining meadow bird populations

Author(s): Schelfhout, S.¹; Hendrix, J.²; De Schrijver, J.¹; Parmentier, G.¹; De Schrijver, A.³; Moeneclaey, I.¹; De Pauw, K.¹; Verheyen, K.¹; Mertens, J.¹

Affiliation(s): ¹Forest & Nature Lab, Department of Environment, Faculty of Bioscience Engineering, Ghent University, Belgium; ²Natuurpunt vzw, Belgium; ³Research Centre AgroFoodNature, HOGENT University of Applied Sciences and Arts, Belgium

E-mail: stephanie.schelfhout@ugent.be

ABSTRACT

We present the first results of the LIFE project *Nardus* & *Limosa* in Belgium to highlight the complex puzzle field managers have to lay for reaching multiple nature goals on former agricultural land. The project aims to combine two apparently conflicting objectives: (1) restoring species-rich *Nardus* grassland (H6230*) and (2) maintaining populations of meadow birds, such as Black-tailed godwit (*Limosa limosa*). Phosphorus-poor fields are rare opportunities on which restoration of *Nardus* grassland is easier to accomplish. In fields where soil phosphorus concentrations need to be depleted, the grassland restoration measures can (temporarily) negatively affect populations of meadow birds. In the coming years, we will compare the effectiveness of standard restoration measures to measures adjusted to safeguard the nests and foraging chicks.

Keywords: Ecological restoration, Grasslands, Biodiversity, Restoration strategy/planning, Soils



Fig. 1 Map showing soil sampling points (green: P-target reached or almost reached; yellow: P-target attainable by mowing; orange: P-target possible by P-mining; red: P-target not possible by mowing or P-mining, topsoil removal needed or choose a different target) based on soil phosphorus concentrations and calculations. Bird icons depict nesting Black-tailed godwits and curlews in 2019 and 2020.

Maintenance of *Leucanthemum vulgare* and *Achillea millefolium* in meadow sward in fifth year after oversowing

Author(s): Janicka, M.¹; Pawluśkiewicz, B.²

Affiliation(s): ¹Department of Agronomy, Faculty of Agriculture and Biology, Warsaw University of Life Sciences – SGGW, ul. Nowoursynowska 159, 02-776 Warsaw, Poland; ²Department of Environmental Improvement, Faculty of Civil and Environmental Engineering, Warsaw University of Life Sciences – SGGW, ul. Nowoursynowska 159, 02-776 Warsaw, Poland

E-mail: maria_janicka@sggw.pl

ABSTRACT

The conservation status of “Lowland hay meadows” (6510) in Poland shows that only about 20% of sites have the favourable status (FV). The main reason for this is reseeding with more productive grass species or abandonment of extensive management. A very simplified sward species composition and lack of representative species for this habitat were the inspiration to undertake research on the introduction of these species. The aim of this study is to assess the persistence of two species, typical for the Arrhenatherion meadow, in the fifth year after sowing: *Leucanthemum vulgare* and *Achillea millefolium*. The experiment was designed as a randomised complete block, with eight replications, on the plots of 2 m². In spring 2016 seeds were sown by hand, in broadcast manner, close to the centre of the plot, within an area of 0.5 x 0.5 m. In the sowing year two top-cuttings and one productive cut were made. In the following years the plots were mowed usually twice.

Fast and lasting effect was obtained after oversowing with *L. vulgare* – the species of early-flowering and early seed dispersal. The abundance of *A. millefolium* population increasing gradually during the following years. In 2017, it was 27.4% for *A. millefolium*, and 48.9% for *L. vulgare*. In 2020, the percentage of these species was smaller, but still significant. *A. millefolium* accounted for 13.5% and *L. vulgare* 11.8% of biomass. The level of soil coverage by plants of sown species and their height were correlated with the coverage by resident species. The dominant species were the tall grasses *Arrhenatherum elatius* and *Bromus inermis* (49-64% of biomass). The increasing in the species richness was observed, from 12-15 species in the first year to 27 species in the last year of the experiment. The maintenance of sown species in the sward is threatened by highly dispersing in adjacent areas: invasive alien species (*Solidago canadensis*, *S. gigantea*, *Erigeron annuus*), expansive nitrophilic species (*Urtica dioica*, *Cirsium arvense*, *Anthriscus sylvestris*) and nitrophilic ruderal species (*Artemisia vulgaris*, *Tanacetum vulgare*). Our studies have shown that by overseeding and systematic mowing, it is possible to increase the biodiversity of “Lowland hay meadows” (6510), improve their landscape and aesthetic functions, but maintaining the desired species composition requires mowing twice a year.

Keywords: Grasslands, Species reintroduction, Evaluation and monitoring, Biodiversity

Monitoring land degradation processes and restoration actions through remote sensing tools: the NewLife4Drylands project

Author(s): Carabassa Vicenç^{1,2}, Mazzetti Paolo³, Adamo Maria Patrizia³, Blonda Palma³, Petracchini Francesco³, Santoro Mattia³, Tarantino Cristina³, Tomassetti Laura³, Manakos Ioannis⁴, Calzolari Costanza⁵, Ugolini Francesca⁵, Ungaro Fabrizio⁵; Domingo Cristina¹, Masó Joan¹, Montero Pau¹, Georgiadis Christos⁶, Petrou Nikos⁶, Assennato Francesca⁷, Dantona Marco⁷, Di Leginio Marco⁷, Luise Anna⁷, Marinosci Ines⁷, Munafò Michele⁷, Smiraglia Daniela⁷, Cambria Vito Emanuele⁸, Vitale Marcello⁸, Baxevani Popi⁹, Damianakis Kostis⁹, Probonas Michalis⁹

Affiliation(s): ¹CREAF, Cerdanyola del Vallès 08193, Spain; ²Univ Autònoma Barcelona, Cerdanyola del Vallès 08193, Spain; ³CNR - Istituto sull'Inquinamento Atmosferico" (CNR-IIA, IT); ⁴Centre for Research and Technology - Hellas (CERTH, GR); ⁵CNR - Istituto per la BioEconomia (CNR-IBE, IT); ⁶Hellenic Society for the Protection of Nature (HSPN, GR); ⁷Istituto Superiore per la Protezione Ambientale" (ISPRA, IT); ⁸Università "La Sapienza" (SAPIENZA, IT); ⁹University of Crete" (UoC, GR)

E-mail: v.carabassa@creaf.uab.cat

ABSTRACT

NewLife4Drylands is a LIFE Preparatory Project co-funded by the European Union under the LIFE programme. It started on January 2021 and it will end in June 2023. NewLife4Drylands deals with the specific need set by the "Life-Environment" subprogram "Restoration of desertified land through nature-based solutions" to contrast the soil degradation leading to desertification by using NBS. NewLife4Drylands focuses on developing a protocol based on remote sensing techniques for the identification of a framework for achieving land degradation neutrality (LDN), combating desertification and for a mid and long-term monitoring of restoration interventions on desertified lands. The protocol will be an instrument for a clear, specific and costless assessment of the restoration process useful for further decision-making concerning restoration interventions. Six European areas (in Greece, Spain and Italy) affected by land degradation and desertification which either have NBS and restoration activities ongoing - implemented in the context of other LIFE+ or existing projects - or are candidate for restoration have been selected. Free high resolution time-series data from Landsat and the Copernicus Sentinel satellites at high temporal repetitiveness (every 16 or 5 days, respectively) combined with high spatial resolution (30 or up to 10 meters, respectively) will be investigated for monitoring processes at various spatial and temporal scales. The new hyperspectral satellite PRISMA data from the Italian Space Agency will be considered for information integration. The availability of ground reference data will be essential for calibration and validation of satellite imagery analysis.

Keywords: drylands and desertification, ecosystem services, Nature-based solutions, restoration monitoring, remote sensing

Network AgriPVplus - Linking restoration measures to crop production and solar power generation

Author(s): [Dullau, S.](#)¹; Meyer, M. H.¹; Dittmann, S.¹; Gottschalg, R.¹; Tischew, S.¹

Affiliation(s): ¹Anhalt University of Applied Sciences, 06366 Köthen, Germany

E-mail: sandra.dullau@hs-anhalt.de, maren.meyer@hs-anhalt.de, sebastian.dittmann@hs-anhalt.de, ralph.gottschalg@hs-anhalt.de, sabine.tischew@hs-anhalt.de

ABSTRACT

Agrioltaic (Agri-PV) involves the use of agriculture land to produce food and generate solar energy simultaneously. Such dual used systems have been developed in recent years. So far, however, their potential to contribute to biodiversity and ecosystem services restoration has been rarely discussed. We will present an innovative triple use approach, the AgriPVplus system, that combines crop production, solar energy generation, and restoration of biodiversity. This approach enables to, e.g., improve species diversity in intensively used agricultural areas or the restoration of degraded soil, resolves land-use conflicts, and foster socioeconomic benefits.

Within the project NetPV-Land, funded by the German Federal Ministry of Education and Research, the Anhalt University of Applied Sciences will establish a European cross-sectoral network aiming to raise the awareness of innovative AgriPVplus approaches, demonstrating its potential for restoration, and providing an online platform for the development of international activities.

The network AgriPVplus will:

- build an interdisciplinary research group of ecologists, photovoltaic engineers and agricultural scientists;
- form a cross-sector collaboration between science, the solar industry, farmers, and relevant stakeholders;
- develop joint projects of European-wide relevance;
- demonstrate the application of well tested restoration methods for the triple use approach of Agri-PV systems and research of its effects and synergies;
- support the EU Restoration Agenda of the EU 2030 Biodiversity Strategy and the EU's 2050 climate neutrality goal.

Keywords: integrated restoration, biodiversity, synergy, photovoltaic, agriculture

Restoration strategies in boreal forests: Differing field and ground layer response to ecological restoration by burning and gap cutting

Author(s): *Espinosa del Alba, C.*¹; *Hjältén, J.*²; *Sjögren, J.*³

Affiliation(s): ¹²³*Swedish University of Agricultural Sciences, Sweden*

E-mail: clara.esdal@hotmail.es

ABSTRACT

The boreal biome is one of the largest and its forests have been widely exploited for centuries. Consequently, large areas have suffered ecological simplification and loss of biodiversity. Under the current circumstances passive conservation measures are no longer enough and active restoration techniques need to be developed and assessed. We evaluated short- and long-term effects of two restoration methods aimed at mimicking natural disturbances affecting vascular plants (field layer) and bryophytes (ground layer). The experiment consisted of 18 forest stands in northern Sweden; each assigned to a different treatment: prescribed burning, gap cutting and untreated stands left as controls. A before-after control-impact study design was applied and data was collected once prior to restoration (2010) and twice post restoration; one year (2012) and eight years after (2019). We analysed the differences in species richness and Shannon Diversity with linear mixed effect models and community composition changes with multivariate methods. Fire treatment caused an initial decline in diversity for both layers, but in the long-term, field layer surpassed the species richness and Shannon Diversity values found prior to restoration. Ground layer bryophytes species richness and Shannon Diversity remained lower than pre-treatment. Prescribed burning should, therefore, be used with caution in core areas for bryophyte diversity. Community composition in burned stands differed significantly between each time point as well as when compared to other treatments, for both layers. By contrast, we found no significant differences in diversity measures or community composition after gap cutting. The absence of effects from gap cutting suggests that minor changes in canopy cover does not affect the vegetation structure of forest stands. The organism group-specific responses, and temporal variability to restoration, highlight the importance of including more than one organism group, different restoration methodologies, and long-term studies in order to properly assess restoration outcomes at landscape level.

Keywords: biodiversity, forests/woodlands, restoration strategy/planning

Restoring habitat diversity in intensively-farmed agricultural landscape. Results of LIFE Ostrovné lúky, Slovakia

Author(s): Brossmannová, A.¹; Filagová, Ž.²; Kúdela, M.³,

Affiliation(s): ^{1,2}BROZ-Association for nature conservation and sustainable development, Slovakia;

³Komenius university – Faculty of Natural Sciences, Slovakia

E-mail: brossmannova@broz.sk

ABSTRACT

The objective of project LIFE Protection of Birds in SPA Ostrovné lúky (LIFE12 NAT/SK/001155) was the restoration of habitats of Annex I species of The Birds Directive – Lesser Grey Shrike (*Lanius minor*), Tawny Pipit (*Anthus campestris*) and Red-footed Falcon (*Falco vespertinus*) in SPA Ostrovné lúky. The Natura 2000 Special Protected Area (SPA) lies in a region which has in the past 50 years been drastically transformed by intensifying agriculture. In fact, Slovakia has the largest monoculture fields in the EU and the largest monoculture blocks can be found directly in SPA Ostrovné lúky (SPA Ostrovné lúky average: 18ha, EU average: 4 ha). Today, agricultural land covers 95% of the SPA and only 0,66% is covered by grasslands. By comparison, in 1865 the ratio was 63% of grasslands to 25% of fields. Grasslands are the dominant feeding habitat of the target species, therefore this drastic loss of habitat has led to a dramatic decrease in bird species in the area and to several local extinctions including the target species *Falco vespertinus* and *Anthus campestris*. Our project was aimed at increasing the availability of habitats for these species through several key activities: restoration of lowland meadows, restoration of pastures, restoration of small-scale wetlands, restoration of biocorridors, re-introduction of traditional willow pollarding and increasing the availability of nesting and perching sites. We achieved a two-fold increase in grassland cover (100 hectares of grasslands restored), restored 60 small-scale wetlands, 17 km of biocorridors (tree-lines and flowering belts), pollarded 500 old pollard willows and installed 530 nesting boxes and nesting perches. Monitoring has shown that the population trend of target species *Lanius minor* in the area is increasing (3-4 pairs in 2012 to 9 pairs in 2019). Future monitoring will show the effect of restoration activities on *Falco vespertinus* and *Anthus campestris*.

Keywords: Grasslands, Peatlands/wetlands, Biodiversity, Croplands, History and tradition

Role of fire recurrence and severity in the specific composition and diversity of species in a *Pinus pinaster* forest

Author(s): Riveiro, S. E.¹; Cruz, O.¹; Reyes, O.¹

Affiliation(s): ¹Grupo BIOAPLIC. Área de Ecoloxía. Departamento de Biología Funcional. Facultade de Biología. Universidade de Santiago de Compostela. 15782, Santiago de Compostela. España

E-mail: sheila.riveiro@usc.es

ABSTRACT

Forest fires produce great changes in plant communities, affecting their composition and diversity. The recurrence and severity of the fire can play a relevant role in these changes. In this study, the composition and diversity of the Monte Pindo forest were analyzed after the big fire of September 2013. The field work consisted of identifying the plant species present in plots subjected to different scenarios of recurrence and severity of fires. Composition and diversity were calculated in 40 plots corresponding to 4 fire scenarios from frequency data. Composition data reveal the abundance of resprouting species, which could be related to a high frequency of fires throughout the history of Mount Pindo. Regarding the diversity indices analyzed (specific richness and Shannon diversity at alpha, beta and gamma level), no significant differences were found between the 4 recurrence and severity scenarios.

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Keywords: fire recurrence, fire severity, *Pinus pinaster*, specific composition, species diversity.

Safeguarding success: exploring community engagement strategies that support long-term restoration success in European wetlands

Author(s): [Stijn den Haan](#)^{1,2}, Laszlo Pinter^{2,3}

Affiliation(s): ¹*International Institute for Industrial Environmental Economics (IIIEE), Lund University, Lund, Sweden*

²*Department of Environmental Sciences and Policy, Central European University, Vienna, Austria*

³*International Institute for Sustainable Development (IISD), Winnipeg MB, Canada*

E-mail: Stijn.denhaan@mespom.eu

ABSTRACT

European wetlands are highly valuable ecosystems, and their rapid decline renders them a priority for ecosystem restoration efforts. Although successful ecosystem restoration requires the engagement of local communities, little is known about effective community engagement strategies in European wetland restoration projects. By interviewing restoration practitioners, this research explored community engagement strategies used by nine successfully completed EU LIFE-funded wetland restoration projects across eight European countries.

Interviews were analysed using qualitative content analysis, guided by a literature-based interdisciplinary set of community engagement principles. The analysis led to the formation of a new conceptual framework for community engagement in European wetland restoration projects, which groups the identified community engagement strategies into six themes: (i) **connect** with the local community by creating networks, partnerships, personal relationships, ensuring visible leadership, and early and broad stakeholder involvement; (ii) **empower** the local community by creating a common vision, creating structures for representation and participation, managing power dynamics, and facilitating bottom-up initiatives; (iii) **learn** from and **teach** to the local community by adapting to the local context, exchanging knowledge, and building capacity and resources; (iv) **integrate** restoration activities into the local community by creating locally relevant benefits and local events; (v) **demonstrate** the success of restoration activities and use focal species for restoration; and (vi) **persist** in the local community by creating successor projects and committing to long-term collaboration with the local community.

Moreover, using the perspectives of restoration practitioners, this research identified the community engagement strategies which were considered most important in supporting the long-term success of European wetland restoration projects. Using theoretical underpinnings, these may build resilience in the social-ecological wetland systems. Overall, these findings may guide practitioners and policymakers to enhance the long-term success of future wetland restoration efforts in Europe and possibly beyond, for the benefit of the planet and its people.

Keywords: Wetlands, ecosystem restoration, community engagement, EU LIFE

Single treatment of invasive *Asclepias syriaca* is not enough: lesson from a long-term succession study site

Author(s): [Csecserits, A.](#)¹, Berki, B.², Botta-Dukát, Z.¹, Kövendi-Jakó, A.¹, Mártonffy, A.², Rédei, T.¹, Szitár, K.¹, Halassy, M.¹

Affiliation(s): ¹Centre for Ecological Research, Institute of Ecology and Botany, Hungary, ²Eötvös Loránd University, Hungary

E-mail: csecserits.aniko@ecolres.hu

ABSTRACT

Invasive alien species are one of the main threatening factor to biodiversity. Their spread endangers not only primary habitats, but also secondary, spontaneously regenerating habitats.

There are many abandoned agricultural fields in Hungary, where spontaneous regeneration has started, but it is in some cases hampered by invasive plant species. We started a monitoring program of old-fields in a calcareous sandy region of Central Hungary, called Kiskunság, in 2000. In 2015 the local nature conservancy used an herbicide treatment to control the spread of the invasive clonal herb, common milkweed (*Asclepias syriaca* L.) on half of the studied old-fields. We studied the long term changes (1) in the cover of invasive species and (2) of habitat specialist (target) and generalist (non-target) plant species between 2000 and 2020. We used 40 permanent plots in 4 m x 4 m size to monitor the vegetation. We used linear mixed effect models, where the monitoring year, time since abandonment and treatment were the explanatory variables, the site identity the random factor and response variables were the cover of invasive species, specialist and generalist species.

The cover of milkweed increased in the first decade of monitoring, then in the first year after the herbicide treatment it was significantly lower, however five years after the management it reached pre-treatment level again. The cover of specialist species increased during the succession, but this increase stopped at the time of treatment and it did not continue thereafter.

We conclude that the perennial invasive species, milkweed could regenerate after a single chemical management. On the other hand, the specialist species could not spread during the short time decrease of invasive species. Thus we think that complex management - e.g. regular cutting, propagule intake - is needed to lower the cover of invasive species and restore the target vegetation.

Keywords: biodiversity, grasslands, invasive species, evaluation and monitoring,

Social acceptance of the use of reclaimed water for agricultural irrigation

Author(s): Mañas, P.¹; De las Heras, J.²

Affiliation(s): ^{1, 2} Higher Technical School of Agricultural and Forestry Engineering-Albacete. University of Castilla-La Mancha, Spain

E-mail: mariap.manas@uclm.es¹; Jorge.heras@uclm.es²

ABSTRACT

Wastewater resource recovery will need to overcome a range of constraints to achieve a high rate of return but success would significantly advance progress against the Sustainable Development Goals and others, including adaptation to climate change, 'net-zero' energy processes, and a green, circular economy. In agriculture, the volume of water potentially recoverable from wastewater could irrigate up to 31 million hectares. World wastewater production is expected to reach 470 billion m³ by 2030, the year by which the SDGs are supposed to be met. Agricultural irrigation with reclaimed wastewater is presented to the Society as a water resource still unknown by most of the stakeholders.

Our study has tried to find out the situation of agricultural irrigation with reclaimed water from a social and economic standpoint. A first study of social perception regarding the use of reclaimed water for irrigation by conducting surveys has been carried out.

The use of reclaimed wastewater it is an alternative solution to the shortage of water for irrigation and, both farmers and Public Administration, would be willing to explore the available options provided that information regarding its use, quality controls, is encouraged, etc, as well as to facilitate the bureaucratic procedures for obtaining permits. From the surveys carried out, it is perceived that there is unanimity regarding the fundamental measures that should be adopted to promote the use of residual water for irrigation, which are:

- Increase information.
- Improve the quality of treated water and
- Facilitate the administrative process.

The use of treated wastewater in irrigation in a safe and controlled manner is a viable option for the sustainable development of agriculture, also complying with the European objectives of Circular Economy.

Keywords: Croplands, Governance and Policy, Sustainable Development Goals (SDGs), Climate change.

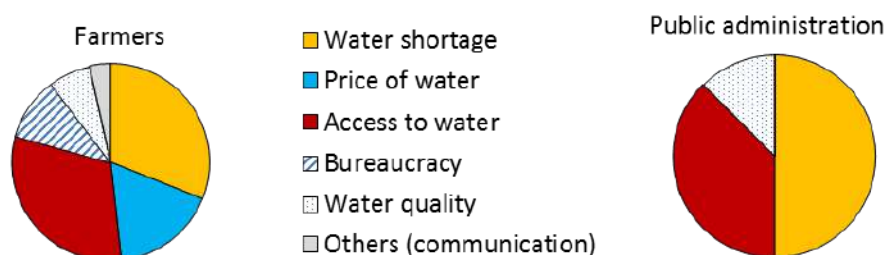


Fig. 1: Problems that affect irrigation practices

The population of *Lagochilus wedenskyi* changes by global warming in the Kyzyl-Kum desert, Uzbekistan

Author(s): Akhmedov, Akbar ; Shomurodov, Habibullo; Nomozova, Zebuniso

Affiliation(s): *SamSU, Uzbekistan; Institute of Botany, uzbekistan; SamSU, Uzbekistan*

E-mail:

ABSTRACT

Global warming-related changes in climatic conditions, these developments have affected the vegetation cover of Uzbekistan and the Ineffective use of plant resources for human welfare has resulted in the loss of plant biodiversity worldwide. In parallel, desertification is going due to global climate change and the number of endangered species has increased. In combination with the number of Red List plant species having almost doubled in the last 30 years: from 163 at 1984 to 324 at present.

The study was conducted in South-West part (Kuljiktai) of Kyzyl-Kum desert. The average elevation is 500-600 m a.s.l. The climate of the area is quite similar to other desert zones of Uzbekistan which are characterized by low annual rainfall (60 mm) and high air temperature (average 31°C and maximum temperature 46°C). Soil cover is represented by diverse types, but the prevailing ones are grey-brown with different levels of salinization. *Lagochilus wedenskyi* is an endemic species to the Kyzyl-Kum desert and is under high global warming and human pressure. The overall goal of this research is to assess the status of *L. wedenskyi* in the wild. We estimated the vegetation cover and described the environmental condition of *L. wedenskyi* and as well as analyzed meteorological data for this study area.

This result showed that populations of *L. wedenskyi* in their native range are affected by climate conditions, lack of water, stomatal regulation at high CO₂ and eroded soil. The future of *L. wedenskyi* is unclear due to multiple anthropogenic threats. This includes direct threats, such as grazing, and indirect threats, such as climate change.

In conclusion, these results indicated that species might in the near future become extinct in the wild. That's why for restoration we created a seed bank of *L. wedenskyi*.

The re-vegetation of wood ash and oil shale ash treated Puhatu cutaway peatland in NE Estonia

Author(s): Ots, Katri ; Tullus, Tea; Tilk, Mari

Affiliation(s): *Estonian University of Life Sciences; Estonian University of Life Sciences; Tallinn Botanic Garden*

E-mail:

ABSTRACT

Abandoned peatlands may stay non-vegetated for years after peat extraction because the original vegetation has been destroyed and the chemical conditions of residual peat for the germination of seeds and growth of plants are unfavourable. Re-vegetation of cutaway peatlands depends from different factors: size of abandoned fields, microtopography, water regime and time since the last peat harvesting, moisture conditions, the depth of residual peat, and/or specific residual peat chemistry, wind erosion, frost heaving, viable diaspores in peat etc.

The main objectives of study was observe the effect of wood and oil shale ash application on the biomass formation, coverage, composition and richness of vascular plants cover on the Puhatu cutaway peatland. Wood ash and/or oil shale ash (0.8–1.8 kg ash per square) were applied manually in June 2011. The experimental field consisted of five blocks (each divided into three plots of size 10 m × 20 m). An inventory of vascular plant layers was made in summer of 2016, 2017 and 2019.

The results showed that the re-vegetation process was significantly accelerated by ash application: especially after wood ash treatment (15 t ha⁻¹), eight years after the treatment vegetation was still absent from the unfertilized reference area. Altogether, 23 vascular plant species and the average cover 3.3–58.8% were recorded in the treatment areas, including a protected species *Epipactis palustris*. The fertilization with wood ash (15 t ha⁻¹) and a mixture of wood ash (10 t ha⁻¹) and oil shale ash (8 t ha⁻¹) has ensured rapid formation of ground vegetation on Puhatu cutaway peatland, the total dry mass of plants formed 361 g m⁻² and 420 g m⁻², respectively.

The restoration of native forests improves the connectivity of the green infrastructure in the urdaibai biosphere reserve

Author(s): Lorena Peña*, Ibone Ametzaga-Arregi, Beatriz Fernández de Manuel, Unai Ortega

Affiliation(s): *Department of Plant Biology and Ecology. University of the Basque Country (UPV/EHU). P.O. Box 644, 48080 Bilbao, Spain.*

* *Corresponding author. Tel.: +34 94 6015376*

E-mail: lorena.pena@ehu.eus

ABSTRACT

In the last century, the changes in the landscape have been drastic, with an increase in artificialization, a decrease in the surface of natural areas and an increase in the fragmentation of the landscape. In the case of the Basque Country, these changes have been evident throughout the territory, including in the Urdaibai Biosphere Reserve (UBR), where fast-growing forest plantations are the predominant vegetation, while the Atlantic mixed forest (potential vegetation) has been relegated to a few small patches distributed throughout the UBR. To reverse this situation, different actions to restore native forests are being carried out by the LURGAIA Foundation, which manages some 200 ha of land in custody in the UBR. The objective of this study is to analyze the connectivity of these areas under restoration for the movement of different fauna species, as well as to incorporate them into a Green Infrastructure proposal (GI). For this, the multifunctional areas that provide multiple ecosystem services (ES) were identified by mapping seven regulation services and their overlap. Subsequently, these areas were connected using two different criteria, one through ecological corridors and the other based on ES. The connectivity analysis was carried out using the Linkage mapper program, with which the least-cost routes and bottlenecks were identified. The results indicated that the restoration of native forests improve the connectivity of the GI and that it is necessary to continue regenerating more areas where ES supply is lower to improve connectivity in the UBR. The data provided in this study are useful for the foundation to prioritize those areas that are the most suitable to carry out custody within the RBU.

The use of excavation earth in quarry restoration: can it favor biodiversity?

Author(s): Jorba, M.¹, Samper, I.², Gasion, J.², Bracho, C.¹, Salvado, H.¹, Brotons, J.¹, Pujade, J.¹

Affiliation(s): ¹ *Universitat de Barcelona, Facultat de Biologia, Diagonal 643 08028 Barcelona*; ² *Gestora de Runes de la Construcció S.A., Nàpols, 222-224, baixos 08013 Barcelona*

E-mail: montsejorba@ub.edu

ABSTRACT

Construction activities generate excavation materials that must be managed. In Catalonia, the “Gestora de Runes” (GRC’s) carries out this management by looking for points where materials are generated and areas where they can be deposited. In many cases, the excavated soils can be used in the quarry restoration.

Quarries scar the landscape and create heavily altered spaces that must be restored. The use of excavated soils to fill mining voids can be a good solution. However, these soils usually have a powerful seed bank that determines the type of vegetation that is established, mostly dominated by herbaceous. This may seem like a malfunction in forest settings. Our study highlights the role of this vegetation as a source of biodiversity in homogeneous forest landscapes. The study has been carried out in a 10 ha quarry restored with excavated soils from different sites, located in Gavà (Barcelona). Initially, the dominant spontaneous plants were *Chenopodium album*, *Beta vulgaris* and *Amaranthus* sp. A few years later, *Anacyclus valentinus*, *Sinapis arvensis*, *Piptatherum miliacea*, *Asphodelus fistulosus*, *Galactites tomentosa* dominate, with a less represented mosaic of *Medicago sativa* and *Cynodon dactylon* from the sowings.

This plant composition attracts certain bird communities and a wide range of insects. Filling the quarries with excavated soils solves two problems at the same time, if the repercussions in the environment where they are carried out are taken into account. The example of restoration presented could be considered a failure if we want to return to the pre-initial period of the quarry. However, the herbaceous vegetation obtained favor populations of birds and insects, increasing biodiversity in the forest environment of the quarry. Using excavated soils can be an alternative to create mosaics of habitats in continuous landscape matrices and quarries

Keywords: quarry restoration, excavated soils, biodiversity, fauna

Trees from the fog: restoring degraded landscapes using fog capture ecotechnologies

Author(s): Carabassa, Vicenç^{1,2*}; Oliva, Saúl⁸; Domene, Xavier^{1,2}; Brandon, Rainero³; González, Francisco³; Regalado, Carlos⁴; Ritter, Axel⁵; Arencibia, María Teresa⁵; Martel, Gilberto⁶; Mota, Andre⁷; Viera, Gustavo⁸

Affiliation(s): ¹CREAF, Cerdanyola del Vallès 08193, Spain; ²Univ Autònoma Barcelona, Cerdanyola del Vallès 08193, Spain; ³Consejería de Medio Ambiente. Cabildo de Gran Canaria. Agustín Millares Carló 14, 1 35003 Las Palmas de Gran Canaria. Spain; ⁴Instituto Canario de Investigaciones Agrarias (Canarian Crop Research Institute). Spain; ⁵Universidad de La Laguna. Spain; ⁶Instituto Tecnológico de Canarias, S.A. Spain; ⁷Comuniade Intermunicipal Viseu Dão Lafões. Portugal; ⁸Gestión y Planeamiento Territorial y Medioambiental. Gobierno de Canarias Fco. Gourié 107, 35002 Las Palmas de Gran Canaria. Spain

E-mail: v.carabassa@creaf.uab.cat

ABSTRACT

The impacts of climate change are becoming increasingly perceptible and severe. Many semi-arid regions are suffering significant declines in water availability and temperature increases. This has led to faster desertification and more forest fires. It is necessary to implement adaptation measures aimed at reducing the vulnerability of these ecosystems and strengthening their resilience. LIFE Nieblas aims to evaluate the mitigation of the different impacts and effects of climate change by testing innovative methodologies of reforestation. These innovative methodologies, based on the collection of fog water for watering the planted seedlings on restoration projects, do not significantly increase the carbon footprint, and in some cases, it could even reduce it compared with the traditional methodologies. Their effectiveness and their costs and benefits, including as far as possible the externalities they produce, will be taken into account.

The main goals of the project are:

- Demonstrate and disseminate the effectiveness, efficiency and capacity of the innovative methodologies and the equipment linked to them in contrast to traditional methodologies.
- Create synergies between the results of the Project and reforestation, environmental, agrarian, and energy and water management sectors and policies in the EU.

Keywords: biodiversity, climate change, drylands and desertification, ecosystem services, planting techniques

Urban grasslands experiment: effects of soil and mowing regime on biodiversity and amenity value

Author(s): De Vrieze, E.¹; Schelfhout, S.¹; DeCock, E.¹; Moeneclaeys, I.¹; Vanhellemont, M.²; Baeten, L.¹; Mertens, J.¹

Affiliation(s): ¹Forest & Nature Lab, Department of Environment, Faculty of Bioscience Engineering, Ghent University, Belgium; ²Research Centre AgroFoodNature, HOGENT University of Applied Sciences and Arts, Belgium

E-mail: ellen.devrieze@ugent.be

ABSTRACT

Biodiversity is declining faster than at any time in human history. Increasing urbanization induces habitat loss and fragmentation, causing deterioration of natural ecosystems and biodiversity. The region of Flanders, situated in the northern part of Belgium, is among the regions with the highest degree of urban sprawl in Europe. Thus, it is crucial to tackle biodiversity-loss caused by urbanization not only by diminishing the negative influences but also by seizing the given opportunities. Creating species rich grasslands in urban environment can provide food and shelter for insects, reduce management costs and can increase the amenity value of the city. However, little is known concerning the creation and management of these novel, urban grasslands. Due to the urban microclimate, the high soil heterogeneity and recreational pressure, the direct translation of measures concerning grassland creation and management in natural and semi-natural environment is not advisable.

In this research, we aim to formulate concrete measures for the creation and management of species-rich grasslands in urban environment, taken the amenity value, management and biodiversity value into account. We will set up an experiment in the city of Ghent, Belgium (figure 1) where we introduce a seed mixture consisting of a broad range of species. The introduction of species is constant across all treatments. We will look at the effect of contrasting abiotic starting situations combined with different management practices on plant species richness, potential associated biodiversity, productivity and aesthetic value.

Keywords: Ecological restoration, Grasslands, Biodiversity, Soils, Urban and periruban environments

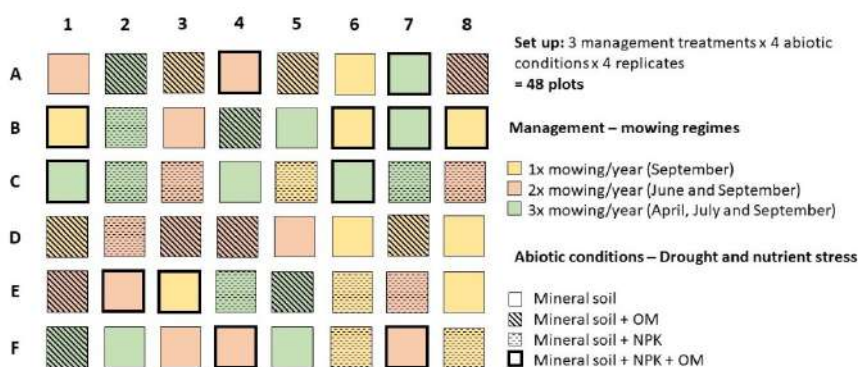


Figure 1: Set up of the experiment: combination of 4 abiotic starting conditions and 3 mowing regimes randomized across the parcel. OM = organic material, NPK = nutrients. The addition of OM enhances the water retention ability of the soil, increasing drought tolerance of the plants.



*Technical Secretariat
ALO CONGRESS, S.L.*

*C/ Numancia, 73, 7º C2 - 08029 - Barcelona - Phone: (+34) 933 633 954
secretary@sere2021.org*

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