



FOREST ADAPTATION TO CLIMATE CHANGE

-FRECUENTLY ASKED QUESTIONS-



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CONTENT

1. EFFECTS OF CLIMATE CHANGE IN FORESTS	¡Error! Marcador no definido.
2. WHAT CAN WE DO?	5
3. NATURAL SOLUTIONS FOR ADAPTATION TO CLIMATE CHANGE.....	7
4. MATURE STANDS AND ADAPTATION.....	¡Error! Marcador no definido.
5. ADAPTATION AND ECONOMIC USE.....	9
6. THE OWNER'S PERSPECTIVE.....	¡Error! Marcador no definido.
7. TO LEARN MORE	13

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1. EFFECTS OF CLIMATE CHANGE IN FORESTS

What is the role of forests in the context of climate change?

Forests are one of the main carbon stores on earth. They significantly contribute to remove CO₂ from the atmosphere through photosynthesis and keep it sequestered for centuries. Moreover, at a local scale, they play a very important role for microclimate control, since they provide mild temperature and greater humidity.

But, on top of the ability to capture carbon, forests bring a great number of services to society: they provide raw materials, they are essential to keep a fertile soil, they regulate the water cycle, they are a reservoir of biodiversity, they provide recreation opportunities and they contribute to human wellbeing and health. Climate change can affect these services; therefore, we need to work to adapt forests to new climate conditions, guaranteeing their maintenance in the long term.

How will climate change affect forests?

At a global scale, climate models predict rising temperatures, particularly minimum temperatures, and increase in the intensity and duration of heat waves. Regarding rainfall, it seems there will be a reduction in the total amount of rain, although the trend is not that clear; what models do predict is a greater frequency and intensity of extreme events, such as storms and floods.

Although the severity of these changes might vary depending on each particular context, in general these new scenarios make us think that forests will be affected, both from a physiological and ecological point of view: most likely, forests will suffer a loss of strength and decay due to thermal stress and lack of water. This will result in poor resistance against insects, fungus, mistletoe and other pathogens, changes in the species composition (with the disappearance of some), greater frequency of favourable conditions for major fires (high temperatures, low atmospheric humidity and wind) and greater occurrence of tree falls caused by gale.

Why are forests vulnerable to climate change?

Most European forests and especially Mediterranean forests are the result of heavy human use. For centuries, forests have provided firewood and timber and have been a source of food and shelter for livestock. But in the last decades, forests abruptly stopped being used this way and most

forest's new surface grows on former croplands. On top of this, over five million hectares have been repopulated since the beginning of the 20th century.

Therefore, most of our forests are young, thick and homogeneous – and thus they face high competition. They lack age diversity and their small or medium bearings and poor species often occupy big continuous areas with barely any clearings or gaps. This structure makes them highly vulnerable to climate change and to disturbances such as fires, droughts or plagues that could become heavier and more frequent.

Which forests are more vulnerable to climate change?

Even though a case-by-case assessment is necessary, in principle there are some forest types that will be more sensitive to the effects of climate change. On the one hand, those that are currently already in non-optimal conditions, such as those that are on the edge of their distribution area (for instance, beech forests located on southern boundaries) or those who are submitted to environmental stress conditions or degradation conditions. Moreover, young forests such as those that regenerate after fire, those that have recently colonized croplands or many repopulations on which works to reduce density have not been carried out can be highly vulnerable to droughts, plagues and fires. To these, we need to add relict, very fragmented or very small forests, forests that are linked to the presence of water (riparian forests), and forests on basins where a reduction of water resources will likely take place.

Forest types that are better adapted to thermal and xeric conditions, such as oak groves or Aleppo-pine woodlands, might be in a better position in some situations as opposed to more vulnerable forests. Nevertheless, on semi-arid areas of distribution they could also disappear and give way to treeless landscapes and ultimately to desertification.

2. WHAT CAN WE DO?

Adaptation or mitigation?

We propose two strategies to face the climate change challenge: mitigation and adaptation. **Mitigation** is about reducing greenhouse gases emissions (CO₂, but also methane and others) as much as possible at the same time that the elimination of the excess of these gases in the

atmosphere accelerates. Forests are responsible for the capture of at least one third of the world CO₂ emissions, but they are also responsible for between 20 and 25% of global emissions caused by deforestation.

Adaptation is about preparing ecosystems and societies to the predictable effects of climate change. Forests are essential ecosystems for human wellbeing, therefore guaranteeing their adaptation to new ecological conditions is a priority.

These strategies should be complementary and consistent. For instance, carbon rich soils also have benefits such as a greater water holding capacity and a reduction of the risks of erosion: both are important aspects for adaptation.

What is resilience?

Resilience is the ability of an ecosystem to recover its structure and functioning after being modified by a disturbance (for instance, forest regeneration after a fire). In the context of climate change, with more frequent and intense extreme events, resilience contributes to a greater adaptability to change.

What can we do to adapt forests to climate change?

Preparing forests to face climate change demands working in different directions. On the one hand, we need to improve forests' resilience, that means their ability to recover after disturbances (like a drought, a storm or a fire). And on the other hand, we need to improve the species and ecosystem's ability to adapt when facing chronic dangers —such as the rising of temperatures, the change of rainfall patterns, etc.—. Well-preserved, diverse and well-balanced forests will be increasingly more resilient and will have greater ability to adapt.

We need to accept that forests change and that they naturally adapt to the changing conditions of their environment. Nevertheless, the speed of change in climate conditions exceeds this ability and therefore we need to manage this change to prevent undesired conditions for forests (desertification is an extreme one) and in order not to lose the ecosystem services they provide.

This adaptation will happen on two dimensions: the local dimension and the landscape dimension. The **local** (or “stand”) dimension acts on the species composition, the density, the age structure, etc. The **landscape dimension** will promote a mosaic of stands of varying ages and different

habitat types (open and wooded areas) in order to obtain a more resilient landscape as a whole.

What type of actions should be carried out?

There are many measures that can be implemented in order to improve forests' adaptation abilities.

Some focus on the preservation of well-preserved or highly vulnerable strongholds and on the maintenance of natural processes through the creation of reserves or strictly protected areas.

Others might require forestry initiatives, such as causing natural regeneration through small disturbances, promoting that trees of different ages live together, increasing the diversity of the tree canopy species, or clearing the forest to reduce competition.

Larger scale interventions could be considered such as improving the forest species' ability to spread (connectivity) or creating landscape mosaics where different types of forests are combined with open areas; to this end we could use controlled fire or livestock.

Moreover, restoring rare habitats such as small wetlands or peatlands are relevant actions, together with paying special attention to some species that are particularly vulnerable to climate change, with exceptional actions that could lead to assisted migration or *ex – situ* breeding.

3. NATURAL SOLUTIONS FOR ADAPTATION TO CLIMATE CHANGE

What are “natural solutions”?

As opposed to adaptation solutions based on technology or engineering (for instance, the building of dams to avoid sea storms), the so-called “natural solutions” are those that promote the preservation or restoring of ecosystems in good conditions as a more effective adaptation alternative (for instance restoring dune fences or reefs).

They get inspiration from nature and imitate it to solve problems and bring many simultaneous benefits. They are cheaper and more efficient since they comprehensively approach social, economic and environmental challenges (among them, climate crisis and biodiversity).

Particularly considering forests, natural solutions aim at keeping or restoring favourable conditions for conservation as a tool to improve the capacity to adapt. Some examples of natural solutions for forests:

diversifying the species composition, improving their structure, promoting greater heterogeneity or diversifying the landscape through the inclusion of more mature stages.

Are adaptation and biodiversity preservation compatible?

Yes. Every adaptation strategy needs to consider forest preservation in order to guarantee forests' existence in the long-term. Actually, the so-called "adaptation-based ecosystems" revolve around the idea that ecosystems in good conditions, those that preserve their components (species) and their functions, are more resilient and have greater ability to adapt to new situations.

What makes an adaptation strategy different?

Forest adaptation strategies should not be in principle too different to those that are carried out with other objectives, such as reducing competition for water or preserving certain biodiversity elements. Nevertheless, their key feature is to clearly specify climate change adaptation objectives: the final goal of an adaptation strategy should be to guarantee the continuity of most goods and services that forests provide in the context of change due to climate conditions.

Therefore, specific attention to future climate models and the assessment of ecosystems vulnerability to climate change are necessary, together with an ongoing analysis of results.

4. MATURE STANDS AND ADAPTATION

What are mature stands?

In forests, mature stands are those fragments that have remained unused and free from recent disruptions and that have aged naturally. Under these conditions, mature stands show very particular features: big centennial trees, variety of tree species of various ages, clearings that are formed when old trees die and fall and deadwood (see [Proyecto LIFE RedBosques](#))

These stands are highly valuable and host exceptional biodiversity with many threatened and fragile species. Therefore, these stands need to be identified, protected and studied.

Attributes linked to forest maturity are good indicators of a highly valuable and threatened biodiversity. Therefore, mature stands can be used as a reference for ecological recovery that aims at preserving biodiversity linked to maturity.

How can mature forests contribute to adaptation?

When forests in mosaic shape endure, with patches that show the different stages of ecological succession and that include mature stands or strongholds, we find a resilient mosaic able to adapt to varied climate conditions.

Moreover, the most mature stands could become models or inspiration for forest management aiming at improving ecosystems' integrity when trying to strengthen adaptation abilities.

What aspects of forest maturity are linked with greater resilience?

LIFE RedBosques_Clima project aims at identifying the structures and the species composition that are found in mature stands (and the processes that generate them) linked to greater resilience so that they can be used as a reference when designing management strategies that try to improve the adaptation abilities of younger forests. The following stand out:

- greater diversity of forest species with different and complementary functions
- the coexistence of trees of varying ages
- clearings and gaps in the tree canopy
- big decomposed trunks
- more species that are tolerant to drought conditions

5. ADAPTATION AND ECONOMIC USE

Are adaptation measures compatible with forestry use?

Often, adaptation measures are precisely based on promoting use as a way to reduce forest vulnerability (by reducing density, underbrush coverage...). In any case, these strategies need to be viable in the long term (considering climate scenarios) and improve forest preservation conditions, guaranteeing forests' continuity.

Among the various options, adaptation based on natural solutions seems particularly appropriate for mountains where the main objective is to

preserve biodiversity (particularly for protected areas) since it will aim at improving the preservation conditions as a tool for adaptation. This approach that aims at biodiversity preservation is reinforced in Natura 2000 areas, where there is a legal framework that compels to preserve certain habitats and species. This adaptation model could also be useful in “protective” forests that do not suffer major forestry use but play other relevant roles (erosion control, microclimatic, recreational...) and that might be affected by climate change.

Nevertheless, this type of forestry management does not necessarily imply the lack of use (although it could happen at some point) and the improvement of forest preservation conditions is compatible with its use. Even mountains that are mainly productive can be managed with an approach that combines commercial exploitation with the improvement of preservation conditions. For those mountains where exploitation is not possible (remote, inaccessible areas...) restoring natural conditions might be the most efficient option for adaptation.

How to promote adaptation measures?

The main difficulty for the effective adaptation of forests is the lack of management capacity due to the enormous surface that we need to act on. At a time of abandonment of rural areas, lack of manpower and when forestry measures are profitable only in some places (in general in those areas where mechanisation is possible), the challenge is to involve public and private owners, to mobilize new funds and to develop novel methods with lower cost and lower maintenance in the long-term, such as the renaturalisation of ecosystems.

People who have a relationship with the forest and its preservation are responsible for the implementation of adaptation measures: planners, managers, owners, users, etc...

Can we keep managing forests as usual?

Forests need a planned management in order to reach multiple objectives as society demands. Among them, adaptation to climate change stands out. In some cases, the preservation of natural processes and non-intervention will be necessary, for instance in order to protect highly mature areas. In others, forestry techniques will be a key tool to reach adaptation objectives. Operations to reduce mass density, opening of clearings, selection of trees, etc... have been carried out for decades

with different objectives in mind and can now be redirected in order to reach biodiversity preservation objectives and climate change adaptation goals.

Other techniques such as restoring of habitats, management of key processes like wild or domestic herbivory or fire control, could also be used.

6. THE OWNERS' PERSPECTIVE

How can we get funds for adaptation measures?

In some cases, forest adaptation measures will take the shape of silviculture treatments (spacing, weeding, cleaning...). When the products that are obtained have value (wood), there will be commercial gain from the forest and therefore direct profit for the owner. Often, the obtained resources will be enough to finance adaptation measures.

But, in remote and inaccessible areas, or low-productivity areas due to environmental conditions, getting direct profit from selling timber will be difficult. In that case, there might be economic return in the mid-term from recreational, tourist and hunting use...

Mature forests with no direct economic value could become profitable if they increase the ecosystem services they offer in the future, such as headwaters that lead to reservoirs, soil retention or nature enjoyment.

Often, these actions will have to be funded by the Administration to be viable, either through specific funds addressed to forestry management, aids to ownership, tax benefits or other financial mechanisms.

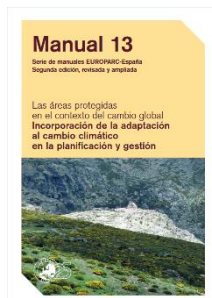
In the case of protected areas, opportunities to use these alternative funding options are easier to find.

Why is it interesting for a private owner to adopt adaptation strategies?

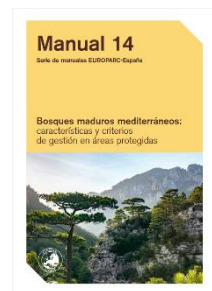
For most forest owners, economic profit is not the main driver for their activities. Attachment to the land and inherited responsibility over heritage that should be passed on to next generations in good conditions often play an important role in the decision-making process. In our current climate change context, when increasingly frequent major disruptions such as fire and drought are taking place, forest management aiming at risk reduction (increasing biodiversity, heterogeneity, etc) and therefore maintenance of ownership in good conditions is a good project for those mountains and an incentive to be more active at management for many owners.

In short, adapting forests to climate change means reducing the risk of losing their heritage and will lead to current and future forest benefits for owners.

7. TO LEARN MORE ...



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