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Tropospheric ozone uptake under drought conditions - A case study of the Urban Trees in Vienna, Austria

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Abstract:
Tropospheric ozone is an air pollutant that in the last decades has gained relevance, as it causes strong and sometimes irreversible consequences to human and environmental health. Its formation, removal, and importance are described in this master thesis based on a literature review from the last 20 years with special attention to the interactions plants and their physiology have on the ozone cycle, like emission of biogenic volatile organic compounds (BVOC), stomatal conductance and their water relationship. An experiment under laboratory conditions was developed in the Institute of Forest Ecology of the University of Life Science, BOKU, Vienna, using gas exchange cuvettes. It consisted of testing the effect of salt and drought stress in the capacity to uptake tropospheric ozone on four species with different types of BVOC emission or and strategies toward stress defense. From these trees only *B. pendula* significantly decreased its ozone uptake under drought stress, *F. sylvatica* presented the lowest performance, and *C. betulu*s and *Q. robur* the largest one.

Additionally, a compilation of the type of BVOC and degree of drought stress tolerance was done for each specie of the urban forest in Vienna, which compromises 202214 individuals growing in parks, roadsides, and other wooded, and are equivalent to more than 299 species and 76 genera. A list of the species, which are recommended not-to-be used anymore, was developed. They represent more than 29% of the total urban forest, with 39 genera and 77 species. The included trees are either sensitive to drought stress or high mono- and isoprene emitters (BVOC); these characteristics enhance directly and indirectly to ozone formation.

Keywords: BVOC, urban-forest, tropospheric-ozone-uptake

Recommendation of native species for the reforestation of degraded land using live staking in Antioquia and Caldas' Departments (Colombia)

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Abstract:
Although Colombia is one of the countries with the greatest biodiversity in the world, it has many degraded areas due to agricultural and mining practices that have been carried out in recent decades. The high Andean forests are especially vulnerable to this type of soil erosion. The corporate purpose of 'Reforestadora El Guásimo S.A.S.' is to use wood from its plantations, but it also follows the parameters of the Forest Stewardship Council (FSC). For this reason, it carries out reforestation activities and programs and, very particularly, it is interested in carrying out ecological restoration processes in some critical sites. The study area is located between 2000 and 2750 masl and is considered a low Andean humid forest (bmh-MB). The average annual precipitation rate is 2057 mm and the average temperature is around 11 ºC. The soil has a sandy loam texture with low pH, which limits the amount of nutrients it can absorb. FAO (2014) suggests that around 10 genera are enough for a proper restoration. After a bibliographic revision, the genera chosen were Alchornea, Billia, Ficus, Inga, Meriania, Miconia, Ocotea, Protium, Prunus, Psidium, Symplocos, Tibouchina, and Weinmannia. Two inventories from 2013 and 2019, helped to determine different biodiversity indexes to check the survival of different species and to suggest the adequate characteristics of the individuals for a successful vegetative stakes reforestation.

Keywords: Reforestation, native species, adaptation, vegetative reproduction.

Effects of Syrian war on forest conservation – Insights and actions for enhancing biodiversity

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Abstract:
In March 2011 the devastating conflict erupted in Syria causing the migration of more than 11 million Syrians, about 1,4 million refugees have fled to the coastal area which contains 90% of the vegetation of the country causing huge pressure on the natural resources. The aim of the study is assessing the damage on the forest area using remote sensing techniques and temporal and spatial analysis on Landsat 5 and 8 imageries of two different years before and after the conflict (2011 and 2019), in addition, to study the status of the habitats of endangered and endemic species by crossing their spatial data from the IUCN red list with the change detection map. Results showed a forest loss of 10% of the Syrian forest area which represents 2% of the total area of the country with user accuracy of 70% causing forest fragmentation and habitat loss to a number of endangered and endemic plant and animal species. Understanding the forest change during the conflict is important for anticipating future conservation strategies especially in the areas where the livelihoods of locals are dependent on the forest resources.

Keywords: conflict, change detection,Syria,conservation.

Climate-growth relations of yellow-cedar (*Callitropsis nootkatensis*), western hemlock (*Tsuga heterophylla*) and Sitka spruce (*Picea sitchensis*) on Haida Gwaii (Canada).

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Abstract:
Climate change is impacting forest ecosystems across the globe. In North America, changes in tree species growth and health status have been well documented. In this study I aimed to determine if climate-growth relations of yellow-cedar (*Callitropsis nootkatensis*), western hemlock (*Tsuga heterophylla),* and Sitka spruce (*Picea sitchensis*) changed over the course of the 20th century on Haida Gwaii (BC, Canada). Further, I aimed to determine if climate correlations differed between the three species. A single site was sampled in 2016 on Haida Gwaii, an archipelago off the Pacific coast of British Columbia (Canada). The climate of Haida Gwaii is strongly influenced by the Pacific Decadal Oscillation (PDO), a multi-decadal change in sea-surface temperature. I tested for significant differences in monthly maximum temperature and total precipitation between three phases of the PDO that occurred in the 20th century (1901-1945 (positive), 1946-1976 (negative) and 1977-2015 (positive)). I then performed climate-growth analysis using the residual chronologies of each species, by correlating maximum monthly temperature and total precipitation against growth, for each PDO phase. The results highlight instability in climate-growth relations across time and a divergent response to climate between species. In the warm phases of the PDO, yellow-cedar and western hemlock preferred a warmer growing season, whereas Sitka spruce preferred cooler growing season temperatures. In the negative phase, each species growth was limited by warmer previous growing season conditions, but cooler conditions in the current year. Precipitation was less significantly correlated with growth than temperature. All species were positively associated with wetter winter conditions in 1946-1976 and 1977-2015 but limited by high current May rainfall across every phase. Despite sharing similar microclimatic conditions, I found that yellow-cedar, western hemlock, and Sitka spruce responded differently to a changing climate over the 20th century.

Key words: Growth, Dendrochronology, Mixed-forest, Climate Change

Spatial and temporal characterization of fire regimes in Turkey using MODIS active fire and burned area data

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Abstract:
Vegetation fires in Turkey have been studied almost exclusively on the forested areas of the Mediterranean coastline and mainly with respect to wild fires, which are those reported by forest agencies on the provincial and regional level. But biomass burning is a broader phenomenon. For example, at the end of the summer, it is common practice in agricultural regions in the mid-latitudes, to burn croplands after the harvest.

The MODerate resolution Imaging Spectrometer (MODIS) sensor on board of TERRA and AQUA satellites has already been employed successfully to study fire regime characteristics and their potential drivers at the global and the regional level. Here we propose a first study of vegetation fire regimes over Turkey by taking advantages of the most recent versions of both the active fire (MCD14ML, collection 6) and burned area (MCD64A1, collection 6) products derived from the MODIS sensor during the period from 2003 to 2019. Using these two datasets we computed 12 fire regime variables at the spatial resolution of the Turkish provinces. We identified fire incidence and its inter-annual variability, seasonality, intensity, fire size distribution and vegetation types affected by fire. The variables will be normalized and clustered to define the potential fire regimes with their distinctive fire attributes.

Keywords: Fire regimes, Remote sensing, MODIS, Cluster analysis, Fire drivers, Turkey, Pyrogeography

‘Tree based ecosystem service potential of church forests and trees in their agricultural matrix near Lake Tana, Ethiopia’.

Hilina Yohannes

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Abstract: Church forest fragments have enormous importance for saving the last segments of primary forest and biodiversity on earth. They are currently being threatened by natural and human-induced factors. The objective of this research was to study the diversity of tree species, their ecosystem services (ES), and ecosystem multifunctionality (ESMF) of church forest fragments and their adjoining agricultural matrices in the East of Lake Tana (Northwestern highlands) of Ethiopia. Ecosystem services were analyzed based on the Millenium Ecosystem Assessment (MEA) classification of ecosystem services. The data was analyzed by using Statistical Package for the Social Sciences (SPSS v.16), Microsoft office excel. In addition to this, multiple regression analysis was undertaken to explain the factors affecting diversity, ES, and ES multifunctionality in both church forests and the agricultural matrices. The results show that there are higher tree diversity indices (average Shannon diversity index (H’=2), Simpson diversity indices (0.8), and Shannon evenness (0.76)), and a higher alpha diversity and gamma diversity in church forests than agricultural matrices. The ecosystem services indicate a higher average ES in agricultural matrices, but this difference was not significant according to the performed t-tests. Based on the MEA division, there are higher cultural and regulating services in the agricultural services than the church forest fragments. The multifunctionality metrics indicate that there are higher average multifunctionality levels in the agricultural matrices than church forests and this indicates the deliberate plantings of multifunctional trees by farmers in the respective matrices. The multiple regression analysis indicates factors affecting the church also affects the matrices and vice-versa. These major results indicate the role of the church and matrices as a separate component and the relationship between these two important ecosystems. Conservationists, foresters, and policymakers should take into account this interdependence and apply a holistic measure while conserving biodiversity’s in these areas.

Keywords: Church forests, Ecosystem, Ecosystem services, Multifunctionality

Forests and forest sectors of Bosnia and Herzegovina, Croatia, Serbia and Slovenia: an analysis of the current state and future expansion opportunities of FSC certification

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Abstract:
The graduation thesis Forests and forest sectors of Bosnia and Herzegovina, Croatia, Serbia and Slovenia: an analysis of the current state and future expansion opportunities of FSC certification is a celebration of 4 forest rich countries. This thesis has three major purposes: presentation of forestry related data of 4 countries in a single and easy to follow format, analysis of current state of art and expansion opportunities of FSC certification in 4 countries, and enhancement of the broad public awareness of sustainable forest management and FSC forest certification scheme.
Bosnia and Herzegovina, Croatia, Serbia and Slovenia are 4 neighboring forest rich countries. Put together, their forests cover an area of 8 826 920,33 ha or about the size of Serbia. As of June 2020, 5 163 268,15 ha of forest area from considered countries (or about the size of Bosnia and Herzegovina) are FSC certified. Jointly their certified forest area makes 52,58% of total possibly certified forest area and 2,45% of total FSC certified forest area in the world.
According to the results of data mining via secondary sources, main opportunities for the expansion of FSC forest management certification in considered countries lie in private forests certification. Results from the surveys with forest experts from 4 countries further revealed that main barriers that private forest owners currently face towards forest certification are lack of awareness of FSC certification in general as many of them do not manage their forests for commercial forest production, and high perceived costs of certification. Direct or indirect state support, campaigns to raise awareness of FSC certification scheme, and development of regional or national FSC offices are some of the most agreed solutions offered by most forest experts that can help the expansion of FSC certification into private forests.
Similar research was performed for the expansion of FSC chain of custody certification in 4 countries and is also presented in the thesis.

Keywords: Balkan, forest sector, private forest owners, forest certification, FSC

Evaluation of early-vegetation regeneration of areas burned in wildfire and prescribed fires using spectral indices and sar data

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Abstract: The present research has two main objectives: assessing how Sentinel-1 C-band synthetic aperture radar (SAR) data works for wildfires and prescribed fires, when compared to Landsat data; and also at evaluating if wildfires have similar fire severity when compared to prescribed fires. To assess these issues, the study was conducted in Alto Minho, a subregion of Portugal using Landsat data to create a multitemporal analysis. For the SAR response to fire events, Sentinel-1 backscatter values were used, and 29 variables were tested in order to see which ones behave more similarly to the spectral indices. For the comparison between prescribed fires and wildfires, the analyses was conducted using Normalized Burn Ratio (NBR) and Normalized Difference Vegetation Index (NDVI). Using visual interpretation, the Normalized Signal Ratio in percentile 90 (NSR p_90) seems to work properly for areas covered with grass and small bushes, but it also seems to work best when the fire severity in the area is greater. 95% of the plots analysed by NSR p_90 were considered as a good response to fires, when compared to spectral indices. As for the evaluation of wildfires and prescribed fires severity, severity of summer wildfires are significantly different from severity of prescribed fires. Winter/autumn wildfires are not significantly different in terms of severity from prescribed fires.

Keywords: Prescribed fires; Wildfires; Spectral indices; Synthetic-aperture radar

Where are the Innovation in the Brazilian Atlantic forest restoration initiatives?

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Abstract:
Concern about the value of forests and natural ecosystems has increased worldwide and has fostered large-scale international forest restoration agreements, promoting connectivity between ecosystems, including people's well-being. In 2011, at the Bonn Challenge, Brazil committed to restore 12 million hectares by 2030, and to meet this commitment, it is necessary to reduce existing bottlenecks and barriers in FLR projects. It is believed that innovation is an important tool in this process, therefore, this research has as main objective to understand what is the role of innovation in FLR projects in the Atlantic Forest Biome. For this, information will be collected about bottlenecks, the occurrence of innovations, nature, typology, frequency, geographic region and socioeconomic indicators, legal assistance and forest coverage. Data collection will be done through a questionnaire, interviews and bibliographic research of FLR projects in Brazil and in the World. The results of this research are expected to consolidate and expand information on innovations, to understand their role in FLR projects, to help build a network between sectors and projects, promoting the exchange of experiences and, indirectly, helping to build strategies more assertive future plans to promote and expand FLR projects

FSC forest certification as a conservation tool in Portugal: impacts and potentialities

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Abstract:

High Conservation Values (HCV) is a concept introduced by the Forest Stewardship Council that focuses on outstanding forest attributes that need extra consideration when developing sustainable forest management in certified forest areas. The aim of this study is to evaluate the contribution of the FSC HCV approach on conservation focusing on selected Portuguese forest management units. To do so, it was described the HCVs presence in Portugal and the role of FSC certification on enhancing protection outside of formally protected areas and the impacts of the approach implementation for certified organizations was analysed.
This study used primary data from a mail survey to the FSC certificate managers of areas with HCV and secondary data from FSC audit reports. Due to the lack of standardization, results from secondary data analysis are not considered to be entirely reliable, but a starting point for further research. Data was analysed through descriptive statistics on Microsoft Office Excel.
Results concluded that the FSC HCV approach contributes to conservation in certified forests in Portugal. Although HCV areas only account for approximately 6% of the certified forest area, measurement of changes caused by the approach implementation for the certified organization demonstrated a positive impact on forest certification. Moreover, the study also highlighted the role of certification in preserving HCVs present outside of traditionally protected areas like Natura 2000 or national protected areas. Also, survey answers pointed out that certificate managers consider the HCV approach to have an overall positive impact, although weaknesses were pointed out: lack of standard reporting and need of better guidelines.
In order to improve the future of the HCV approach, improvement suggestions were done on report standardization, increased certified organizations guidance and increase of HCV importance under the FSC forest certification scheme.

Keywords: High Conservation Values, conservation, Forest Stewardship Council, forest certification, Portugal

Assessment of vulnerability to cavitation in seedlings of three Douglas-fir genotypes across the Pacific Northwest

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Abstract:
Global warming has demonstrated to affect the potential growth of several type of forests, but the effects can be different not only among tree species but also within the same species. Douglas-fir is considered as the most economically and ecologically valuable forest species in the Pacific Northwestern region and represented by large variability in morphology, genetics, and drought hardiness.
The goal of current research was assessment of water transport performance (hydraulic conductivity) after drought inducement in stems xylem of three contrasting genotypes of Douglas-fir (*Pseudotsuga menziesii*) seedlings from Oregon, USA, and trade-off between safety and efficiency within the species.
We chose three contrasting genotypes (coastal, mountainous, and inlands seed sources) to demonstrate climatic and environmental extremes. Vulnerability to cavitation curves were built for seedling stem xylem by plotting the percentage loss of conductivity versus water potential for each genotype. Vulnerability at xylem water potential at which 50 percentage loss of conductivity happens (Ψ50) varied greatly among seed sources: Inland seed source demonstrated highest resistance and is capable to maintain strong water flow under severe drought. No significant differences were found at air-entry point (Ψ12) and full embolism point (Ψ88). No relation was detected between Ψ50 and maximum sapwood-specific hydraulic (K_s-max) conductivity, indication the absence of trade-off between safety (Ψ50) and efficiency (K_s-max), which allow to choose seed sources for future implementation without compromising. Physiological traits such as height, biomass (roots, wood, foliage, aboveground), wood density were compared. No significant differences were found except aboveground biomass: Coastal seed source showed greatest values in aboveground biomass.
These results show that a genetic-based approach is a promising tool for helping the foresters in planting new stands that might be more resistant to the future environmental conditions.

Keywords: *Pseudotsuga menziesii,* Douglas-fir, hydraulic conductivity, adaptation, drought resistance, seed source, genotype, vulnerability to cavitation curves

Estimation of site index from environmental variables for Eucalypt stands across Portugal.

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Abstract:
Eucalypt (*Eucalyptus globulus* Labill.) is a fast-growing species native to Australia, but used for plantations in Portugal where it became among the most abundant species. Due to the increasing wood demand for pulp and paper companies, the eucalypt plantation areas have expanded across Portugal since the 60's. However, this leads to the land conflict among eucalypt and other species. Not only that, as eucalypt is grown in homogeneous forest occupying large continuous areas, it becomes flammable material for the wildfire, which is one of the main problems for forestry in Portugal. To support the strategic planning process, site index is used to assess the productivity of eucalypt. The objectives of this dissertation were to identify the environmental factors, including climatic, topography and soil factors that determine site index, and subsequently, to develop models predicting the site index from the environmental predictors. The used dataset was collected from 176 permanents plots and 56 trial plots established in eucalypt plantations and observed for 13 consecutive years. Multiple regression was used to determine the key factors affecting the site index. The outcomes of this dissertation were to develop two models: a generalized model using just variables from digitized information that provides the average site index for a 500x500 pixel and a localized model that improves the prediction from the generalized model using local environmental variables such as location in the slope, azimuth, soil. The generalized model was subsequently utilized to map the productivity variation across the country. The two models provide further information about the ecological distribution of eucalypt as well as an effective tool in forest management.

Keywords: site index, *Eucalyptus globulus*. Labill., Portugal, multiple linear regression.

Addressing forest ecosystem management planning concerns with linear programming. an application in Portugal

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Abstract:
Forest management is an extremely complex process that requires the combination of various techniques, practices and methods in order to achieve given environmental, economic and social objectives. Linear programming (LP) is one of the most widely used optimization methods that assists forest managers in the process of the decision-making. The use of alternative formulations of the LP model may help acquire insights about the forest ecosystem management planning problem may thus lead to better plans.
This work presents the study of influence of different LP model formulation on the design of the management plan and on economic values, timber flow, tree species distribution, total carbon stock, cork extracted, biodiversity and cultural services. A total of 16 model formulations (scenarios) were considered for the analysis. Scenarios were obtained by changing the objective function and by adding of management related constraints. The set of objective functions included the minimization of costs, the maximization of the net present value (NPV) over the planning horizon, the ending inventory value (EIV), and the total present value (PVFI = NPV + EIV). The set of constraints included 10% timber even-flow constraints and timber targets per period and per tree species. The study area was Vale do Sousa, Portugal.
The results of the study demonstrated that the LP model formulation has a substantial influence on the proposal of management plan. It allowed to check the trade-offs between economic criteria and changes in timber flows, tree species distribution, extracted cork and carbon stock. Biodiversity and cultural services remained at the same level across scenarios. Results suggest the importance of using alternative formulations to acquire information about the management plan and to explore responses to alternative scenarios and to make better decisions.

Keywords: linear programming, forest management, ecosystem services, forest ecosystem values, optimization methods.

Study the colonization by herbaceous species in green roofs installed with native plants under Lisbon climate

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Abstract:
Policies and objectives 2020 Horizon for urban management (energy conservation and increase of biodiversity), increasing interest and need of cities to build sustainable green roofs in urban spaces has led to an increase of the scientific research and a more specific choice of plant species and nature base solution to be used to guarantee better results. In North Europe, North America, and Asia, EGRs are generally part of the design of new buildings, whilst they are still uncommon in countries Mediterranean area. Weather and environmental conditions can be the limiting factors for the expansion of green roofs in those areas. The use of native species because of high diversity and adaptations to environmental stresses can be a sustainable solution, both in terms of biodiversity and in economics. This study seeks to examine the results of native plants survival rate, flowering duration, flowering intensity, green cover areas of three green roof projects which conducted separately from 2014 to 2020 at the Instituto Superior de Agronomia, Universidade de Lisboa, Then we will investigate those results based on a series of ecological indicators in order to propose a list of suitable native plants to use in green roofs for potential commercial to increasing urban biodiversity.
According to the results of data, among 30 species which evaluate, only *Brachypodium phoenicoides* L., *Lavandula stoechas*, *Rosmarinus officinalis* L., *Antirrhinum linkianum*, *Sedum sediforme*, *Asphodelus fistulosus*, *Centranthus ruber*, *Trifolium incarnatum*, *Briza maxima*, *Serratula spp.*, *Papaver rhoeas*, *Capsella bursa-pastoris*, *Cichorium intybus*, *Chrysanthemum coronarium*, *Scabiosa atropurpurea*, *Foeniculum vulgare*, *Teucrium scorodonia*, *Stachys germanica*, *Plantago lanceolata*, *Lavatera trimestris* showed favorable results. According to the irrigation water used in this study, we can derive that using 60% ETo irrigation compared to 100% ETo not only did not make a significant difference in the growth and development of species but in some species, the effect of low irrigation rate was better, also synthesizing the data, we can conclude that in the Lisbon region the direct planting show better results than pre-cultivated mats.

Keywords: *Extensive green roofs, Walls & roofs vegetation, Native plants, Mediterranean environment, Urban biodiversity, Urban ecology.*

Linear mixed effect models for valuable broadleaved tree species in Catalonia, Spain

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Abstract:

Valuable broadleaved tree species are one of the most important elements of forest products in Europe. They are known for their multiple uses including high-quality timber, environmental, economic, and social benefits. In spite of the importance of these species, there is no much information on the performance of the species in the Mediterranean conditions and few models have been developed on the growth of these trees in relation to the site characteristics and weather variables. The adaptation and performance of the valuable broadleaved tree species to the Meditteranean condition is not well known. There are also limited studies on the effect of weather and site characteristics on the performance of the valuable broadleaved trees plantation in Spain. This is due to the fact that these trees were neglected for a long time as the result of limited knowledge about the trees. The current study focussed on building individual tree-level diameter and height increment models for twelve (12) valuable broadleaved tree species that have been planted from 2001 to 2014 by the Centre Tecnologic Forestal de Catalunya (CTFC) in order to understand the performance of the species and to predict their future growth in the Mediterranean environment. The study used a linear mixed-effect modeling approach for fitting tree-level diameter and height increment models. This statistical technique was employed due to the repeated or longitudinal nature of the data. R programming language was used for fitting the mixed effect models (lmer and lmertest packages were used to fitting the mixed effect model in r) and R markdown was used for the modeling process and to write the thesis and manuscript. The individual diameter and height increment models were developed for 12 broadleaved trees. The study revealed that tree size and seasonal precipitation (Autumn and summer precipitation) are the most important predictors of the tree growth. Summer maximum temperature and winter minimum temperature were also found to have a negative effect on tree growth. We found a minimal effect of site characteristics on tree growth. The models developed by our study clearly identified the most important drivers of the valuable broadleaved growth. These models can be used by forest practitioners, policymakers, and forest managers to predict the future growth of these trees and to apply necessary management alternatives to enhance the growth of these trees.

Keywords: Mixed effect model, valuable broadleaved trees, tree-level model

Spatial and Temporal Analysis of Landscape Fragmentation in Cork Oak Woodlands: Are there differences between certified and non-certified areas？

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Abstract:

Cork oak (*Quercus suber*) is an endemic species to the western Mediterranean Basin. Cork oak forests have high economic value mainly due to cork production but also generate other products and services. As market needs change periodically, managing cork oak landscapes for cork production alone may imply sustainability risks. Additional sources of revenue may come from other products (e.g. livestock production) as well as through payment for ecosystem services (PES). Sustainable forest management plan in cork oak woodlands, should consider not only non-wood forest products such as cork, but services such as carbon storage and water regulation , recreation and tourism, or game pasture and livestock and other ecosystem services. Considering all these services imply large areas of cork oak forests and high cork oak forest cover in the landscape. Cork oak cover loss and fragmentation can be a barrier to sustainable and multiple-use of cork oak woodlands (also known as *montados*) and cork oak landscapes. Additionally, forest certification, a governance tool aiming to promote sustainable forest management, has been expanding in cork oak forests. In this study, I analyze the changes of forest coverage in the cork oak woodlands landscape, especially the fragmentation and forest cover loss, in the *coruche* study area in Portugal. More specifically, I compare and quantify changes in cork oak woodlands landscape between 2005 and 2015, by using four landscape metrics, including percentage of landscape (PLAND), Edge density (ED), mean of perimeter area ratio (PARA_MN), and contiguity index (CONTIG_MN), in the study area. Moreover, I compare the difference these changes on cork oak woodlands landscape within the study period between certificated area and non-certificated area in the study area. My results suggest that forest certification between 2005 and 2015 contributes to the decrease of cork oak fragmentation and implying that certification positively impacted cork oak woodlands.

Keywords: Cork oak, production, Forest certification, landscape metrics, PES (payment to ecosystem services), sustainable forest management, landscape ecology, fragmentation, GIS, remote sensing, carbon.