Convocatoria de ayudas de Proyectos de Investigación Fundamental no orientada

TECHNICAL ANNEX FOR TYPE A or B PROJECTS

1. SUMMARY OF THE PROPOSAL (the summary must be also filled in Spanish)

PROJECT TITLE: Integration of perturbation dynamics in the spatial prediction of biodiversity: the case of fire in Mediterranean ecosystems. BIOPRED

PRINCIPAL INVESTIGATOR: LLUÍS BROTONS ALABAU

SUMMARY
(brief and precise, outlining only the most relevant topics and the proposed objectives):

The current fire regime, with a high impact of large wildfires, is one of the main problems for the maintenance of Mediterranean ecosystems. The impact of fire on the structure of a given landscape and on species distributions is relatively complex. As landscapes are complex entities, for a given set of environmental conditions (topography and climate), landscape structure is the result of interactions between the abiotic (perturbations) and the biotic components (vegetations and fauna). In turn, landscape structure strongly determines the character of these interactions. Predicting the response of species distribution in dynamic landscapes requires the integration of different approaches, methodologies and experiences to account for interactions between different processes acting on these systems.

The **main aim of the project** is to develop conceptual improvements and methodologies that allow the robust prediction of biodiversity distribution changes at a landscape scale in a dynamic context dominated by perturbations. Specifically, **the three objectives of the proposal** are:

(1) To advance in the comprehension of the processes and key interactions between fire regime and species (vegetation and fauna) distributions in landscapes affected by large wildfires.
(2) To develop a modelling system for the overall analysis at the landscape level of the relationships among fire regime and species distributions.
(3) To project to future scenarios of landscape changes under different fire regimes of a number of focal species with different ecological and dispersal capability in order to quantify biodiversity responses to a changing perturbation regime.

We will analyze the responses of different taxa (trees, CREAF group, and birds, CTFC group) to fire dynamics (objective 1). This information will be critical to develop a spatially-explicitly landscape model for Catalonia including specific information on the response of vegetation to fire and succession (objective 2). With this model, we will determine species distribution estimates for trees and birds under future scenarios of landscape change (objective 3).

Key-words: fire regime, global change, landscape, species distribution, biodiversity, trees, birds, spatial model, response to fire, scenarios of landscape change, Mediterranean ecosystems

TITULO DEL PROYECTO: Integración de la dinámica de perturbación en la predicción especial de la biodiversidad: el caso del fuego en los ecosistemas mediterráneos (BIOPRED)

RESUMEN
(breve y preciso, exponiendo sólo los aspectos más relevantes y los objetivos propuestos):

El actual régimen de incendios, con una gran importancia de los grandes incendios, es uno de los principales problemas para el mantenimiento de los ecosistemas mediterráneos. El impacto del fuego en la estructura de un determinado paisaje y en las distribuciones de las especies es relativamente complejo. Como los paisajes son entidades complejas, para una determinada combinación de condiciones ambientales (topografía y clima), la estructura del paisaje es el resultado de las interacciones entre los componentes abiótico (perturbaciones) y biótico (vegetación y fauna). Por su parte, la estructura del paisaje determina en gran parte el resultado de estas interacciones. Predecir la respuesta de la distribución de las especies en paisajes cambiantes requiere la integración de diferentes aproximaciones, metodologías y experiencias para poder interpretar las interacciones entre los diferentes procesos que intervienen en esos sistemas.

El **principal objetivo del proyecto** es desarrollar aproximaciones conceptuales y metodológicas que permitan una predicción robusta de los cambios en la distribución de la biodiversidad en un contexto dinámico dominado por perturbaciones. De manera específica, **los tres objetivos de la propuesta** son:

(1) Avanzar en la comprensión de los procesos e interacciones clave entre el régimen de fuegos y las distribuciones de las especies (vegetación y fauna) en paisajes afectados por grandes incendios.
(2) Desarrollar un modelo para el análisis integral a nivel de paisaje de las relaciones entre el régimen de incendios y las distribuciones de las especies.
(3) Proyectar en escenarios futuros de cambio de paisaje bajo diferentes regímenes de incendios un número de especies con diferentes características ecológicas y de dispersión a fin de cuantificar las respuestas de la biodiversidad en un régimen de perturbaciones cambiante.

Analizaremos la respuesta de diferentes taxones (árboles por parte del grupo del CREAF, y aves por parte del grupo del CTFC) ante la dinámica de incendios (objetivo 1). Esta información será crítica para desarrollar un modelo de paisaje espacialmente explícito para toda Cataluña que incluya información específica de la respuesta de la vegetación al fuego y a la sucesión posterior (objetivo 2). Mediante este modelo, determinaremos las distribuciones de especies de árboles y aves en futuros escenarios de cambio de paisaje (objetivo 3).

Palabras clave: régimen de incendios, cambio global, paisaje, distribución de especies, biodiversidad, árboles, aves, modelo espacial, respuesta post-incendio, escenarios de cambio de paisaje, ecosistemas mediterráneos

2. INTRODUCTION

(maximum **5** pages)

- The introduction should include: the aims of the project; the background and the state of the art of the scientific knowledge, including the essential references; the most relevant national and international groups working in the same or related topics.

Recent changes associated to an increasing impact of human activities on ecosystems are leading to strong **modifications of biodiversity spatial patterns** and functional services **at the global level** (Pimm et al. 1995). The capacity of ecosystems to maintain these services linked to current biodiversity patterns depends on their ability to respond to what is broadly known as global change. **Global change** is the effect of individual and interactive effects of changes in land use, atmospheric composition, climate and biological diversity. It includes a series of anthropogenic impacts that are currently affecting natural systems throughout the world. In the past decades, global change understood as a **complex multidimensional process**, has become, as well as a major threat to human society, one of the most relevant scientific topics.

Global change is likely to have its most critical impacts on ecosystem structure and functioning through the interactions of their different components. **Changes in the perturbation regimes** are good candidates to canalise such **interacting cascade of effects**. Wildfires in particular constitute a major driver in the dynamics and functioning of forests and woodlands across the world including the Mediterranean. Fire regime is highly sensitive to climate change, land use and forest management. Climate change driven by human activity is increasing fire risk in some regions (Piñol et al., 1998; Westerling et al., 2006), while fire suppression policies may result in an accumulation of continuous fuel that is conducive to catastrophic high intensity crown fires (Minnich, 2001). Every year about 45,000 forest fires occur in Europe, and between 1995 and 2004 more than 4 million hectare were burnt in the Mediterranean Region alone. Systems which are less prone to burn are expected to contain less resilient species. Therefore current changes in fire regime are expected to produce **important shifts in community structure** and composition, especially where there are fire-sensitive species lacking efficient post-fire regenerative mechanisms (Nepstad et al., 1999). Therefore, a major challenge is to determine the limits of resilience in the face of changes in fire regime that may result in dramatic shifts of woodland diversity, structure and function. Recently, there have been changes in patterns of wildfires due to warmer, drier climate, land use changes involving fuel accumulation and increased ignition sources, and changes in land management policies (Nepstad et al., 1999; Westerling et al., 2006). These findings have uncovered a trend towards an increase in the number of large-scale fires in the Mediterranean Basin. Large-scale fires are responsible for the largest extent of burnt land. As a result, a large area of woodland is currently under early successional stages, and that the proportion of different land covers has been altered.

Mediterranean Basin ecosystems are amongst the planet's biodiversity hotspots (Blondel & Aronson 1999, Myers et al., 2000). Mediterranean systems are extremely diverse, both in terms of species and interactions between species. Many species have their distribution limits (either northern or southern) in the Mediterranean Basin. Therefore Mediterranean populations of these species are particularly vulnerable to environmental change. Desertification processes could affect a large part of the Mediterranean Basin. The knowledge of the species response to the new, more arid conditions and new fire regimes will allow a better management of the vegetation in front of these processes and in view to reduce erosion and undesired hydrological changes. The **Mediterranean Basin** is therefore commonly proposed as a **model region for the study of global change** impacts because Mediterranean ecosystems afford researchers with the opportunity to investigate the complexity of interactions among multiple drivers of global change (Lavorel et al., 1998, Sala et al. 2000).

Fires in a Mediterranean context

Fire has been widely recognised for a long time as one of the main ecological factors shaping the present mosaic characterising Mediterranean landscapes (Naveh 1994). In the last years, a growing importance of wildfires has been reported in the Mediterranean region, with a marked increase in the frequency and intensity of fire episode, and especially of large wildfires (Moreno et al. 1998, Pausas & Vallejo 1999). The consequences of large wildfires are much greater than it is expected from their number since they represent most of the burn surface (Moreno et al. 1998, Peix 1999). In this line, the data obtained by Terradas et al. (1996) support this pattern: **large wildfires** in Spain represent only 0.8 of the total number of fires produced between 1968 and 1994, but **account for more than 60% of the total b**urn surface. In some regions such as Catalonia improved fire fighting capability in recent years has lead to a more efficient control of most fires with the exception of large wildfires. During the period 1988-1998, large wildfires have been responsible for only 0.4% of total fires in Catalonia but account for more than 75% of the burn surface (Peix 1999).

These results have lead to the consideration of the current fire regime with a high impact of large wildfires as one of the main problems for the maintenance and continuity of Mediterranean forests (Prieto 1995), mirroring what is taking place in many other areas of the world (Minnich & Chou 1997, Piñol et al. 1998, Vélez 2000). The current fire regime is the object of present planning prevention and extinction efforts in order to minimize their socio-economic impact. The ecological effects of the cumulative impact of large wildfires are also poorly understood and have lead to a number of case studies suggesting strong impacts on current biodiversity patterns at different spatial scales (Arnan et al. 2006, 2007, Rodrigo et al. 2006, Moreira et al. 2001, Brotons et al. 2008).

But the fire regime has a living character, and the importance of large wildfires is expected to continue increasing due to the history of land uses, the absence of management in most forests and the trend towards warming temperatures and extreme summer weather conditions (Lloret et al. 2002). These interacting processes are expected to impact **on future fire regime** and increase the sensitivity of Mediterranean forest landscapes to fire (Peñuelas 1996, Piñol et al. 1998). In this line, in recent years a shift of fire impact towards areas not strictly Mediterranean and traditionally less impacted by fire has been reported (Espelta et al. 2002).

Responses of biodiversity to fire perturbation

The contribution of ecological perturbations to the **structure and functionality of biological systems** is a major paradigm in general ecological theory and landscape ecology in particular (Forman 1995). Perturbations of natural origin have a fundamental role in maintaining heterogeneity in the environmental conditions that organisms experience across time and space (Brawn et al. 2001, Pickett et al. 1989). Species capability to withstand or profit from perturbations such as fires depend on a series of specific traits allowing the effective occupation of burn areas. In the first place, vegetative traits such as resprouting capability or site fidelity in more mobile organisms such as birds may allow species to persist in a location after the impact fire. In the second place, reproductive potential and dispersal ability will allow species not present before the perturbation or killed by fire to colonise the new habitats created after its impact (Johst et al. 2002). The comprehension of the capacity of a species to colonise a new habitat has been a central topic in the development of seminal ecological developments such as the Island biogeography theory or its related metapopulation theory (McArthur & Wilson 1967, Hanski 1999, Selmi & Boulinier 2001). These ecological theories consider that the **colonization-extinction dynamics** are the main determinants of the spatial distribution of species at large spatial scales (Purves et al. 2007).

In the case of pioneer species associated to dynamic habitats such as those prevailing in initial post-perturbation stages, it is commonly assumed that dispersal allows the effective colonization of these new habitats created by fire (i.e. "colonizer syndrome", Platt & Connell 2003). Theoretical models on the evolution of dispersal capability in mobile organisms such as birds or mammals show how an increase in the temporal variability linked to the perturbation dynamics favours indeed dispersal. These results support the idea that species associated to initial succession stages are likely to be good colonizers (Pickett et al. 1989). On the other hand, these models also indicate that a larger spatial variability may be also associated with the presence of species showing low dispersal. At present, there are few studies examining to which degree in mosaic landscapes dispersal is limiting the colonization of new habitats generated by perturbations such as fires, and how the persistence of such colonizers is to be limited by the structure of these mosaic landscapes (Rodrigo et al. 2004, Brotons et al. 2008). In fact, a great deal of effort has been devoted to analyse the general impacts of forest fires and has been limited to the evaluation of the local process of recovery of the communities affected by fire at local scales (Brawn et al. 2001, Pons 2002). Most of these approaches have largely ignored the **constraints imposed** to this process by **the landscape context** in which they take place or those derived from the of colonisation and extinction dynamics of the different species at a larger spatial and temporal scale. Given that perturbations are often one the major factors affecting changes in habitat availability at the landscape scale, the established link between colonisation, landscape heterogeneity and perturbation dynamics is of fundamental interest to understand the processes leading to the prevailing ecological patterns observed in this systems (Herrando & Brotons 2002, Johst et al. 2002).

Prediction of patterns of biodiversity change in dynamic landscapes

In a context of global change, the **present challenge** is to develop approaches that allow the **prediction of species responses to further change**. However, predictions of species responses such as shifts in species distribution patterns is not an easy task as many interacting factors constraint current species distributions and are likely to do so in the future. The integration of these elements in **modelling platforms** and methodological approaches to reproduce the responses of landscapes and species distributions to variability in the perturbation regime are the step forward (Grimm et al. 2005).

Most **dynamic processes in forested landscapes** can be described by means of models that account for the growth of individual trees, changes in the populations of different species or functional groups (i.e. Shugart 1984). These models should integrate all available information in order make accurate predictions at the short and long term on the structure and dynamics of forest stands. To do so, is necessary to define different situations and alternative ecological scenarios in different conditions. In defining potential ecological scenarios, in addition to the intrinsic differences in the composition and structure of the communities dominating pre-fire conditions, there are a number of factors that should be taken into account: (a) the characteristics of the perturbation: in relation to its intensity, fire frequency and recurrence which affect plant survival and post-fire conditions; (b) the distance to non burnt areas: post-fire presence of species depending on dispersal events from non-burnt areas will be conditioned by the distance to neighbouring propagule sources; (c) and the post fire conditions: that is the capacity of plants to settle after fire may change according to these post-fire conditions in terms of topography issues, erosive processes and resource availability.

Such constraints on **post-fire vegetation recovery** directly or indirectly linked to fire behaviour and site conditions may be implemented mathematically through modelling approaches such **spatially-explicitly landscape models (SELM**, Fall & Fall 2001). A number of modelling methodologies (see synthesis and approaches in Gardner et al. 1999, Fall & Fall 2001) have been proposed to describe the fire behaviour and its effects on vegetation on natural ecosystems. Statistical models (i.e. Jonson & Gutsell 1994) apply a given probability distribution depending of the forest stand age. This represents a static fire regime, and the applications of these concepts to new environmental conditions would require a new parameterization. In order to address various aspects of the interaction fire-vegetations, one would require a more explicit and dynamic simulation of the fire behaviour (ignition conditions and expansion) and its effects on vegetation (burnt area, post-fire vegetation transitions) (Venevsky et al. 2002).

The models used so far to address fire propagation and vegetation dynamics at a regional scale have ofen been kept extremely simple in order to be able to simulate large areas (i.e. 1000 km^2) during long time periods (500-2000 years). There are, however a number of important problems in order to simulate fire regimes at the regional scale (McKenzie et al. 1996): (i) there is a lack on the ecological effects of fire at a convenient spatial resolution leading to complex model development and evaluation; (ii) process based models are often built for a local scale application and often assume ecosystem homogeneity. This homogeneity is almost always lacking when the model is aimed to be applied at larger, regional scales; (iii) landscape patterns heavily influence fire ignition and expansion patterns, but this behaviour is rarely well known at large spatial scales. With all this in mind, is important to progress towards the **integration of the available information** on these topics in order to develop SELM able to take into account the particularities of the region of interest.

Further investigation and **prediction forecast of more mobile** species distributions may be achieved by linking the results of SELM with a variety of distribution modelling techniques (Akçakaya et al. 2005). **Distribution modelling techniques (SDT)** and approaches have boosted during last years and have become a standard technique to generate species distribution patterns from environmental data available through a number of statistical methods (Guisan & Zimmerman 2000, Diniz-Filho 2003). These methodologies allow in practice the projection of the estimated species niche relationships to future environmental conditions to evaluate the effects of future scenarios of change on biodiversity spatial patterns. However, SDT are based on static statistical approaches and even when these techniques offer often good results in predicting species distributions, they have important drawbacks in predicting their dynamics (Vallecillo et al. in prep), unless the factors and mechanisms leading to such dynamics are explicitly incorporated into the models (Dunning et al. 1992, 1995). In this line, the comparison of static statistical distribution models with **more dynamic approaches such individual-based species distribution models** has been identified as a basic critical step to further develop our capacity to predict changes in species distribution under changing environmental conditions (Dormann 2007)

Research groups working on the topic of the proposal

At the European level different Portuguese, Italian, French and Greek research group have been working for some time on fire behaviour and its effects on fauna and vegetation in Mediterranean, both forested and shrubby systems. The closest relationship between CREAF (Centre for Ecological Research and Ecological Applications) and CTFC (Forest Technology Center of Catalonia) groups has been with the CEFE research institute (*Centre d'Ecologie Fonctionnelle et Evolutive*, Montpellier, France). In fact, the collaboration between these three centres have led to the constitution of an European Associated Laboratory (LEA) explicitly aiming at developing research on the ecology of Mediterranean systems and their response to perturbations. These coalitions have strenghtend the relationships and collaboration of the groups and created a reference for the studies in the topic at the international level. The researchers of the two subprojects have developed strong links with the groups of Dr. Sandra Lavorel (first at CEFE and now at LECA institute in Grenoble, France). Dr. Lavorel has developed a vegetation modelling platform at the landscape scale (LAMOS) with some similarities with the approaches introduced in the present proposal (Keane et al. 2004, Mladenoff 2004).

At the level of plant community ecology research, this study is complementary to the activities developed by a number of national and international research groups. At a national level, the *Centro de Estudios Ambientales del Mediterráneo* (CEAM, Valencia) has conducted relevant studies on the post-fire regeneration patterns of vegetation in different locations in Valencia, including development of landscape modelling platforms (Pausas & Ramos 2006). In this context, the research group that coordinates Dr. Ramon Vallejo within the Forest Research Programme has taken part in a thematic network from the Catalan Government (ALINFO) together with both CTFC and CREAF centres. Other Spanish research teams have conducted research on topics related to fire and post-fire regeneration of plants. These incluye the team from *Area de Ecología de la Facultad de Biología de Santiago de Compostela*, the team from *Area de Ecología de la Facultad de Biología de la Universidad de León*, the fire gorup from the *Universidad de Castilla la Mancha*, and the team from *Departamento de Producción Vegetal de la ETSIA la Universidad de Castilla la Mancha*.

At present, different research groups have worked in the identification of the processes affecting animal communities alter fire. It is important to stress the pioneering work on bird community dynamics and fire in Mediterranean systems of Dr. Roger and their group at the University of Montpellier (EPHE). More recently, the team of Francisco Moreira from Instituto Superior de Agronomía de Lisboa has taken a landscape approach to the study of the distribution of birds in areas affected by fire. Other research groups, mostly in areas with Mediterranean climate in the EEUU, Australia and South Africa have developed works on the responses of fauna to fire perturbation but rarely using a landscape perspective. It is worth stressing that the interactive role of birds in the post-fire regeneration of vegetation has been initially developed in South-Africa (Cowling et al. 1997), and a complete lagoon of information exists on this topic in the Mediterranean basin (Llimona et al. 1993).

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3. OBJETIVES

(maximum **2** pages)

◆ **3.1** Describe the reasons to present this proposal and the **initial hypothesis** which support its objectives (maximum **20** lines)

Landscapes are complex entities. For a given set of environmental conditions (topography and climate), **landscape structure is the result of a complex interaction between the abiotic (perturbations) and the biotic components (vegetations and fauna). In turn, landscape structure strongly determines the character of these interactions**. In this line, and as an example, fires (perturbation) model landscape structure, but in turn the resulting landscape structure (i.e. fuel continuity) will condition the future effects of fire. Furthermore, species characteristics (i.e. their response to fire) will determine landscape structure, which in turn (i.e. habitat fragmentation) will be a key factor behind species responses to further change.

The complexity of landscape dynamics forces researchers to carry out **integrative studies** which combine different methodological approaches at different spatial and temporal scales. First, the knowledge of the processes and key interactions amongst the main elements of the abiotic (perturbation) and biotic (vegetation and fauna) landscape elements will require from field studies and detailed analyses of extensive data bases at the local scale over long time periods (**objective 1** of the present project). Furthermore, the simultaneous analyses of the relationships that these components establish amongst themselves lead to the need to integrate them into a dynamic spatio-temporal framework (**objective 2**). Once these kind of modelling approaches are well calibrated, they can be used to analyze the potential effects future changing conditions of the key elements determining landscape dynamics and species interactions. This information may be of great utility to identify trends in species and landscape responses to the effects of the interacting components of global change (**objective 3**).

◆ **3.2.** Indicate the **background and previous results** of your group or the results of other groups that support the initial hypothesis

During recent years, research on Mediterranean systems has shed light on the landscape changes associated to different fire dynamics. **Two main hypotheses** have been proposed: 1- Fire homogenises landscape composition 2- Fire introduces a heterogeneity factor. The impact of fire on the structure of a given landscape is relatively complex and probably depends on the type of prevailing vegetation and particular perturbation regime of the area. It has been suggested that the vegetation of Mediterranean regions has high resilience after fire (Hanes 1971), due to the ability of plant species to recover by means of resprouting from fire-resistant structures, germination of fire-protected seeds stored in the soil or in the canopy bank (Hodgkinson 1998, Lloret 1998, Pausas et al. 2004), and survival of adult trees because of their thick bark and their umbrella-like shape (Rodrigo et al. 2007). Javier Retana and Marc Gracia and their collaborators at CREAF have shown this pattern in characteristic Mediterranean species of the genera *Pinus* (Gracia et al. 2002, Retana et al. 2002, Broncano et al. 2005) and *Quercus* (Gracia and Retana 2004, Bonfil et al. 2004) However, recent studies of the CREAF group have shown that **not all plant species in the Mediterranean basin survive fire** in all situations. In particular, species without persistence mechanisms after fire because they do not resprout, produce few seedlings after fire and have limited dispersal at long distances (e.g. *Pinus nigra, P. sylvestris* or *P. pinea*) are replaced by other tree or shrub species (Retana et al. 2002; Rodrigo et al. 2004, 2007). Studies conducted by the applicants have shown that these different fire responses are causing vegetation shifts at the regional scale (Retana et al. 2002, Rodrigo et al. 2004). Moreover, the general increase in aridity and the trends observed over the last decades suggest that fires will become more and more frequent in forests composed by these species that are not able to recover fire, which were historically free from this type of disturbance.

From the point of view of **mobile fauna**, research on the resilience of Mediterranean forest systems, including the seminal work of Dr. Roger Prodon, has been often addressed at a local scale using single fires as model study (Pons & Prodon 1991). This work has been continued at the *Universitat de Girona* and *Universitat de Barcelona* in the way of innovative research on the population mechanisms driving bird dynamics after fire (Bas et al. 2005, Herrando & Brotons 2001, Herrando et al. 2001, Herrando et al 2002 a, b, Pons & Prodon 1991, Pons 2001, Pons et al. 2003a, Pons et al. 2003 a,b,c, Pons & Wendenburg 2005). The **research carried out by the CTFC lead group**, Dr. Brotons, Dr. Herrando and Dr. Pons using this approach has already shown a key role of vegetation heterogeneity alter fire as key factor determining species distributions in perturbed habitats (Herrando & Brotons 2002, Herrando et al. 2003, Brotons et al. 2004). This is especially true in species of open habitats that colonise early successional vegetation. These species show a high degree of specificity in habitat selection suggesting that patterns of persistence of species in post-fire habitats are likely to be the complex result of vegetation recovery and specific spatial population patterns such as dispersal (Pons & Prodon 1991, Brotons et al. 2004). Some of the results of these works have lead to the basic hypothesis forming the baseline of the present project.

Dr. Brotons and collaborators have moved a step forward and have explored **bird species distribution patterns** after fire in different landscape contexts at larger spatial extents. Previous work of Dr. Brotons on other systems has shown that landscape context is a key determinant of species distribution in landscapes affected by perturbations such as forest fragmentation (Brotons & Herrando 2001, Brotons et al. 2003 a, b). The results of these more comprehensive approaches in Mediterranean systems, suggest indeed that post-fire bird distribution patterns are also context dependent and in the case of these mobile organisms heavily dispersal constrained and therefore dependent on the availability of nearby populations that can source colonisations of new appearing habitats (Brotons et al. 2005). In this line, the CTFC lead group has opened a new and innovative research field in introducing population dynamics in the understanding of post-perturbation ecological processes. Even when at the European scale it is known that early-successional bird communities appear more heterogeneous than those corresponding to forest habitats (Blondel & Farré 1988), the idea that similar processes may act at more local scales, merits a more detailed analysis. Recent findings of the group in the context of the **DINDIS project** (CGL2005-00031/ BOS), ending in 2008, have allowed more detailed analyses of these responses. Amongst the main findings of the DINDIS project relevant to the hypotheses on which the present project is based is worth mentioning the first described analyses of the large scale effect of fire impact on the distribution of bird species with a great conservation concern such as the Ortolan bunting and the identification of dispersal constraints on the species expansion dynamics (Brotons et al. 2008, Sirami et al. 2008, Vallecillo et al. 2008).

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◆ **3.3.** Describe briefly the **objectives** of the project.

Our main objective is to develop conceptual improvements and methodologies that allow the robust prediction of biodiversity distribution changes at a landscape scale in a dynamic context dominated by perturbations. In particular, in this project we will develop sound biodiversity modelling systems that integrate current ecological theory and accumulated practice on the response of species (both vegetation and fauna) to fire regime in dynamic landscapes. These modelling systems should allow assessing quantitatively the effects of changes in fire regime and climate derived from the interactions of the different components of global change on biodiversity patterns. Our study model will be Mediterranean landscapes heavily affected by forestation/deforestation processes associated to land abandonment and by wildfires. The specific objectives to be addressed in this project are three fold:

Objective 1. Advancing in the comprehension of the processes and key interactions between fire regime and species (vegetation and fauna) distributions in landscapes affected by large wildfires Hypotheses tested: Spatial and temporal population dynamics of the affected species and landscape context are key elements in the response of species distributions to fire in Mediterranean mosaic landscapes and need to be assessed explicitly as constraints in the post-fire prediction of changes in biodiversity patterns.

Objective 2. Developing a modelling system for the overall analysis at the landscape level of the relationships among fire regime and species distributions Hypotheses tested: The integration of available ecological information on species spatial dynamics in a spatially explicit realistic landscape modelling context will allow simulating main pattern of landscape change and species distribution under different scenarios of future conditions.

Objective 3. **Projection to future scenarios of landscape changes under different fire regimes of a number of focal species with different ecological and dispersal capability in order to quantify biodiversity responses to a changing perturbation regime.** Hypotheses tested: changes in the current fire regime will have strong impact on species distribution patterns. Furthermore, the expected changes in species distribution patterns will be an interacting function of different components of global change, in our approach namely climate warming and land use changes.

◆ **3.4. For Coordinated projects** only, the **coordinator** must indicate (maximum **2** pages):

- the global objectives of the coordinated project, the need for coordination, and the added value provided by this coordination
- the specific objectives of each subproject
- the interaction among the objectives, activities and subprojects
- the mechanisms of coordination for an effective execution of the project.

The main objective of the coordinated project seeks to predict changes in biodiversity distribution patterns at a landscape scale in a dynamic context dominated by perturbations using the case of fire in Mediterranean ecosystems as a study model. Predicting the response of biological systems such as species distribution in dynamic landscapes requires **the integration of different approaches, methodologies and experiences** to account for interactions between different processes acting on these systems. The complexity envisaged as a general context for the present project is a first important factor that forces collaboration between different research groups with complementary skills.

Both research groups, CTFC and CREAF have experiences in landscape ecology and modelling approaches ensuring a good baseline to integrate current available, and new information to develop a spatially explicit landscape model (SELM). CREAF has an excellent research record in the study of the responses of different vegetation and faunal components to fire perturbation including much of the information needed in the development of a SELM in a Mediterranean context such as the one prevailing in Catalonia. This includes experience in post-fire vegetation recovery and fire regime analyses. CTFC has gained experience in establishing links between landscape composition and structure and fauna in a dynamic context leading to the development of the MEDFIRE model. The MEDFIRE model is a SELM aimed at simulating forest dynamics under different perturbation regimes. However, the MEDFIRE model requires further development in terms of parameter calibration and incorporation of more reliable base data. **The interaction between CTFC and CREAF** ensures that further development of the MEDFIRE model in the context of this proposal will be based on the most comprenhensive knowledge available so far on the system. Furthermore, the collaboration between the two groups ensures that a range of organisms with constraints at different spatial scales are included in the project and assessments of the effects of changed disturbances regime are therefore representative for a range of ecological conditions.

While the ecological framework of the two coordinated projects is the same, they will address their objectives using two different groups of organisms with marked differences in general biology and mobility. These differences have strong implications in the methodologies needed to address the different objectives of the project.

Specific objectives of the **CTFC coordinated sub-project** (Integration of perturbation dynamics in the spatial prediction of mobile organisms: the case of **birds**")
The specific objectives of this sub-project will be to address the main objectives of the coordinated project (investigate biodiversity responses to fire regime and simulate changes in the spatial distribution of different species to different scenarios of future change) using bird communities as study models. The improvement of the MEDFIRE model, initially developed in a previously MEC funded project (DINDIS), will be also a main objective explicitly addressed within this sub-project in close contact and collaboration with the CREAF lead sub-project.

Specific objectives of the **CREAF coordinated sub-project** (Integration of perturbation dynamics in the spatial prediction of mobile organisms: the case of **trees**")
The specific objectives of this sub-project will be to address the main objectives of the coordinated project (investigate biodiversity responses to fire regime and simulate changes in the spatial distribution of different species to different scenarios of future change) using the main tree species of Catalan forests as study models. In addition to the intrinsic value of the research carried out, the basic information collected regarding

responses of the different tree species to fire regime will be essential to develop a new more robust version of the MEDFIRE landscape model.

Interactions between the coordinated projects. In the present coordinated project, each of the two sub-projects represent complementary approaches to the same general question in terms using the same general background for the analyses of the response of different groups of organisms to future changes in environmental conditions including changes in the fire regime. In Objective 1, each of the groups will concentrate in reviewing from a general point of view the responses of different taxa (trees, CREAF group, and birds, CTFC group) to fire dynamics. This information will be critical to objective 2, development of a SELM for Catalonia including specific information on the responses of trees to fire and succession, and objective 3, development of species distribution estimates for trees and birds under future scenarios of landscape change. Objective 2, in particular will require of a particular effort in terms of coordination between the two subprojects and research groups. The development of the final new version of the MEDFIRE fire (task 2.2, coordinated project CTFC) and the incorporation of new information for which parameterization will be possible (task 2.1., coordinated project CREAF) will be based in a continuous feedback between the two groups allowing the development of a robust SELM to be later used to address objective 3.

The **specific mechanisms for effective coordination** of the two sub-projects will be based in a number of complementary activities aiming at facilitating the exchange of information between the members of the two groups and the coordination of the different activities carried out. The two coordinators of the sub-projects will meet at least every three months in order to arrange a number of thematic workshops (at least 3 each year) aimed at addressing specific questions regarding the modelling procedures and ecological context of the project (objective 2 and 3). Furthermore, each year an annual meeting will be organised and all researchers will present their advances and prospects for the forthcoming months. PhD students and researchers of both CTFC and CREAF will conduct short term research stays in each of the two institutions in order to enhance the coherence of the approaches employed during the development of the different tasks.
Finally, the two groups will make extensive use of internet facilities to enhance communication and information transfer in real time. In addition to traditional internet services, the project will create a internal web page including database services that will allow to have access to a common database on the different issues that will be addressed in common by the project (i.e. MEDFIRE model development).

4. METHODOLOGY AND WORKING PLAN
(in the case of coordinated projects this title must include all the subprojects)

Detail and justify precisely the methodology and the working plan. Describe the working chronogram.

- The working plan should contain the tasks, milestones and deliverables. The projects carried out in the Hesperides or in the Antarctic Zone must include the operation plan.
- For each task, it must be indicated the Centre and the researchers involved in it.
- If personnel costs are requested, the tasks to be developed by the personnel to be hired must be detailed and justified. Remember that personnel costs are eligible only when personnel is contracted, **fellowships are not eligible** as personnel costs.

Work package 1 (Objective 1). Advancing in the comprehension of the processes and key interactions between fire regime and species (vegetation and fauna) distributions in landscapes affected by large wildfires

Task 1.1. Identification of the characteristics of tree species that determine their response to fire at the short and the long term

Researchers in charge (CREAF subproject): Javier Retana, Lluís Comas, Marc Gracia, Albert Alvarez.
Scope
In plant communities, there are different **functional groups of species**, depending on their response to fire. Mediterranean-type plant communities have high resilience after fire because many species only regenerate after fire by means of resprouting from fire-resistant structures, while others only regenerate by germination of fire-protected seeds stored in the soil or in the canopy bank. Several species are facultative and combine the two strategies (facultative species), while others do not have efficient strategies to survive fire and, in fact, may disappear in the post-fire scenario. Although CREAF and other research groups in Spain and other Mediterranean countries have developed a large number of studies on this topic for the most common tree species, there is a lack on information for less abundant species. In this task, we aim at compiling the information available and obtaining in the field the information lacking for **these traits and their temporal and spatial variability patterns**. Besides these life traits directly related to the response of species to fire, we will also obtain information for other characteristics that are also important in the long-term dynamics of vegetation, such as growth rates, dispersal and life cycle, and we will focus our interest in evaluating the spatial and temporal variability of some (optimally the most relevant ones) of these traits.

Methodology
In this task, we will analyze the characteristics that determine the post-fire response of the main tree species dominant in the north-eastern Iberian Peninsula. The **main traits of these species** that contribute to define their response after fire and will be analyzed in this study are:

- Mortality rate of adult trees after fire
- Resprouting ability after different fire severities
- Age of the first reproduction
- Seed production and ability to have a seed bank (serotinous species)
- Density of seedlings established at different times since fire
- Seedling survival curves
- Seedling growth rates
- Growth rates of adult trees

Data of these characteristics will be obtained **from three different sources**: (a) information already available for the applicant group and obtained in previous projects and studies; (b) information obtained from the scientific literature (either international and national journals or reports, floras and other sources); (c) field samplings especially designed to obtained these data. For many of these characteristics, there is information available for a particular area or time since fire for the main tree species of Catalonia. However, and in order to evaluate the response of species at a wider geographical and temporal range, we will try to obtain information of the **spatial and/or temporal variability** shown by the most relevant of these traits:

a. **Climatic gradients**. For species that show a broad geographical distribution, we will analyze the variability of some of these traits along climatic gradients that should include most of the climatic conditions where this species occurs or may occur in the future.
b. **Distance to the unburned edges**. We will analyze the establishment and survival of new individuals at different distances to the unburned edges to evaluate the colonization ability of the different species.
c. **Temporal variability**. We will also try to evaluate whenever possible the year-to-year variability of some of these traits, at least those that are expected to show large interannual variations (e.g. seed production, tree growth). We will carry out both synchronic studies in particular areas during the whole duration of the project and asynchronic studies where we will sample in areas burned in different years.

Field samplings will be carried out in three types of situations: (i) recent fires (occurred in the last five years); (ii) old fires occurred in the 70s and the 80s (the information for older fires is very scarce); (iii) unburned areas. Burned areas will be selected from the historical cartography of forest fires in Catalonia developed at CREAF. Whenever possible, sampling plots will be selected from all plots of regional or national forest inventories (IEFC and IFN2) available in the same area.

Task 1.2 To investigate the main factors determining the regional dynamics of bird communities in regenerating post-fire systems.

Researchers in charge (CTFC subproject): Sergi Herrando, Lluís Brotons, Miguel Clavero, and field assistant contracted.

Scope:

Identification of species specific responses to fire perturbation is a key step needed in the pathway towards prediction of the distribution dynamics of species in landscapes affected by large wildfires. The information gathered so far in the investigations carried out in Catalonia has confirmed that vegetation heterogeneity created by fire and landscape context are the two key elements in the post-fire colonisation and recolonization patterns of birds. Species specific biological traits and landscape structure certainly interact in a complex way to determine bird response to fire disturbance; however, we lack information about the generality of these processes and their relative importance for the whole bird community.

In this task, we aim at compiling the information available and obtaining in the field the information lacking for **these traits and their temporal and spatial variability patterns**. Besides these life traits directly related to the response of species to fire, we will also obtain information for other characteristics that are important in the long-term dynamics of bird populations, such as population resilience, dispersal and behavioural traits, and we will focus our interest in evaluating the spatial and temporal variability of some (optimally the most relevant ones) of these traits. We also ask whether extinction patterns of bird species linked to open habitats and the colonization of those linked to forested habitats is a direct function of time since fire or alternatively, a complex function of regeneration of the vegetation, landscape constraints and species biological traits. This information is essential to reproduce the response of these species to changes in dynamic habitat mosaics as predicted by spatially explicit landscape models (see objective 2).

Methodology

In this task, we will analyze the characteristics that determine the post-fire response of selected bird species in the north-eastern Iberian Peninsula. The **main traits of these species** and the environmental factors that contribute to define their response after fire and will be analyzed in this study are:

- Habitat selection patterns
- Behavioural flexibility
- Site-fidelity
- Reproductive capacity
- Dispersal constraints
- Landscape context

Data to investigate these characteristics will be obtained **from three different sources**: (a) information already available for the applicant group and obtained in previous projects and studies; (b) information obtained from the scientific literature (either international and national journals or reports, bird atlas and other sources); (c) field samplings especially designed to obtained these data. For many of these characteristics, there is scattered information available for a particular area or time since fire for the main bird species in Catalonia. However, and in order to evaluate the response of species at a wider geographical and temporal range, we will try to obtain information of the **spatial and/or temporal variability** shown by the most relevant of these traits. We will specifically analyse the relative weight of species specific traits (biological hypothesis) versus the characteristics of wild fires (landscape hypothesis) in accounting for the observed bird distribution patterns. We will also assess the potential role of interactions between the two and their expected importance in a context of global change.

Field samplings aimed at gather **bird abundance data and richness in different forest fires** will be obtained from different sources. First, we will use information already collected during the DINDIS project (2006-2008). The DINDIS database includes yearly bird information starting in summer 2006 on all fires (58 fires) larger than 50 ha and occurred from the year 2000 onwards. The bird information collected is obtained by means of transect lines with defined distance belts in which any bird contacted is noted during a 15 minutes period. The number of transect per fire is proportional to the size of the fire. Finally, a number detailed information descriptors on vegetation recovery and the state of burnt vegetation (i.e. standing trunks) are also collected for every georeferenced transect by means of GPS positioning. Second, we will survey new fires occurred in Catalonia from 2008 onwards during the posterior respective breeding seasons and further specific surveys in a spatially stratified sub-sets of older, large fires (>250 ha) occurred during the 70's, 80's and 90's using the same methodology implemented for the DINDIS database. For this task, the project will require hiring of a field assistant for 6 months every year in order to arrange the preparation of field surveys, effectively conduct bird surveys, monitor environmental conditions in surveyed sites and compile the collected information in a computer database.

Finally, we will obtain information on bird community dynamics from non burnt area from current **bird monitoring programs** in Catalonia run by the Catalan Ornitological Institute (ICO) (Monitoring of common birds, SOCC and bird atlas project data, www.sioc.cat, Estrada et al. 2004). Data obtained from the SOCC project has a similar structure to the data obtained in the context of the DINDIS project and therefore can be used as reference for areas not affected by fires. Basic biological data on bird species will be retrieved from the extensive ICO database including quantitative, comparable information on species habitat selection patterns and reproductive capacity. The data collected will be analysed by using innovative generalized mixed models and capture-recapture techniques applied to the estimation of species richness from data sets for which individual detectability within transects is less than 1 (COMDYN, http://www.mbr-pwrc.usgs.gov/software/comdyn.html). Given the scale at which bird community structure is likely to be determined and the influence of landscape context, we will make extensive use of remote sensing data such as satellite imagery (i.e. Landsat) and aerial photographs. Remote sensing information will be combined with data collected on site to generate calibrated and comprehensible continuous environmental information.

Task 1.3 Determination of the effect of the post-fire management on post-fire bird colonization processes.

Researchers in charge (CTFC subproject): Pere Pons, Sergi Herrando and field assistant contracted.
Scope:
From the results of the previous project DINDIS, it is derived that dispersal constraints and habitat characteristics determine the post-fire bird community on a given site. There is one factor however, post-fire management practices, that require further, specific examination because of the major impact that it causes in the structure of post-fire vegetation (Lindenmayer et al. 2004). The effects of salvage logging that takes commonly place after fire and the way that wood remains are left on the site radically change the structure perceived by birds and there is a potential interaction between this effect and the likelihood of a species colonising a burn area from pure spatial constraints. In this task, therefore, our main objective will be to analyse high quality data on recolonisation patterns of birds in different forested areas affected by a large fire and subjected to different post-fire forestry treatments.

Methodology
The basic methodology used to analyse the effects of post-fire management on birds will be the assessment of abundance and richness patterns of different bird guilds in different scenarios of post-fire management. We will use information from forested areas affected by medium and large fires (in this study those larger than >250 ha) and will identify in each of the areas three scenarios of post-fire forest management during the first two years alter the fire: salvage logging, partial salvage logging and no logging. Analyses of the salvage logging treatments will include complementary information about the way that wood remains are left on the site.
The information on bird abundance and richness in different forest fires will be obtained from different sources but mainly from the development of DINDIS data base and the use of a sub-set of fires (see task 1.2 above). The hypothesis of a significant effect of post-fire management for each of the observed species will be assessed by means of generalised mixed linear models which will use management treatment, and years since fire as fixed effects and fire, and observer as random effects. We will use information on the abundance of each of the focal species in neighbourhood (as obtained from habitat distribution models generated by the Catalan Breeding Bird Atlas, Estrada et al. 2004) to control for the effect of local bird abundance on the management effects. The task will require gathering of complementary environmental information such as detailed description of post-fire wood remains and standing burnt trunks for the selected fires with a forested pre-fire dominance. This work will be carried out by the field assistant in charge of conducting field surveys for the continuation of the DINDIS field database.

Work package 2 (Objective 2). To develop modelling systems of biodiversity distribution optimising the integration of available ecological information and allow the generation of scenarios of future change under different future fire regimes and environmental constraints.

Task 2.1 Calibration of the main processes that will be improved in the new version of MEDFIRE from the new information generated

Researchers in charge (CREAF subproject): Marc Gracia, Jordi Vayreda, Javier Retana, technical expert contracted.
Scope
The main problem in projecting landscape simulations over long time periods is that complex interactions between the different components of the model should be well parameterized to reproduce ecological sound patterns. The main objective of this task will be to calibrate the main processes identified during the developing of the MEDFIRE model and that could be improved from the new information generated in the first work package (see also Task 2.2.). In relation to the first version of the MEDFIRE model initially developed by the CTFC group in the context of the CICYT project DINDIS, the parameterization will include three key

processes for landscape simulation: fire risk of different forest typologies and structures, transition probabilities after fire among the different forest typologies, and forest maturation patterns.

Methodology
We will develop statistical and probabilistic methods to calibrate the processes that will improve the first version of the Project MEDFIRE. The following three types of changes will be included in the model in the light of the present project and they should be correctly parameterized.

(A) **Fire risk of different forest typologies and structures**. At the moment, to simulate fire regime the MEDFIRE model is stochastic based on data on current fire regime and fire extent in Catalonia. The new version requires and important task of identification and calibration of relevant processes on fire dynamics at the landscape level. From the information obtained in a previous project of the CREAF group, we have accumulated data on the synoptic factors that affect the spatial distribution of fire severities in forest fires and on the role of fuels on fire effects. We will calibrate two key aspects of fire risk: (i) the relationship between different forest typologies and structures (defining different fuel models) and their probability of burning in different synoptic conditions (dominant winds, topography, …); (ii) fire behaviour, which determines the pattern of fire severities in a wildfire.

(B) **Transition probabilities after fire among the different forest typologies**. Post-fire changes in forest composition account for direct and non-direct (i.e. changes in dominant tree species) forest regeneration dynamics after the impact of fire in a given area. In the previous version of the model MEDFIRE, transition probabilities of dominant tree species after a fire were based on the information given by Rodrigo et al. (2004). In this paper we included transitions probabilities established for some tree species in few fires located in three different regions. However, post-fire transition probabilities depend on the climate of the region and on environmental characteristics in the first years after fire. In this task, regions and tree species not included in Rodrigo et al. 2004 will be parameterized using new tables with modified transition probabilities for recent re-burns based on the new information obtained in objective 1, in particular the response of species to climatic gradients and the interannual variability of key processes.

(C) **Forest maturation**. In the first version of MEDFIRE, forest structure was based on seral stages (from 1 to 4) determined by the Spanish forest map, and forest maturation was determined by the change in seral stage, which was currently set after a fixed number of years. In the new version of the model, we will parameterize forest maturation using data from the Spanish Forest Inventory (IFN2 and IFN3) and from the Ecological Forest Inventory of Catalonia (IEFC). We will analyze the changes through time of variables synthesizing forest maturation, such as tree cover, basal area or mean tree size. We will develop different functions in relation with time for the main monospecific and mixed forest typologies.

The development of this task and the pertinent integration into the MEDFIRE project will require of the hiring of a technical expert in computer models by the CREAF group in order to allow an optimal coordination with the CTFC group at the specific technical level required by the calibration of the MEDFIRE model.

Task 2.2. Improvement and development of the MEDFIRE landscape simulator model to reproduce the changes observed in Catalan landscapes affected by fire during the last 25 years.

Researchers in charge (CTFC subproject): Lluís Brotons, Andrew Fall, computer programmer assistant contracted.
Scope:
The objective of this task is to improve and further develop the MEDFIRE model developed in the context of the DINDIS project in order to allow projections of the Catalan landscape beyond the short time windows for which this model has been used so far (<10 years). The MEDFIRE model simulates changes in a simplified version of the the Spanish forest map for Catalonia attributed to an active predetermined fire regime. At present, MEDFIRE has two main modules that allow the recreation of landscape dynamics. The first

simulates fire behaviour in different synoptic conditions according to main climatic, topographic and wind conditions of each of the identified sub-regions. The second sub-module is in charge of modelling changes in forest composition and age associated to time (maturation) and derived from the impact of fire (transitions in forest types derived from non-direct regeneration processes).
The main problem in projecting landscape simulations over long time periods is that complex interactions between the different components of the model should be well parameterized to reproduce ecological sound patterns. The main objective of this task will be to integrate the main processes identified during the developing of the MEDFIRE model and conduct careful evaluation of parameter calibration from available data sets.

Methodology
The MEDFIRE model is **an explicit landscape dynamics model** implemented in the **SELES language** (Spatially Explicit Landscape Event Simulator, http://www.seles.info). These models use spatially explicit grided objects that can be modified through modelling processes that incorporate dynamic events which modify the properties of the objects according to a series of previously set rules.
The MEDFIRE is responsible of mimicking changes in landscape composition derived from succession and fire dynamics and it is therefore composed of two separate sub modules each dealing with a different landscape event. These two submodels responsible for the main dynamic processes affecting forest land in Catalonia are maturation (**succession submodel**) and fire (**fire submodel**). The main purpose of the landscape dynamics model is to update the Spanish forest map (SFM) for Catalonia with different forest classes (i.e. each corresponding to a dominant tree species or a mixed of dominant tree species), age and land use classes.

The **succession sub-model** is responsible for the simulation of time related changes in forest composition. This submodel determines the characteristics of the potential transitions in terms of dominant tree species that affect each cell each year according to the event affecting it. Two main types of changes are included in the model and should be correctly parameterized in the light of the present project. A- *Post-fire changes* in forest composition: including all changes in dominant tree forest species after fire event affects a given cell. B- *Forest maturation,* and C- *Succession*: including changes in seral stage and transitions of shrub to forest structures. The information needed to parameterize the succession sub-model of MEDFIRE will be collected by task 3.1 (coordinated project CREAF).

The **fire submodel** is intended to simulate fire regime in the study area. At the moment, the model is stochastic based on data on current fire regime and fire extent. This distribution is estimated from data on current fire regime in Catalonia (Diaz-Delgado et al. 2004). One an ignition starts a fire; a fire size is obtained from a fire size distribution aimed at mimicking the one obtained from real data from the period 1960-1999. Ignitions will be better parameterized using the real ignitions recorded by the Environmental service of the Catalan Government. The sub-model sets each year the amount of area to be burnt from a given distribution of burnt area per year. One an ignition starts a fire; a fire size is obtained from a fire size distribution aimed at mimicking the one obtained from real data from a given period of time. Ignitions are not at random, but decrease in areas with high summer precipitation and increase near roads. Once a fire is set, fires do not burnt at random. Rather they will burn according to specific rules driven by topography and prevailing wind conditions. Finally, fire spreads according to the characteristics of the burning fuel or main forest species. Fire spread will be also parameterized using the information collected by task 3.1 (coordinated project CREAF).

Model parametrization is a complex task and often it has been argued that spatially explicit landscape and population models cannot provide reliable predictions because of the difficulty of obtaining direct estimates for the different parameters and because of error propagation (Wiegand et al. 2004). To calibrate the MEDFIRE model we will use a procedure that will compare the simulated landscape dynamics with distinct features of known landscape dynamics in the area. This procedure detects model parametrizations that will not reproduce known landscape dynamics and therefore reduce the range of potential parameter values for a given model. Further, a pattern or a combination of various patterns that embed information on the entire model dynamics can reduce uncertainty in model predictions (Wiegand et al. 2004, Grimm et al. 2005).The information needed to carry out this task will be obtained primarily from the analyses of landscape dynamics and fire regime data available for Catalonia for the last 30 years (Diaz-Delgado et al. 2004). The improvement of the MEDFIRE model will require of a computer programmer assistant during the second year of the project. This person will be in charge of helping Lluís Brotons and Andrew Fall in the coding the new calibration processes into the new final version of the MEDFIRE model.

Work package 3 (Objective 3). **Projection to future scenarios of landscape changes under different fire regimes of a number of focal species with different ecological and dispersal capability in order to quantify biodiversity responses to changing perturbation regime.**

Task 3.1 Identification of future scenarios of landscape change under different fire regimes and current climate change trends.

Researchers in charge (CTFC and CREAF subprojects): Lluís Brotons, Sergi Herrando, Miguel Clavero (CTFC), Javier Retana, Marc Gracia (CREAF).

Scope:
In this task, we will **develop different scenarios of future landscape change** under different environmental conditions. Specifically and using the calibrated MEDFIRE model, we will develop four main different scenarios corresponding to different fire regimes: present fire regime, present fire regime under climate warmer summer conditions and present fire regime with enhanced fire fighting capability (smaller fire sizes). These three scenarios will assume that forests are not managed and therefore grow without any interference from human activities. Finally, we will investigate the development of an alternative scenario modelling using the current fire regime, but applying it to a maturation sub-module that incorporates forest management strategies aimed at favouring forest structures more resilient to fire.

Methodology
The generation of the **different scenarios of future landscape trajectories** will be based on the reparametrization of the final MEDFIRE model generated in task 2.2, or alternatively on the use of dynamic environmental conditions (i.e. climatic conditions which are assumed to be static in the basic version of the MEDFIRE model). In particular, we will vary specific parameters that will allow a new behaviour of the fire model for a given hypothesis of future change. Present fire regime MEDFIRE model will be base in the exact model parameters generated from task 2.2, whereas alternative future scenarios will be based in published reports of expected drivers of environmental change.

Main drivers of future change will be assumed to be based on **future climatic change derived from IPCC scenarios**. The climatic series to be used have been widely applied and consider climate change scenarios A2 (mid-high) and B2 (mid-low) relative to the concentration of green house gases developed by IPCC in 1996.These scenarios derived from global circulation models indicate for the western Mediterranean a stronger variability and a general decrease in precipitation, especially in summer. This will probably associated to a general increase in temperature and evotranspiration leading to a decrease in resources for vegetation during summer months. Integration of future climatic effects on the MEDFIRE model will be achieved by two different means. First we will feed the basic model with updated climatic summer conditions (drawn from a statistic distribution). This will be performed by means of a downscaled climatic grid which combined current climatic patterns (low resolution) with general patterns of change predicted by the global scenarios (coarse resolution). Climate will have an influence on landscape change by affecting ignition probability and the risk of catastrophic fires in the landscape. Second, we will use different fire risk probabilities associated to different summer conditions which lead to radical effects on fire regime from one year to the next.

The scenario considering an enhanced fire-fighting capability will be developed by introducing the possibility of a fire to stop under particular conditions. This should be introduced into the model without changing the main parameters leading to the current fire regime. The building of the scenario including forest management strategies will be based on a simple additional module that will simulate the thinning of some forest stands at different temporal intervals. The main effect of thinning rate should be diminish fuel load and therefore enhance fire fighting capability.

Task 3.2 Assessment of the effects on species distribution of future landscape scenarios based on different fire regimes and climate conditions. The case of trees

Researchers in charge (CREAF subproject): Javier Retana, Jordi Vayreda, Marc Gracia, technical expert contracted.

Scope:

In this task, we aim at assessing quantitatively the potential effects of changes in the fire regime in sessile organisms such as trees. We will **analyze the distributions of the most abundant tree species** in Catalonia under different fire regimes and climate conditions, based on the information obtained in the work package 1 and the model developed in work package 2. We will try to evaluate these species distributions at the short and the long term. This is because most seeders have larger growth and dispersion rates, shorter life cycles and lower shade tolerance than resprouter species: a few years after fire seeders might be expected to be more abundant in the post-fire plant communities than resprouters, but in the long time scale this pattern could be inverted.

Methodology

We will derive distribution models for future conditions derived from the MEDFIRE model for a number of focal species for which enough data can be collected. Thus, we will carry out **distribution models for the main ten tree species in Catalonia**, which represent 89% of trees inventoried in the Ecological Forest Inventory of Catalonia (IEFC) and the Second National Forest Inventory (IFN2): *Pinus halepensis, Pinus nigra, Pinus pinaster, Pinus pinea, Pinus sylvestris, Pinus uncinata, Quercus cerrioides/humilis, Quercus ilex, Quercus suber* and *Fagus sylvatica*. These species cover most of the trees burned in forest wildfires occurred in Catalonia en the last 20 years and are representative of the different climatic conditions and fire regimes of the region.

We will simulate **species distribution by means of the model MEDFIRE for the different fire regime scenarios** described in task 3.1. To evaluate the effect of the different fire regimes on species distributions, we will compare the distributions obtained with MEDFIRE for the different species with those obtained with linear modelling methods. These methods use information from the forest inventories already available (IEFC, IFN2 and IFN3) and relate the presence of each species to a particular set of environmental conditions. The simulations project the present distributions to future ones where environmental conditions are favourable for the presence of each particular species. A more complex methodology will be applied for the few species for which a large amount of information is available. In these cases, we will develop of a spatially explicit population model that will incorporate in each cell in the landscape processes such as mortality, growth, reproduction and dispersal. The technical expert that will be needed to develop task 2.1 will be also in charge of coordinating the run of the MEDFIRE model for the different scenarios with the CTFC group.

Task 3.3. Assessment of the effects on species distribution of future landscape scenarios based on different fire regimes and climate conditions. The case of birds.

Researchers in charge (CTFC subproject): Lluís Brotons, Sergi Herrando, Pere Pons and Miguel Clavero.

Scope:

In this task, we aim at assessing quantitatively the potential effects of changes in the fire regime in mobile organisms such as birds. **We will compare different methodologies to built distribution models** in order to determine the level of complexity needed to accurately project distributions of **mobile species** to future environmental conditions. According to the results obtained in the project DINDIS, dispersal is a key factor in determining changes in distribution of species in dynamic landscapes. Recently, statistical based distribution models, commonly used to project species distribution to future conditions, have been criticized because they lack the capability to reproduce ecological dynamic processes such as dispersal constraints of highly mobile species. We will finally apply the resulting methodologies to each of the scenarios generated in Task 3.1. and quantitatively evaluate the responses of different species groups to changes in fire regime and landscape structure.

Methodology

Here we will used pure **environmental based distribution** models as **null models** and compare their ability to reproduce future distribution changes with more elaborate distribution models of increasing complexity. The basic methodology used to estimate future species distribution will be to estimate by means of generalized linear modelling methods species-habitat relationships and project these to future environmental conditions. Then, we will build a second, **stepwise distribution model** that will **update the species distribution** using new environmental conditions but using information on the previous species distribution estimates. In this case, the null model will be compared with a variety of species-habitat relationship that will use information on the previous distribution of the species to update the species distribution at given time steps. This spatial information will be integrated into the habitat models by mean of contagion variables that will describe the abundance of the species at *t*-1 (where *t* corresponds to a given modelling time in years) in the neighbourhood of every cell in the landscape. The third and more complex methodology will be to explicitly integrate the results from the MEDFIRE model (at 1 year steps) with a **spatially explicit population model**. This complex approach will include explicit modelling for each cell in the landscape of population processes such as breeding, mortality and dispersal by means of parameters obtained from the bibliography. Our more complex approach will be to simulate species distribution in real time (1 year time steps) by means of a spatially explicit population model that will incorporate explicitly mortality, reproduction and dispersal.

We will derive comparative distribution models for future conditions derived from the MEDFIRE model for a number of focal species for which enough data can be collected in the most demanding model. At least data for one species, the Ortolan bunting (*Emberiza hortulana),* this kind of complex data set is already available. For models 1 and 2 (simpler models) we will derive distribution models for the different scenarios generated in Task 3.1. for all species for which data is available in Catalonia (about 150 species).

Initial models will be generated for the year 2000 and every 5 years. For the first two periods, we will evaluate the predictions with two different set of data. Since evaluation of distribution modelling of a dynamic process is an essential step we will be using a general data set and a more specific one aimed at capturing the most dynamic of the expected changes in distributions (i.e. areas affected by fire). For the first evaluation part, we will be using bird abundance data collected in line transects from the Catalan Common Bird Monitoring Scheme started in 2002 (SOCC) and now in place in over 250 sites across Catalonia. Second, we will be using information gathered in the context of the DINDIS project and continued during the present BIOPRED project (DINDIS database, see tasks 1.2 and 1.3 of objective 1). This information will allow us to track changes in distribution after fire impact over different landscape context and over a number of years, thus offering especially suitable dataset to evaluate the results of distribution modelling processes. The process here described allows integrating an evaluation component in the modelling of species future distributions. This is a shortcoming in many applications of distribution modelling to future projections (Dormman 2007) and therefore will be addressed specifically in the present task.

4.1 CHRONOGRAM

This chronogram must indicate the persons involved in the project, including those contracted with project funds.
Write in bold the name of the person responsible of each task.

Tasks	Centre	Persons	First Year (*)	Second Year (*)	Third Year (*)
1.1. Identification of the characteristics of tree species that determine their response to fire at the short and the long term	CREAF	**Javier Retana** **Lluís Comas** Marc Gracia Albert Avarez	XXXXXXXXXXXX	XXXXXXXXXXXX	XXXXXXXXXXXX
1.2 To investigate the main factors determining the regional dynamics of bird communities in regenerating post-fire systems	CTFC	**Sergi Herrando** Lluís Brotons Miguel Clavero Field assistant	XXXXXXXXXXXX	XXXXXXXXXXXX	XXXXXXXXXXXX
1.3 Determination of the effect of the post-fire management on post-fire bird colonization processes	CTFC	**Pere Pons** **Sergi Herrando** Field assistant	XXXXXXXXXXXX	XXXXXXXXXXXX	XXXXXXXXXXXX
2.1 Calibration of the main processes that will be improved in the new version of MEDFIRE from the new information generated	CREAF	**Marc Gracia** **Jordi Vayreda** Javier Retana Technical expert	XXXXX	XXXXXXXXXXXX	
2.2. Improvement and development of the MEDFIRE landscape simulator model to reproduce the changes. observed in Catalan landscapes affected by fire during the last 25 years	CTFC	**Lluis Brotons** Andrew Fall Computer programme		XXXXXXXXXXXX	XXXXXXXXXXXX
3.1 Identification of future scenarios of landscape change under different fire regimes and current climate change trends.	CTFC CREAF	**Lluís Brotons** Sergi Herrando Miguel Clavero Marc Gracia		XXXXXXXX	XX

		Javier Retana			
3.2 Assessment of the effects on species distribution of future landscape scenarios based on different fire regimes and climate conditions. The case of trees	CREAF	**Javier Retana** **Jordi Vayreda** Marc Gracia Technical expert			XXXXXXXXXXXX
3.3. Assessment of the effects on species distribution of future landscape scenarios based on different fire regimes and climate conditions. The case of birds.	CTFC	**Lluís Brotons** Sergi Herrando Miguel clavero Pere Pons			XXXXXXXXXXXX

(*) Mark an X inside the corresponding boxes (months)

5. BENEFITS DERIVED FROM THE PROJECT, DIFUSION AND EXPLOTATION OF RESULTS
(maximum **1** page)

The following items must be described:

- Scientific and technical contributions expected from the project, potential application or transfer of the expected results in the short, medium or large term, benefits derived from the increase of knowledge and technology.
- Diffusion plan and, if appropriate, exploitation plan of the results.

Scientific contributions

One of the most widespread critiques to the current ecological theory stands that an excessive simplification of the dynamics of ecological systems, both at the spatial and temporal levels, does not allow a correct exploration of their real functioning. Although a simplistic approximation has turned out to be extremely useful for ecology to progress as a strong scientific discipline, the **incorporation of the intrinsic spatio-temporal heterogeneity** of ecological systems will be an essential step forward to understand from a more holistic point of view its organization and dynamics. The present project will contribute to this challenge by developing our knowledge of the dynamics of species distributions in Mediterranean landscapes affected by fire, and explicitly incorporating spatial and temporal constraints in the responses of species to changes in the environment.

In the line of the research developed by the CTFC and CREAF groups, the present project aims at developing an **innovative multiscale approach** that aims at evaluate the distribution dynamics of species with different ecological characteristics. A particularly important contribution of the present project is a much needed landscape modelling platform to simulate changes in landscape composition and structure under different scenarios of fire regime and climate change. After the development and parameterization of this regional-scale, landscape model, we will have a new tool available to better assess the impact of global change on the biodiversity and functionality of Mediterranean systems.

Dissemination plan

The application and dissemination of the results to the scientific community as well as to State, Regional and local Spanish Administrations and institutions constitutes one of the main priorities of the present proposal. The following actions will be carried out to ensure the transfer and diffusion of the results obtained:

(a) ***International scientific publications.*** The main results are likely to be published in leading international scientific journals in the areas of general ecology (e.g., *Ecology*, *Functional Ecology*, *Oecologia*), conservation biology (e.g., *Biological conservation, Journal of Applied Ecology*) and landscape ecology (e.g. *Biodiversity and Distributions, Landscape Ecology, Global Change Biology*).

(b) ***Popular science publications.*** We also aim at publishing in less academic journals at the national (*e.g.*, *Ecosistemas*, *Montes*) and possibly international level to reach the wider audiences potentially interested.

(c) ***National/international scientific congresses.*** The results obtained will be presented in national and international congresses and other scientific forums. This will enhance the immediate exchange of information with other groups that are working on the issues included in this program.

(d) ***Website****.* From the beginning of the program a website will be set up. This will be a reference website for the main results and datasets developed in the project. This website could be used by researchers from other groups, professional sectors involved, and the general public.

(e) ***Working seminars with administrations and organizations related with management of the environment.*** The most significant results will be presented at the end of the project in working sessions aimed at communicating our conclusions to persons involved in the management and conservation of the environment. Both CTFC and CREAF have close links with the Catalan authorities (four departments of the Catalan Government are represented in their board), and there are frequent meetings and working sessions with those departments, in agreement with the applied nature of the institutes.

(f) 6. BACKGROUND OF THE GROUP
(In the case of a coordinated project the topics 6. and 6.1. must be filled by each partner)
(maximum **2** pages)

- **Indicate the previous activities and achievements of the group in the field of the project:**

  If the project is related to other previously granted, you must indicate the objectives and the results achieved in the previous project.

  If the project approaches a new research field, the background and previous contributions of the group in this field must be indicated in order to justify the capacity of the group to carry out the project.

Background of the group lead by the CTFC

The research carried out by the coordinator of the present project has been focused on the understanding of the role of spatial heterogeneity in the functioning of ecological systems. Birds have been used as study models in the analysis of the behavioural and population processes behind distribution patterns of species in landscape mosaics with a complex spatio-temporal structure. The trajectory of Dr. Brotons combines a rich experience in behavioural ecology with advanced knowledge of landscape ecology and spatial modelling, allowing a sound basis for the assessment of question on ecological parameters acting at different spatial scales. The knowledge of the hierarchy of ecological processes determining distribution and species abundance patterns is currently a hot topic in ecology and conservation biology. The research of the mechanisms by which perturbation regime (including the direct and indirect impacts of human activities), is incorporated into the landscape dynamics appears as the next, critical step forward in our understanding of dynamic ecological systems.

The research group of CTFC formed by Dr. Brotons, Dr. Herrando and Dr. Pons has focused on this topic using the impact of fire on bird communities as study models. In order to obtain further examples of the research carried out by the group lead by the CTFC see references included in the section 3.2 and the CV of the group members. The long lasting collaboration of these researchers led to the DINDIS project (grant CGL2005-00031/ BOS, 2005-2008), "Dynamics of bird distribution in Mediterranean mosaic landscapes affected by large forest fires (DINDIS)". The general objective of this project was to identify the role of different ecological processes that determine species distribution of open habitat, mainly early successional, species, in highly spatio-temporal heterogeneous systems. By combining landscape ecology, biogeographic approaches and cutting-edge spatial analysis methods, the project aimed at developing a multiscale modelling platform aimed to assess and predict patterns of species distribution changes. Even when the period is not fully completed, the main objectives of the project have been achieved. In particular, objective 1, the investigation of spatial patterns of bird colonisation of new fragments of open habitat created by forest fire impact, has lead to the generation of the DINDIS database an extensive database of information on post-fire colonisation by birds that includes all new fires appearing in Catalonia after the year 2000. The analyses of this database have provided new insights on the importance of the landscape context in the determining post-fire bird community pools. Objective 2, the analyses of the patterns in distribution change at large spatial scales of open habitat birds in relation with changes in the availability of habitat, has lead to the description of the first example of a species of great conservation concern, the Ortolan bunting. Overall, our results support the hypothesis that wildfires, especially those affecting open woodlands or shrubby areas, play a critical role in the ecology of the Ortolan bunting and have contributed to the recent expansion of the species. Furthermore, we have shown that colonisation appears to be limited, not only by the availability of new burnt habitat but also by specific dispersal constraints. We suggest that, for several European threatened species associated with open habitats, burnt areas may partially compensate for the widespread loss and deterioration of farmland habitat, opening new management opportunities for their conservation. Objective 2, Identification of landscape elements that allow the persistence of open habitat species in colonised habitat fragments, has lead to the identification of non-direct regeneration of vegetation as a key element in the persistence of open habitat species at a landscape scale. Finally, objective 4, development of a spatial modelling platform aimed at predicting open habitat species distribution dynamics in different scenarios of landscape change and fire regime, has been accomplished via an stay of Dr. Brotons in Canada with Dr. Andrew Fall during the year 2007. This collaboration has lead to the development of the model MEDFIRE (see section Methodology). The development of the MEDFIRE model during the DINDIS project has seeded the approach that is planned to be developed in the BIOPRED project. Finally, Dr. Miguel Clavero has joined the group in the context of the DINDIS project in 2008 and completed the group with proved skills in the analyses of community dynamics in a context of global change.

Articles derived from the DINDIS project (CGL2005-00031/ BOS):

Brotons, L., Herrando, S. & Pons, P. (2008) Wildfires and large scale changes in the distribution of an open habitat bird species: the ortolan bunting (Emberiza hortulana) in Mediterranean Landscapes. Journal of Applied Ecology, in press.

Sirami, C., Brotons, L. Burfield, I., Fonderflyck, J. & Martin, J.L.(2008) Is land abandonment having an impact on biodiversity? A meta-analytical approach to bird distribution changes in the north-western Mediterranean. Biological Conservation, in press.

Vallecillo, S., Brotons, L. & Herrado, S. (2008) Assessing the response of open-habitat bird species to landscape changes in Mediterranean mosaics. Biodiversity and Conservation, in press.

Sirami, C., Brotons, & Martin, J.L. Spatial extent of animal species response to landscape changes: colonization/extinction dynamics at the community-level in two contrasting habitats. Ecography, pending second revision.

Gil-Tena, A., Brotons, L. & Saura, S. Mediterranean forests and forest bird distribution changes in the late XXth century in a context of global change. Submitted to Global Change Biology.

Vallecillo, S., Brotons, L., Thuiller, W. Predicting changes in species distribution using niche-based models: the role of land-cover changes and fire disturbance processes. Submitted to Conservation Biology.

Background of the group lead by the CREAF

CREAF is one of the reference institutes in Spain conducting basic and applied research on terrestrial ecology. Overall, more than 100 people work at CREAF, including permanent researchers, UAB and UB lecturers and professors, researchers hired for specific purposes, PhD students and postdoctoral researchers. The size of the institute and the diversity of expertise of its researchers (experts in ecology, geography, forestry, environmental sciences, etc.) create a critical mass that allows the implementation of ambitious projects that require the support of experts in different topics. This proposal combines aspects of several of the main research lines at CREAF (forest inventories and datasets, vegetation dynamics, fire ecology, modelling) and would therefore benefit from the expertise of researchers from the institute and, at the same time, would strengthen the links between them.

The **research group of CREAF** that participates in this proposal has studied since many years ago the dynamics of Mediterranean forests and the response after fire of the most characteristic Mediterranean species of the genera *Pinus* and *Quercus*. They have described in recent studies that different *Pinus* species (e.g. *P. nigra, P. sylvestris* or *P. pinea*) are replaced by other tree or shrub species after fire, and that these responses are causing vegetation shifts at the regional scale. More recently, and within the INIA project RTA-04015 that will finish in 2007, researchers of the group have analyzed the effect of environmental variables and forest structure on the pattern of fire severities in large wildfires. They have shown that both topography and climate have a decisive role in fire severity, but forest structure may modulate fire behaviour by reducing fire severity in stands with large trees and tree canopy discontinuity.

The research team of CREAF for this project consists of four researchers, who belong to a research group considered as consolidated by the Catalan government: “Forest ecosystem dynamics and fire ecology”, lead by J Retana. We detail the **research lines of each of the applicants** with regard to the topic of the proposal:

Dr. Javier Retana. Professor of ecology at the UAB and director of CREAF. His research is focused on forest dynamics, ecological succession and the effects of disturbances (Bonfill *et al.*, 2004; Rodrigo *et al.*, 2004), and fire ecology and the regeneration of communities after fire (Retana *et al.*, 2002; Ordóñez *et al.*, 2006; Rodrigo *et al.*, 2006). His experience in the study of vegetation dynamics at the landscape level, the effects of fire, and population dynamics will be instrumental in the implementation of this project.

Dr. Marc Gracia. Reader in forest science and silviculture at the UdL and researcher at CREAF. His main research lines include the dynamics of Mediterranean forests and patterns of tree growth and regeneration under topographic and management gradients and the role of forest structure on fire behaviour and severity after large wild fires. His experience in silvicultural models and planning of landscape structure will be particularly valuable within the framework of this proposal.

Mr. Jordi Vayreda. Researcher at CREAF. His research is focused on relational database management and analysis of forest inventories and the implementation of software to manage and query forest inventories databases. He will provide his expertise in these tools on the development of relationships of forest maturation in the different forest typologies identified.

Mr. Lluís Comas. Researcher at CREAF. His research is focused on the analysis of forest inventory databases, photo interpretation and digital thematic cartography, and field studies on tree species characteristics. He will provide his expertise in the study of the response of species after fires and the development of thematic cartography that will be used in the model.

6.2 PUBLIC AND PRIVATE GRANTED PROJECTS AND CONTRACTS OF THE RESEARCH GROUP
Indicate the project and contract grants during the last 5 years (2003-2007) (national, regional or international)
Include the grants for projects under evaluation

CTFC GROUP

Title of the project or contract	Relationship with this proposal (1)	Principal Investigator	Budget EUROS	Funding agency and project reference	Project period (2)
Dynamics of bird distribution in Mediterranean mosaic landscapes affected by large forest fires (DINDIS)	1	Lluís Brotons	86.156 €	Minister of Education and Science (Cicyt)	12/2005-12/2008 C
Bird Distribution in Mediterranean Mosaics in a context of global change	1	Lluís Brotons	120.000 €	HPMF-CT-2002-01887.	1/2003-12/2004 C
Desarrollo de un modelo que integre la regeneración natural y las intervenciones de restauración para optimizar la gestión de zonas afectadas por grandes incendios forestales	2	J. Ma. Espelta (CREAF), M. Gracia (CTFC)	27.406 €	Ministerio de Ciencia y Tecnología-INIA (RTA02-074-C2-2)	1/2002-12/2004 C
Nou Atles dels Ocells Nidificants de Catalunya	2	Vittorio Pedrochi, Joan Estrada, Sergi Herrando y Lluís Brotons (Institut Català d'Ornitologia)	150000 €	Dep. Medi Ambient, Generalitat de Catalunya, Fundació Territori i Paisatge	1/1998-12/2004 C
Modélisation prédictive de la biodiversité et conservation: influence de la gestion forestière et du changement du paysage sur les oiseaux	2	Lluís Brotons y Jean Louis Martin (CNRS)	5500 €	Comunidad de Trabajo de los Pirineos	1/2004-12/2004 C
Développement d'instruments pour la gestion intégral des paysages forestiers et établissement d'un réseau transfrontalier de parcelles expérimentales et de monitoring	1	Josep Maria Espelta (CREAF), Roger Prodon, Jean Louis Martin (CNRS)	38000 €	Comunidad de trabajo de los Pirineos (INTERREG IIIA)	1/2003-12/2005 C
Fragmentation, complementation and functioning of protected areas for species conservation: the Crau example	3	Thierry Dutoit y Axel Wolff (Universite Marseille, CNRS)	75000 €	Ministère de l'Aménagement du Territoire de la France	1/2000-12/2004 C

Mediterranean ecosystems in a changing world	1	Sandra Lavorel (CNRS)	20000 €	Centre National de la Recherche Scientifique (Laboratorio Asociado Europeo)	1/2000-12/2003 C
Sistema d'Informació Territorial d'Espais Lliures de la provincia de Barcelona (SITXELL)	3	Lluís Brotons y Roser Campeny (Minuartia S.L.)	45000 €	Diputació de Barcelona	01/2002-12/2005 C
Estado, dinámica e impactos de la invasión de la hormiga argentina (*Linepithema humile*) en ecosistemas mediterráneos	3	Xavier Espadaler, UAB	28000 €	MEC (Plan I+D+I) Referencia: CGL2004-05240-C02-02/BOS	8/2004 - 8/2007 C
Efectos de la presencia de la hormiga argentina (*Linepithema humile*) en la biodiversidad y procesos ecológicos de ecosistemas mediterráneos	3	Xavier Espadaler, UAB	24377 €	MYCIT Referencia: REN2000-0300-C02-02/GLO	12/2000-12/2003 C

CREAF GROUP

Title of the project or contract	Relationship with this proposal (1)	Principal Investigator	Budget	Funding agency and project reference	Project period (2)
			EUROS		
Vulnerabilidad y adaptación al cambio climático en el litoral mediterráneo: la problemática del agua	2	J. Terradas J. Retana	687.000 euros	Fundació Territori i Paisatge	2008-2010 C
Realización del inventario de bosques singulares en Cataluña	2	M. Gracia	490.239 euros	Departament de Medi Ambient i Habitatge, Generalitat de Catalunya	2007-2010 C
Plasticidad ecológica del pino albar (*Pinus sylvestris* L) y posibles cambios en la distribución de esta especie como consecuencia del cambio climático	1	J.Martínez (participant: J. Retana)	118.580 euros	CICYT (GCL2007-60120)	2007-2010 C

Desarrollo de un sistema informático de soporte a la decisión para el análisis del valor de conservación del bosque	2	M. Gracia	85.000 euros	Fundación Biodiversidad	2007-2009 C
Las hormigas en los bosques maduros: estudio como elementos clave para la conservación de los bosques de montaña	3	J. Retana	12.000 euros	Fundació Territori i Paisatge	2007-2008 C
Diseño y demostración de técnicas de restauración y mejora de la biodiversidad de bosques de montaña: aplicación a los bosques de la zona periférica del Parque Nacional de Aigüestortes i Estany de Sant Maurici	2	M. Gracia	68.000 euros	Fundación La Caixa	2006-2008 C
Manuales de gestión de hábitats	1	J. Retana M. Gracia	450.000 euros	Diputación de Barcelona	2006-2010 C
Análisis y modelización de los principales procesos demográficos que controlan la regeneración sexual de encinas y robles mediterráneos en diferentes escenarios ecológicos y de gestión	2	J.M. Espelta (participant: J. Retana)	42.594 euros	INIA	2005-2008 C
Dinàmica d'ecosistemes forestals i ecologia del foc	1	J. Retana	26.600 euros	DURSI-SGR (SGR-2001-00420)	2005-2008 C
Análisis y modelización de la distribución espacial de la severidad de quema a escala de paisaje y de rodal en grandes incendios forestales	1	J. Retana	66.170 euros	INIA (RTA04015)	2005-2007 C
Importancia del grado de madurez del bosque sobre la conservación de comunidades animales. Aplicación al caso de pájaros, micromamíferos e himenópteros en el Parque Nacional de Aigüestortes i Estany de Sant Maurici	1	J. Retana	43.067 euros	Ministerio de Medio Ambiente	2005-2007 C
Desarrollo de instrumentos para la gestión integrada de paisajes forestales: Establecimiento de una red transfronteriza de parcelas experimentales y de monitoreo	2	J.M. Espelta (participants: M. Gracia, J. Retana)	480.950 euros	EU - INTERREG	2002-2005 C

Desarrollo de un modelo que integre la regeneración natural y las intervenciones de restauración para optimizar la gestión de zonas afectadas por grandes incendios forestales	1	J. Retana	8.695.000 ptas.	INIA (RTA02-074)	2002-2004 C
Factores que afectan a la variabilidad de las comunidades de hormigas y plantas después del fuego: Efecto de las interacciones entre ambos grupos en su dinámica postincendio	2	A. Rodrigo (participant: J. Retana)	6.894.250 ptas.	CICYT (REN2001-2500/GLO)	2002-2004 C
Grupo de Ecología Terrestre	2	J. Terradas (participants: J. Retana, M. Gracia)	8.500.000 ptas.	CIRIT (SGR-2005-00619)	2001-2004 C

(1) Write 0, 1, 2 or 3 according to: 0 = Similar project; 1 = Very related; 2 = Low related; 3 = Unrelated.
(2) Write C or S if the project has been funded or it is under evaluation, respectively.

7. TRAINING CAPACITY OF THE PROJECT AND THE GROUP
(In the case of Coordinated Projects this issue must be filled by each partner)

This title must be filled only in case of a positive answer to the corresponding question in the application form. Justify that the group is able to receive fellow students (from the Suprograma de Formación de Investigadores) associated to this project and describe the training capacity of the group. In the case of coordinated projects, each subproject requesting a FPI fellowship must fill this issue.

Note that all necessary personnel costs should be included in the total budget requested. The available number of FPI fellowships is limited, and they will be granted to selected projects as a function of their final qualification and the training capacity of the groups.

Training capacity of group lead by the CTFC

The **CTFC has a long experience in the coordination of international research networks** and since 1999, this centre has coordinated one of the regional centres of the European Forest Institute (EFI) – MEDFOREX. This regional centre has recently become a regional branch of EFI (EFIMED) aimed at promoting international, high level research in a Mediterranean context in topics dealing with forest externalities and multifunctionality of Mediterranean forests including biodiversity issues. MEDFOREX and EFIMED (more information www.medforex.net) has provided to the CTFC with a great experience in the management of international programs and international networks with more than 34 research centres from 15 Mediterranean countries. This has lead to the development of an international PhD with 5 PhD theses defended so far. In association with other Universities and research center, the CTFC has coordinated the PhD works of 11 students.

The CTFC has also been active in the **promotion and organisation of national courses** on Geographic Information Systems topics, and international such as the European Master of Forestry organised in cooperation with other 4 European universities (more information *http://gis.joensuu.fi/silva/Projects/MScEF/MSCEF.htm*) or the international course on *Criteria for Multifunctional Management of Mediterranean Forests* organised jointly with the Instituto Agronómico Mediterráneo in Zaragoza.

The member of **the CTFC group belonging to *Universitat de Girona*** works in the research group “Animal Biology” within the line “Ecological perturbations and animal land communities” (http://www.udg.edu/rectorat/grupsrecerca/grct18/). This group and more specifically Dr. Pons, has taken part in the Environment PhD. Programme of the *Universitat de Girona*. This programme has been recently awarded with a special mention by the Spanish Minister of Education and Science. The coordinator of the BIOPRED project, Lluís Brotons has taken part as an invited professor in the course in 2004. Finally, it should be stressed that the Animal Biology research group comprises at present 5 doctors and 10 PhD students 6 of which are associated to active research projects.

The **Catalan Ornitological Institute (ICO)** carries out courses for researchers interested in birds as study models. Periodically, ICO organises advanced courses on bird monitoring and habitat characterisation as well as courses on data analyses and statistics applied to ornithological topics. In the context of a recent implication in international projects, ICO teaches courses and conferences within and outside Europe, such as those developed in 2004 and 2006 at the University of Guadalajara (Mexico). Dr. Sergi Herrando, as researcher in charge of the Department of Applied Ornithology of the ICO, coordinates the formation duties of new research personnel. This coordination is in the form of courses, conferences or discussion sessions on the design, methodologies and results of the research projects carried out by the collaborators of the ICO.

Training capacity of group lead by the CREAF

This proposal presents a **good opportunity to carry out a PhD thesis** on the characteristics of tree species that determine their response to fire and on their spatio-temporal patterns of variability. This work would be initially at the plot level, and will be complemented by larger scale and modelling studies analyzing the distribution of these species in different climate and fire regime scenarios, which will be conducted in collaboration of other members of our research team and the CTFC group.

The **training capacity of our team** is shown by the numerous masters and PhD theses supervised by the applicants in the last years or currently in progress, as well by the fact that many of the recent doctors trained within the group have research positions: F. Picó presented his PhD in May 2002, and he is currently researcher at the Estación Biológica de Doñana (CSIC). M. Gracia, participant in this proposal, presented his PhD in November 2000, he was assistant professor at the Universidad de Lleida and he is currently researcher at CREAF. RM Román-Cuesta presented her PhD in July 2002; she has been postdoctoral researcher at the Universities of Edinburgh and Oxford (UK), where she currently works. P Cortés presented her PhD in April 2003, and she now works for the Environment Department of the Autonomous Govern of Catalonia. JL Ordóñez presented his PhD in May 2004 and he is now researcher at CREAF. The most recent doctor (X Arnán) has applied for postdoctoral fellowships and is currently waiting for the outcome of their proposals.

In the following we list the **PhD theses supervised** by the applicants of the CREAF group in the last years:

- Patrones observados y factores que determinan la variabilidad espacio-temporal de la regeneración del pino carrasco (Pinus halepensis Mill.) después de un incendio. MARIA JOSÉ BRONCANO, Universidad Autónoma de Barcelona (UAB), March 2000. Sobresaliente “Cum Laude”. Supervisor: Javier Retana
- Demographic analysis of three herbaceous perennial plants with different life histories: a matrix modelling approach. XAVIER PICÓ, UAB, May 2000. Sobresaliente “Cum Laude”. Supervisor: Javier Retana
- La encina y los encinares en Cataluña. Aproximación a su distribución, dinámica y gestión. MARC GRACIA, UAB, November 2000. Sobresaliente “Cum Laude”. Supervisor: Javier Retana
- Regeneración natural y restauración de la zona afectada por el gran incendio del Bages y Berguedà de 1994. ABDESSAMAD HABROUK, UAB, February 2002. Apto “Cum Laude”. Supervisors: Javier Retana and Josep Maria Espelta.
- Human and environmental factors influencing fire trends in different forest ecosystems. ROSA MARÍA ROMÁN CUESTA, UAB, July 2002. Apto “Cum Laude”. Supervisors: Javier Retana and Marc Gracia.
- Distribución y dinámica de un *Quercus* caducifolio (*Quercus cerrioides* Willk. & Costa) y uno perennifolio (*Q. ilex* L.) en Cataluña. PILAR CORTÉS GIMENO, UAB, April 2003. Apto “Cum Laude”. Supervisors: Javier Retana and Josep Maria Espelta.
- Análisis y modelización del reclutamiento de *Pinus nigra* en zonas afectadas por grandes incendios. JOSÉ LUIS ORDÓÑEZ GARCÍA, UAB, May 2004. Apto “Cum Laude”. Supervisor: Javier Retana.
- Dinámica post-incendio e interacciones entre plantas y hormigas mediterráneas. XAVI ARNÁN, UAB, April 2006. Apto “Cum Laude”. Supervisors: Javier Retana and Anselm Rodrigo.