ERC Starting Grant
Research proposal (Part B2)

Section 2: ***The Project proposal*** (max 15 pages + Ethical Issues)

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 (hereafter referred as to global 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 (see Canadell *et al.* 2007 for a recent synthesis). In parallel, and inspired by an increasing concern on the ecological consequences of biodiversity loss, many 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. Hooper *et al.* 2005, Hector & Bagchi 2007). However, much uncertainty remains as how the results of these studies 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 (Pacala & Deutschman 1995, Tilman & Kareiva 1997, Wiegand *et al.* 2007). 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, Kikivdze 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, Maestre & Reynolds 2007), and much remains unknown on the potential effects of global change on the ecosystem processes and services that are dependent on attributes of biotic communities. Expanding these studies to include other communities and 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 and adaptation actions.

The overall objective of this project is to evaluate the relationships between community attributes and ecosystem processes in dryland ecosystems under different global change scenarios. Technically, drylands are defined as regions that have an index of aridity (ratio of mean annual precipitation to mean annual potential evapotranspiration) of 0.05 to 0.65 (Middleton & Thomas 1997). These ecosystems are a key terrestrial biome, covering 41% of Earth's land surface and supporting over 38% of the total global population of 6.5 billion (Reynolds *et al.* 2007), and are highly vulnerable to global change and desertification (Körner 2000, Reynolds *et al.* 2007), two of the most important and pressing environmental and socio-economical issues currently faced by mankind. The sensitivity of drylands to these problems derives from the fact that their primary productivity is strongly limited by precipitation and soil nutrient availability, and both of these factors are undergoing changes associated with increasing atmospheric greenhouse gases and air pollutants from combustion of fossil fuels and agricultural practices (Reynolds *et al.* 2007). Because of the extent of dryland ecosystems globally, and

[1] Ecosystem "functioning" and "processes" are used interchangeably in this proposal

the dependence of an important part of the human population on them for goods and services, it is crucial to understand how they may be affected by global change and, more specifically, to know how the attributes of biotic communities inhabiting them will modulate ecosystem responses to it. The specific objectives of this project 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 drylands.
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 examine the complexity of these interactions using an integrated framework. My proposed use of different experimental approaches, multiple biotic communities and spatial scales (from local- to global-scale studies) to test the same core ideas, as well as its integration with diverse modeling schemes, is novel, and will add further value to the project by allowing wider generalizations of the results obtained. Such integrated framework has not been tackled before when studying the impacts of global change on terrestrial ecosystems, and constitutes a ground breaking advance over current research efforts on this key environmental issue, which constitutes a priority research for the European Union. The data gathered during the project 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 dryland ecosystems. These will be important to stakeholders and government agencies to aid in developing appropriate management and mitigation strategies for lands that may already be impaired via historical overuse and mismanagement. In short, this project will have notable impact on existing theoretical and applied research regarding the effects of global change on community attributes and ecosystem functioning, and will "open the door" to new research lines concerning the functional role of community attributes and their importance as modulators of ecosystem responses to global change. I expect the research to be conducted to be published in top multidisciplinary journals such as *Science*, *Nature*, *PLOS Biology* or the *Proceedings of the National Academy of Sciences USA*, as indicated by the journals evaluating my current research (see Part B1, section 1a, for details).

ii. Methodology

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

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 different reasons: i) BSC are a key, but understudied, biotic component of dryland ecosystems worldwide, with important effects on vascular plant establishment, soil stability, infiltration and nutrient cycling (Belnap 2004, Maestre *et al.* 2002, Bowker *et al.* 2008); ii) recent studies (Wohlfahrt *et al.* 2008) indicate that a significant amount of carbon dioxide is being sequestered in BSC, suggesting that these organisms may be playing a much larger role in global carbon cycling and in modulating atmospheric CO_2 levels than previously thought, iii) their small size allows to experimentally manipulate the effect of multiple global change drivers at a reasonable cost and with minimum environmental impacts. The experiment will be conducted in two *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 dryland areas of the Mediterranean basin, and their structure resemble that of the vegetation found in other dryland areas of the world (Valentin *et al.* 1999, Fig. 2).

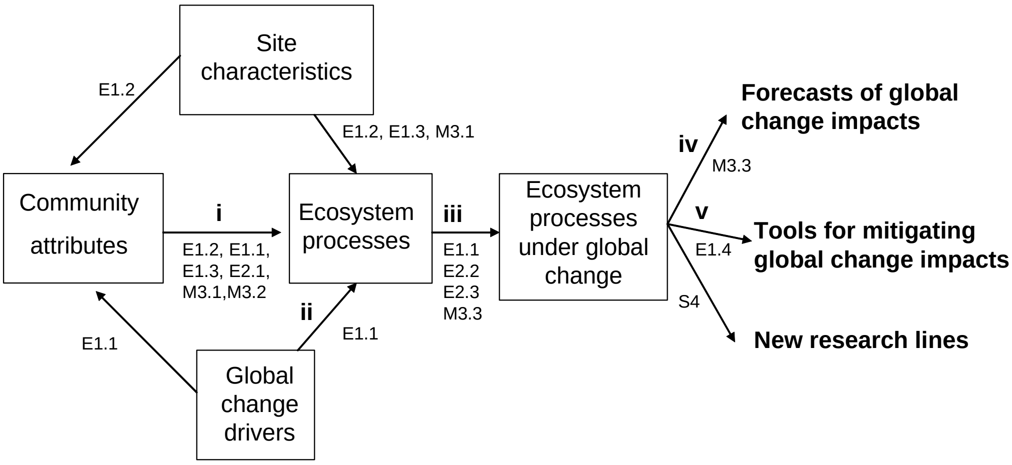

Figure 1. Integrated framework of the project, showing the different tasks proposed and their links with its specific objectives (i-v) and overall goals (text in bold). E = experiment, M = modeling approach, S = synthesis. The numbers (1.1, 1.2…) correspond to the number of the experiment/ modeling approach/synthesis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

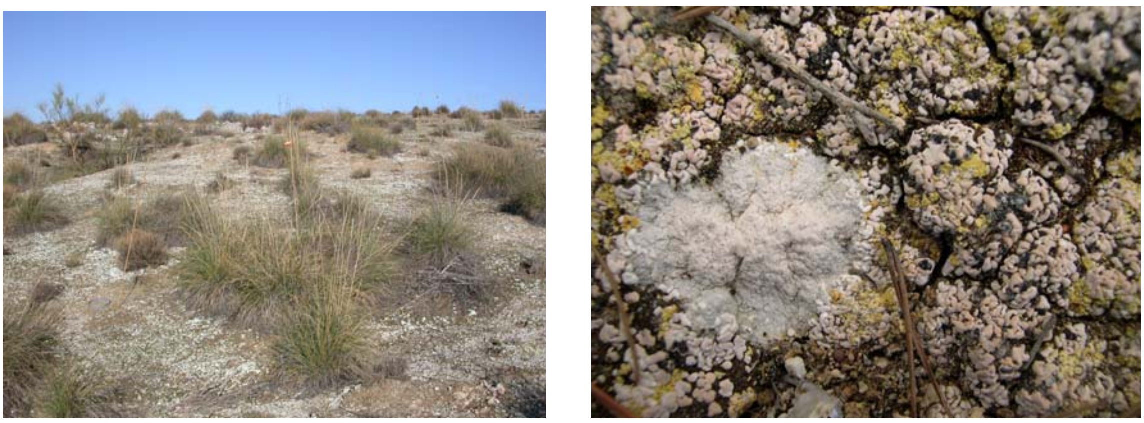

Figure 2. Typical *Stipa tenacissima* steppe (left), where patches of this plant species are surrounded by a well-developed biological soil crust (white patches dominating the space between plant tussocks), and a close-up view of the lichens dominating this crust (right): *Diploschistes diacapsis*, *Fulgensia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

Using a factorial design, the experiment will evaluate the effects of the following treatments on ecosystem functioning: BSC cover (poorly developed communities with cover < 10% 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 dryland 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 central and south 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 follows 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 has been previously tested in a pilot study, and both devices have been found to behave satisfactorily.

A reduced version of this experiment (including only manipulations of temperature and rainfall) was set up in August 2008 (Fig. 3) in central Spain (Aranjuez) with the support of the British Ecological Society and of a short-term (1-year) project provided by the Spanish Ministry of Science and Innovation (MCINN) to finalists of the 2007 Starting Grant competition (see funding ID in part B1 of the proposal). I would like to highlight that the funding provided by MCINN is insufficient to set up the full experiment as planned and, more importantly, its short duration cannot guarantee its monitoring, which should be carried out for the next four years to obtain enough data to make reliable predictions. The ongoing experiment will be expanded using this Starting Grant to include the three global change factors described here, and to replicate it in an additional site in southern Spain. The full experiment will be set up during the first year of the proposal, and will be monitored until its end. The response variables to be measured are summarized in Table I. 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 available 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).

Figure 3. View of an experimental plot with an open top chamber and a rainfall shelter (left), and of part of the area in central Spain where the experiment 1.1 has been set up (right).

The effects of the treatments evaluated on the response variables measured will be analyzed with appropriate ANOVA models. Structural equation models will also be employed with a subset of replicates (those containing BSC) to evaluate the effects of BSC attributes (species richness, diversity, cover and spatial pattern) on these response variables.

This experiment will allow evaluating, for the first time, whether multiple, and co-occurring, biotic attributes can modulate ecosystem responses to global change. 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- and belowground biotic communities. An appropriate assessment of the effects of biotic attributes (including biodiversity) on ecosystem functioning requires the measurement of a wide variety of variables (Hector & Bagchi 2007). However, the vast majority of studies on the topic have focused on measuring a single (or a few) function (Hooper *et al.* 2005), limiting our ability to accurately predict and model potential impacts of global change on ecosystem functioning. By conducting a comprehensive assessment of ecosystem functions related to carbon, nutrient and water fluxes, this experiment will also overcome this limitation. If successful, its results will open new horizons on the study of effects of biotic community attributes as modulators of global change impacts, as well as on their links with ecosystem functioning under different global change scenarios.

Table I. Summary of the experiments planned (see the text for details). AB = aboveground biomass, AP = available soil P, 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, and VP = vascular plants.

Experiment	Nature	Organisms studied	Response variables to be measured	Duration (years)
1.1	MFE	BSC, MO	AP, CO_2E, NCO_2, LD, MB, MD, MF, NF, NM, PA, SE, SM, SI, TN	5
1.2	NE	VP, BSC, MO	AP, CO_2E, MC, MD, SE, TN	3
1.3	NE	BSC	CO_2E, NCO_2, NM, SM, ST	5
1.4	MFE	BSC, MO	AP, AS, NCO_2, MB, MD, MF, NF, SE, SI, TN	2
2.1	CGE	BSC, MO	CO_2E, MB, MD, MF, NCO_2, SE, SM, ST	3
2.2	CGE	BSC, MO	CO_2E, NCO_2, MB, MD, MF, SE, SM, ST	3
2.3	CGE	VP, MO	AB, AP, CO_2E, MB, MD, MF, SE, SM, ST, TN	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 multiple plant communities (*S. tenacissima* steppes, Mediterranean shrublands dominated by species such as *Quercus coccifera*, *Rhamnus lycioides* and *Rosmarinus officinalis*, and *Pinus halepensis* forests) along a large geographical gradients within the Iberian Peninsula (from central to south and southeast 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) per community type 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 I) 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 18 composite soil samples per site collected according to a stratified random sampling (6 samples collected under the canopy of the two dominant vascular plant species 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 Spanish-Latin American research network EPES (http://www.remedinal.org/proyectoepes/; see funding ID, part B1 of the proposal, for details). 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 drylands of Chile, Mexico, Venezuela, Brazil, 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 drylands of Australia, China, Morocco, Tunisia, Peru 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 200-250 sites located in representative dryland ecosystems of the world and sampled according to a standardized methodology. The data gathered will be analyzed using hierarchical generalized linear models, structural equation modeling and classification tree analysis, among other techniques.

This study 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. If successful, its results will allow assessing a series of key questions at the frontier of knowledge in ecosystem terrestrial ecology, will open new horizons on the study of how attributes of above- and belowground biotic communities interact as drivers of ecosystem functioning, and will provide new opportunities for the design of management actions aiming to preserve and restore the functioning of dryland ecosystems worldwide. The database generated with this experiment will also allow evaluating the relationships between the attributes of above- and belowground biotic communities and ecosystem functioning along environmental gradients at a global scale, testing if these relationships are general or idiosyncratic. A large number of aside relevant questions, including the analysis of biotic interactions at different spatial scales and that of the biogeography of microorganisms at large spatial scales (two topics currently receiving notable attention; Brooker *et al.* 2008, Fierer & Jackson 2006), will also be examined with this database.

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 (Fig. 4). 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 related to the water, carbon and nitrogen fluxes, 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 secured funding for this monitoring will conclude in June 2010), so a long-term dataset can be obtained for the modeling activities (see below). In addition, I will use the funds provided by this project to expand current measurements to include seasonal measurements of net CO_2 exchange. These measurements cannot be taken with my current level of funding because lack of appropriate equipment and technical support. The data gathered with this experiment, 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 dryland ecosystems, such as those being developed in North American Long-Term Ecological Research (LTER) stations like Sevilleta (http://sev.lternet.edu/) or Shortgrass Steppe (http://sgs.cnr.colostate.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 LTER station devoted to monitor soil CO_2 and N fluxes in dryland areas of Europe, which will be integrated in the recently developed Spanish LTER network (http://mercurio.ebd.csic.es/).

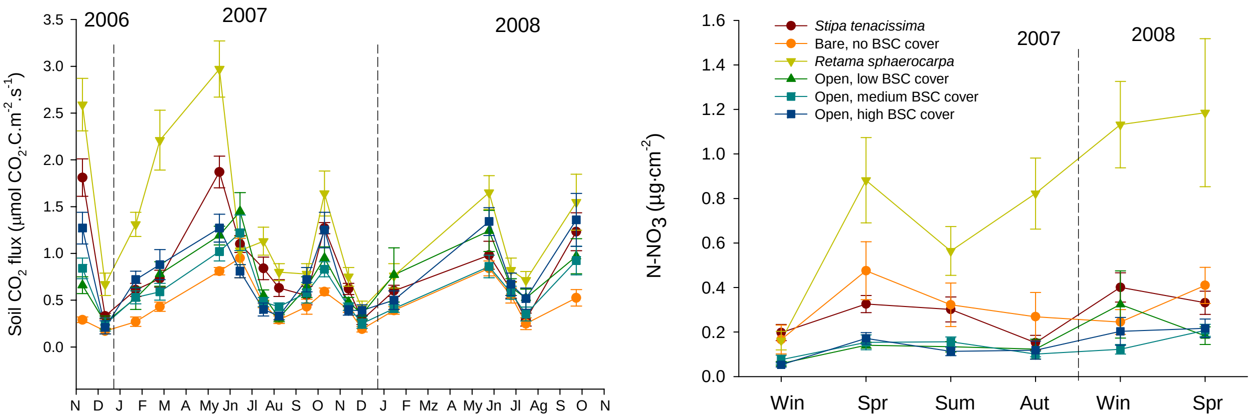

Figure 4. Small-scale spatio-temporal heterogeneity in soil CO_2 flux (left) and nitrification (right) in a *Stipa tenacissima* steppe from central Spain. Note the important effects that the cover of biological soil crusts (BSC) has on both fluxes. Data represents means ± SE (F. T. Maestre, unpublished data).

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 both BSC and vascular plants, as management and restoration protocols are poorly developed for BSC (Bowker 2007) and restoration initiatives commonly carried out with vascular plants in drylands often fail (Maestre & Cortina 2004). 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 dryland 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 and low vascular plant cover. Different BSC and vascular plant 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), and the survival, growth and physiological status of the introduced plants, 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).

Albeit there are a surprising number of BSC restoration studies worldwide (reviewed in Bowker 2007), none of them have been conducted in dryland areas of Europe. Furthermore, the experiments conducted so far have just aimed to promote faster recovery of BSC communities in general or of key taxa within them, without evaluating what particular BSC characteristics should be restored to best promote the recovery of those ecosystem functions of interest. The last issue also applies to current and past initiatives to restore degraded ecosystems and to combat desertification in European drylands, which over the last decades have focused on promoting the establishment of single-specific plantations (mostly of conifers such as *Pinus halepensis*) with the belief that such action would by itself promote the recovery of ecosystem structure and functioning (Maestre & Cortina 2004). This experiment will take existing approaches forward by specifically focusing on the effects of key biotic attributes on different ecosystem functions. If successful, this part of the project will bring new opportunities for the design of restoration actions aiming to recover BSC- and plant-mediated ecosystem functions in drylands worldwide.

2) <u>Common garden experiments</u>

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. 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 typically found under field conditions (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. All the combinations 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 be maintained during the following three 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 I) will be measured at the end of the experiment as described above. The effects of the treatments on the different response variables measured 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, 8 and 16 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 focuses on species richness as a surrogate of biodiversity for two reasons: i) it has been the biodiversity component most widely studied (e.g. Hooper *et al.* 2005), 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). Increases and reductions in temperature and rainfall, respectively, will be achieved using the same approach described in Experiment 1.1. Each combination of richness, spatial pattern, temperature and rainfall will be replicated ten times for a total of 240 microcosms. The experiment will be set up in the facilities of the URJC during the second year of the project, and will last for three 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 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 field surveys to be conducted prior to the beginning of 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 eight times for a total of 192 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. Net ecosystem CO_2 exchange, temperature and moisture measurements will be taken on a bi-monthly basis. Net ecosystem CO_2 exchange will be measured using a custom-built chamber coupled to a LI-COR 6400 Portable Photosynthesis System. 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 dryland 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 the attributes of both 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-Functional Types (PALS-FT; Reynolds *et al.* 2004) and its Community version (PALS-CM; Zimov *et al.* 1996) for their use in the areas surveyed with the Experiment 1.2. PALS-FT is a mechanistically-based ecosystem model that simulates processes such as soil CO_2 efflux, soil water dynamics, above- and belowground plant productivity, net CO_2 exchange, and nutrient cycling over time scales ranging from days to decades. PALS-CM is a phenomenologically-based model that simulates ecosystem changes occurring over longer time scales (decades to centuries). PALS-FT consists of four principal modules (for full details see Shen *et al.* 2005): (1) soil water distribution and extraction via evaporation and transpiration; (2) soil, surface, and canopy energy budgets; (3) plant growth, including phenological and physiological responses of key principal plant functional types (FTs); and, (4) nutrient cycling, including soil organic matter, decomposition, and availability of inorganic N. PALS-CM works with an annual time step under constant conditions to determine steady-state values of biomass ($dB/dt = 0$) of the plant FTs. The model uses the same FTs as PALS-FT, where each has a characteristic maximum growth rate that is diminished when supplies of light, water, or nitrogen are suboptimal (or increased with elevated CO_2). This growth rate, which represents a FTs resource "demand," is further modified by competition coefficients that are determined by the priority of access of each group to a limiting resource (light, water, or nitrogen). PALS-CM provides maximum flexibility for incorporating various plant FTs, ecosystem dynamics (e.g., the effects of nutrient limitations and soil water availability at different depths in the horizon on growth rates) and for linking model output gleaned from PALS-FT.

PALS-FT and PALS-CM have been successfully used in different hot and cold deserts of North America to simulate the effects of global change on ecosystem structure and functioning (Zimov *et al.* 1996, Reynolds *et al.* 2004, Shen *et al.* 2005, 2008). I will adapt these models to account for the characteristics of the plant species dominating the ecosystems studied, and will develop a new module to incorporate BSC into its current framework. The revised PALS models 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-FT and PALS-CM) will be used to conduct simulation experiments according to different global change scenarios (Schröter *et al.* 2005). These will aim to decipher how multiple interactions of elevated CO_2, N availability, and differing precipitation regimes will interact to affect different plant FTs and ecosystem functional processes (mainly C, N, and water cycles). They will also 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 drylands. In addition, I plan to edit a monograph entitled “Global change ecology of drylands: 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 dryland 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 and modeling activities 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 data and associated metadata gathered during the project will also be posted on public repositories, such as the Data Registry of the Ecological Society of America (http://data.esa.org/) and the online archive developed by the Knowledge Network for Biocomplexity (http://knb.ecoinformatics.org/index.jsp). These actions will facilitate the use of these data in meta-analyses and syntheses by external researchers, providing an adding value to the research conducted and increasing its impact among the scientific community.

iii. Resources (incl. project costs)

The team that will conduct the research planned will be formed by eight members: myself as the principal investigator, six members recruited during the duration of the project and one Ph.D. student already working with me. All the members to be recruited will devote 100% of their working time to the project, and will have contracts with full health care/unemployment/retirement benefits according to Spanish laws. The recruitment processes will strictly follow the guidelines given by the Commission Recommendation of 11 March 2005 on the European Charter for Researchers and on a Code of Conduct for the Recruitment of Researchers (www.europa.eu.int/eracareers/europeancharter). The profiles of the members to be recruited are the following:

1) *A post-doctoral research associate with a Ph.D. in Ecology, Environmental Sciences, Forest Engineering or related fields and a background on community and ecosystems ecology*. He/she will be contracted during the first 3 years of the project, and will collaborate with the PI in the development of Experiments 1.1, 1.2 and 1.3 outlined above.

2) *A post-doctoral research associate with a Ph.D. in Ecology, Environmental Sciences, Forest Engineering or related fields and a 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 (3.1, 3.2 and 3.3) presented 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 last 4 years of the project, and will conduct his/her Ph.D. research based on Experiments 1.4, 2.1, 2.2 and 2.3 outlined above.

4) *Two field assistants*, who will help researchers with the set up, maintenance and data gathering of all field and common garden experiments, as well as with data management and curation. They will be hired for the whole duration of the proposal.

5) *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 help the PI with all the administrative issues related to the acquisition of the equipment and consumables needed to carry out the work described. He/she will be contracted during the whole duration of the proposal.

I will devote the 75% of my working time to the project. Apart from coordinating and leading the work of all the members to be recruited, supervising both the Ph.D. student and the post-docs, I will be in charge of the syntheses and meta-analyses to be conducted by the end of the project (presented in section 4 above). As mentioned above, there is a Ph.D. student (Cristina Escolar) already working with me on the Experiment 1.1. She has been funded by the British Ecological Society for the period 2008-2011 (see section B1 for details), and will join the team until the end of her fellowship at no extra cost for the project.

The overall budget requested for the project, including indirect and subcontracting costs, is **1,463,375 €**. This will be distributed among the five years of the project as presented in Table II. Most of this budget will be spent in hiring the different members of the team. The budget requested for the principal investigator corresponds to my salary costs, derived from my dedication to the project according to the rates established by the host institution.

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 recently built plant growth facilities. Some pieces of equipment (e.g. a TDR system for soil moisture measurements, a San^{++} analyzer for nutrient analyses, a LI-COR 8100 Automated soil CO_2 system, microplate readers, spectrophotometers, gas chromatographers and other equipment for conducting different soil, molecular and microbiological 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 6400XT portable photosynthesis system to measure net CO_2 exchange, additional LI-COR 8100 and TDR units (justified by the simultaneous and intensive use of this equipment in different experiments) and weather stations.

In addition to the equipment costs, funding is requested for laboratory and field (e.g. sensors for temperature and moisture monitoring) consumables, as both physio-chemical, microbiological and molecular analyses and the monitoring of environmental variables in the field are an important part of the project. The amounts requested for traveling are justified by the large amount of field work involved throughout the duration of the project, and for the need of conducting one-time surveys in Morocco, Tunisia, Australia, China, Peru and the USA. The funding requested for other direct costs correspond to the rental of a car for conducting fieldwork in Spain. Subcontracting costs are requested for the financial audits of the project.

Table II. Summary of the budget of the proposal.

	Cost Category	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Total (Y1-5)**
Direct Costs:	*Personnel:*						
	PI	45,945	47,783	49,695	51,682	53,750	248,855
	Senior Staff	0	0	0	0	0	0
	Post docs	33,168	34,495	53,812	37,309	38,802	197,586
	Students	0	23,450	24,388	25,364	26,378	99,580
	Other	67,536	70,237	73,047	75,969	79,008	365,797
	Total Personnel:	146,649	175,965	200,941	190,324	197,937	**911,817**
	Other Direct Costs:						
	Equipment	16,804	16,804	16,804	16,804	16,804	84,020
	Consumables	29,300	24,700	17,800	9,400	5,000	86,200
	Travel	13,000	18,000	17,000	14,000	10,000	72,000
	Publications, etc	2,000	3,000	4,000	4,000	5,000	18,000
	Other	8,255	8,255	8,255	8,255	7,755	40,775
	Total Other Direct Costs:	69,359	70,759	63,859	52,459	44,559	**300,995**
	Total Direct Costs:	216,008	246,724	264,800	242,783	242,496	1,212,812
Indirect Costs (overheads):	Max 20% of Direct Costs	43,202	49,345	52,960	48,557	48,499	242,562
Subcontracting Costs:	(No overheads)	0	2,000	2,000	2,000	2,000	8000
Total Costs of project:	(by year and total)	259,210	298,069	319,760	293,340	292,995	**1,463,375**
Requested Grant:	(by year and total)	259,210	298,069	319,760	293,340	292,995	**1,463,375**

References

Araújo, M. B. & New, N. 2007. *Trends Ecol. Evol.* 22: 42-47.
Belnap, J. 2004 *Front. Ecol. Environ.* 1: 181-189.
Bowker, M. A. 2007. *Restor. Ecol.* 15: 13-23.
Bowker, M. A. *et al.* 2008. *Soil Biol. Biochem.* 40: 2309–2316
Brooker, R.W. *et al.* 2008. *J. Ecol.* 96: 18-34.
Campbell, C. D. *et al.* 2003. *Appl. Environ. Microbiol*. 69: 3593-3599.
Canadell, D. *et al.* (eds). 2007. *Terrestrial Ecosystems in a Changing World*. Springer, Berlin.
Moreno, J. M. (ed.). 2005. *Evaluación Preliminar de los Impactos en España por Efecto del Cambio Climático*. Ministerio de Medio Ambiente, Madrid.
Fierer, N. & Jackson, R.B. 2006. *Proc. Natl. Acad. Sci. USA* 103: 626-631.
Fortin, M. J. & Dale, M. 2005. *Spatial Analysis*. Cambridge University Press.
Fowler, D. *et al.* 2007. *Water Air Soil Pollut.: Focus* 7: 41–47.
Fridley, J. *et al*. 2007. *Ecology* 88: 3-17.
Gotelli, N. J. 2000. *Ecology* 81: 2606-2621.
Gotelli, N. J. & Colwell, R. K. 2001. *Ecol. Lett.* 4: 379-391.
Hector, A. & Bagchi, R. 2007. *Nature* 488: 188-191.
Hinojosa, M.B. *et al.* 2005. *J. Environ. Qual.* 34: 1789–1800.
Hollister, R. D. & Webber, P. J. 2000. *Global Change Biol.* 6: 835–842.

Hooper, D. U. *et al*. 2005. *Ecol. Monogr*. 75: 3-35.
Kikivdze, Z. *et al*. 2005. *Ecology* 86: 1395-1400.
Körner, Ch. 2000. *Ecol. Appl*. 10: 1590-1619.
Lax, A. *et al.* 1994. *Arid Soil Res. Rehab*. 8: 9-17.
Maestre, F. T. & Cortina, J. 2004. *Forest Ecol. Manage.* 198: 303-317.
Maestre, F. T. *et al*. 2005. *Funct. Ecol.* 19: 566-573.
Maestre, F. T. *et al*. 2006. *Microb. Ecol.* 52: 365-377.
Maestre, F. T. & Reynolds, J. F. 2007. *Oecologia* 151: 512-520.
Middleton, N. J. & Thomas, D. S. G. (eds). 1997. *World Atlas of Desertification*. Edward Arnold.
Pacala, S. W. & Deutschman, D. H. 1995. *Oikos* 74: 357–365.
Perry, J. N. *et al.* 1999. *Ecol. Lett.* 2: 106-113.
Reich, P. B. *et al.* 2004. *Proc. Natl. Acad. Sci. USA* 101**:** 10101-10106.
Reynolds, J. F. *et al.* 2004. *Oecologia* 141: 194-210.
Reynolds, J. F. *et al.* 2007. *Science* 316: 847-851.
Schröter, D. *et al*. 2005. *Science* 310: 1333-1337.
Shen, W. J. *et al*. 2005. *Ecol. Mod.* 189: 1-24.
Shen, W. J. *et al*. 2008. *J. Geophys. Res.* 113: G03024.
Subler, S., Blair, J. M. & Edwards, C. A. 1995. *Soil Biol. Biochem*. 27: 911-917.
Thuiller, W., Araújo, M. B. & Lavorel, S. 2003. *J. Veg. Sci.* 14: 669-680.
Tilman, D. & Kareiva, P. (eds). 1997. *Spatial Ecology*. Princeton University Press.
Topp, G. C. & Davis, J. L. 1985. *Soil Sci. Soc. Am. J.* 49: 19-24.
Vance, E. D. *et al.* 1987. *Soil Biol. Biochem*. 19: 703-707.
Valentin, C. *et al.* 1999. *Catena* 37: 1-24.
Wiegand, T. 2007. *Proc. Natl. Acad. Sci. USA* 104: 19029-19033.
Wilsey, B. J. & Polley, H. W. 2004. *Ecology* 85: 2693-2700.
Wohlfahrt, G. *et al.* 2008. *Global Change Biol*. 14: 1475-1487.
Yahdijan, L. & Sala, O. E. 2002. *Oecologia* 133: 95-101.
Zavaleta, E. S. *et al*. 2003. *Proc. Natl. Acad. Sci. USA* 100: 7650-7654.
Zhou, Z. *et al.* 2006. *Funct. Ecol.* 20: 753–762.
Zimov S.A. *et al.* 1996. *Clim. Change* 33: 111-120.
Zornoza, R. *et al.* 2006. *Soil Biol. Biochem.* 38: 2125-2134.

iv. Ethical issues

(Note: Research involving activities marked with an asterisk * in the left column in the table below will be referred automatically to Ethical Review)

	Research on Human Embryo/ Foetus	**YES**	**Page**
*	Does the proposed research involve human Embryos?		
*	Does the proposed research involve human Foetal Tissues/ Cells?		
*	Does the proposed research involve human Embryonic Stem Cells (hESCs)?		
*	Does the proposed research on human Embryonic Stem Cells involve cells in culture?		
*	Does the proposed research on Human Embryonic Stem Cells involve the derivation of cells from Embryos?		
	I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROPOSAL	X	

	Research on Humans	YES	Page
*	Does the proposed research involve children?		
*	Does the proposed research involve patients?		
*	Does the proposed research involve persons not able to give consent?		
*	Does the proposed research involve adult healthy volunteers?		
	Does the proposed research involve Human genetic material?		
	Does the proposed research involve Human biological samples?		
	Does the proposed research involve Human data collection?		
	I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROPOSAL	X	

	Privacy	YES	Page
	Does the proposed research involve processing of genetic information or personal data (e.g. health, sexual lifestyle, ethnicity, political opinion, religious or philosophical conviction)?		
	Does the proposed research involve tracking the location or observation of people?		
	I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROPOSAL	X	

	Research on Animals	YES	Page
	Does the proposed research involve research on animals?		
	Are those animals transgenic small laboratory animals?		
	Are those animals transgenic farm animals?		
*	Are those animals non-human primates?		
	Are those animals cloned farm animals?		
	I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROPOSAL	X	

	Research Involving Developing Countries	YES	Page
	Does the proposed research involve the use of local resources (genetic, animal, plant, etc)?		
	Is the proposed research of benefit to local communities (e.g. capacity building, access to healthcare, education, etc)?		
	I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROPOSAL	X	

	Dual Use	YES	Page
	Research having direct military use		
	Research having the potential for terrorist abuse		
	I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROPOSAL	X	

Section 3: *Research Environment* (max 2 pages)

i. PI's Host institution

The host institution, Rey Juan Carlos University (URJC), strongly supports this proposal. Created 11 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, Physics and Biological Sciences. 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, and has a program to fund small "start-up" research projects for those researchers that are starting their career in the university. 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 encouraging the recruitment of "Ramón y Cajal" and "Juan de la Cierva" researchers, two programs created by the Spanish Ministry of Science and Innovation (MCINN) to recruit high-profile post-doctoral scientists in any field who want to develop their scientific career in Spain. As an example, the URJC is stimulating the recruitment of "Ramón y Cajal" researchers by providing additional research funding to that provided by the MCINN 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 unlimited access to the libraries, the plant growth facilities and all the advanced equipment available at the Technological Support Center (http://www.urjc.es/cat/index.htm), as well to other university laboratories depending on the needs of the project. In addition, the URJC will 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/), which is specialized in the management of large research projects funded by the European Union. The latter will consist of 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, including the management of intellectual property rights. It must be also noted that the URJC has a significant participation (both as project coordinator and partner) throughout the 6th and 7th Framework Programmes, as well as in other European research initiatives such as INTERREG IIIB and IIIC, AGRI-GEN-RES and CULTURE. 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.

My department (Biology & Geology) is mostly formed by young and talented professors and researchers, with a strong background in areas such as ecosystems ecology, community ecology, evolutionary biology, plant and lichen taxonomy and phylogeny, conservation biology, restoration ecology, global change biology and biodiversity research (for more information and recent publications see http://www.escet.urjc.es/biodiversos/engl/main.htm). The Biodiversity and Conservation area is rather young, as it was created in the year 2000. However, it is becoming a national and international reference in the fields of plant biology, biological conservation, global change and terrestrial ecology. It is currently formed by 21 professors and five researchers, including three "Ramón y Cajal" and two "Juan de la Cierva" fellows. A good example of the research excellence and future potential of this group of researchers is given by the number (more than 200 articles published in international journals listed in the JCR database) and quality (two articles in *Science* and other two articles in *Nature*, plus many more in top Ecology/Plant Biology/Conservation journals, such as *Trends in Ecology and Evolution*, *Ecology Letters*, *Annual Review of Ecology and Systematics*, *Ecology*, *American Naturalist*, *Conservation Biology*, *Proceedings of the Royal Society B*, *Journal of Ecology*, *Journal of Animal Ecology*, *Oikos*, *Oecologia* and *Ecological Applications*) of the publications they have produced during the period 2004-2008, as well as by the number of research projects leaded by them (more than 30 research projects obtained in competitive calls since 2003, raising more than 2,000,000 € in total). Another indicator of the international visibility of these researchers is their inclusion in the Editorial

Boards of seven scientific international journals included in the Journal of Citation Reports database (*Journal of Ecology*, *Biological Conservation*, *Tree Physiology*, *Restoration Ecology*, *Arid Land Research and Management* and *Journal of Plant Research*), and the positions they hold in the government bodies of the Spanish section of the *International Geosphere-Biosphere Program* (IGBP), the *International Association for Lichenology* and the *Organization for the Phyto-Taxonomic Investigation of the Mediterranean Area*. The visibility of my department is reinforced by the international collaborations currently hold with researchers from other universities and research centers from Spain and abroad, by the participation in Spanish and International research networks (e.g. GLOBIMED [www.globimed.net], EPES [http://www.remedinal.org/proyectoepes/], and ARIDnet [www.biology.duke.edu/aridnet]), and with an active Ecology/Conservation Biology seminar program. This program has brought to the URJC international top researchers such as Richard Webster (Rothamsted Research, UK), Hans de Kroon (Radboud University Nijmegen, The Netherlands), Elisabeth Huber-Sannwald (Instituto Potosino de Investigación Científica y Técnica, Mexico), Lohengrin Cavieres (University of Concepción, Chile), Julio Gutiérrez (University of La Serena, Chile), Michael Hutchings (University of Sussex, UK) and Matthew A. Bowker (Northern Arizona University, USA). International visits scheduled for 2009 within the program include Nicholas J. Gotelli (University of Vermont, USA) and Richard Bardgett (University of Lancaster, UK).

In summary, the stimulating research environment provided by the Biology & Geology department, and the strong support of the URJC to this proposal will be of great help to ensure its success in the case it is funded.