LIFE UNCINATA*

D6.1
Technical prescriptions for fuel reduction per stand

Project Acronym: UNCINATA

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NATURA 2000

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Technical prescriptions for fuel reduction per stand

1 Introduction

The Forest Science and Technology Centre of Catalonia (CTFC) is the coordinating partner of the project LIFE21-NAT-ES-LIFE-UNCINATA/101074730, “Restoration, conservation and resilience of mountain pine forests on calcareous substrates in the Pyrenees”. This project is co-financed by the European Union’s LIFE financial instrument and aims, among other objectives, to improve and conserve mountain pine (*Pinus uncinata*) forests on calcareous soils in the Pyrenees through the implementation of silvicultural treatments and prescribed burning at strategic locations in order to reduce the risk of large forest fires that may affect the habitat.

Within the framework of work package WP6, task T6.1, “Prescribed burning and mechanical treatments in strategic areas to reduce fire risk in exposed stands of *Pinus uncinata**”, includes the implementation and subsequent monitoring of experimental and demonstrative forest management actions.

The CTFC promotes the implementation of the actions described in this document by virtue of the agreements signed between the research institution and the public administrations holding ownership of the public or private forests, whether municipalities, EMDs (decentralised municipal entities), or the Government of Catalonia.

The proposed actions have been presented to the technical management services of the respective EIN and ENPE areas, as well as to the public forest services of the Directorate General for Forests and Environmental Management, and to the relevant territorial sections and district offices.

This document details the delineation, design and technical execution conditions of the actions to be carried out in each pilot site.

2 Objectives

The objective of this deliverable is the concretisation of the technical prescriptions for fuel reduction per stand, in line with the objective of the task 6.1, which aim to reduce risk of high intensity wildfires on exposed stands of *Pinus uncinata*.

A combination of fuel reduction treatments is justified and described as a proposal for firefighting strategic areas. These treatments aim to:

- Reduce fuel load in order to decrease the intensity of a potential wildfire.
- Create and maintain strategic areas for fire extinction.

3 Selection of the sites

Nine different possible treatment zones were assessed regarding the potential positive effects of the fuel treatments, their cost-efficiency (cost per protected area), their technical viability, the type of property and possibilities to engage forest owners, the interests or preferences of key stakeholders such as Protected Areas and DARPA (Catalan competent administration), etc. This process ended up with the selection of three sites:

- Adraén
- Boumort
- Coll de Port

4 Diagnosis

4.1 Adraén

4.1.1 Location

The treatment area is located at the western end of the Cadí mountain range (SAC ES00000018), at the watershed division between la Vansa and Segre rivers valleys. It extends to the west along the south face of the division from the “Collada de la Mà”, at approximately 1.600 m altitude.

4.1.2 Legal and administrative status

The selected intervention area comprises Action Units numbers 16, 14 and 17 of Strategic Management Point number 1 (Adraén) of the Large Forest Fire Prevention Plan of the Cadí-Moixeró Natural Park (PPGIF).

Associated cartography (PPGIF):

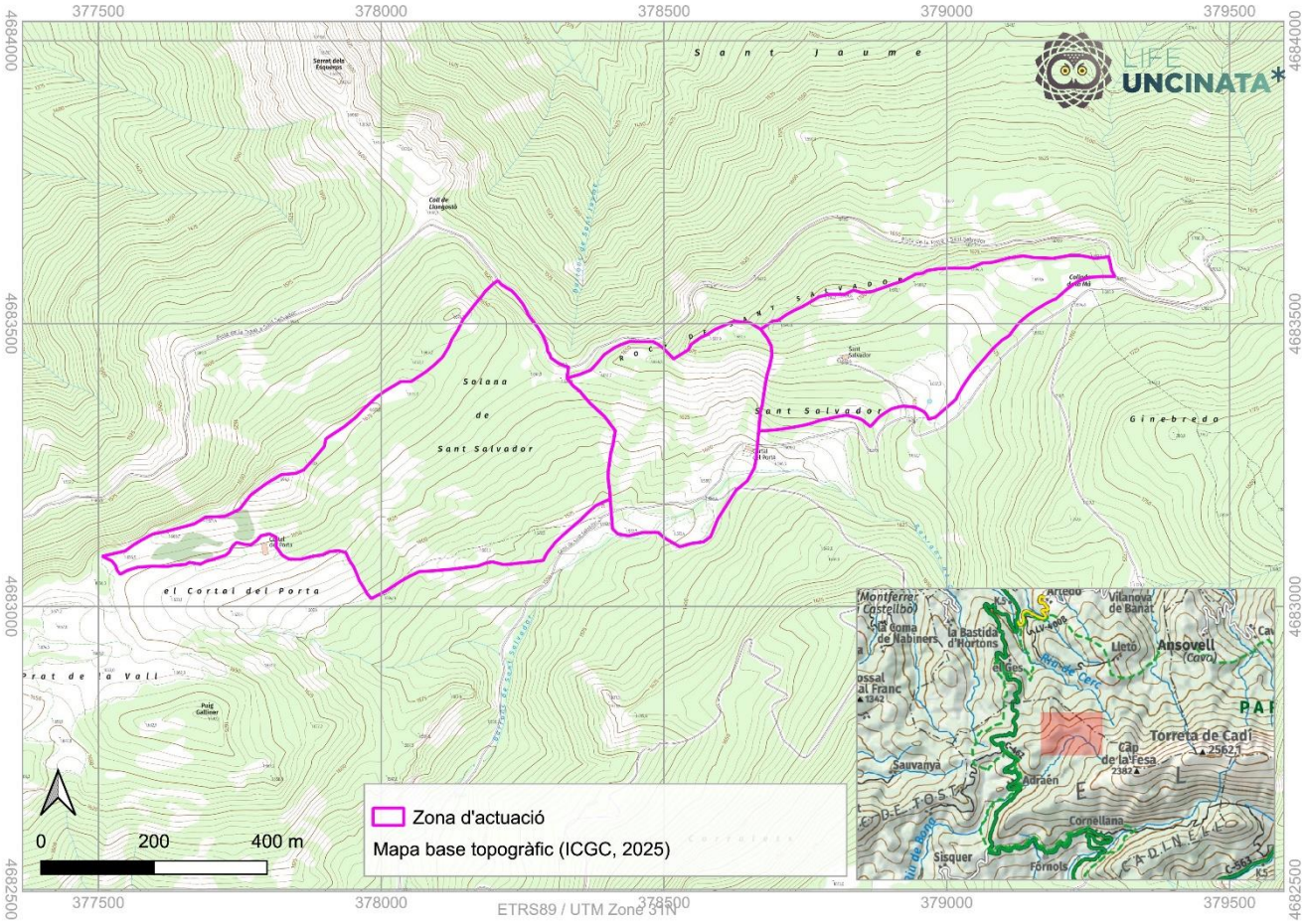

Figure 1. Action Units of PEG 01 Adraén within the PPGIF. From left to right: UA 16, 14 and 17, respectively.

Table 1. Basic data of each AU as described in PPGIF.

AU	Sur. (ha)	Action
16	20,8	Establishment of a low fuel load area in a partially mechanisable zone, with dense sclerophyllous or coniferous forests and abundant shrubland. The intervention includes understory clearing, tree thinning, pruning, cutting and mulching of slash, and extraction of timber to the landing.
14	9,2	Establishment of a safety area in dense sclerophyllous or coniferous forests with very abundant shrubland. The intervention includes tree felling, understory clearing, cutting and mulching of slash, and extraction of timber to the landing.
17	10,4	Establishment of a low fuel load area in a partially mechanisable zone, with dense sclerophyllous or coniferous forests and abundant shrubland. The intervention includes understory clearing, tree thinning, pruning, cutting and mulching of slash, and extraction of timber to the landing.

Table 2. Property information

Name of the property	Approximate surface (ha)	Ownership	IOF
Comunal d'Adraent	30,7	La Vansa I Fòrnols Municipal Council	SI (Not in force)
La Bella	1,9	Generalitat de Catalunya	SI
Muntanya Del Cadí	0,7	Generalitat de Catalunya	SI
Ginebreda	0,6	La Vansa I Fòrnols Municipal Council	SI
Altres finques	6,6	---	---
Total	40,4	---	---

The whole area is inside the Cadí-Moixerò Natural Parc and Natura2000 network “Prepirineu Central Català” ES0000018.

4.1.3 Stand characterization

Large strategic area with four different formations:

- **Montane xeric grassland** frequently grazed by domestic cattle
- **Mosaic of scattered trees and abundant heliophilous shrubland**. Variable initial shrub cover. Areas partially suitable for mechanisation.
- **Open forest dominated by *Pinus sylvestris***. Forest resulting from the colonization of former open spaces, where pioneer trees are differentiated from subsequent generations that have grown in competition. Secondary tree species such as *Betula pendula, Pinus uncinata, Quercus ilex, Quercus humilis, Acer opalus*, etc. can be found scattered individually or in small groups. Broadleaves are often suppressed by the main canopy or under canopy gaps. Where there is greater density, the mass is regularized with two or

more age classes in a single stratum. Variable initial canopy cover (CC), with an average of approximately 60%, showing frequent gaps, where trees preserve living branches down to low stratum. These gaps often come from the death of small groups of trees, due to unknown cause. Eventually, sparse vital pine regeneration mainly under canopy gaps. Abundant and variable understory, denser under canopy gaps, with an initial cover of approximately 70%. Area partially suitable for mechanisation.

- **Dense forest dominated by *Pinus sylvestris***. Same characteristics than the former formation but for canopy and understory density. Variable initial canopy cover (CC), with an average of approximately 80%. Sparse and variable understory, with an initial cover of approximately 20%. No significant tree regeneration.

4.2 Boumort

4.2.1 Location

The treatment area is located in the Serra de Boumort, within the municipality of Conca de Dalt. It lies to the northwest of the Cap de Boumort (2,077 m), at the foot of the Solana de la Font del Camí, at the boundary with the Pletiu Sobirà, at an approximate altitude of 1,879 m.

4.2.2 Legal and administrative status

The selected intervention area corresponds to parcel 00001 (cadastral reference 25090A01200001). The intervention is included in the Prescribed Burning Plan of the Font del Camí (Boumort National Hunting Reserve), drafted by Forest4, SCCL in 2025.

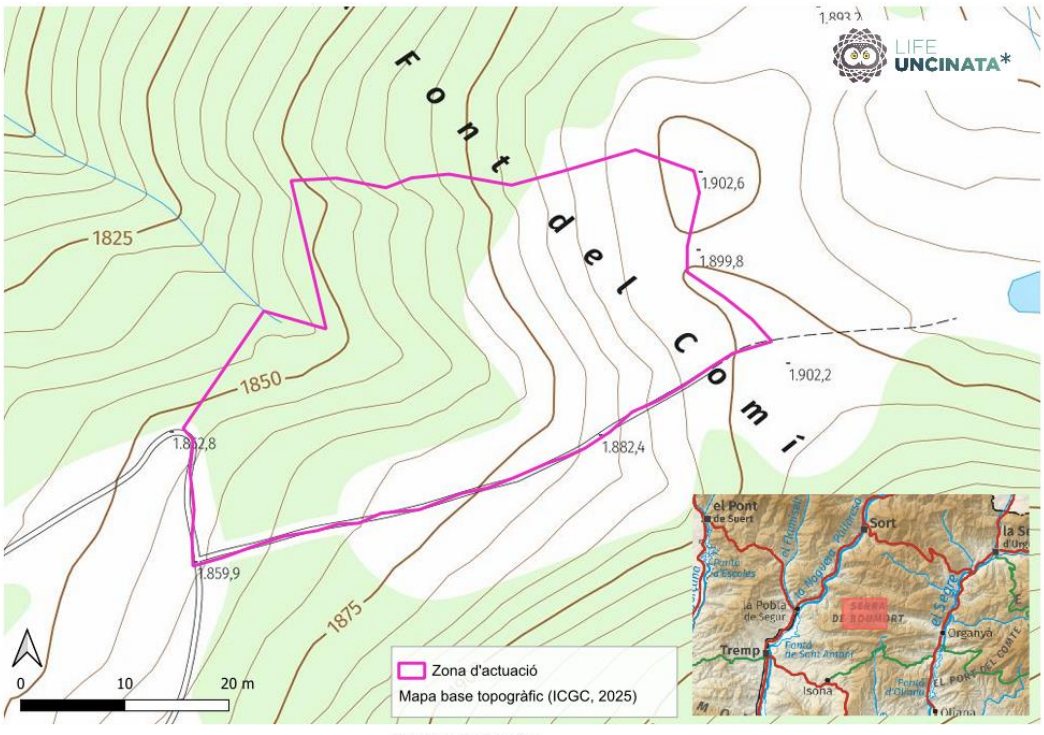

Figure 2. Intervention area of the Prescribed Burning Plan of the Font del Camí, Boumort National Hunting Reserve.

Table 3. Basic data of the intervention as described in the Prescribed Burning Plan.

Sur. (ha)	Action
3,3	Reduction of surface fuel load through direct prescribed burning of the understory. The intervention includes the creation of perimeter defence lines and point-ignition burning of the shrub and herbaceous layers.

Table 4. Property information

Name of the property	Approximate surface (ha)	Ownership	IOF
Boumort	3,3	Generalitat de Catalunya	YES

The entire area falls within the Serra de Boumort Site of Community Importance (PEIN, code ES510178) and the Natura 2000 network "Serra de Boumort - Collegats" ES5130010. The area hosts habitats of community interest, notably the priority habitat 9430 — Black pine (*Pinus uncinata*) calcareous forests.

4.2.3 Stand characterization

Open forest dominated by *Pinus uncinata*, with a mean diameter at breast height of 21.3 cm and a mean height of 11.1 m. The canopy cover fraction is approximately 40%, with frequent gaps where the herbaceous and shrub layers develop more vigorously. Trees preserve living branches down to a mean height of 3.4 m from the ground, generating vertical fuel continuity with the understory. Sparse *Pinus uncinata* regeneration is observed, mainly occurring under canopy gaps.

The understory is dominated exclusively by *Juniperus communis*, distributed in small groups, with a mean shrub cover of 22.5% and a mean height of 51.6 cm.

Developed herbaceous layer, with a mean cover of 72.8%, reflecting the influence of active grazing by domestic and game ungulates in the area, which favours the maintenance of herbaceous cover over shrub encroachment.

4.3 Coll de Port

4.3.1 Location

The treatment area is located at the Coll de Port, within the municipality of Josa i Tuixén, to the north of the Serra de Port del Comte and to the southeast of the Refugi de l'Arp, at an approximate altitude of 1,849 m.

4.3.2 Legal and administrative status

The selected intervention area corresponds to parcel 4 of polygon 5, in the Fanarals area (cadastral reference 25147A005000040000JL), within the municipality of Josa i Tuixén (Lleida). The intervention is included in the Resolution authorising prescribed vegetation burns at the "Coll de Port" site, issued by the Directorate General of Forest Ecosystems and Environmental Management of the Generalitat de Catalunya.

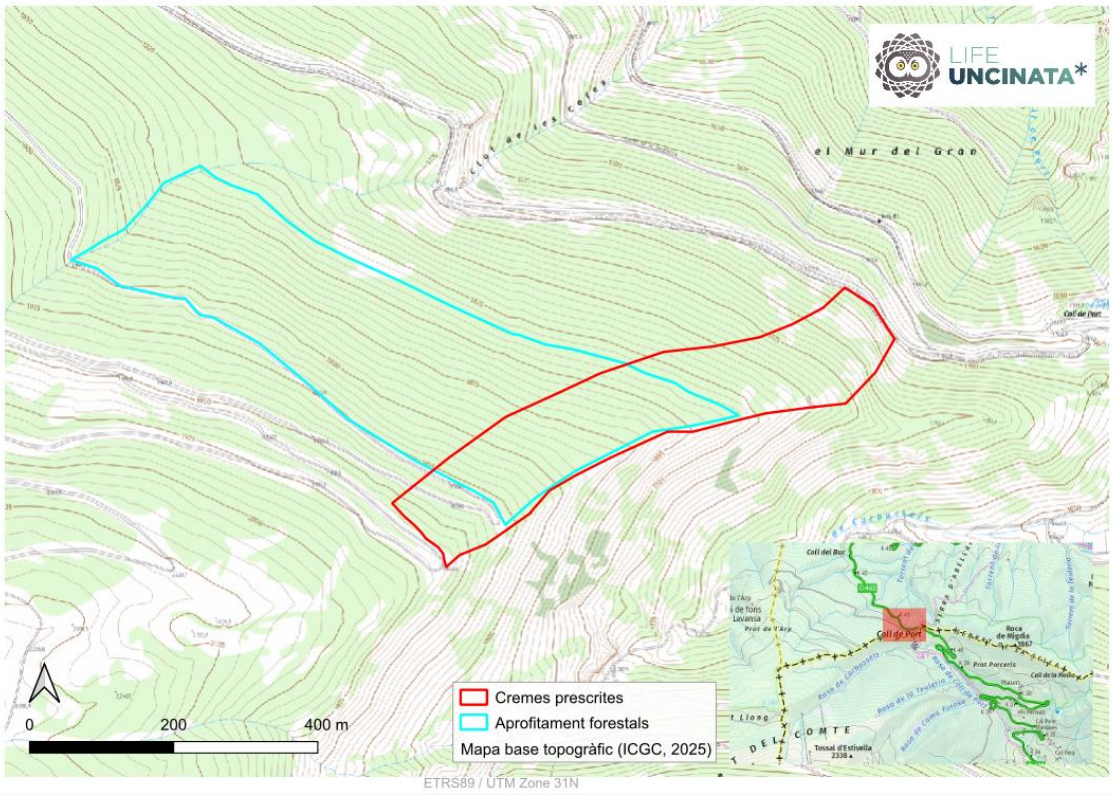

Figure 3. Intervention area of the prescribed burning authorisation at the Coll de Port site, municipalities of Josa i Tuixén and La Coma i la Pedra.

Table 5. Basic data of the intervention as described in the Prescribed Burning Plan.

Sur. (ha)	Action

20,0	Maintenance of a low fuel load forest structure at the Strategic Management Point (PEG) of the Coll de Port, through prescribed burning of the understory and woody debris resulting from previous silvicultural treatments. The intervention aims to reduce understory cover below 30% in order to limit the probability of crown fire.

Table 6. Property information

Name of the property	Approximate surface (ha)	Ownership	IOF
---	20,0	Public and private (Josa i Tuixén / La Coma i la Pedra)	YES

The entire area falls within the Plan of Areas of Natural Interest (PEIN) Serres d'Odèn - Port del Comte and the Natura 2000 network "Prepirineu Central Català" ES0000018.

4.3.3 Stand characterization

Dense and homogeneous forest dominated by *Pinus uncinata*, with presence of *Pinus sylvestris* at lower elevations. With a mean diameter at breast height of 19.5 cm and a mean height of 15.8 m, the stand shows a regular structure of adult appearance. The canopy cover fraction exceeds 70% over most of the area, decreasing below 40% on the south-facing slope close to the pass. Trees preserve living branches down to a mean height of 7.5 m from the ground, limiting vertical fuel continuity with the understory. The stand contains woody debris from previous silvicultural treatments which increase the severity of a potential wildfire, with potential impacts on adult trees in the managed stands and the risk of passive crown fires.

The understory is composed of *Juniperus communis*, specially in canopy gaps and a dominant herbaceous layer, with a cover of about 68%.

5 Treatment design

5.1 Adraén

In view of the demonstrative and experimental purpose of the intervention, a combination of treatments has been selected and adapted to the PEG cartography and the characteristics of the terrain. These actions aim to modify the structure of the existing forest stand in order to alter the behaviour of a potential wildfire, thereby facilitating suppression operations and increasing the likelihood of preventing a Large Forest Fire.

Accordingly, the interventions focus on reducing surface, ladder and canopy fuel loads, and/or on modifying their spatial arrangement where necessary, in order to favourably alter fire behaviour. To this end, efforts are primarily directed towards reducing the cover and height of understory fuels, also reducing ladder fuel cover and decreasing the density of canopy.

This fire prevention objective, which is critical, is combined with the preservation or enhancement of valuable elements for biodiversity, as far as both objectives are compatible. This approach is done through the improvement of biodiversity hosting capacity, through the promotion and adaption of the different indicators of the Potential Biodiversity Index (IBP).

Therefore, we propose an improved approach to pyro-silviculture through the compatibilization of both management objectives:

- Fire prevention through fuel reduction.
- Preservation and/or enhancement of the valuable elements for biodiversity.

Both objectives are often seen as incompatible due to strong trade-offs. Here, we aim at minimizing them and further finding synergies through the incorporation of the latest knowledge in an innovative approach.

No treatment has been prescribed on montane xeric grassland as it is already a low fuel load formation. Fuel reduction treatments have focused on open or dense Pinus sylvestris forest and on the mosaic of scattered trees and abundant heliophilous shrubland.

To enable the treatments execution and experimental monitoring, the pilot site has been divided into different intervention units regarding forest formation and objectives.

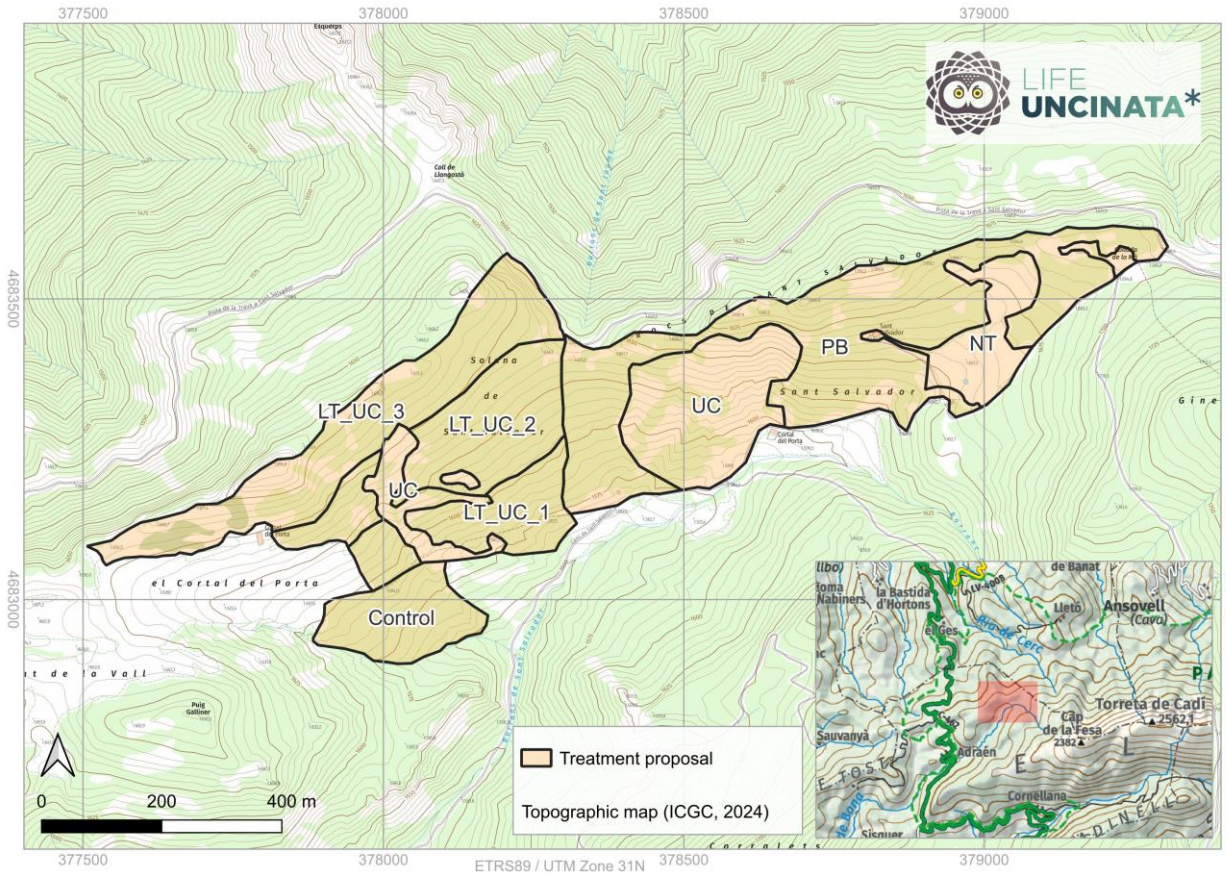

Figure 4. Detail of the intervention units in Adraen. Control, no treatment, experimentsl control zone; NT, no treatment; UC, understory clearing; PB prescribed burning; LT_UC low thinning and understory clearing.

5.1.1 Fire prevention through fuel reduction

Three different fuel reduction treatments will be applied to maximize cost-benefit of the interventions, adapt to the different stand characteristics and constraints, and to stablish an experimental design to compare the effectivity of prescribed burning and silvicultural treatments for fuel reduction.

Three comparable and adjacent zones have been selected to host a control zone (with no treatment at all), silvicultural treatments (T_UC) and prescribed burning (PB). Inside these areas, there are some open spaces with low canopy cover in the form of mosaic of scattered trees and abundant heliophilous shrubland (UC).

Direct prescribed burn of the understory has been chosen as the most cost-effective form of fuel reduction treatment using fire, as it does not require previous extra intervention on the forest. Surface and ladder fuel are the most affected in this treatment but shows complementary effects reducing canopy fuel by increasing canopy base height and inducing death on the most vulnerable tree individuals (Piqué & Domènech, 2018).

Silvicultural treatments have been designed based on Forest Management Guidelines for *Pinus sylvestris* forests with the main objective of improving resistance to wildfires combined with wood production, number Ps11 (Piqué, Beltrán, et al., 2011), and CVFoc (Piqué, Castellnou, et al., 2011). Treatments include mixed or low thinning to reduce canopy and ladder fuel loads and to increase average canopy base height. They also include shrub clearing and slash mastication to grind and compact surface fuel load. Also, on canopy gaps, where trees have preserved low living branches, these should be pruned to break vertical fuel continuity.

5.1.2 Preservation/enhancement of valuable elements for biodiversity

We adapted the fire prevention proposal based on the assessment of its compatibility with the promotion of valuable elements for biodiversity. These valuable elements that can be promoted by forest management can be identified and quantified using Potential Biodiversity Index (IBP) for montane mediterranean formations, such as *Pinus sylvestris* forests in the Pyrenees (Baiges et al., 2022). The following strategies have been selected:

- **Native tree species promotion**. Retention and promotion of most vital tree individuals of species different from the dominant *Pinus sylvestris,* as a general and basic rule to promote diversity and resilience to disturbances.
- **Preservation of multiple vegetation strata.** Up to 5 different vegetation strata should be present with cover > 20%.
    - **Possible counter-effect on fire prevention strategy**: Maintenance of vertical and horizontal continuity of the structure.
    - **Proposed solution:** Preserving up to 20 - 30% of original shrub cover, in small shrub patches. These patches should be selected based on the species composition following Busquets & Beltrán (2024) recommendations, and on the priority to break vertical continuity.
- **Large living tree retention.** Many large or old living tree individuals should be preserved.
    - **Possible counter-effect on fire prevention strategy**: In this kind of forest, large or old trees are often pioneer trees which show less vigour and worse technologic characteristics than the rest. The promotion of these trees over younger and vital ones as a general rule, may entail the stagnation or loss of vigour of the stand.
    - **Proposed solution:** If these pioneer individuals were majority, they should be promoted over the most vital ones with certain restraint. As a reference, trees larger than 67,5 cm in diameter, if present, should be preserved in a density of at least 5 tree/ha; if this was not possible, trees larger than 47,5 cm in diameter, if present, should be preserved in a density of at least 8 trees/ha.
- **Standing and downed large deadwood preservation or promotion.** Many large standing or downed deadwood should be preserved, if present, or generated if not.

- **Possible counter-effect on fire prevention strategy**: (1) fine dead fuel load increase, (2) risk of fall of the snags during wildfire suppression operations, (3) posing difficulties to silvicultural treatments mechanisation.
- **Proposed solution:** Standing dead wood should be generated as short stakes (≈1,5 m long). No previously present standing dead trees should be left in a distance of 2 times the mean height of the trees from the main roads. Present and newly generated downed deadwood should be lopped and the branches processed as stated in the technical prescriptions. Logs should remain branch free, in contact with the soil. As a reference, standing or downed deadwood larger than 37,5 cm in diameter, should be preserved or generated in a density of at least 3 tree/ha; if this was not possible, standing or downed deadwood larger than 17,5 cm in diameter, should be preserved or generated in a density of at least 3 trees/ha.

- **Preservation of tree related microhabitats.** Trees bearing tree related microhabitats (Bütler et al., 2020) must be respected and promoted(Camprodon, 2013; Camprodon et al., 2020; Guixé & Camprodon, 2018). Specially applies to the less frequent microhabitats present in the stand.
  - **Possible counter-effect on fire prevention strategy**: Some tree related microhabitats are related to tree pathogens, low vitality or lower technologic characteristics. Promoting these trees over younger and vital ones as a general rule, if these are majority, may entail the stagnation or general loss of vigour of the stand.
  - **Proposed solution:** If some particular microhabitat (e.g. crown deadwood, parasitic plant, canker, etc.) is dominant among others, and especially frequent (many more than 8 trees/ha) it could be penalised over more vital individuals.

Other considerations regarding plants or fauna of special interest:

- The site is in a **potential breeding area of the *Tetrao urogallus*** according to unpublished reporting on the species. General instructions for compatibilization of forest management and *Tetrao urogallus* habitat and population conservation prescribe a necessary understory cover between 30% and 80% for breeding areas.
  - **Possible counter-effect on fire prevention strategy**: Maintenance of vertical and horizontal continuity of the structure.
  - **Proposed solution:** Preserving up to 20 - 30% of original shrub cover, in small shrub patches.

5.2 Boumort

The intervention at the Boumort site consists of a direct prescribed burn aimed at recovering and maintaining open spaces, improving forage for wild ungulates, and modify the structure of the existing forest stand with the objective of alter the behaviour of a potential wildfire, and facilitate the suppression operations of a large forest fire.

A single fuel reduction treatment is designed, adapted to the characteristics of the stand and its management objectives. The intervention focuses on reducing shrub cover, rejuvenating herbaceous species and reducing surface and ladder fuel loads, in order to reduce the severity of a surface fire, the impact on mature trees and the risk of a crown wildfire.

To enable experimental monitoring of the treatment effects, vegetation monitoring plots have been established within the prescribed burning area prior to the intervention, allowing future before-after comparison of stand structure and vegetation composition. The response of the soil is of particular interest, as it is planned to manage natural fires in the mountain zones allowing them to burn under pre-established conditions as a natural process (Vilà-Vilardell et al., 2025). The effects of fire management on the forage provision in the treated stand will be compared with a wildlife exclusion plot, established an adjacent and structurally similar area.

5.2.1 Fire prevention through fuel reduction

Direct prescribed burning of the understory has been selected as the most cost-effective fuel reduction treatment for this stand, where no previous mechanical intervention has been necessary. The burn aims to partially consume surface and ladder fuels with minimal impact on tree canopies. Surface fuel and shrub layer are the most affected strata in this treatment, which also may activate the seed bank of germinating species, increasing the quantity and quality of existing pasture. The pattern of burning by ignition points will allow managing fire intensity and minimising the impact on the best-formed individuals of *Juniperus communis*, maintaining a minimum of 50% of shrub cover unburned for biodiversity conservation purposes.

5.3 Coll de Port

The intervention in the Coll de Port site is located in a strategic area that divides two main valleys. The main objective is to maintain a forest structure that reduces the intensity of a potencial wildfire and reduce the probability of crown fire in order to facilitate fire extintion.

Figure 5 shows that the area includes a forest zone with remnants of an old exploitation (B) and an area with a recent exploitation (Th, ThB). Within the framework of the Life Uncinata, a

prescribed burning (B and ThB in figure 5) will be carried out with the aim of reducing surface fuel, whether shrubby or in the form of forest remains.

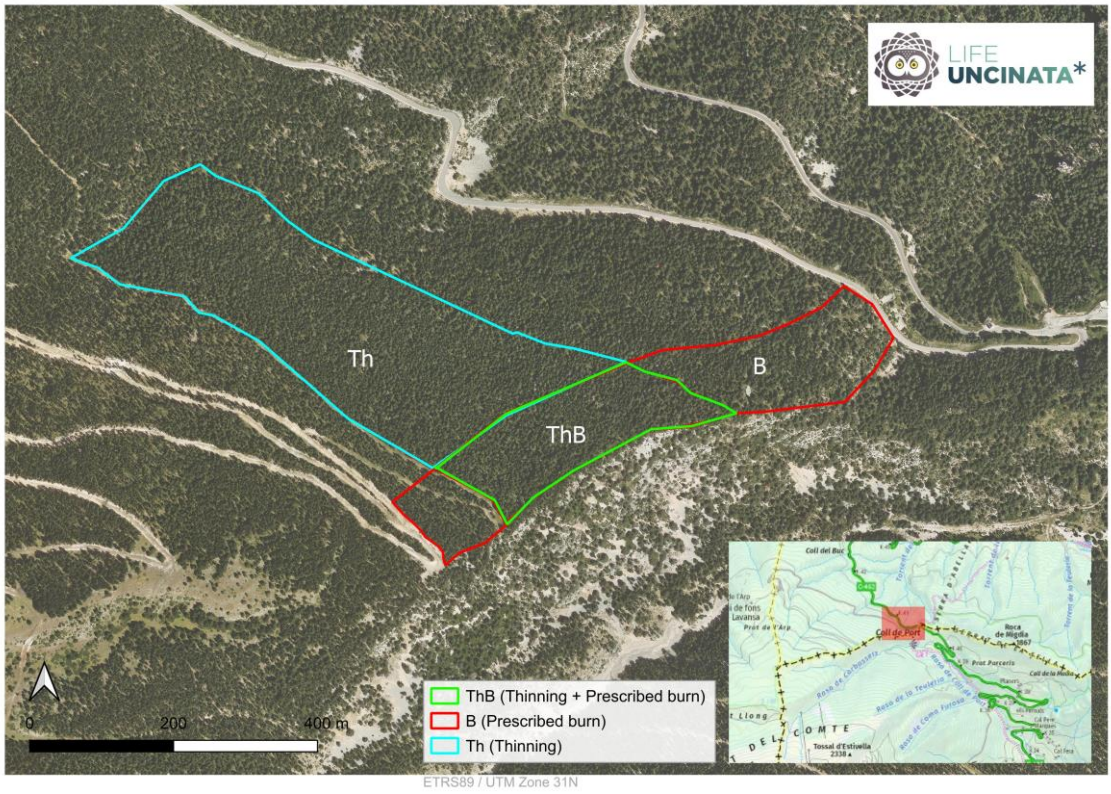

Figure 5. Detail of the intervention units in Coll de Port. Th, silvicultural thinning only; B, prescribed burning only, targeting understory fuel and woody debris from previous silvicultural operations; ThB, combined thinning and prescribed burning.

5.3.1 Fire prevention through fuel reduction

The prescribed burning component targets both the understory shrub layer and the woody debris accumulated from prior thinning operations, which represent a significant surface fuel load. The burning pattern aims to partially consume surface fuel and woody debris with minimal impact on the best-formed tree individuals of *Pinus uncinata* and *Pinus sylvestris*. The silvicultural treatments had reduced the canopy and ladder fuel loads and increased the mean canopy base height.

The area allows the direct comparison of three fuel reduction treatments applied to adjacent and structurally comparable areas (Figure 5). To enable experimental monitoring of the treatment effects, vegetation monitoring plots have been established within each treatment area prior to the interventions, allowing future before-after and between-treatment comparison of stand structure, vegetation composition and impacts on the soil. The combination of mechanical thinning and

prescribed burning has been shown to be particularly effective in reducing both fire hazard and forest vulnerability to drought events in sub-Mediterranean pine forests (Vilà-Vilardell et al., 2023).

6 Description of the proposed actions

The actions to be carried out are as follows:

Table 7. Actions to be carried out on each site.

Site	Actions
Adraén	• Selective understory clearing • Localised pruning • Mixed selective thinning • Treatment of woody slash generated by thinning operations • Extraction (skidding) of timber generated by thinning operations • Sorting and classification of timber obtained from thinning operations • Monitoring report on labour and resources allocated to each task • Direct prescribed burning
Boumort	• Direct prescribed burning
Coll de Port	• Forest debris burning

6.1 Adraén

Each type of action to be implemented is described in detail below. The specification of the actions to be carried out in each forest stand, on each site, as well as their quantification in terms of thinning intensity, is presented in Table 8.

Table 8. Detail of the actions in Adraén.

AU	Sur. (ha)	Characteristics
UC	7.0	Mosaic of scattered trees and abundant heliophilous shrubland. Variable initial shrub cover. Areas partially suitable for mechanisation. Includes: • **Selective understory clearing**, with a final understory cover of < 25%, aimed at reducing surface and ladder fuel loads. Due to slope conditions, manual methods are generally required. **Where terrain conditions allow, mechanised clearing shall be prioritised.**

		• **Localised pruning** of live branches on trees that generate vertical fuel continuity, below 1.5 m in height, affecting fewer than 100 stems per hectare.
LT_UC_1	3.4	Open forest dominated by *Pinus sylvestris*. Variable initial canopy cover (CC), with an average of approximately 60%. Abundant and variable understory, with an initial cover of approximately 70%. Area partially suitable for mechanisation. Includes: • **Mixed selective thinning** of light intensity and heterogeneous spatial distribution, aimed at reducing ladder fuels and canopy fuel density. Manual felling. Applicable where FCC exceeds 70%. Final maximum FCC ≈ 70%. Extracted VOB < 20%. • **Selective understory clearing**, with a final understory cover of < 25%, to reduce surface and ladder fuel loads. Where feasible, mechanised clearing shall be prioritised. In areas where mechanisation is not possible, manual clearing shall be carried out. • **Treatment of silvicultural slash** using mechanical methods wherever possible. Where mechanisation is not feasible, slash shall be cut with a chainsaw in accordance with the specifications set out in the corresponding section. • **Localised pruning** of live branches on trees generating vertical fuel continuity, below 1.5 m in height, affecting fewer than 60 stems per hectare. • **Extraction of the timber obtained**, to the landing, using the method deemed most appropriate. • **Sorting and classification of the timber obtained** at the stacking or landing area.
LT_UC_2 and LT_UC_3	13.3	Dense forest dominated by *Pinus sylvestris*. Variable initial canopy cover (CC), with an average of approximately 80%. Sparse and variable understory, with an initial cover of approximately 20%. Area partially suitable for mechanisation. Includes: • **Mixed selective thinning** of moderate intensity and heterogeneous spatial distribution, aimed at reducing ladder fuels and canopy fuel density. Manual felling. Applicable where CC exceeds 70%. Final maximum FCC ≈ 70%. Extracted VOB < 30%. • **Treatment of silvicultural slash** using mechanical methods wherever possible. Where mechanisation is not feasible, slash shall be cut with a chainsaw in accordance with the specifications set out in the corresponding section. • **Localised pruning** of live branches on trees generating vertical fuel continuity, below 1.5 m in height, affecting fewer than 20 stems per hectare.

		• **Extraction of the timber obtained**, to the stacking or loading area, using the method deemed most appropriate. • **Sorting and classification of the timber obtained** at the landing or loading area.
PB	13.8	Dense forest dominated by *Pinus sylvestris*. Variable initial canopy cover (CC), ranging between 50 and 80%. Abundant and variable understory, with an initial cover ranging between 20% and 70%. Slope ranging from low to moderate. Includes: • **Creation of defence lines** by manual means. Vegetation and organic soil removal down to the mineral soil in approximately 1-meter-wide stripes along the perimeter of the prescribed burning area. • **Direct prescribed burning** of the understory reducing understory cover to less than 30%. Affection to the best tree individuals must be avoided as far as possible. Ignition must be carried out by manual means using drip torches.

6.1.1 Selective understory clearing

Selective understory clearing will be carried out, with a final understory cover of 20 – 30%, in order to reduce surface and ladder fuel loads. **Up to 20 - 30% of shrub cover will be left intact, grouped in small patches, taking advantage of areas with poorer accessibility where there is no vertical fuel continuity with the tree layer.** Priority will be given to preserving understory vegetation that does not generate vertical fuel continuity, as well as species with higher biodiversity value, in patches where a minimum distance of 4 m exists between the shrub layer and the base of tree crowns.

Shrub vegetation located beneath trees that generates vertical fuel continuity (i.e. less than 4 m between the shrub layer and the base of the tree crowns) will be preferentially cleared.

The clearing treatment is partially marked, as explained in the section Interpretation of treatment marking. Priority species to be preserved include those with the highest scores according to wildfire prevention criteria and their role as shelter and/or food resources for wildlife, as well as any broadleaved tree species forming part of the shrub layer (*Acer opalus, Ilex aquifolium, Quercus ilex, Prunus avium,* etc.).

The treatment will preferably be carried out using mechanical means (hammer or chain mulcher mounted on a tractor, robot, or similar equipment). Where these means cannot be used, manual brushcutters will be employed.

6.1.2 Localised pruning

Live branches will be pruned from trees that generate vertical fuel continuity with the shrub layer, up to a maximum height of approximately 1.5 m on the stem. This pruning will be applied only to

trees located in clearings or open areas where low live branches create continuity with the understory layer. Pruning will be executed using manual chainsaw.

6.1.3 Mixed selective thinning

A **mixed selective thinning** of light to moderate intensity and heterogeneous spatial distribution will be carried out to reduce ladder fuels and canopy fuel density.

The final canopy cover fraction (CCF) will be approximately 70% throughout the stand. The extracted standing volume (VOB) will range from 0% in some areas to up to 30% in others, depending on the initial conditions, always with the objective of achieving a maximum canopy cover of 70%, and never reducing canopy cover in areas where it is initially below 70%. Areas that originally exhibit a canopy cover close to the target value (≈70%) and do not present ladder fuels in the form of suppressed or co-dominant trees will not be treated.

The operation consists of felling and delimbing the trees selected for removal. Felling shall be carried out manually using chainsaws. All technical conditions specified in this document must be complied with (see Section *Technical conditions for implementation*).

All trees to be felled are marked in accordance with the guidelines specified in Section *Interpretation of thinning marking*.

Some trees will be cut to a height of 1.3 m (snags), following the marking scheme, in order to generate standing deadwood. The stems of trees cut in this manner will be left delimbed and laid on the ground to generate downed deadwood.

6.1.4 Treatment of woody slash generated by thinning operations

Reduction of the size and accumulation of woody slash generated by thinning operations (branches, crowns, etc.). This treatment shall be applied across the entire area of the stands where slash is produced, and at the stacking point if necessary, using mechanical means whenever possible (hammer or chain mulcher mounted on a tractor, robot, or similar equipment). Where mechanisation is not feasible, manual methods shall be used.

The operation consists of mechanically shredding the woody slash, whether previously windrowed or scattered, with a minimum of two passes.

Where mechanisation is not possible, the operation consists of cutting woody residues with diameters > 5 cm and < 27.5 cm into pieces < 1 m in length and dispersing them to avoid accumulations exceeding 50 cm in height. Pieces with diameters > 27.5 cm that are not extracted shall be left delimbed but not cross-cut. Cutting in pieces must be done using manual chainsaw and a manual brushcutter must be used to further crush the fine fraction.

In all cases, woody slash generated by the operations shall be manually removed within a 20 m buffer on both sides of main forest roads.

6.1.5 Extraction of timber obtained from thinning operations

The operation consists of extracting the timber generated by thinning operations to the stacking or loading point.

The stacking/loading site shall be located along the lower main forest road and will be defined during the works initiation meeting by the district forest engineer or the officer responsible for timber management.

The permitted means for timber extraction are as follows:

- Forestry tractor (adapted tractor or skidder) equipped with a cable winch. The cable used should preferably be a synthetic cable with a length > 30 m.
- Animal traction, using adequately equipped and trained equids, handled by personnel with appropriate training.

The permitted extraction methods are as follows:

- Log extraction (stem-only harvesting).
- Whole-tree extraction (whole tree harvesting). In this case, cutting slash will be generated at the landing and shall be managed in accordance with the principles described in Section *6.1.4 Treatment of woody slash generated by thinning operations*.

6.1.6 Sorting and classification of timber obtained from thinning operations

The different timber products obtained shall be stacked in separate piles at the stacking or loading area.

The operation consists of identifying and separating the extracted logs (either whole or cut into sections) according to the type of timber product. Product classification aims to maximise the utilisation of the harvested wood and shall include, at a minimum, three product categories: chipping, sawlogs, and special products. The final number of product categories and their specific characteristics shall be defined during the works initiation meeting by the district forest engineer or the officer responsible for timber management.

Timber piles shall be constructed so that the first row of logs does not come into direct contact with the ground, using other logs (from the residual product class) as bearers.

6.1.7 Monitoring report on labour and resources allocated to each task

In order to analyse and compare the productivity of the different methods used under the varying conditions of the forest stands, the contractor shall compile a brief report detailing the allocation of material and human resources for each task in each stand.

The report shall include a descriptive sheet for each stand indicating:

- Start and end dates of the works.
- A table describing the number of workdays invested in each task and the equipment or means allocated to each.
- An observations section, where the contractor may provide any relevant considerations regarding the works carried out, such as difficulties or problems encountered, solutions adopted, mistakes and successes, etc.

The CTFC will provide a .docx template to be completed by the contractor with the required information.

6.1.8 Direct prescribed burning

The operation **consists on removing surface and ladder fuels**, minimizing labour input **using fire as a natural element of the ecosystem and a tool**. Surface and ladder fuels percentage cover must be reduced under 30%. Some affection to the canopy is accepted, up to 10 – 20% tree mortality. Affection to the best tree individuals must be avoided as far as possible.

The burning will be carried out by the fire department's forestry support unit (GRAF, Departament d'Interior, Generalitat de Catalunya), which has a long history of burning under forest canopy. They elaborate the burn plan, process authorisations and execute the burning.

Before any ignition, the site must be prepared to enable the fire control operations. This is done creating **defence lines** along the full perimeter by **removing understory vegetation and scraping away the organic layer down to mineral soil, forming approximately 1-m-wide strips** that interrupt fire spread and provide a clean edge for holding actions. Around 1.450 meters of defence line must be created before the burn. This is tied to a tactical layout that takes advantage of the terrain and access, improving both containment and mobility for hose/hand-tool support where required.

Optimal meteorological conditions of the burning day must match the experts' recommendation, which in this case implies: availability of 1h and 10h fuels; less than 10 km/h wind; day before no rain, low RH, soft wind; day after RH irrelevant, soft wind.

Ignition is implemented using manual drip torches, with the pattern selected on the day to match the resulting fire intensity with the objectives and limit convective heating of crowns. The firing sequence is designed to consume ladder and surface fuels while avoiding affecting the best-formed pines. Holding and contingency actions run continuously in parallel with ignition. Resources should include two forest squads 2 GRAF units and an EPAF unit as assigned in the plan.

Required “retén” (stand‐by/patrol) will be determined according to burn behaviour and subsequent meteorology. This is especially important under canopy where smouldering in duff, dead tree roots, can persist and re‐ignite.

6.2 Boumort

6.2.1 Direct prescribed burning

The burns will be conducted by a private company with extensive experience in the use of fire (RNC de Boumort). The area was decided in a field visit by the LIFE coordinator team, responsibles for the Natura 2000 protected areas and the GRAF Firefighter unit. The burnings have the permits of the property owner and those responsible for forest management and biodiversity of the Generalitat of Catalonia.

To incorporate the environmental requirements of Environmental Service (Serveis Territorials de Lleida del Departament de Territori, Habitatge i Transició Ecològica amb nº Expedient: A1150_09_2025), prescribed burns will be carried out between August 15 and November 1, with a pattern of ignition by points, which allows to manage the intensity and leave unburned specific individuals of Juniperus communis for biodiversity conservation. To accomplish this requirement, before burning, CTFC team will clearly mark the individuals to be not affected by fire, to maintain unburned a minimum of 50% of the bush coverage.

6.3 Coll de Port

6.3.1 Burning woody slash generated by thinning operations

The burns will be conducted by trained personnel from the GRAF Firefighter unit of the Generalitat de Catalunya. The area was decided in a field visit by the LIFE coordinator team and the GRAF Firefighter unit. The burnings have the permits of the property owner and those responsible for forest management and biodiversity of the Generalitat of Catalonia. The burning pattern will be spot-burning with the aim of reducing the debris by 80% and minimize the damage of trees and soil.

7 Technical conditions for execution

7.1 General provisions

Strict compliance with all forestry and environmental protection regulations applicable to forests and natural areas shall be ensured. The actions shall conform to the descriptions and quantitative specifications set out in this document. Any modification shall be agreed upon by all parties and duly recorded.

All machinery and tools used in the implementation of the actions must be in perfect working condition and properly inspected. Personnel must be duly qualified or have demonstrable experience.

During periods when the contractor is not carrying out operations (public holidays, night-time, rainfall), forest roads and tracks must not be obstructed by logs, machinery or any other objects that could hinder traffic or pose a risk to users.

All existing infrastructure in the area (signage, fences, etc.) shall be respected, and any damage caused by the contractor shall be fully repaired by the contractor.

7.2 Silvicultural treatments

The interpretation of the marking described in this document shall be strictly respected.

No climbing or vine species growing on trees that are not to be removed during the operations shall be cut.

No climbing or vine species should be cut, unless indicated

No standing or downed dead trees already present within the intervention stands shall be felled or disturbed, except where this is deemed essential to carry out the operations under adequate safety conditions for operational staff. In the case of encountering downed dead trees, these shall similarly be respected, except where it is necessary to move or cut them in order to allow the tractor to pass, enable the extraction (skidding) of felled trees or to ensure the safety of operational staff.

Downed Deadwood only can be cut into pieces to enable mechanisation. If they don't hinder the operations, they should not be cut.

In general, tree felling cuts shall be straight, made at ground level, and leave stumps with a height of less than 10 cm. However, some stumps may be left at a greater height (> 50 cm) eventually to enhance biodiversity through the generation of this type of deadwood. These high stumps shall correspond to trees with rocks at the base or other obstacles that prevent safe cutting at ground level, or to trees with pronounced basal curvature or other stem defects.

Tree felling shall be carried out, as far as possible, in a manner that avoids trees falling onto retained trees or plant species of particular interest. Furthermore, felling shall be conducted so that extraction operations are progressive, and stems are aligned. The fan-shaped effect, which may cause damage to regeneration or to other trees and plant species if a misaligned tree is dragged, shall be avoided. Previously identified extraction routes shall always be followed.

7.2.1 Interpretation of thinning marking

The entire intervention area has been fully marked by CTFC technical staff. The boundaries of the intervention area are not physically marked on the ground. To delimit the treatment area, it is sufficient to follow the treatment marking, and in case of doubt, refer to the digital boundaries provided by CTFC in .KML format.

Trees have been marked using different spray-painted symbols that indicate the actions to be taken. Trees to be felled are marked in red, pink or orange, according to the following criteria:

- Two or more dots on the stem and one dot at the base → Tree to be felled.
- One horizontal line at a height of 1.3 m, a big cross above the line and one dot at the base → Tree to be felled, leaving the stump as high as possible (always under safe working conditions), generating a standing deadwood snag approximately 1 – 1.5 m high. The cut stem shall be delimbed and left lying on the ground, without cross-cutting or extraction. Branches and crown material (slash) shall be processed in accordance with the general recommendations (see Section, *Treatment of slash generated by thinning operations*).
- Two parallel horizontal lines → Ring-barking or girdling the tree (cutting the cambium around the stem with a chainsaw, without felling the tree).
- Trees with no marking shall not be felled, except for reasons of working safety or operational necessity.
- Trees marked with a white line on each side shall not be felled.
- In some cases, the same tree may be marked for felling and simultaneously marked with another colour (green, blue, etc.). In such cases, the tree shall be felled.

Table 9 summarises the different types of actions and the markings that indicate them.

Table 10. Type of actions on trees and marking indications

Actions	Marking
Felling the tree	• Two or more dots at the stem and one at the stump in red, orange or pink. • May present other colour marks (blue, green, etc.). In this case felling marking prevails.
Felling the tree leaving a high stump (1 – 1.5 m) and the stem lying on the ground	• One horizontal line at a height of 1.3 m + a big cross above the line
Ring-barking or girdling the tree	• Two horizontal and parallel lines in red, orange or pink.
Not felling the tree	• One white line on each side of the stem • No red, orange or pink marking (may be marked with other colours)

WHITE **stripe:** future tree, do not cut.

RED, **PINK** **or** **ORANGE** **dot:** Cut.

Not marked: do not cut but for security reasons or to enable other operations.

Ring-barking or girdling: two RED, PINK or ORANGE stripes: cutting cambium all around the stem, without cutting the stem.

High stump and ground lying stem: one line in **RED, PINK or ORANGE** Tree to be felled, leaving the stump as high as possible (always under safe working conditions), generating a standing deadwood snag approximately 1 – 1.5 m high. The cut stem shall be delimbed and left lying on the ground, without cross-cutting or extraction.

7.2.2 Interpretation of understory clearing marking

The understory has been marked using red and white plastic tape and red, pink or orange spray paint. Only part of the total area has been marked. The marked understory area shall serve as a guide and reference for applying the treatment in the unmarked area.

- The markings delineate the small patches of understory that are NOT to be cleared. The remaining understory within the marked area shall be cleared.
- In areas of the stand where no understory marking is present, operators shall decide which species to clear and which to retain, in accordance with the criteria set out in Section *Selective understory clearing*.

7.2.3 Extraction of timber obtained from thinning operations

As a general rule, delimbing shall be carried out within the stand, and stem extraction by skidding shall be performed towards the forest road or existing skid trail. Whole tree harvesting could be also performed, therefore delimbing would take place in the skidding trail or the stacking or loading area. Any other extraction method must be explicitly agreed with CTFC staff.

The permitted and recommended means of extraction are detailed in Section *Extraction of timber obtained from thinning operations*.

In all cases, stems shall be skidded aligned, and care shall be taken to avoid damage to the bark of retained trees. In addition, the extraction operations shall avoid disturbing water- or rock-related habitats (stone walls, water streams, etc.).

Some trees with a diameter greater than 20 cm may be left on the ground without extraction in order to provide downed deadwood within the stand, at an indicative maximum density of 10 trees per hectare, and always fully delimbed. Trees to be retained shall be those with no commercial value or where extraction would be complex or likely to cause significant damage to the soil, aquatic or rocky features, or to other trees and shrubs that must be preserved. In all cases, the stems to be left within the stand must be approved by the CTFC.

7.3 Wildfire prevention during operations

All applicable legislation on wildfire prevention and control shall be strictly observed, and all necessary measures shall be adopted to prevent the ignition of unnecessary fires.

During the works, any flammable materials present on site shall be adequately protected.

The intervention area is located within the municipality of La Vansa i Fórnols, which has been designated as a high wildfire risk municipality under Decree 64/1995 of 7 March, establishing wildfire prevention measures.

- As the municipality is classified as high wildfire risk, between 15 March and 15 October, the contractor must hold a valid Authorisation for activities involving wildfire risk.
    - Conditions applicable to all authorisations for activities involving wildfire risk:
        - Prior to starting the activity, the DARPA wildfire danger website must be consulted to check whether the activity has been suspended due to the level of risk shown on the map, or as a result of extraordinary measures.
        - A minimum of one water-based fire extinguisher per machine with power > 10 hp, one water backpack with a minimum capacity of 15 litres per vehicle, and one fire beater per worker must be available.
        - A mobile phone must be available in order to immediately report any incident to 112.
        - The authorisation must be carried by the person in charge during the execution of the activity, who shall ensure compliance with its conditions.
        - The fire prevention and suppression equipment specified in the authorisation must be present at the location where the authorised activity is being carried out.
        - The activity shall be carried out exclusively on the days and during the hours specified in the authorisation.
- Throughout Catalonia:
    - Tree crowns from forestry operations that are not removed shall be cut up or shredded and spread directly on the ground (slash management)
    - On rural roads and forest roads, in accordance with Decree 166/1998 of 8 July, regulating access to the natural environment (DOGC No. 2680 of 14/07/1998), vegetation slash must be cleared for a minimum distance of 20 m on both sides of these routes.

Article 48.6.d of Forest Law 43/2003 establishes that when the wildfire danger map (see: http://www.gencat.cat/medinatural/incendis/mapaperill/ or by calling the citizen information service 012) indicates a very high or extreme wildfire danger, the use of the following machinery is prohibited on forest land and within a 400 m buffer surrounding it: mulchers, chippers, mechanical brushcutters with hammers or chains, chainsaws, and manual brushcutters using metal discs or blades.

7.4 Protected areas

One hundred per cent of the intervention area is included within the Natura 2000 Network. Therefore, authorisation from the competent management authority is required (to be processed by the CTFC).

7.5 Areas of faunal and floristic interest

One hundred per cent of the intervention area is located within or near different areas of faunal and floristic interest.

7.6 Topography

The rugged terrain constitutes a limiting factor for the mechanisation of understory clearing within the intervention area. For this reason, the use of mechanical means shall be prioritised wherever possible, and where access with such means is not feasible, manual methods shall be employed.

7.7 Access

Access to the forest stands is of sufficient quality and density for the planned means of operation.

Upon completion of the contracted works, any forest roads or tracks used shall be left in the same condition as prior to the treatments, with any necessary repair works to be carried out at the contractor's expense.

7.8 Public hydraulic domain

No known impacts on the public hydraulic domain have been identified.

7.9 Management of other waste

All non-forestry waste generated (chemical products, containers, packaging or other objects) shall be collected and removed from the forest by the contractor and managed selectively in accordance with applicable legislation.

Any containers, bags, plastic tapes and other small- or medium-sized waste already present within the stand shall also be collected and deposited in authorised containers or recycling facilities for selective treatment.

7.10 Work equipment

On the part of the contractor, operational staff responsible for tree felling and delimbing must have specific training and prior experience in the use of chainsaws. Personnel responsible for timber extraction must have specific training and prior experience in the use of winches and forestry tractors or other logging means. During operations, there must be personnel present within the stand with specific training in occupational risk prevention and first response to emergencies in forestry works.

7.11 Liaison and monitoring

CTFC technical staff shall act as the liaison body with the contractor's executive management and shall carry out periodic monitoring of the operations.

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