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DR FERNANDO PULIDO (Orcid ID : 0000-0001-5620-1918)

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Targeted policy proposals for managing spontaneous forest expansion in the Mediterranean

Elsa Varela[1,2], Fernando Pulido[3]*, Gerardo Moreno[3] & Miguel Á. Zavala[4]

[1] Center for Agro-Food Economics and Development (CREDA-UPC-IRTA), edifici ESAB, Esteve Terrades 8, 08860 Castelldefels, Spain.

[2] Catalan Institute of Agrifood Research and Technology (IRTA), Torre Marimon, 08140 Caldes de Montbui, Barcelona, Spain.

[3] Institute for Dehesa Research (INDEHESA), University of Extremadura, Centro Universitario, 10600 Plasencia, Spain.

[4] Forest Ecology and Restoration Group, Department of Life Sciences, Universidad de Alcalá (UAH), Edificio Ciencias, Campus Universitario, 28871 Alcalá de Henares, Madrid, Spain.

*Corresponding author: nando@unex.es

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ABSTRACT

1. Recent forest expansion in Euro-Mediterranean countries predominantly results from secondary succession in abandoned farmland, rather than from artificial afforestation. This major forest transition involves the delivery of both ecosystem services and disservices, which must be balanced through new land-use planning and policy approaches.
2. Ecosystem services arising from this expansion of forests include increased carbon sequestration, water infiltration, provision of forest products, soil retention, and forest coalescence. Nevertheless, ecosystem disservices such as reductions in water yield, landscape homogenisation, increased wildfire risk, and/or the loss of high nature value managed habitats caution against generalisation of the benefits of such expansion.
3. Most EU funds related to forests are being allocated to conservation, restoration, or fire prevention and extinction efforts, whereas sustainable forest management and the maintenance of multifunctional agro-silvo-pastoral mosaics are hampered by the lack of financial incentives and by environmental regulations.
4. *Policy implications*. We advocate for more-targeted policies based on landscape planning that favours multifunctionality while reducing environmental and economic uncertainties and maximizing the ecosystem service/disservice ratio. The following recommendations follow from this approach: (1) a climate-smart policy favouring fire-resistant landscapes and enhancing value chains that stimulate active forest management; (2) the adoption of a territorial perspective, beyond forest and farm-based measures and payments, that relies on management actions and minimizes socio-ecological tensions; (3) re-focusing CAP Pillar II grants from afforestation and forest protection measures to sustainable forest management; (4) transforming the CAP direct payments to support multifunctional farming systems (e.g. agroforestry); (5) a more balanced inclusion of different land uses in the Natura 2000 network and intensification of the support for High Nature Value farming in less-favoured areas.

RESUMEN

1. El aumento de la superficie forestal en los países del norte del Mediterráneo se debe sobre todo a procesos de sucesión secundaria en zonas agrícolas abandonadas, más que a reforestaciones. Esta transición forestal tiene implicaciones para la provisión

tanto de servicios de los ecosistemas como de servicios negativos o diservicios que deben ser abordados mediante nuevos enfoques políticos y de gestión territorial.

2. Los servicios de los ecosistemas derivados del aumento de superficie forestal incluyen el secuestro de carbono, la infiltración de la escorrentía, la provisión de productos forestales, la retención del suelo y la reducción de la fragmentación de la superficie forestal. Sin embargo, distintos diservicios como la reducción de agua en los cauces de los ríos, la homogeneización del paisaje, el aumento del riesgo de incendios y/o la perdida de hábitats agrarios de alto valor natural, previenen contra la generalización de los beneficios de dicha expansión.
3. La mayoría de los fondos europeos para la gestión de sistemas forestales se destinan a financiar la conservación, restauración, o los esfuerzos de prevención y extinción de incendios, mientras que la gestión forestal sostenible y el mantenimiento de los mosaicos agro-silvo-pastorales está en peligro por la falta de financiación y las regulaciones medioambientales.
4. Implicaciones para las políticas: Abogamos por la implementación de políticas basadas en la planificación a escala de paisaje que favorezcan la multifuncionalidad del territorio, reduzcan las incertidumbres medioambientales y económicas y maximicen el ratio servicios/diservicios de los ecosistemas. De este enfoque derivan las siguientes recomendaciones: (1) una política climáticamente inteligente que favorezca paisajes resistentes al fuego y que favorezcan las cadenas de valor que estimulan una gestión activa del bosque; (2) la adopción de una perspectiva territorial, más allá de las medidas forestales y agrícolas, que se base en la gestión activa y minimice las tensiones socio-ecológicas; (3) re- enfocar el Pilar II de las ayudas de la PAC a la reforestación y la protección del bosque por ayudas y medidas para la gestión forestal sostenible; (4) transformar los pagos directos de la PAC para apoyar los sistemas agrarios multifuncionales (e.g. sistemas agroforestales); (5) una consideración más equilibrada de los distintos usos del suelo en la red Natura 2000 y una intensificación del apoyo a los espacios agrarios de alto valor natural en zonas desfavorecidas.

Keywords: Ecosystem services, ecosystem disservices, forest expansion, multifunctionality-oriented policy, Mediterranean forest, mosaic landscapes, wildfire risk.

Palabras clave: Servicios de los ecosistemas, disservicios de los ecosistemas, expansión forestal, políticas para la multifuncionalidad, bosque Mediterráneo, paisajes en mosaico, riesgo de incendios

1. THE FOREST TRANSITION IN THE MEDITERRANEAN

The Mediterranean basin is home to 7.3% of the global population, and accounts for 10.4% of the global GDP and almost one third of international tourist arrivals (FAO, 2018). Despite a long history of continual land use by humans, it is the world's second-largest biodiversity hotspot due to the richness of species associated with Mediterranean forests (Myers, Mittermeier, Mittermeier, da Fonseca, & Kent, 2000). Due to the multifunctional character of these forests, non-wood products may be more important for society than wood-based products, in terms of both income and intangible benefits (Campos et al., 2020).

Forest cover in the Mediterranean region totals 88 million hectares, and this area has been expanding at a net rate of 0.85% per year since 1990 (FAO, 2018). Nowadays, forests occupy 21% of the entire broader ecoregion, with 64% of these forests being located in Spain, France, Turkey, and Italy, wherein forests account for 15-37% of national land cover (FAO, 2018). The expansion of forests in this area was initially triggered by economic development in the mid-20th century (Cervera, Pino, Marull, Padró, & Tello, 2019), leading to secondary succession in abandoned farmlands. This transition is still ongoing and represents a challenge for human-shaped landscapes in the Mediterranean, which largely depend on traditional agro-silvo-pastoral practices to support biodiversity and secure the provision of services (Bugalho, Caldeira, Pereira, Aronson, & Pausas, 2011).

2. ECOSYSTEM SERVICES AND DISSERVICES IN EXPANDING MEDITERRANEAN FORESTS

Forests in the Mediterranean basin have been managed for millennia, continuously providing key ecosystem services (ES) to society (FAO, 2018). Conversion from agriculture is expected to increase supply of ES, although some ecosystem disservices (EDS) and trade-offs are also emerging, especially in the unmanaged spontaneous forests which are the predominant type resulting from forest expansion.

As a result of new forest cover, soil erosion decreases and overall soil conditions can improve (Vallejo et al., 2012), with increases in soil organic matter content, aggregate stability, hydraulic conductivity, and/or water holding capacity (Van Hall, Cammeraat, Keesstra, & Zorn, 2017). New forests may play a relevant role in climate regulation through carbon sequestration and storage in woody biomass. In Spain, for example, new forests grow 25% faster than mature stands, and in the period between 1986 and 2007 stored up to 9% of the total C emissions (Vilà-Cabrera, Espelta, Vayreda, & Pino, 2017). Further, they maintain C stocks similar to those of pre-existing forests (45 Mg ha^{-1}). While these new forests represent a significant accumulation of carbon in the form of biomass, carbon accumulation in soil can be negligible over several decades (Romanyà, Rovira, Duguy, Vallejo, & Rubio, 2007). Moreover, while revegetation of arable lands produces a long-term increment in soil organic matter (Padilla, Vidal, Sánchez, & Pugnaire, 2010), results for the conversion of grasslands to forest are more controversial (Dass, Houlton, Wang, & Warlind, 2018). In some cases, forest soils store more carbon than those of the former grasslands (Padilla et al., 2010), while the opposite may also hold true (Muñoz-Rojas et al., 2015). Given this prevailing biomass accumulation, the water-carbon duality emerges as a key challenge in forest expansion management. Forest spread can modify the hydrological cycle, increasing not only water infiltration rates and the water holding capacity of soil, but also water losses by transpiration and rainfall interception (Cosandey et al., 2005), predominantly resulting in a negative balance in terms of water yield (Nasta et al., 2017). The combined effects of forest regeneration and climate change have the potential to reduce annual streamflows by up to 30% in some parts of the Mediterranean (Banqué Casanovas et al., 2020). If aridity increases due to climate change, adaptation measures should aim to enhance the ecosystem water balance and minimise the risk of forest dieback due to intense competition for water resources (Moreno-Gutiérrez et al., 2012). In arid areas, the increase in carbon sequestration may not offset the losses in water provisioning services financially speaking (Ovando, Beguería, & Campos, 2019), yet forest management can improve both carbon sequestration and water provision through reductions in density (Banqué Casanovas et al., 2020).

The relationship between forest expansion and biodiversity in Mediterranean landscapes is complex and multifaceted. Although habitat quality for wildlife scores lower in recently encroached land than in mature forests or well-established afforestations (Requena-Mullor, Quintas-Soriano, Brandt, Cabello, & Castro, 2018), forest expansion may represent an opportunity to reduce fragmentation and enhance the conservation of forest specialist species such as birds (Regos et al., 2016) or large carnivorous species (Mangas, Lozano, Cabezas-Díaz, & Virgós, 2008). Land-use legacies may also play a significant role in forest expansion processes. In crop-dominated landscapes resulting from agricultural intensification, forest recovery seems to lead to increased landscape diversity, while the opposite holds true for transitions from abandoned agroforestry mosaics or semi-natural grasslands (Burrascano et al., 2016; Otero et al., 2015). Overall, there is empirical and theoretical evidence indicating that β-diversity is a key driver of landscape-scale multifunctionality (Van Der Plas et al., 2016).

The evolution of these new forests towards more diverse successional stages can be hampered by increasing forest disturbances. Wildfires in five Euro-Mediterranean countries (France, Greece, Italy, Portugal, and Spain) burn approximately 450,000 ha per year, representing 85% of the total burnt area in the entire European Union (San-Miguel-Ayanz & Camia, 2010). The spontaneous forest expansion process that leads to high biomass content and continuity in early successional stages creates favourable conditions for the spread of wildfires (Verkerk, Martinez de Arano, & Palahí, 2018). While active forest management practices are scarce in many parts of the Mediterranean (Valente et al., 2015), managing density in these new forests would contribute to reductions in wildfire risk, improvements in water use efficiency, and reductions in stand vulnerability (Giuggiola, Bugmann, Zingg, Dobbertin, & Rigling, 2013).

Table 1 summarizes the main positive and negative impacts of forest expansion dynamics in the Mediterranean, while the main groups of services and disservices associated with Mediterranean forest spread, as well as their ecological bases, are summarised in Table 2.

3. FOREST EXPANSION UNDER THE CURRENT POLICY FRAMEWORK

Given the absence of a legally binding European forest policy, forest-related issues are further complicated by different sectoral interests entailing multiple and often competing objectives (Lazdinis, Angelstam, & Pülzl, 2019). As a result, forest expansion in Euro-Mediterranean countries is occurring as rather unplanned encroachment associated with the abandonment of land uses that agriculture and conservation policies have promoted, both advertently and inadvertently, throughout the last decades. The Common Agricultural Policy (CAP) has also passively encouraged forest expansion through direct payments to farmers, promoting a dualistic phenomenon of land abandonment in marginal areas and intensification in lowlands.

The European Agricultural Fund for Rural Development (EAFRD) channels funds for sustainable forest management (SFM) from the second pillar of the CAP. For the last period evaluated in Europe, 2013-2017, SFM measures consumed only 4.8% of the total EAFRD budget, while 95% was allocated to afforestation and the protection of existing forests. Mediterranean countries generally represent the largest share of investment in the latter. Furthermore, the support for prevention of and restoration from wildfires, natural disasters, and catastrophic events consumed the largest share of the budget (>30%) (EEIG Alliance Environment, 2017).

This reactive approach to forest disturbances is also reflected in land degradation plans. Spain is the country with the largest vulnerable area amongst the Euro-Mediterranean countries, with 8.5% classified as a high level of land degradation (Salvia, Kelly, Wilson, & Quaranta, 2019). The Spanish National Action Plan to Combat Desertification that was approved in 2008 (MAPAMA, 2008) includes a number of priority actions, but the efforts have been limited to the restoration of burnt areas after large fires, with investment totalling nearly EUR 70 million for the same period of 2013-2017 (FAO, 2018).

The new EU biodiversity strategy launched in May 2020 aims to establish at least 30% of land in EU as protected areas and to plant 3 billion trees in the EU by 2030. In Mediterranean landscapes, a loose tree planting strategy may make little sense since spontaneous forest expansion and afforestation have occurred widely under the framework of the CAP. Large-scale afforestation of agricultural land has been carried out since the 1990s, aiming to deliver environmental benefits and prevent certain land from being cultivated. In Spain, forest cover increased by 3.5 million ha in the period of 1990-2013; the areas afforested under CAP account for roughly 20% of this increase (Vadell et al., 2019). Despite the fact that positive effects on bird communities were revealed (Santos, Tellería, Díaz, & Carbonell, 2006), these patches do not necessarily enhance the richness of woodland species (Carrascal, Galván, Sánchez-Oliver, & Rey Benayas, 2014). Most Euro-Mediterranean forest types are protected by the European Natura 2000 network. However, grasslands and tree-grass ecosystems harbour more threatened plant and animal species than forests (Burrascano et al., 2016). Accordingly, forest-centred conservation policy can hamper the maintenance of the multifunctional mosaic landscapes that are key for biodiversity. For example, buffer zones around protected areas in the Mediterranean are hotspots in terms of biodiversity of woody and threatened bird species, and regulating and provisioning services (e.g. fodder and water) are higher in areas of low-level protection (Lecina-Diaz et al., 2019). This ES provision pattern is largely linked to traditional ecosystem management (Castro et al., 2015).

The EU Bioeconomy Strategy (European Commission, 2018) emphasises the potential of biomass and wood-based products as sources of renewable energy (Ronzón &Sanjuán, 2020). Tree growth in the Mediterranean exceeds wood extraction, indicating that there is room for increases in provisioning. Using the biomass from new forests may represent an economic incentive for forest management aimed at improving stand resilience to wildfires as well as water provisioning. Nevertheless, bioenergy prospects in Mediterranean forests reveal certain limitations related to aspects such as property fragmentation or the low productivity and profitability of forest products, requiring solutions that go beyond mere technological recipes (Puy, Tàbara, Bartrolí Molins, Bartrolí Almera, & Rieradevall, 2008). Although southern European countries have developed their own bioeconomy strategies, these primarily focus on the industrial transformation of biomass and show only weak coherence with local social or environmental agendas (Martínez de Arano et al., 2018).

4. POLICY RECOMMENDATIONS

Forest-dominated areas in the Mediterranean require coordinated policies to tackle the multiple socio-ecological challenges while simultaneously securing the provision of multiple ES. Table 2 summarise the key policy recommendations to support the principal needs of landscape use and planning which can optimise the ratio between ES and EDS and are based on current ecological knowledge.

Climate-smart policy in the Mediterranean can be geared towards creating fire-resistant landscapes and promoting multifunctionality by enhancing value chains that stimulate active management for the provision of goods and services besides those related to wood (Verkerk et al., 2018). Due to the warming climate, biomass accumulation and forest fragment coalescence, wildfires are expected to increase in terms of both intensity and area affected (i.e. megafires) following rural abandonment. This challenge requires an integrated forest policy that addresses both local and landscape-level land uses, with indicators that are based on and reflective of the minimisation of socio-ecological damages and losses (Moreira et al., 2020). The EU Bioeconomy Strategy, the European Forest Strategy, and the CAP should adopt a territorial perspective beyond forest- and farm-based measures and payments. Supporting multifunctionality at local and regional scales – driven by underlying α- and β-diversity, respectively – is essential to ensure resilience against the increasing risks posed by fires and other risk factors.

The CAP could foster forest management strategies encompassing the whole range of ES as well as biodiversity to prevent forest degradation by re-focusing the Pillar II grants from afforestation and forest protection measures to SFM efforts (EEIG Alliance Environment, 2017). Support measures should be adapted to forest landscape dynamics, shifting from general funding to afforestation measures, to allocating earmarked budgets to competitiveness, and environmental and climate services. There is also a need to transform the direct payments, improving their support for multifunctional farming systems (e.g. agroforestry) (Pe'er et al. 2020) and including reliable tracking of the expenditures which benefit biodiversity and encouraging the use of high-impact measures such as result-based schemes (ECA, 2020). Payments for additional carbon sequestration have the potential to enhance multifunctionality if properly integrated into sound forest management practices, for example by favouring water production over direct payments for surface-water regulation (Ovando et al., 2019). Regarding conservation policy, a more balanced inclusion of different land uses in the Nature 2000 network and intensification of the support for High Nature Value farming in less-favoured areas would increase β-diversity while mitigating the risk factors associated with forest expansion.

A number of initiatives acting as “good seeds” (Bennett et al., 2016) have been arising in the Mediterranean as a response to the effects of land abandonment, unplanned forest spread and increased wildfire vulnerability on biodiversity and ES provision. In the central Apennines (Italy), the Romagna Acque company established payments to landowners in the catchment area of their dam, which are collected through an extra charge in the water bill (1% to 3%), to compensate them for converting their coppice forests into even-aged stands. The positive impact of the payment scheme was a general decrease in soil erosion in the catchment area of 20%, a consistent reduction in nitrogen, and pH stabilisation (Muys et al., 2014). In the northern and central parts of Portugal, the Zones of Forest Intervention (ZIF) emerged in 2005 as a governmental measure to promote joint forest management plans for small properties. A ZIF represents a continuous bounded area of primarily forest land, wherein active forest management and development of structural measures for protection against forest fires are promoted (Valente, Coelho, & Soares, 2012). From the 12 ZIFs covering an area of around 47,000 ha in 2007, a steady evolution of this program has led to the involvement of more than 26,000 forest owners in 223 ZIFs covering 1.4 million ha as of 2019. The MOSAICO project (https://www.mosaicoextremadura.es) in western Spain intends to reduce the risk of wildfires by supporting rural innovators in the agrarian, livestock, and forestry sectors in 24 municipalities (covering 200,000 ha) in the Extremadura region. By supporting 244 agroforestry initiatives contributing to fuel load reductions in 2017-2020, an estimated 11% decrease in potential wildfire risk was achieved through this program (Bertomeu et al., 2019). Specifically, a new type of preventative infrastructure (“productive fuel breaks”) is being used to mitigate fire risk of woody encroachment, thereby retaining both rural populations and landscape multifunctionality. Similarly, traditional forest management practices in some mountain areas in central Spain, such as the Urbion model forest, have succeeded in maintaining traditional multifunctional management schemes (e.g. including timber, mushrooms, cattle, game, and recreation) as well as a low fire risk, by developing governance schemes that are deemed satisfactory for all of the stakeholders involved (http://www.urbion.es/) (Segur et al., 2014). Overall, these initiatives highlight the importance of developing policies that are well-grounded in ecological knowledge as well as aligned with governance mechanisms (sensu Ostrom, 1999) that ensure sustainability both at the local and landscape-territorial levels.

5. AUTHORS' CONTRIBUTIONS

E.V. conceived the structure of the manuscript and led the writing process. F.P., E.V., G.M., and M.A.Z. carried out the literature survey and wrote specific sections. All authors contributed critically to the drafts and gave final approval for publication.

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Data availability statement

This article does not use data.

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Table 1. Dynamics of forest expansion in the Mediterranean: Management interventions and policy recommendations

DYNAMICS OF FOREST EXPANSION				
Positive (+) Impacts	Negative (-) Impacts	Ecological basis for trade-offs between + & - impacts	Management interventions	Policy recommendations
Forest coalescence provides more habitat for forest-dependent species (Mangas et al., 2008; Regos et al., 2016) Biodiversity conservation and enhancement (Regos et al., 2016; Van Der Plas, 2016)	Increasing forest cover may lead to landscape homogenization, with reduced landscape-level multifunctionality and likely losses of farmland species (Burrascano et al., 2016; Carrascal et al., 2014; Otero et al., 2015)	Forest expansion may reduce fragmentation and provide habitats for forest specialist species. Land-use legacies seem to determine whether the overall/final impact of forest expansion is positive or negative. Forest expansion leads to sharper separation between forest and arable land, resulting in fewer habitats for species adapted to a biodiversity-rich anthropogenic landscape, with an overall decrease in β-diversity.	Maintenance of multi-functional agro-silvo-pastoral mosaics. Promotion of synergetic relationships with adjacent agriculture and forestry land-use types. Active support for extensive livestock grazing in heterogeneous landscapes. Locally based projects for biomass use.	- Natura 2000 network: More balanced inclusion of different land uses, considering agroforestry and grassland areas as valuable sources of biodiversity. Acknowledgement of and support for traditional landscape-management practices (e.g. extensive grazing) in biodiversity conservation efforts. - CAP* Pillar I: Intensification of support for High Nature Value farming and coupled agricultural lands. - CAP* Pillar II: Intensification of support for Less Favoured Areas. Afforestation measures should be coupled with control of the encroachment and homogenization of mosaic-rich landscapes due to forest expansion. - EU Biodiversity Strategy: The strict protection of 10% of the territory announced by the should not exclude extensive livestock grazing. The proposal to plant at least 3 billion trees can encompass the recovery, protection, and enhancement of trees in wood pastures, such as Dehesas.
Soil erosion decreases (Vallejo et al., 2012) Soil structure and overall conditions can improve in the revegetation of arable lands (Padilla et al., 2010; Vallejo et al., 2012; Van Hall et al., 2017)	Conversion from grasslands to forest yields inconclusive results (Dass et al., 2018; Muñoz et al., 2015; Padilla et al., 2010). Soil degradation is possible after land abandonment (e.g. via the collapse of terraces) or recurrent wildfires (del Campo et al., 2019).	Revegetation of arable lands produces a long-term increase in soil organic matter. The recovery of soil conditions after cropland abandonment due to vegetation encroachment is limited. Carbon storage may either increase or decrease.	Promotion of integrative land management, avoidance of compartmentalization between farm and forestland, and adoption of management practices that promote increased carbon storage in farmed soils. Implementation of stricter monitoring of landscape encroachment dynamics.	- Spanish national plan to combat desertification: it should move away from reactive approaches (restoration of forests burnt by wildfires) and work on the development of priority activities such as 'agroforestation' of agricultural lands or silvicultural treatments in forest areas. - Natura 2000: Acknowledgement of traditional ecosystem management practices as ES and biodiversity-conservation practices. Recognition of and support for traditional practices in grasslands and wood pastures as biodiversity hotspots.

* CAP: Common Agricultural Policy (European policy)

Table 2. Impacts of forest expansion on the provision of ES & EDS in the Mediterranean: Management interventions and policy recommendations

IMPACTS OF FOREST EXPANSION ON THE PROVISION OF ECOSYSTEM SERVICES (ES) AND ECOSYSTEM DISSERVICES (EDS)				
Ecosystem services (ES)	Ecosystem disservices (EDS)	Ecological basis for ES-EDS dualities/trade-offs	Management interventions	Policy recommendations
Improved climate regulation through C sequestration in woody biomass and soil (Romanyà et al., 2007; Vilà-Cabrera et al., 2017) Increased potential for biomass and timber provision (Pais et al., 2020; Verkerk et al., 2018)	Increased wildfire risk (Verkerk et al., 2018)	New forests may grow 25% faster than mature stands. Large C accumulation in biomass vs. negligible C accumulation in soil for decades. The evolution of these forests can be hampered by wildfires. Spontaneous forest expansion leads to high biomass content and vertical and horizontal connectivity, creating favourable conditions for the spread of wildfires.	Adoption of landscape approaches to forest planning, with fire-resilient (mosaic) landscapes wherein forest discontinuities are maintained in strategic areas with high wildfire risk. Management of forests to avoid high-density stands and wildfire-prone structures. Wood-biomass mobilization coupled with extensive grazing as a fire prevention tool. Exploration of the value of non-wood forest products to promote active forest management. Farmland protection (and even creation of new farms) and fire-smart management (conversion of shrublands and coniferous forests to deciduous forests) to reduce fire hazard and optimize biodiversity conservation.	- EU Bioeconomy strategy: Its implementation should enhance wood mobilization and the market for non-wood forest products through innovative linkages with local social agendas to overcome property fragmentation and low profitability of forest products. It should involve the adoption of a value-chain perspective from rural producers to the final consumer. - National and regional wildfire management plans should be based on the performance of indicators reflecting the minimization of socio-ecological damage and loss. To avoid lock-ins and fire paradox scenarios, they should aim for gradual increases in the budgets allocated to wildfire prevention activities rather than focusing on reactive policies oriented toward wildfire suppression. - CAP*: it must support grazing in woody ecosystems, removing the coefficients that result in penalization in area-based payments when trees are present. - Overarching principles: Embracement of a territorial perspective beyond forest- and farm-based measures and payments, in order to support local and landscape-level forest multifunctionality.
	Reduced water yield (Banqué Casanovas et al., 2020; Cosandey et al., 2005; Nasta et al., 2017)	Forest cover increases infiltration but also water losses via rainfall interception and transpiration. Forests increase green/blue water ratios with respect to grasslands. Streamflow can be reduced by up to 30% in some areas. Reduced tree density may negatively affect	Climate-smart forestry can improve both C sequestration and water provision through density reduction and promotion of open woodland structures. Silvicultural management aimed at the promotion of forests of mixed conifer and	- CAP* Pillar II: shifting of the focus of grants from afforestation and forest protection measures to sustainable forest management practices. - New EU Strategy on Adaptation to Climate Change: it should focus more on soil carbon than on carbon biomass. Climate change adaptation plans should be designed at catchment level.

		water quality.	broadleaved species would contribute to increase forest stand resilience. Density management would reduce stand vulnerability to increased climate aridity. Maintenance of coppice rotation and pollarding of ash, oak, and beech to prevent highly drought-vulnerable legacies.	- Result-based payments for ES: these should be enacted at landscape-level to favour additional C sequestration and blue water production, and their integration into sound forest-management policies. -Overarching principle: policies should foster the maintenance of traditional forest-management methods for obtaining firewood and forage.
	Increased water stress and tree dieback (Moreno-Gutiérrez et al., 2012)	Likely increases in aridity due to climate change are expected to increase the competition for water resources in Mediterranean countries. Drought directly affects tree performance and can exacerbate the impacts of mortality factors due to increased competition.		

* CAP: Common Agricultural Policy (European policy)