European Research Council

ERC Starting Grant – Stage 2
Research proposal

Biotic community attributes and ecosystem functioning: implications for predicting and mitigating global change impacts

BIOCHANGE

Principal Investigator: Fernando T. Maestre
Hosting Institution: Universidad Rey Juan Carlos, Móstoles, Spain
Project duration in months: 60

Project summary (possibly copy/paste of abstract from the administrative part)

Increases in nutrient availability and temperature, and changes in precipitation patterns and biodiversity are important components of global environmental change. Thus, it is imperative to understand their impacts on the functioning of natural ecosystems to predict the consequences of global change, and to establish effective mitigation actions. Biodiversity has been the subject of many studies, which have led to major advances in describing its relationship to key ecosystem processes, such as productivity, nutrient cycling and carbon dioxide (CO_2) fixation and release. However, little is known on the relative importance of biodiversity against other attributes of biotic communities, such as species cover and spatial pattern, as a driver of these processes. Furthermore, the effects of global change on the relationships between these attributes and ecosystem functioning are virtually unknown. The overall objective of this project is to evaluate the relationships between community attributes (species richness, composition, evenness, cover, and spatial pattern) and key processes related to ecosystem functioning (nutrient cycling, soil CO_2 flux and net CO_2 exchange, nitrogen fixation, litter decomposition, microbial functional diversity, and water infiltration and availability) in arid and semiarid ecosystems under different global change scenarios. Its specific objectives are to: i) evaluate the relative importance of community attributes as drivers of ecosystem functioning using multiple communities (vascular plants, microorganisms and biological soil crusts) and a combination of manipulative field, natural and common garden experiments, ii) assess how multiple global change drivers (temperature, nutrient availability and precipitation) will affect key ecosystem processes, iii) test whether global change drivers modify observed community attributes-ecosystem functioning relationships, and whether these attributes modulate or ameliorate responses to global change, iv) develop models to forecast global change effects on ecosystem functioning in arid and semiarid regions, and v) set up protocols for the establishment of restoration and mitigation actions based on the results obtained. This proposal will provide valuable insights on the relationships between community attributes and processes governing ecosystem functioning, and an important database to test the generality of established paradigms based on results obtained with other model systems. It will also open the door to new research lines exploring the functional role of attributes such as spatial pattern and their importance as modulators of biotic community responses to global environmental change.

A. Principal Investigator (PI) *(max. 4 pages)*

i. CV

Education, honors and awards

Ph.D. in Biology, awarded by the University of Alicante on 1st July 2002. Qualification: Extraordinary Award (Highest mark in Spain).
Bs.C. in Biology, awarded by the University of Alicante on 25th January 1999. Qualification: Extraordinary Award (Highest mark in Spain, best rank of the 1994-1998 Biology promotion).
Bs.C. Extraordinary Award, awarded by the University of Alicante in January 1999.
Award for Academic Excellence, awarded by the Valencian Regional Government in May 1999.
Ph.D. Extraordinary Award, awarded by the University of Alicante in January 2005.
Journal of Vegetation Science Editors´ Award 2006. Third Best Paper published in the journal on that year (Maestre, F. T., M. Bradford & J. F. Reynolds. 2006. Soil heterogeneity and community composition jointly influence grassland biomass. *Journal of Vegetation Science* 17: 261-270).

Professional experience

"Ramón y Cajal" Research Fellow, Department of Biology and Geology, University of Rey Juan Carlos (Spain), 01/10/2005-onwards
Postdoctoral Fulbright Fellow, Spanish Ministry of Education and Science, Department of Biology, Duke University (USA), 01/10/2003- 30/09/2005
Associate in Research, Department of Ecology, University of Alicante (Spain), 01/01/2003-30/09/2003
Graduate Research Fellow, Spanish Ministry of Education and Science Ministry, University of Alicante (Spain), 01/01/1999-31/12/2002
Undergraduate Research Fellow, Spanish Ministry of Education and Science, University of Alicante (Spain), 01/12/1997-30/05/1998

Publication Record

I have published 50 articles in international, peer-reviewed, scientific journals included in the JCR database (3 more are currently under review), 9 articles in Spanish peer-reviewed scientific journals, 17 articles in popular Spanish journals, 15 book chapters and three whole books (in Spanish). Ten publications relevant to this proposal are:
1) Reynolds, J.F., D.M. Stafford Smith, E.F. Lambin, B.L. Turner II, M. Mortimore, S.P.J. Batterbury, T.E. Downing, H. Dowlatabadi, R.J. Fernández, J.E. Herrick, E. Huber-Sannvald, R. Leemans, T. Lynam, **F. T. Maestre**, M. Ayarza & B. Walker. 2007. Global desertification: Building a science for dryland development. *Science* 316: 847-851.
2) **Maestre, F. T.** & J. F. Reynolds. 2007. Amount or pattern? Grassland responses to the heterogeneity and availability of two key resources. *Ecology* 88: 501-511.
3) **Maestre, F. T.** & J. F. Reynolds. 2007. Biomass responses to elevated CO_2, soil heterogeneity and diversity: an experimental assessment with grassland assemblages. *Oecologia* 151: 512-520.
4) **Maestre, F. T.** & J. F. Reynolds. 2006. Spatial heterogeneity in nutrient supply modulates plant nutrient and biomass responses to multiple global change drivers in model grassland communities. *Global Change Biology* 12: 2431-2441.
5) **Maestre, F. T.**, F. Valladares & J. F. Reynolds. 2006. The stress-gradient hypothesis does not fit all relationships between plant-plant interactions and abiotic stress: Further insights from arid environments. *Journal of Ecology* 94: 17-22.
6) **Maestre, F. T.**, A. Escudero, I. Martínez, C. Guerrero & A. Rubio. 2005. Does spatial pattern matter to ecosystem functioning? Insights from biological soil crusts. *Functional Ecology* 19: 566-573.

7) **Maestre, F. T.**, F. Valladares & J. F. Reynolds. 2005. Is the change of plant-plant interactions with abiotic stress predictable? A meta-analysis of field results in arid environments. *Journal of Ecology* 93: 748-757.
8) **Maestre, F. T.**, M. Bradford & J. F. Reynolds. 2005. Soil nutrient heterogeneity interacts with elevated CO_2 and nutrient availability to determine species and assemblage responses in a model grassland community. *New Phytologist* 168: 637-650.
9) **Maestre, F. T.** & J. Cortina. 2004. Do positive interactions increase with abiotic stress? A test from a semi-arid steppe. *Proceedings of the Royal Society of London B (Supplement)* 271: S331-S333.
10) **Maestre, F. T.**, S. Bautista & J. Cortina. 2003. Positive, negative and net effects in grass-shrub interactions in Mediterranean semiarid grasslands. *Ecology* 84: 3186-3197.

Participation in Research projects

In addition to the projects listed in Table I (see below), I have participated in the following research projects obtained in competitive calls from public and private funding agencies:
Technical assistance to elaborate management plans for the recovery and conservation of endangered species in Galicia; Funded by the Xunta de Galicia (Spain) with 20,000 €; Duration: June 2007- June 2008; Principal investigator (PI): Dr. Luis G. Quintanilla.
Experimental basis for the ecological sustainability of highway hillslopes; Funded by CINTRA and Fundación Biodiversidad (Spain) with 184,804 €; Duration: June 2006-June 2010; PI: Dr. Fernando Valladares.
Ecosystem processes in Mediterranean steppes: relationships between composition, structure and function; Funded by the Comunidad de Madrid (Spain) with 30,500 €; Duration: December 2005-March 2007; PI: Dr. Fernando T. Maestre.
Research Network on Ecological Restoration in Madrid; Funded by the Comunidad de Madrid (Spain) with 743,000 €; Duration: January 2006-January 2010; PI: Dr. Adrián Escudero.
Indicators of success in the restoration of Mediterranean ecosystems; Funded by the Comisión Interministerial de Ciencia y Tecnología (Spain) with 60,000 €; Duration: December 2005-December 2008; PI: Dr. Susana Bautista.
ARIDnet: A Research Network for Testing New Paradigms for Global Desertification; Funded by the National Science Foundation (USA); Duration: October 2003 - October 2008; PI: Dr. James F. Reynolds.
What drives ecosystem functioning? Evaluation of an hypothesis using biological soil crusts from semiarid environments of Madrid; Funded by the Comunidad de Madrid (Spain) with 24,168 €; Duration: January 2005 - January 2006; PI: Dr. Adrián Escudero.
Water and nitrogen fluxes in biological crusts of semiarid areas; Funded by the Comisión Interministerial de Ciencia y Tecnología (Spain) with 91,400 €; Duration: December 2001-December 2004; PI: Dr. Jordi Cortina.
Selection of provenances to improve restoration of plant cover and soil erosion control in semiarid areas; Funded by Fundación CEAM (Spain) with 84,142 €; Duration: January 2001-January 2005; PI: Dr. Juan F. Bellot.
Restoration of degraded ecosystems in Mediterranean regions; Funded by the European Union (GD XII) with 130,480 €; Duration: January 1998 – February 2001; PI: Dr. Ramón Vallejo.
Restoration of plant cover in semiarid areas and control of erosion in areas with high desertification risk; Funded by Fundación (Spain) with 85,879 €; Duration: January 1996 - January 1999; PI: Dr. Juan F. Bellot.

International Experience

Rothamsted Experimental Station, Department of Statistics, UK (15/06 – 31/07/1999); Topic: Spatial analysis of ecological data.

University of Montana, Division of Biological Sciences, USA (01/06 – 31/08/2000); Topic: Evaluation of ecosystem impacts of the invasion by *Acer platanoides*.
Duke University, Department of Biology (20/09 – 20/12/2001); Topic: Assessing the effects of soil nutrient heterogeneity on the performance of *Prosopis glandulosa* seedlings.
Rothamsted Research, Plant and Invertebrate Ecology Division, UK (22/08 – 12/09/2003); Topic: Spatial analysis of ecological data.
Duke University, Department of Biology, USA (01/10/2003 – 30/09/2005); Topic: Assessing the effects of global change and nutrient heterogeneity on model grassland communities.
University of Vermont, Department of Biology, USA (28/06 – 31/08/2007); Topic: Evaluating the effects of abiotic stress on the structure of semiarid plant communities.

Editorial Responsibilities

Member of the Editorial Boards of the international scientific journals *Journal of Ecology* (since September 2006) and *Arid Land Research and Management* (since November 2005), and of the Spanish journal *Ecosistemas* (since September 2004).

Referee of more than 100 scientific papers for journals such as *Ecology*, *Ecological Applications*, *Ecology Letters*, *Oecologia*, *Proceedings of the Royal Society B*, *Journal of Ecology*, *Oikos*, *Ecography*, *New Phytologist*, *Journal of Vegetation Science*, *Forest Ecology and Management*, *Restoration Ecology*, *Microbial Ecology*, *Plant and Soil*, *Basic and Applied Ecology*, *European Journal of Soil Science*, *Annals of Botany*, *Plant Ecology, Rangeland Ecology & Management* and *Applied Vegetation Science*.

Referee of scientific projects for the Grant Agency of the Czech Republic, the United States-Israel Binational Science Foundation (USA), the Andalusian Evaluation Agency (Spain) and FONDECYT (Chile).

ii. Self Evaluation

During my Ph.D. at the University of Alicante, I was trained as a community ecologist with a strong emphasis on quantitative statistical methods and on field-based, applied research (restoration of degraded ecosystems in semiarid areas using environmental heterogeneity and plant-plant interactions). The skills acquired during this stage were complemented with the short-term research stays conducted at different internationally recognized research centers and, specially, during my two-year post-doctoral stay at Duke University as a Fulbright fellow. During that stay I developed an independent, original, research program on global change using controlled environments (to evaluate the joint effects of nutrient heterogeneity and global change drivers on plant community structure and functioning), and had the chance to interact with (and learn from) some of the most prominent global change scientists (James F. Reynolds, Robert Jackson and William Schlesinger, among others). Since my return to Spain in late 2005, with a “Ramón y Cajal” Research Fellow, I have implemented an independent research program, using plants and biological soil crusts as model organisms, to evaluate the relative importance of the attributes of biotic communities on ecosystem functioning and to assess how this relationship changes along environmental gradients.

I am a curious, dynamic person with a high motivation for learning new things, have a strong capacity to work with teams and to motivate my colleagues, and maintain a rigorous work ethic. Despite I was awarded with my Ph.D. five years ago, my research activities have led to numerous publications in high quality peer-reviewed journals (see examples above). These have received 390 citations so far, and my current *h index* is 11 (statistics obtained from the Web of Science on 5rd September 2007). Many of my publications are multi-author works, reflecting the collaborative approach that I take to research and the large number of connections established with scientists from Spain and abroad (I am currently maintaining research collaborations with scientists from the USA, UK, China, France, Canada, Germany, Portugal, The Netherlands, Sweden, Chile, Argentina, Peru, Mexico, Brazil and Ecuador). However, it must be noted that I have led most of the research I have been involved in (I am the leading author of 74% of all my publications). My research activities and collaborative approach to research have given me an increasingly high profile within the ecological community. As a consequence, I was appointed to the Editorial Board of the *Journal of Ecology*, one of the leading ecological journals, in September 2006, being the youngest member of the Board since then.

From the beginning of my research career I have not narrowed my scientific activities to a particular research topic or organism. A recent review I have co-authored in *Science* on desertification, which introduces a new synthetic and multidisciplinary paradigm to evaluate desertification issues in any part of the world, and my appointment to the Editorial Board of *Arid Land Research and Management*, one of the leading journals on fundamental and applied research of arid and semiarid soils, are good examples of my broad ecological research interests and expertise. I have also a special interest on training and mentoring young scientists, and I am currently mentoring three Ph.D. students, and two undergraduate students, in my department.

The skills acquired over my research career, have provided me with the ability to conduct innovative and multidisciplinary research on different aspects of the ecology of terrestrial ecosystems, and to manage appropriately the research funds I lead. Since 2005 I have led three research projects, and in one of them (*INTERCAMBIO*, Table I) I am coordinating the work of 21 scientists from Spain and Chile. Overall, my career so far demonstrates my value as an independent research leader, and my potential to become a reference in the field of terrestrial ecology.

iii. Funding ID

Currently I have funding from the British Ecological Society and from the BBVA Foundation for conducting research related to this application (see table I). I am also collaborating in a CYTED-funded project (*EPES*, table I), which coordinate the establishment of a research network between scientists from Spain and six Latin-American countries (Mexico, Chile, Argentina, Peru, Ecuador and Brazil) aiming to evaluate the composition/structure and functioning of a semiarid ecosystems along wide geographical gradients. However, this project does not provide funding to conduct research activities within each country (such funds need to be provided by each partner).

An ERC grant would complement perfectly my current funding, as the work proposed to develop with this application is built on my current research. Furthermore, and more important, an ERC grant would allow me to substantially expand my research activities to cover key topics that cannot be afforded with my current level of funding, and to establish an independent laboratory and research group within my Department. Such a group would focus on the evaluation and mitigation of global change impacts in terrestrial ecosystems.

Table I. Current and foreseen proposals for work related to this ERC application.

Title	Funding scheme/ organization responsible	Participation	Size of the grant (in €)	Duration
Testing the effects of biodiversity and spatial pattern on ecosystem functioning: An experimental approach using biological soil crusts (SPABIOCRUST)	Early Career Project Grant / British Ecology Society	Principal investigator	34,018	01/05/2006 - 30/08/2008
Assessment of ecosystem processes in semiarid environments as a tool to mitigate global change impacts (EPES)	Research network/ Latin-American Program of Science and Technology for Development (CYTED)	Co-Investigator	102,000	01/05/2007 – 01/05/2010
Plant-plant interactions and ecosystem functioning under global change (INTERCAMBIO)	Research program on conservation ecology/ BBVA Foundation	Principal investigator	200,000	30/08/2007 – 30/08/2010

B. Research Project *(max. 10 pages)*

i. State-of-the-art and objectives

The recently released 4th Assessment Report of the Intergovernmental Panel on Climate Change (http://www.ipcc.ch/) provides unequivocal evidence of global environmental change, including increases in temperatures, nutrient availability and atmospheric carbon dioxide concentration ([CO_2]), and changes in precipitation patterns. Over the last two decades, many studies have been conducted to advance our understanding of how these global change drivers affect terrestrial ecosystems (Canadell *et al.* 2007). Parallel biodiversity studies have focused on describing the effects of species richness, composition or evenness on ecosystem processes[1] such as productivity and nutrient cycling (e.g. Hector & Bagchi 2007). However, much uncertainty remains as how the aforementioned results scale up to landscape and regional levels because of the complicating importance of spatial patterning, which is known to strongly impact ecosystem functioning, stability and dynamics (Tilman & Kareiva 1997). Given that non-random spatial patterns in the attributes of biotic communities (e.g., species composition, evenness, cover and richness; hereafter community attributes) and ecosystem processes (e.g., soil CO_2 efflux, nutrient cycling, net CO_2 exchange, nitrogen fixation, and litter decomposition) are the norm, rather than the exception, in most ecosystems (Fortin & Dale 2005), elucidating mechanistic relationships between spatial patterns in community attributes and ecosystem processes merits special attention. However, very few studies have empirically evaluated the relationship between such patterns and ecosystem processes (Maestre *et al.* 2005), and none have used an experimental approach.

Substantial research efforts are being devoted to predict how community attributes such as species richness will respond to global change drivers like climate change (Araújo & New 2007), exotic species invasions (Fridley *et al.* 2007), land use changes (Zhou *et al.* 2006) and increases in [CO_2] and nutrient availability (Zavaleta *et al.* 2003). However, the impact of these drivers on the relationships between species richness and key ecosystem processes is virtually unknown (Zhou *et al.* 2006). The very few studies evaluating joint changes in species richness and global change drivers on ecosystem processes have been conducted with herbaceous plants (e.g. Reich *et al.* 2004). Expanding these studies to include additional community attributes, and to incorporate their spatial pattern, is essential to advance our understanding of the effect of these attributes on ecosystem functioning, to accurately predict the ecological consequences of global change, and to establish effective mitigation actions.

The overall objective of this project is to evaluate the relationships between community attributes and ecosystem processes in arid and semiarid ecosystems under different global change scenarios. These ecosystems are a key terrestrial biome, covering 41% of Earth's land surface and supporting over 38% of the total global population (Reynolds *et al.* 2007), and are highly vulnerable to global change and desertification (Körner 2000, Reynolds *et al.* 2007). Its specific objectives are:

i) to evaluate the relative importance of community attributes as drivers of ecosystem functioning using multiple communities (vascular plants, microorganisms and biological soil crusts) and a combination of manipulative field, natural and common garden experiments.

ii) to assess how multiple global change drivers (temperature, nutrient availability and precipitation) will affect key ecosystem processes.

iii) to test whether global change drivers modify observed community attributes-ecosystem functioning relationships, and whether these attributes modulate or ameliorate responses to global change.

iv) to develop models to forecast global change effects on ecosystem functioning in arid and semiarid regions.

v) to set up protocols for the establishment of mitigation actions based on the results obtained.

This project is highly relevant for the study of global change as it aims to study the joint impacts of multiple community attributes and global change drivers on key ecosystem processes, and to

[1] Ecosystem "functioning" and "processes" are used interchangeably

examine the complexity of these interactions using an integrated framework. My proposed use of different experimental approaches and multiple biotic communities to test the same core ideas will add further value to the project by allowing wider generalizations of the results obtained. This project will “open the door” to new research lines concerning the functional role of community attributes and their importance as modulators of the responses of ecosystem processes to global change. It will also provide an important database to test the generality of established paradigms, new modeling approaches to predict the consequences of global change on ecosystem functioning, and new methodologies to mitigate predicted impacts of global change in semiarid ecosystems. Finally, by developing an integrated framework, this project will have notable impact on existing theoretical and applied research concerning of the effects of global change on community attributes and ecosystem functioning.

ii. Methodology

This project is based on the establishment of natural and manipulative field and common garden experiments, the monitoring of experiments already running, the development of modeling approaches, and the synthesis of all the data gathered during the project (Fig. 1).

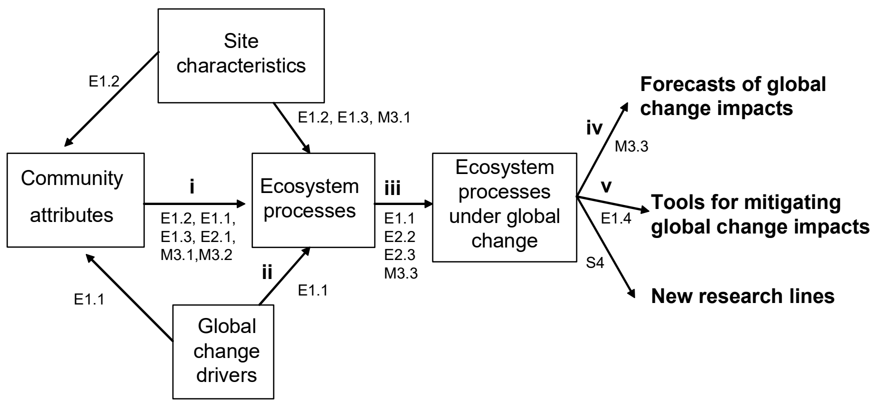

Figure 1. Integrated framework of the project, showing the different tasks proposed and their links with its specific objectives (i-v) and overall goals (text in bold). E = experiment, M = modeling approach, S = synthesis. The numbers (1.1, 1.2…) correspond to the number of the experiment/ modeling approach/synthesis given in the text.

1) Field experiments. The following experiments will be set up and maintained during the duration of the project:

1.1) Impacts of multiple global change drivers on ecosystem functioning

This experiment will contribute to objectives **i**, **ii** and **iii** of the proposal. It will focus on biological soil crusts (BSC) as a model biotic community for two main reasons: i) BSC are a key, but understudied, biotic component of arid and semiarid ecosystems worldwide, with important effects on ecosystem functioning in these areas (Belnap 2004); and ii) their small size allows to experimentally manipulate the effect of multiple global change drivers at a reasonable cost and with minimum environmental impacts (Fig. 2). The experiment will be conducted at two semiarid *Stipa tenacissima* steppes (located in central and southeastern Spain) to allow a wider generalization of the results obtained. These steppes are one of the most representative vegetation of the semiarid areas of the Mediterranean basin, and their structure resemble that of the vegetation found in other semiarid areas of the world (Fig. 2).

Using a factorial design, the experiment will evaluate the effects of the following treatments on ecosystem functioning: BSC cover (poorly developed communities with cover < 25% vs. well developed communities with cover > 75%), nutrient availability (ambient vs. addition of 3.2 kg nitrogen$\cdot$m$^{-2}\cdot$year^{-1}), temperature (control vs. a 4º annual increase in temperature), and rainfall (control vs. a 20% reduction in rainfall). The basic working plot will have a size of 1.5 × 1.5 m, and all the treatments will be applied at this level. Seven replicates per combination of treatments will be established, resulting in a total of 112 plots per site. These will be established following a randomized block design with 7 blocks to account for the spatial heterogeneity in abiotic factors within each site. The amount of nitrogen (N) to be added in the increased N treatments is roughly equivalent to increasing by 25% the current average N deposition rates in most semiarid regions of Spain (data for 2004; http://www.emep.int/), and aims to simulate likely increases in this N source by the second half of this century (if current deposition trends are maintained; Fowler *et al.* 2007). The increase and reduction in temperature and rainfall, respectively, correspond to the average predictions of regional circulation models for the period 2071-2100 in semiarid Spain (Moreno 2005). Nitrogen additions will be conducted in the form of slow-release nitrogen pellets early during the spring. Air temperature and rainfall will be increased and decreased by using open top chambers (OTC) and rainfall shelters (RS), respectively. The design of OTC and RS will follow the basic guidelines of Hollister & Webber (2000) and Yahdijan & Sala (2002), respectively. The effects of the OTC and RS on air/soil temperatures, air humidity, and soil moisture will be monitored using automated sensors (HOBO Pro v2 Temp/RH and H8 Data Loggers, Onset corporation Bourne, USA, and ECH$_2$O, Decagon, Pullman, USA). The performance of OTC and RS will be assessed prior to the establishment of the experiment by conducting a pilot study; depending on the results of this test, their design may be modified to minimize their effects on air temperature and humidity (RS) or rainfall (OTC).

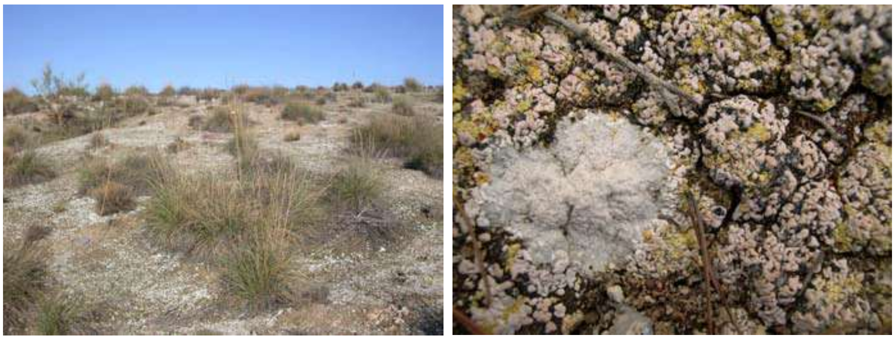

Figure 2. Typical semiarid steppe (left), where patches of *Stipa tenacissima* are surrounded by a biological soil crust, and a close-up view of the lichens dominating this crust (right): *Diploschistes diacapsis*, *Fulgensia subbracteata* and *Psora decipiens* (white, yellow and pink thalli, respectively).

This experiment will be set up by the end of the first year of the proposal, and will be monitored for four years. The response variables to be measured are summarized in Table II. Soil CO_2 efflux and moisture will be measured monthly with a LI-COR 8100 Automated Soil CO_2 Flux System (LI-COR, Lincoln, USA) and with the time-domain reflectometry (TDR) technique (Topp & Davis 1985), respectively. Net CO_2 exchange, *in situ* NH_4^+ and NO_3^- mineralization and N fixation measurements will be conducted seasonally with a LI-COR 6400 Portable Photosynthesis System, with ion-exchange resin bags (Subler *et al.* 1995), and with the acetylene reduction method (Maestre *et al.* 2006), respectively. The activities of soil enzymes, soil infiltration, microbial biomass and microbial diversity will be measured at the beginning of the experiment and then once every year as described in Zornoza *et al.* (2006), Maestre *et al.* (2002), Vance *et al.* (1987) and Maestre *et al.* (2006), respectively. Total soil N and P and microbial functional diversity will be measured at the same time intervals using a San^{++} Analyzer (Skalar, Breda, The Netherlands) and the technique developed by Campbell *et al.* (2003), respectively. The decomposition of *S. tenacissima* litter will be assessed using litterbags; clean, air-dried, dead leaves of *S. tenacissima* will be enclosed in thin litter bags of 2 mm nylon mesh (2 gr per bag), and will be placed over the soil surface at the beginning of the experiment (48 bags per plot). Bags will be removed from the field at 6-months intervals to assess the decomposition rate. The composition of BSC components will be evaluated by visual censuses and pigment analyses every six months from the beginning of the experiment (Maestre *et al.* 2006).

The effects of the treatments evaluated on the response variables measured will be analyzed with appropriate ANOVA models. The attributes of BSC (species richness, diversity, cover and spatial pattern) will be used in these analyses as covariates.

This experiment will allow evaluating, for the first time, whether multiple, and co-occurring, community attributes modulate the response of ecosystem processes to multiple global change drivers. Another unconventional aspect of the experiment, but not less relevant, is the evaluation of the effects of multiple global change drivers simultaneously on both ecosystem functioning and above (BSC)- and belowground (microbial) biotic communities. If successful, its results will open new horizons on the study of community attributes as modulators of global change impacts, as well as on their links with ecosystem functioning under different global change scenarios.

Table II. Summary of the experiments planned (see the text for details). AB = aboveground biomass, AS = soil aggregate stability, BSC = biological soil crusts, CGE = common garden experiment, CO_2E = soil CO_2 efflux, NCO_2 = net CO_2 exchange, LD = litter decomposition, MB = microbial biomass, MC = microbial composition, MD = microbial diversity, MF = microbial functional diversity, MFE = manipulative field experiment MO = microorganisms, NE = natural experiment, NF = N fixation, NM = *in situ* NH_4^+ and NO_3^- mineralization, PA = pigment analyses, SE = activity of soil enzymes related to N (urease), C (*β*-glucosidase) and P (phosphatase) cycles, SI = soil infiltration, SM = soil moisture, ST = soil temperature, TN = soil total N, TP = soil total P, and VP = vascular plants.

Experiment	Nature	Organisms studied	Response variables to be measured	Duration (years)
1.1	MFE	BSC, MO	CO_2E, NCO_2, LD, MB, MD, MF, NF, NM, PA, SE, SM, SI, TN, TP	4
1.2	NE	VP, BSC, MO	CO_2E, MC, MD, SE, TN, TP	3
1.3	NE	BSC	CO_2E, NM, SM, ST	5
1.4	MFE	BSC, MO	AS, NCO_2, MB, MD, MF, NF, SE, SI, TN, TP	2
2.1	CGE	BSC, MO	CO_2E, MB, MD, MF, NCO_2, SE, SM, ST	2
2.2	CGE	BSC, MO	CO_2E, NCO_2, MB, MD, MF, SE, SM, ST	2
2.3	CGE	VP, MO	AB, CO_2E, MB, MD, MF, SE, SM, ST, TN, TP	3

1.2) Joint effects of BSC and plant attributes on ecosystem functioning along natural gradients

This experiment, to be conducted during the first three years of the project, will evaluate how the community attributes of BSC and vascular vegetation influence ecosystem functioning in semiarid *S. tenacissima* steppes along a large geographical gradient (from the Center to SE Spain) including natural variations in rainfall, temperature and overall nutrient status. It will contribute to objective **i** of the proposal.

A minimum of 30 sites (dimensions 30 × 30 m) will be selected for this study. At each site, I will assess the composition (species richness and evenness) and structure (species density, total cover, spatial pattern and patterns of species co-occurrence) of perennial vegetation using data gathered from four 30 m long transects and 80 sampling quadrats (1.5 m × 1.5 m size) and the combination of rarefaction techniques (Gotelli & Colwell 2001), null models (Gotelli 2000) and spatial pattern analyses (Perry *et al.* 1999). The survey of the visible components of BSC (mosses and lichens) will be conducted following a stratified random sampling. A total of 15 50 cm × 50 cm quadrats will be randomly placed in bare ground areas and under the canopy of plant patches (30 quadrats per plot, 60 quadrats per site), as these microsites present substantial differences in the composition and structure of the BSC communities living on them. The complete list of moss and lichen species will be registered in each quadrat, and from these data I will estimate species richness, diversity and co-occurrence patterns as described above. Main abiotic features (co-ordinates, elevation, soil type, soil textural characteristics, rainfall, slope and aspect) will also be obtained at each site.

A number of ecosystem functions (Table II) will be assessed once at each site (excepting litter decomposition rates, which will be assessed over a 3-year period) using the methodology described above. The composition of soil microbial communities will be evaluated using the Ester-Linked Fatty Acid procedure (Hinojosa *et al.* 2005). All these measurements will be carried out in 12 composite soil samples per site collected according to a stratified random sampling (6 samples collected under the canopy of *S. tenacissima* and 6 in bare ground areas devoid of vascular plants).

The data from this study will be integrated within a large-scale database to be developed by the research network EPES (Table I). As mentioned above, EPES does not provide funds for carrying out the research, which need to be provided by the research groups supporting it. Currently, there are plans to establish experimental sites in semiarid ecosystems of Chile, Mexico, Peru, Brasil, Argentina and Ecuador (6-15 per country). In addition, and with the support of this Starting Grant, I will establish additional research sites (8-12 per country) in semiarid ecosystems of Australia, China, Africa (most likely in Morocco or Tunisia) and the United States. These sites will be sampled using the same methodology described in the above paragraph. The goal is to obtain a global database containing data from 100-150 sites located in representative arid and semiarid ecosystems of the world. The data gathered will be analyzed using hierarchical generalized linear models, structural equation modeling and classification tree analysis, among other techniques.

If successful, this experiment will allow assessing a series of key questions at the frontier of knowledge in ecosystem terrestrial ecology, and will provide new opportunities for the design of management actions aiming to preserve and restore the functioning of semiarid ecosystems worldwide. It will evaluate the relative importance of BSC, microorganisms, vascular vegetation and abiotic factors as drivers of ecosystem functioning at different spatial scales (from regional to global), and will nicely complement the results of the Experiment 1.1. The database generated will also allow exploring a large number of additional relevant questions, including the study of the consistency of the relationships found among vegetation types and the study of the biogeography of microorganisms in semi-arid ecosystems at different spatial scales.

1.3) Biotic attributes and small-scale heterogeneity in ecosystem functioning

In November 2006, I started a study where monthly measurements of soil CO_2 efflux, temperature and moisture, and seasonal measurements of *in situ* NH_4^+ and NO_3^- mineralization, are being collected in a *S. tenacissima* steppe located in Central Spain. A total of 78 sampling points located in different microsites (15 below *S. tenacissima* canopies, 15 below *Retama sphaerocarpa* canopies, 12 on bare ground soil without BSC and 36 on bare ground soil with different BSC cover, spatial pattern, richness and composition) are being monitored using the methodology presented in Experiment 1.1. This study aims to: i) monitor small-scale spatio-temporal patterns in key ecosystem processes, and ii) evaluate the relative importance of different community attributes of BSC (species richness, evenness, cover and spatial pattern) as drivers of these processes. These measurements will be continued during the five years of the project (current funding for this monitoring will conclude in August 2008), so a long-term dataset can be obtained for the modeling activities (see below). This dataset, which will contribute to objective **i** of the proposal, will be the first of its kind, as programs aiming to monitor soil CO_2 and N fluxes in semiarid ecosystems, such as those being developed in American Long-Term Ecological Research (LTER) stations like Sevilleta (http://sev.lternet.edu/), do not take into account the spatial heterogeneity of surface soil properties such as BSC. In addition, this Starting Grant will contribute to establish the first European LTER station devoted to monitor soil CO_2 and N fluxes in semiarid areas, which will be integrated in the recently developed Spanish LTER network (http://www.redote.org/eng-index.htm).

1.4) Restoration experiment

This experiment, which will contribute to objective **v** of the proposal, intends to test whether the results from previous experiments can be applied for establishing effective management actions aiming to maximize the recovery of ecosystem processes under global change. It will be carried out during the last two years of the project using BSC, as management and restoration protocols are poorly developed for these organisms (Bowker 2007). Four sites, located along a rainfall gradient spanning from Central to SE Spain (aiming to simulate the reduction in rainfall predicted by climate change models for most of BSC habitats in Spain), and showing clear symptoms of degradation, will be selected. At each site, I will establish experimental plots in eroded areas without BSC. Different BSC re-inoculation treatments, which will include manipulations of their biotic attributes (species composition, spatial pattern, richness, cover and evenness), will be established. The nature, number and levels of treatments will be defined during the third year of the project according to the results obtained from Experiments 1.1, 1.2, 1.3, 2.1 and 2.2 (see below). The changes in cover of the visible components of BSC (mosses and lichens) will be assessed seasonally from the beginning of the experiment. A series of ecosystem processes (Table II) will be measured at the beginning and the end of the experiment as described above. Soil aggregate stability will be assessed with the methodology of Lax *et al.* (1994).

The experiments conducted so far aiming to restore BSC have just aimed to promote faster recovery of BSCs in general or of key taxa within them, without evaluating what particular community attributes should be restored to best promote the recovery of those ecosystem functions of interest (Bowker 2007). This project will take these approaches forward by specifically focusing on the effects of community attributes on key ecosystem functions. If successful, this part of the project will bring new opportunities for the design of restoration actions aiming to recover BSC-mediated ecosystem functions in arid and semi-arid ecosystems worldwide.

2) Common garden experiments. The overall objective of these experiments is to test for the relative roles of community attributes as surrogates of ecosystem functioning under different global change scenarios using highly-controlled experimental settings. They will contribute to objectives **i**, **ii** and **iii** of the project, and will provide additional insights into the mechanisms driving the responses observed in the field.

2.1) Spatial pattern-ecosystem functioning experiment 1

This experiment aims to test for the independent effects of species richness (2, 4, 8 and 16 species), evenness (maximal evenness vs. communities with a geometric distribution of abundances among species, Wilsey & Polley 2004) and spatial pattern (clumped versus random) on ecosystem functioning using BSC-forming soil lichens as a model system. Microcosm units will be built from PVC pipe (length 8 cm, internal diameter 20 cm) and filled with 7 cm of homogenized field soil. Intact pieces of the ten most common soil lichen species found in the field (Maestre *et al.* 2005) will be collected, separated into species and cut into homogeneous 0.5 cm-side square fragments. These fragments will be added to the surface to reach 80% coverage of each microcosm unit, which is within the range found in the field (39-98%, Maestre *et al.* 2005).

Random draws (24 for each of the species richness levels) will be made from the species pool. After draws, I will randomly assign the cover of each species to have either maximal evenness (equal distribution of cover among species; 40% each in 2 species, 20% each in 4 species, 10% each in 8 species, and 5% each in 16 species mixtures) or a more realistically low evenness based on a geometric distribution among species which produced rank-abundance slopes of approximately -0.26 (the average slope found in an unpublished BSC survey in 100 30 cm × 30 cm plots located in Central Spain). Thus, for each random draw, the high and low evenness treatments will have the same species. Each combination of species richness and evenness will be established under two spatial patterns: clumped and random. Each combination of richness, evenness and spatial pattern will be replicated six times for a total of 96 microcosms. In addition, monocultures of selected species, as well as microcosms without soil lichens, will be established to have baseline data to compare the effects of the different species used and the colonization of other microorganisms during the experiment, respectively.

The experiment will be set up in the facilities of the Universidad Rey Juan Carlos (URJC) during the first year of the project, and will last for two years. Soil CO_2 efflux, temperature and moisture measurements will be taken on a monthly basis; additional surrogates of ecosystem functioning and of belowground community composition and diversity (Table II) will be measured at the end of the experiment as described above. The effects of the treatments on the different response variables evaluated will be evaluated using appropriate ANOVA models.

By manipulating community attributes using a factorial experimental approach, this study will allow to estimate the relative importance of species diversity and spatial pattern and as drivers of ecosystem functioning without the confounding effects of variables such as cover (which can modify the effects of biodiversity through its effect on the number of individuals; Gotelli & Colwell 2001). If successful, the results will open new research lines in the study of spatial ecology (Tilman & Kareiva 1997), and in our understanding of the functional role of this important feature of biotic communities. Furthermore, this study will rank among the first biodiversity experiments conducted with BSC, and thus its results will provide an important dataset to compare the results of studies carried out using other model organisms.

2.2) Spatial pattern-ecosystem functioning experiment 2

This microcosm experiment, which is linked to Experiments 1.1 and 2.1, will independently test for the effects of species richness (4 and 8 species), spatial pattern (clumped vs. random), temperature (control vs. a 4º annual increase in temperature), and rainfall (control vs. a 20% reduction in rainfall) on ecosystem functioning using BSC as a model system. Its major objective is to evaluate the relative importance of species spatial pattern and richness as modulators, *per se* (i.e. independently of other community attributes), of ecosystem responses to two major global change drivers. This experiment focus on species richness as a biodiversity component for two reasons: i) it has been the component most widely studied, and ii) to keep the size of the experiment manageable.

The experiment will be established following a split-plot design, with temperature and rainfall as between-plot factors, and species richness and spatial pattern as within-plot factors. Otherwise, the methodology of this experiment will mirror that of experiment 2.1 (same pool of species, type of microcosm, total cover and response variables measured), and will ran in parallel to it. Increases and reductions in temperature and rainfall, respectively, will be achieved using the same approach as in Experiment 1.1. Each combination of richness, spatial pattern, temperature and rainfall will be replicated six times for a total of 192 microcosms. The experiment will be set up in the facilities of the URJC during the first year of the project, and will last for two years.

The results of this experiment will complement those of Experiments 1.1 and 2.1. The inclusion of both BSC attributes and global change drivers in the design of the experiment (BSC attributes other than cover are not included in the design of Experiment 1.1), will provide important mechanistic insights on the role of species richness and spatial pattern as modulators of ecosystem responses to global change. This mechanistic understanding will be used to refine the information provided by the field experiments during the modeling activities (see below).

2.3) Spatial pattern-ecosystem functioning experiment 3

This common garden experiment aims to test, using a factorial design, for the independent effects of species richness (4, 8 and 16 species), spatial pattern (clumped vs. random), temperature (control vs. a 4º annual increase in temperature), and rainfall (control vs. a reduction in rainfall of 68 mm·year^{-1}) on the functioning of perennial herbaceous assemblages. The experimental units will consist on 1 m × 1 m plots, which will be established in a common garden at the Plant Growth facilities of the URJC. For this experiment, a pool of twenty species commonly found in semiarid grasslands from Central Spain will be selected. Recently germinated seedlings will be used for this experiment to control the overall density in the experimental plots, which will mimic that found in the field (as revealed by surveys to be conducted prior to the experiment).

The experiment will be established following a split-plot design, with temperature and rainfall as between-plot factors, and species richness and spatial pattern as within-plot factors. Increases and reductions in temperature and rainfall, respectively, will be achieved using the same approach as in Experiment 1.1. Random draws will be made from the species pool (48 for each of the species richness levels). These will be randomly assigned to every possible combination of spatial pattern, temperature and rainfall. Each combination of treatments will be replicated six times for a total of 144 experimental plots, which will be grouped in blocks according to the whole-plot treatments.

The experiment will be set up during the second year of the project, and will run for three years. Soil CO_2 efflux, temperature and moisture measurements will be taken on a monthly basis. Aboveground biomass production will be estimated in each plot after every growing season. Soil cores (0-15 cm depth) will be extracted then to estimate belowground biomass, and to measure the activities of soil enzymes, total N and P, microbial functional diversity, and microbial biomass and diversity as described above. The colonization of the plots by natural species will be assessed with seasonal surveys.

This experiment differentiates from current global change and biodiversity experiments in that it incorporates explicitly the spatial pattern of the members of the community being studied in the design. It will complement the results of Experiments 2.1 and 2.2, and will allow establishing a wider generalization of the role of species richness and spatial pattern as modulators of ecosystem responses to global change.

3) Modeling activities. The data gathered in the field and common garden experiments will be used to set up models of ecosystem functioning taking into account multiple community attributes. These models will contribute to objectives **i**, **iii** and **iv** of the proposal, and will be used to predict how changes in these attributes may impact the functioning of semiarid ecosystems under different global change scenarios. The following modeling activities will be carried out:

3.1) Development of predictive models at different spatial scales

Using the data gathered from Experiments 1.3 and 2.1, I will develop and validate a predictive model (Model 1) to describe small-scale changes in two basic ecosystem processes (soil CO_2 efflux and N cycling) using abiotic factors (soil moisture, organic matter content, texture and temperature) and attributes of BSC (species richness, evenness, cover and spatial pattern) and microbial (species richness and biomass) communities as predictors. Statistical approaches such as generalized linear models, logistic regression, generalized additive models and classification tree analysis (Thuiller *et al.* 2003) will be used on its development. In addition, I will also implement a model at a larger spatial scale (Model 2), using the data gathered in Experiment 1.2 and similar statistical approaches, to predict changes in soil CO_2 efflux and N cycling using site characteristics (climate, organic matter content, latitude, longitude, texture and nutrient content) and the attributes of BSC (species richness, evenness, cover and spatial pattern), microbial (species composition, richness and biomass) and plant (species richness, evenness, cover and spatial pattern) communities as predictors.

3.2) Adaptation and validation of available ecosystem models

In addition to the development of predictive models based on the data gathered from the different experiments, I will adapt the Patch Arid Land Simulator (PALS) model for its use in the areas surveyed with the Experiment 1.2. PALS is a process-based ecosystem model including major ecosystem processes in arid and semiarid ecosystems (soil CO_2 efflux, soil water dynamics, ecosystem productivity, net CO_2 exchange, and nutrient cycling), and has been successfully used in different deserts of North America (Reynolds *et al.* 2004, Shen *et al.* 2005). I will adapt this model to account for the characteristics of the plant species dominating the ecosystems studied, and will modify it to incorporate the effects of BSC on ecosystem functional processes (mainly C, N, and water cycles). The revised PALS model will be validated using the data gathered in Experiment 1.2.

3.3) Forecasting of potential impacts of global change on ecosystem processes

Both the predictive models developed (Models 1 and 2) and the ecosystem models adapted (PALS) will be used to conduct simulation experiments according to different global change scenarios (Schröter *et al.* 2005). They will help to assess the relative importance of different global change drivers and community attributes on ecosystem functioning, and to discriminate the responsible mechanisms for the observed patterns. The data provided by the Experiments 1.1 and 2.2 will be used to validate the forecasts from Model 1. Predictions from Model 2 will be compared with those of the validated PALS model.

The modeling activities will start during the third year of the project, once enough data from the field experiments become available. The testing and development of these models may involve additional data not gathered in the experiments planned, as well as the evaluation of ecosystem models currently unavailable. This may require adjustments in some of the measurements to be collected and/or conducting additional field surveys to gather the information required.

Albeit particularly challenging, the proposed combination of field/common garden experiments and modeling can provide additional confidence when modeling global change impacts on ecosystems, which are commonly associated to large uncertainty levels (Schröter *et al.* 2005, Araújo & New 2007). If successful, this part of the project will open new horizons for the development of further models and experiments incorporating biotic attributes as modulators of ecosystem responses to global change, and will provide policy markers and land managers with relevant data for the establishment of new management and restoration strategies aiming to minimize its impacts.

4) Synthesis and meta-analyses. Together with the modeling activities, the data gathered from all field and common garden experiments will be combined with those of published studies to conduct different syntheses and quantitative meta-analyses. At least three large meta-analyses will be conducted by the end of the project: i) an assessment of the relative importance of species richness, composition, evenness, spatial pattern and cover as drivers of ecosystem functioning; ii) the evaluation of the effects of joint changes in temperature, rainfall and nutrient availability on the performance of organisms (BSC, vascular plants and microorganisms) and on ecosystem processes depending on them (carbon, nutrient and water fluxes), and iii) the relative effects of aboveground and belowground communities on ecosystem functioning in arid and semiarid environments. In addition, I plan to edit a monograph entitled "Global change ecology of semiarid ecosystems: scientific challenges and management implications". This work will summarize most of the results of this project, as well as those from selected case studies from other parts of the world. Its main objectives are to synthesize the state-of-the art knowledge on the effects of global change on semiarid ecosystems, to identify future directions for research, and to provide specific guidelines for managers and policy makers dealing with the management of these areas.

These syntheses will complement the scientific papers derived from the different experiments proposed, and will also facilitate the dissemination of the results obtained from the project. In addition, and to contribute to this diffusion among non-scientific audiences, a web page will be developed. It will contain all the relevant information from the Starting Grant (members, objectives, publications and major results), as well as different databases containing the data gathered by the project as they become published. The latter will facilitate the use of these data in meta-analyses and syntheses by external researchers, increasing its impact among the scientific community.

iii. Resources

The team that will conduct the research planned will be formed by eight members, the principal investigator, which will devote most of his time to the project, and seven members recruited during the duration of the project. Their profiles are the following:

1) *A post-doctoral research associate with background on community and ecosystems ecology*. He/she will be contracted during the first 2.5 years of the project, and will collaborate with the PI in the development of Experiments 1.1 and 1.2.

2) *A post-doctoral research associate with background on ecological modeling and forecasting*. He/she will be contracted during the last 2.5 years of the project, and will be responsible for testing, developing and validating the different modeling approaches presented in section 3) above.

3) *A graduate student, with a Bs.C. in Biology, Environmental Sciences, Forest Engineering or related fields*. He/she will be contracted during the first 4 years of the project, and will conduct his/her Ph.D. research based on Experiments 2.1, 2.2 and 2.3 outlined above.

4) *A graduate student, with a Bs.C. in Biology, Environmental Sciences, Forest Engineering or related fields*. He/she will be contracted during the last 4 years of the project, and will conduct his/her Ph.D. research based on Experiments 1.1, 1.3 and 1.4 outlined above.

5) *Two field assistants*, who will help researchers with the set up, maintenance and data gathering of all field and common garden experiments.

6) *A laboratory technician*, who will help researchers with the analysis in the laboratory of all the samples gathered during the field and common garden experiments. He/she will also be in charge of data management and curation, and will help the PI with all the administrative issues related to the acquisition of the equipment and consumables needed to carry out the work described.

The host institution has the basic infrastructure needed to carry out the research project, including fully equipped laboratories for conducting a wide range of plant and soil analyses and plant growth facilities. Some pieces of equipment (e.g. a TDR system for soil moisture measurements, a LI-COR 8100 Automated soil CO_2 system, gas chromatographers and other equipment for conducting microbial diversity analyses, climate controlled growth chambers, and a San^{++} analyzer for nutrient analyses), and all the laboratory facilities and instrumental available at the host institution will be used for the research planned in the project as needed. However, to fully achieve the objectives of the project it is necessary to acquire some pieces of equipment. These include a LI-COR 6100 portable photosynthesis system to measure net CO_2 exchange, an additional LI-COR 8100 unit (justified by the simultaneous and intensive use of this equipment in different experiments), sensors for temperature and moisture monitoring, a microplate reader and a spectrophotometer for analyzing the activities of soil enzymes and for carrying out analyses of microbial functional diversity, weather stations and minor pieces of equipment (e.g. global positioning system units and personal digital assistants for conducting field work), and computers for the members of the team to be recruited.

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C. Research Environment *(max. 2 page)*

i. Transition to independence

My position within my University, as a "Ramón y Cajal" research fellow (http://www.mec.es/ciencia/jsp/plantilla.jsp?area=cajal_eng&id=11), allows me to develop an independent research program, as I have no contractual obligations for teaching. However, the level of funding commonly available for researchers in my position makes extremely difficult to recruit people and to acquire infrastructure and laboratory equipment, and therefore is a serious limitation for creating an independent laboratory. As a consequence, I still need to participate in all the stages involved in research (including experimental setup and monitoring, and data curation and analysis), which constrains my productivity and my ability to become an independent researcher. A Starting Grant would provide me with the resources needed to establish my own laboratory within my Department, and to substantially expand the research I am currently doing into new, exciting, and mostly under explored, research areas with important scientific, political and socio-economical implications. Such a grant would definitively consolidate my profile within the ecological and global change research community, and would provide the resources to become an independent research leader.

ii. Hosting institution

The host institution (URJC) strongly supports this proposal. Created 10 years ago, the URJC is the youngest public university located in the Madrid region. It is an expanding University with an ample number of degrees in Environmental, Engineering, Health and Social sciences, and with strong research groups on Chemical Engineering and Biological Sciences. My department (Biology & Geology) is mostly formed by young and talented teachers and researchers, with a strong background in areas such as terrestrial ecology, evolutionary biology, plant and lichen taxonomy, conservation ecology and biodiversity research (for more information and recent publications see http://www.escet.urjc.es/biodiversos/engl/main.htm). The URJC is maintaining very active policies to increase its research activity. It has established its own incentive program to motivate its teachers and researchers to become involved as much as possible in research activities. It is also seeking to attract and retain top researchers in different fields, as well as young and talented researchers. As an example of the latter, the URJC is stimulating the recruitment of "Ramón y Cajal" researchers by providing additional research funding to that provided by the Spanish Ministry of Education and Science for this program.

The URJC will provide all the material and intellectual resources it has for the successful development of this proposal. It will provide all the facilities needed to accommodate the research team (furnished office space, laboratory space, office consumables, etc.), as well as access to all the research and bibliographical resources currently available at this institution. This includes access to the plant growth facilities and equipment at the Technological Support Center (http://www.urjc.es/cat/index.htm), and to other university laboratories depending on the needs of the project. In addition, the URJC will develop and host the web page of the project, cover the costs related to office and laboratory space, communication expenses and office supplies (at no additional cost for the project), and will provide assistance for managing the project towards its Center for Research & Development and Technology Transfer (http://cinttec.urjc.es/). The latter will include administrative support and assistance with the economic and scientific reporting of the development of the project to the ERC, as well as with the technological transfer of those results with potential practical applications. Lastly, the press service of the URJC (http://www.urjc.es/prensa/) will help to disseminate the results and publications derived from the project among newspapers, television and radio stations.