



ENVIRONMENT WORKSHOPS 2013

***“OAK FORESTS COPING WITH
GLOBAL CHANGE: ECOLOGY AND
MANAGEMENT”***

Baeza, Spain. September 30th- October 2nd 2013



UNIVERSIDAD DE CÓRDOBA



ORGANIZED BY:

Teodoro Marañón. Institute of Natural Resources and Agrobiology (IRNAS-CSIC). Sevilla. Spain.

Rafael Villar. Department of Botany, Ecology and Plant Physiology. University of Córdoba. Spain.

Ignacio M. Pérez Ramos. Institute of Natural Resources and Agrobiology (IRNAS-CSIC). Sevilla. Spain.

COORDINATED BY:

Dr. Lourdes Soria. International University of Andalusia. Baeza, Jaén. Spain.

e-mail: Workshops.Environment@unia.es

SCOPE

The genus *Quercus* has about 500 species distributed throughout the Northern Hemisphere. Oak forests and woodlands are very abundant in the Mediterranean region and are vital providing a variety of ecosystem services. They provide with raw materials like cork, wood and fuel, and fodder for wild and domestic animals. The silvopastoral system known as “dehesa” provides habitats for wild animals and contributes to a higher biodiversity at the landscape scale. Oak trees provide a climate regulating service by their capacity to sequester carbon and therefore to mitigate the effects of climatic change. There is an increasing demand for cultural services provided by oak woodlands, mainly for recreation, ecotourism, and to enjoy their aesthetic and spiritual values. However, Global Change is affecting negatively oak forests and therefore diminishing their ecosystem services and in consequence human well-being. Main drivers are: land use change, introduction of exotic pathogens, air and soil pollution deteriorating oak health, and climatic change, in particular the reduction of rainfall. The aims of the workshop are to analyse the vulnerability and resilience of *Quercus* species coping with Global Change; to review the main ecological processes related with the regeneration of oaks and how they influence the recruitment and persistence of oak forests; to discuss the different management options for coping with the decline of oak forests and to assure their sustainability, showing case studies from Spain, Portugal and Mexico.

PROGRAM

Sunday, September 29th

16:30 Bus departure from Barajas Airport
(Meeting Point International arrivals at Terminal T1)

21:30 Arrival to Baeza. Registration. *Dinner*

Monday, September 30th

08:30-09:30 *Breakfast*

09:30-10:00 Organizers: *Workshop introduction and presentation of participants*

Session 1. Oaks from an historical perspective

10:00-10:40 **Arndt Hampe:** *Oaks in Southern Europe: from history to ecology*

10:40-11:00 General discussion

11:00-11:30 *Coffee Break*

Session 2. Genetic diversity and resilience

11:30-12:10 **Antonio González Rodríguez:** *Oak genetic diversity in México*

12:10-12:50 **María Valbuena:** *Genetics of Iberian Quercus: an atypical forest genus*

Poster Session:

12:50-13:05 **Carmen Hermida:** *Environmental influence on the evolution and kinetic properties of Rubisco in Quercus*

13:05-13:30 General discussion

13:30-15:30 *Lunch*

Session 3. Global change and oak resilience

15:30-16:10 **Miguel A. Zavala:** *Vulnerability and resilience of Iberian Quercus coping with Global Change: theoretical models and applications*

16:10-16:50 **Jofre Carnicer:** *Effects of climate change on Quercus species: experimental, observational and synthesis studies*

Poster Session:

- 16:50-17:05 **Tiziana Gentilesca: *Forest dieback: a study case of Quercus spp. population in Southern Italy***
- 17:05-17:15 General discussion
- 17:15-17:45 *Coffee Break*
- 17:45-19:00 **General Poster Session:**
- 20:00 *Guided tour to Baeza*
- 21:00 *Dinner*

Tuesday, October 1st

- 08:00-09:00 *Breakfast*

Session 4. Regeneration ecology of oaks

- 9:00-9:40 **Ignacio M. Pérez Ramos: *Spatiotemporal patterns of recruitment through plant ontogeny in Mediterranean oak forests***
- 9:40-10:20 **Fernando Pulido: *Linking regeneration ecology to oak woodland management***
- Poster Session:**
- 10:20-10:35 **Herminia García Mozo: *Influence of airborne pollen availability and meteorological factors on Holm oak acorn production in southern Spain***
- 10:35-10:50 **María Dolores Carbonero: *Patterns of acorn production in Spanish oak savannas***
- 10:50-11:00 General Discussion
- 11:00-11:30 *Coffee Break*
- 11:30-11:45 **Pedro Villar Salvador: *Bottlenecks for oak recruitment in a Mediterranean shrubland***
- 11:45-12:00 **Ramón Perea: *Oak regeneration under high levels of wild ungulates: The use of chemically vs. physically-defended shrubs***
- 12:00-13:30 **Round-table discussion:
Oak woodlands (dehesas) ecosystem services and management
Javier Navarrete, Fernando Pulido and Pilar Fernández Rebollo**

13:30-15:30 *Lunch*

Session 5. Oaks coping with stress under global change

15:30-16:10 **Jesús Camarero:** *Global-change drivers of oak decline*

16:10-16:50 **Ismael Aranda:** *Global change and oak response to combined stresses*

16:50-17:00 General Discussion

17:00-17:30 *Coffee Break*

17:30-18:10 **Rafael Villar:** *Growth of Quercus and responses to environmental factors*

Poster Session:

18:10-18:25 **María Patrocinio González Dugo:** *Remotely sensed monitoring of dehesa ecosystem evapotranspiration and water stress*

18:25-18:40 **Ana García Nogales:** *Holm oak (Quercus ilex subsp. ballota) intraspecific variability along a latitudinal gradient. A test of the Core-Periphery Paradigm*

18:40-19:00 General Discussion

19:00-19:30 **General Poster session:**

21:00 *Special Conference Dinner*

Wednesday, October 2nd

08:00-09:00 *Breakfast*

Session 6. Conservation and management

09:00-09:40 **Pilar Fernández Rebollo:** *Management of oak woodlands in Spain*

9:40-10:20 **Vanda Acácio:** *Pathways for resilience in cork oak land use systems in Portugal: the role of ecological and land use factors*

Poster Session:

10:20-10:35 **Will Simonson:** *Mediterranean wood pastures for biodiversity: Making the Lynx*

10:35-10:50 **Alma García Moreno:** *Nutritional status of Quercus ilex L. in response to different uses of Mediterranean open woodlands*

10:50-11:00 General discussion

11:00-11:30 *Coffee Break*

11:30-12:10 **Mario González Espinosa: *Ecological attributes of Quercus spp. and its application in guiding the restoration of humid forests in southern México***

12:10-12:20 General discussion

Session 7. Concluding Remarks

12:20-13:00 **Teodoro Marañón: *Oak forest ecology and management: an overview***

13:00-13:30 General discussion and Closure of the Workshop

13:30-15:00 *Lunch*

15:00-17:00 Meeting of working groups: planning collaborative experiments and projects, oak networks and brain storming.

21:00 *Dinner*

Thursday, October 3rd

07:30 Bus departure to Barajas airport

12:30 Arrival Madrid-Barajas airport [Terminal T1](#)

SPEAKERS:

Teodoro Marañón

Institute of Natural Resources and Agrobiology (IRNAS-CSIC). Sevilla. Spain.

teodoro@irnase.csic.es

Rafael Villar

Department of Botany, Ecology and Plant Physiology. University of Córdoba. Spain.

bv1vimor@uco.es

Ignacio M. Pérez Ramos

Institute of Natural Resources and Agrobiology (IRNAS-CSIC). Sevilla. Spain.

imperez@irnase.csic.es

Vanda Acácio

Centre of Applied Ecology "Prof. Baeta Neves". Higher Institute of Agronomy (ISA). Technical University of Lisbon. Portugal.

vanda_acacio@yahoo.com

Ismael Aranda

Forest Research Center (CIFOR-INIA). Madrid. Spain.

aranda@inia.es

Jesús Julio Camarero

Pyrenean Institute of Ecology (IPE-CSIC). Zaragoza. University of Barcelona. Spain.

jjcamarero@ipe.csic.es

Jofre Carnicer

Community and Conservation Ecology Group, Centre for Ecological and Evolutionary Studies (CEES), University of Groningen. The Netherlands.

jofrecarnicer@yahoo.es

Pilar Fernández Rebollo

School of Agricultural and Forestry Engineering. University of Córdoba. Spain.

Ir1ferep@uco.es

Mario González Espinosa

Department of Biodiversity Conservation. The College of the Southern Borderlands (ECOSUR). San Cristóbal de las Casas. Chiapas. México.

mgonzale@ecosur.mx

Antonio González Rodríguez

Centre of Research in Ecosystems (CIECO). UNAM Campus at Morelia. México.

agrodriig@cieco.unam.mx

Arndt Hampe

French National Institute for Agricultural Research (INRA, UMR1202 BIOGECO), Cestas, France.

arndt@pierroton.inra.fr

Fernando Pulido

Forest Research Group (GIF). School of Forestry and Natural Resources. University of Extremadura. Plasencia. Spain.

nando@unex.es

María Valbuena

Forest Genetics and Ecophysiology Research Group. E.T.S. Forestry Engineering. Technical University of Madrid (UPM). Madrid. Spain.

maria.valbuena@upm.es

Miguel A. Zavala

Forest Ecology and Restoration Group. Department of Life Sciences. University of Alcalá. Spain.

ma.zavala@uah.es

Javier Navarrete Mazariegos

Life+ bio. Dehesa Project Manager. Consejería de Agricultura, Pesca y Medio Ambiente. Junta de Andalucía. Sevilla. Spain.

javier.navarrete.m@juntadeandalucia.es

SPEAKERS ABSTRACTS

OAKS IN SOUTHERN EUROPE: FROM HISTORY TO ECOLOGY

Arndt Hampe

INRA, UMR1202 BioGeCo, F-33612 Cestas, France, arndt@pierroton.inra.fr

Oaks are key components of Southern European forest systems, and their ecological, societal and economic value for the region can hardly be overstated. Great concern exists that ongoing rapid climate change is likely to overstrain the capacity of oaks and other forest tree species to track suitable climate spaces, potentially leading to widespread extinctions through the coming decades. This worry is further supported by numerous species distribution models that predict major displacements of potentially suitable areas for oak forest growth in mediterranean regions. It remains however relatively little appreciated that this deeply troubling picture stands in some contrast to empirical records of species responses to past climatic changes.

Fossil and genetic data indicate that extensive range dynamics and massive community reshuffling occurred during past periods of rapid climate transitions. But there is little evidence that past major warming events were accompanied by increased large-scale extinction rates.

The current geographical distribution of oaks in Southern Europe is the ephemeral outcome of a long trajectory of population and range dynamics driven by recurrent changes in species' abiotic and biotic environment. Recent years have seen a rapid accumulation of empirical evidence that has provided detailed insights into these dynamics and the ecological and evolutionary processes that have accompanied (and sometimes facilitated) them. This presentation will give an overview upon the varied history of South European oaks as revealed by molecular studies. This plant group includes some of the most compelling examples known for the extreme evolutionary resilience that trees can exhibit, but also for the great potential of microevolutionary change that tree populations can develop in given situations - a combination that has been termed the 'great paradox of the tree habit'. The insights gained and the intense ongoing research on South European oaks should help with better understanding the challenges they are facing under modern climate change and their potential to cope with the future world.

Related references:

Hampe A, Pemonge MH, Petit RJ (2013) Efficient mitigation of founder effects during the establishment of a leading-edge oak population. *Proc R Soc B* **280**: 1764.

- Lumaret R, Mir C, Michaud H, Raynal V (2002) Phylogeographical variation of chloroplast DNA in holm oak (*Quercus ilex* L.). *Mol Ecol* **11**: 2327-2336.
- Magri D, Fineschi S, Bellarosa R *et al.* (2007) The distribution of *Quercus suber* chloroplast haplotypes matches the palaeogeographical history of the western Mediterranean. *Mol Ecol* **16**: 5259-5266.
- Petit RJ, Hampe A (2006) Some evolutionary consequences of being a tree. *Annu Rev Ecol Evol Syst* **37**: 187-214.
- Rodríguez-Sánchez F, Hampe A, Jordano P, Arroyo J (2010) Past tree range dynamics in the Iberian Peninsula inferred through phylogeography and palaeodistribution modelling: a review. *Rev Palaeobot Palynol* **162**: 507-521.

OAK GENETIC DIVERSITY IN MEXICO

Antonio González Rodríguez

The genus *Quercus* is one of the most important groups of woody plants in Mexico, in terms of species richness, biomass, and ecological and economic value. According to a recent estimate there are about 161 oak species in Mexico, what represents 32-40% of the worldwide total species number. These species belong to the three sections of the *Quercus* subgenus: *Lobatae* or red oaks (with 76 species), *Quercus* or white oaks (81 species) and *Protobalanus* or intermediate oaks (4 species). Furthermore, approximately 109 of the species are endemic to the country. Therefore, the study of genus *Quercus* in Mexico constitutes a good opportunity to analyze how different processes have shaped the diversification, distribution, and patterns of population genetic variation of oaks in this region. In the presentation, I will describe the results of recent studies covering three main topics: phylogeography, hybridization, and functional variation along climate gradients.

Regarding phylogeographic patterns, recent studies employing chloroplast DNA microsatellites (cpSSRs) on several Mexican oak species and species complexes with broad geographical distributions (*Q. affinis-Q. laurina*, *Q. castanea*, *Q. deserticola*, *Q. magnoliifolia-Q. resinosa*, *Q. rugosa*) have in all cases revealed considerably higher levels of genetic diversity and lower genetic structure in comparison to both European and North American species. One possible explanation for this result is that in Mexico oaks probably maintained large historical population sizes and dynamic gene flow among populations through recent glacial cycles. This inference is also supported by several lines of evidence indicating that the cold periods of the Pleistocene allowed the expansion and increased the connectivity of montane forests, particularly at the tropical latitudes of Mexico.

Hybridization among oak species in Mexico has been repeatedly reported and is probably an important mechanism influencing their genetic diversity. Examples of hybrid zones have been characterized in Mexico, including two and even three species simultaneously. These hybrid zones have been found to be best described by the mosaic model, in which pure species populations and hybrid populations are patchily distributed along a zone of overlap between the involved species, and strong associations occur between genetic variation and environmental variables. Such studies may help to uncover the

processes influencing oak hybridization and its importance as a source of novel genotypes contributing to the adaptive evolution and diversification of the genus.

Mexico is characterized by marked environmental variation associated to altitudinal and latitudinal gradients. Using both observations under natural conditions and common garden experiments, the functional variation of particular oak species in response to precipitation and temperature gradients has been analyzed. In particular, variation in leaf phenology in two white oaks (*Q. magnoliifolia* and *Q. resinosa*) along a latitudinal gradient showed contrasting responses to temperature and precipitation indicating divergent adaptation patterns in these two co-occurring oak species.

In conclusion, Mexican oak species that have been studied so far are characterized by higher genetic variation and lower genetic structure than their counterparts at higher latitudes, and exhibit interesting patterns of functional variation as a result of adaptation to the particular climatic conditions of the Mexican territory. Characterizing such variation and its genetic basis should be a research priority and is necessary for the conservation and management of this important genus.

GENETICS OF IBERIAN *QUERCUS*: AN ATYPICAL FOREST GENUS

María Valbuena

Forest Genetics and Ecophysiology Research Group. E.T.S. Forestry Engineering. Technical University of Madrid (UPM).

Mating systems constitute the natural mechanisms by which species maintain the genetic variability needed to adapt to environmental conditions along time and space. In plant species, mating systems are characterized by the type of reproduction (asexual or sexual), fertilization process (allogamous or autogamous) and by pollen and seed dispersal mechanisms. These features have crucial influence in natural population dynamics, namely regeneration, migration, colonization and extinction processes, which leave genetic tracks among the individuals of a given population. Therefore, the survey of neutral genetic variation allows us to infer such biological and demographic events regardless of the effects of natural selection.

The genus *Quercus* is one of the most important clades of woody angiosperms in the northern hemisphere in terms of species diversity, ecological dominance, and economic value. It includes keystone species in a wide range of habitats from Mediterranean semi-desert to subtropical rainforest. Part of their past and present success rely on the characteristics of their mating systems that have allowed the species to spread and adapt to environmental and anthropogenic changes along millennia. The particular stem and root sprouting capacity of several species allow them to persist after ecological disturbance -either natural or anthropogenic- successfully competing with other taxa. The weak reproduction barriers among species -even from different sections of the genus- promote hybridization, an outstanding mechanism that increase within-species genetic diversity, allowing the evolution and persistence of populations under very low census sizes (as those proper of climatic refugia). Wind pollination leads to long distant gene dispersal that erodes genetic differentiation among populations and allows hybridization at long distances. Moreover, zoochory of acorns promote the long distant dispersal of seeds, leading to successful colonization processes, as the ones after the Plesitocene glaciations of northern hemisphere from southern glacial refugia, like the Iberian Peninsula.

Based on these features and their ecological and economic importance, oaks are long standing models for the study of hybridization and structure of genetic variability at individual and population levels. In this lecture, several examples of evergreen, marcescent and deciduous Spanish *Quercus* species are shown to illustrate the natural capacity of this genus to preserve high levels of genetic diversity under adverse conditions, which confers them the ability to cope with natural and human disturbances providing them their characteristic resilient nature. In this sense, the preservation of intraspecific genetic diversity and the potential of species to interact should be crucial elements in management and conservation programmes.

EFFECTS OF CLIMATE CHANGE ON QUERCUS SPECIES: EXPERIMENTAL, OBSERVATIONAL AND SYNTHESIS STUDIES

Jofre Carnicer, Romà Ogaya, Adrià Barbeta, Jordi Sardans, Joan LLusà and Josep Peñuelas.

Quercus trees are dominant, late-successional species in the Mediterranean basin and therefore largely influence the observed responses of forests to global change in this region. Here we review the evidence provided by long-term, decadal manipulative experiments simulating the effects of increased drought in Holm oak forests. These experiments mainly suggest dampening negative effects of drought on growth and mortality, and reductions in foliar and flower production, leaf photochemical efficiency, crown condition and non structural carbohydrate content (NSC). These negative effects of drought could in turn trigger shifts in community composition. However, the reported negative effects of warming on oak forests could be to some extent compensated by other processes. For example, large-scale observational data in the Iberian peninsula suggest that oaks are currently becoming widespread and dominant with the advance of forest succession across extensive areas. Moreover, recent studies suggest that Holm oaks may act as key inhibitors of pine recruitment dynamics in this region on a large scale. Finally, there is also empirical evidence for large-scale drought-induced food web disruptions in Quercus species, and changes in bird communities triggered by the successional advance of Quercus species. All this evidence suggests that Holm oak may act as a keystone species in this region in the face of ongoing global change.

SPATIOTEMPORAL PATTERNS OF RECRUITMENT THROUGH PLANT ONTOGENY IN MEDITERRANEAN OAK FORESTS

Ignacio M. Pérez-Ramos

*Instituto de Recursos Naturales y Agrobiología de Sevilla (IRNAS, CSIC), P.O. Box 1052,
Sevilla 41080, Spain*

The process of natural recruitment of a given plant should be analysed following a 'linking-stages' approach, where plant recruitment is explored across consecutive demographic stages (seeds, seedlings, saplings) that are connected by transitional processes (dispersal, germination, emergence and survival). All these recruitment-driving processes are usually context-dependent, appearing different types of plant–plant and plant–animal interactions as a function of the microsite where the seed is dispersed. These interactions are particularly complex in heterogeneous environments, such as Mediterranean oak woodlands, where their magnitude and sign may vary both spatially and temporarily. On the one hand, the spatial distribution of seed rain across different microhabitats will alter the subsequent stage-specific probabilities of recruitment. On the other hand, the suitability for recruitment of different microhabitats can also change over the life-cycle of the plant (concept of ontogenetic conflict) since the most favourable sites for one stage may not be the most favourable for others. Finally, this complex network of interactions, which strongly determine the net balance of overall recruitment, could be seriously altered in the future by the expected decline in water availability caused by climate change. We conclude that within- and among-species differences through plant ontogeny, arising from species differential response to microhabitat heterogeneity and environmental changes, could be of great importance for oak species niche segregation, driving stand dynamics and spatial pattern distribution along the landscape.

LINKING REGENERATION ECOLOGY TO OAK WOODLAND MANAGEMENT

Fernando Pulido

Universidad de Extremadura

nando@unex.es

Oak forest are managed by humans for diverse products throughout the northern hemisphere. Historical changes have resulted in forest clearance in those cases where livestock production is the main goal, that is, in oak silvopastoral systems. Continuous grazing, combined with other practices such as firewood harvesting and burning, is associated to decreased regeneration success and oak woodland decline in the long term. Here I assess the generality of these principles using data from an extensive literature survey comparing reproductive rates of 47 oak species in systems with disparate management regimes, mainly in Spain and California. This review shows that we lack conclusive studies addressing seed limitations of recruitment as well as long term studies quantifying juvenile success and individual oak replacement rates. However, chronic regeneration failure has been demonstrated in certain systems through studies of landscape change, and several techniques have been proposed to ensure regeneration, including seeding, planting, and livestock exclusion. The reliability of such techniques and their side-effects on the whole ecosystem function and management is discussed within the frame of ongoing global environmental change.



LIFE+ bioDEHESA: FACING THE CHALLENGES OF DEHESAS CONSERVATION AND MANAGEMENT

Javier Navarrete Mazariegos, (1), Sillero Almazán, M.L. (2), Guzmán Álvarez, J.R. (1)

(1) Consejería de Agricultura, Pesca y Medio Ambiente. Junta de Andalucía

(2) Agencia de Medio Ambiente y Agua. Junta de Andalucía

Dehesas are mostly identified as types of open oak forests traditionally transformed by humans to obtain pastures for livestock. Such transformation resulted in an agro-silvicultural system of high nature value providing a number of ecosystem services to the society, however still too unaware of their relevance. *Dehesas* can be found notably in mediterranean areas of Spain and Portugal, where they are even considered part of the natural and cultural heritage of both countries. Particularly in Andalusia, these unique landscapes occupy about 1 million hectares. Over recent decades, increasing number of *dehesas* have been in decline and so has their conservation status, sometimes because of abandonment, agricultural intensification or unsuitable practices. Hence the importance of developing specific regulations, policies and tools.

Regional Law 7/2010, governing *dehesas*, has defined the concept of a *dehesa* for regulatory purposes as a forestry exploitation primarily comprising wooded areas (mainly holm, cork and gall oaks or wild olive trees, and sometimes other species) with crown closure or canopy cover values between 5% and 75%, which enable the development of livestock grazing, as well as other forestry, hunting or agricultural uses.

The European cofinanced project *Life+ bioDehesa* (Life11 BIO/ES/000726) aims to enhance the sustainable and integrated management of *dehesas* in order to improve the situation of biodiversity through the dissemination of demonstrational actions that address the main challenges related to their conservation.

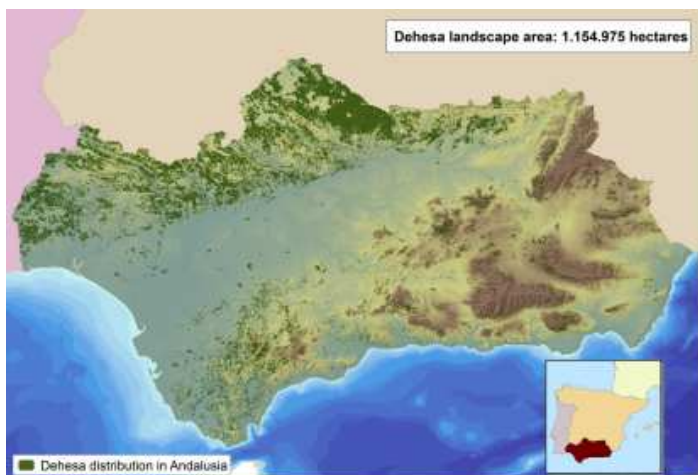
Its specific objectives are to strengthen the capacity of *dehesas* in Andalusia to respond to their deterioration, ageing and vulnerability to climate change; to demonstrate the feasibility of integrated management that respects the conservation of this habitat and promotes biodiversity; to transfer the best available knowledge and the latest technical innovations to the entire *dehesa* community; to contribute to institution building and human capital formation to support integrated management; and finally, to enhance public awareness about the importance of agro-forest systems such as *dehesas* for the purpose of establishing appropriate European, national and regional guidelines and policies.

The Ministry of Agriculture, Fisheries and Environment belonging to the Regional Government of Andalusia (Spain) acts as the beneficiary coordinator in the project. Besides, the associate partners include two public agencies (AGAPA and AMAYA), the University of Córdoba (UCO), one research and training institute (IFAPA) and six organizations directly linked to the *dehesa* sector (APROCA, ASAJA, COAG, ENCINAL, FAECA and UPA).

Amongst the vast dehesa area, 42 properties have been selected according to concerted criteria. An Integrated Management Plan has been drawn up including every different approach involved in a dehesa farm (livestock, forestry, hunting, wildfires...), and will be applied on those exploitations in order to be tested before legal approval. Cooperation agreements will then be signed with landowners, since concrete conservation measures will be implemented in this Pilot Dehesas Network dealing with woodland renovation, rational pruning, livestock and hunting species management, improved grazing, pastureland management, soil and water conservation, control of forest pests and diseases and habitat diversification. The effects of those actions will be monitored and evaluated through appropriate socio-economic and environmental indicators.

The project will also test other related horizontal tools, including an oak decline assessment service, nursery protocols to prevent plant reproductive material from being infested by pathogens like root-rot disease involved in forest decline, protocols to detect and diagnose oak decline, an inventory of critical areas for conservation of the dehesa and its biodiversity, an inventory of dehesa areas that are inhabited or have the potential to be inhabited by threatened species and a geographic information system (GIS).

The basically demonstrative nature of this project will be highlighted by the creation of a technical advisory service made up of consultants partnering with agricultural organizations who will follow a specific training programme that will enable the transfer of results to the whole of the dehesa sector. Additional dissemination actions are also considered, such as field trips to the Pilot Dehesas Network, a manual of best practice for dehesas conservation, communication actions and materials, awareness campaign about the importance of consuming dehesa products for biodiversity conservation, electronic newsletters, website, international visibility, networking with other projects, seminars, etc.



GLOBAL-CHANGE DRIVERS OF OAK DECLINE

J. Julio Camarero

ARAID-Instituto Pirenaico de Ecología (CSIC)

Forest decline is a hot topic in current global-change ecology. Decline is characterized by high levels of defoliation and crown dieback, reduced or altered primary and secondary growth and increased mortality rates. In cases when these symptoms are not triggered or produced by a unique biotic agent the general term “decline” is used. This issue has been intensively studied in drought-prone Mediterranean oak forests, where water deficit is regarded as one of the major drivers of dieback. However, oak decline has also been observed in temperate regions where other causing agents have been detected (temperature extremes, flooding and pollution). Researchers have detected several components of global change causing oak decline (climate warming, changes of biogeochemical cycles such as increasing N deposition, land-use modifications such as altered coppice cycles, shifts in pathogens’ distributions). However, the interactions among those potential drivers of decline acting at different spatio-temporal scales are little known. For instance, (i) how climate warming modifies drought stress at biome or forest scales?, how this translates into oak decline?; (ii) why some stands or species or individuals are more prone to decline or to recover after decline than others?; (iii) what are the ecophysiological mechanisms causing oak decline?; (iv) how interact climate and changes in land-use to trigger decline?; (v) how are the pre- and post-decline successional dynamics? I use examples of recent oak decline detected across the Iberian Peninsula to illustrate scientific and management gaps within these research questions, and to encourage further research in this area.

FUNCTIONAL INTEGRITY IN THE RESPONSE TO DROUGHT BY QUERCUS SPECIES

Ismael Aranda and Jesús Rodríguez-Calcerrada

The genus *Quercus* present in the North Hemisphere, comprising roughly 400 species from tropic to temperate zones (Nixon 2006), with leaf habits ranging from evergreen to deciduous species. Ecology of the genus is highly variable, with species living on very dry ecosystems with almost only 300 mm (e.g. *Quercus coccifera*) to tropical areas with rainfall around 2000 mm (e.g. Fowells 1965; Costa et al. 1997). However, a common characteristic of many species is their high tolerance to drought, relative to other species inhabiting the same ecosystems (Abrams 1988; Abrams 1990; Cano et al. 2013).

The high variation of the ecological niche of *Quercus* species is explained, at the genetic and evolutionary level, by a high potential of inter-specific crossing and intra-specific genetic variability (Ramírez-Valiente et al. 2009). Both factors would explain the high geographical range occupied by some species, and the high evolutionary potential of *Quercus* species. Furthermore, it is paradoxical to observe in this group phenomena of local adaptation within species (Ramírez-Valiente et al. 2009), for instance to dry sites, coexisting with processes of high specific evolutionary convergence from different phylogenetic lineages on the same habitat (Cavender-Bares et al. 2004). The latter is especially relevant in areas of high species richness like Central and North-America. In addition, species of *Quercus* conjugate a high degree of phenotypic plasticity (Gratani et al. 2003), along with maintenance of high levels of intra- and inter-population variability for important functional and morphological traits (Ramírez-Valiente et al. 2010). The species *Quercus suber* L., without being one of the species with widest distribution, it is an example of this high degree of inter- and intra-population differentiation for traits related to phenology or drought tolerance. Something similar is observed for other *Quercus* species where intra-population variability has been studied such as *Quercus petraea*, *Quercus robur*, *Quercus pubescens*, *Quercus ilex* (Gratani et al. 2003; Arendt et al. 2010) or the American *Quercus oleoides* or *Quercus virginiana* (Cavender-Bares 2007).

Throughout the talk, the main functional, ecological and genetic mechanisms that allow considering many *Quercus* species as relatively drought tolerant will be revisited. A brief review of the functional response of some species at different ontogenetic states enables us to build up a picture of the different mechanisms displayed to cope with water stress from the leaf through the canopy to the full tree. The water as limiting factor on many cases is interacting with other resources such as light or nutrients, making very complex to disentangle the final impact of drought upon seedling performance, and in general, of the interplay among different abiotic factors in nature. This interplay would be especially relevant for important biological phases, such as seedling recruitment. On this respect, some possible functional trade-offs emerge from the need of seedlings to respond to the interaction of water and light.

Some examples will be presented where adjustment of the phenotype to optimize the

capture of light could be detrimental to face water stress. Even though *Quercus* species show a high phenotypic plasticity to both factors (Valladares et al. 2002; Quero et al. 2006), the existence of possible trade-offs could constraint their capacity to thrive under conditions where light and water concur as permanent stressors. This is frequent in some forest ecosystems with a high tree stocking in the Mediterranean area, but even in Temperate and Tropical zones the need to deal with different stress factors at the same time may modulate the capacity of acclimation and adaptation of *Quercus*. The talk will finish by making a short remark of the aspects that deserve a higher scientific effort in order to increase our understanding on the adaptive potential of *Quercus* species and improve their management. Both factors are important in the fate of *Quercus* species in the future, as a consequence of the ongoing climate change. At this respect, we will present some examples of how future drier conditions might affect the physiology and regeneration potential of *Q. ilex*, derived from long-term throughfall-reduction field experiments.

- Abrams MD (1988) Sources of variation in osmotic potential with special reference to North American tree species. *Forest Science* 34: 1030-1046.
- Abrams, MD, (1990) Adaptations and responses to drought in *Quercus* species of North America. *Tree Physiology* 7: 227-238.
- Arend M, Kuster T, MS Günthardt-Goerg, M Dobbertin (2011) Provenance-specific growth responses to drought and air warming in three European oak species (*Quercus robur*, *Q. petraea* and *Q. pubescens*) *Tree Physiology* 31, 287–297
- Cano FJ, Sánchez-Gómez D, Rodríguez-Calcerrada J, Warren CR, Gil L, Aranda I (2013) Effects of drought on mesophyll conductance and photosynthetic limitations at different tree canopy layers. *Plant Cell and Environment* (in press, DOI: 10.1111/pce.12103)
- Cavender-Bares J, Holbrook NM (2001) Hydraulic properties and freezing-induced cavitation in sympatric evergreen and deciduous oaks with contrasting habitats. *Plant Cell Environ* 24:1243–1256
- Cavender-Bares J, Kitajima K, Bazzaz FA (2004) Multiple trait associations in relation to habitat differentiation among 17 Floridian oak species. *Ecol Monogr* 74:635–662
- Cavender-Bares J (2007) Chilling and freezing stress in live oaks (*Quercus* section *Virentes*): intra- and inter-specific variation in PS II sensitivity corresponds to latitude of origin. *Photosynthesis Research* 94: 437-453.
- Costa M, Morla C, Sainz H (eds) (1997) Los bosques ibéricos. Una interpretación geobotánica. Ed. Planeta, Barcelona, 572 pp.
- Fowells H (1965) Silvics of forest trees of the United States. USDA For Serv Agric Handbook No 271, pp 557-640.
- Gratani L, Meneghini M, Pesoli P, Crescente MF (2003) Structural and functional plasticity of *Quercus ilex* seedlings of different provenances in Italy. *Trees, Structure and Function* 17:515–521
- Quero JL, Villar R, Marañón R, Zamora R (2006) Interactions of drought and shade effects on seedlings of four *Quercus* species: physiological and structural leaf responses. *New Phytologist* 170: 819–834.
- Nixon KC (2006) Global and neotropical distribution and diversity of oak (genus *Quercus*) and oak forests. *Ecological Studies*, 185, 1–13.
- Ramírez-Valiente JA, Lorenzo Z, Soto A, Valladares F, Gil L, Aranda I (2009) Elucidating the role of genetic drift and directional natural selection in genetic differentiation of cork oak (*Quercus suber* L.) *Molecular Ecology*. 18: 3803–3815
- Valladares F, Chico JM, Aranda I, Balaguer L, Dizengremel P, Manrique E, Dreyer E (2002) The greater seedling high-light tolerance of *Quercus robur* over *Fagussylvatica* is linked to a greater physiological plasticity. *Trees, Structure and Function* 16: 395–403.

GROWTH OF *QUERCUS* AND RESPONSES TO ENVIRONMENTAL FACTORS

Rafael Villar, Bárbara López-Iglesias, Paloma Ruíz-Benito and José Luis Quero

Plant growth is a process that depends on intrinsic characteristics of the species and abiotic factors. Plants require a positive growth to survive. In some cases, growth rates may fall to zero, indicating that gains and losses are very balanced.

The study of the growth in *Quercus* species has a wide interest for several reasons. On the one hand, knowledge of the factors affecting the growth of *Quercus* species may help us to predict changes that may suffer in relation to the expected climate change. On the other hand, knowing conditions and situations related to zero growth can serve as predictors of survival and therefore of the maintenance of *Quercus* populations. In addition, there are now quite interest to know the potential for carbon sequestration of *Quercus* forests in Spain, as a measure to mitigate the increase of CO₂ in the atmosphere.

Plant growth is defined as the increase in biomass over time. Studies under controlled conditions typically measure growth based on the increase of biomass, however, these estimates are much more complicated in field conditions. Therefore, in many field studies, growth is estimated based on the increase in diameter or height, which are considered good predictors of biomass and growth. In this talk, I will discuss the results of the estimates of growth based in biomass, diameter and height and propose some guidelines to improve the estimates. The data of field studies are based on adult *Quercus* individuals obtained by the Inventario Forestal Nacional (IFN). The species considered in the IFN are *Q. ilex*, *Q. suber*, *Q. faginea*, *Q. canariensis*, *Q. pyrenaica* and *Q. robur*. The predictors for biomass and growth were taken from Montero et al. (2005).

I will present results about the growth response of *Quercus* species to changes in various factors (availability of water, light and nutrients and temperature) (Quero et al, 2006, 2008) and the range of conditions (precipitation and temperature) in which the different species of *Quercus* have maximum growth.

Montero, G., Ruiz-Peinado, R., Muñoz, M. 2005. Producción de biomasa y fijación de CO₂ por los bosques españoles. CIFOR- INIA. ISBN: 84-7498-512-9

Quero, J.L, Villar R., Marañón T., Zamora R. (2006) Interactions of drought and shade effects on seedlings of four *Quercus* species: physiological and structural leaf responses. *New Phytologist* 170: 819–834

Quero JL, Villar R, Marañón T, Zamora R, Vega D, Sack L. 2008. Relating leaf photosynthetic rate to whole-plant growth: drought and shade effects on seedlings of four *Quercus* species. *Functional Plant Biology* 35: 725-737

MANAGEMENT AND CONSERVATION OF OAK OPEN WOODLANDS IN SOUTHERN SPAIN

Pilar Fernández Rebollo

School of Agricultural and Forestry Engineering. Forestry Department. University of Córdoba. Edificio Leonardo da Vinci. Campus Universitario de Rabanales. Crta. Madrid-Cádiz Km. 396. 14071 Córdoba, España. ir1ferep@uco.es

Oaks are widespread in many types of woodland within the Northern hemisphere. In the Iberian Peninsula, oaks are well represented and constitute the main trees in open woodlands. Like others savannas ecosystems of the world, Mediterranean open woodlands in the Iberian Peninsula are the result of human intervention over closer natural woodlands, by eliminating trees and shrubs to enhance pasture and fruit production and to enable occasional cereal and legume cropping. The persistence of these management practices over time has resulted in the development of a farming system called Dehesa in Spain and Montado in Portugal. The association of herbaceous plants with woody perennials (trees and with lesser extension shrubs) in the same area, and the existence of ecological and economic interactions between both components, has led to the inclusion of Dehesa and Montado into Agroforestry systems.

Traditional Dehesa farming system involved local livestock breeds with long production cycles, reared exclusively with farm resources without external inputs of fodder. Occasional cropping used to be assembled with grazing practices in order to close the nutrient cycles. Throughout history, dehesa farming system has evolved pushing by different pressures including market and policy. For example, a general replacement of sheep by cattle has taken place in the last decades, mainly as a consequence of the higher labour demand required for sheep farming together with the collapse of the price of wool. In recent years, as a result of the first European reform of the Common Agricultural Policy (CAP), the stocking rate has experienced a noticeable increase and, since 2006, the stocking rate comes down again, due to decoupling of CAP payment from production. On the other hand, dehesas located in marginal areas have been abandoned, shifting grazing by livestock to wild animals. Both process (intensification and abandonment) usually has resulted in specialization of Dehesa and hence in a simplification of uses, practices and knowledge. In spite of these trends, Dehesa still is recognised as extensive farming system and a multiple-use system.

Such agrosilvopastoral management has shaped a distinctive landscape. Although it is characterised mainly by a low oak density in a random mixture with understorey of pasture or crop (Moreno & Pulido 2009), a diversity of vegetation and habitat types can be identified at farm level and at higher spatial-scale. The microhabitats mosaic associated to tree canopy, within habitats mosaic associated to uses or singular elements results in high biodiversity (Marañón *et al.* 2009). Indeed, Dehesas has been classified as High Nature Value (HNV) systems, according to the classification proposed by the European Environment Agency. This concept was established in the last two decades to identify low-intensity land uses and to

promote understanding that the conservation of biodiversity across large areas depends on the continuation of extensive farming systems (Beaufoy & Cooper, 2008). Besides environmental connotations, Dehesa is home to important cultural heritage; therefore it is also considered a “cultural landscape”.

Oaks are key part of Dehesa and contribute to the provision of ecosystem services that community demands. However, their contribution relies on farming practices to the extent that they affect oak function and dynamic. Many studies have analysed the effects of different farming practices focusing mainly on vegetation structure (Ramírez & Díaz 2008), floristic composition of pasture (Tárrega et al. 2009), soil quality (Gómez-Rey et al. 2013; Seddaiu et al. 2013) or tree regeneration (Pulido et al. 2010). However, less information is available about their effects on functions of mature oaks within Dehesa and studies around this topic are still needed.

Pruning, a widespread practice conducted in Dehesa to produce firewood and browse fodder, reduces or not affects acorn yield (Cañellas et al. 2007, Alejano et al. 2008; Carbonero 2011), slightly decreases acorn mass and modifies acorn production pattern, reducing masting behavior (Carbonero 2011). Ongoing research has also shown that pruning can affect nutrient composition of acorn. These effects are dependent on pruning intensity. Nevertheless, the role of pruning deserves more mindfulness, extending the researches toward the analysis of its effects under different environmental conditions (e.g. tree density or water deficit).

Livestock grazing may control shrub cover and hence increase the opportunities for mature oaks by decreasing competition for soil nutrients and water (Silva and Rego 2003; Cubera and Moreno 2007), or by avoiding the alteration of soil environment through toxin or allelopathic compounds production (Chaves and Escudero 1997; Dias et al. 2010). Nevertheless, the nature and magnitude of the interactions shrub-tree are dependent on the species (Rolo & Moreno 2011) and further research is necessary in order to clarify the conditions in which the net balance for tree may be positive or negative.

Nutrient cycling via livestock can be important in enhancing or maintaining soil fertility. This fact may improve, not only pasture quality and production, but also nutritional status, growth and acorn production of oaks (Garcia et al. 2012; 2013). Nevertheless, overgrazing can cause soil degradation that may lead to a worsening of the oaks functions. However, to date comprehensive scientific criteria of overgrazing under different environmental and management contexts have not been addressed yet. On the other hand, oaks can also be benefited from fertilization applied to crop and pasture. But recurrent cropping and heavy grazing decrease the opportunities for oak regeneration (Pulido, 2010). In short, oak function and dynamic in Dehesa depends on the net result of multiple interactions largely driven by farming practices.

References

- Alejano, R.; Tapias, R.; Fernández, M.; Torres, E.; Alaejos, D. 2008. Influence of pruning and the climatic conditions on acorn production in holm oak (*Quercus ilex* L.) dehesas in SW Spain. *Annals of Forest Science*, 65 (2), 1-5.
- Beaufoy, G.; Cooper, T. 2008. Guidance Document to the Member States on the Application of the HNV Impact Indicator. Report for the European Evaluation Network for Rural Development, Brussels.
- Cañellas, I.; Roig, S.; Poblaciones, MJ.; Gea- Izquierdo, G.; Olea, L. 2007. An approach to acorn production in Iberian dehesas. *Agroforest. Syst.*, 70, 3-9.
- Carbonero MD. 2011. Evaluación de la producción y composición de la bellota de encina en dehesa. Tesis doctoral. ETSIAM, Universidad de Córdoba.
- Chaves, N.; Escudero, JC. 1997. Allelopathic effect of *Cistus ladanifer* on seed germination. *Funct Ecol* 11: 432–440.
- Cubera, E.; Moreno, G. 2007. Effect of land-use on soil water dynamic in dehesas of Central-Western Spain. *Catena* 71: 298-308.
- Dias, T.; Malveiro, S.; Martins-Loução, MA.; Sheppard, LJ.; Cruz, C. 2010. Linking N-driven biodiversity changes with soil N availability in a Mediterranean ecosystem. *Plant Soil* 341: 125-136.
- García-Moreno, A.; Carbonero, MD., Moreno, F.; Leal, JR.; Hidalgo, MT.; Fernández-Rebollo, P. 2012. Influencia de la presión de pastoreo en el contenido de nutrientes en hoja de encina en la dehesa. En: RM. Canals, L. San Emeterio (eds), *Actas de la 51 Reunión Científica de la SEEP, Nuevos retos de la ganadería extensiva: un agente de conservación en peligro de extinción*. 51-58. ISBN 987-84-9769-277-9. Pamplona.
- García-Moreno, A.; Carbonero, MD.; Moreno, F.; Leal, JR.; Hidalgo, MT.; Fernández-Rebollo, P. 2013. Efecto del pastoreo en la producción de bellotas de la encina en la dehesa. Consecuencias para el follaje del árbol. En: L. Olea, MJ. Poblaciones, S. Rodrigo, O. Santamaría (eds), *Actas de la 52 Reunión Científica de la SEEP. Los pastos: nuevos retos, nuevas oportunidades*. 537-544. ISBN 978-84-695-6999-3. Badajoz.
- Gómez-Rey, MX.; Madeira, M.; Gonzalez-Prieto, SJ.; Coutinho, J. 2013. Soil C and N dynamics in a Mediterranean oak woodland with shrub encroachment. *Plant Soil*. doi: [10.1007/s11104-013-1695-z](https://doi.org/10.1007/s11104-013-1695-z)
- Marañón, T.; Pugnaire, F.; Callaway, RM. 2009. Mediterranean-climate oak savannas: the interplay between abiotic environment and species interaction. *Web Ecology* 9: 30-43.
- Moreno, G.; Pulido, F. 2009. The functioning, management, and persistence of dehesas. In: Rigueiro-Rodríguez A, Mcadam J, Mosquera-Losada MR (eds) *Agroforestry in Europe: Current Status and Future Prospects*, Springer, Berlin, pp. 127-160.
- Pulido, F.; García, E.; Obrador, JJ.; Moreno, G. 2010. [Multiple pathways for tree regeneration in anthropogenic savannas: incorporating biotic and abiotic drivers into management schemes](#). *J Appl Ecol* 47: 1272-1281.
- Ramírez, JA.; Díaz, M. 2008. The role of temporal shrub encroachment for the maintenance of Spanish holm oak *Quercus ilex* dehesas. [Forest Ecol Manag](#) 255: 1976-1983.
- Rolo, V.; Moreno, G. 2011. Shrub species affect distinctively the functioning of scattered *Quercus ilex* trees in Mediterranean open woodlands. *Forest Ecol Manag* 261: 1750-1759.
- Seddaiu, G.; Porcua, G.; Ledda, L.; Roggero, PP.; Agnelli, A.; Cortic, G. 2013. Soil organic matter content and composition as influenced by soil management in a semi-arid Mediterranean agro-silvo-pastoral system. *Agr Ecosyst Environ* 167: 1– 11.
- Silva, JS.; Rego, FC. 2003. Root distribution of a Mediterranean shrubland in Portugal. *Plant Soil* 255 (2): 529-540.
- Tárrega, R.; Calvo, L.; Taboada, A.; García-Tejero, S.; Marcos, E. 2009. Abandonment and management in Spanish dehesa systems: Effects on soil features and plant species richness and composition. *Forest Ecol Manag* 257: 731–738.

PATHWAYS FOR RESILIENCE IN CORK OAK LAND USE SYSTEMS IN PORTUGAL: THE ROLE OF ECOLOGICAL AND LAND USE FACTORS

Vanda Acácio

Cork oak is today restricted to the western part of the Mediterranean Basin, its largest extent being in Portugal (737,000 ha - about 30% of the species distribution area). There are two main types of cork oak land use systems coexisting in Portugal: (1) agro-silvopastoral systems (the montados or dehesas), which occupy about 70% of the distribution area in Portugal and are found mainly in the province of Alentejo, on flat terrain, and (2) cork oak forests, which occupy the remaining 30% and are mainly located in the mountain regions of Algarve, hilly areas of Alentejo and the north of the country. Agro-silvopastoral systems have lower tree density (40-80 trees/ha) and the understory is used for grazing, crops, or both. Cork oak forests have higher tree density (>80-100 trees/ha) and a shrubby understory, if not regularly cleared for fire prevention.

Overexploitation of the land led to soil erosion, failures in cork oak recruitment, and loss of forests and national forest inventories show that tree density of Portuguese cork oak stands has fallen over the last decade. Disturbed cork oak forests of southern Portugal with loss of soil moisture and nutrients are quickly colonised by early successional heathland rockrose (*Cistus* spp.) shrubs forming highly persistent patches. Although traditionally shrublands have been considered as a transient successional state, I present evidence that *Cistus* shrublands, characterized by lower plant biomass and diversity than cork oak forests, can represent persistent alternative states in areas originally covered by cork oak forests.

I present a state-and-transition model representing the cork oak landscape and hypothetical transitions between vegetation states, as a contrasting view to the traditional succession model. Each patch-type is conceived as a vegetation state and each transition is driven by both ecological and land use mechanisms that act in conjunction to affect cork oak natural regeneration, seedling establishment and tree recruitment. The overall effect of multiple disturbances at different scales as well as the net effect of plant-plant interactions on oak performance and recruitment vary along resource gradients such as water availability and soil fertility, affecting different phases of the recruitment cycle and shaping the trajectories of vegetation change. I use landscape dynamics analysis, field experiments and landowner interviews to determine and understand the different factors and disturbances that contribute to each vegetation transition, for a study area in southern Portugal. I discuss alternative pathways that drive vegetation transitions towards forest recovery or maintenance, or to the persistence and expansion of shrublands. I show that multiple disturbances (overexploitation, wildfires and drought) and multiple oak recruitment limitations contribute to positive feedback mechanisms that maintain *Cistus* shrublands, with likely associated critical thresholds, which may prevent colonisation by cork oak even after external disturbances cease. Unless concerted management actions and restoration programs are undertaken, the cork oak land use systems in Portugal will not be sustainable.

ECOLOGICAL ATTRIBUTES OF *QUERCUS* SPP. AND ITS APPLICATION IN GUIDING THE RESTORATION OF HUMID FORESTS IN SOUTHERN MEXICO

Mario González-Espinosa, Luis Galindo-Jaimes, Guadalupe Méndez-Dewar, María Magdalena Alcázar-Gómez, Neptalí Ramírez-Marcial, and Angélica Camacho-Cruz

The genus *Quercus* (Fagaceae) is one of the most speciose genera within the Mexican tree flora, including some 165 species (*encinos* or *robles* as they are commonly called in Mexico). For the state of Chiapas, a recent account reports at least 28 species of *Quercus*. Most of the species in this southern mountainous state thrive at 1000-2800 m elevation. Most forests dominated by *Quercus* spp. (always as forest canopy elements), include 2-3 (-4) coexisting species and form a tight functional group showing more similarities than differences among them. The most common situation involves their coexistence with 1-2 species of *Pinus*. Oaks are the main firewood resource for local peasant *mestizo* and indigenous communities, and the main raw material to make charcoal, one of the few household sources of cash income from local markets; their timber is also valued for rustic buildings and tool handles. However, *Quercus* spp. provide a number of other ecosystem services that have not been sufficiently valued. We will present original data derived from experiments on the regeneration niche of several *Quercus* spp. conducted under field and common garden conditions. The responses of seedlings and juveniles to gradients of light and water are relevant to model their performance under varying scenarios of climate change. Species of *Quercus* may serve as nurse plants for other woody species during secondary succession, and therefore, can be used as such in forest restoration projects. Short- and long-term forest dynamics models suggest that these truly keystone functional group should guide management and restoration strategies to prevent adverse impacts of extensive pine-rise derived from traditional uses, and conventional afforestation plans that use pines and exotics.

OAK FOREST ECOLOGY AND MANAGEMENT: AN OVERVIEW

Teodoro Marañón

IRNAS, CSIC, Av. Reina Mercedes 10, 41080 Sevilla, Spain

In this lecture I will review the importance of the oak woodlands and forests and how they are affected by global change, I will analyze the main research topics related with oaks, and finally I will summarize the main knowledge gaps and future lines of research as discussed during the workshop.

Oak forests and woodlands are important ecosystems in the Mediterranean region, in North America (USA and Mexico), and in Central Asia (China). They are vital providing a variety of ecosystem services. They provide with raw materials like cork (from *Q. suber*), wood and fuel, and fodder for wild and domestic animals. In Spain and Portugal the silvopastoral system known as “dehesa” provides habitats for wild animals and contributes to a higher biodiversity at the landscape scale. Oak trees provide a climate regulating service by their capacity to sequester carbon and therefore to mitigate the effects of climatic change; they regulate air and water quality and contribute to soil formation and protection. Cultural services are important for local populations: there is an increasing demand for recreation, ecotourism, and to enjoy their aesthetic and spiritual values. However, Global Change is affecting negatively oak forests and therefore diminishing their ecosystem services and in consequence human well-being. Main drivers are: land use change, introduction of exotic pathogens, air and soil pollution deteriorating oak health, and climatic change, in particular the reduction of rainfall.

The research interest on oaks is growing exponentially. A search in the Web of knowledge with the topic “*Quercus*” produces more than 13.000 papers, with a recent rate of more than 800 papers per year (during the last 5 years). Among the countries, Spain is the second, only after the USA, in the publication of papers related with *Quercus*. Among the most repeated key words in a selection of papers (from 2000 to 2012) analyzed were: climate-change, regeneration, species richness, drought and disturbance. Different scientific networks, associations, web pages and conferences devoted to the study of oak trees and forests will be reviewed.

The main knowledge gaps identified during the workshop will be discussed and summarized, as well as the proposed lines of research for the future.

PARTICIPANT

AVILA CASTUERA JOSÉ MANUEL

jmavila@irnas.csic.es

Departamento de Geoecología,
Biogeoquímica y Microbiología
Ambiental. Instituto de Recursos Naturales
y Agrobiología de Sevilla (IRNAS-CSIC)
Sevilla España

BENITO MATÍAS, LUIS FERNANDO

lusfbm@gmail.com

CNRGF "El Serranillo" SILvicultura y
Montes. DG Desarrollo Rural y Política
Forestal. Minist. Agricultura, Alimentación
Medio Ambiente. GUADALAJARA.
SPAIN

**CARBONERO MUÑOZ, MARIA
DOLORES**

mariad.carbonero@juntadeandalucia.es

Institute of Agricultural and Fishing
Research and Education (IFAPA) Hinojosa
del Duque Center. Cordoba. Spain.

DOMÍNGUEZ BEGINES, JARA

jara@irnas.csic.es

Instituto de Recursos Naturales
Agrobiología de Sevilla, IRNAS-CSIC.
Sevilla. Spain.

FÉRRIZ NÚÑEZ, MACARENA

macfernu@gmail.com

C/ San Andrés, 1. 6º H. Almería. Spain

GALAN SOLDEVILLA, CARMEN

bvlgasoc@uco.es

Departamento de Botánica, Ecología
Fisiología Vegetal Edif. Celestino Mutis,
Universidad de Córdoba. CORDOBA.
SPAIN.

GARCÍA DE LA RIVA, ENRIQUE

Enga70@gmail.com

Area de Ecología, Universidad de
Córdoba, Edificio C-4 "Celestino Mutis",

Campus de Rabanales, Córdoba.

Andalucía. Spain

GARCIA MORENO, ALMA MARIA

almariagarcia@gmail.com

IFAPA - Área de Producción Ecológica y
Recursos Naturales. Consejería de
Agricultura, Pesca y Medio Ambiente.
Centro Alameda del Obispo CORDOBA.
SPAIN

GARCIA MOZO, HERMINIA

bv2gamoh@uco.es

Departamento de Botánica,
Ecología Fisiología Vegetal Edif. Celestino
Mutis, Planta 3ª Universidad de Córdoba.
CORDOBA. SPAIN

GARCÍA NOGALES, ANA

agarnog@upo.es

DEPARTAMENTO DE SISTEMAS
FÍSICOS, QUÍMICOS Y NATURALES.
UNIVERSIDAD PABLO DE OLAVIDE.
SEVILLA. ESPAÑA

GENTILESCA, TIZIANA

Tiziana.gentilesca@unibas.it

SCHOOL OF AGRICULTURE, FOREST,
FOOD AND ENVIRONMENTAL
SCIENCES. UNIVERSITY OF
BASILICATA, LUCANO. ITALY.

GONZÁLEZ DUGO, MARÍA PAT.

mariap.gonzalez.d@juntadeandalucia.es

Instituto Andaluz de Investigación y
Formación Agraria y Pesquera (IFAPA).
Consejería de Agricultura, Pesca y Medio
Ambiente. Centro Alameda del Obispo.
Córdoba. SPAIN

HERGUIDO SEVILLANO, ESTELA

estela.herguido.sevillano@gmail.com

Grupo de Investigación GeoAmbiental,
Departamento de Artes y Ciencias
Territorio. Facultad de Filosofía y Letras,

Universidad de Extremadura. Cáceres.
Spain

HERMIDA CARRERA, CARMEN

carmen.hermida@uib.es

RESEARCH GROUP OF PLANTS IN
MEDITERRANEAN CONDITIONS
BIOLOGY DEPARTMENT
UNIVERSITY. Palma de Mallorca. Illes
Balears. Spain.

HERRERO MÉNDEZ, ASIER

asier@ugr.es

Forest Ecology and Restoration Group
Department of Life Sciences, University
of Alcalá. Campus Universitario, 28871
Alcalá de Henares (Madrid), Spain.

HERREROS DE TEJADA

JARAQUEMADA, FERNANDO

ferherrerros@gmail.com

C/ Concordia, 32, 3º 3ª, 08004 - Barcelona
Barcelona. Spain

LEVERKUS, ALEXANDRO B

leverkus@ugr.es

Depto Ecología, Fac. Ciencias, Univ.
Granada. Granada. España.

**NAVARRO FERNÁNDEZ, CARMEN
MARÍA**

c.navarro@csic.es

Department of Geoecology, Biochemistry
and Environmental Microbiology. Institute
of Natural Resources and Agrobiología of
Seville, (IRNAS - CSIC). Seville. Spain

OLARIETA ALBERDI, JOSÉ RAMÓN

jramon.olarieta@macs.udl.cat

Dept. Medi Ambient i Ciències del Sòl.
Universitat de Lleida. Lleida. Spain.

PADILLA DÍAZ, CARMEN Mª

cmpadilla@irnas.csic.es

Departamento de Geoecología,
Biogeoquímica y Microbiología
Ambiental. Instituto de Recursos Naturales
Agrobiología de Sevilla (IRNAS) – CSIC.
Sevilla España.

PEREA GARCÍA-CALVO, RAMÓN

ramon.perea@upm.es

DEPARTAMENTO
SILVOPASCICULTURA, ETSI.
MONTES, UNIV. POLITÉCNICA DE
MADRID. Spain.

QUERO PÉREZ, JOSÉ LUIS

jose.quero@uco.es

Departamento de Ingeniería Forestal
Escuela Técnica Superior de Ingeniería
Agronómica y de Montes. CÓRDOBA.
SPAIN

SEBASTIAN FERRER, SAMUEL

samuelsebastian37@hotmail.com

PLAZA DE CERVANTES S/N.
AYUNTAMIENTO DE ALCALÁ DE
HENARES. MADRID. SPAIN

SIMONSON, WILLIAM DAVID

wds10@cam.ac.uk

Department of Plant Sciences, University
of Cambridge, Cambridge. UK.

VILLAR SALVADOR, PEDRO

pedro.villar@uah.es

Departamento de Ciencias de la Vida, U.D.
Ecología, Universidad de Alcalá. Alcalá de
Henares. Madrid. SPAIN.

POSTER PARTICIPANT:

IMPACTS OF CORK OAK DECLINE ON CARBON, NITROGEN AND PHOSPHORUS FLUXES IN MEDITERRANEAN MIXED FORESTS

J.M. Avila¹, B. Ibáñez¹, A. Gallardo², L. Gómez-Aparicio¹.

¹Institute of Natural Resources and Agrobiology of Seville (IRNAS-CSIC)

²Departamento de Sistemas Físicos, Químicos y Naturales. Universidad Pablo de Olavide

In the last decades an increasing number of tree decline events has been detected worldwide. Extensive work has been conducted to analyse the main causes underlying these processes (climate change, pollution, exotic pathogens). However, few works have focused on the potential consequences of forest decline for ecosystem functioning. In this work, we assessed the "footprint" of individual cork oak (*Quercus suber*) trees with different levels of decline on C, N and P cycles in mixed oak forests of Southern Spain. Specifically, we measured soil respiration rates in spring and summer of 2011 and 2012 and ammonium, nitrate and phosphorous availability in spring and summer of 2010, 2011 and 2012. We detected a decrease of respiration rates under dead cork oak trees, likely due to a decrease in root activity. Furthermore, we detected a decrease in nutrient availability under defoliated and dead cork oak trees, particularly in phosphorus levels. This result could be due to a decrease in the primary production of the trees affected by decline, diminishing the incorporation of phosphorus into the soils. In summary, our results suggest that the decline and mortality of cork oak trees decrease cycling rates and pools of carbon and nutrients in forest soils.

ARE READY SEEDLINGS OF *QUERCUS SP* MYCORRHIZATED WITH *TUBER MELANOSPORUM* TO COPE GLOBAL CHANGE?

Benito-Matías, L. F.¹, Álvarez-Lafuente, A., Peñuelas, J. L & Nicolás, J.L.

C.N.R.G.F. “El Serranillo”. Dirección General de Desarrollo Rural y Política Forestal. Subdirección General de Selvicultura y Montes. Ministerio de Agricultura, Alimentación y Medio Ambiente. Crta Fontanar, s/n. 19004, Guadalajara, SPAIN.

¹Corresponding author: lusfbm@gmail.com

The fungi, ectomycorrhizal and endomycorrhizal, enhance uptake and utilization of nutrients and water by plant roots, facilitating the development of the plants, and its study are basics to forestation and rehabilitation of ecosystems. The production of mycorrhizal fungi provides higher economic value than any other forest product in many Mediterranean areas. *Tuber melanosporum* is a very known fungi for its economic value. Black truffle orchards generates significant reforested land rents. But not only the value of *Tuber melanosporum* is economic. This fungi must have an ecological implication. One idea is that could be supporting its host to resist drought. An experiment has been carried in order to know this effect on water stress resistance of three species of *Quercus* (*Q. ilex*, *Q. faginea* and *Q. coccifera*) seedlings inoculated and mycorrhizated with spores of *Tuber melanosporum*.

Quercus seedlings were obtained from acorns pregerminated and were inoculated at 3-month-old. The plants were housed in a greenhouse with an average daily temperature of 20-30°C, and were fertilised weekly during summer with 120 mg of N/year. A control treatment with no-inoculated seedlings was analyzed too. At the end of the first year we evaluated the presence of *Tuber melanosporum* in short roots. Lot half was planting in February in an experimental field, where the amount of water in soil was controlled. In middle summer, for each specie, chlorophyll fluorescence and water relations by recording predawn and mid-day leaf water potentials were analysed in nursery and field and comparing with control seedlings.

Keywords: *Quercus ilex*, *Quercus faginea*, *Quercus coccifera*, *Tuber melanosporum*, global change, water stress.

PATTERNS OF ACORN PRODUCTION IN SPANISH OAK SAVANNAS

*María Dolores Carbonero*¹, *Alma García-Moreno*², *Pilar Fernández-Rebollo*²

¹Department of Agricultural Production, Institute of Agricultural and Fishing Research and Education (IFAPA), Hinojosa del Duque, Road El Viso, km 15, 14270 Córdoba, Spain

²Department of Forestry, Campus de Rabanales, Leonardo da Vinci, University of Córdoba, Apdo. 3048, 14071 Córdoba, Spain

Dehesas are the most widespread agroforestry systems in Europe, representing open woodland where holm oak, *Quercus ilex* L. subsp. *ballota* (Desf.) Samp., is the most prevalent tree species. Holm oaks are important drivers of community and ecosystem processes, contributing to the profitability and sustainability of these open woodlands. Indeed acorn production is a useful indicator to check the tree status in different oak forest. Despite this fact, little is known about the productive behaviour of holm oak in open woodlands. This paper focuses on the identification of holm oaks clusters according to patterns of acorn production over time and the characterisation of acorn weight and appearance within each cluster. We have sampled acorn production in 50 trees for a six year period in monospecific open woodland without environmental gradients in Cordoba (Spain). Different patterns of acorn production were identified: two groups with high production and biennial cycles with a total absence of synchrony between them; and a third larger group with low but not biennial production. Acorns of high potential production trees have similar weight to those of low potential trees and the constancy of acorn weight does not appear to be associated with the productive capacity of holm oak. Acorn appearance is a fairly stable variable over time and cannot be associated with a particular productive pattern. Given the importance of this tree in this system and the lack of viable seedling, a deeper understanding of the productive behaviour of the Holm oak and the relationship between acorn weight and yield, are issues of great interest and could provide to natural resource managers greater insight into the dynamics of Holm oak open woodland, setting up practices for maintain tree diversity and regeneration.

PLANT-SOIL FEEDBACKS IN DECLINING QUERCUS SUBER FORESTS

J Dominguez-Begines, L Gómez-Aparicio, JM Ávila, A Pozuelos, LV García

IRNAS-CSIC. 41080 Sevilla, Spain; Email: jara@irnas.csic.es

In a plant-soil feedback process, plant species change the chemical, physical or biological soil properties, which in turn modifies the performance of the own plant community. Many recent studies have demonstrated that these feedbacks play an important role in determining the abundance and coexistence of species in plant communities. Nevertheless, very few studies have been conducted with tree species, especially in Mediterranean ecosystems. In this work, we evaluated the existence of plant-soil feedbacks in two declining *Quercus suber* forests of SW Spain: a closed forest with low abundance of the aggressive soil pathogen *Phytophthora cinnamomi*, and an open woodland with high abundance of the pathogen. We collected soil samples under three categories of *Q. suber* adults: “Healthy”, “Defoliated” and “Dead”. Half of the soil samples were sterilized to separate abiotic vs biotic effects. *Q. suber* acorns were sown in pots filled with each soil treatment (n=10 replicates) in a greenhouse under controlled conditions. After four months, we measured shoot and root dry biomass in all seedlings. Our results suggest the existence of abiotic negative plant-soil feedbacks in the closed forest. In the open forest, on the contrary, we did not find evidence of plant-soil feedbacks (i.e. seedling performance did not vary among the three soil categories). At this site, however, the sterilization treatment suggested a general strong negative effect of the soil community on seedling performance. Overall, our results suggest that changes in soil abiotic and biotic properties induced by the decline of *Q. suber* trees have severe negative effects on conespecific seedlings. These changes could imply a competitive disadvantage for this species, with negative consequences for its abundance and dominance.

Key words: oak decline, *Quercus suber*, soil pathogens, plant-soil feedback.

HOLM OAK PHENOLOGY IN AFFORESTED DEHESAS

*Ferriz M, Carbonero MD, Hidalgo MT, Leal JR, García A, Fernández Rebollo P**

University of Córdoba, ETSIAM, Forestry Department

*ir1ferep@uco.es

The Afforestation Program of Agricultural Lands began in 1991, as part of the accompanying measures of CAP reform, aiming to transform agricultural areas to forests. In Andalucía, many marginal agricultural systems joined to this program. More than 150,000 hectares were afforested mainly with holm oak, cork oak, carob tree and stone pine. Nowadays some of these oak afforested areas constitute new dehesas where pasture and acorns are grazed by sheep and pigs. Trees of these new dehesas come from tree nursery, as a consequence, less genetic variability is expected owing to acorn harvesting is carried out from a few number of mother trees by tree nurseries. According to this, the objective of this study was to evaluate phenology variability in a holm oak afforested area. The area was planted 18 years ago under the Afforestation Programm of Agricultural Lands. Nursery seedlings were used although acorns from mature trees of the surrounding area were sown in order to replace dead plants in the following years. 40 holm oaks were selected (in one half hectare plot) and during spring in 2012 phenological status (foliation, masculine and femenine flowering) was assessed weekly. From these data, phenofase duration and phenofase overlaps were obtained. Overlap between masculine and feminine flowering were calculated at individual and population levels. Results indicate that there is a difference of 28 days in leaf emerging between the earliest oak and the latest, 10 days in masculine flowering start and 16 in femenine flowering start. Masculine and femenine flowering overlap is observed at individual level, though it is low as expected. At population level, more than 25% oaks show overlapping between masculine and femenine flowering being 6 days the average overlap period. We concluded that phenology variability in the afforested area is high, maybe as a consequence of the high rate of initial plant mortality that forced an intense acorn sown, increasing in this way the seed's procedence.

Key words: *Quercus ilex*, acorn, vegetative development, flowering, overlap.

FUNCTIONAL TRAITS VARIATION ACROSS FIVE SPECIES OF QUERCUS

Enrique G. de la Riva^{1*}, *Ignacio M. Pérez-Ramos*², *Carmen M. Navarro-Fernández*², *Manuel Olmo*¹, *Teodoro Marañón*² and *Rafael Villar*¹

¹ Área de Ecología, Facultad de Ciencias, Universidad de Córdoba, 14071 Córdoba, Spain

² Instituto de Recursos Naturales y Agrobiología de Sevilla, IRNAS, CSIC, 41012 Seville, Spain

Quercus is one of the most abundant and economically important genera of woody plants in the Iberian Peninsula. Different species of *Quercus* are mainly linked to a water gradient (Urbietá 2008), and knowing the morpho-functional traits of different *Quercus* species can help us to understand the mechanisms that control the distribution patterns and structure of these communities.

The aim of the study is, first to determine the variation of functional traits at leaf, stem and root level of five different species of *Quercus* (*Quercus ilex*, *Quercus coccifera*, *Quercus canariensis*, *Quercus suber* and *Quercus faginea*) widely distributed in Andalusia, and second to determine the existence of a main axis of covariation in leaf, stem and root, which can be understood as "economic plant spectrum" at *Quercus* level. Sampling was conducted in different plots of Sierra Morena (Córdoba) and Sierra de Alcornocales (Cadiz). Six individuals were sampled per species and we quantified several key functional traits at the leaf level (specific leaf area, dry matter content, chlorophyll, nitrogen concentration and carbon isotopic ratio), stem (density and dry matter content) and root (root specific area, dry matter content and density).

According to the obtained results, the different species of *Quercus* show patterns in their functional strategies; in dry conditions stand species of *Quercus* with a conservative resource-use strategy showing high values of dry matter content in leaf and stem, low specific leaf and root area, chlorophyll and leaf-N concentration. In contrast, in wet sites stand species of *Quercus* with opposite attributes.

NUTRITIONAL STATUS OF *QUERCUS ILEX* L. IN RESPONSE TO DIFFERENT USES OF MEDITERRANEAN OPEN WOODLANDS

*Alma M. GARCÍA-MORENO*², *María D. CARBONERO-MUÑOZ*³,
*María SERRANO-MORAL*¹, **Pilar FERNÁNDEZ-REBOLLO*¹

(1) Department of Forestry, Campus de Rabanales, Leonardo Da Vinci, University of Córdoba, Apdo. 3048, 14071 Córdoba, Spain. Telephone: +34 957 21 84 10. Fax n°: +34 957 21 20 95 *E-mail: ir1ferep@uco.es

(2) Department of Ecological Production and Natural Resources. Institute of Agriculture and Fishing of Andalucía (IFAPA) Centro “Alameda del Obispo”, Avda Menéndez Pidal s/n Apdo 3092. Córdoba, Spain.

(3) Department of Agricultural Production. Institute of Agriculture and Fishing of Andalucía (IFAPA) Centro “Hinojosa del Duque”, Crta. El Viso, km 15. 14270. Hinojosa del Duque, Córdoba, Spain.

Mediterranean open woodlands have been facing a dual process of intensification and abandonment, due to socioeconomic changes happening in European countries in the last decades. This dual process, which can coexist even on a local scale, has resulted in the alteration of structure, composition and production of the vegetation. Several studies have analysed the effects of land use change on different traits of oak open woodlands. However, less information about its effect on the nutritional status of mature Holm oaks is available. In order to clarify the effects of such land use changes on trees, we analyzed the shoot growth, nutrient and water status of Holm oak leaves in different open woodlands in the southern Iberian Peninsula. We have chosen two areas of open woodland. The first area is illustrative of an abandonment process, where patches of open woodland grazed at low intensity were interspersed with patches without livestock use or occasionally grazed, and hence with a dense shrub understory. In this area, two adjacent plots with different land use within six farms were selected: grazed areas (native pasture + Holm oak) and abandoned areas (shrub species + Holm oak). Farms were grouped into two habitat types according to the shrub composition: *Cistus* shrub and Mixed shrub. The second area represents intensified open woodland whose pasture understory have been grazed by livestock at different intensities in a continuous way and for a long period. Six plots with high grazing intensity and six plots with moderate grazing intensity were chosen. Leaf samples from Holm oaks of all plots were collected and contents of water (WC), N, P, Ca, Mg, and K were determined. Length of

current-year shoots was measured in each tree as an indicator of tree growth. Significant differences were found in leaf N concentration and WC between land uses in *Cistus* shrub habitat. Trees of abandoned areas showed lower leaf N concentration and WC than trees of close grazed areas. Regarding with Mixed shrub habitat, significant differences were found in leaf P concentration and WC between land uses, but on this occasion the lowest values were found in grazed areas. Abandoned areas encroached by Mixed shrub have showed higher foliar N, P, Ca and Mg concentrations than areas encroached by *Cistus* shrub after grazing suppression. The same pattern was observed in WC. High grazing intensity has improved shoot growth and leaf N and Mg concentrations.

Although there are other social and environmental reasons for maintaining extensive grazing in Mediterranean open woodlands, our results showed that, if understory is composed of nearly monospecific *Cistus ladanifer* L. shrub, grazing increases Holm oak nutritional and water status and hence, could be a good strategy in the face of climate change.

Keywords: Holm oak, Leaf nutrient, Water content, Shoot growth, Dehesa

INFLUENCE OF AIRBORNE POLLEN AVAILABILITY AND METEOROLOGICAL FACTORS ON HOLM-OAK ACORN PRODUCTION IN SOUTHERN SPAIN.

Herminia García-Mozo¹, Eugenio Dominguez-Vilchez¹, Carmen Galán¹.

¹Department of **Botany, Ecology and Plant Physiology**, University of Córdoba, Agrifood Campus of International Excellence (CeIA3), 14071, Córdoba, Spain.

E-mail: bv2gamoh@uco.es

Different arboreal species, especially perennial ones present high variations on fruit production cycles. This phenomenon, known as masting or mast seeding, is characterized by the intermittent production of large seed crops by a population of plants.

Many oaks species show high year-to-year variation in acorn production or mast seeding events, and this is also one of the characteristics of the holm-oak (*Quercus ilex* subsp. *ballota* (Desf.) Samp.) acorn production. This species has a high variability on fruit production among individuals and years. This anemophilous tree is the main species of the “dehesa” ecosystem in South Spain. Holm-oak acorn production is of vital ecological and economic importance in this area since the amount and quality of them influences on wild animal feeding system and also they are the basic feed for domestically-bred high-quality meat pigs, known as “Iberian pigs”. The understanding of fruit production is basic to this ecosystem in order to achieve a sustainable management and enhance wildlife and pig feeding.

Different studies have been conducted on several aspects of acorn production in this ecosystem, however the production dynamic is still poorly understood to explain in detail all the causes for the occurrence of mast-years. The main unknown question is: Are these variations completely random or are there some factors controlling them? In this case, what factors are influencing these variations? Several studies have tried to clarify these questions and traditionally there were three theories related to “seed-dispersal”, “predator satiation” and “wind pollination” hypotheses. The two formers hypothesis matched with the idea of random production patterns as a strategy to guarantee the continuity of the species. Nevertheless, recent studies reveal as inconsistent this type of theories and are more favourable with the “wind pollination” hypothesis which indicates that the size of flower and pollen production

greatly influences acorn crop size as well as the meteorological conditions registered during flowering and fruiting processes.

With the aim to determine the main causes of variations on South Spain, a study was conducted from 1998 to 2010 in a holm-oak natural area of South Spain placed at the Northern of the province of Cordoba (Andalusia, Spain), in the natural park of Hornachuelos. During this period floral phenology, airborne pollen emission, meteorology and fruit production were analyzed. Our study determines the main factors influencing in the acorn production dynamic and, on this base, we build a preliminary model explaining acorn production pattern in a holm-oak.

Airborne pollen during flowering season was the main factor determining final acorn harvest, but also some meteorological variables played an important role to explain acorn crop variations, specially humidity and temperature of April and September months. The reliability of the proposed model was externally validated using data not included in its construction; validation yielded acceptable results, with a minimum error of estimation. Further research could extend the use of airborne pollen counts in forest studies relating anemophilous species, in order to optimize agricultural policies. The present results offer a scientific analysis for future acorn previsions and could be the basis for a potential general model for holm-oak acorn crop forecasting in South Spain.

Keywords: acorn production, pollen, oak forest, model, holm oak, *Quercus ilex* subsp *ballota*, aerobiology, phenology

**HOLM OAK (*QUERCUS ILEX* SUBSP. *BALLOTA*) INTRASPECIFIC VARIABILITY
ALONG A LATITUDINAL GRADIENT. A TEST OF THE CORE-PERIPHERY
PARADIGM**

García-Nogales A., Cortés-Gañán R., Rodríguez JGP., Espinar R., Linares JC., Seco JI. and Merino J.

Dep. Sistemas Físicos, Químicos y Naturales. Universidad Pablo de Olavide. Carretera de Utrera, km 1. Sevilla 41013. (jamerort@upo.es)

Evolution seems to have favored more abundant defensive biochemical endowments in populations native to boundaries of the distribution range as a response to higher overall levels of stress in these areas; with the result of individuals inherently more resistant to stress. The synthesis and operation of greater (and more complex) defensive endowments would result in both, higher costs of tissue synthesis and maintenance. Higher costs would result in lower metabolic energy availability for growth, and thus in lower growth rates in the individuals at the area boundaries. Our main goal is to compare populations of *Quercus ilex ballota* native to both, boundaries and core locations of the distribution range of the species.

For this purpose we collected acorns from 6 populations of *Q.i. ballota* located across the range of this species (from North of Spain to South of Morocco). Potted seedlings grown in homogeneous conditions were considered for the comparison. Comparisons include tree individuals growing in natural conditions from the same six populations.

Results so far show that maintenance costs were significantly higher in the leaves of the plants native to the two boundary localities considered, indicating that these populations expend more energy in processes other than growth and reproduction. Also, boundary populations displayed both, lower Photosynthetic rates and Photosynthetic Capacity than those from the core, suggesting that boundary populations are less plastic in the use of resources.

The response to ozone fumigation shows a general decrease in photosynthetic rate and stomatal conductance in the 6 populations considered. However, the boundary populations show the lowest decrease in both, internal CO₂ concentration and Water Use Efficiency, reflecting higher capacity for regulating the fine Mesophyll Photosynthetic Capacity-Stomatal Conductance relationship in fumigated plants. These results suggest that boundary populations are more resistant to ozone fumigation than core ones.

In general terms, the observed pattern boundary-core is a constitutive one, suggesting that populations in the study could be considered ecotypes.

FOREST DIEBACK: A STUDY CASE OF QUERCUS *SPP* POPULATION IN SOUTHERN ITALY

Gentilesca T, Ripullone F, Colangelo M, Borghetti M

School of Agricultural, Forest, Food and Environmental Sciences - University of Basilicata,
Viale dell'Ateneo Lucano, 10. 85100 Potenza, Italy

Stress episodes (Anderegg *et al.*, 2012, Choat *et al.*, 2012, Engelbrecht 2012, Sturrock *et al.*, 2011). The rise and the diffusion of those phenomena, most of them drought-related and heat-induced, appears quietly impressive and alarming. In Italy, isolated phenomena of tree mortality of individual *Quercus spp* trees were observed; in particular in Basilicata region several cases (*e.g.* Gorgoglione (MT), Sarconi (PZ), and Oriolo and San Paolo Albanese, within the Pollino National) of decaying forests and widespread mortality in *Quercus spp* populations have been reported. In this study we show the preliminary results of a long-term established study at Gorgoglione (Mt), Southern Italy, where a *Quercus cerris* and *Quercus pubescens* forest is suffering severe decline.

In the summer of 2013 field works were carried out in order to assess the plant pathological status of forest and to establish a LTER study site. Dendrochronological sampling was carried out following standard methodology (Fritts 1976; Cook and Kairiukstis 1990). Tree cores were taken from 10 decaying and 10 healthy trees for a long-term dendrochronological study, on the same trees leaves from the upper crown were also sampled to assess plant nutrient and carbon/nitrogen isotope compositions. Plant status were identified following the international scale based classification on visual symptoms of decay by considering five classes of leaf defoliation and discoloration (*i.e.* from class 1, healthy tree, to class 5, dead tree). Preliminary investigations showed a slightly decreasing trend in pattern of growth for decaying trees with respect to healthy trees. Most trees showed reduction in latewood from 1960 up to 2012. Current tree growth was not directly correlated with visual symptoms of decay and foliar isotope compositions did not show significant differences between decaying and healthy trees.

REMOTELY SENSED MONITORING OF DEHESA ECOSYSTEM EVAPOTRANSPIRATION AND WATER STRESS

M.P. González-Dugo^a, A. Andreu^a, M.J. Polo^b

^a Andalusian Institute for Agricultural and Fisheries Research and Training (IFAPA), Alameda del Obispo, Apdo. 3048 Córdoba, Spain

^b Fluvial Dynamics and Hydrology Research Group, Interuniversity Research Institute of the Earth System in Andalucía, Campus de Excelencia Internacional Agroalimentario (ceiA3), University of Córdoba, Campus de Rabanales, Córdoba, Spain

Mediterranean Sea Basin climate, with recurrent droughts and high precipitation variability, is likely to be worsened for oak forest conservation given the decrease in fresh water supply predicted under conditions of climate change. It is expected that the region become warmer and drier, both changes exacerbating the scarcity of water. Understanding the hydrological, atmospheric and physiological processes driving the ecosystem functioning in relation to the use of water will help to improve the management and conservation of the dehesa ecosystem. Key indicators of ecosystem health in this water-limited environment are the transpiration rate and the lack of water stress. The integration of remotely sensed data, supplied by satellite and airborne sensors, into energy and water balance models may provide a tool to timely and accurately monitor these indicators over large areas.

An extended approach to assess evapotranspiration (ET) with remotely sensed inputs computes a surface energy balance using the shortwave bands to estimate vegetation canopy properties, such as ground fraction cover and leaf area index, used for net radiation and soil heat flux calculations, and radiometric surface temperature (T_R) for estimating surface sensible heat flux, obtaining the evapotranspiration as a residual of the balance. The ratio of actual to potential evaporation informs about the system water stress. Some energy balance models distinguish soil/substrate and vegetation contributions to the radiative temperature and energy exchanges and they have proven to be reliable in semiarid sparse canopy cover landscapes. In particular, the two-source energy balance (TSEB) model of Norman et al. (1995) and Kustas and Norman (1999) has shown to be robust for a wide range of partially-vegetated landscapes. The TSEB formulation is evaluated and applied here during the years 2012 and 2013 using medium (100 m) and low resolution (1 km) satellite data over a dehesa

located in Cardeña (Cordoba). The application in this environment is challenging due to the complexity of the canopy structure, with sparse tree cover and large areas of grass and bare soil substrate, strongly influencing the radiative and turbulent energy flux exchanges, and their interactions, and also due to the particular functional and physiological attributes adopted by the vegetation to survive in such water-limited environment.

The results are validated using field measurements obtained by an energy flux tower, installed in the study site, equipped with an eddy covariance system and instrumentation to separately measure all the components of the energy balance. This analysis will serve a double purpose, on one hand, to provide insights into the ecosystem response and sensitivity to water scarcity, and second to set the basis for an operative tool to monitor the ecosystem health through the estimation of the system evapotranspiration and water status.

INVESTIGATING THE ROLE OF PHYSICAL ENVIRONMENT AND LAND MANAGEMENT ON THE TEMPORAL DYNAMICS OF TREES IN MEDITERRANEAN WOODED PASTURELANDS

Herguido Sevillano, E.; Lavado Contador, J. F.; Jariago García, A.; Schnabel, S.

Grupo de Investigación GeoAmbiental, Departamento de Artes y Ciencias del Territorio, Facultad de Filosofía y Letras, Universidad de Extremadura.

Director: Lavado Contador, J. F.

The conservation and sustainability of trees in Iberian open woodlands and pasturelands (dehesas and montados) are recently been highlighted as elements of concern, both for scientists as for the managers of these ecosystems. Considering the important role that trees plays in those systems, aspects such as thinning, aging or the lack of tree generational replacement are being investigated as some of their main environmental concerns.

The temporal dynamics of trees in 4 wooded rangelands (dehesa farms) in Extremadura (SW Spain) are analyzed as related to the influence of several physical-environmental and farm management characteristics. Orthophotos taken in 1956 and 2009 have been classified by object-based and isocluster classification methods in order to gain precise information about tree location and its temporal dynamic during this lapse time. In order to gain knowledge about the relationship between temporal tree dynamic with physical and management related aspects, spatially distributed variables were assessed for the study farms. Among the physical-environmental information, several topographical variables and elements were considered. Land use and land management information consisted in variables like land use intensity, influence of the farm facilities (ponds, roads, buildings, fences and other infrastructures), agricultural activities and livestock management.

The temporal dynamic was investigated by identifying areas of tree regeneration, disappearance and permanence over time. The dynamic of trees will be analyzed by means multivariate and data mining statistical methods.

ENVIRONMENTAL INFLUENCE ON THE EVOLUTION AND KINETIC PROPERTIES OF RUBISCO IN QUERCUS

Carmen Hermida¹, Arantxa Molins¹, Eustaquio Gil², Maxim Kapralov³ and Jeroni Galmés¹

*1Grup de Recerca en Biologia de les Plantes en Condicions Mediterrànies.
Dept. Biologia. Universitat de les Illes Balears, Ctra. Valldemossa Km 7.5, 07122 Palma,
Spain*

*2 Unidad de Recursos Forestales. C.I.T.A. de Aragón. Avda. Montañana 930 50059
Zaragoza, Spain*

*3Research School of Biology. The Australian National University, Canberra ACT 0200
Australia*

Rubisco catalyses the fixation of atmospheric CO₂ in the form of organic matter. It is hypothesized that Rubisco will have evolved differentially according to the environmental conditions and leaf traits governing internal gas diffusion patterns. Specifically, it is expected that species with sclerophyllous leaves and/or from most xeric and hottest environments will have enhanced their affinity for CO₂ at the expenses of lowering the speediness for the carboxylation reaction (k_{cat}).

We investigated the variability of the chloroplast gene *rbcL* encoding the large subunit of Rubisco in about 200 species of *Quercus*. Our sampling contains species inhabiting a wide range of environments, with contrasting temperature and water availability regimes, as well as species with different leaf ecology (evergreen vs deciduous).

Sequence analysis revealed the presence of several polymorphic positions in the amino acid sequence of the enzyme, demonstrating that mutations on Rubisco encoding genes are feasible. The qualitative analysis of the mutations suggests that differences in the Rubisco kinetic properties among closely related species will be significant. Clustering the species according to the *rbcL* sequences resulted in a number of different haplotypes. Few representatives of each haplotype have been selected and in vitro kinetic characterization of their Rubiscos is under way. The final objective is to relate specific amino acid substitutions with the in vitro kinetic traits of the enzyme, and the photosynthetic properties of the different *Quercus* species. Such information will be valuable for targeted mutagenesis projects aiming the enhancement of the photosynthetic capacity and yield of crops.

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VULNERABILITIES AND ADAPTATION TO CLIMATIC CHANGE IN SPANISH OAK FORESTS

Herrero Méndez, Asier

Department of Life Sciences, University of Alcalá. Campus Universitario, 28871 Alcalá de Henares (Madrid), Spain.

The main objective of the poster is to summarize the vulnerabilities and potential impacts of climatic change in Spanish oak forests, as well as to describe adaptation techniques to diminish the negative effects of climate impacts.

Climatic models predict reductions of -4 to -27% in annual total precipitation for Southern Europe at the end of the 21st century, with the largest decreases expected for the summer season. Also, a rise in annual mean temperatures of 3-4°C until the end of 21st century is predicted for the European Mediterranean area, but the increase will be higher in summer (4-5 °C) than in winter (2-3 °C). This will lead to longer and more severe summer droughts. In fact, an increase in the frequency and severity of extreme climatic events, such extreme droughts and heat waves, is also predicted by the main climatic models.

The main impacts of described climatic changes could be a reduction in growth (and therefore in the capacity of carbon sequestration), weakening of plant vigor, and tree mortality. The predicted climatic changes could also affect the regeneration of oak species, decreasing seed production and seedling establishment. Among other impacts, an increase of frequency of fires, damages due to high speed winds, and pest or pathogen effects could be found. In fact, some of these impacts have been already recorded associated to an increase of aridity and severity of extreme climatic events. Some of these changes could also alter the structure and composition of oak forest communities.

The adaptation management strategies destined to diminish the vulnerabilities and potential impacts of climatic change can be grouped in five classes. First, adaptation techniques to improve the vigor of oak forests include prescribed thinning and tree trimming. Second, adaptation management to improve oak species regeneration boosts natural facilitation processes and also protection against mammal herbivores. Adaptation techniques with the aim of reduce the vulnerability to fire include fuel reduction, promotion of mixed oak forests, and maintaining of an adequate crown structure that difficult fire expansion. Adaptation techniques promoting high heterogeneity of oak forest, with diverse species and uneven age and size composition, could increase the resistance and resilience of these formations. Finally, genetic adaptation techniques consider the use of local varieties and assessment of genetic variation and differentiation.

The use of diverse adaptive management techniques is necessary to assure an optimal adaptation capacity of oak forests under the current climatic change scenario.

POST-FIRE REGENERATION OF THE HOLM OAK (*QUERCUS ILEX* SUBSP. *BALLOTA*) UNDER DIFFERENT BURNT-WOOD MANAGEMENT REGIMES

Alexandro Leverkus¹, Jorge Castro¹, José María Rey Benayas²

1. Departamento de Ecología, Facultad de Ciencias, Universidad de Granada. E-18071 Granada. Email: leverkus@ugr.es; jorge@ugr.es, FAX: +34 958 243238.

² Departamento de Ecología. Edificio de Ciencias, Universidad de Alcalá. 28871 Alcalá de Henares, Madrid, Spain. Email: josem.rey@uah.es, Tel:+34 918854987, Fax: +34 918854929

Jay-mediated acorn dispersal can be an important mechanism for oak recolonisation after forest fires. Given the preference of jays for forest habitats, the removal of burnt but standing tree trunks may reduce this animal-plant interaction. To test this, an 18-ha plot was established in a burnt pine reforestation after the “Lanjarón” fire (province of Granada, Spain), with three replicates of three burnt-wood management regimes: Salvage Logging (i.e. the felling and removal of all burnt trees), Partial Cut (felling 90% of the trees but without biomass extraction), and Control (with no actions taken). Within the plot some pine clusters – totalling 1.5 ha – survived the fire, and 45 m from the plot several unburnt mature holm oaks acted as acorn sources. We exhaustively monitored the whole plot for oak seedling emergence from 2006 through 2012. We found 801 seedling of acorns dispersed either before the fire or before treatment implementation, with greater densities close to the seed source. 447 post-treatment seedlings emerged: 63% under live pine clusters and 37% in the rest of the plot. During the first years, emergence was greatest in the Control treatment, but live pine clusters acquired importance with time due to the natural fall of dead trees in Control. Live pines enhanced seedling survival yet suppressed their growth, leading to a situation similar to that previous to the fire. Fire allowed for the growth of pre-existing seedlings and, in combination with the mutualistic jay-oak interaction, created a window of recruitment that allowed the natural colonisation of holm oaks, especially where burnt tree trunks were left standing.

VARIATION OF ECTO- AND ARBUSCULAR MYCORRHIZAS IN *QUERCUS* SPP. UNDER DIFFERENT SOIL CONDITIONS

C. M. Navarro-Fernández¹, E. G. de la Riva², J. R. Vera¹, M. Olmo², I. M. Pérez-Ramos¹, R. Villar² & T. Marañón¹

¹ Instituto de Recursos Naturales y Agrobiología de Sevilla (IRNAS, CSIC), 41012, Seville, Spain

² Área de Ecología, Facultad de Ciencias, Universidad de Córdoba, 14071, Cordoba, Spain

Mycorrhizas are a mutualistic symbiosis between root plants and soil fungi. They represent key ecological factors governing the cycles of major plant nutrients and have a significant influence on plant health and productivity. *Quercus* species have the ability to form symbiosis with ecto- and arbuscular mycorrhizal fungi but the latter have been less explored. This study pretends to examine the variation of both types of mycorrhizal colonization in natural conditions. The study area is located in Sierra Morena mountain range in southern Spain (Cordoba). We selected three sites of mediterranean oak forest where *Quercus coccifera*, *Quercus ilex* and *Quercus faginea* were present. Eight 20m-long transects in every site (a total of 24 transects) were randomly set up to measure the abundance of *Quercus* spp. and soil characterization. For each transect, one root sample was collected per each *Quercus* sp. present. It was quantified ecto- and arbuscular colonization and correlated with soil parameters. Differences in soil characteristics were found among sites. Notably, it was found high level of Cu and As at one site. There was not variation in ectomycorrhization between species and sites. However, *Q. coccifera* and *Q. faginea* showed high significant arbuscular colonization in the site with high level of Cu and As. In *Q. coccifera*, a strong correlation between arbuscular colonization and these soil parameters was found. Results could suggest a role of arbuscular mycorrhizal fungi in these plants affected by the stress of soils rich in trace elements.

THE SOIL FACTOR IN THE DISTRIBUTION OF MEDITERRANEAN OAK FORESTS IN MONTSEC (NORTHEASTERN SPAIN)

J. R. Olarieta, A. Bargaés*, R. Rodríguez-Ochoa

Dept. Medi Ambient i Ciències del Sòl. Universitat de Lleida

Rovira Roure, 177. Lleida 25198. Spain

* Present address: Department of Forest Ecology and Management.

Swedish University of Agricultural Sciences. Umeå. Sweden

The distribution of *Quercus* species in the Mediterranean is usually explained on the sole basis of climatic variables, but stands dominated by either *Quercus ilex* or *Q. faginea/Q.cerrioides* frequently appear side by side under homogenous climatic conditions. The objective of this paper is to test two hypotheses: the development of forest stands dominated by either *Q. ilex* or *Q. faginea/Q. cerrioides* is i) significantly influenced by soil conditions, and ii) particularly by soil available water holding capacity (AWHC). We studied 46 plots dominated by either *Q. ilex* or *Q. faginea/Q. cerrioides* in the Montsec mountains at altitudes between 700 m and 900 m. In each plot, we counted the number of trees of every species, measured their height and diameter and estimated the basal area of each species. A soil pit was dug in each plot, described, and classified. Samples from all horizons were taken and analysed for the main physical and chemical variables. Soils are mostly Lithic Haploxerolls, and their rootable depth varies between 4 cm and 90 cm, and the proportion of rock fragments and the pH in the mineral surface horizon range from 3% to 95% and from 6.8 to 8.2, respectively. Regression tree analysis suggests that *Q. ilex* dominates on soils with an AWHC of less than 22 mm and in soils with values higher than this if the rock fragment content is higher than 26%. Logistic regression analysis also shows that stands dominated by *Q. ilex* require shallower soils with a higher amount of rock fragments, but the model with AWHC on its own provides less explanatory power. Logistic regression of the presence/absence of *Q. faginea/Q. cerrioides* suggests that in this region these semi-deciduous species require soils with lower contents of rock fragments and sand and higher pH. Soil water availability is an important factor in the present distribution of these Mediterranean oaks, and, therefore, in their future distribution under climate change, but other soil variables, such as aeration porosity, also play a significant role.

INFLUENCE OF CLIMATIC CONDITIONS ON MAST SEEDING IN TWO MEDITERRANEAN *QUERCUS* SPECIES

*Carmen M. Padilla-Díaz**, Ignacio M. Pérez-Ramos, Teodoro Marañón

Instituto de Recursos Naturales y Agrobiología de Sevilla (IRNAS, CSIC), Avda. Reina Mercedes, 10, 41012, Sevilla.

*corresponding author: cmpadilla@irnas.csic.es

Mast-seeding or masting is the annually variable production of seeds which commonly occurs in many perennial plant species. Although numerous studies have demonstrated the influence of climatic conditions on mast seeding (resource matching hypothesis), there is not a consensus on the identity and the level of species-specificity of the main abiotic factors driving this process. Acorn production was monitored during 10 consecutive years (from 2002 to 2012) in two Mediterranean oaks –*Quercus canariensis* and *Quercus suber*– coexisting in “Los Alcornocales” Natural Park (southern Spain), with contrasting differences in leaf habit and seed-drop timing. The influence of climatic variables was evaluated by calibrating maximum likelihood estimators of acorn production. Acorn crop size (both initial and mature seed production) was strongly driven by two main climatic factors in both studied oak species: drought and temperature. On the one hand, spring water deficit caused a significant reduction of acorn production in both oak species (exponential for *Quercus canariensis* and linear for *Quercus suber*). Moreover, we also found evidences of a negative effect of summer drought in the deciduous species. On the other hand, in the case of *Q. suber*, we detected a positive linear effect of the increase of temperature in February, and an exponential negative effect of the increase of temperature in May on acorn production. These results suggest the existence of a strong asynchrony between species in the process of mast seeding and a certain species-specificity in the main abiotic predictors affecting it, likely due to their contrasting differences in seed-drop phenology and foliar habit. Our results suggest that among-year differences in climatic conditions act as important cues for masting behavior in the studied species and, thereby, the projected changes in environmental conditions due to climate change could have strong negative consequences for acorn crop size.

OAK REGENERATION UNDER HIGH LEVELS OF WILD UNGULATES: THE USE OF CHEMICALLY VS. PHYSICALLY-DEFENDED SHRUBS

*Ramón Perea * and Luis Gil*

Universidad Politécnica de Madrid. Ciudad Universitaria s/n. 28040. Madrid (Spain)

*Correspondence author: ramon.perea@upm.es

Wild ungulate populations have increased dramatically in the last decades, limiting oak regeneration. However, how different types of shrubs (chemically vs. physically-defended) act as seedlings facilitators under different types of ungulate damage (browsing or rooting) remains largely unknown. Here, we integrate both biotic and abiotic stress to assess seedling survival in three microsites [open, under chemically-defended (aromatic) shrubs and under physically-defended (spiny) shrubs]. We studied seedling survival of a Mediterranean oak (*Quercus pyrenaica*) for two contrasting levels of abiotic stress (dry vs. wet growing seasons) in environments where deer (*Cervidae*) and wild boar (*Sus scrofa*) are abundant. After the first summer 24.7% of seedlings were still alive in a wet year whereas only 9.0% seedlings survived in a dry year. Seedling survival was higher under shrub cover, independently of the annual weather conditions and the shrub type. Shrubs, on average, reduced seedling mortality by ungulates approximately 75% in a wet year and only 50% in a dry year due to the greater and earlier impact of browsers (deer) in drier years, when preferred food (green grass) is scarce. Physically-defended shrubs prevent wild boar damage better than other microsites, reducing 35-59% boar damage in comparison to other types of shrubs and 70-77% in comparison to open microsites and, therefore, serve as good nurse shrubs in environments where wild boar are abundant. Physically-defended shrubs also worked well as defense against browsers at low abiotic stress (wet years) but diminished its efficiency in comparison to chemically-defended shrubs at high abiotic stress due to the greater browsing activity of deer on spiny shrubs in dry years. Thus, we recommend the use of chemically-defended shrubs as seedling protectors against browsers. Restoration efforts (e.g. oak reforestation) under high level of ungulates should take into account the type of ungulate damage (browsing vs. rooting) and the predominant type of shrub mechanism against herbivores (chemical vs. physical) to use shrub cover more efficiently in future oak restoration practices.

EARLY DETECTION OF DIEBACK PROCESSES OF *QUERCUS ILEX* FROM SPECTRAL DATA AT REGIONAL AND LOCAL SCALES

Rocío Hernández-Clemente & José Luis Quero

Departamento de Ingeniería Forestal. Escuela Técnica Superior de Ingeniería Agronómica y de Montes. Edificio Leonardo Da Vinci. 1ª Planta. Campus de Rabanales. Crta. N-IV km. 396, C.P. 14071, Córdoba

In recent years, a widespread oak mortality in Andalusia has been described, being mainly attributed to complex associations involving abiotic and biotic factors, such as intense rainfall events, severe droughts, affection *Phytophthora cinnamomi* and overexploitation of dehesas, i.e., Mediterranean savannah-like ecosystems. Trees exposed to these long-term stresses, combined with high levels of radiation and temperatures, undergo a decline of photosynthesis and efficiency of photosystem II, which is not easily reversible even in conservative species such as Mediterranean evergreen oaks (mainly *Quercus ilex* and *Quercus suber*). Several authors have shown that dieback must be related to the physiological status and biochemical and transpirational alterations, resulting an early stomatal closure and degradation in key pigments such as chlorophyll (Ca+ b), carotenoids (Cx+c) and anthocyanins. This work suggest an innovative methodology to spatially analyze the early detection of dieback in dehesas, based on the physiological variables and key pigment content, and using high-spatial-resolution hiperspectral and thermal sensors and spatial models to monotorize the actual physiological status of dehesas. Early detection of the dieback will be based on mapping physiological variables of and contents of the key pigments that regulate the efficiency of photosynthesis. The methodology will combine local scale to have accurate information of the physiological dynamic and regional scale to map the physiological status in order to early act on the ecosystem before the dieback will be irreversible. The physiological information at regional scale will improve the agro-forestry management, implementing strategies to control the loss of trees, woodland efficiency and restoration planning.

**MEDITERRANEAN WOOD PASTURES FOR BIODIVERSITY –
MAKING THE LYNX**

*Will Simonson*¹, *Harriet Allen*², *Paul Hotham*³, *Erin Parham*³, *Eduardo Santos*⁴

¹Department of Plant Sciences, University of Cambridge, UK

²Department of Geography, University of Cambridge, UK

³Fauna and Flora International, Cambridge, UK

⁴League for the Protection of Nature, Portugal

¹Forest Ecology and Conservation Group, Department of Plant Sciences,
University of Cambridge, Downing Street, Cambridge, CB2 3EA
wds10@cam.ac.uk

The poster describes a new collaborative project launched in August 2013 with funding support from the Cambridge Conservation Initiative (CCI). *Making the Lynx* aims to develop novel tools for biodiversity conservation in *montado* wood pasture landscapes of southern Portugal, including decision support for the targeting of agri-environment schemes and forest certification. These landscapes have a very rich associated biodiversity value, and yet this is being threatened by current trends in land use and biophysical properties. Quantified evidence for the deterioration is lacking, however, and not only undermines the design and targeting of biodiversity conservation interventions, but also makes it less easy to engender the involvement of landowners and decision-makers. The project aims to address this, supporting and drawing impetus from ongoing efforts in Iberia to save the Iberian Lynx (*Lynx pardinus*). This critically endangered feline is to be reintroduced into these landscapes and represents a flagship species whose conservation would ensure the survival of a host of other wildlife. The project has the potential to benefit up to 23 IUCN Red List, 110 Birds Directive and 40 Habitats Directive species of conservation importance.

The first objective of the project is to model biodiversity losses and gains associated with landscape change. Taking three study areas in southern Portugal we will: (1) use remote sensing to chart land-cover change over a 30-year period; (2) match species occurrence (birds, butterflies/moths and vascular plants) to different components of a wood pasture landscape; and (3) translate the observed land-cover change to estimated changes in biodiversity using Morphological Spatial Pattern Analysis (MSPA) and other landscape modelling tools to take into account habitat geometry and connectivity. Scenarios of future biodiversity change will also be developed.

The results of this work will feed into the development of a spatially-explicit decision-support tool for the maintenance and enhancement of *montado* biodiversity. The tool will be tested and piloted in the Moura/Barrancos study area and, building on this, different channels of communication will be used to develop consensus and action on biodiversity conservation priorities across the wider region.

BOTTLENECKS FOR OAK RECRUITMENT IN A MEDITERRANEAN SHRUBLAND

Pedro Villar-Salvador^{1*}, *Lorenzo Pérez-Camacho*¹, *Jesús A. Cuevas*²

¹Departamento de Ciencias de la Vida, Universidad de Alcalá, Alcalá de Henares, 28871 Alcalá de Henares, Madrid.

²Servicio de Planificación de Espacios Protegidos, Consejería de Medio Ambiente y Ordenación del Territorio, CAM, Madrid.

*. Corresponding author.

Shrublands dominated by pioneer shrubs are widespread in the Mediterranean Region. These shrublands frequently are colonized by oaks, a process that occurs very slowly. We have analyzed the main constraints of oak recruitment in retama (*Retama sphaerocarpa*) shrublands, which are widespread in many areas inside the Iberia Peninsula and North of Africa. In these shrublands, oak saplings under shrubs are much more frequent than in shrubland gaps. Oak recruitment in retama shrublands is hindered by the lack of oak stands close to shrublands, pointing out to dispersal and seed availability limitations at the landscape level. In retama shrublands close to oak stands, main acorn dispersers are the European Jay (*Garrulus glandarius*) and the wood mouse (*Apodemus sylvaticus*). Both dispersers preferred *Quercus ilex* than for *Q. faginea* to disperse acorns, which might contribute to the greater recruitment of *Q. ilex* than *Q. faginea* in retama shrublands. Jays disperse acorns to retama shrublands from trees mainly placed in the edge of the forest and, especially, from isolated oak trees close to the forest but seldom from trees placed inside the forest. Therefore, isolated oak trees close to oak stands play an important role in oak colonization into shrublands. Within the shrubland, jays and mice mainly cache acorns under the retama shrubs rather than in gaps; therefore seed rain is concentrated under shrubs. However, the proportion of seeds cached by mice under shrubs is reduced the farther the shrubs are from the oak forest. Most of the acorns cached by jays and rodents are predated before they can germinate. A great part (27-50%) of the acorns is predated 7-14 days after dispersal. Short term predation is mainly achieved by rodents. In late spring, when seedlings emerge, almost all acorns cached by mice were predated, while around 10% of the acorns cached by jays remained intact. Post-dispersal predation increased with proximity to oak stands and acorn predation and recovery by jays was greater under shrubs than in gaps. Emergence of *Q. faginea* seedlings was greater than *Q.*

ilex seedlings. Overall, *Q. ilex* seedling emergence was higher under the shrubs than in the gaps. In contrast, emergence of *Q. faginea* seedlings was independent of the microsite. Only 5% of acorns dispersed by jays germinated in spring. Seedling survival after the first summer ranged from 0 to 30% and it was significantly lower under shrubs than in gaps, where frequently no seedling survived. Most seedling mortality can be attributed to drought and to a lesser extent to predation, which did not differ between gaps and under the shrubs. We conclude that, by order of importance, the distance between the shrublands and oak stands, seedling survival to the first summer, the presence and abundance of jays, post-dispersal acorn predation and the presence of isolated mature oaks in the shrublands are main bottlenecks for the recruitment of oaks in retama shrublands.

INFLUENCE OF SEED SIZE ON GROWTH AND SURVIVAL OF *QUERCUS ILEX* L. SEEDLINGS

*P. Ríos Castaño*¹, *JR. Leal Murillo*², *R. Villar*³, *P. Fernández Rebollo*²

¹ Agronomy Department, University of Córdoba, Campus Universitario de Rabanales, Ctra. Madrid-Cádiz km 396, 14014-Córdoba, Spain; ² Forestry Department, University of Córdoba, Campus Universitario de Rabanales, Ctra. Madrid-Cádiz km 396, 14014-Córdoba, Spain; ³ Botany, Ecology and Plant Physiology Department, University of Córdoba, Campus Universitario de Rabanales, Ctra. Madrid-Cádiz km 396, 14014-Córdoba, Spain.

One of the most important factors affecting the establishment of *Quercus ilex* seedlings is the amount of reserves available in the seed. Several studies have found that mother plants have a strong influence on seed size. It is expected that plants from larger-seed should have advantages at the first steps of the recruitment and on this way higher probability of survival. To demonstrate it, seeds of four mother plants from the south of Spain with a wide range of seed size were collected and cultivated under two different water regimes. Once all seeds were germinated, they were transferred to a plastic pots (50 cm high, 10.5 cm diameter) located in a greenhouse. Seedlings of every progenitor were divided into two groups; one was cultivated with a normal irrigation and the second one with limited water availability. During four months, plants were irrigated and weekly the height and the number of leaves of every plant was measured. After these four months, all plants were undergo to a totally drought, simulating a summer drought. We scored the date of death of every plant and after that we harvested the whole plant. Leaves, stems and roots (differentiating in thick, intermediate and fine roots) were weighted. ANOVA analyses were run in order to know the maternal influence and the water treatment on every variable.

Morphological variables of seed and germination capacity were strongly determinate by progenitors, being the smallest seeds which presented the faster germination. On the other hand, bigger acorns emerged faster. Plant biomass was also positively related with seed size. There were differences in the root mass and root architecture due to the irrigation treatment; seedlings cultivated with normal irrigation presented a higher fine roots biomass than those cultivated with water restriction, concentrating them into the first layers of the substrate. On the other hand, plants with less water availability developed higher fine roots biomass on the deeper layers. Plants from bigger seeds and therefore with higher biomass died before than little ones. We concluded that progenitors influence seed size, and this influence has important traits related to the regeneration phase of *Quercus* as the germination, emergence, growth and survival. Therefore, we recommend that in restoration programs, the widest genotypic variability should be preserved, in order to cope with the predicted climate change.

Keywords: seed mass, parents, drought, seedling morphology