capermed

Comittee on Air Pollution Effects Research on Mediterranean Ecosystems

Thursday 3rd – Friday 4th July 2014

Faculdade de Ciências da Universidade de Lisboa
Building C1, room 1.3.33A

Proceedings

by Silvana Munzi

capermed Committee on Air Pollution Effects Research on Mediterranean Ecosystems

Programme

Thursday 3rd July 2014 – Faculdade de Ciências da Universidade de Lisboa

14:00 Registration
14:30 Welcome: Presentation of CAPERMed by Organizers and Opening Act

Monitoring, Indicators and Assessment
Chair: Silvana Munzi, Centro de Biologia Ambiental, Faculdade de Ciências da Universidade de Lisboa

14:45 **Anticipating global tipping points using ecological indicators: climate change, eutrophication and chemical pollution** – C. Branquinho, Centro de Biologia Ambiental, Faculdade de Ciências da Universidade de Lisboa

15:30 **Lichen functional diversity as early-warning indicators of global change in Mediterranean drylands** – P. Matos
Biomonitoring heavy metals and nitrogen in southern Europe – S. Izquieta
Mosses and heavy metal pollution in Mediterranean environments – B. Estebanez
Detecting biological effects of air pollutants with sensitive organisms (lichens) – L. Paoli
Guidelines to measure the impact of reactive nitrogen on ecosystems: the use of lichens as biomonitors under global change – P. Pinho
16:30 *Coffee break + poster*

Monitoring, Indicators and Assessment
Chair: Rocío Alonso, Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

17:00 **Building a giant army of tiny soldiers for farming in the Mediterranean** – C. Cruz
La Castanya (Montseny): a long term atmospheric deposition site for the study of effects to forested catchments – A. Avila
Measurement and modelling of pollutant dry deposition to semi-natural Mediterranean ecosystems – M.R. Theobald
Latitudinal change to ozone sensitivity in *Quercus ilex* L. across its latitudinal range – J. Merino
Ozone fluxes and epidemiology of ozone injury to forests – E. Paoletti
Adapting Mediterranean forests to climate change and ozone – P. Sicard
Ecotoxicology of Air Pollution Research Group- CIEMAT - R. Alonso
18:30 Poster session + Aperitif

20:00 ***Conference dinner***

Friday 4th July 2014 – Faculdade de Ciências da Universidade de Lisboa

Ecosystem Structure and Function

Chair: Raúl Ochoa-Hueso, Hawkesbury Institute for the Environment, University of Western Sydney

09:15 **Impacts of atmospheric nitrogen deposition on (semi-)natural ecosystems: an overview** - Roland Bobbink, B-WARE Research Centre, Radboud University

10:00 **Mediterranean is different; in terms of ecosystem responses to N deposition too! Understanding why through temperate-like relic, circum-Mediterranean fir forests** – J.A. Carreira

Integrating the impacts of N pollution on the structure and functioning of Mediterranean ecosystems – T. Dias

Effects of reactive nitrogen on the health condition and the biodiversity of forest areas - D. Elustondo

Nutrient Network: some initial results and getting involved – C.J. Stevens

You are NOT what you eat: the hopeless lack of homeostasis in N/P stoichiometry under chronic N deposition in *Abies pinsapo* forests – B. Viñegla

11:00 *Coffee break + poster*

Ecosystem Structure and Function

Chair: María Arróniz-Crespo, School of Environment, Natural Resources and Geography, Bangor University

11:30 **A nitrogen addition experiment in a coastal Mediterranean Ecosystem** – S. Mereu

The role of living organisms as modulators of the response of arid ecosystems to climate change and N deposition – E. Manrique

Functional diversity under changing environments: impacts on ecosystem services – L. Concostrina-Zubiri

Linking plant functional diversity to the provision of ecosystem services in Mediterranean drylands – A. Nunes

Ecological impacts of increased nitrogen deposition in semiarid Mediterranean Spain – R. Ochoa-Hueso

Ecosystem Structure and Function

Chair: Cristina Cruz, Centro de Biologia Ambiental, Faculdade de Ciências da Universidade de Lisboa

12:30 **Carbon storage in grasslands: the impact of atmospheric nitrogen pollution** – I.B. Rogers

Ozone removal by a mixed oak-hornbeam mature forest in the Po Valley and related effects on net photosynthesis – G. Gerosa

Responses of *Abies pinsapo* Boiss to ozone in both field and growth chamber conditions – J.I. Seco
Measuring the impact of dust deposition in a mixed landscape: the role of vegetation in ameliorating its effects – A. Santos

13:30 *Lunch*

14:30 Discussion session 1
Research in Mediterranean environment: state-of-the-art and perspectives
Moderator: Cristina Branquinho, Centro de Biologia Ambiental, Faculdade de Ciências da Universidade de Lisboa

16:00 *Coffee break*
16:30 **Horizon 2020 R&I opportunities for the biodiversity and ecosystems services within Call 2015** – A. Carvalho, Horizon2020 Framework Programme Promotion Office
17:00 Discussion session 2
Round table "Possible common initiatives"
Moderator: Elena Paoletti, Istituto per la Protezione delle Piante, Consiglio Nazionale delle Ricerche

18:00 Committee Meeting

Centro de Biologia Ambiental

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Participants

Alonso del Amo, Rocío (rocio.alonso@ciemat.es)
Ecotoxicology of Air Pollution Research Group - Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas
Abstract page: 14, 34

Our main research lines are:
Ozone effects on growth, physiology and biochemistry of Mediterranean vegetation and their interaction with other stress factors.
Measuring air pollutants with passive samplers.
Atmospheric deposition to natural ecosystems.
Effects of air pollutants and climate change on natural ecosystems
Critical loads and levels.
Urban and periurban forests.

Arroniz-Crespo, María (m.arroniz-crespo@bangor.ac.uk)
School of Environment, Natural Resources and Geography, Bangor University
Abstract page: 31

My main research interest is focused on bryophyte ecophysiology. Research topics linked to CAPER*med* are:

- Physiological responses of bryophytes to nitrogen deposition
- Establishment of critical loads and levels of N base on bryophyte physiological responses
- Biomonitoring studies of N deposition: identification of suitable species and variables (biomarkers)
- Monitoring atmospheric deposition with passive samplers

As a postdoc at Bangor University (UK), I am studying the contribution of N inputs by epiphytic cyanobacteria to the N budget of boreal feather mosses, the transfer and availability of fixed N to other components of the ecosystem and how this influences on the function of the boreal forest (N availability and turnover). To know more about this project please visit our website at http://borealngap.weebly.com/.

Avila, Anna (anna.avila@uab.cat)
CREAF - Universitat Autònoma de Barcelona
Abstract page: 9

We are interested in: 1) the effects of pollutant and natural emissions on rain chemistry, 2) the contribution of atmospheric deposition to the biogeochemistry of Mediterranean forests, and 3) the use of lichens as bioindicators.

Bermejo, Victoria (victoria.bermejo@ciemat.es)
Ecotoxicology of Air Pollution Research Group - Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas
Abstract page: 14, 34

Effects of increased deposition of tropospheric ozone and atmospheric nitrogen compounds on crops, trees and pastures, and their interaction with other stress factors like drought and pathogens. Effects are characterized from physiological level (gas exchange at leaf and canopy) to ecosystem level (yield, biodiversity).
The Ecotoxicology of Atmospheric Pollution Group manage from de late 80s an Open Top Chamber (OTCs) experimental field, specifically designed for studying the atmospheric pollutant effects on vegetation. This kind of facility is currently the experimental system most employed for establishing pollutant-dose/plant-response relationships.
Definition of critical levels and loads (thresholds for plant protection) in the frame of the United Nations Convention on Long-range Transboundary Air Pollution (CLRTAP/UNECE).

Bobbink, Roland (r.bobbink@b-ware.eu)
B-WARE Research Centre, Radboud University
Abstract page: 15

Dr Roland Bobbink is senior scientist at B-WARE Research Centre BV, Radboud University, Nijmegen, The Netherlands. In the period 2008-2011 he was also director of this Research Centre. He has studied the consequences of atmospheric N loads on the structure and functioning of (semi-)natural ecosystems since the early 1980s. Since 1990 he also worked on the development of the empirical approach for N critical loads in Europe and was the leading author of the last three background paper on the empirical approach. Late ron, ecological restoration of degraded nature reserves became his second major research aim. He worked in species-rich calcareous and acidic grasslands, heaths, fens and related wetlands and shallow softwater lakes.

He is (co)author of around 120 peer-reviewed scientific papers and book chapters, 3 books and ca. 100 publications in Dutch. He is member of the national committee on ecological restoration in the Netherlands, chair of the Netherlands-Flanders Ecological Society (2008-2013) and leading author of the 2009-2010 UN/ECE update of the empirical N critical loads.

Branquinho, Cristina (cmbranquinho@fc.ul.pt)
Centro de Biologia Ambiental, Faculdade de Ciências da Universidade de Lisboa
Abstract page: 2, 3, 7, 23, 24, 29, 32

My main research interests are 1) Environmental Pollution: monitoring the impact of pollution or anthropogenic activities, such as, mines, quarries, industrial, rural and urban areas on different environmental matrixes: air, soil, water, plants and also at ecosystem level. 2) Ecological Management and Restoration: relate land-use changes and landscape fragmentation with changes in biodiversity. Monitoring environmental quality in an integrated and holistic perspective. Proposing managing options for the ecological restoration of degraded ecosystems. 3) Plant Ecology and Ecophysiology: physiological basis of plants and cryptogams responses to several types of pollution. Ecology of rare plants in particular those with metal tolerance. 4) Environmental Health studies: developing environmental biomonitoring to assess human exposure to toxic pollutants mainly, heavy metals, dioxins, furans and PAHs. Relating several environmental bioindicators with public health indicators in order to develop efficient tools for evaluation of the Human health risk assessment for chronic effects on health.

Carreira de la Fuente, José (jafuente@ujaen.es)
Department of Botany, Zoology and Ecology, Universidad de Jaén
Abstract page: 16, 20, 28

I'm interested in understanding how the response of Mediterranean forests and shrublands to global change is modulated by interactions among its different components such as pollutant atmospheric inputs, climate change and land-use alterations. I focus on responses regarding soil biogeochemistry, plant ecophysiology and population and community dynamics. As experimental systems I choose study cases which are singular in that their unique combination of state factors renders them highly vulnerable to those global change drivers. For instance, by using tertiary-relic conifer forests currently under Mediterranean-type climate and growing on serpentinic mountains along an N deposition gradient, I have explored hypotheses on how interactions between nutrient-poor soils and increased climate-seasonality may accelerate the development of the N saturation syndrome even under moderate N deposition rates. Using the same model-system, but comparing Spanish and Moroccan locations differing in historical and current land-uses, I have explored how land-use change modulate the climatic vulnerability of forests through its effects on stand canopy structure and soil status. As an additional example of may research approach, by using edapho-endemic, semiarid scrublands on steep, dolomitic sandy-soils, I have study how legacy effects of the fire-disturbance regime may be more important than short-term effects of the last fire event in determining current ecosystem N and P biogeochemical status.

Concostrina Zubiri, Laura (lczubiri@fc.ul.pt)
Centro de Biologia Ambiental, Faculdade de Ciências da Universidade de Lisboa
Abstract page: 23

I am a dryland ecologist with especial interest in Community and Ecosystem Ecology, and Functional Diversity. My research is focused on understanding how communities respond to changes in abiotic and biotic conditions such as climate gradients, disturbance-recovery processes and microsite environment, from local to regional scales, and to disentangle the consequences of these changes to ecosystem functioning. Recently, I have directed my attention to Functional Diversity. I am now focused on measuring functional effect traits and functional diversity along environmental gradients to evaluate the drivers of functional structure in drylands. Also, I am interested in the effects of functional traits and diversity on ecosystem processes, and their contribution to ecosystem services. My object of study are Biological Soil Crusts (terricolous lichens, bryophytes and cyanobacteria), a complex ecosystem component that highly contributes to dryland biodiversity and functioning by playing critical roles in these ecosystems, such as carbon and nitrogen fixing, soil formation, and topsoil water dynamics regulation.

Cruz, Cristina (ccruz@fc.ul.pt)
Centro de Biologia Ambiental, Faculdade de Ciências da Universidade de Lisboa
Abstract page: 8, 17, 35

I am interested in the physiological mechanisms that determine the suitability of terrestrial plants to their environments, especially in environments rich in ammonium.
My main scientific interest is the physiological ecology of nitrogen (N) acquisition and impacts of increased N availability in terrestrial plants. The distinct effects of NO_3^- and NH_4^+ on plant performance and species preference for one of these chemical species of N have been a constant in my research. I am examining the role of plant N fluxes in several key areas: ecological succession, primary productivity, carbon nitrogen interactions, physiology of inorganic nitrogen assimilation and the role of plant micro-organism interactions in nitrogen acquisition. Special attention is given to rhizospheric microbial consortia (free living N fixers, phosphate solubilizers and arbuscular mycorrhizal fungi) in nitrogen acquisition, the mechanisms and fluxes involved are part of the research programme.
The approach is highly multidisciplinary, ranging from biochemical processes to field ecological analyses. Techniques include enzymatic kinetics, net flux kinetics, ionic and metabolic profiling of tissues, and growth analysis. The biological systems used are carob (*Ceratonia siliqua* L.), *Arabidopsis thaliana* and in vitro arbuscular mycorrhizal fungi cultures. New projects are considering the physiology of the endophyte *Piriformospora indica* and its application as a biofertilizer in order to maintain food security and environmental sustainability.

Cruz de Carvalho, Ricardo (rfcruz@fc.ul.pt)
Centro de Biologia Ambiental, Faculdade de Ciências da Universidade de Lisboa
Abstract page: 2, 32

My current research focus is plant ecophysiology, more recently in bryophytes and cyanobacteria from biological soil crusts, mainly the study of photosynthetic metabolism under stress conditions, using non-invasive techniques (IRGA, oxygen electrode, chlorophyll fluorescence). Also interested in oxidative stress.

De Marco, Alessandra (alessandra.demarco@enea.it)
ENEA – Agenzia Nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile
Abstract page: 12, 13, 33

Plant ecophysiological responses to air pollution and climate change factors, under controlled and ambient conditions.
Epidemiology of ozone injury.
Micrometeorological assessment of stomatal ozone flux.
Parameterisation and validation of stomatal ozone flux models.

Monitoring and biomonitoring of ozone pollution.
Nitrogen budget at national level and impact of food production on nitrogen cycle.
GAINS Europe, GAINS-Italy user, with the possibility to elaborate new emission scenarios and assess impacts on ecosystems.
Modelling approach for estimation of nitrogen critical loads at national level.
User of dynamic modeling for estimation of air pollution impacts and recovery of plant ecosystems.

Dias, Teresa (mtdias@fc.ul.pt)
Centro de Biologia Ambiental, Faculdade de Ciências da Universidade de Lisboa
Abstract page: 8, 17

My main research interests are nitrogen cycling in ecosystems and nitrogen nutrition as a driving force for plant and soil ecology using physiological and biochemical approaches at the scale of the ecosystem.

Elustondo Davíd (delusto@unav.es)
Department of Chemistry and Soil Science, Universidad de Navarra
Abstract page: 4, 18

Research interests:

- Effects of atmospheric pollution on forests
- Ecosystem responses to reactive nitrogen
- Impacts of nitrogen over biodiversity and biogeochemical cycles
- Nitrogen impacts in Mediterranean ecosystems
- Urban air quality
- Climate change and GHG fluxes
- N and C stable isotopes
- Analytical quality assurance and quality control

Topic areas
The overall objective of our group is to address the problem of reactive nitrogen in a comprehensive and integrated perspective, identifying the hazards associated with the excess of Nr and promoting a set of measures to help reducing their impact on the natural environment. Currently, our activity is mainly focused on the study of its effects on forest ecosystems, being especially interested in its interaction with other pollutants and its effect on the main biogeochemical cycles. To that end, we are involved in several European programmes like ICP Vegetation, ICP Forests and ICP IM (our centre is the National Focal Point and the only plot in Spain).
Another important aspect of our research is the study of the effects of Nr over biodiversity. To that respect, our group is currently studying the evolution of Nr over time and its effect on the changes in biodiversity in the vicinity of N hot-spots, like pig farms and heavily-trafficked areas.
On the other hand, we have also experience in studies of biomonitoring of heavy metals and nitrogen using mosses, lichens and tree leaves through of our participation in biomonitoring surveys as those carried out in the framework of the ICP Vegetation programme.
Finally, we are actively involved in air quality projects, both indoors and outdoors, focused on the monitoring of air pollutants in urban environments, with a special interest in the determination of VOC and particulate matter.

Elvira Cozar, Susana (Susana.elvira@ciemat.es)
Ecotoxicology of Air Pollution Research Group - Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas
Abstract page: 14

Our main research lines are:
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Atmospheric deposition to natural ecosystems.
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Critical loads and levels.
Urban and periurban forests.

Estébanez Pérez, Belén (belen.estebanez@uam.es)
Universidad Autónoma de Madrid
Abstract page: 5

Our team interests include ultrastructure, functional morphology, and ecology of bryophytes, one of the groups of bioindicators most widely used. We have some background experience on mosses as environmental bioindicators, including variation in richness at different geographical scales, responses of vascular macrophytes and aquatic mosses to environmental perturbations, and ultraviolet effects on moss spores. Our team is also trying to develop a simple way to estimate moss physiological activity in the field.
We believe that one of the main factors explaining the effect of anthropogenic pollution on bryophytes is their diverse resistance to heavy metals. We have studied this especially on lead. We are establishing *in vitro* thresholds of tolerance to lead for several moss species, and are also checking the extent of ultrastructural damage under several lead doses during the germination of selected urban species. We are investigating the relationship between terricolous moss communities and content of lead in soils. Recently, our team has undertaken the study of tolerance mechanisms in several species (metal accumulation *vs.* exclusion strategies). Besides, we are assessing the applicability in Mediterranean areas of biomonitoring methods widely used in Europe for heavy metal deposition, both in urban and rural environments.
In summary, we are interested in studying the role of bryophytes as indicators using several observation scales, from ultrastructure to physiological responses and changes in communities.

Fusaro, Lina (lina.fusaro@uniroma1.it)
Università di Roma "La Sapienza"

Dr. Lina Fusaro owns a Post Doctoral position in the Department of Environmental Biology, Sapienza University of Rome. She has a qualified skill in the field of ecophysiology, developed during more than seven years of research work, and supported by the participation to summer schools and specific international training activities (Pisa 2009, 2010; Lisbon, 2012). She graduated in Natural Sciences (2008) with a master thesis about the different use of water resources from Mediterranean maquis species in a coastal dune ecosystem. Thanks to her skills in the analysis of plant gas exchange and photosystems functionality, she was invited to join the ACCENT-VOCBAS international campaign (2007), where she was trained to the use of the sap flow technology. She also took part to an exchange of staff supported by the ACCENT-VOCBAS network, during which she was trained to the use of the Open Top Chambers Facility of the Research Centre for Atmospheric Pollution and Ecosystems (C.R.IN.ES) in Bergamo. During her PhD in Ecological Sciences (2008-2012), she has focused their research activity on the combined effect of abiotic stress factor in Mediterranean maquis species, both in field and in controlled conditions experiments. Research lines: 1) interaction of oxidative stresses on Mediterranean species; 2) how acclimation of leaf dark respiration changes in stressful environment; 3) study responses of woody species, with different water strategy, to increased Nitrogen deposition. During the last year she was involved in new research line developed in her hosting laboratory regarding analysis of vegetation functionality and environmental quality in urban and natural areas in order to evaluate the contribution of urban forests to the air quality improvement by pollution removal.

Gerosa, Giacomo (giacomo.gerosa@unicatt.it)
Catholic University of Brescia
Abstract page: 27, 34, 36, 37

The Environmental Physics and Ecophysiology research group of the Catholic University has been working since ten years on the following main research topics:

1) Micrometeorological measurements of gaseous pollutants, water and energy fluxes between biosphere and atmosphere.
2) Experiments in controlled environment (Open-Top Chambers) for evaluating the effects of ozone and other abiotic stresses (drought, nitrogen deposition, water salinity) on vegetation.
3) Measurements of greenhouse gases emissions from soil (CO_2, N_2O).

The research group includes expertise in:
- Flux measurements with eddy covariance and gradient techniques (on crops, forests and seminatural vegetation).
- Assessments of ecophysiological effects of ozone and water stress on vegetation (crops and forests) in relation to photosynthesis, gas-exchange, chlorophyll fluorescence, yield and biomass reduction, foliar injury.
- Stomatal conductance modelling.

Izquieta Rojano, Sheila (sizquieta@alumni.unav.es)
Laboratory of Integrated Environmental Quality, Department of Chemistry and Soil Science, Universidad de Navarra
Abstract page: 4, 18

Keywords: Heavy metals, Nitrogen deposition, N stable isotopes, biomonitoring, mosses, moss physiology.
One of the main research lines our group is involved in is the study of heavy metals and nitrogen deposition through the use of different kind of biomonitors, specially mosses.
We have recently started using N stable isotopes to detect N emissions from anthropogenic sources. Several articles published in the last years have proved that the biomonitoring surveys using mosses and lichens might be a simple approach to determine not only the atmospheric deposition of nitrogen but also its origin.
Finally, since not long ago, we have focused our interest on the study of the physiological response of mosses to a nitrogen deposition gradient in the vicinity of a livestock area (high NH_3 emissions). The aim of the survey is to assess the suitability of these biomonitors as diagnostic indicators of elevated nitrogen deposition.

Lo Cascio, Mauro (maurolocascio@yahoo.it)
Department of Sciences for Nature and Environmental Resources, Università di Sassari
Abstract page: 21, 35, 38, 39

I'm PhD student at the PhD school of "Agrometeorology and Ecophysiology of Agricultural and Forestry Eco-Systems" at the University of Sassari, (Italy) - Dept. of Science for Nature and Environmental Resources (DipNET) - funded by Euro-Mediterranean Center for Climate Changes (CMCC).
The Ph.D. course aims to provide a high qualification in the field of management of agricultural and forestry productive systems and in the conservation, protection and enhancement of natural resources.
My PhD project is on the effects of nitrogen depositions on Mediterranean ecosystem with a focus on plant water relations and soil properties.

Manrique Reol, Esteban (e.manrique@csic.es)
Museo Nacional de Ciencias Naturales, CSIC
Abstract page: 22, 25

Study the effect of climate change and nitrogen (N) deposition on several biotic communities (plants, biocrusts and microbes) in drylands through the evaluation of the composition and diversity of soil microbial communities in drylands, determining which major environmental factors drive these structural attributes. Study the response of key ecosystem functions (nutrient cycling, trace gases emission) to global change drivers (climate change, Nitrogen deposition).
Key words: Climate change, nitrogen deposition, drylands, microorganisms, ecosystem services, ecosystem functioning, biocrusts, biodiversity, trace gas exchange, nutrient cycling, plant communities.

Marzuoli, Riccardo (riccardo.marzuoli@unicatt.it)
Catholic University of Brescia
Abstract page: 27, 34, 36, 37

The Environmental Physics and Ecophysiology research group of the Catholic University has been working since ten years on the following main research topics:
1) Micrometeorological measurements of gaseous pollutants, water and energy fluxes between biosphere and atmosphere.
2) Experiments in controlled environment (Open-Top Chambers) for evaluating the effects of ozone and other abiotic stresses (drought, nitrogen deposition, water salinity) on vegetation.
3) Measurements of greenhouse gases emissions from soil (CO_2, N_2O).
The research group includes expertise in:
- Flux measurements with eddy covariance and gradient techniques (on crops, forests and seminatural vegetation).
- Assessments of ecophysiological effects of ozone and water stress on vegetation (crops and forests) in relation to photosynthesis, gas-exchange, chlorophyll fluorescence, yield and biomass reduction, foliar injury.
- Stomatal conductance modelling.

Matos, Paula (psmatos@fc.ul.pt)
Centro de Biologia Ambiental, Faculdade de Ciências da Universidade de Lisboa
Abstract page: 2, 3, 24

My current scientific interests focus on the development of new tools to identify the first signs of environmental change, as this could be the key to prevent or ameliorate its effects on ecosystems and human society. It's currently accepted that these early-warning indicators should be based on the overall response of ecosystems, reason why we've been focusing on lichen functional diversity, which is also an understudied group (main works focus on plants). To do so we've been studying the pattern of change of lichen functional diversity on ecotonal areas along climatic gradients in space in Mediterranean drylands, as surrogates of the temporal changing patterns expected to happen according to future climate change scenarios. We are also interested to see how to disentangle the effects of other global change drivers, in this context of climate change. We aim that this early-warning indicators of global change developed here in the drylands, can be applied worldwide, so we are also developing work on other ecotones along climatic gradients in other parts of the world.

My research group evaluates structural and functional changes in plant communities in response to changes or disturbance, from ecophysiological studies and the isotopic signals, to the phenological and climatic changes, as an approach to scale up from plant to the community level. This approach is also complemented by the use of remote sensing tools, developed by our group, to upscale to the regional scale. This knowledge and the scientific principles of structure and functioning of ecosystems is used not only to develop early-warning tools for global change, but also to develop ecological management processes and define a sustainable strategy for the ecological restoration of degraded ecosystems, as well as the use of biological organisms for monitoring the impact of pollution on environment and on ecosystem functioning.

Mereu, Simone (simonemereu@uniss.it)
Department of Sciences for Nature and Environmental Resources, University of Sassari
Abstract page: 21, 35, 38, 39

The Laboratory of Agrometeorology and Ecophysiology, mainly focuses on the biogeochemical cycles and fire regimes in both agricultural and wooded Mediterranean ecosystems. Biogeochemical cycles are monitored and analysed using Eddy Covariance technology over three ecosystems: A vineyard, an Urban ecosystem and a coastal Mediterranean maquis. This last site runs since 2005, was part of the CarboEurope network and is a candidate for class II sites of the ICOS network. The lab is also a branch of the EuroMediterranean Center for Climate Change (CMCC) and thus research activities also focus on the modelling of impacts and adaptation strategies to climate change including changes in NPP, species

distribution, agricultural water requirements, fire risk, and land use change. In 2012 we started collecting comprehensive data in the Coastal Mediterranean Maquis Eddy Covariance site aiming at: 1) partitioning the NEE fluxes in its different components (Soil CO_2 effluxes, species specific photosynthesis and respiration rates, respiration and photosynthesis of the biological crust); 2) species specific WUE; 3) Spatial analysis of soil properties and soil meteorological variables. The Nitrogen addition experiment was also started in 2012 at the same site.
In 2014 we joined the TreeDivNet network by establishing a diversity manipulation experiment with Mediterranean trees following the IDENT design (www.treedivnet.ugent.be/SiteIDENT.html). This experiment aims at identifying Functional Diversity effects on different ecosystem functions as NPP, Water Use Efficiency and Nutrient Cycle.

Merino Ortega, José Á. (jamerort@upo.es)
Physical, Chemical and Natural Systems Department, Universidad Pablo de Olavide
Abstract page: 11, 16, 20, 28

1. Analysis of the sensitivity of plant species to toxic gases and its relationships with plant traits.
2. Plant carbon balance and environmental stress (including toxic gases) focusing on interpopulation differences.

Morillas, Lourdes (lourdesmorillas@msn.com)
Department of Sciences for Nature and Environmental Resources, Università di Sassari
Abstract page: 21, 35, 38, 39

My research group is interested in assessing the effect of nitrogen (N) fertilization on soil processes and the role of the soil biological crust (BSC) as a key regulator of these processes in a Mediterranean ecosystem. We are focusing on soil and BSC respiration and its dependence on meteorological factors such as temperature and moisture. On the other hand, we are also looking into the effects of N addition on the interaction of the indigenous shrub Juniperus phoenicea with biological soil crust. We are also planning to participate in a network called Drought-Net Research in order to accomplish an international drought experiment following a common experimental design and standardized measurement protocols during a period of 4 years in all kinds of ecosystems. The main goals of this network are (1) to assess patterns of differential terrestrial ecosystem sensitivity to drought, and (2) to identify potential mechanisms underlying those patterns. This project will start in 2015.

Munzi, Silvana (ssmunzi@fc.ul.pt)
Centro de Biologia Ambiental, Faculdade de Ciências da Universidade de Lisboa
Abstract page: 2, 6, 29

Currently, I develop my research mainly in the field of: 1) biomonotironing, using lichen as ecological indicators in urban, forest and rural areas, in particular to evaluate the influence of human activities and thus providing science-based indication for environmental management and protection; 2) lichen ecology and ecophysiology especially related to environmental levels of reactive nitrogen and other pollutants, in order to understand the molecular and metabolic mechanisms responsible for lichen sensitivity/tolerance; 3) manipulation experiments in Mediterranean environment to investigate the single or synergistic effects of climate changes and excess nitrogen on Mediterranean ecosystems.

Nunes, Alice (alicemnunes@gmail.com)
Centro de Biologia Ambiental, Faculdade de Ciências da Universidade de Lisboa
Abstract page: 2, 3, 24

My main research interests/questions comprise:
Mediterranean vegetation diversity and ecophysiology, particularly vegetation primary and secondary succession patterns, main adaptations to different sources of stress and as a tool to restore degraded areas

- Functional diversity and plant functional traits, especially plant functional pattern in response to land degradation and as links to ecosystem functioning and services
- Ecological indicators, as a way of integrating both the effect of environmental or disturbance factors and ecosystem resilience
- Desertification and land degradation in drylands, the use plant functional knowledge to early-detect and mitigate it and its relation with global change drivers
- Ecological restoration, particularly how can an approach based on plant functional traits improve the planning and monitoring of restoration actions of degraded drylands
- Plant facilitation and competition along resource gradients, mainly in the context of restoration
- Soil quality and restoration

I am a member of Environmental Stress and Functional Ecology group, within the Centre for Environmental Biology at Faculdade de Ciências of Universidade de Lisboa. The objective of this group is to contribute to the understanding of key problems in functional biodiversity and plant ecological adaptation related with environmental and anthropogenic factors in different types of ecosystems. It aims at:

(i) evaluating structural and functional changes in plant communities in response to changes or disturbance, including ecophysiological studies and the isotopic signals of C, N, O and H, as an approach to scale up from the plant to community level;

(ii) using scientific principles of structure and functioning of ecosystems to develop ecological management processes and define a sustainable strategy for the ecological restoration of degraded ecosystems, as well as the use of biological organisms for monitoring the impact of pollution on environment and on ecosystem functioning.

Ochoa-Hueso Raúl (R.OchoaHueso@uws.edu.au)
Hawkesbury Institute for the Environment, University of Western Sydney
Abstract page: 25

I have broad interests on the effects of human-induced global environmental change on ecosystem structure and functioning and the link between them. I am also interested on how these undesired negative impacts affect key ecosystem services such as above-ground and below-ground carbon storage.
My core expertise is on the ecological impacts of increased nitrogen deposition and climate change on terrestrial ecosystems. My experience includes research along extant and simulated nitrogen deposition and climatic gradients in semiarid portions of Spain, where I have led work evaluating impacts on: (1) plant and soil microbial communities and (2) soil chemistry, biogeochemistry and functioning; my research also focuses on (3) the identification of suitable indicators of increased nitrogen deposition, particularly through the evaluation of enzyme activities measured in widespread species of bio-crust-forming mosses and lichens. I am particularly interested in how direct responses at the soil (nutrient availability and microbial community composition and activity) and biocrust/plant levels interact with each other to produce changes at the ecosystem scale (for example, the ability of semiarid ecosystems to store extra carbon and nitrogen).

Paoletti, Elena (e.paoletti@ipp.cnr.it)
Istituto per la Protezione delle Piante – Consiglio Nazionale delle Ricerche
Abstract page: 12, 13, 33

Plant ecophysiological responses to air pollution and climate change factors, under controlled and ambient conditions.
Free-air simulation of ozone exposure.
Carbon and water budgets of plants/plant ecosystems under ozone pollution.
Epidemiology of ozone injury.
Micrometeorological assessment of stomatal ozone flux.
Parameterisation and validation of stomatal ozone flux models.
Monitoring and biomonitoring of ozone pollution.
Ozone pollution and emission of biogenic volatile organic compounds.

Paoli, Luca (paoli4@unisi.it)
Department of Life Science, Università di Siena
Abstract page: 6

We use sensitive organisms (lichens) to assess the biological effects of air pollution on the ecosystems, in particular around point sources of environmental contamination. Our research focuses on the estimation of the biological effects of air pollution from: 1) waste management strategies (incineration, landfilling, industrial composting), 2) use of renewable energy sources (geothermal energy), 3) cement production (quarries, cement plants), 4) urban environment (vehicular traffic, domestic heating), 5) agriculture (livestock farming, agricultural activities; nitrogen pollution), and environmental alterations linked to climatic stress, in particular in dry environments.
We investigate biodiversity, element bioaccumulation and physiological responses in native and/or transplanted lichens around point sources as well as in lab experiments. We also record physiological responses of sensitive/tolerant species treated under laboratory conditions with specific pollutants to foresee future changes at community level. In particular, at physiological level we deal with the damage endured by cell membranes (measured as electrolyte leakage), photosynthetic efficiency, measured as chlorophyll *a* fluorescence emission, chlorophyll degradation, overall viability assessed by the enzimatic activity of dehydrogenase, ergosterol and MDA production and the alteration of other secondary metabolites. We are recently working on the variation of magnetic properties of lichens exposed to air pollution as biological indicator, in particular in connection to traffic emissions, landfills and cement production.

Pinho, Pedro (ppinho@fc.ul.pt)
Centre for Natural Resources and the Environment, Instituto Superior Técnico, Universidade de Lisboa
Abstract page: 2, 3, 7, 24, 29

I'm graduated in Biology, MSc in GIS and PhD on Biology- Ecology. I currently a post-doc working on the use of vegetation functional groups and spatial patterns to assess the effect of environmental changes, with both natural and human origin: desertification and land degradation, climate alterations, eutrophication and land-use/cover. I also work on lichen biodiversity and ecology. In general I'm interested in considering the spatial characteristics of ecological data to study the relation of biological and environmental variables.

Rogers Beltrán, Isabel (i.rogers@lancaster.ac.uk)
Lancaster Environment Centre, Lancaster University
Abstract page: 26

I am investigating the effects of atmospheric nitrogen deposition on carbon storage in grasslands. In particular, I am interested in decoupling the direct and indirect effects of nitrogen on carbon in these systems. In order to do this, I am combining research carried out on two semi-long term acid grassland experiments (North Wales and Norway) with a mesocosm experiment set up at Lancaster University.
I belong to the 'Biodiversity and Global Change' group at Lancaster University. Our research covers the impacts of global changes on plant ecology and soil biogeochemistry and ecology across a wide variety of ecosystems, including grassland, peatland, and tropical forest.

Santos, Artur (amvsantos@fc.ul.pt)
Centro de Biologia Ambiental, Faculdade de Ciências da Universidade de Lisboa
Abstract page: 29

The main objectives of ESFE (Environmental Stress & Functional Ecology) is to contribute to the understanding of key problems in functional biodiversity and plant ecological adaptation related with environmental and anthropogenic factors in different ecosystems, particularly:

1) Structural and functional changes in plant communities in response to changes or disturbance, with special attention being given to ecophysiological studies and the isotopic signals of C, N, O and H.
2) Scientific principles of structure and functioning of ecosystems to develop ecological management

processes and define a sustainable strategy for the ecological restoration of degraded ecosystems, as well as the use of biological organisms for monitoring the impact of pollution on environment and on ecosystem functioning.

My main research interests are:

1) Environmental pollution: Monitoring and modelling the impact of anthropogenic activities on different environmental matrixes and at the ecosystem level.
2) Environmental health studies: Use of biomonitors (e.g. lichens) to assess human exposure to toxic pollutants, contributing for human health risk assessment.
3) Green economy and ecosystem services: Studying the dynamics and value of ecosystem services, integrating economic and ecological perspectives.

Sicard, Pierre (pierre.sicard@acri-st.fr)
ACRI-ST, Sophie Antipolis, France
Abstract page: 12, 13

- ✓ Ground-level ozone & Plant responses to ozone
- ✓ Epidemiological studies - Field survey of real plant damage
- ✓ Phytotoxic ozone dose & Stomatal ozone fluxes & DO3SE model
- ✓ Visible injury: crown defoliation, crown discoloration and ozone-induced symptoms
- ✓ Flux-effect relationships & Statistics
- ✓ Exposure-based critical levels and ozone flux-based critical levels
- ✓ Air pollution control strategies

Stevens, Carly (c.stevens@lancaster.ac.uk)
Lancaster Environment Centre, Lancaster University
Abstract page: 19, 26

My research is concerned with understanding how global environmental change impacts on plant communities, soil ecology, soil biogeochemistry and plant-soil interactions. The majority of my research is focused on herbaceous systems. I have a particular interest in the impacts of atmospheric nitrogen deposition on grasslands and have published widely on this topic. I use a variety of approaches to address ecological questions from small scale experiments to regional surveys.

Theobald, Mark (mrtheo@ceh.ac.uk)
Department of Agricultural Chemistry and Analysis, Higher Technical School of Agricultural Engineering, Technical University of Madrid
Abstract page: 10

The research group "Contamination of agrosystems by agricultural practices" studies the environmental impacts of pollutants produced by agricultural practices. These pollutants include: greenhouse gases, nitrate leaching and the emissions of nitrogen oxides and ammonia.

The group's topic areas related to the objectives of CAPERMED are:

- Measurement and modelling of ammonia emissions from agricultural activities
- Modelling the atmospheric dispersion of ammonia
- Measurements of dry deposition of numerous compounds (e.g. ammonia, HNO_3, ozone) using micro-meteorological techniques
- Evaluation of the uncertainty in European nitrogen deposition estimates

Viñegla Pérez, Benjamín (bvinegla@ujaen.es)
Animal Biology, Plant Biology and Ecology Department, Universidad de Jaén
Abstract page: 11, 16, 20

I am interested in understanding how forest ecosystems respond to different kinds of perturbations (i.e., air pollution, changing climatic conditions or land use changes), mainly focusing on Mediterranean relict forests since environmental conditions in these ecosystems are already to stressing conditions, e.g., recurrent summer drought or intense anthropic influence and are suitable models for testing, for example, climate change processes. The main processes I am interested in eco-physiological responses as tools to determine sensitivity of individuals under varying structural and functional conditions and the role of soil functionality on plant-soil interactions and trees responses. I am also interested in the role of intra- and inter-specific relationships on individuals sensitivity, growth and survival by means of measuring functional traits from the point of view of either central tendencies or variance in leaf (e.g., carbon assimilation and respiration rates, leaf nutrient content) and wood (e.g., wood density) functional traits.

Oral presentations

Anticipating global tipping points using ecological indicators: climate change, eutrophication and chemical pollution

C. BRANQUINHO[1*], S. MUNZI[1], P. PINHO[1,2], S. AUGUSTO[1,3], R. CRUZ de CARVALHO[1], P. MATOS[1,4], A. NUNES [1,4], C. BARROS [1,5]

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[2]*CERENA, Instituto Superior Técnico, Universidade de Lisboa, Lisboa, Portugal.*
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As a result of human activities and climate change, ecosystems are experiencing changes from local to global scales. The high impact of these changes leads to the proposal of a new era –Anthropocene. Scientists have been attempting to quantify environmental, economic and social limits to human activities on Earth. On a global change framework some authors analyzed the safety of 9 planetary systems (variables of high importance to global habitability) and concluded that the rate of climate change and eutrophication already crossed the safety boundaries of the earth system, whereas chemical pollution, albeit important, has not yet been quantified. Ecosystems have critical thresholds, the so-called tipping points, at which the system changes abruptly to an alternative state. Once that threshold is crossed, a switch back to the initial state of the system may be impossible leading to losses in biodiversity, ecosystem services and human well-being. These tipping points are extremely difficult to forecast, thus reliance on early-warning signals indicating the imminence of a critical threshold is key. The first signs of ecosystem response to global change drivers are either too small or too complex to be measured by conventional means. Moreover, it is not possible to predict the integrated effect of multiple variables acting on the ecosystem just relying on the driver's measure. Therefore, it is proposed to use measurable and integrated ecological surrogates of the structure, composition and function of ecosystems, named ecological indicators (EI). In a global change framework it is critical to compare the impact of global environmental policies worldwide, in order to support the 3 United Nations conventions: biodiversity, climate change and desertification. The underlying conceptual hypothesis is that it is possible to identify and develop integrated EI of the effects of global change drivers (climate change, eutrophication and chemical pollution) on ecosystem structure and function. Those EI should have early-warning potential and be as universal as possible. Thus, it will be possible to track global changes in a comparable way (worldwide) predicting and developing strategies to steer away from thresholds.

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Lichen functional diversity as early-warning indicators of global change in Mediterranean drylands

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As a result of global change, dryland ecosystems may change non-linearly, meaning that beyond a certain pressure the ecosystem may undergo a sudden change towards another alternative state. These abrupt and potentially irreversible transitions are expected to increase in Mediterranean ecosystems, so current research is now focusing on detecting the early signs that could indicate if a critical threshold is approaching. Despite the progress in research during the last decade, no early warning indicators were yet developed, mostly, because forecasting the early-signs of critical transitions is extremely difficult as it implies traditionally large amounts of data and long-time data series. The solution to overcome this problem could be the use of pattern of change over space as a surrogate of the temporal changing patterns in ecotones (transition areas between adjacent biomes), as these are also the ones most likely to show the first early signs of change.

It is currently accepted that these early-warning indicators should be based on the overall response of ecosystems as indicators. Functional diversity has been given promising results in this field; however most of these works focus on plants while those of other organisms remain unknown. Lichens are amongst the ecosystem components most sensitive to changes, and could fulfil that role. They have been used as ecological indicators, early-warning systems and recent works suggest that they respond to global warming.

Our research concept is that lichen functional diversity can be used as a universal early-warning indicator of global change in Mediterranean drylands. This work will allow us to early detect the signs of climate change and to map risk areas. Our work has been focusing on a desertification gradient within the transition between dry-subhumid and semi-arid, but because this is a functional approach, this tool has the potential to be universal. Thus, additional work is being done in other ecotonal transitions in other parts of the world so it can be validated to other regions and used worldwide in a comparable way. This tool will be highly important to the identification of areas in risk of global change to timely predict and develop strategies to avoid these critical transitions.

Acknowledgements to FCT-MEC for: PTDC/AAC-CLI/104913/2008, SFRH/BPD/75425/2010, SFRH/BD/51407/2011, SFRH / BD / 51419 / 2011, Investigador FCT Contract.

Biomonitoring heavy metals and nitrogen in southern Europe

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The study of heavy metals and nitrogen (N) deposition through the use of different kind of biomonitors, specially mosses, is one of the main research lines of our group.
Since 1997, when we joined "The International Cooperative Programme on Effects of Air Pollution on Natural Vegetation and Crops (ICP Vegetation)", we have been routinely participating in the moss biomonitorization surveys carried out by this programme. Our first studies were focused on evaluating the effects of ozone, and progressively were extended to the study of nitrogen and heavy metal atmospheric pollution by using mosses as biomonitors. One important weakness detected in these surveys was the important lack of data in the Mediterranean area due to the difficulty to satisfy the sampling guidelines established by the ICP-Vegetation. Thus, we have been studying different species in order to find a suitable biomonitor for this region.
On the other hand, we have recently started using N stable isotopes to detect N emissions from anthropogenic sources. Several articles published in the last years have proved that the biomonitoring surveys using mosses and lichens might be a simple approach to determine not only the atmospheric deposition of N but also its origin. To that end, we have been studying mosses herbarium and present material to identify different trends over time since 1982 to date, and we are currently immersed in processing $\delta^{15}N$ data from different countries in Europe to evaluate the relationship among $\delta^{15}N$ signatures and the uses of soil (industrial, urban, rural areas) and man-made emissions.
Finally, we have determined the physiological response of mosses to a N deposition gradient in the vicinity of a livestock area. To that end, enzymatic activities (phosphomonoesterase (PME) and nitrate reductase (NR)) and pigments contents (chlorophyll *a* and *b* and carotenoids) are being used in order to assess their suitability as diagnostic indicators of elevated N deposition.

Mosses and heavy metal pollution in Mediterranean environments

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The role of mosses in biomonitoring of heavy metal deposition is widely known. In one hand, this group of plants is diverse and almost ubiquitous in terrestrial environments. In the other, mosses are able to absorb atmospheric pollutants through their whole surface, and, as most species are perennials, they allow recording the deposition of pollutants over several years.

There are several programs in Europe using mosses in biomonitoring heavy metal pollution. However, both the methods and the species used have been standardized for North & Central European habitats. In the Mediterranean region, the applicability of these methods is frequently uncertain.

In order to assess the effect of heavy metals in Mediterranean areas, we are currently working on several lines, as follows:

- *In vitro* experiments to evaluate lead tolerance of moss species. We have detected significant differences between closely related species from rural and urban environments, as well as among different families. Besides, we have found that one of the urban species is able to germinate under extremely high concentrations of lead, a previously unrecorded tolerance in plants. Finally, we have also studied the ultrastructural effect of lead on spore germination, where we have found an exclusion mechanism in at least one of the species.
- Critical assessment of biomonitoring methods using moss communities to estimate the environmental impact of different human activities. We have established some guidelines for successful comparisons of moss diversity and abundance between urban settlements, validating our observations with official measurements of pollution levels. In addition, we have studied the effect of highways through sampling of terricolous mosses. We have evaluated to which extent they are applicable in highly fragmented, Mediterranean landscapes, and analyzed how the persistence of lead in soils contributes to the differences in community composition.

Currently, we are extending our studies to a wider spectrum of moss species and contamination sources, such as car batteries and metal mining.

Detecting biological effects of air pollutants with sensitive organisms (lichens)

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We use sensitive organisms (lichens) to assess the biological effects of air pollution on the ecosystems, in particular around point sources of environmental contamination. Our purpose is testing and selecting physiological parameters and functional groups of lichen species suitable for bioindication purposes. Our research focuses on the estimation of the biological effects of air pollution from: 1) waste management strategies (incineration, landfilling, industrial composting), 2) use of renewable energy sources (geothermal energy), 3) cement production (quarries, cement plants), 4) urban environment (vehicular traffic, domestic heating), 5) agriculture (livestock farming, agricultural activities; nitrogen pollution), and environmental alterations linked to climatic stress, in particular in dry environments.
We investigate biodiversity, element bioaccumulation and physiological responses in native and/or transplanted lichens around point sources as well as in lab experiments. We also record physiological responses of sensitive/tolerant species treated under laboratory conditions with specific pollutants to foresee future changes at community level. In particular, at physiological level we deal with the damage endured by cell membranes (measured as electrolyte leakage), photosynthetic efficiency, measured as chlorophyll *a* fluorescence emission, chlorophyll degradation, overall viability assessed by the enzymatic activity of dehydrogenase, ergosterol and MDA production and the alteration of other secondary metabolites.
We are recently developing a method to use the variation of magnetic properties of lichens exposed to air pollution as biological indicator, in particular in connection to traffic emissions, landfills and cement production. All data support the use of lichens as a reliable and effective system to monitor the effects of air pollution at ecosystem level.

Guidelines to measure the impact of reactive nitrogen on ecosystems: the use of lichens as biomonitors under global change

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When deposited in natural and semi-natural ecosystems, excessive reactive nitrogen has negative effects on biodiversity and cascading impacts on ecosystems functioning. It is therefore critical to recognize and even anticipate these effects. However, the available monitoring stations are clearly insufficient to properly characterize nitrogen deposition in space and do not provide a measure of impact on ecosystems, nor do the modelling approaches. We have used ecological indicators to solve these problems, focusing on atmospheric ammonia. Of all extensively monitored organisms, lichens were shown to be amongst the most sensitive to nitrogen and can be regarded as early-warning tools, anticipating sudden and sometimes irreversible effects on ecosystems. We present here our research lines on the establishment of guidelines to the use of lichens on monitoring the effects of nitrogen on ecosystems.

We have used measures of lichens nitrogen concentration and isotopic composition to map nitrogen pollution on several spatial scales and to identify nitrogen sources in areas where multiple sources of reactive nitrogen are located, including industrial and agriculture ones. These works were based on spatial explicit analyses that were required to reply questions on the where and what nitrogen sources were found. We have also used lichen diversity to establish the threshold concentration that aims at protecting ecosystems, the critical levels (for nitrogen atmospheric concentration) and critical loads (for nitrogen deposition). Although lichen richness has been used to monitor the impact of industrial pollution, nitrogen was shown to have more subtle impacts. Thus our approach was based on the use of functional response groups, and was very successful in determining thresholds for Mediterranean ecosystems on a number of different situations and spatial extends, including large regions where multiple pollutants were present, including NO_x and other typical Mediterranean pollutants such as dust. This type of indicators has the potential of being universal, as although species may change across biomes, functional groups will not. Further work includes the importance of climate and historical background on the effect that excessive nitrogen has on ecosystems.

Building a giant army of tiny soldiers for farming in the Mediterranean

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One of the major challenges of this century is to meet requirements for food and feed of a growing population (food security) while decreasing the environmental impacts of production (environmental sustainability). Within the European Union, the Mediterranean Basin is the principal area for the production of fruit and vegetables, and also a biodiversity hotspot threatened by nitrogen (N) pollution, resultant also from the intensification of agriculture.

The productivity of most systems, including agricultural systems, is limited by the availability of phosphorus (P) and N. As such, maximizing the role of plant–microbe interactions in governing the availability of these nutrients will enhance the economic and environmental sustainability of agriculture. A major cause of agricultural pollution is crops' low efficiency in using fertilizers, with the 'lost' nutrients polluting the environment and affecting the receptor ecosystems. Within the European Union alone, the impacts of the N losses have been estimated at €70–320 billion per year.

The N losses occur primarily due to nitrification so that inhibiting nitrification is a priority. Improvement can also be made by manipulating rhizospheric microbial communities which help reduce costs and increase environmental sustainability. Long-term management of soil fertility due to agricultural practices influences the mycorrhizal symbiosis and may change mycorrhizal benefits to plants, namely N and P gains and increased resistance to water stress and pathogens. Soil microorganisms may have other important indirect roles because they interact and regulate plant and microbial functionality and performance. Therefore we focus on understating what drives:

- More competitive root systems;
- Effective microbial auxiliary communities adapted to crops and soils; and
- Efficient inhibition of nitrification and thus reduction of greenhouse gases emissions.

We gather a team of: i) microbiologists specialized in soil ecology and inoculants; ii) biologists with extensive experience on the impacts of agriculture on ecosystems; iii) a strong connection with industry and the productive fabric through the participation of companies; and iv) a strong connection with agricultural enterprises and associations of producers. By covering plant and soil interactions and their end-users we hope to deliver means that enable the farmers to produce more polluting less.

La Castanya (Montseny): a long term atmospheric deposition site for the study of effects to forested catchments

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La Castanya Biological Station in the Montseny mountain range started as site for biogeochemical studies in 1979. Since then and until today precipitation chemistry has been measured with the aim of: 1) tracking the effects of pollutant emission changes in rain chemistry and deposition, and 2) studying the contribution of atmospheric deposition to the biogeochemistry of the forest ecosystem. Throughfall, litterfall, litter decomposition, soil water chemistry, soil chemistry and streamwater chemistry and fluxes were also measured for shorter periods within this long-term span. Structural characteristics of the forest, such as aboveground and root biomass and mineralomasses, net primary production, LAI, basal area have also been determined. This provides an excellent ground for the study of the effects of air pollution and climate change on unperturbed forest ecosystems in the Mediterranean area.
La Castanya site is 40 km distant from Barcelona. Comparisons of deposition fluxes and exposure to pollutants have been made for holm oak forests lying at different distances from the Barcelona metropolitan area and have shown differences related to pollutant exposure.
Total N deposition in Montseny is in the range 15-20 kg N $ha^{-1}y^{-1}$, well above threshold values (e.g. 10 kg N $ha^{-1}y^{-1}$) reported as starting nitrogen saturation symptoms in forest ecosystems in Europe. One symptom of N saturation is the increase of nitrate leaching through the drainage waters. A comparison of streamwater chemistry surveys in undisturbed catchments in Montseny carried out during 1981-1984 and in 2007 showed higher nitrate, alkalinity, and base cation streamwater concentrations in the recent survey, and lower sulphate concentrations. This likely reflects changes in atmospheric deposition, though the effect of increasing temperatures (leading to accelerated weathering rates and thus higher alkalinity and base cations) may also have a role.

Measurement and modelling of pollutant dry deposition to semi-natural Mediterranean ecosystems

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The research group "Contamination of agrosystems by agricultural practices" of the Technical University of Madrid focuses on the environmental impacts of agricultural management and strategies to mitigate these impacts. One of the lines of research of the group is the measurement and modelling of dry deposition of air pollutants, with a special focus on ammonia emitted by agricultural practices.

Measurement techniques used by the group range from low-cost deposition flux measurement systems that can be installed in remote locations without the need for mains power to state of the art continuous gradient and eddy covariance flux techniques. A low-cost deposition measurement system has been used to measure mean monthly dry deposition fluxes of ammonia and nitric acid at a semi-natural grassland site 40 km north of Madrid during a period of more than a year as part of the European project NitroEurope and regional project Agrisost. These results provided the first estimates of ammonia and nitric acid deposition to a Spanish semi-natural ecosystem. As part of the ÉCLAIRE European project the group has made intensive measurements of dry deposition of ammonia and ozone to a semi-natural grassland site near Madrid using gradient and eddy covariance techniques. The results of these intensive measurements provide detailed information that can be used to model and understand the deposition processes for this type of Mediterranean ecosystem.

The group is also involved in the European deposition modelling work of the ÉCLAIRE project and is the coordinator of the work package looking at the uncertainty of the nitrogen deposition estimates output from European modelling activities (from the EMEP model). Specifically, the group is coordinating the work analysing the uncertainty in the European deposition estimates as a result of the coarse spatial resolution used by the European modelling. The group is also coordinating the activity developing methods to improve the spatial resolution of concentration and deposition estimates of the EMEP model using sub-grid estimation techniques.

Latitudinal change to Ozone sensitivity in *Quercus ilex* L. across its latitudinal range

A. GARCÍA-NOGALES[1], D. VÁZQUEZ-HIDALGO[1], B.VIÑEGLA[2], J.G.P. RODRÍGUEZ[1], J.C. LINARES[1], J.I. SECO[1], J. MERINO[1]

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Holm oak (*Quercus ilex* L.) is one of the most representative evergreen tree species of the Mediterranean Basin landscapes. Its wide latitudinal range (from Southern France to Southern Morocco) includes a variety of soils and climates which results in a diversity of habitats characterized by different degrees of stress. Populations native to the boundaries of the range might exhibit an higher endurance to stress owing to the more extreme abiotic conditions in those habitats. On this line, we are testing the hypothesis that individuals of *Q. ilex* native to the borders of its range are more resistant to Ozone fumigation than those native to the core of the range.

We collected acorns from 6 populations of *Q. ilex* across the range of this species; from North Spain to South Morocco. Potted seedlings were grown in controlled growth chambers in a 80 ppb ozone atmosphere, and in free ozone air conditions. The experiment lasted for 120 days. We analyzed the seedling response to the ozone treatment by considering morphological, gas exchange and fluorescence variables.

Results so far show that populations differ in both gas exchange and fluorescence variables, and also in their response to ozone treatment. Thus, individuals native to the boundaries of the range had both, lower photosynthetic rate and capacity; and expend more energy in processes other that growth and reproduction (i.e., maintenance).

The global effect of the ozone treatment was a decrease in the photosynthetic rate, conductance and photosynthetic capacity, a loss of efficiency of the Photosystem II and an increase in the amount of energy dissipated as heat (NPQ). In the most of the cases, the patterns of response to treatment were associated to latitude; with populations native to higher latitudes being generally more resistant to ozone. Besides, the two populations native to the range boundaries did show the lowest decreases in both, internal CO2 concentration and Water Use Efficiency, reflecting higher capacity for regulating the fine mesophyll-stomatal apparatus relationships when plants were fumigated. These results suggest that boundary populations are more resistant to ozone than core ones.

Ozone fluxes and epidemiology of ozone injury to forests

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Although tropospheric ozone is an important greenhouse gas and phytotoxic air pollutant, quantification of its effects on real-world forests is challenging. Ozone, in fact, is a strong oxidant and does not accumulate in the environment. Effects on forest indicators are thus aspecific. In addition, effects depend on the amount of ozone entering through the stomata (flux) rather than the amount of ozone in the air (exposure). Epidemiology is the study of patterns, causes, and effects of diseases. Large-scale epidemiological investigations focused on ozone impacts on plant indicators may provide a quantitative assessment of ozone injury. A complication is that ozone co-varies with beneficial (air temperature, solar irradiation) and detrimental (soil water stress) factors. Most of the previous epidemiological evaluations of the environmental impacts of ozone focused on ozone exposure only. We report here novel results from cross-comparing of soil, meteorological, ozone and plant databases for Italian and French forests, where stomatal ozone fluxes were investigated. The results were obtained within the FO3REST Life+ ENV/FR/208 project.

Adapting Mediterranean forests to climate change and ozone

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Ground-level ozone (O_3) is an important atmospheric pollutant, a pressing sanitary problem for human and ecosystem health, and a serious climate forcer. The European region at highest O_3 risk is the Mediterranean area. Indeed, the climate change is expected to be more pronounced in the Mediterranean Basin than in most other regions of the world. In the Western European Mediterranean area, we demonstrated for the first time that the ozone control measures are effective at rural sites, while O_3 levels are still increasing in the cities over the time period 2000-2010. This result is challenging the traditional knowledge about O_3 pollution.

To date, most experiments to establish biologically relevant plant responses to ozone have been performed under controlled conditions, not representative of actual field conditions, and the results may not provide realistic results for developing standards. An assessment based on phytotoxic ozone dose (PODY) and on real plant damage is more appropriate. The LIFE+ FO_3REST project allows testing the current exposure-based critical levels (AOT40) and suggesting new ozone flux-based critical levels for Mediterranean forest protection against ozone pollution. A field survey of ozone-induced symptoms was carried out (ICP-Forests protocol) in 54 plots in Southeastern France and Northwestern Italy. Stomatal ozone fluxes were modelled and correlated to real-world forest impacts in terms of visible injury (stippling/mottling, crown discoloration and leaf loss) in 2012 and 2013. The indicators POD0 and POD1 were calculated thanks to the DO3SE model using the available parameterization for Mediterranean and continental deciduous broadleaf forests and conifers. Spearman test was carried out to understand the relative contribution of O_3 (concentrations or stomatal uptake) to visible injury occurrence. From the flux-effect relationships we derived and proposed new flux-based critical levels CLef for forest protection. In a climate change context, with information in hand, policymakers can make decisions about new legislation for air pollution control strategies in Europe.

Ecotoxicology of Air Pollution Research Group- CIEMAT

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The Ecotoxicology of Air Pollution research group of CIEMAT has more than 20 years of experience studying the effects of air pollution on ecosystems and agrosystems. The main research interests are the effects induced by tropospheric ozone (O_3) and atmospheric nitrogen deposition, two of the main drivers of the global change in Mediterranean areas. Effects are characterized from cell to ecosystem level on crops, trees and pastures, highlighting the effects on plant physiology, growth development and ecosystem services and the interactions with other stresses such as drought, nutrition and pathogens. The group was pioneer studying O_3 induced effects in Spanish horticultural crops in the early 90s. The group set up the first Open Top Chamber (OTCs) experimental field in Spain in the late 80s, specifically designed for studying air pollutant effects on vegetation. Recently, this facility has been relocated and improved.

In the last years, the group has established a new experimental area to analyse atmospheric N deposition on a Holm oak forest located close to Madrid City (Tres Cantos). This facility is part of a small network of 3 Holm oak forests in Spain analysing N deposition and effects under different soil and climatic conditions as part of a national funded project. Gases and particle concentration, meteorology and soil water availability are continuously monitored inside and outside the forest to estimate atmospheric-plant-soil fluxes and effects. Also air pollutants are being monitored in the mountain area of Sierra de Guadarrama, recently incorporated in the National Park network.

One of the key aims of the Group is linking science with policy. In this sense, the experimental results are combined with models to perform pollution risk assessment for the Mediterranean area, under the framework of the United Nations Convention on Long-Range Transboundary Air Pollution (UNECE/CLRTAP). The CIEMAT team has contributed to the definition of critical levels and loads of ozone and nitrogen for the protection of Mediterranean vegetation and ecosystems and to assessing the effects of air pollution on ecosystems services such as biodiversity or food security. These activities are supported by the Spanish Ministry of Agriculture, Food and Environment. Currently the Group participates in several national and European research projects aiming to understand the impacts of air pollution on vegetation and to identify the co-benefits in combating air pollution and climate change. Also the role of peri-urban forests for improving the environmental quality in cities is being assessed.

Impacts of atmospheric nitrogen deposition on (semi-)natural ecosystems: an overview

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The effects of increased atmospheric nitrogen deposition, from both NO_y & NH_x, on structure and functioning of semi-natural and natural ecosystems of conservational value are reviewed. Besides direct toxicity, long-term nitrogen enrichment may gradually increased the availability of nitrogen in several vegetation types leading to loss of biodiversity. Soil acidification is especially important after nitrification of ammonium in weakly buffered environments. In addition, negative effects of reduced nitrogen (ammonium/ammonia) may also affect the floral composition of the community. The susceptibility of vegetation to secondary stresses or disturbances (pathogens & pests; frost & drought) may be affected by air-borne nitrogen pollutants but the relevant data are absent for most situations. The sensitivity of various (semi-)natural ecosystems to N deposition will be treated in detail for species-rich grasslands, heaths and forests. Most data were obtained in boreal and temperate parts of Europe, but in the recent decade several studies are showing the impacts of atmospheric nitrogen depositin in Mediterranean Europe, too. Finally, it is concluded that it is crucial to control emissions of N compounds to the atmosphere, in order to reduce or prevent effects on diversity in sensitive systems across Europe.

"Mediterranean" is different; in terms of ecosystem responses to N deposition too! Understanding why through temperate-like relic, circum-Mediterranean fir forests

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Current biogeochemical theory on the consequences of N deposition in forest ecosystems has mainly developed from studies on temperate regions. However, research on the issue in Mediterranean regions is scarce and strongly biased toward Californian. Nevertheless, these limited studies point out to remarkable singularities in the way Mediterranean ecosystems respond to N deposition (eg, leaky N-cycle and high nitrification under relatively low N inputs even in aggradative forests), which do not easily fit within prevalent conceptual models on N saturation. Atmospheric N inputs are expected to increase in some Mediterranean regions in the coming decades. In order to better assess N critical loads, forecast impacts and develop mitigation strategies for Mediterranean ecosystems, we urgently need to improve our understanding of the mechanisms underlying this "Mediterranean oddity". For this task, an ideal approach would be to apply "Mediterranean seasonality" treatments to N-saturated temperate forests, to check responses. As a surrogate of this disparate experiment, we employ relic, circum-Mediterranean conifer forests. They represent remnants of temperate/boreal forests, more widely distributed in the Tertiary, that became isolated at high altitude, N-facing slopes of coastal mountains, forced by Quaternary glacial cycles and "Mediterraneization" of climate in the Mediterranean basin. Despite mean annual rainfall and temperature in the range typical for temperate regions (1000-2000mm; 9º-12ºC), climatic conditions in their current locations are "Mediterranean" regarding seasonality and long summer droughts.

We have mainly focused on *Abies pinsapo*-fir forests, endemics from southern Spain (west-Baetic range), where an N deposition geographic gradient exist around the industrialized area of Campo de Gibraltar. We are now extending our studies to *Abies pinsapo* and *Cedrus atlantica* forests in northern Morocco, and planning to expand to other relic conifer mountain forests near industrialized and/or heavily urbanized areas (eg, *Pinus sylvestris*, Sierra Nevada, Granada, Spain; *Abies cephalonica*, Athens, Greece). In our studies, we compare stands along N deposition gradients in terms of biogeochemical budgets (bulk deposition, throughfall, soil leaching and stream water chemistry), N saturation indicators in soils (N pools and fractions, microbial N mineralization and inmobilization, nitrification and denitrification) and vegetation (N and aminoacid profiles in tissues, N use efficiency in physiological processes, differential gene expression/N metabolism), including ^{15}N natural abundance. We have also performed nutrient-addition experiment at plot and stand scales, using ^{15}N-labelling to track the fate of added-N. Finally, we have examined the role of N and P interactions in the development of the N saturation syndrome (P limitation in trees induced by chronic N deposition, remediation management through compensatory P fertilization).

Integrating the impacts of N pollution on the structure and functioning of Mediterranean ecosystems

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Increased nitrogen (N) availability affects ecosystem stability at local and global scales and is transforming the way we deal with N, i.e., it is changing from being a limiting nutrient to a pollutant. Little is known about the effects of N deposition on Mediterranean Basin ecosystems, which have experienced intensive human development and impact for millennia, and where N deposition is expected to increase threefold by 2050.

Many studies have addressed single aspects of the impacts of N pollution on Mediterranean ecosystems: anthropogenic N deposition, changes in species diversity, impact on soil-atmosphere gaseous fluxes, NO_3^- leaching, soil microbiology and organic matter decomposition, etc. However, the impacts of driver changes across European Mediterranean ecosystems are poorly understood and have been hampered by a lack of integrated system-level studies. Therefore our aim was to develop an integrated system-level approach to study the responses of nutrient poor Mediterranean ecosystems to increased N availability. Specifically we focus on the cascading interactions between structure and functioning of above- and below-ground communities to understand whether:

- Changes in N dose and form affect N biogeochemistry and biodiversity;
- Alleviating N limitation may exacerbate other limitations (e.g. phosphorus and water);
- Changes in ecosystem structure translate into changes in ecosystem functions and services; and
- These structural and functional changes can be related to land use.

We have been applying two complimentary approaches to answer these questions, by focusing on an N gradient and an N-manipulation field experiment located in southern Portugal. Identifying structural and functional indicators of increased N availability and refining the N critical loads for Mediterranean ecosystems is a major goal of our research, thus putting our science at the service of society, in general, and policy makers, in particular.

Effects of reactive nitrogen on the health condition and the biodiversity of forest areas

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The overall objective of our group is to address the problem of reactive nitrogen (Nr) in a comprehensive and integrated perspective, identifying the hazards associated with the excess of Nr and promoting a set of measures to help reducing their impact on the natural environment. To that end, we are involved in several projects where we try to determine the levels and sources of Nr in the ecosystems at local, regional and global scale. Since 2005, when we joined the *International Cooperative Programme on Integrated Monitoring of Air Pollution Effects on Ecosystems (ICP IM)*, being currently the National Focal Point in Spain, we have been studying the effect of atmospheric pollutants on forests health. The intensive monitoring carried out in different forest plots over the last years has allowed us to study the effect of N deposition and its interaction with other pollutants such as ozone and particulate matter on the forest ecosystems. Such a massive information has also enabled us to estimate the critical loads of Nr in different ecosystem types and use these data for the reparametrisation of the existing models for Mediterranean conditions.

Another important aspect of our research is the study of the effects of Nr over biodiversity. To that end, our group is currently involved in several projects focus on studying the evolution of Nr over time and its effect on the changes in biodiversity at different scales. From a local point of view, several areas located in the vicinity of N hot-spots, like pig farms and heavily-trafficked areas, are being intensively monitored to establish a deposit gradient that allows us to relate changes in biodiversity to Nr concentrations and also determine the empirical critical levels for forest protection with respect to Nr environmental levels. At the same time, several attempts to relate the observed and modelled changes in atmospheric Nr to biodiversity databases are being carried out in order to determine the effect of Nr over biodiversity and predict its future evolution in ecosystems with a high ecological value (Nature 2000).

Finally, GHGs soil fluxes have been periodically analysed in the monitored forest plots to quantify the contribution of Nr to global warming and their interaction with carbon sequestration.

Nutrient Network: some initial results and getting involved

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Nutrient Network (NutNet: http://www.nutnet.umn.edu/) is a global research co-operative with scientists from all over the globe working on the interactions between nutrient addition and grazing in herbaceous systems. This co-ordinated research network consists of the same experiment run in over 40 sites worldwide and collecting a range of data on plants and soils.
The aims of the Nutrient Network are as follow:
1. To collect data from a broad range of sites in a consistent manner to allow direct comparisons of environment-productivity-diversity relationships among systems around the world. This is currently occurring at each site in the network and, when these data are compiled, will allow us to provide new insights into several important, unanswered questions in ecology.
2. To implement a cross-site experiment requiring only nominal investment of time and resources by each investigator, but quantifying community and ecosystem responses in a wide range of herbaceous-dominated ecosystems (i.e., desert grasslands to arctic tundra).
The Nutrient Network is keen to expand and get more sites in the Mediterranean region. I will describe the network and how to get involved.
Scientists within the network are addressing a wide range of ecological questions and recent work has included a focus on the relationship between atmospheric nitrogen deposition and vegetation productivity. I will present results from this investigation which show that globally nitrogen deposition is an important driver of vegetation productivity, explaining as much variation in productivity in herbaceous systems as climate does.

You are NOT what you eat: the hopeless lack of homeostasis in N/P stoichiometry under chronic N deposition in *Abies pinsapo* forests

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Although N deposition may increase forest primary production in the short term, it can lead to the forest decay associated the N saturation syndrome when deposition becomes chronic. Under these conditions, changes in nutrient stoichiometry are promoted, resulting in a shift in the primary limiting nutrient, from N to P. Several studies developed in temperate regions have already described the relationship between high N deposition rates and P deficiencies. However, studies in the Mediterranean region are really scarce despite its singularity in the way Mediterranean ecosystems respond to N deposition, which does not easily fit in the accepted N saturation paradigms.

In order to evaluate the applicability of N saturation models in Mediterranean ecosystems we have focused on *Abies pinsapo* fir forests, an endemic temperate-like species subject to the Mediterranean seasonality, where an N deposition geographic gradient exists around the industrialized area of Campo de Gibraltar.

Our main goal has been to perform a diagnosis of the nutrient stoichiometry in the trees in order to evaluate unbalancing nutrient contents reflecting N saturation and P limitation. We have compared forest stands close to the N source (N saturated) vs. stands located further from the source (N limited). Besides, we have developed a compensatory P fertilization experiment to show up the role of N and P interactions in the development of the N saturation syndrome and P limitation in trees and to evaluate the alleviation of the N saturation symptoms and the eventual retrieval of primary production.

In this sense we have evaluated the response of trees from stands along a deposition gradient and under the P fertilization treatment at several hierarchical levels: *i*, the genomic level, examining differential gene expression, *ii*, the biochemical level attending to the accumulation of amino acids as a detoxification mechanism and the N/P content in the different age needles (up to 5 years), and *iii*, the ecohpysiological level, evaluating photosynthetic rates and N and P photosynthetic use efficiency.

Due to the high longevity of *A. pinsapo* needles we have extended the evaluation of the N/P relationships in up-to-15-years-old needles, including the evaluation of needle functional traits and the fate of N by means of the addition of ^{15}N in different needle cohorts, and have made a comparison with *Pinus pinaster* trees located in the same places and with much lower needle longevity, in order to reveal the different strategies of both species under N saturation.

A nitrogen addition experiment in a coastal Mediterranean Ecosystem

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Understanding how CO_2 fluxes from the different components of the ecosystem (soil, below and above ground biomass, and the biological crust) respond to meteorological variables is becoming crucial to accurately predict how ecosystems will be affected by global change. Eddy covariance technology, coupled with ancillary measurements, is perhaps the most reliable approach to reach this goal, however at global scale, only few research groups are monitoring ecosystem level CO_2 and energy fluxes in Mediterranean shrub ecosystems. Since 2005, one of these study sites is located in a coastal area in north-west Sardinia and it is currently being implemented to fulfil the standards fixed by the ICOS network.
The study site is characterized by the dominance of *Juniperus phoenicae*, which accounts for about 53%, while other shrubs account for another 27%. The remaining 20% is bare soil with a well developed biological crust.
In April 2012 a nitrogen (N) addition experiment was set up close to the site in order to study its effects on ecosystem functioning. Special attention is given to N effects on CO_2 fluxes (soil, leaf photosynthesis and respiration), and on carbon allocation (leaf and roots). Eight plots of 36 m^2 were traced in order to systematically include at least one entire plant of *J. phoenicae* and a portion of bare soil. Four of the plots are periodically treated with 7.5 kg N ha^{-1} at the beginning of each season.
Soil CO_2 fluxes are measured monthly over six collars placed in each plot (3 in the bare soil and three in the under canopy). Leaf level photosynthesis and respiration are being measured since June 2014.
To determine the N effect on the carbon partitioning, shoot elongation, leaf biomass to shoot diameter ratios, and litterfall, are all being periodically measured since April 2012. Fine root turnover and litterfall decomposition rates are planned to start in spring 2014.
An additional and independent experiment focuses on how community composition and drought affect plant N uptake of twelve Mediterranean species. The experimental design includes a species richness (SR) gradient (1, 2, 4, 6) and three levels of functional diversity (FD) for each SR level. Hypothesis is that N use increases in efficiency at higher (FD) as a result of niche complementarity and that the effect is stronger at low water availability.

The role of living organisms as modulators of the response of arid ecosystems to climate change and N deposition

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Global environmental change (GEC) will have major impacts on the functioning of biotic communities, and will foster important changes in their current composition and diversity. Given that crucial ecosystem functions and services, such as productivity, nutrient cycling and carbon storage, depend on biodiversity, biodiversity losses associated to GEC, are predicted to be accompanied by yet further extreme ecological events and potential catastrophic shifts in natural ecosystems. However, large uncertainty exists about how GEC-induced alterations in the composition and diversity of biotic communities will impact ecosystem functioning and the ability of ecosystems to provide goods and services. This is particularly true for terrestrial microbial communities, as we are only starting to understand the role that environmental factors play in determining their abundance, distribution and diversity.

Our group aims to understand how multiple biotic communities (vascular plants, biocrusts and microbial communities) modulate the impacts of two major GEC drivers (climate change and N deposition) on ecosystem functioning in drylands at multiple spatial scales (from local to global). Drylands, highly sensitive to GEC, extent globally and in Spain cover two thirds of the territory, and the dependence of an important part of the human population on them for goods and services, makes crucial to understand how drylands may be affected by GEC and, more specifically, to know how their biotic communities will modulate ecosystem responses to GEC: i) To evaluate the composition and diversity of soil microbial communities in global drylands,

ii) To determine the relative importance of microbial and plant communities and abiotic factors as drivers of ecosystem multifunctionality in drylands at regional and global scales,

iii) To test how climate change- and N deposition-induced changes in biocrust and microbial communities affect key ecosystem processes related with nutrient and with the exchange of trace gases between the soil and the atmosphere, and

iv) To assess how soil biotic legacy effects of climate change affect vascular plants and ecosystem processes, as well as the resistance and resilience of soil microbial communities to climate change.

For doing this we propose the use of different experimental approaches, multiple biotic communities and spatial scales to test the same core ideas, to allow wider generalizations of the results obtained.

Functional diversity under changing environments: impacts on ecosystem services

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Mediterranean drylands are one of the most vulnerable ecosystems in the face of global change. Particularly, climate change (e.g. air pollution) effects ecosystem structure and functioning constitute a serious threaten to the goods and services they provide. Thus, it is urgent not only to identify the different drivers of ecosystem services, but also to assess how they are affected by environmental changes. In this context, functional diversity has emerged as a key concept in ecological research, since it links the range, variety and abundance of functional traits at the community level to their effects on ecosystem processes, and thus, on ecosystem services delivery. In dryland ecosystems, terricolous lichens, mosses, and cyanobacteria forming "Biocrusts" can be on one of the most abundant life forms. They play important roles in multiple compartments of global system (e.g., atmosphere, pedosphere, biosphere), and also in the interaction between them. However, their functional diversity and contribution to ecosystem services have been understudied. The project "Functional diversity of Biocrusts: towards ecosystem services quantification in drylands" ("BCSES"), focuses on Biocrust communities aiming to disentangle the effects of their functional traits and functional diversity on ecosystem processes. We will study Biocrusts multifunctionality along environmental gradients in drylands worldwide, including the Mediterranean region. After that, we will have a more precise measure of the critical functions they perform in drylands and how they respond to environmental factors (e.g. climate). The final objectives of the project are to quantify the contribution of Biocrusts to ecosystem services in drylands by modelling the distribution of functional units and assess the potential impacts of environmental changes on the services they provide. This knowledge will complement and improve the scope of management, conservation and restoration strategies in the face of global change, traditionally focused on species diversity, rather than functional diversity, and regarding vascular plants almost exclusively.

Linking plant functional diversity to the provision of ecosystem services in Mediterranean drylands

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Mediterranean landscapes are the result of a long history of anthropogenic and natural disturbances. A remarkable example is the agro-silvo-pastoral system of Holm-oak (*Quercus ilex* L.) woodlands (*montado*) which occupy large areas in southern Iberian Peninsula. However, these areas are increasingly being affected by desertification and land degradation processes, which cause biodiversity loss, affecting the provision of critical ecosystem services. The human-pressure in these areas together with the expected climatic change scenarios (e.g. changed precipitation patterns) can further enhance these processes, requiring urgent monitoring actions to timely prevent and/or reverse their effects.

The impact of global change factors on ecosystems has been frequently evaluated through plant species richness. However, the monitoring of such impacts requires an understanding not only of the dynamics of vegetation change but also of the underlying ecological processes. Therefore, ecosystem monitoring should consider the diversity of species traits in addition to species diversity, since they are the key drivers of ecosystem processes and resilience. Functional traits of organisms have large impacts on the magnitude of ecosystem functions (e.g. productivity, water and nutrient cycling, decomposition), and thus quantifying functional trait diversity and linking it to ecosystem processes is a rapidly expanding area of research.

Our research has been focused on the study of plant functional diversity along a desertification gradient in Mediterranean Holm-oak woodlands, aimed at modeling its relation with ecosystem functionality and provision of services. We further use this functional approach (i) to early-detect the effects of climate change and desertification; (ii) to better predict ecosystem future trajectories; (iii) as a tool to plan management strategies and ecosystem restoration actions (and improve its cost-effectiveness). We believe it can greatly contribute to mitigate global change impacts, increase biodiversity and improve the provision of ecosystem services in Mediterranean areas.

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Ecological impacts of increased nitrogen deposition in semiarid Mediterranean Spain

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The current and potential impacts of nitrogen deposition on semiarid Mediterranean ecosystems of Europe are still poorly characterised. Since 2007, our group uses a combination of controlled (greenhouse and field experimental conditions) and observational studies to evaluate and predict the impacts of increased nitrogen deposition, alone and/or in combination with alterations in rainfall patterns, on the structure and functioning of grasslands, shrublands and forests from the semiarid portions of Spain. We are particularly interested in how direct responses at the soil (nutrient availability, microbial community composition, and enzyme activities related to the main nutrient cycles) and biocrust/plant levels interact with each other (indirect responses) to produce changes at the ecosystem scale (for example, the ability of semiarid ecosystems to store extra carbon and nitrogen). Our research also focuses on the identification of suitable indicators of increased nitrogen deposition, particularly through the evaluation of enzyme activities measured in widespread species of biocrust-forming mosses and lichens (in particular, *Pleurochaete squarrosa* and *Cladonia foliacea*).

The field experiment started in October 2007 and has been continuously running until now. It is located in a rosemary-kermes oak shrubland close to Aranjuez (central Spain) and consists in 24 plots divided into 4 treatments (0, 10, 20 and 50 kg N ha^{-1} yr^{-1}) in a 6-block design. Main lessons from this experiment include the role of the environmental heterogeneity (both in space and time) on the response of semiarid ecosystems to increased nitrogen availability; this environmental variability (e.g., patchy distribution of shrubs and/or availability of micronutrients) often mediates the response of different elements of the ecosystem (e.g. biocrusts and plants) to simulated nitrogen deposition. We have also demonstrated that different forms of inorganic nitrogen (i.e., oxidised vs. reduced) can have different, even opposite, effects; for example, certain annual species can be negatively affected by increased ammonium availability in calcareous soils where nitrate is usually the dominant form of mineral nitrogen.

Future challenges for our group include the evaluation of the impacts of nitrogen deposition on semiarid ecosystems at the Basin-scale in order to find common patterns of response across a wide array of environmental gradients and to finally be able to predict the overall response of these areas to future increases in nitrogen availability.

Carbon storage in grasslands: the impact of atmospheric nitrogen pollution

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Human processes account for the conversion of more N_2 into reactive N than is produced naturally in the world per year. This has caused significant changes to the global N cycle, and has disrupted the sensitive nutrient balance of ecosystems worldwide. It is known that the C and N cycles are very closely linked. Soil is a major C sink, which makes it essential for climate change mitigation. By looking at the effects of N dose and form on the above and belowground C pools of acid grasslands, this project aims to further our understanding of how grassland soil can be managed as a C sink, and what processes should be prioritised when devising mitigation strategies for the effects of N on these systems.

In 2007, replicated N-addition experiments were set up on two species-rich, acid grassland sites; one in Trefor, North Wales, the other in Revna, Norway. Since then, N has been added in three doses (0, 35 and 70 kg N ha^{-1} yr^{-1}) and three forms (oxidised N, reduced N and a 50-50 combination). In 2013 and 2014, analyses of soil, aboveground biomass and gas fluxes were carried out to see if the treatments have had any effects on the amount of C stored in these grasslands.

Although preliminary analysis of the data collected so far does not show significant differences between treatments, some interesting patterns have emerged. In Wales, for example, the 50-50 combination treatments seem to be having a negative impact on aboveground biomass. This is not seen in Norway, where reduced aboveground biomass is only present in the reduced nitrogen treatment, an effect probably caused by increased acidity in these plots. In addition, the combination treatments have decreased the CN ratio of the vegetation at the Welsh site, potentially making litter in these plots more readily decomposable – an effect present in the oxidised and reduced treatments, but to a much lesser extent. Interestingly, although N addition seems to have led to some changes in the vegetation at these sites, no treatment effects were found at either site when soil C and N were analysed. There were also no changes in the C and N content of soil microbial biomass as well as soil at different depths. Further investigations such as organic matter fractionations and ingrowth cores will be carried out in order to build a better picture of what may be happening at these sites.

Ozone removal by a mixed oak-hornbeam mature forest in the Po Valley and related effects on net photosynthesis

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In the framework of the ÉCLAIRE Project of the 7th EU framework programme a joint field campaign and a following long-term one had been conducted at an Oak-Hornbeam mixed mature forest in the Po Valley (Bosco Fontana, Mantova, Italy). Inside the forest, a 42 m tall micrometeorological tower was installed to measure the mass (O_3, CO_2, H_2O) and energy exchange between the ecosystem and the atmosphere. The focus of this work will be on the ozone flux measurements which started in June 2012 and are currently running.
The ecosystem behaved as a relevant sink for tropospheric ozone, both in summer and in winter, with an average monthly ozone removal of 5.8 kg ha^{-1} and a total annual deposition of more than 70 kg ha^{-1}. The stomatal flux was estimated by deriving the bulk stomatal resistance through the inversion of the Monteith equation. The maximum stomatal fraction was observed in July 2013 (55%) and the minimum in October 2012 (13%). A strong interannual variability about the stomatal deposition between summer 2012 and 2013 was observed. The phytotoxic ozone doses taken up by the plants were respectively 13.5 mmol m^{-2} in 2012 and 29 mmol m^{-2} in 2013.
The non-stomatal deposition, obtained as a residual between the total and the stomatal ozone fluxes, was investigated too. In the joint field campaign Neimitz et al. (2013) found that half of the non-stomatal deposition, was due to NO soil emission, which were on average above 100 mg N m^{-2} s^{-1}. A minor part of the non-stomatal fluxes (6%) was attributed to isoprene reactions with ozone. A large part of the non-stomatal deposition (44%) was not explained. An investigation on this part, with particular attention on the deposition on non-transpiring surfaces, will be showed.
Additional measurements of O_3, NO and NO_2 concentrations along the tower profile, allowed to estimate the ozone storage inside the trunk space. The ozone storage can be seen as a part of the deposition flux which is temporarily stored into the trunk space. Taking it into account, the daily course of the non-stomatal deposition significantly changed, with important consequences for non-stomatal interpretation and for proper modelling of the non-stomatal processes.
An estimation of the ozone impact on the whole ecosystem was assessed by looking at the departure from the carbon dioxide balance closure. First results of CO_2 exchange seem to indicate a net emission of CO_2 from the ecosystem, as it should not be expected from a healthy mature forest ecosystem where, typically, the carbon balance is zero. Again, a general limitation of the net carbon uptake has been observed at high ozone stomatal fluxes.
Finally, the great differences observed in the two years highlight the need for long time series of flux measurements. Moreover, this kind of studies will help in raising the awareness of the policy makers on the ecosystem services offered by the vegetal ecosystems.

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Responses of *Abies pinsapo* Boiss to ozone in both field and growth chamber conditions

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Abies pinsapo is an endemic relict fir species native to Andalucía (Southern Spain) where it forms almost monospecific forests. Following the last glacial period, it got isolated in wet mountains (in between 1200 and 1800 m o.s.l.), but subjected to the drought constrictions of a Mediterranean-type climate. Proximity to sources of air pollution (industrial factories of the Bay of Algeciras) raises the possibility that these forests are subjected to the effect of oxidizing gases. Our mail goal is to elucidate the main determinants of *A. pinsapo* sensitivity to ozone.

The study combines field (adult trees) and lab (seedlings) analysis including forest atmosphere quality (O_3), leaf and plant structure, and gas exchange variables.

Four years old seedlings were grown at low light intensity (150 μE) to mimic seedling habitat, and fumigated during three months (six hours per day) in controlled growth chambers at 0 ppb, 150 ppb and 250 ppb air ozone concentrations.

Seedlings appear to be quite resistant to treatment. Thus, seedling gas exchange parameters remained undisturbed, through the first month (150 ppb treatment), while underwent only a 35% decrease in the strongest treatment (250 ppb). Observed decreases were associated to losses in photosynthetic capacity, chlorophyll concentration and stomatal control (the last in the strongest treatment only). By opposite, leaf structure was very sensitive to O_3 treatment in both seedlings (lab) and mature trees (50 ppb in field conditions). Discrepancies between physiological and structural responses appear to be related with both, dissimilar sensitivity of specific physiological processes to O_3, and light intensity differences in field and lab conditions.

From the methodological point of view, the results warn about the danger of using single indicators (for example: gas exchange parameters), or particular growth conditions (for example, growth chambers) to quantify the effect of a pollutant.

Measuring the impact of dust deposition in a mixed landscape: the role of vegetation in ameliorating its effects

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Particulate matter pollution is a major human health concern, interfering with respiratory tract, or acting as conductor to absorption of toxic substances like heavy metals (HM). HM are persistent in the environment and subject to bioaccumulation in food-chains. They are known to have adverse effects on the environment and human health. In the Mediterranean region, due to its bio-climatic characteristics, particulate matter pollution has an exceptional importance. High temperatures and low precipitation during summer hinder rain scavenging and promote dust resuspension, while intense insulation supports photochemistry and secondary aerosol formation.

Air quality assessment based on instrumental monitoring is highly accurate and provides high temporal resolution, but, besides expensive has a very little spatial relevance. However, a high spatial resolution is important, especially in the Mediterranean areas, where areas with high population density are mingled with dust pollution sources. In order to overcome these problems and to provide maps of HM deposition, we have been using lichens as ecological indicators, more specifically as bio-accumulators. Lichens, symbioses of fungi and algae, are long-lived, slow growing organisms. Having a simple anatomy (without waxy cuticle, stomata and root system) and a large surface area to volume ratio, lichens rely directly on atmospheric deposition for nourishment. Thus, lichens thus readily trap and accumulate pollutants, both from wet and dry deposition. To map the impact of dust deposition caused by heavy metals for each type of land-use we choose a large area in central Portugal (20km x 20km) with industrial land-use, mainly cement plants and glass industry associated with small to medium urban areas, important roads and a large area of forest plantations. We showed that the concentration of HM in lichens is associated with atmospheric dust deposition in the region produced in industrial, urban areas and roads. With this information we could provide maps with high spatial resolution showing the deposition of HM and the critical areas where mitigation or adaptation measures are important. This analysis also revealed the importance of forests in reducing HM concentration, suggesting their role as sinks of HM at the landscape level.

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Posters

Is it possible to estimate atmospheric nitrogen deposition by analysis of terrestrial mosses?

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Mosses are considered to act as an integrator of the contaminant load that they receive, take up pollutants due to biological characteristics such as the absence of a protective cuticle and the lack of roots, and provide quantitative values reflecting levels of atmospheric deposition. These features make mosses suitable candidates to be biomonitors of air pollution. However, mosses are a diverse group of plants with over 10,000 described species worldwide which exhibit a wide variety of life forms and biology.

As a bryophyte ecophysiologist, I have been studying the physiological responses of mosses to nitrogen (N) deposition in different types of ecosystem. My experience shows that mosses cannot be considered as a single functional group with respect to their response to N deposition, and thus that a moss species should not necessarily be expected to be a good biomonitor of atmospheric N deposition just because it belongs to this group of plants. In this paper, I will illustrate this finding by comparing species of bryophyte within three ecosystems. In this paper, I will discuss why two common mosses of European grasslands, *Pseudoscleropodium purum* and *Rhytidiadelphus squarrosus*, significantly differ in their suitability to be biomonitors of N deposition, as a result of their biological differences. I will explain how the substrate type preference of *Braunia secunda*, a common moss found in tropical mountain forest in Mexico, renders this moss a better bioindicator of N deposition than other co-occurring moss species, such as *Thuidium delicatulum* or *Leptodontium viticulosoides*. Finally, I will show that in semiarid Mediterranean ecosystems, the moss *Pleurochaete squarrosa* is a better predictor of N deposition than the lichen *Cladonia foliacea*, because of its physiological response to N loads. In addition, I will discuss the problem of nitrogen saturation that occurs in certain variables, such as N% in moss tissue, and consider how the measurement of a suite of selected physiological variables may reduce this problem in areas with high N loads.

I conclude from my experience that, within mosses, efficacy as a biomonitor of N deposition is species-specific. Therefore, preliminary studies are recommended in order to select a suitable species before going on to conduct biomonitoring studies of atmospheric nitrogen deposition.

Desiccation tolerance mechanisms under climate change scenario

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Water is the most important element for life. During land invasion, the first plants had to face an extreme dry environment, undergoing desiccation, a process in which tissues virtually lose almost all water. Therefore, plants developed desiccation tolerance mechanisms through which they could experience the dry state and return to normal function upon rehydration, occupying different habitats from deserts to full aquatic environments, with different life forms.

Bryophytes from dry habitats are organized in more dense forms like cushions. Thus, they naturally retain more water by capillarity and dehydrate more slowly than the ones from damp locations when submitted to the same drying conditions. In denser bryophytes, it is expected higher water surface tension and water will be lost at lower rates than the less dense bryophytes. Morphology, life form and colony structure, can be a determinant factor in the adaptation of bryophytes to each habitat and corresponding predicted levels of desiccation. Current climate change, mostly driven by air pollution, is changing water availability and pushing many habitats, specially the Mediterranean, to desertification. The adaptations required for bryophyte survival may have a tremendous impact on their survival and distribution. We tested morphology as a means to control dehydration rate in life forms of bryophytes from contrasting habitats, ranging from semi-arid to aquatic, and discuss its application as a trait to classify bryophyte sensitivity to aridity.

Measuring and modeling ozone fluxes in Mediterranean forest ecosystems in Italy

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Ozone is the main oxidant stressor in Mediterranean climates, especially in Italy, where high temperatures and large emission of precursors (Nitrogen oxides and hydrocarbons) from anthropic sources lead to the formation of this secondary pollutant. Field sites where ozone fluxes are measured continuously with Eddy Covariance are ideal to quantify the total amount of ozone removed by the vegetation and partition this removal between stomatal and non-stomatal sinks. In this study, we collected ozone flux measurements from two representative Mediterranean forest ecosystems in Italy: A Holm Oak forest (*Quercus ilex*) located inside the Presidential Estate of Castelporziano, Rome, and a stone pine (*Pinus pinea*) forest in San Rossore, Pisa. Measurements were carried out during all seasons in order to capture ecophysiological responses to seasonal changes in meteorology and stomatal fluxes were calculated using the Monteith evaporative/resistive methods. Innovative approach of above and below canopy ozone flux measurements helped partitioning non-stomatal ozone fluxes between its main contributors (soil and cuticles), and new models were elaborated to predict water evaporation from soil. A second goal was to validate models to predict stomatal fluxes for ozone-risk assessment purposes. Two modeling approaches were used: the first one is the empirical Jarvis approach based on multiplicative algorithm; the second, process-based approach uses Ball-Berry equation. Results show that stomatal component explained almost the totality of ozone fluxes during the winter season, while it was below 60% during the warm seasons. The Jarvis approach better predicted absolute magnitude of stomatal ozone fluxes, while the Ball-Berry approach better reproduced the dynamics of stomatal ozone fluxes during the day although it diverged from the measured fluxes. Finally, we applied advanced statistical analyses to quantify reductions in gross primary production due to ozone, and found that reduction was better related to stomatal ozone deposition than to ozone concentration, and that the negative effects of ozone occurred within a day of exposure/uptake. This long-term research advanced our understanding of typical Mediterranean forests in biosphere-atmosphere exchange.

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Yield response of some Italian and Spanish cultivars of durum wheat to elevated ozone: a varietal screening

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Durum wheat is the main wheat species grown in Southern Europe countries. Hence, the evaluation of the response of the main cultivars of durum wheat to tropospheric ozone is a priority for Southern Europe. The present work investigated the O_3 effects on five cultivars of durum wheat, three of them from Italy (*Colombo, Sculptur, Faraon*) and two from Spain (*Gallareta* and *Vitron*) in terms of yield and related physiological drivers.
The experiment was performed in the open-top chambers (OTC) facility of C.R.IN.E.S at Curno, Italy, from 09th March to 15th June 2013. Each *cv* was sown in 12 pots (three plants per pot) and pots were randomly assigned to 4 OTC (three pots per OTC for each *cv*), two of them supplied with charcoal filtered air (-50% of ambient air ozone = CF) and two with ozone enriched air (+50% of ambient air ozone = EN). During the experiment the ozonated plants were exposed to a daylight AOT40 value of 11.561 ppm•h, well above the UN/ECE critical level of 3 ppm•h, while the control (CF) plants experienced an exposure of 0.432 ppm•h.
Periodical measurements of stomatal conductance, chlorophyll-a fluorescence and growth were performed during the growing season. Furthermore, macroscopic (chlorotic/necrotic spots) and microscopic (cell death and H_2O_2 deposits in mesophyll tissue) symptoms development were followed on the flag leaves. At the end of the season plants were harvested and the stems and the ears of each plant were separately dried and weighted. Then the grain yield was assessed per each OTC as total grain weight and hectoliter weight.
The Italian *cv Sculptur*, the most productive one without ozone, together with the *cv Colombo* resulted the most ozone sensitive *cvs*, with a grain yield decrease of 16% ($p<0.05$) and 10% (ns) respectively in the EN treatment. Nevertheless very small differences were observed in the hectoliter weight between the two ozone treatments. The remaining *cvs* did not show any negative effect of ozone but rather a slight yield stimulation (between 1 and 5%, ns). The Spanish *Gallareta* resulted the best performing *cv* when both CF and EN yield are considered.
Ozone affected the earing and the plants growth: the number of ears was quite uniformly reduced by ozone, with a remarkable low for *Sculptur*, and the losses of the aboveground biomass confirm the ozone sensitivity of *Sculpur* and *Colombo* (-20% and -25% respectively, both $p<0.01$).
The stomatal conductance was greatly decreased by ozone in all *cvs* (between 11% and 37%, $p<0.01$), but it is notable that the most sensitive *cvs* showed the highest *gs* values, even under the ozone treatment, which implies a highest ozone dose. This would confirm that the stomatal dose is an important driver of the plants' response to this pollutant.
On the contrary the overall performance of the photosynthesis (PI) - assessed by the OJIP test on the chlorophyll fluorescence measurements – was not affected by ozone. Thus, the observed reduction of productivity in the sensitive *cvs* is not to be ascribed to a damage of the photosystyems but rather to a dissipation of the available energy for the metabolic defense against the oxidative stress.
Finally, the observation of the the *Sculpure cv* behavior suggests that the breeding strategy of selecting a greater gs to increase the yield may not be appropriate under increasing ozone conditions.

Nitrogen deposition effects on leaf physiology of Mediterranean species

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Atmospheric nitrogen (N) deposition and climate change are among the most relevant drivers of biodiversity loss, also affecting ecosystem functions and services. Consequently, there is a growing need to improve our understanding of their isolated and combined effects. Atmospheric N deposition can alter plant functionality and diversity because of species differences in resource acquisition, resource-use efficiency and allocation, and growth response. Nitrogen deposition might increase also the susceptibility of plants to other biotic and abiotic stresses like drought events increasing shoot:root ratios, changing the response pattern of stomatal conductance to drought, altering the Water Use Efficiency.
We hypothesized that N addition would increase mesophyll conductance in order to support the increased demand for CO_2 by an augmented photosynthetic capacity. However, during drought stress, these effects would disappear or even reverse to avoid excessive water loss. The hypothesis will be tested in two Mediterranean sites with similar climatic conditions: Arrábida (Portugal) and Capo Caccia (Italy). Nitrogen treatments in Arrábida started in 2007 with 40 and 80 Kg/ha/y, while in Capo Caccia they were started in 2011 with 30 Kg/ha/y. In order to compare the two sites, the same parameters will be measured, namely the maximum net assimilation rates (Anmax), net assimilation rates, leaf respiration, and stomatal conductance in field conditions, chlorophyll fluorescence, and the foliar N and carbon concentrations in leaves of different age classes. Photosynthetic Nitrogen Use Efficiency (PNUE) will be estimated, paying attention to the relation between PNUE and N pertaining to structural and cell wall materials.

Stomatal conductance, photosynthesis and growth response of hornbeam and oak young trees after a two-years treatment with ozone and nitrogen addition

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An Open-Top Chambers (OTC) experiment with ozone enrichment and increased nitrogen deposition has been performed during two consecutive years (2012 and 2013) in Northern Italy on young trees of *Quercus robur* and *Carpinus betulus*.
Two hundreds and sixteen saplings of each species were potted and placed in 12 Open-Top Chambers following a split-plot design with 3 randomized blocks and two factors: ozone concentration, the main factor, at 4 different levels (CF-45%, NF, NF+35%, NF+70%), and nitrogen irrigation (NDep), the nested factor, at 2 different levels (tap water for control, tap water +NDep of 70Kg of $N*ha*y^{-1}$). These treatments were applied for two consecutive growing seasons.
In both years stomatal conductance (g_s) measurements and CO_2 assimilation response curves have been made throughout the season to assess the impacts on physiological and photosynthetical parameters. Half of the saplings was harvested at the end of 2012 season, while the remaining half was harvested at the end of 2013, in order to estimate the effects of both stresses, alone and in combination, on the total biomass production and on the root/shoot partition of the plants.
After two years of treatments, a general positive effect of nitrogen deposition on biomass production was found in both species, as it could be easily expected. This biomass increase was particularly intense in *C. betulus* (+76% of the total biomass, + 65% of roots biomass).
Q. robur showed a greater response to ozone than *C. betulus* in the control Ndep conditions. Oak plants showed a 10% and 18% of reduction of the total and root biomass in NF+70% treatment. This response was also found in the plants subjected increased to nitrogen deposition (-15% for total biomass, -16% for roots biomass).
Hornbeam seemed stimulated by O_3 when no nitrogen was added (+5% of total biomass). However, NDep treatment made hornbeam more susceptible to ozone, which caused a 30% biomass decrease in both shoots and roots.
Looking at g_s as a possible driver of the plants' response to ozone, we found that ozone lead to a 21% decrease of g_s in oak plants when they had a total biomass reduction of 10%. This response is confirmed in NDep treatment (-18% in g_s, -15% in total biomass). Thus, oak seemed to be more vulnerable to g_s limitation because of the consequent reduction of CO_2 assimilation.
In hornbeam, without nitrogen addition, ozone caused a slight reduction on g_s leading to a decrease of stomatal dose and a small increase in total biomass (+5%).
On the contrary, nitrogen deposition caused a significant increase of g_s (+23%) that lead to an increased ozone uptake, thus suggesting an overwhelming of the detoxifying defence (-30% in total biomass).
Stomatal conductance, thus, reveals to be a key driver of the plant's response to ozone, but the final manifestation of the effect seems to be modulated by the detoxifying capacity of the plants.
The general decrease of g_s in both species caused by ozone (also found in 2012 measurements), suggests the need to include an $f(O_3)$ modifying function in the stomatal conductance models which will be defined for these two species.
Some of biomass responses are partially in disagreement with the results of the first year, likely for the presence of a carry over effect. This fact highlights the importance of performing long-term experiments (more than 1 year) for the investigation on ozone and nitrogen effects on biomass.

Biomass response of young Holmoak trees after one season of ozone treatment in well watered condition

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An Open-Top Chambers (OTC) experiment with ozone enrichment has been performed on young trees of *Quercus ilex* from April to September 2013 in Northern Italy.
Forty-eight 3 years old plantlets were potted and placed in 12 Open-Top Chambers arranged in 3 randomised blocks where the ozone factor assumed 4 different levels (CF-40%, NF, NF+30%, NF+74%). The plants were irrigated every night with about 0.4 L of water.
At the end of the season all the plants were harvested and biomass production was separately assessed for stem, roots and leaves after oven drying.
The stomatal ozone dose was calculated by applying a jarvisian model for stomatal conductance following the parameterisation published in the UN-ECE Mapping Manual, but with the g_{max} value calculated from gas exchange measurements performed in June and September. The latter measurements have been also used to check the model fit.
The 99th percentile of the measured stomatal conductance to water with CO_2 concentration between 350 and 450 ppm was 358 mmol m^{-2} s^{-1}, and it was taken as g_{max} in the stomatal model. This value is only 50 unit greater than that found by Fares et al. (2013), and about 90 units greater than the value proposed by the UNE-CE Mapping Manual.
The biomass reduction was quite generalised in the ozonized plantlets, but greater for the roots which showed a 27% decrease in the OZ++ treatment. The stem reduction and the foliar biomass in the same treatment were respectively -16% and -17%.
The relationship between ozone exposure (daylight AOT40) and the biomass reduction was significant ($p<0.05$) for roots and showed a 5% of biomass decrease every 10'000 ppb.h of AOT40 ($R^2=0.39$). A similar relationship for shoots biomass was slightly less significant ($p<0.09$), while for leaf biomass was non-significant ($p<0.16$)
At the conference a flux-effect relationship for roots and shoots biomass decrease, based on stomatal flux, will be presented too. Elaborations are still in progress.

Effects of nitrogen addition on the interaction of the indigenous shrub *Juniperus phoenicea* with biological soil crust

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It is well known that biological soil crust (BSC) exert a strong influence onvascular plants, although the literature related to this effect is frequently contradictory, reporting consequences ranging from negative to positive. Besides, most of these studies have considered both plant and BSC communities as a whole, without taking into consideration the species involved, despite the fact that plant-BSC interaction are likely to be highly species-specific.We aim to assess the N addition effects on the interaction of *Juniperus phoenicea* with the BSC, looking into the soil processes that are being affected by N addition.

The study site is dominated by *J. phoenicea* for about 53%, other shrubs cover another 27%, and the remaining 20% is composed by soil with a well developed biological crust. In April 2012 a N addition experiment was set up. Eight plots of 36 m^2 were selected in order to systematically include at least one entire plant of *J. phoenicea* and a portion of soil covered with BSC not smaller than 6 m^2. Four of the plots are periodically treated with 7.5 kg N ha^{-1} at the beginning of each season. There is a clear increasing gradient in species relative abundance and BSC abundance in general from the edge of each *J. phoenicea* crown towards its outer perimeter. Near the trunk the development of BSC is low because the ground is partially covered by litterfall, increasing at around 50 cm from the edge and then decreasing again as we move farther, probably because of trampling or due to drier soils.

To achieve our goal, we will select one subplot including at least one entire plant of *J. phoenicea* from each fertilized and control plot. We will assess the species composition of the BSC and abundance annually, and we will also explore the fine root turnover and the water use efficiency by using isotopes. Besides, we are developing a non destructive methodology to assess moisture content of the BCS using hyperspectral reflectance, given the relationship between reflectance and biophysical parameters.

Effects of meteorological changes and nitrogen addition on the soil processes: the modulator role of biological soil crust

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Despite climate change and atmospheric nitrogen (N) deposition are two of the most important and concomitant global change drivers, the effects non additive that they can generate on soil processes are still unpredictable. We aim to assess how the combined effect of soil N additions and expected changes of precipitation pattern and temperatures will affect CO_2 fluxes and N cycle in a Mediterranean shrubland. Given the ecological and functional importance that the biological soil crust (BSC) has proved to have in our study site and its dependence on meteorological variables, we hypothesize that it has a modulator role in the soil responses.

The study site is dominated by *Juniperus phoenicea* for about 53%, other shrubs cover another 27%, and the remaining 20% is bare soil with a well developed biological crust. In April 2012 a N addition experiment was set up. Eight plots of 36 m^2 were selected in order to systematically include at least one entire plant of *J. phoenicea* and a portion of soil covered with BSC not smaller than 6 m^2. Four of the plots are periodically treated with 7.5 kg N ha^{-1} at the beginning of each season. Since April 2013, CO_2 fluxes in the bare soil are being measured in both the intact soil and after removal of the BSC. Measures are performed in both the control and N-treated plots. In each plot, soil temperature and moisture content are measured every 30 minutes. Soil CO_2 fluxes are measured weekly. Such design allows estimating the contribution of the BSC to soil CO_2 fluxes, to determine how this contribution changes as a function of temperature and soil moisture, and to distinguish the N effect on the BSC respiration from that of the deeper soil layers.

It is planned to treat the plots with stable N isotopes to determine the N cycle in both treatments.