

# Guide to Action

## Reducing the risk of forest fires

Compilation of prevention and management practices  
in mountainous areas in Southern Europe







Typical forest in the mountains of Southern Europe.  
Credit: CREAM.



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Typical forest in the mountains of Southern Europe.  
Credit: Associació de propietaris del Montnegre i el Corredor.



# 1. Why this guide? The problem of forest fires in forests in Southern Europe

Forest fires are one of the world's most significant hazards, not only due to their effects on natural resources but also because of the direct and indirect damage they inflict on people and property. Their risk is having a huge impact on Mediterranean mountainous areas, where in spite of forest fires being a common occurrence, they have become more frequent, intense and numerous over recent decades, affecting larger areas.

In these mountainous areas of the Mediterranean, temperature increases, episodes of extreme drought and variable rainfall, all a result of climate change, have reduced the water content in plants and the soil. Along with increased evapotranspiration, this has exacerbated water stress, as well as the likelihood of high-intensity fires, due to an increase in the number of days with extreme fire risk. On the other hand, the abandonment of agricultural and livestock practices in rural areas on the north coast of the Mediterranean is causing crop and pastureland to be progressively replaced by tree species, increasing the amount of forested land. If, in addition, these forests are not properly managed, as a result of this abandonment and the low returns on forests, and they are usually located in periurban areas mixed with residential buildings, we are left with dense forest stands<sup>1</sup> with low vitality and growing vertical and horizontal continuity, creating an enormous amount of available fuel close to areas at risk of ignition. This is especially alarming in the context of the risk of sixth-generation fires, characterised as spreading extremely quickly and capable of altering local meteorological conditions, making them almost impossible to extinguish.

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1. A forest stand is a group of woody plants that cover a relatively large area and interact with each other (together as a community) and grow in relation to their environment.

Faced with this situation, tough preventative measures are required. How a fire spreads is determined by three factors: meteorology, topography and fuel; of which fuel is the factor that can be better controlled, namely by suitable forest management.

This is why forest management has begun to incorporate many fire prevention practices in recent years. Nevertheless, it is not always easy to recognise what these entail, their differences or the best practices for each situation and specific objective.

This guide aims to resolve these questions and gather current knowledge on forest management practices that prevent fires. The final aim is to provide tools for forest managers and owners to be able to tackle the growing risk of forest fires.

Burning of logging residues to reduce the fuel load available.  
Credit: Associació de Propietaris del Montnegre i el Corredor.



## 2. What are we proposing?

### Guide aims

The main aim of this guide is to compile the various practices that can be implemented from a forest management perspective to prevent fires and prepare for their impacts, on a small-scale "estate" level. It also aims to detail when, how and where to apply each of these practices with the intention of facilitating decision-making.

This guide is designed to be used by forest owners and managers of agro forestry estates. It does not attempt to focus on designing infrastructures to prevent fires, as this must be tackled in actual fire prevention planning. Instead, it aims to include small management actions in order to improve the way an estate affected by forest fires can prepare for them. Therefore, this guide can be seen as an overview providing managers with the actions proposed from various perspectives, which have come out of specific forest interventions.

This document refers throughout to the practices and regulations provided in large forest fire prevention planning in Catalonia. With some adapting, these guidelines can be extended to other mountainous regions of the Mediterranean and represent the solutions that are being used in many other areas. In the same way as the Special Emergency Plan for Forest Fires in Catalonia (**INFOCAT Plan**) it includes ideas, practices and solutions from many regions in Mediterranean Europe and the world that have similar problems with the risk of large forest fires. As such, this guide is based on the following sources: fire prevention plans (PPI), in particular the most recent drafted on forests in mountainous areas (Priority Protection Perimeters or PPP, as set out in the INFOCAT Plan); prevailing legislation; proposals to adapt forest management to include the risk of large forest fires (LFF) (Piqué et al, 2011); and the latest proposals for adapting Mediterranean forests to climate change.



The practices mentioned in the guide fall into two main groups:

1. Urgent actions to protect infrastructures from large forest fires and altering fire behaviour to reduce the risk of spread.
2. Incorporating fire into forest management as an aspect to consider in decision-making; taking into account the potential impact of fire on an estate and how to create more resistant and resilient structures and provisions.

Each group describes each of the actions that encapsulate its objectives, when and how to perform them, as well as their strengths and weaknesses. A flow diagram will be included to facilitate the selection of each action.

Aerial view of the Alt Empordà (Girona, Spain) after a fire in July 2012. The fire affected 13,000 ha and killed four people.  
Credit: Albert Álvarez.





### 3. Compilation of practices for the prevention and management of forest stands against fires

This section compiles the practices for the prevention and management of forest stands against fires. Each practice will be described in greater or lesser detail, depending on its type. Practices with lesser detail indicate greater flexibility for adopting actions depending on the characteristics of the area in question. These have been organised into the following two types of actions:

- A.** Urgent actions for protecting infrastructures and altering the behaviour of a fire
  - Reduction of the impacts of a fire on the key infrastructures of an estate (i.e. buildings, roads, crops, etc.)
    - a.** Protection strips (FP)
    - b.** Auxiliary traffic strips or accessibility strip (FAT)
    - c.** Urban-forest interface (IUF)
  - Altering a fire's behaviour.
    - d.** Strategic Area (AE) or Strategic Management Points (PEG)
    - e.** Complementary Area (AC) or Management Development Areas (AFG)
- B.** Actions that incorporate fire into forest management as an aspect to consider in decision-making
  - Reduction in the vulnerability of forest stands to fire and preparation for greater resistance and recovery.
    - a.** Improvements in landscape structure and composition. Development of mosaic landscapes, alternating open spaces (agricultural land or pastures), pastureland with low-density trees, and forests.
    - b.** Improvements to the structure and composition of forest stands. Increased complexity.



### 3.1 Urgent actions for protecting infrastructures

This section focuses on urgent actions aimed at protecting from fires and altering the behaviour of a fire to reduce the risk of its spread. Figure 1 shows the various types of actions and documents referred to and commented on in this section.

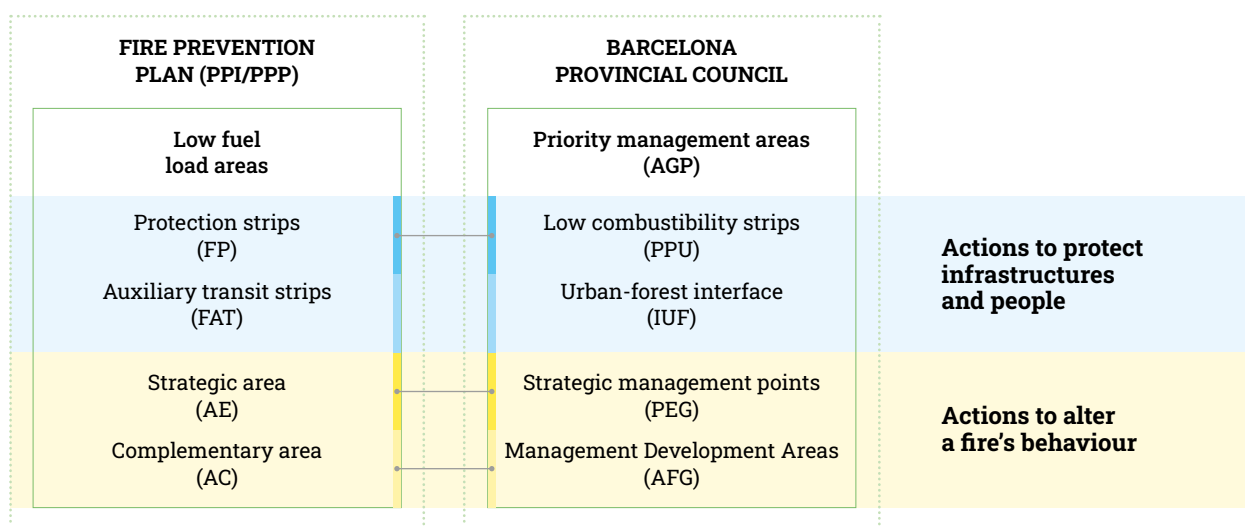


Figure 1: List of figures and practices applied in Catalonia.

#### 3.1.1 Actions whose main aim is to reduce a fire's impact on key estate infrastructures

This concerns a set of urgent actions that have a two-way function: protection of key estate infrastructures in the event of fire and reduction of the amounts of fuel close to possible points of ignition.





Protection strip (FP) around a residential development.  
Credit: Associació de Propietaris del Montnegre i el Corredor.



## Protection strip (FP)

**Definition:** According to Catalan law 5/2003, of 22 April, on prevention measures against forest fires in residential developments not immediately connected to the urban grid; this is defined as *"an area of at least 25 m around residential developments, buildings and installations not immediately connected to the urban grid, free of dry vegetation with a thinned forest stand."*

Aims	Effect sought against fire
Improve infrastructure protection (housing, stores, plantation, roads).	Reduce the forest fuel load around an infrastructure.
Improve mobility around infrastructures.	Reduce the risk of spreading close to potential ignition points.

## Where?

The specific location can be viewed in the Prevention Plan for Residential Developments (PPU) of the municipality in which the residential development or isolated building/installation is located.

Compulsory	Optional
Residential developments not immediately connected to the urban grid located less than 500 m from forest land.	Buildings and installations with an agricultural or livestock purpose.
Isolated buildings or installations located on forest land.	Attached housing.

## Advantages/disadvantages

Strengths	Weaknesses
Easy implementation as a result of clear criteria with legal backing.	Lower FCC means more light reaching the ground, encouraging the regrowth of shrub species and favouring evapotranspiration. This increases maintenance efforts and costs, as well as exacerbating water stress.
Compatible usages throughout grazing maintenance.	Maintenance must be regular for the reduction in fuel to be effective.
	Problem in maintenance via grazing: conflicts with domestic animals, low availability of resources.

## What and how?

Vegetation in the protection strips must comply with the characteristics established in Decree 123/2005, of 14 June, regarding prevention measures against forest fires in residential developments not immediately connected to the urban grid; or in the corresponding technical forest report.

### Management

#### Thinning and/or selective felling to convert into pastureland

Forest Canopy Cover (FCC):	< 35% <sup>2</sup>
Vertical discontinuity (distance between strata):	Yes
Horizontal discontinuity (distance between crowns):	Yes
Distance between adult trees (> 15 cm trunk diameter):	> 6 m (recommended 8 m)
Distance between shrubs or young trees (< 15 cm):	> 3 m

#### Pruning

Partial suppression of tree branches  
Branch-free trunk: < 5 m or < 2/3 of the tree's height.

#### Undergrowth clearing

FCC of undergrowth: < 15%<sup>3</sup>

#### Removal of logging residues (crown, pruning offcuts, etc.)

Cut and chopped (< 20 cm).  
Uniform distribution or removal: height < 1 m

#### Maintenance actions

Mechanical means (shredder, strimmer).  
Grazing.  
Controlled burning.

2. If there are no adult trees, the FCC of the shrubs and young trees, combined, can reach 35%.

3. In areas with gradients of over 40%, the maximum admitted cover can be increased to protect the ground from erosive processes. However, vertical discontinuity must always exist between the ladder fuel and the top strata. Ladder fuels are hanging or climbing vegetation at least 1.30 m off the ground that does not form part of the dominant or co-dominant strata. They include small trees, bushes, climbers or dead trees.



## Auxiliary traffic strips or accessibility strip (FAT)

**Definition:** Managing vegetation either side of a road. Management includes removing vegetation that may be overhanging the road such as tree branches that are growing into vehicles' headroom.

### Aim

Improve traffic safety during a fire.

### Effect sought against fire

Improve visibility on the road and in the immediate environment.

Facilitate access for extinction teams.

FATs are not designed to alter fire behaviour, limit spread, or make the roads a safe space in the event of being trapped by fire or for performing extinction manoeuvres.

## Where?

### Location

20 m of both verges, although this can depend on visibility, driving danger, curves, etc.

## Advantages/disadvantages

### Strengths

Easily implemented due to simple and clear criteria.

Easy maintenance and cheaper if a scrub-clearing machine is used.

### Weaknesses

Does not involve any alteration of a fire's behaviour or its effects.



## What and how?

Following the indications set out in the Government of Catalonia's Firefighter's Guide (GUI.INVE.003 V1.2020) is recommended for the definition of FAT.

### Management

#### Removal of vegetation overhanging the road

Cutback and removal of (tree-related) vegetation that may partly overhang road (width of the road and the vertical space above it).

Cutback and removal of branches and trees on both sides of the road that enter into vehicles' headroom: > 4.5 m in height over the road free of vegetation.

#### Pruning

Partial suppression of tree branches

Branch-free trunk: < 1/3 of the height of the tree and any that overhang the road and into vehicles' headroom.

#### Removal of logging residues (crown, pruning offcuts, etc.)

Cut and chopped.

Uniform distribution or removal: height < 1 m

#### Mowing

Removal of grass layer.

Width: 1-2 m.

#### Maintenance actions

Mechanical means: chainsaw, trimmer, tractor-mounted verge cutter.

Grazing.



Auxiliary traffic strips or accessibility strip (FAT) next to a road.  
Credit: Associació de Propietaris del Montnegre i el Corredor.



## Urban-forest interface (IUF)

**Definition:** Areas around residential developments, population centres, buildings and installations on forest land. They are areas adjacent to the compulsory protection strips (FP), which include hillsides or basins where a fire would travel that could affect residential developments, population centres, buildings and installations that need to be protected. Its main objective is to protect people and infrastructures.

### Aim

Improve protection for infrastructure (housing, stores, plantation, roads) and people.

### Effect sought against fire

Reduce the forest fuel load around an infrastructure.  
Reduce the release of burning particles causing secondary outbreaks in the vicinity of the houses.

## Where?

### Location

Between 100 and 500 metres beyond the compulsory 25 m protection strips (FP) around residential developments, population centres, buildings and installations on forest land.

## Advantages/disadvantages

### Strengths

Support the functionality of protection strips (FP).

Compatible usages possible if maintained by grazing.

Lesser need for maintenance than the FPs, given that the FCC is higher.

### Weaknesses

Difficult to implement due to unclear boundary criteria and no legal backing.



Urban-forest interface (IUF) around a residential development.  
Credit: Associació de Propietaris del Montnegre i el Corredor.

## What and how?

Actions are based on improving the structure and composition of the forest (see actions proposed in 'Improvements to the structure and composition of forests').

The aim of the actions is to reduce the fuel load and the uniformity of the forest and break up its continuity both vertically and horizontally.

### Management

#### Selective thinning or selective felling

Forest Canopy Cover (FCC):	70-80%
Horizontal discontinuity (distance between crowns):	Yes
Distance between adult trees (> 15 cm trunk diameter):	> 4-6 m
Maintenance of species present, encouraging maximum biodiversity.	
Selection of the most robust and healthiest trees.	

#### Coppice management

Species suitable for coppice management.
Selection of 1-3 coppice sprouts of the best developed and positioned stumps.

#### Selective clearing

FCC of undergrowth: < 30%
Height: < 1.3 m
Coppice-with-standards over tree-like undergrowth (1-3 sprouts/stump)
Removal of flammable species and encouragement of species that shelter and/or feed fauna.



Urban-forest interface (IUF) around a residential development.  
Credit: Associació de Propietaris del Montnegre i el Corredor.



### 3.1.2 Actions to alter a fire's behaviour

This concerns a set of actions focused on determining which are priority areas for altering the behaviour of a fire to reduce the risk of it spreading and turning into a high-intensity fire. The aim of this section is for the owner or manager to recognise these areas and prioritise them in forest management. It involves practices that can have an impact on the areas requiring action rather than applying any particular forest management method. In this way, the method applied will depend on each specific area. These areas are clearly defined in a PPI (of a PPP) or are considered Priority Management Areas (AGP).

In the PPI of the PPPs, some areas are defined as low fuel load areas (ABC). Some of these the plant cover is altered to change a fire's behaviour, and at the same time, reduce certain forest areas' vulnerability to fire. ABCs are broken down into strategic areas (AE) and complementary areas (AC). These areas are equivalent to those defined in the AGP as Strategic Management Points (PEG) (see Figure 1) and Management Development Areas (AFG).

Forest management in Strategic Areas (AE) or Strategic Management Points (PEG) to alter vegetation and fire behaviour.  
Credit: CREAM.







Forest management in Strategic Areas (AE) or Strategic Management Points (PEG) to alter vegetation and fire behaviour.  
Credit: CREA.



## Strategic Area (AE) / Strategic Management Points (PEG)

**Definition:** Areas in which vegetation is altered to facilitate extinction manoeuvres and change fire behaviour. These require access, safe areas to deploy extinction manoeuvres and a forest structure that prevents crowns from burning. Their main aim is to facilitate fire extinction.

Aim	Effect sought against fire
Increase fire extinction and contention ability to limit the effects of large forest fires.	Reduce the energy arriving at the area where the extinction manoeuvres are performed.
Facilitate and enhance safety for extinction teams.	Ensure personnel can be mobilised safely.
	Avoid crown fires, reducing continuity.
	Reduce medium- or high-intensity surface fires by decreasing the fuel surface cover <sup>4</sup> .
	Reduce vertical continuity by removing ladder fuel.
	Reduce the potential for secondary fires to break out.

### Where?

Type of location (established in the PPI/AFG)	Examples
Topographically critical points.	Saddles, ridgetop and valley trough junctions, valley bottoms, hillsides or mountainsides out of the wind.
Sites that are not topographically critical but due to their forest structure offer an opportunity for changing a fire's behaviour.	Areas in forest areas interspersed with cropland.

The specific location of these areas in Catalonia can be viewed in the PPI for the area or in the AFG established by Barcelona Provincial Council (<https://dadesobertes.diba.cat/datasets/arees-de-gestio-prioritaria-agp-per-a-la-prevencio-dincendis>).

### Advantages/disadvantages

Strengths	Weaknesses
If there is a PPI, its location and characteristics will be clearly outlined.	They are considered to prevent fires from escalating onto a larger scale and so do not include small-scale specifics.
	They do not take productivity into account, just the main objectives.

<sup>4</sup>. Surface fuel: Fuel below 1.30 m in height. Could be undergrowth, coppicing, grasses, branches, fallen trees or logging residues.

## What and how?

Sizes vary, but are proportional to the expected fire behaviour and the objectives sought. Each area will be managed differently depending on its specific characteristics.

### Management

#### Thinning, selective felling or selective cutting to convert into pastureland

Forest Canopy Cover (FCC):	< 60-70%
Vertical discontinuity (distance between strata):	Yes
Horizontal discontinuity (distance between crowns):	Yes

#### Undergrowth clearing

FCC of undergrowth: < 15%

#### Removal of logging residues (crown, pruning offcuts, etc.)

Cut and chopped.

Uniform distribution or removal: height < 1 m

#### Creation and return of land to crops or pasture

Removal of trees.

Minimal earth movement.

Removal of stumps/seeding (optional).

Crops other than summer cereals.

Tillage in periods of high risk

#### Maintenance actions

Mechanical means (shredder, strimmer).

Grazing.

Controlled burning.

#### Improved access

Road maintenance.

Signage



## Complementary Areas (AC) / Management Development Areas (AFG)

**Definition:** Area of land with vegetation managed in such a way as to improve how strategic areas work and their potential. These are also areas that due to the structure of their forests and strategic situation, are suitable for changing the behaviour of a forest fire so that it doesn't become bigger and turn into a large forest fire. The objective is to minimise fire spread.

Aim	Effect sought against fire
Improve effectiveness of fire prevention infrastructures outlined in the PPI, supplementing and reinforcing them.	Improve operational safety.
Change fire behaviour and reduce the risk of it spreading.	Allow an infrastructure foreseen in the PPI to be located in a particular place that, due to the distance from secondary fires, speed or intensity of the fire is not possible elsewhere.

### Where?

The areas are characteristically similar to the AE/PEG.

Type of location (established in the PPI)	Examples
Topographically critical points.	Saddles, ridgetop and valley trough junctions, valley bottoms, hillsides or mountainsides out of the wind.

The specific location of these areas in Catalonia can be viewed in the PPI for the area or in the AFG established by Barcelona Provincial Council in the province of Barcelona (<https://dadesobertes.diba.cat/datasets/arees-de-gestio-prioritaria-agp-per-a-la-prevencio-dincendis>).

### Advantages/disadvantages

Strengths	Weaknesses
If there is a PPI, its location and characteristics will be clearly outlined.	They are considered to prevent fires from escalating onto a larger scale and so do not include small-scale specifics.
	They do not take productivity into account, just the main objectives.

## What and how?

Sizes vary, but are proportional to the expected fire behaviour and the objectives sought.

### Management

#### Thinning, selective felling or selective cutting to convert into pastureland

Forest Canopy Cover (FCC):	< 60-70%
Vertical discontinuity (distance between strata):	> 4 m
Horizontal discontinuity (distance between crowns):	Yes

#### Undergrowth clearing

FCC of undergrowth: < 15%

#### Removal of logging residues (crown, pruning offcuts, etc.)

Cut and chopped.

Uniform distribution or removal: height < 1 m

#### Creation and return of land to crops or pasture

Removal of trees.

Minimal earth movement.

Removal of stumps/seeding (optional).

Crops other than summer cereals.

Tillage in periods of high risk

#### Maintenance actions

Mechanical means (shredder, strimmer).

Grazing.

Controlled burning.



Forest Management implemented in Complementary Areas (AC) or Management Development Areas (AFG). Credit: CREAF.



## 3.2 Actions that incorporate fire into forest management decisions

### 3.2.1 Reduction in the vulnerability of forest stands to fire

#### Improvements in landscape structure and composition

**Definition:** Development of mosaic landscapes, integrating forests, pastureland and crops with different structure and compositions.

Aim	Effect sought against fire
Diversify landscape structures and composition.	Change fire behaviour. Halt its spread across large areas.

#### Where?


##### Location

Area with a high continuity of forest stands.

Estates involved in agricultural and/or livestock activities.

#### Advantages/disadvantages

Strengths	Weaknesses
Diversify estate resources: not only forest production but also agricultural and/or livestock	Maintaining a mosaic landscape is linked to the estate's agricultural and livestock activities. Without these, it is impossible to maintain.
Diversify habitats and with them, area biodiversity.	Creation requires much investment, which must be offset by the agricultural and livestock benefits in its maintenance.



Actions to improve the landscape's structure and composition, keeping vegetation down through grazing. Credit: CREAM.

## What and how?

### Management

#### Creation of pastureland with low-density trees

Forest Canopy Cover (FCC):	< 20%
Vertical discontinuity (distance between strata):	< 300-400 trees/ha
Horizontal discontinuity (distance between crowns):	Yes

#### Undergrowth clearing

FCC of undergrowth: < 15%

#### Removal of logging residues (crown, pruning offcuts, etc.)

Cut and chopped.

Uniform distribution or removal: height < 1 m

#### Creation and return of land to crops or pasture

Removal of trees.

Minimal earth movement.

Removal of stumps/seeding (optional).

Crops other than summer cereals.

Tillage in periods of high risk

#### Maintenance actions

Mowing or harvesting.

Grazing.



Actions to improve the landscape's structure and composition, encouraging a mosaic landscape.  
Credit: Associació de Propietaris del Montnegre i el Corredor.



## Improvements to the structure and composition of forests

**Definition:** Creation of forest structures which break up the verticality of some strata, while horizontal continuity can vary. Discontinuity with the aerial strata (crowns) is prioritised to prevent crown fires. At the same time complex compositions and structures are created with trees of different sizes and species to enhance forest resistance and resilience.

Aim	Effect sought against fire
Increase the resistance and resilience of forests.	<p>Achieve a structure that is less vulnerable to crown fires by reducing the continuity of fuel.</p> <p>Modify the amount and distribution of available fuel.</p> <p>Increase forest complexity to encourage its post-fire resilience: encourage mixed forests and a variety of structures.</p> <p>Reduce competition and water stress.</p> <p>Keep the environment in half-shade, avoiding direct sunlight from entering that can cause water stress and substantial regrowth, resulting in a high FCC.</p> <p>Reduce the potential for fires to become large forest fires.</p>

## Where?

### Location

Area with a high continuity of forest stands.

A priority in areas involving: AE-PEG, AC-AFG, IUF.

## Advantages/disadvantages

Strengths	Weaknesses
Encourages the diversification of products, some with high forestry value.	The first action can be unprofitable, as it depends on subsidies.
Encourages biodiversity.	More common actions (lower but more frequent returns).
Encourages species with different strategies against fire.	
Continuous actions can reduce clearing costs.	

## What and how?

Following the instructions contained in the document *Integration of the risk of large forest fires into forest management: Types of fire and vulnerability of forest structures in crown fires* (Piqué et al 2011), is recommended. It establishes the management criteria depending on the forest formations and the vulnerability of its stands to generating crown fires.

### Management

#### Selective thinning or selective felling

Forest Canopy Cover (FCC): 70-80%

Horizontal discontinuity (distance between crowns): Yes

Maintain secondary or companion species present to encourage maximum biodiversity.

Selection of the most robust and healthiest trees.

#### Coppice management

Species suitable for coppice management.

Selection of 1-3 coppice sprouts of the best developed and positioned stumps.

#### Selective clearing

FCC of undergrowth: < 30%.

Height: < 1.3 m.

Coppice-with-standards over tree-like undergrowth (1-3 sprouts/stump)

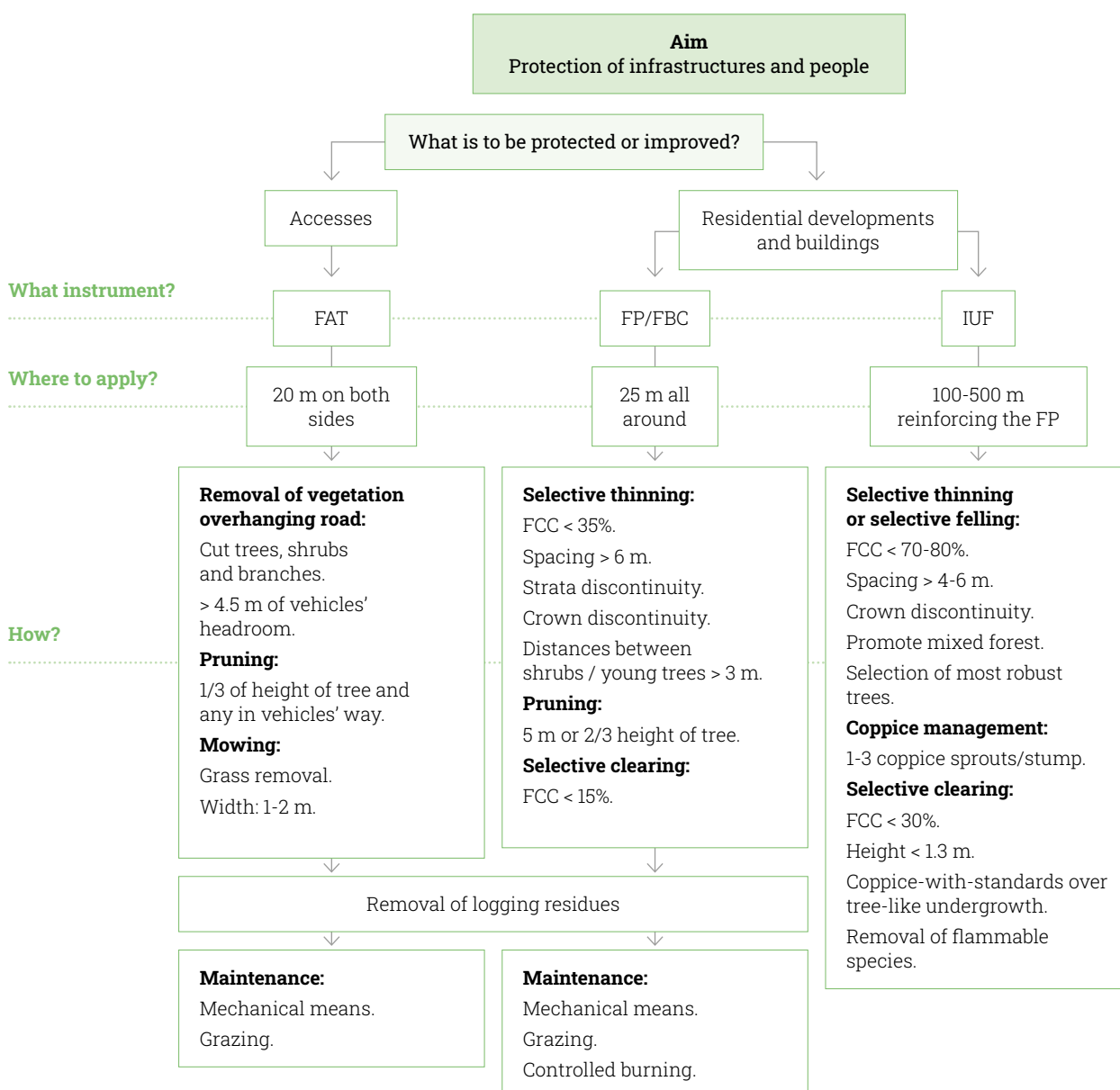
Removal of flammable species and encouragement of species that shelter and/or feed fauna.

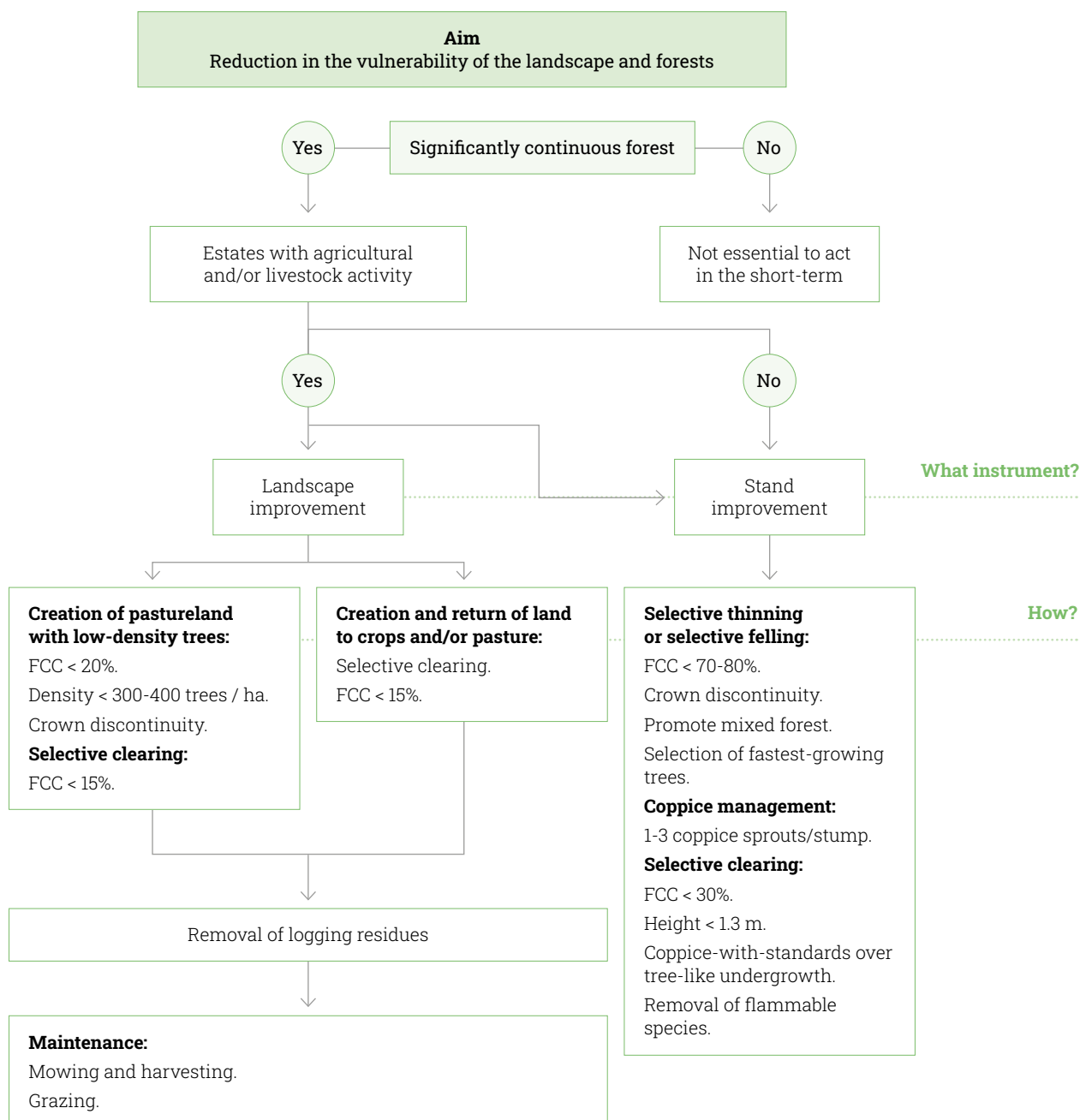


Improvements to the structure and composition of forests  
Credit: Associació de Propietaris del Montnegre i el Corredor.



## 4. Decision-making flow for the most suitable practice in each case





\* There is no specific diagram for the AE/PEG and AC/AFG areas as the various management techniques described can be applied in both. The importance of the AE/PEG y AC/AFG lies in the zoning, not in the management technique applied.



## 5. Conclusion

The aim of this guide is to provide tools to estate managers and owners to be able to perform actions that prevent fires.

Three kinds of approaches have been used to tackle the issue. Firstly, owners can attempt to reduce the effects of fires on estate infrastructures, such as housing, stores, plantations, gardens, etc.

Then, in the event that fire prevention planning exists that proposes actions within the estate, owners can opt to implement these actions on their own initiative, complying with the planning designed on a scale beyond their own individual situation, which is proposed to have a direct impact on the general behaviour of a fire.

And finally, owners can perform actions to improve the resistance and resilience of the forest stands on their estate to fire. In this case, only the estate owners can play an active role allowing these measures to be introduced. Furthermore, and in the current context of climate change, these actions take on significance in the establishment of forests that are more adapted to the current climate situation and which, as a knock-on effect, end up impacting on the development of extreme situations in future disturbances.

Despite the difficulties in tackling the current problem of forest fires on a small-estate scale, given that it is a global problem, actions aimed at mitigating the effects of a fire and increasing the capacity and speed of recovery post-fire can be implemented.

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Typical forest in the mountains of Southern Europe.  
Credit: CREA.



**Credits:** Lúdia Guitart Xarpell (Associació de propietaris del Montnegre i el Corredor), Martí Rosell Ibarz (Forest4 SCCL), Marc Fernández Bou (Agrupació forestal del Montnegre i el Corredor SL), Jordi Pagès Castellà (Forest4 SCCL), Diana Pascual Sánchez (CREAF), Eduard Pla Ferrer (CREAF).

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