

INFORMED Conference in Zagreb, May 9th 2018: From science to practice, what can be learned from interdisciplinary research in relation to future ecosystem services of Mediterranean forests?

8:30-9:00	Registration
9:00-9:10	Welcome address by Dijana Vuletić, Tamara Jakovljević on behalf of the Croatian Forest Research Institute and Lukrecija Butorac on behalf of the Institute for Adriatic Crops and Karst Reclamation
9:10-10:30	Setting the scene - Lidija Zadnik-Stirn, Univ. Ljubljana (Slovenia): Present and future links between IUFRO and interdisciplinary research in the light of adaptive management, strategies and governance of (Mediterranean) forests - Valentina Garavaglia, FAO (Italy): State of the Mediterranean Forests by FAO - François Lefèvre, INRA (France): A social-ecological approach of resilience in Mediterranean forests, concepts and methods
10:30-11:00	Coffee break
11:00-12:45	Lessons from interdisciplinary research in five case studies - Aitor Ameztegui et al., CTFC (Spain): Assessing the provision of ecosystem services under different socio-economic and climate change scenarios: the case of Sub-mediterranean pine forests in central Catalonia - Vasja Leban et al., Univ. Ljubljana & SFI (Slovenia): Developing future land use scenarios - Experiences and results from Slovenian case study - Laetitia Tuffery et al., AgroParisTech & INRA (France): Combining ecological modeling and economic analysis in a prospective analysis of ecosystem services in the Mt Ventoux MAB Reserve - Mariem Khalfaoui et al., INRAT & INRGREF (Tunisia): Decision making support through spatially distributed valuation: Tunisian Cork Oak Forest's - Ricardo Alia et al., INIA (Spain): Ecosystem services in the Castilian plane under different climatic scenarios
12:45-14:00	Lunch
14:00-15:30	Lessons from focused research - Giulia Corradini et al., Univ. Padova (Italy): is public spending through the Rural Development Policies supporting an increased resilience of Southern European forests? - Mitja Ferlan et al., SFI (Slovenia): Carbon pools and sequestration in Mediterranean forests: the case of Slovenia's Mediterranean - Aitor Ameztegui et al., CTFC (Spain): Scenarios and models to evaluate future ecosystem services in Mediterranean forests - Lluís Coll et al., CTFC & Univ. Lleida (Spain): Forest management options to adaptation in the Mediterranean basin: efficacy and tradeoffs
15:30-16:00	Coffee break
16:00-17:45	Panel discussion 1) Climate change and multiple risks: how can we increase resilience and/or reduce vulnerability of Mediterranean forests? 2) Biodiversity, bioeconomy, bioenergy: where is the most probable future of the Mediterranean forests seen from inside? 3) Mediterranean forests and cultural ecosystem services (tourism, recreation, env. education, sport, forest bathing): towards a “tertiarisation” of Mediterranean forests? with: Teresa Baiges Zapater (CPF), Valentina Garavaglia (FAO), Valentino Govigli (EFIMED), Stjepan Posavec (IUFRO) and INFORMED scientists: François Lefèvre (INRA), Ricardo Alia (INIA), Lluís Coll (Univ. Lleida), Davide Pettenella (Univ. Padova), Hamed Daly-Hassen (INRAT)
17:45-18:00	Concluding take home messages by the four stakeholders and Croatian hosts

Present and future links between IUFRO and interdisciplinary research in the light of adaptive management, strategies and governance of (Mediterranean) forests

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Rapid social, economic, climatic, environmental, technological and other changes demand an innovative paradigm for considering ecosystem services, management and governance. There is a strong need to develop an optimal interdisciplinary decision making process which enhances forest resilience for developing forest functions and supplying ecosystem services on which human well-being depends. Forest management is shifting from timber production towards a far-reaching, multi-functional management approach emphasizing social and ecological objectives. Consequently, sustainable and multi-functional developments applied to forest systems reveal different forest management scenarios. We are faced with a decision process in which scenarios must be determined and evaluated according to the present state of the forest ecosystems, and the goals and preferences of the end-users. Incorporating local actors (e.g., residents, visitors, representatives of various groups who benefit or lose from the preferred scenarios) in the decision process is one of the most important goals when measuring social and ecological consequences.

The majority of work to generate an up-to-date ecosystem/forest decision process will be conducted by researchers from the study region (in this case the Mediterranean), and by the non-profit, non-governmental scientific organizations, such as the global network for forest science, IUFRO. This presentation addresses IUFRO's structure, present research themes with the associated emphasis areas and institutional goals, and the future vision, strategies and core values under the interdisciplinary concepts, while IUFRO does not see forests in isolation but as systems interconnected to other environmental and human systems. From this point of view, IUFRO's principle is to develop strong linkages through interdisciplinary research for adaptive and sustainable management, and innovative strategies to enhance the governance of forests globally, including the Mediterranean region.

These linkages are supported through research topics related to the interconnections between ecosystems and services for people (rural development), climate and land-use change (affecting water and soil resources), environmentally sound products, biodiversity, and human health and well-being. In the future, special attention must be paid (according also to EFIMED) to Mediterranean forests which are specific what makes them a unique natural heritage. So, scientific groups, from which more research is required, as well as the general public must ensure sustainability and multiple-use, avoid emerging risks (including fire), and develop innovative silviculture and management for ecosystem services, resilience and bioeconomy in Mediterranean forests.

State of Mediterranean Forests 2013 and 2018

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² *Plan Bleu, France*

To compensate for the lack of data and provide sound basis for the management of Mediterranean forests in the future, members of the Committee on Mediterranean Forestry Questions–Silva Mediterranea requested FAO, at a meeting held in April 2010 in Turkey, to prepare a report on the state of Mediterranean forests, in collaboration with other institutions. The first edition of the State of Mediterranean Forests (SoMF) was published in 2013, coordinated by Plan Bleu and FAO. The SoMF 2013 has successfully documented the main questions on Mediterranean forestry, the need to have a monitoring process at regional level to inform on the status of Mediterranean forest resources, and to promote the role of Mediterranean forests at international level. Its key findings have been the basis for the elaboration of the Strategic Framework on Mediterranean Forests that was endorsed by the high-level segment of the third Mediterranean Forest Week. Through this Strategic Framework, the SoMF 2013 has contributed to identify priorities for the Mediterranean forest sector and has facilitated the monitoring of progress in these priorities through projects, initiatives, and policies in key topics regarding Mediterranean forests.

The Committee Silva Mediterranea has recognized the importance of the SoMF 2013 and confirmed the wish to have a new edition. While the 2013 edition relied on systematic data coverage for all countries of the Mediterranean region so as to set a regional overview, the second edition will deal with subjects more focused, both geographically and thematically, but still having a regional interest. The SoMF 2018 aims at demonstrating how important Mediterranean forests are to implement solutions to tackle global issues such as global change and demographic increase. The State of Mediterranean Forests 2018 will be a tool to promote and highlight the role of Mediterranean forests in the global agenda on forests and that will contribute to support the regional dynamic.

A social-ecological approach to resilience in Mediterranean forests: concepts and methods

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Mediterranean forests and human communities have been tightly linked for long historical time: in this region of the world, human activities have shaped forests structure and impacted forests dynamics, while, thanks to their biodiversity, forests have long provided multiple contributions to people. Furthermore, in the Mediterranean climate, anthropogenic impacts have interacted with natural sources of disturbance such as fire, drought and pests, which jointly maintain the Mediterranean forests in a permanent context of changes. The future of the Mediterranean region consists of very likely trends (such as increased human pressure, increased temperature, increased water deficit) and multiple uncertainties on the adaptive potential and response of complex forest systems to management in a context of climate and social changes. Thanks to this adaptive potential and response, Mediterranean forests are rich of valuable resources, both in terms of biodiversity and of knowhow which could also benefit to forest adaptation beyond the area, and they are facing new risks and uncertainties. To support decisions in this challenging context, the research project INFORMED “*INtegrated research on FOrEst Resilience and Management in the mEDiterranean*” developed a social-ecological and resilience thinking approach. The research involved life and environmental sciences, forestry sciences, social sciences, and it has been based on interactions with stakeholders. Grounded on a series of cases studies in the ten partner countries, combining data acquisition and modeling, the research had four main objectives: (i) to assess the potential response of Mediterranean forests to disturbance and management, (ii) to assess adaptive forest management strategies, policy and governance options for their expected impact on resilience, (iii) to elaborate exploratory global change scenarios specifically dedicated to the Mediterranean forests, (iv) to assess future ecosystem services based on ecosystem functions and their economic evaluation under various global change scenarios at multiple time horizons. Trans-disciplinary integration of applied research activities was more particularly developed in five case studies.

**Provision of ecosystem services under different socio-economic and climate change scenarios:
The case of Sub-Mediterranean pine forests in central Catalonia**

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The rapid changes that global change is imposing on natural systems have set off the scientific and societal interest in forecasting the impacts of socio-economic development for both ecosystems and human-wellbeing. The Intergovernmental Platform on Biodiversity and Ecosystem Services has identified the use of ecological modelling in combination with scenario forecasting as fundamental pillars to advance in the understanding of such impacts. Here, we aim at evaluating the influence of forest management on the future provision of ecosystem services by Mediterranean forests under a global change context. The study was conducted in the Solsones county, in the transition zone between the plains of the Ebro valley and the Pyrenean mountains (northeastern Spain). We evaluate the dynamics of the three main forest types in the area: black pine (*Pinus nigra*), Scots pine (*Pinus sylvestris*) and mixed forests. We build a set of 16 simulation scenarios that incorporate drivers of landscape change that operate at multiple scales: climate change (RCP 4.5 and RCP 8.5), supra-national policies (Business as usual, maximizing biomass carbon, maximizing wood removal, and adaptive management), and local context (forest management scenarios). We used the model of forest dynamics SORTIE-ND to simulate forest dynamics under each of these scenarios. SORTIE-ND produces annual estimates of stand structure, based on the position, size, growth and mortality of every tree in a plot. It is therefore particularly suitable for evaluating the provision of different goods and services that depend on forest characteristics at different spatio-temporal scales: timber production, carbon sequestration, mushroom production, regulation of water cycle and prevention of erosion. Moreover, we quantified fire risk and vulnerability to drought of each stand under each scenario. We present here the preliminary results of this project for the short, medium and long term (2035, 2050 and 2100), and discuss the next steps and research needs.

Developing future land use scenarios: experiences and results from Slovenian case study

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Ecosystem services (ES) supply and demand are constantly changing over time and space. Their future evolution in time can be forecasted by undertaking various approaches, e.g. deterministic/stochastic modelling, scenario planning. The latter, mainly due to its inductive nature, enables the analysis of future development by considering a certain level of uncertainty. This study aimed at exploring relevant drivers of global change that may affect land use distribution on a landscape level using quantitative and qualitative research methods. After exploring basic characteristics of the study area, we designed three scenario narratives: a) “business as usual” – where no significant changes occur, b) “development” – where policies prioritise the economic development and progress, c) “close-to-nature” – where policies emphasise the importance of sustainable and environmental-friendly development. Subsequently we conducted a workshop with relevant stakeholders (e.g. forest service, municipalities, non-governmental organizations) to adjust and validate the proposed narratives, assess the drivers and acquire additional information concerning the area under study. In collaboration with workshop participants and based on past land use changes, we calculated the expected future land use changes, and designed transition likelihood and priority matrices. The scenarios time frame was 20 years; from 2015 to 2035. For each scenario, we introduced various constraints and non discretionary factors (e.g. settlement vicinity, slope), based on their relative relevance and participants’ theoretical considerations. Demographic and socio-economic factors were the key driver for expanding urban areas, beside the attractive landscape, enjoyable climate and proximity to the coast. From our experiences, qualitative insights from the workshop offered an advantageous option for calibrating scenarios, thus improving their consistency and validity. Scenario maps generated using qualitative and quantitative research methods are potentially useful for further exploration of supply of and demand for ES on a landscape level and offer an attractive alternative to other approaches.

Combining ecological modeling and economic analysis in a prospective analysis of ecosystem services in the Mt Ventoux MAB Reserve

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Forest ecosystems provide many ecosystem services (soil protection, wood and NWFPs, recreation, etc.) and are a reservoir of biodiversity, thus playing an essential role in our societies. In the context of global change and increasing anthropogenic pressures on Mediterranean forest ecosystems, careful consideration should, therefore, be given from public policies to forests adaptation.

In this context of climate change and public policy evolutions, a multidisciplinary approach is needed. Climate change induces ecosystem changes (i.e. carbon sequestration or basal area variations), and public forest management policies impact land-use/land-covers. Thus, both drivers of change are closely interconnected and must be studied simultaneously to provide a robust spatially explicit valuation of ecosystem services.

The Mont Ventoux is a Man and Biosphere Reserve also characterized by the multi-functionality of its forest areas. We combine biophysical and economic assessment of three ecosystem services on this territory, along different global change scenarios developed in collaboration with local stakeholders.

We use a process-based ecological model (i.e. CASTANEA) to predict the impact of climate change on the functioning of nine forest types at five altitudinal levels and two orientations (south and north). In parallel, a stakeholder-based analysis is carried out to estimate the evolution of the supply of ecosystem services according to different land use / land covers changes (implementation in the InVEST tool). Carbon sequestration and timber production are estimate by both approaches (CASTAENA and InVEST), soil erosion control and habitat quality are given by InVEST.

Our first results have shown that in the case of RCP 8.5, the risk of mortality is very high. Regarding the evolution of carbon sequestration, results depend on the species and scenarios studied. Concerning the total economic value of our three ecosystem services, the economic results of policy scenarios vary according to climate change scenarios: at horizon 2050, RCP 4.5 is more favorable to the Biomass option and RCP8.5 is more favorable to the inaction (i.e. Baseline). Moreover, across climate scenarios, four major forest species impact our economic results *Pinus nigra*, *Pinus halepensis*, *Quercus ilex*, *Quercus pubescens*. An analysis regarding ecosystem services synergies seems necessary to capture all the impacts of climate and policy scenarios on the multi-functionality of the forest.

Decision Making support through spatially distributed valuation: Tunisian Cork Oak Forest's ecosystem services

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Forest ecosystems contribution to human's wellbeing are considered as an important anthropogenic pillar to face the global changes due to the relevance of the regulation services they provide

In Mediterranean countries, where the climate changes effects are exponentially increasing, the value of the forests' ecosystem services is even higher and their preservation is worthier. However, the biophysical and economic value of such services is usually non observable due to their non-marketable characteristics, leading to their underestimation by decision makers.

Thus, for a better guidance of decision making, it is more appropriate to take into consideration the location and climatic situation and define ecosystem services supply values with reference to their spatial distribution.

In the present study, Cork, wood, grazing and carbon storage and Soil erosion services were chosen to be studied at Tunisian cork oak forests level: Ain- Snoussi. The estimation of biophysical and economic value of ecosystem services' supply was carried, however only grazing, carbon storage and Soil erosion services were studied with emphasis on their spatial distribution. It is a cumulative multidisciplinary research based on biophysical models results implemented into the Geographic Information System (GIS) to analyze spatial data.

The estimation results support the importance of the regulation services' importance, presenting 49% of the Total economic value of the studied area while grazing represents 33%. The spatial distribution of the values constitutes a solid asset toward an effective management.

Keywords: Carbon storage, soil erosion, Economic Valuation, Mapping

Is public spending through the Rural Development Policies supporting an increased resilience of Southern European forests?

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The paper deals with the topic of governance tools to increase forest resilience in Mediterranean region, the last task of the Working Package 4 “Economic evaluation and governance of the Informed project” of the Informed project. The focus of the analysis has been the European Union (EU) member countries and, more specifically, the implementation of the Forest Measures defined by the Rural Development Programs (RDP) (period 2007-2013). These measures represent by far the most relevant source of financial support to forest owners and forest managers activated by the national and regional authorities. Under these measure traditional incentive schemes (subsidies to cover investment costs) but also some more innovative market-based tools such as the Payments for Environmental Services and information services have been implemented with the aim of supporting not only new plantations and new agroforestry systems, but also the resilience and the active management of already existing forests and the related provision of environmental services. This analysis shows that in the period 2007-2013 in the EU Mediterranean countries about 4.66 billion EUR were spent for the Forestry Measures. Comparing this figure with the one that each country spent for the RDP for all measures, Forestry Measures accounted for a very small part (from 1.9% in Slovenia to 5,6% in Spain). In relation to the planned expenditure, the real investments has been quite limited, reaching peaks of -80% and -90% for some measures in some countries (this could induce a transfer of financial resources from the forestry sector to other rural development sectors in the near future). A relatively high amount of the available financial resources has been invested in the creation of new forests (i.e. in mitigation more than adaptation measures aiming at increasing the resilience of already existing forests): more than one third of the budget in Spain and Italy, more than half in Portugal and 85% in Greece; on the contrary, Cyprus and France devoted a little share of the total forest budget to afforestation investments. In all countries, the measures for the protection of biodiversity and for the establishment of payments for ecosystem services (the Natura2000 payments in forests and Forest environment payments) were scarcely applied. No lessons have been learned from the previous planning period where these innovative policy tools have been planned but scarcely used. When looking at the actions that may be part of the adaptive strategies required to cope with extreme events impacting on existing forests, the expenditure varies widely across EU Mediterranean countries. The total public expenditure for the management and restoration of existing forests was on average 7.43 €/year per ha of forests, with a high variation, from 16.5 €/ha in Italy to the 0.6 €/ha/year in Greece. These data shows the gap between rhetoric and reality, a gap between the general statements on the rationale of public spending in the forestry sector (with the focus on the needs for enhancing the resilience of European forests and the provision of public services) and the real investments carried out in the sector.

Carbon pools and sequestration in Mediterranean forests: the case of Slovenia's Mediterranean

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Spontaneous afforestation is one of the most prominent land-use changes in Europe, Mediterranean and beyond. Carbon and water exchange of these lands has rarely been studied. In our study, almost ten years of carbon and water vapor exchange measurements were evaluated for two ecosystems, located in close proximity in the sub-Mediterranean region of Slovenia (45°32'36" N 13°55'05" E) but differing in successional stage. Secondary forest developed on a former semi-dry calcareous grassland was compared with the nearby extensive karst pasture. On both sites eddy covariance system was used along with other meteorological and soil measurements needed for the interpretation of instantaneous, seasonal, and yearly CO₂ and H₂O fluxes. The occurrence of drought seemed to largely govern ecosystem functioning and productivity; more than the drought severity the length of the period below threshold soil water content determined yearly gross primary productivity. For years with mild drought, the secondary forest was shown to sequester more than three-fold larger amount of carbon than the grassland. In terms of phenology, the grassland shifted from C source to C sink earlier in the season but sink capacity was soon diminished, particularly in dry years. Based on long term (10 years) measured climatic and net ecosystem carbon exchange data different climate model simulations (eg. RCA4 and CCLM_4-8-17 EURO-CORDEX) and future scenarios RCP 4.5 and RCP 8.5 for Europe will be used to simulate ecosystem carbon sequestration strength up to year 2100.

Scenarios and models to evaluate future ecosystem services in Mediterranean forests

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One of the main aims of the INFORMED project is to evaluate the resilience of Mediterranean forests in the face of global change. The study of resilience in complex social-ecological systems, such as Mediterranean forests, requires an integrative framework of analysis to explore the interactions between ecological and socio-economic processes at multiple spatio-temporal scales. One way of approaching this is by the generation of future global change scenarios that explicitly reflect our beliefs about the plausible specific combinations of direct and indirect drivers at various spatial, temporal and sectorial scales under explicit assumptions on the future functioning of human societies. Here, we first present the results of a systematic review of the scientific literature on the use of future scenarios in ecological research, focusing on their application in the assessment or evaluation of biodiversity and ecosystem services. Our results show that forecasting efforts make relatively little use of modelling approaches accounting for actual ecological processes and feedbacks between different socioecological sectors; predictions are generally made on the basis of a single driver of change, mainly climate. There is still much scope to work towards achieving higher levels of realism in impact assessment forecasting exercises. This will require better integration of multiple ecological processes and driving forces in models and scenarios, and advancing on integrative approaches that consider the interdependencies between socio-ecological systems and nature systems. Second, we also present the protocol for global change scenario definition developed within the INFORMED project. We discuss the different scales considered (global, supra-national/national, local), the drivers that act at each of these scales (climate, policy, management), and the methodology used to generate the scenarios, based on the construction of qualitative narrative storylines, which provide the descriptive framework from which quantitative scenarios can be formulated after a participatory process involving local and regional level stakeholders.

Forest management options to adaptation in the Mediterranean basin: efficacy and trade-offs

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As global climate becomes warmer, the maintenance of the structure and function of Mediterranean forests constitutes a key challenge to forest managers. Management strategies for forest adaptation to climate change needs to consider the different temporal scales over which ecological mechanisms and rapid environmental changes act. Therefore, the use of such strategies should not be only addressed towards attaining short-term objectives such as decreasing the immediate risk of a particular disturbance, but also towards the promotion of resilience as a key objective for long-term adaptation.

Here we describe a theoretical framework for classifying management strategies and we provide an overall evaluation of their efficacy, explicitly recognizing trade-offs with other, untargeted ecosystem components. We then use this framework to provide a quantitative synthesis of the efficacy of management strategies in the Mediterranean basin. Our analysis shows that research has focused on strategies aimed at decreasing risk and promoting resistance in the short-term, rather than enhancing long-term resilience. In addition, management strategies aiming at short-term benefits frequently have unintended consequences on other adaptation objectives and untargeted ecosystem components.

We conclude that novel empirical studies and experiments focusing both on adaptation objectives and multiple responses and processes at the ecosystem level are needed. Such progress is essential to improve the scientific basis of forest management strategies and support forest adaptation in the Mediterranean basin.