EIP-AGRI Focus Group
Forest Practices & Climate Change

MINIPAPER 8: Techniques and practices to manage fire risk in the forest (biomass management, Silvopastoralism)

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INTRODUCTION - MOTIVATION

Forests, unique in time and space, formed human history and are still closely related with our lives and future. Forests or forest ecosystems are characterized by the species they contain which are, in turn, depended on local environmental conditions and mostly temperature and precipitation. Climate and humans influenced and formed the present composition of forest ecosystems in the past with climate playing the leading role in the past but human actions taking the leading role lately. This influence was most evident in the Mediterranean basin in the past but is becoming evident throughout Europe lately with, among others, species composition changes and forest fires.

Forest fires, one of the modern environmental problems exacerbated by climate change, cause extensive damages, especially in areas where unfavorable climatic conditions are prevalent, that is, prolonged dry-season. The need for drastic reduction of forest fires occurrence and extend of disaster in forest ecosystems and neighboring areas is imperative due to the loss of human lives, forest capital, private property, public infrastructure they cause and extensive environmental degradation with the release of large amounts of greenhouse gases further accelerating climate change and air pollution by smoke particles.

The reduction of forest fires and their risk can be achieved by the application of two categories of complementary measures, ie prevention measures and suppression measures.

Prevention measures refer to the *management of forest biomass (including annual grass, litter and dead wood, bushes, trees)*, landscape management (avoiding forest continuity, and homogenization and draining of peat soils and restoration through rewetting of drained peat soil), the *reduction of fire outbreaks* and the *information/education to the public*. Suppression measures are related to quick scenario assessment, *firefighting* and *infrastructure*, such as access roads and water supply points. Effective implementation of these measures requires a reliable fire risk assessment.

In this mini paper we will elaborate on techniques and practices to reduce forest fire risk. This information is needed as it will be used by practitioners, forest managers and policy makers.

ACTIONS TO REDUCE FOREST FIRE RISK

Forest fires depend on the triangle "fuel, oxygen, and heat" to ignite and spread so any forest management actions that need to be implemented can relate to the "fuel", "spread" and "cause to ignite" part. The usefulness of such actions is related to the readiness of firefighting forces and the adoption of long-term and short-term measures, such as, for example, define specialized locations for bbqs, camping, better information of the public or the prohibition of a. barbecuing in the countryside for a certain period of time, b. burning of residues etc. These actions facilitate forest management planning on a long-term basis and are imperative for forest health and its resilience. A powerful tool to forest management has to always take into account a number of factors based on the location.

In the following paragraphs we will present forest practices and techniques that reduce forest fire risks and, consequently, mitigate climate change by less GHG emissions and biomass release (reduction). We will separate these in long and short-term practices.

1. SHORT-TERM PREVENTION PRACTICES

Forest management which includes planning and rigorously implement thinnings and tending operations so to reduce flammable and flammability of biomass and transfers of organic matter to litter and deadwood pools, promote the bush or tree species whose residues are less prone to ignition. Short-term prevention practices include all those techniques that can be realized at a short time period or instantly. These include:

1.1 Silvopastoralism:

Description of key issue: Silvopastoralism represents an ideal tool to reduce amount of flammable biomass, especially for grass and woody vegetation of low height. Silvopastoralism is the agroforestry practice of

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livestock grazing in a land system composed of woody components. These wood components could be a forest species or other type of tree such as olive, cherries, apple etc or a combination of them. The major advantage of silvopastoralism is that livestock removes the flammable understory vegetation, enhances organic matter decomposition and nutrient mobilization by soil trampling (due to their traffic inside the system), diversify and enhance farmer's income from livestock products, which are generally of high quality, and several other ecosystem services (Figure 1). As with all land uses, silvopastoralism should be practiced under a sound management plan taking into account the carrying and stock capacity of the area.

State-of-the-art of research/practice: There is a clear indication that silvopastoralism may reduce forest fire risk by the removal of the flammable understory vegetation. Specifically, in an on-going experiment in Greece, it was found that since 2008 only 4.2% of the forest fires (over 30000 ha) included oak silvopastoral systems (Pantera et al 2017, unpublished data). More data will be available soon.

Existing best practices, tools: There are several best practice reports and examples that all indicate successful ways to reduce understory biomass, and subsequently reduce forest fires risk, by silvopastoralism. In the website of the AGFORWARD project (AGFORWARD, 2017), there are numerous successful, traditional or modern, examples as well as in the EURAF website (www.agroforestry.eu).

Figure 1: Grazing livestock removes understory biomass while providing extra income to the farmer through meat and dairy products. Regeneration is accomplished by protective measures (tubes and wire-nests in this picture) (photo by A. Pantera).

1.2 Thinnings / Creation and maintenance of forest fires prevention strips:

Description of key issue: Repeatedly removing woody biomass (thinnings or resulting from natural mortality), ensures both additional biomass and less standing and lying dead wood. This is especially important in removing large trees, under a sound management plan taking into account biodiversity conservation, which can generate large pieces of dead wood that burn slowly for long period of time, from which fire may restart later. Thinnings may contribute to biodiversity as they provide shelter to more fauna species. In certain agroforestry systems, land fragmentation created by the different land uses and management schemes, represents an excellent example of forest-fires breaks. Specifically, in the alley cropping agroforestry systems, the agricultural component may represent a forest-fire prevention and hault point. Forest-fire strips are one of the prevention measures applied by the Hellenic Forest Service.

State-of-the-art of research/practice: The fragmentation of large areas of forests by fire-breaks can be a successful measure to remove flammable biomass. These areas are also very important for the immediate access of firefighting forces to control a forest fire. It is a common forest fire prevention measures applied in Greece.

Existing best practices, tools, etc.: In the AGFORWARD site, there are numerous examples of alley-cropping systems (Figure 2) that may represent and explain the advantages of these low-height vegetation (mostly vegetables and cereals) strips (AGFORWARD 2017b). Some ZIF – Forest Intervention Zones in Portugal also assure the definition and maintenance of fire breaks with the landowners, because most of the forest is private.

Figure 2: Alley cropping, the agroforestry practice by which trees are planted in rows and the intermediate space is used for low-height crops such as vegetables and cereals, are excellent forest fire strips (Photo by D. Kitsikopoulos)

1.3 Clearing the stored biomass by mechanical means

Description of key issue: This issue is related to the previous one and refers to the removal of the existing flammable biomass by mechanical means such as tractors. It is a fast way to remove the accumulated understory vegetation as well as stumps and large roots but is limited by local topographic conditions, resources (time and funding) and labour. However it is also widely used in forest fires in Greece and Portugal to immediately create strips to hault on-going forest fires.

State-of-the-art of research/practice: Removal of stored understory vegetation by mechanical means (tractors)

Existing best practices, tools, etc.: In USA, in a pine forest, the owners use tractors to collect the pine needles understory which they subsequently sell for gardening for soil protection and enhancement (Wallace and Ward, 2011). Shrub control with a shrub shredder, besides decreasing flammable biomass also contributes to enhance carbon storage on soil (http://www.terraprima.pt/en/projecto/1). Of course all of the above involve subsequent biomass removal.

1.4 The use of prescribed fire

Description of key issue: This issue refers to the removal of the existing flammable biomass by the use of fire. Prescribed burning can be described as "to reduce the level of vegetation fuel (shrubs, litter, grass, etc.) to decrease the risk of fire". The technique is applied by specialist teams (foresters, fire fighters, etc.) (www.fireparadox.org). Besides the contribution to the biomass control, prescribed fires can also be used with the goal to maintain and restore native ecosystems composition, structure and function, because fire is a natural component in the Mediterranean climate, but wildfires should no longer occur due to the social, economic and environmental impacts.

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State-of-the-art of research/practice: In Portugal and several other countries, the use of prescribed fire is regulated by law, can only be performed by accredited technicians, with an approved Prescribed Fire Plan and an Operational Burning Plan. Several research projects contributed to the definition of the proper climatic conditions (temperature, wind, etc) to the use of prescribed fire according to the site characteristic's (vegetation, slope, humidity content, etc.). Some constrains are reported in relation to this technique: commercial constrains (e.g. cannot be used in cork oak forests because decreases the cork economic value) and environmental constraints related to the GHG emissions. There's no consensus among the scientific community about this issue because there is large uncertainty associated with estimating carbon emissions from both prescribed fires and wildfires. Estimates depend on a wide range of fire regime factors, including the severity and type of fire, as well as the spatial heterogeneity of the vegetation and post-fire recovery patterns (Weidinmyer and Neff 2007 cited on Association for fire ecology et al, 2013), but those in favor argue that the merits of prescribed fire outweigh potential carbon emission effects in the long-term.

Existing best practices, tools, etc.: www.fireparadox.org (e.g. demonstration sites, handbooks and simulators); http://idlcc.fc.ul.pt/MDMF/index.php (e.g. maps and meteorological / forest data);

2. LONG-TERM PREVENTION PRACTICES:

Long-term prevention actions include all those techniques that require a long-term management plan and cannot be accomplished at a year-level. These include:

2.1 Environmental education

Description of key issue: Education represents the "Alpha" and "Omega" in all environmental issues and has to precede and complement any action including forest fires prevention and climate change measures. It can include all educational levels and it has to be an on-going process. Any prevention measure has no meaning if it is not in parallel supported by environmental education as many of the forest fires are related to the human factor. Young children have to be aware of the multiple goods forest provide to them, their families and the social context they live in, in order to become active ambassadors to environmental protection and, of course, forest fires prevention. The same is true also for adults.

State-of-the-art of research/practice: In an environmental awareness research that was conducted with the people living in or close to a traditional valonia oak silvopastoral system, it was found that young children of age 6 – 12 were more concerned and wiling to actively protect the forest against, among other threats, fires than children of ages 12-16, less in 16-18 and even less local inhabitants of over 18 years old (Pantera et al 2013).

Existing best practices, tools, etc.: There are numerous environmental education centers in Greece and other countries who may, and many do, actively participate in environmental education on forest fires prevention (KPE 2017). In Portugal, forest services assure annual awareness programs, including the "young volunteer to the forests" in the prevention side of the fire issue.

2.2 Policy including overcoming land use conflicts and enforcing legislation on forest land use and possible changes

Description of key issue: Forest continuity at the landscape scale (both in forest land and forest structure) favours spread of fires and, in the end, the increase of the so-called megafires (San-Miguel-Ayanz et al. 2013). Forest modeling and management at the landscape scale is evolving at the academic level but is very difficult to implement due to policy and ownership idiosyncrasy reasons. It is important to overcome these barriers in order to prevent potential catastrophes at higher scales.

State-of-the-art of research/practice: Models demonstrate the importance of landscape structure affecting fire spread. However, it is still necessary to understand the fraction and distribution of agricultural land needed to prevent the spread of megafires. Similarly, the role of the critical wildland–urban interface in preventing massive crown fires is not clear yet (Loepfe et al. 2012).

Existing best practices, tools, etc.: An example is the "The FIRE PARADOX project" (Fernandes et al. 2011); Busby et al. (2012), and more information can be also found in minipaper 1 of this series. A detailed description on policy and how it can affect the adoption of a specific land management practice (in this case agroforestry) is given by Dr. M.R. Mosquera-Losada under the framework of the AGFORWARD project (Mosquera- Losada et al 2017).

2.3 Innovative afforestation and species selection:

Description of key issue: Afforestation of marginal and degraded lands is seen as one key action to enhance the removals of CO_2 from atmosphere and store it permanently in C pools on land. Nevertheless, afforestations have particularly high risk of failure, because of high exposure to natural disturbances, among which fire is most prevalent. Reforestation with less demanding species such as valonia oak (*Quercus ithaburensis* subs. *macrolepis*) is important for degraded and xeric habitats of lowland and foothill zone (Pantera 2001). This choice of species should ensure the ecological balance in inhospitable environments for the more demanding deciduous and broadleaved species, protecting the soil from erosion. Also, the direct relationship of the organic matter to carbon cycle in forest ecosystems, and thus with the mechanisms of the Kyoto Protocol, strongly raise the need to assess the biomass of different forest species.

State-of-the-art of research/practice: expensive activities of maintenance of soil cover in "black" (with artificial soil cover) in young plantations (no grass); permanent ground survey of fire prone areas; early thinnings; promotion of roots-based coppices collection of dead wood and especially dead stumps removal;

Existing best practices, tools, etc.: enforcement of post-harvest crop fields clearing by burning or sowing in the field after harvest; larger planting schemes which prevent early formation of thick litter deposit; planting tree species which form thick bark in early ages; establish afforestation with fire-breaks. Excellent examples of this are given by the science of Agroecology (AGROECOLOGY EUROPE 2017).

2.4 Conversion of abandoned agricultural lands-how to share the benefits?

Description of key issue: Land abandonment due to lack of rural development results in uncontrolled afforestation and forest densification. This results in biomass material increase, with the subsequent increases in forest–fires risks, as described before. Moreover, such lands are normally associated with difficulties in finding the owner. Legislations and innovative ways of shared management (and potential benefits) should be implemented in order to carry out the appropriate short-term prevention actions.

State-of-the-art of research/practice: Semi-arid but also mountainous or low productive areas in Southern Europe are the most recent areas affected by land abandonment. In any case, all over Europe, still 3–4% of current farmland is considered to be affected in the near future.

Existing best practices, tools, etc.: http://ec.europa.eu/eurostat/statistics-explained/index.php/Agri-environmental_indicator_-_risk_of_land_abandonment

2.5 Rewetting of drained peat soil

Description of key issue: Wetlands provide barriers to the spread of forest fires. Draining of peat soil to enable the use of the drained land for forestry may improve forest productivity but it also increases the risk of forest fire and leads to substantial emission of greenhouse gasses to the atmosphere (Meyer et al. 2013; He et al. 2016).

State-of-the-art of research/practice: Draining of peat soil is widespread, at least in boreal areas.

Existing best practices, tools, etc.: Rewetting of drained peatland not only provides protection against forest fire but also contributes to climate change mitigation.

Finally, as mentioned at the beginning of this mini-paper, a very important action to reduce forest fires risk includes the organization of existing practices and actions and the acquisition of any additionally needed.

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3. CONCLUSIONS

Summary of lessons learnt on the key issue

Forest fires have been closely interrelated to Mediterranean landscapes and environment since the beginning of recorded history. What changed in time is the type of human interventions and their intensity. So, the study of human interventions and the acts that should be taken to confront them, are really important to confront forest fires and reduce their contribution to climate change through reduced GHG release and biomass release.

Based on the above, short and long-term prevention practices can be applied. Of the short-term ones, forest management is very important and includes planning and rigorously implementing thinnings (and tending operations), and promotion of those plant species whose residues are less prone to ignition. Silvopastoralism, an agroforestry practice, represents an ideal tool to reduce the amount of flammable biomass, especially for grass and woody vegetation of low height. Another tool is thinning and the creation and maintenance of forest fires prevention strips. Repeatedly removing woody biomass, resulted from thinnings or natural mortality, ensures both additional biomass for harvest and less standing and lying dead wood. In agroforestry systems, land fragmentation created by the different land uses and management schemes, represents an excellent example of forest-fires breaks. Clearing the stored biomass by mechanical means, such as tractors, can remove the existing flammable biomass contributing to farmers' income by the resulting removed biomass. Another tool is prescribed fire that should be used with caution and under an approved "Prescribed Fire Plan" and an "Operational Burning Plan". The long-term prevention actions include all those techniques that require a long-term, in time, management plan. Maybe the most important one is environmental education which has to precede and complement any action including forest fires prevention and climate change measures. Another important tool is policy including overcoming land use conflicts and enforces legislation on forest land use and possible changes. Forest modelling is a useful tool to demonstrate the importance of landscape structure affecting fire spread. Still research is needed to understand the fraction and distribution of agricultural land needed to prevent the spread of mega fires. Afforestation of marginal and degraded lands is seen as one key action to enhance the removals of GHG from atmosphere and store it permanently in C pools on land. Other practices involve the conversion of abandoned agricultural lands and the identification of the ways to share the benefits, and the rewetting of drained peat soil as wetlands provide barriers to the spread of forest fires.

4. RESEARCH NEEDS

a. Knowledge gaps to be covered by Research:

- ✓ review studies on ignition and propagation of forest fires, identification of the land uses and practices that are most suitable to manage an area prone to fires, which forest management techniques provide more fire-resistant forests,
- ✓ Is necessary to investigate how fire suppression policies influence fire regimes (Piñol et al. 2007). In general, more attention should be given to anthropogenic factors when generating landscape projections (Brotons et al. 2013).
- ✓ Research and technical efforts should aim at identifying areas that have not previously faced high fire risks, and therefore may have low vegetation resilience, but might suffer from forest fires due to climate change.
- ✓ Research to develop strategies for the adequacy of communications (see minipaper 1 in this series).
- ✓ Reinforce carbon dynamics studies according to the fire regime and management options (e.g. wildfires versus prescribed burning).

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b. Research needs from practice:

- ✓ Across existing affected afforested areas identify the tree species that behave better according to peak of fire season: tree species with late and slow, than early and fast seasonal leaf falling (e.g. senescence in oaks) or tree species with long continuous annual growth which tend to have a long period of falling leaves over late summer so high decomposition already in year of their growth (e.g. *Robinia*);
- ✓ Identify tree species which have good post-fire behaviour: vigorous sprouting from roots or stumps with and without management intervention, tree species with less numerous sprouts, able to get vigorous foliage and/or new branches after burning;
- ✓ There is always a need for reliable data on the efficiency of fire and fuel management initiatives at mid to large spatial and temporal scales.
- ✓ Standards for the adequacy of communications (see minipaper 1 in this series).

5. IDEAS FOR INNOVATIONS

Ideas for innovative projects /solutions

- A RIA on developing, testing and, especially, implementing DSS at the landscape scale, considering the environmental and economic benefits of fire prevention strategies.
- Develop low-fire mosaic spatial models - landscape level planning of crops and woodlands establishment, efforts for rewetting of drained peat soils, taking into consideration the local soil and relief features, and set up regional/local pre-screening tools of fire management for concerned agencies
- Focus public funding to develop wood industry based on fire tolerant tree species and wood that was damaged by forest fire
- Develop field trials with exotic species (after screening of all environmental risks)
- Investigate agroforestry systems relation to forest fires risk

6. Potential EIP AGRI Operational Groups

1. OG on the development of local strategies to locate the owners of abandoned lands, together with administrations, landowners, associations, researchers, etc.

2. OG on agroforestry practices to reduce forest fires risk

Further research needs coming from practice, ideas for EIP AGRI operational groups and other proposals for innovation can be found at the final report of the focus group, available at the FG webpage https://ec.europa.eu/eip/agriculture/en/content/focus-groups/new-forest-practices-and-tools-adaptation-and

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