SUPERB
Upscaling Forest Restoration

Serbia & Croatia – Floodplain forest

Restoration Workplan

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1 Restoration goals

1.1 General demo description

Cross-border Demo is covered with riparian forests that are in contact to ground water and/or seasonal inundation. In these forests the dominant tree species are those that can cope with

flooding. Typically, riparian forests have the most diverse mosaic of forest types in European regions. Serbian part of the demo area in the protected area – Biosphere Reserve "Gornje Podunavlje". Croatian part is additionally described as fragmented forests plantations (poplar clones) which can be found on alluvial (riverine) soil and eugley-amphigley soils surrounded by agricultural land with intensive food production. Six stands in Croatia are under Natura 2000.

The initial status of the demo is (1) Large tracts of riparian forests have been cleared for agriculture and urban development in the past. (2) Damming and regulation of rivers has changed flooding regime. (3) Decline of trees as a result of changed disturbance regimes and drought stress of trees. (4) Low resistance of poplar plantations against climate disturbances. (5) A need to increase forest ecosystem services and food production in conditions of climate changes. Insight into history of the poplar plantation establishment reveals that interest into poplar plantations arises quite early in the 20th century (ca 1920 in Croatian part of demo area), mostly in two ways: (1) by afforestation on agricultural land and (2) by planting of poplars after clearcutting of natural mixed species forest with the aim of higher wood production and in cases when there were significant problems with regeneration of such forests. (6) Invasive non-native tree species (e.g. *Acer negundo, Prunus serotina*) and plant species (e.g. *Echinocystis lobata*) present an obstacle for natural regeneration, tree growth and negatively impact species biodiversity.

The restoration in Serbian part of the Cross-border Demo during 2022/2023 season is planned on the area of cca 28 ha. Other selected pilot cases ranging from single stands to larger landscapes, i.e., from one to 1.000 ha which are connected to area of management unit. In Croatia: (1) about 1.000 ha of similar stands are in the last three decades successfully restored by planting oak and hornbeam after clear cut of devitalised non-native poplar plantations; (2) about 2.000 ha of areas could still be restored in Croatia. Croatian restoration area will be set on two restoration sites (53,5 ha). Fist site is planned to be restored in season 2022/2023, while the second restoration site will be restored in the next season (2023/2024).

Cross-border Demo is surrounded by fragmented agriculture land together with patches of forest, meadows, and pastures. Public Enterprise "Vojvodinašume" oversees the forest and protected area management in this region in Serbia. The forests in Croatian case are owned mostly by state and managed by Croatian Forests Ltd. Some smaller parts are owned by private forest owners.

1.2 Problems and restoration goals

Within SUPERB and the Cross-border Demo, the restoration with successional planting of pioneer species (willows, poplars) on areas and late successional species such as oaks and elms (replacement of monospecific stands/plantations) is planned. Further on, planting the mixed-species forests, where pedunculate oak- and European hornbeam dominate among naturally widespread native species. The restoration using these types of species will have high positive impact on strengthening the biodiversity and resilience of riparian ecosystems in this area.

The goal is that trough restoration of devitalised poplar plantations into mixed oak forests greater potential in biodiversity and ecosystem services is achieved. Through other educative activities we aim to promote the importance of functional riparian forests.

The restoration goals are to find the best forest restoration techniques for improvement of wood production, carbon sequestration, biodiversity, and the increase of stand resistance.

Also, monitoring and mapping of the biodiversity changes on the landscape level. In addition, the investigation in the changed environment would be observed on the ecosystem services provided by herbs, honey plants, mushrooms, and health related ES (tree VOCs content) but also the ecosystem disservices (EDS) such are allergenic plants. The activity will demonstrate cross-sectoral approach in restoration of water-sensitive forest types, includes the collaborative work of water boards, forest managers, research institutions and nature protection authorities. The final output is rehabilitation of natural forest stands.

In specific, the restoration requires removing all recently devitalised non-native poplar plantations and replacement with more resistant and economically interesting late successional mixed species stands. Observed low vitality is a consequence of changes in site conditions (hydro-melioration, climate changes, etc.) but in some cases also a consequence of the fact that poplars are in their third consecutive rotation. This replacement of tree species composition is prescribed by forest management plans for selected demo area. Even though preferred silvicultural method is shelterwood in general, in the case of replacement of poplars removal of all trees is necessary. It prevents spreading of unwanted non-native poplar regeneration on the aimed replacement area, which can hinder growth and development of aimed natural tree species, thus decreasing the cost of clearing and tending measures. In addition, aimed mixed species stands will have natural species composition with intent to increase the tree species diversity.

Nevertheless, there are specific constraints to set goals. By the FSC rules 3-5 mature trees per hectare are left both in Serbia and Craotia (included in forest management plans) for maintaining biodiversity (there is no special research efforts in terms of poplars suitability for native saprophylic organisms). Even though the main goal of restoration activities will be restoring overmature, devitalised or degraded stands (non-native poplar plantations) to naturally occurring mixed species stands dominated by *Quercus robur* L., only certain species are allowed to be used for forest restoration/artificial regeneration (planting, sowing). These species are defined by Law on forestry and Law on nature protection with strongly nature-oriented species selection for demo area. In some areas the use of non-native tree species is completely banned (e.g. protected areas), while in some area forestry acts are not in line with nature protection acts. In addition, support of domestic tree species and provenances are defined by Law on forest reproductive material as well. These rules apply to both Croatia and Serbia. *Quercus robur* L. and *Fraxinus angustifolia* Vahl. are late successional tree species in our demo area and it is decided that *Quercus robur* L. will be used for restoration, as there are many health issues with *Fraxinus angustifolia* Vahl. recorded in Croatia and since 2015 it is also present in Serbia. One of the biggest is ash dieback (*Hymenoscyphus fraxineus*) which caused a significant damage to *F. angustifolia* Vahl. stands. It is also very important to note that there is no alternative domestic tree species in Croatia and Serbia at the moment for narrow-leaved ash. Furthermore, there are also no *F. angustifolia* Vahl. seedlings in Croatian nurseries since its production is banned from November 2021. Croatian Forests Ltd. produced enough seedlings of *Q. robur* for one of the restoration sites where planting is expected in the spring or autumn of 2023 (Depending on the site conditions, e.g. flooding). We can expect some problems with the production of *Q. robur* L. seedlings for the second restoration site, where planting will be executed in 2024., as acorn fruiting of *Q. robur* L. was absent in 2022. In this case, we will adapt the age of oak seedlings to the availability of acorns for seedling production. Alongside the *Q. robur* L., *P. avium* and *Sorbus spp*. will be planted to support biodiversity. *Sorbus* trees production in nurseries is sometimes problematic. If there will not be enough *Sorbus spp*. seedlings, *P. avium* will be planted instead. Natural regeneration of other tree species is expected and will be supported during the tending of young stands (e.g. *Ulmus* sp., *Tilia* sp.).

According to the forestry laws and silvicultural principles in Croatia, there are no need for planting the accompanying tree species since they occur naturally. Situation in practical forestry follows the principles prescribed by law – accompanying tree species do occur

naturally. Anyway, in the case natural regeneration would not be sufficient artificial regeneration by seeds will be done. In the first age class (up to 20 yrs.) activities on clearing and respacing are those that influence vertical and horizontal pattern of species composition. Thus, it is expected that these species will spread naturally from surrounding areas, and they will be further supported through tending measures in restoration area. More information about seedlings quantity, origin and age can be found further in the text in the paragraph: Restoration activities (Table 3.1, Table 3.2, Table 3.3).

Considering other activities, the focus would be put on the wide range of ES: provisional and traditional (cultural): herbs, honey plants, mushrooms; health related (tree VOCs content) and ecosystem disservices (EDS) such as allergenic plants.

Low productive agricultural land could be returned to forests. In the long term, climate change may severely alter flooding regime in the sense of increase of winter and decrease of spring flooding owing to reduced snow melt. Furthermore, impact of spontaneous introduction of invasive plant species, pests and diseases could be mitigated by replacement to mixed species stands.

2 Current situation

As we can see from the map (Figure 2.1 Map showing all Croation stands (monitoring and restoration) provided, the Croatian part of the demo is composed of 13 monitoring stands and 2 restoration sites scattered around the city of Osijek alongside Drava River. It is mainly characterized by patches of forests that used to be a part of a bigger riparian ecosystem. Due to extensive land use and damming and regulation of rivers, vitality of trees declined. Here, the selected stands are poplar monocultures with low resistance to climate disturbances. Furthermore, some stands were under landmines for a long time and thus they were unmanaged. Now, the area is mostly cleared of landmines and management is again possible. 6 out of 13 monitoring stands are under some kind of protection (Natura 2000, regional park).

Considering Serbian part of the demo, there are 9 stands and one restoration site all placed within the Biosphere Reserve “Gornje Podunavlje” (Figure 2.3). This Reserve is positioned in the far northwest part of Serbia, on the triple border with Hungary and Croatia. “Gornje Podunavlje" is a protected natural asset that extends along the left bank of the Danube River. It is part of a vast complex that runs across Hungary (National Park "Danube-Drava") and Croatia (Nature Park "Kopački rit"), forming an ecologically distinct entity. It is part of the extensive "Bačko Podunavlje" biosphere reserve, which comprises the "European Amazon," and represents one of the best-preserved marshy moor units on the whole Danube, which poures into an unending network of backwaters and canals across the Biosphere Reserve's floodplain woods. This Biosphere Reserve was included on the UNESCO World Heritage List in June 2017. Same as in Croatian part of the demo area, low-vitality poplar monoculture forests were selected for restoration. The goal is to bring back the dominance of Penduculate oak in this area, which is its natural habitat, while restoring biodiversity of the broader area which was endangered with extensive use of fast growing species (such as poplars) in the past.

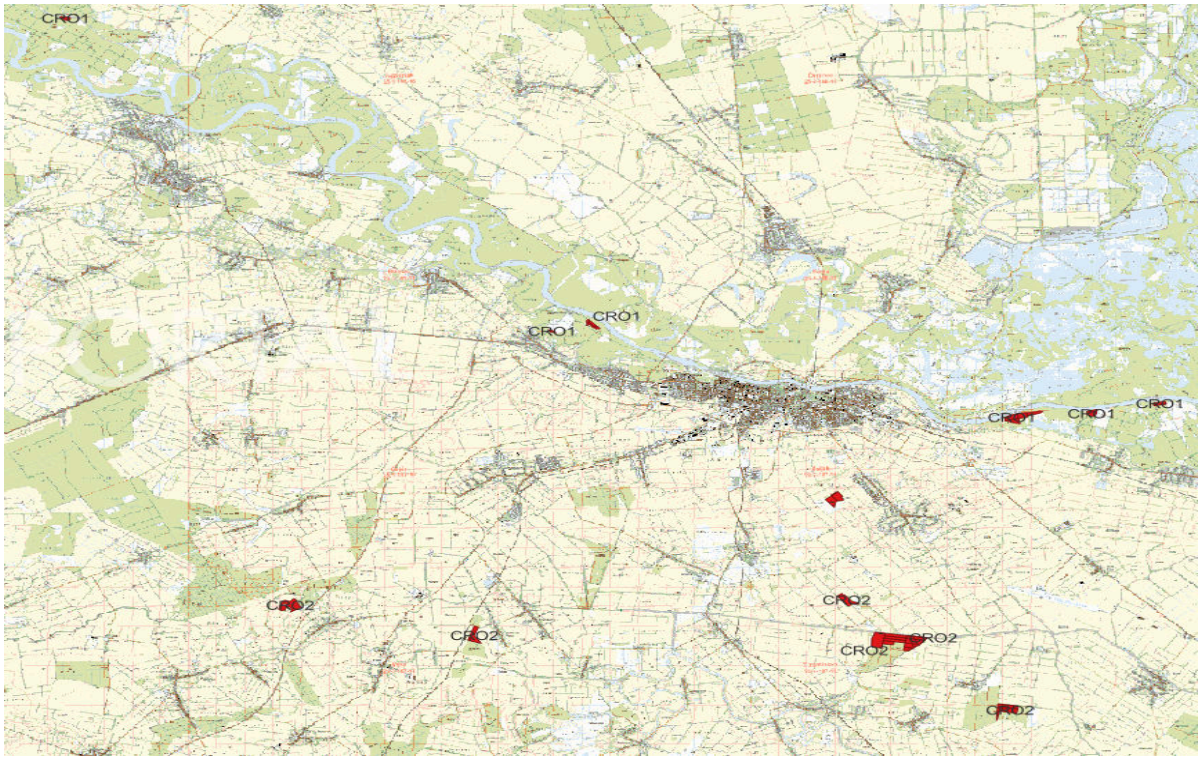

Figure 2.1 Map showing all Croation stands (monitoring and restoration)

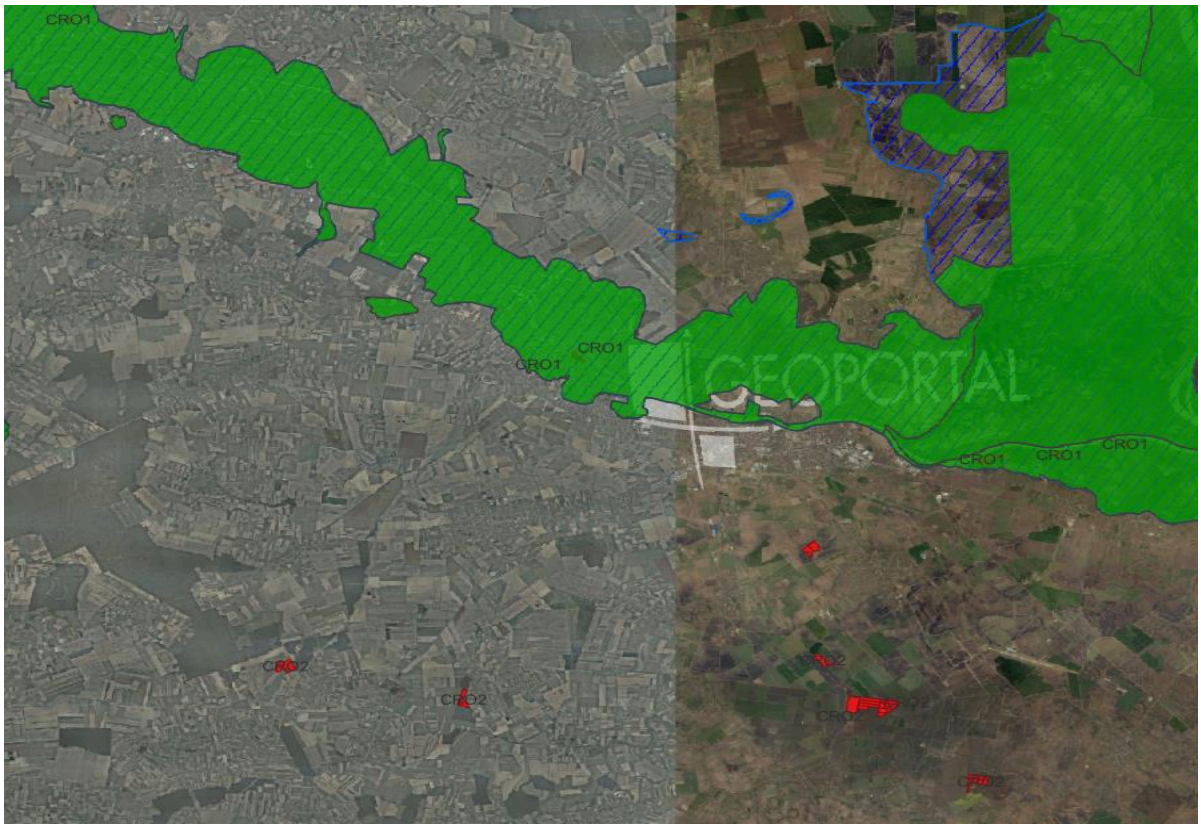

Figure 2.2 Six stands under green layer are Croatian monitoring site 2 and are part of Natura 2000

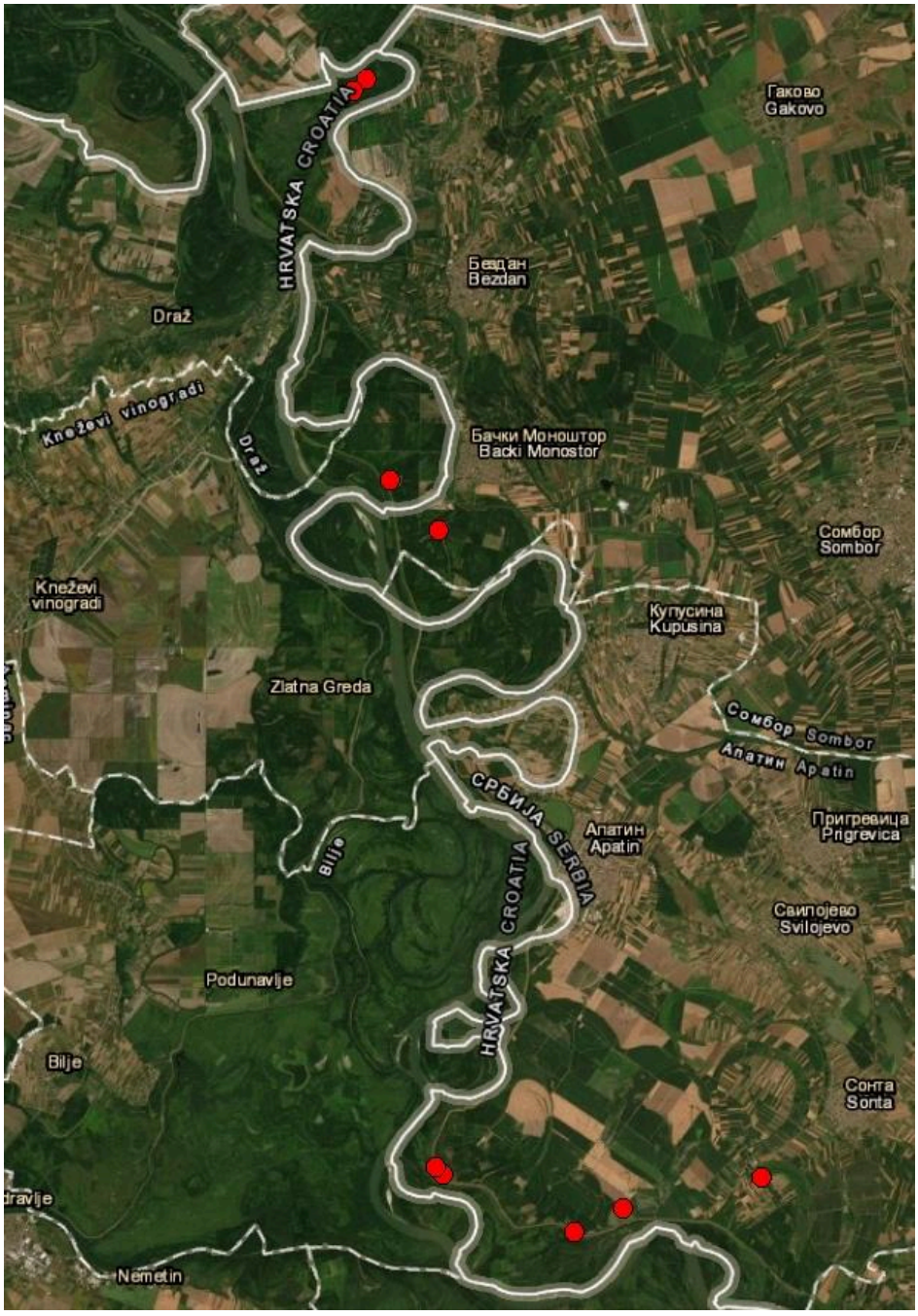

Figure 2.3 Map showing all Serbian stands (monitoring and restoration)

3 Restoration activities and initial assessment

3.1 Description of restoration activities

Table 3.1 Overview of Croatian restoration sites – Stand 1a

Category	explanation
Site name	Department 1a
Size	31,09 hectares
Restoration measures	Promoting natural regeneration by final cut of devitalized poplar plantations, selective removal of trees – and planting of native tree species (Q*uercus robur* L.*, Prunus avium* L.*, Sorbus sp.*) while supporting native vegetation. Natural regeneration of other tree species is expected and will be supported during the tending of young stands (e.g. *Ulmus* sp., *Tilia* sp.). Protection of seedlings with fencing (protection against wildlife - grazing). Tending if necessary.
Targeted improvement	Restoration of devitalized poplar plantations in oak forests will lead to the enhancement of forest ecosystem services and better forest resistance and resilience to ongoing climate change. Replacement of poplar trees with more valuable climax tree species where possible is planned, while supporting tree species diversity.
Location	
Pre-treatment	Removal of overmatured poplar trees, removal of shrubs if needed. Selection of trees for cutting, measurement of trees, removal of shrubs (mechanical), Removal of overmatured poplar trees (clear cut), dispatching of cut poplar trees with the use of mechanisation. Hand digging holes for seedlings.
Materials used	Posts, nails and netting for protection of natural regeneration. Black locust posts (3 meters high). Iron rebar mesh (400 cm*220cm ø 8mm) with a narrower gap in the lower section for protection against wildlife. Nails and wire
Plants	Native species of oak, wild cherry and sorbus sp. will be used to support tree species diversity, row planting (dimensions of planting hole according to plant age) with the aim of increasing possibilities for the use of forest mechanisation. *Pedunculate oak – *Quercus robur* L.

	Age: 2+0 Height: 50 - 80 cm, Origin: known origin, identification code for provenance: 1.1.2. - Croatia – seed region Middle Podravina, registration number of seed object: HR-QRO-SI-112/399, code of seed certificate: HR 169/2021). Autochthonous, Forest Administration Slatina, Forest office Slatina, forest management unit Slatinske nizinske šume: 44a, 64a, 65a, 66ab, 67bc, 68a, 79abc,82ab,90b,91a,92bc,93ab,103ab,104ab. Quantity: 5000 pcs per ha. *Wild cherry – *Prunus avium* L. Age: 1+0 Height: 50 - 80 cm, Origin: known origin Quantity: 100 pcs per ha **Sorbus* spp. Age: 1+0 Height: 50 - 80 cm, Origin: known origin Quantity: 100 pcs per ha *Sorbus trees production in nurseries is sometimes problematic, if there will not be enough of seedlings wild cherry will be planted instead. For the production of one-year old seedlings the production is just starting, thus the provenance of these tree species will be determined according to availability, but respecting the Low on forest reproductive material. In total: 161668 seedlings will be planted. Seedlings will be planted in a hand dug out holes in the field. There is no use of chemical repellents against wildlife instead a fence will be used.
Posttreatment	Replacement of failed plants, weeding, control of herbivores, additional planting if needed. Mechanical control of weeds if needed. Monitoring of stand health and monitoring of pests.
Planning by year	Selection of trees has been done in 2021. 2022: Removal of shrubs, Clear cutting of poplar trees and export. 2023: Finalizing the extraction of trees, Export of trees, chemical (if it is acceptable and needed) and mechanical preparation (machines) for planting, placement of fences, planting of pedunculate oak and wild fruit trees (sorbus spp., wild cherry) 2024: tending if needed 2025: Tending if needed, inspection of the fence and monitoring of pests and diseases

Table 3.2 Overview of Croatian restoration sites – Stand 95b

Category	explanation
Site name	Department 95b
Size	22,41 hectares
Restoration measures	Promoting natural regeneration by final cut of devitalized poplar plantations, selective removal of trees –and planting of autochthonous tree species (Q*uercus robur* L.*, Prunus avium* L.*, Sorbus* sp.) while supporting autochthonous vegetation. Natural regeneration of other tree species is expected and will be supported during the tending of young stands (e.g. *Ulmus* sp., *Tilia* sp.). Protection of seedlings with fencing (protection against wildlife - grazing). Tending if necessary.
Targeted improvement	Restoration of devitalized poplar plantations in oak forests will lead to the enhancement of forest ecosystem services and better forest resistance and resilience to ongoing climate change. Replacement of poplar trees with more valuable climax tree species where possible is planned, while supporting tree species diversity.
Location	
Pre-treatment	Removal of overmatured poplar trees, removal of shrubs if needed. Selection of trees for cutting, measurement of trees, removal of shrubs (mechanical), Removal of overmatured poplar trees (clear cut), dispatching of cut poplar trees with the use of mechanisation. Hand digging holes for seedlings
Materials used	Posts, nails and netting for protection of natural regeneration. Black locust posts (3 meters high). Iron rebar mesh (400cm*220cm ø 8mm) with an narrower gap in the lower section for protection against wildlife. Nails and wire
Plants	Native species of oak, wild cherry and sorbus sp. will be used to support tree species diversity, row planting (dimensions of planting hole according to plant age) with the aim of increasing possibilities for the use of forest mechanisation.

	*Pedunculate oak – *Quercus robur* L. Age: Will be determined according to availability of seed resources and production process (optimal aimed seedling age 1+0 or 2+0) Height: Will be determined according to availability of seed resources and production process (optimal aimed seedling height 50 - 80 cm) Origin: known origin - The provenance of these tree species will be determined according to availability, but respecting the Low on forest reproductive material. Quantity: 5000 pcs per ha. **Wild cherry – *Prunus avium* L. Age: 1+0 Height: 50 - 80 cm, Origin: known origin Quantity: 100 pcs per ha **Sorbus spp. Age: 1+0 Height: 50 - 80 cm, Origin: known origin Quantity: 100 pcs per ha *There might be some problems with pedunculate oak seedlings as in this year (2022) there are no seed from which seedlings will be grown in Croatia and region, therefore the origin and the age of seedlings will be determined according to available seed resources. The provenance of these tree species will be determined according to availability, but respecting the Low on forest reproductive material. **Sorbus trees production in nurseries is sometimes problematic, if there will not be enough of seedlings wild cherry will be planted instead. The provenance of these tree species will be determined according to availability, but respecting the Low on forest reproductive material. In total: 116532 seedlings will be planted. Saplings will be planted in a hand dug out holes in the field. There is no use of chemical repellents against wildlife instead a fence will be used.
Posttreatment	Replacement of failed plants, weeding, control of herbivores, additional planting if needed. Mechanical control of weeds if needed. Monitoring of stand health and monitoring of pests.
Planning by year	2022: - 2023: Removal of shrubs, Clear cutting of poplar trees and export. 2024: Export of trees, chemical Preparation (if needed and acceptable) and mechanical preparation (machines) for planting, planting of pedunculate oak species and wild fruit trees (sorbus spp., wild cherry) 2025: Tending if needed, inspection of the fence and monitoring of pests and diseases.

Table 3.3 Overview of Serbian restoration sites

Category	explanation
Site name	Department 39 e
Size	28 ha
Restoration measures	Before restauration, the site condition is determined and selection of most favourable species for each restoration site and afforestation was done. For all sites in Serbian part the soil types are determined. After that, restoration measures will be defined according to the regulations of the Republic of Serbia. Restoration measures of promoting natural regeneration has certain activities. At the beginning the final cut of devitalized poplar plantation must be done. After the sowing and planting on regeneration area, selective removal of trees of invasive species should be done to promote native vegetation growth. Protecting natural vegetation with fencing and tending. Replanting if needed and plant care.
Targeted improvement	Restoration of devitalized poplar plantations in oak forests will lead to the enhancement of forest ecosystem services and better forest resistance and resilience to ongoing climate change. Replacement of poplar trees with more valuable climax tree species where possible is planned, while supporting tree species diversity.
Location	
Pre-treatment	Removal of overmatured poplar trees, invasive species and removal of shrubs if needed.
Materials used	Posts, nails, and netting for protection of natural regeneration
Plants	Native species of pedunculate oak (*Quercus robur*) will be used, minimum 1550 plants/ha, while other species such as (*Fraxinus angustifolia, Carpinus betulus)* will occur naturally in the period of first 20 years as shown in a practice. Origin is defined according to the regulations in Republic of Serbia must be from the same provenance region. Seedlings are aged up to 2+2 or sowing with seeds. Protection against herbivory is foreseen with fencing.

Posttreatment	Restoration measures will be defined according to the regulations in Republic of Serbia. Posttreatment according to regulation defined as replacement of failed plants if success of don't reach 90% after the 3rd year of planting. Weeding measure is prescribed one times in the years until the 3rd year of planting (manual removal and taruping). Selective removal of unwanted and invasive species is performed after the 3rd year after the planting, which is obligated by the Serbian law and the costs for this activity will not take part in the project budget. In extreme year it is possible the watering of planted seedlings.

3.2 Initial assessment of restoration sites (where actual restoration takes place)

3.2.1 Objectives

The purpose of the initial forest inventory is to describe the state of the forest trees (if desired dead wood) and optionally herb layer and to be able to assess future effects (success and failures) of the measures on the ecosystem biodiversity and functions. The observations are conducted and recorded at plot scale, in a sample design laid out over the restored areas involving several aspects of the stand structure.

The initial assessment includes measurements of the adult trees, saplings and seedlings (and optionally ground vegetation inventory of non-tree species). These aspects are described in these guidelines.

In case the restoration stand is located within the chronosequence stand, the forest inventory information is retrieved from the WP6. However, for the restoration stands that are not inside of the chronosequence stand, assessment of the initial forest state needs to be done.

3.2.2 Sampling design

The measurements are conducted at the sampling point (plot) scale. A regular sample design of measurement plots is laid out depending on size of restoration site (Table 3.4).

Table 3.4 The criteria table of number of plots established accordingly to the size of the restoration site.

Size of restoration site (ha)	Number of plots
<1 ha	3
1 – 5 ha	10
5 – 20 ha	20
20 – 100 ha	30
100 – 1000 ha	50

Overall, the initial assessment is a simplified design of the chronosequence monitoring design. It only has a central sampling point. In order to avoid biasing the location of the sampling points (for example, by establishing them in the middle of a clearing, or seeking equidistance to trees nearby), the location of the centre is randomly determined within the stand.

The random selection of plot positions is secured by walking a fixed number of steps in a fixed direction from the stand border. This is a way to eliminate perception biases and tendencies to position plot centres at a best spot, which could yield biased estimations of the total stand density.

Concentric subplot design

Around each selected sampling point, concentric plots of different sizes are used to measure the different components of forest structure, to ensure efficiency in the inventory effort (Figure 3.1). Accordingly, characteristics that require larger effort are measured over smaller plots, whereas larger plots are employed to record rarer events only. To quickly decide in the field which trees belong to each subplot type, you may simultaneously measure diameter at breast height (dbh) and distance to plot centre. The different plot sizes (Figure 3.1) are designed to be integer divisions of a hectare, to facilitate rapid in situ assessment of within-stand variability. The different subplots involved are:

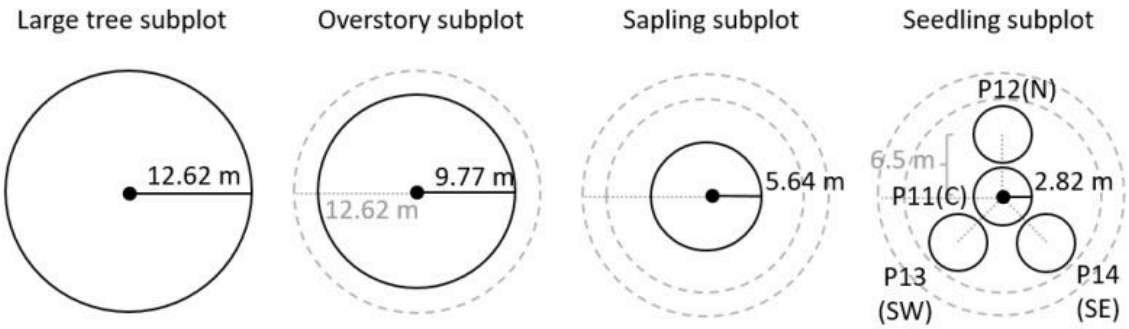

Figure 2. Field plot design for multilayered forest following a circular subplot design.

1. One large tree subplot (12.62 m radius) where only large adult trees (>27 cm dbh) will be measured;
2. One overstory subplot (9.77 m radius) where all adult trees (> 7cm dbh) will be measured;
3. One sapling subplot (5.64 m radius) where the smaller trees (saplings) will be measured and deadwood biomass will be assessed;
4. Four seedling subplots (2.82 m radius) where seedlings will be counted.
5. In addition, aground vegetation inventory of non-tree species will be done over 1-m quadrats within seedling subplots.

Figure 3.1 Plot size to measure different components of forest structure.

In case bare land is afforested (stand after bark beetle calamity, or restoration focuses on forest area expansion on former cropland), then only assessment of seedlings and sapling subplots is established and recorded. In the subplots it is possible to make an additional assessment of herb layer and dead wood. In case of an existing stand in which group or

selective fellings are carried out in combination with introducing new tree species, then the large tree to seedling plots are established.

3.2.3 Timing

Data can be collected during a short campaign, as well as in third year of the project. Since the initial assessment is a singular measurements campaign, it is possible to combine it with other field measurements (e.g. WP6 monitoring).

3.2.4 Measurements

General information

The recorded data are collected in the Excel spreadsheet provided. General information is recorded under the tab 'Stand'. The tab 'Stand' include information of country, stand, stand size and number of plots for the initial assessment. Second tab 'Plot' include the GPS coordinates, specifying in the comments which is the geographical system employed for them (please, use ESPG codes for national systems). Optionally, we can record approximate terrain slope and aspect in the site. Relevant observations on the plot environment and location can also be recorded (e.g., proximity to roads or infrastructure, recent management interventions, previous land use) in the field 'Comments'. Additionally, we add approximate percentages of coverage for each of the tree, shrub and the herbaceous layers, assessed visually and expressed separately and not relatively to each other (their sum may therefore be higher than 100%). Tab 'Species' includes the species codes that are used across all demo areas. If possible we provide suitable allometric models for the species in the demo area which can make the best biomass predictions according to the local knowledge. There are additional fields to add any relevant information concerning allometry: height or below ground biomass, relevant references, etc.

Adult tree inventory (Large tree and overstory subplot)

The tree inventory includes all the standing, living or optionally dead adult trees (dbh > 7 cm). Intermediate-sized trees (dbh between 7 and 27 cm) are measured on a 9.77-m radius plot, whereas large trees (dbh > 27 cm) are measured on a 12.62 m-radius plot (Figure 3.1). In each case, the species and dbh of all the corresponding trees are recorded. If decided to do the optional assessment of dead trees, when the species of dead trees cannot be determined, it should be recorded whether these are hardwood or softwood species.

Tree heights is determined for few living trees (only 3 measurements for each of the dominant species present) trying to approximately cover the full range of tree heights and giving measurement of one small, median and one tall tree. Height measurements are conducted either on the intermediate sized trees from the 9.77 m-radius plots, or on the large trees from the 12.62 m-radius plots. It is however important that each height measurement is linked to a dbh measurement, and thus recorded at the row corresponding to the same tree (the rest of rows can be left empty for height measurement). If dead top broken trees are found within the plot their decay class is recorded according.

Saplings inventory (Saplings subplot)

Trees with dbh < 7 cm are also measured individually and recorded, as long as they are higher than 1.30 m (saplings). These trees are measured only when they are at a distance within 5.64 m from the plot centre, to limit the surveying effort needed for these smaller trees. Individual tree codes for saplings are start the count from "101", to aid their distraction from the bigger trees and facilitate the combination of overstory and sapling layers. If the height measurement of the smaller tree was taken from one of these saplings, add its corresponding height here alongside its dbh.

Seedlings inventory (Seedlings subplots)

For trees with height below 1.30 m measurement is based on counting each individual. The counting is done over 4 different subplots of 2.82 m radius, which should be distributed according to Figure 3.1. Using a telescopic pole, rapid counts of seedlings can be carried out around each subplot centre. Record seedling counts per subplot grouped by species and height class. The height classes only need to be determined approximately: below 20 cm (class 1), 20 – 80 cm (class 2), or above 80 cm (class 3).

Optional additions to the initial assessment in the restoration stands

Richness of ground vegetation using iNaturalist (Central quadrats at seedling subplots)

Each species of non-tree vascular plants (herbs, ferns, shrubs) present in each if the 1-m quadrats within each seedlings subplots are identified using the iNaturalist application. To be included in this list, plants can originate either within the quadrat, or outside it, as long as some part of them is present either directly on the quadrat floor, or on its vertical projection, up to a height of 5 m.

Before going in the field requires:

- Download the iNaturalist app for iPhone or Android.
- Create an account using the app or the website (https://www.inaturalist.org/home)
- Transmit your user information to SUPERB Wageningen team by email (gert-jan.nabuurs@wur.nl, sara.filipek@wur.nl, silke.jacobs@wur.nl, bas.lerink@wur.nl).

Once in the field, you should follow the steps depicted in Figure 3.1 for any species you observe in each quadrat and repeat the process for every seeding subplot (i.e., 4 quadrats per plot). Use the Subplot codes to identify them as in Tables in Initial_forest_assessment protocol. More information can be found on the web (https://www.inaturalist.org/pages/getting%252Bstarted) or checking the tutorials of the iNaturalist App (https://www.inaturalist.org/pages/video%252Btutorials) where explanations are given on how to add an observations using different devices or the website.

Lying deadwood (Saplings subplot)

For all lying deadwood pieces (diameter > 7 cm) found within the 5.64 m-radius saplings subplot (Figure 3.1), the diameter at mid-length, total length, and decay class is recorded. For

pieces of deadwood intersecting the borderline, the criterion for inclusion is whether any part of it within the 5.64 m distance of the plot centre as a diameter > 7 cm. It is recommended to use a tree calliper for measuring lying deadwood diameter. The decay class is determined according to the following categories: 1 –Sound (recently dead); 2 –Intermediate (partially rotten); or 3 –rotten.

3.3 Costs assessment

The costs of restoration consist of direct cost of various restoration activities that are taken place in restored sites. The direct costs are divided into several categories such as site preparation (e.g. soil preparation - ploughing, topsoil removal), materials (e.g. wooden polls for fences, fence net), plants (e.g. cost of seeds, seedlings, saplings) and labor costs (e.g. person costs for soil preparation, planting, installing fences, maintenance like weeding).

Please note that Croatian Forests Ltd. contributes to restoration activities in Croatian side with large part of labor cost and partly in materials for restoration activities (in total Croatian forests are financially supported from SUPERB by 47.363 EUR for labor and 111.680 EUR for materials and site preparation). In addition, there is a trend of rapidly increasing costs of materials and labor due to economic crisis.Following cost assessment excludes overhead, opportunity costs, buying land.

Table 3.5 Overview of the direct restoration costs for Croatian sites

Cost category	unit	2022	2023	2024	2025
Site preparation	€/ha	-	177,78 (1a-31,09 ha)	177,78 (95b-22,41 ha)	-
Materials	€/ha	-	371,91 (1a)	527,22 (95b)	-
Plants	€/ha	-	1.994,93	1.994,93	-
Labor	€/ha	-	?	?	-

Table 3.6 Overview of the direct restoration costs for Serbian site

Cost category	unit	2022	2023	2024	2025
Site preparation	€/ha		574.46		
Materials	€/ha		429.56	155.01	
Plants	€/ha		847.37	310.70	
Labor	€/ha		3292.94	1508.66	
Total costs	€/ha		5144.33	1974.38	

The rough estimation of the direct restoration cost on Serbian part is given in the Table 6. We are not able to provide the actual cost data in detail, due to the national laws. For any purchase of goods and/or services we need to do the public procurement in order to ensure equal chances for any potential goods/services provider.

Until we finish the process or procurement for these planned activities within restoration in our part of the demo, we can't give you the exact information. We hope that we could get the offer from the services provider and sign a contract until the end of this year or beginning of the next. Nevertheless, as soon we have the exact data, we will update this document.

4 Monitoring

4.1 Site and stand selection for Monitoring, Reporting and Verification of Biodiversity and Ecosystem Services in chronosequence

4.1.1 Sampling design

Within the demo several relatively homogeneous landscape units have been selected. These are “sites”. On each site, multiple stands represent a restoration chronosequence and within each stand, up to 5 inventory plots are selected. Within this design, plots are the smallest scale and minimum spatial unit of study. Plots therefore represent nested replicates within a stand (or habitat) at a single point of restoration. A stand encompasses an area of continuous habitat in the same condition (i.e. same stage of restoration). The area used for samplings within a stand is approximately 1 ha. This is a size that is also used in a number of other large projects quantifying biodiversity in forests (e. g. LIFEPLAN, Biodiversity Exploratories) and thus ensures comparability of results. This size can capture much of stand level structural heterogeneity. Similarly, several spatial replicates of soil samples capture and represent soil conditions and biodiversity of the whole stand. A site is a relatively homogenous landscape unit in terms of climate, topography, geomorphology and soil type and encompasses stands across a restoration gradient. The chronosequence consists of 6 stands within the same site that represent the same forest type and cover a gradient from ‘disturbed or degraded/before restoration’ towards a ‘reference ecosystem’ representing target conditions for restoration. In between these two end-members of the restoration sequence, there are stands that have been restored in the past and represent a chronosequence of stand development since restoration.

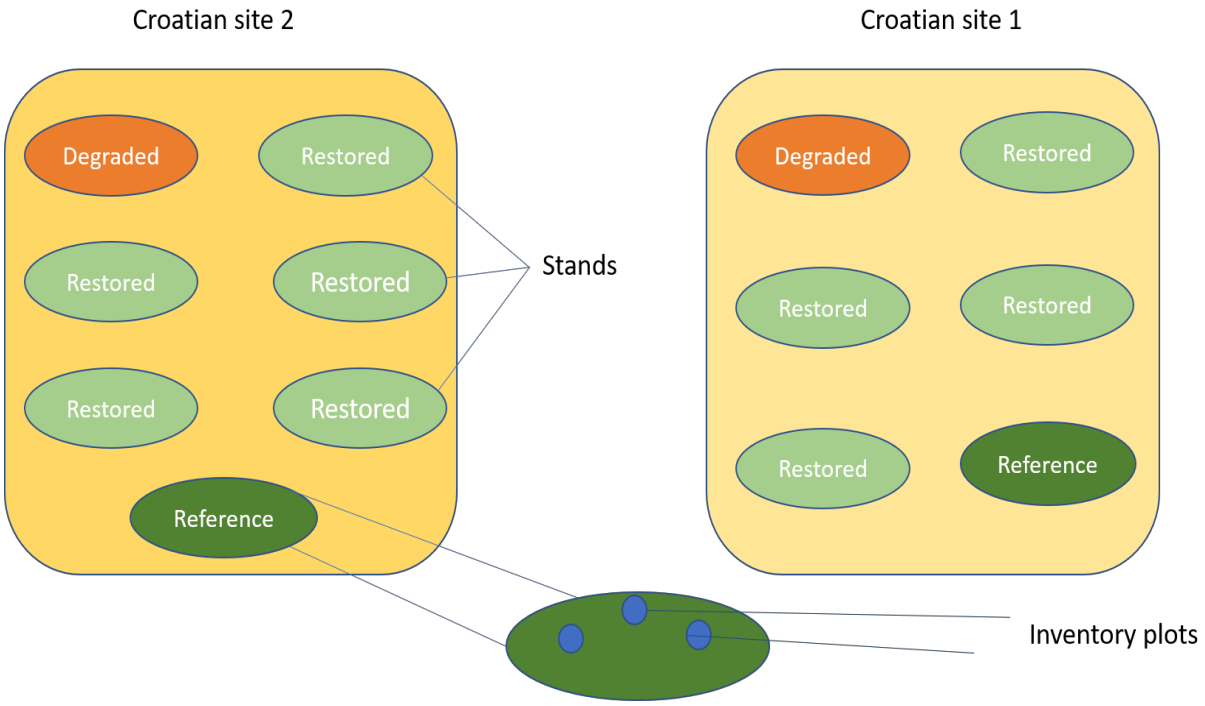

Figure 4.1 onitoring design of Croatian sites

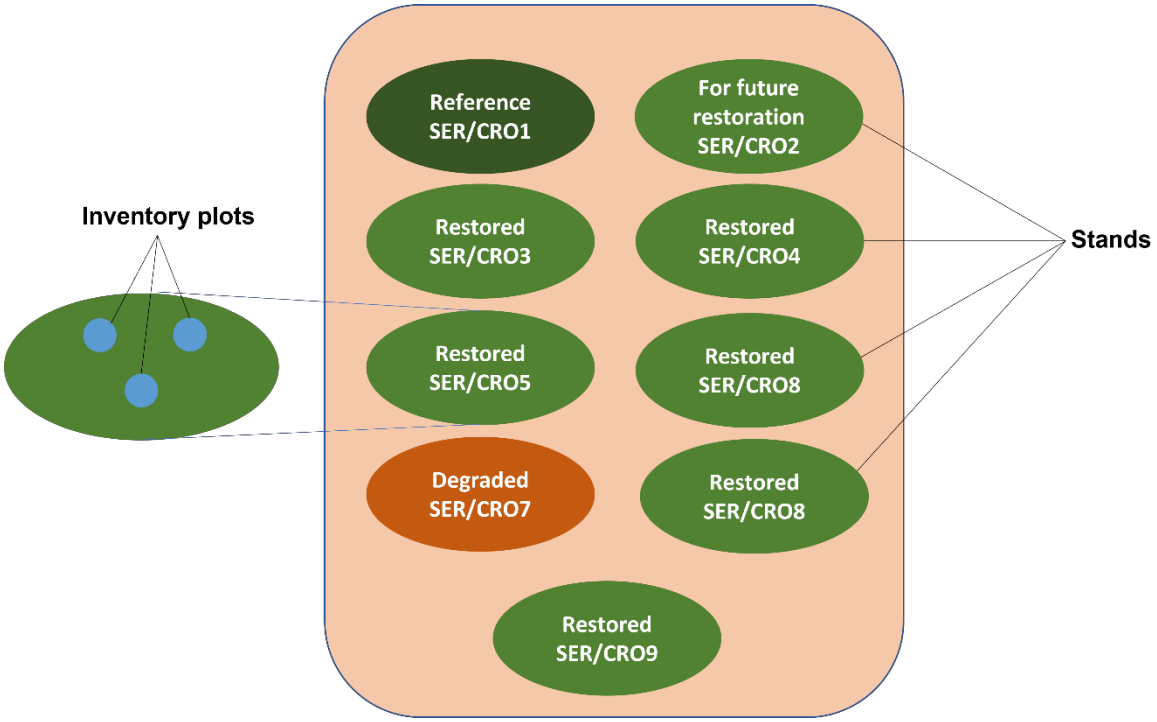

Figure 4.2 Monitoring design of 9 stands in Serbian site

4.1.2 Description of chronosequence sites

Table 4.1 Overview of chronosequence stands on Croatian site1

Site1_Stand	Lat_dec,Lon_dec	Stand code	Area size (ha)	Elevation (m)	Terrain slope	Soil type	Vegetation type (Forest type)	Tree species
SER/CRO1 - Degraded stand	682173.070432179 5047838.46503889	22a	8,86 ha	0-82 m	0-0°	N/A area was uned mines	Alno-Padion, Alnion incanae, Salicion albae	*Populus euramericana*
SER/CRO2 - restored stand	664354.398578338 5052340.26954778	1c	8,45 ha	0-85 m	0-0°	alluvial (riverine soil)	Alno-Padion, Alnion incanae, Salicion albae	*Quercus robur, Fraxinus angustifolia*

SER/CRO3 - restored stand	662917.203090628 5052000.29925917	4b	1,83 ha	0- 85 m	0-0°	alluvial (riverine soil)	Fraxino-Ulmetum laevis	*Quercus robur, Fraxinus angustifolia*
SER/CRO4 - restored stand	679581.66245307 5052000.29925917	19a	32,12 ha	0-83 m	0-0°	alluvial (riverine soil)	Alno-Padion, Alnion incanae, Salicion albae	*Quercus robur*
SER/CRO5 - restored stand	684577.116990437 5048313.46341516	46b	6,12 ha	0-82 m	0-0°	alluvial (riverine soil)	Alno-Padion, Alnion incanae, Salicion albae	*Quercus robur, Fraxinus angustifolia*
SER/CRO6 - Reference stand	645589.680079202 5067938.49430086	42a	4,72 ha	87-91 m	0-11°	Alluvial-meadow soils	Genisto elatae-Quercetum roboris aceretosum tatarici	*Quercus robur, Fraxinus angustifolia, Populus Euramericana, Ulmus laevis*

Table 4.2 Overview of chornosequence stands on Croatian site2

Site2_Stand	Lat_dec,Lon_dec	Stand code	Area size (ha)	Elevation (m)	Terrain slope	Soil type	Vegetation type (Forest type)	Tree species
SER/CRO1 – Degraded stand	673415.864620413 5038308.08461502	93a	16,54 ha	84-85 m	0-0°	Eugley-amphigley	Genisto elatae Quercetum roboris caricetosum remotae	*Robinia pseudoacacia,Populus euramericana*
SER/CRO2 - Restored stand	675146.825218825 5036368.46825096	2a	28,94 ha	84-85 m	0-0°	amphigley	Carpino betuli-Quercetum roboris	*Quercus robur, Quercus cerris, Ulmus minor, Fraxinus angustifolia*

SER/CRO3 - Restored stand	674909.114341079 5036130.65677206	2b	6,22 ha	84-85 m	0-0°	Eugley-amphigley	Carpinion betuli	*Quercus robur, Ulmus minor, Salix caprea, Populus alba, Acer campestre*
SER/CRO4 - Restored stand	675787.970698592 5036151.61996572	3a	37,02 ha	84-86 m	0-0°	Eugley-amphigley	Carpinion betuli	*Quercus robur, Ulmus minor, Salix caprea, Populus alba, Acer campestre*
SER/CRO5 - Restored stand	679128.872559873 5032761.73881187	13a	23,57 ha	84-86 m	0-0°	Eugley-amphigley	Genisto elatae Quercetum roboris caricetosum remotae	*Quercus robur, Ulmus minor, Acer campestre, Salix caprea, Populus tremula*
SER/CRO6 – restored stand	653586.707795555 5038041.87625856	68a	26,71 ha	88-89 m	0-0°	Eugley - amphigley	Carpino betuli Quercetum roboris	*Quercus robur, carpinus betulus, acer campestre, fraxinus angustifolia, prunus avium*
SER/CRO7 – Reference stand	660145.189098235 5036490.38218258	57a	16,01 ha	87-88 m	0-0°	Eugley-amphigley	Carpino betuli quercetum roboris	*Quercus robur, Carpinus betulus, acer campestre, lmus minor, tilia spp.*

Figure 4.3 Map showing Croatian monitoring site 1 along the Drava river (Eugley-amphigley soil)

Figure 4.4 Map showing Croatian monitoring site 2

Table 4.3 Overview of stands on Serbian site 1

Site2_Stand	Lat_dec,Lon_dec	Stand code	Area size (ha)	Elevation (m)	Terrain slope	Soil type	Vegetation type (Forest type)	Tree species
SER/CRO 1 – Reference stand	7336319 5087571	6 b	4.71	84	0-0°	Fluvisol	*Alno – Quercion roboris*	*Quercus robur*
SER/CRO 2 - plantation for future restauration	7335878 5087179	6 i	13.83	84	0-0°	Fluvisol	*Alno – Quercion roboris*	*Populus euramericana*
SER/CRO 3 - Restored stand	7338384 5072015	24 d	1.3	83	0-0°	Fluvisol	*Alno – Quercion roboris*	*Quercus robur*
SER/CRO 4 - Restored stand	7336783 5073790	15 l	3.5	82.5	0-0°	Fluvisol	*Alno – Quercion roboris*	*Quercus robur*
SER/CRO 5 - Restored stand	7337978 5049840	22 c	3.5	81.5	0-0°	Fluvisol	*Alno – Quercion roboris*	*Quercus robur*
SER/CRO 6 – restored stand	7337694 5050109	22 a	4.5	81.5	0-0°	Fluvisol	*Alno – Quercion roboris*	*Quercus robur*
SER/CRO 7 – Degraded stand	7342490 5047785	39 e	28	81	0-0°	Fluvisol	*Alno – Quercion roboris*	*Quercus robur*
SER/CRO 8 – restored stand	7344078 5048519	51 c	37.61	80.5	0-0°	Fluvisol	*Alno – Quercion roboris*	*Quercus robur*

SER/CRO 9 – restored stand	7348994 5049500	50 h	17.99	80.5	0-0°	Eugley	*Alno – Quercion roboris*	*Quercus robur*

Table 4.4 Description of chronosequence stands on Croatian site 1

Category	Explanation
Site area	62,1 hectares
Stand area	SER/CRO 1 (22a) – 8,86 ha SER/CRO 2 (1c) – 8,45 ha SER/CRO 3 (4b) – 1,83 ha SER/CRO 4 (19a) – 32,12 ha SER/CRO 5 (46b) – 6,12 ha SER/CRO 6 (42a) – 4,72 ha
Location	Shapefile provided
Description	**SER/CRO 1 (22a)** **Degraded stand.** Poplar plantation (*P.euramericana*) that was left unmanaged due to the mines. Stand consists of overmatured poplar trees with a low vitality. Age of the stand is 34 years. Soil is unkwnow due to the mines but probably alluvilal (riverine) soil. **SER/CRO 2 (1c)** **Restored stand.** Used to be a poplar plantiont, now is a young *Quercus robur* and *Fraxinus angustifolia* stand. Age of the stand is 16 years. It grows on alluvial (riverine) soil. **SER/CRO 3 (4b)** **Restored stand.** This forest has been planted on failed *P. euramericana* plantation. Now consists of *Quercus robur* and *Fraxinus angustifolia* of good vitality. Age of the stand is 27 years. It grows on alluvial (riverine) soil. **SER/CRO 4 (19a)** **Restored stand.** Used to be a poplar plantation. Young *Quercus robur* stand that has been planted one year ago. It grows on alluvial (riverine) soil **SER/CRO 5 (46b)** **Restored stand.** *Quercus robur* and *fraxinus angustifolia* stand with *Acer negundo* and *Ulmus minor*. Stand is 21 years old and it grows on alluvial (riverine) soil. **SER/CRO 6 (42a)**

	Old growth/reference stand. 84 years *Quercus robur* and *Fraxinus angustifolia* stand of good quality and vitality. It grows on alluvial (meadow) soil.

Table 4.5 Description of chronosequence stands on Croatian site 2

Category	Explanation
Site area	155,01 hectares
Stand area	SER/CRO 1 (93a) – 16,54 ha SER/CRO 2 (2a) – 28,94 ha SER/CRO 3 (2b) – 6,22 ha SER/CRO 4 (3a) – 37,02 ha SER/CRO 5 (13a) – 23,57 ha SER/CRO 6 (68a) – 26,71 ha SER/CRO 7 (57a) – 16,01 ha
Location	Shapefile provided
Description	**SER/CRO 1 (93a)** **Degraded stand.** Poplar plantation (*P.euramericana*) of low quality and vitality. Stand consists of overmatured poplar trees. Age of the stand is 43 years. It grows on eugley-amphigley soil. **SER/CRO 2 (2a)** **Restored stand.** Used to be a poplar plantation, now is a young *quercus robur* stand with some *Quercus cerris, Ulmus minor* and *Fraxinus angustifolia* trees. Age of the stand is 32 years and it grows on amphigley soil. **SER/CRO 3 (2b)** **Restored stand.** Young *Quercus robur* stand that has been planted after clear-cut of poplar plantation. Now consists of *Quercus robur* and some *Acer campestre* and *Ulmus minor* trees. Age of the stand is 12 years and it grows on eugley-amphigley soil. **SER/CRO 4 (3a)** **Restored stand.** Young Quercus robur stand planted after cut of the P. euramericana plantation. We can find Quercus robur along with Fraxinus angustifolia, Robbinia pseudoacacia and Prunus avium trees. The stand is 21 years old and it grows on eugley-amphigley soil. **SER/CRO 5 (13a)** **Restored stand**. Young Quercus robur stand planted after cut of the P. euramericana plantation. Additional planting was done in 2002 and 2008. We can find Quercus robur along with Ulmus minor, Acer campestre, Salix caprea and Populus tremula trees. Age of the stand is 21 years old (additional planting in 2002,2008). It grows on eugley-amphigley soil.

	SER/CRO 6 (68a) **Restored stand.** Young Quercus robur stand that has been sown after clear-cut of P.euramericana plantation. We can find Quercus robur, Carpinus betulus, Acer camprestre and Fraxinus angustifolia within the stand. The age of the stand is 28 years and it grows on eugley-amphigley soil. **SER/CRO 7 (57a)** **Reference stand**. 101 years old Quercus robur stand of good vitality and quality. Mainly composed by Quercus robur with some Carpinus betulus, Ulmus minor, Acer campestre and Tilia spp. It grows on eugley-amphigley soil.

Table 4.6 Description of chronosequence stands on Serbian site 1

Category	Explanation
Site area	114,94 hectares
Stand area	SER/CRO 1 (6 b) – 4,71 ha SER/CRO 2 (6i) – 13,83 ha SER/CRO 3 (24 d) – 1,3 ha SER/CRO 4 (15 l) – 3,5 ha SER/CRO 5 (22 c) – 3,5 ha SER/CRO 6 (22 a) – 4,5 ha SER/CRO 7 (39 e) – 28 ha SER/CRO 8 (51 c) – 37,61 ha SER/CRO 9 (50 h) – 17,99 ha
Location	Shapefile provided
Description	**SER/CRO 1 (6 b)** **Reference stand** 120 years old. *Quercus robur* stand of good vitality and quality. Mainly composed by *Quercus robur* with some Carpinus betulus and Acer campestre. It grows on fluvisol. **SER/CRO 2 (6 i)** **Poplar plantation - degraded stand for future restoration.** Poplar plantation (*P.euramericana*) of low quality and vitality. Stand consists of overmatured poplar trees. Age of the stand is 40 years. It grows on fluvisol. **SER/CRO 3 (24 d)** **Restored stand.** Young *Quercus robur* stand that has been established after clear-cut of poplar plantation. Now consists of *Quercus robur*treesand it grows on fluvisol. **SER/CRO 4 (15 l)** **Restored stand.** Young *Quercus robur* stand established after cut of the *P. euramericana* plantation. The stand is 6 years old and it grows on fluvisol. **SER/CRO 5 (22 c)**

	Restored stand. Young *Quercus robur* stand established after cut of the *P. euramericana* plantation. Age of the stand is 2 years and it grows on fluvisoll. **SER/CRO 6 (22 a)** Restored stand. Young *Quercus robur* stand that has been established after clear-cut of *P.euramericana* plantation. The age of the stand is 8 years and it grows on fluvisoll. **SER/CRO 7 (39 e)** **Degraded stand.** Poplar plantation (*P.euramericana*) of low quality and vitality – clear cutted this year. **SER/CRO 8 (51 d)** **Restored stand.** Young *Quercus robur* stand that has been established after clear-cut of poplar plantation. Now consists of *Quercus robur (*11 year old*)* trees and it grows on fluvisol. **SER/CRO 9 (50 h)** **Restored stand.** Young *Quercus robur* stand that has been established after clear-cut of poplar plantation. Now consists of *Quercus robur (*12 year old*)* trees and it grows on fluvisol.

4.1.3 Description of monitoring measures

Plot based forest inventory:
Over the three forthcoming years, regular plot-based inventory of trees is conducted once in several inventory plot for evaluation of the success of natural regeneration. It includes identifying causes of tree mortality, and assessment of biodiversity. For ground vegetation, we mainly follow the ICP Forest guidelines (Canullo et al. 2011), which in short means that herb layer species richness and abundance is assessed. Temporal replicates are not needed for regular forest inventory work, so the data are acquired during a short campaign. It would be desirable to also survey tree-related microhabitats as indicators for the potential presence of certain taxa of forest-dwelling species. This survey, which follows a catalogue developed by Kraus et al. (2016), is an optional component. In addition, data on non-tree species are collected using iNaturalist app, to compare the benefit from citizen science approaches in ecosystem regeneration projects. See protocol below for more information.

Soil carbon and soil biological activity
In all inventory plots a single assessment of soil carbon and soil biological activity/diversity takes place in the first two years of the project. For this purpose, the KU Leuven team is carrying out the soil sampling.

4.1.4 Planning of monitoring

On Serbian part the - Inventory data of plots according to management plan is given in Table Table 4.3. All plots in Serbian case will be measured at the end of December 2022. All monitoring plots in Croatian case will be measured in 2023 depending on the habitat conditions (e.g. flooding). The soil sampling for carbon and biological activity will be collect according to the plans of WP6 request for Croatian and Serbian case.

5 Stakeholders

Throughout the course of the SUPERB project the demo leaders are guided and supported by Prospex Institute (PI, leader of WP2) in their work on stakeholder engagement.
The following activities are at the centre of this guidance and support:

- Stakeholder mapping at the demo level
- Serie of at least 3 co-creative Stakeholder Workshops
- Co-development and implementation of a stakeholder engagement strategy

The coordination of requests for stakeholder input from the demos:

1. *Stakeholder mapping at the demo level*

In March and early April 2022, the demo carried out an initial mapping of their stakeholders, with stakeholders defined as all those actors (groups and individuals) who affect or are affected by the restoration work in the demo. The demo leaders applied the Prospex-CQI methodology and collected the stakeholders' information and contact details in the QUIP database set up by PI (allowing for GDPR-related exceptions). The demo leaders aimed to map at least 50 individuals at this stage and to fill in at least 2-3 entries for all the stakeholder (sub-) categories identified by PI together with the demo. Throughout the project, they will continue adding individual stakeholders to the database across the different categories.

2. *A series of at least 3 co-creative stakeholder workshops in each demo*

Throughout the project time (2022-2025) demo leaders will organise and facilitate at least the following 3 co-creative workshops for the full range of their diverse stakeholders:

- The *vision and design workshop* has been held on 21th of June 2022, in which the demo leaders with representatives set of stakeholders inform and co-decide on demo's restoration vision, goals and workplans.
- The *implementation workshop* in January 2024, in which the demo leaders consult representative set of stakeholders on the current project implementation and will engage them to inform and co-decide on the further implementation.
- The *review and upscaling workshop* in May 2025, in which the demo leaders will engage representatives set of stakeholders on evaluating the demo restoration results achieved and on devising an approach to upscaling.

Prospex Institute guides and supports the demo leaders in the design and organisation of the workshops. The participants to the workshops are invited based on the stakeholder mapping conducted in the demo. Employing the Prospex-CQI methodology, the demo leaders aim to fulfil the quota recommended by PI for each of the stakeholder (sub-) categories.

The demo leaders report on each of the stakeholder workshops to SUPERB and to the participating stakeholders, also on how the stakeholder input is used in the restoration process. The demo make sure that the input at each stage is effectively incorporated into the decision-making on the latter. PI supports and monitors the demo leaders on this point.

The demo leaders are strongly encouraged to organise further stakeholder events besides the three workshops listed above. PI, the demos and leaders of WP7 collaborate on conceptualising additional stakeholder workshops and events as part of developing the demo-specific stakeholder engagement strategies.

3. *The co-development and implementation of a stakeholder engagement strategy for each demo*

In August-September 2022 the demo leaders, PI and WP7 collaborated on drafting the first version of the demo-specific stakeholder engagement strategies. These strategies explain the ways in which the demo engaged full range of diverse stakeholders and especially beyond the three stakeholder workshops over the course of the project. The strategies are based on *inter alia* the following input:

- An analysis of the pool of stakeholders emerging from the stakeholder mapping
- Initial insights from the online mapping through direct stakeholder interaction online (Task 2.2, led by WP2 partner Kings College London and WP2 co-lead EFI).
- Any relevant insights from the SUPERB Hackathon (a co-creative laboratory for all SUPERB partners that took place on 9-11 March 2022 with the aim of identifying common challenges to success in the demos and devising approaches for solutions).
- The outcomes of the 1st stakeholder workshop (on vision and design) to be inserted in this workplan, and how it has affected the design or implementation
- Close dialogue between the demo leaders and PI on demo-specific stakeholder engagement needs

The demo-specific stakeholder engagement strategies will be finalised by PI in May 2023. Throughout the course of the project PI guides, supports, and monitors the demo leaders in the implementation of the strategies, and will collaborate on their revision whenever such is considered desirable and/or necessary.

5.1 Reflection of 1st stakeholder workshop

Opportunities and challenges posed to the demo's work by the participants' feedback

Overall, there was strong support among the workshop participants for the demo's envisioned plan of action. The participants were fully on board with the demo's vision of creating functional, mixed riparian forests, converting to native species, and monitoring and addressing the situation on the landscape level. Most participants also agreed with the demo's choice of species for restoration. Furthermore, the participants applauded the demo's focus on restoring biodiversity rather than putting the forest's economic value above all, while also acknowledging the importance of the other social and economic ecosystem services provided by the forest area. All this gives the demo a broader expert mandate to proceed according to plan while receiving specialist backing from the forestry professionals who attended the workshop, which they said they would be happy to provide.

On the other hand, forestry professionals present at the workshop voiced their concerns about the long rotation period of the *Quercus robur* L. They also warned about the risks of water level decrease and of possible shortages in reproductive material adapted to the climate change. It was noted that addressing both challenges would be difficult with the limited workforce and finances available to the demo team, and this is the reason why the demo is focusing on the reproductive material and planting and not on hydrology improvement. In addition, sometimes the changes of planting material production cycle acquire changes in seed production (e.g. seed stands, etc.) and it could be more challenging and time consuming to do significant changes in tree species assortment. In the short run, these opinions are unlikely to translate into less support for the demo's plans by the area's forest experts.

However, concrete ways of addressing them should be considered in the demo's work plan. This is because they highlight factors that may indeed negatively impact restoration success and upscaling opportunities. In turn, this could weaken both the standing of the demo's efforts with the local forestry circles and the value of these efforts to the area and its diverse stakeholders.

Workshop learnings for the stakeholder engagement strategy

The demo team did not feel that the workshop revealed any further tensions to be addressed between the demo's plans and the participants' views and among the perspectives of the different stakeholders present. However, most of the contributions during the workshop came from people with expertise in forestry: forest managers, state officials working in the sector, actors involved in forest value chains and researchers. Participants without any substantial knowledge about forest restoration (such as the community members, Y, Z) found it difficult to engage in the discussion, which was largely focused on technical matters and the somewhat more broadly accessible topic of climate change. They also felt excluded due to the highly specialist nature of the surveys.

Consequently, non-specialist opinions on the value of forest and the topic of social challenges and opportunities to restoration remained underexplored. Furthermore, the participants did mention that forest ecosystem services beyond biodiversity – such as ecotourism, flood protection, enabling beekeeping and shielding of agricultural land – are important to the area. However, there was little discussion of how such services affect which stakeholder groups in the area, and how they could be covered in the demo's plans. Therefore, in the stakeholder engagement strategy that the demo will develop in the coming months it will be important to propose ways of capturing the interest/opinions/advice of a wider group of stakeholders. As part of this broader engagement the demo will consider the role that the area's forest already plays in different stakeholders' livelihoods and wellbeing (e.g., through tourism, as a site for school trips, or as protection for agricultural land). It will also consider how this role can be reinforced through the demo's restoration activities (possibly through plans for future upscaling).

In addition, while the workshop discussions were lively, the demo team could not tell whether the state officials in particular were speaking their mind or were following a safe standard script. It also took a lot of effort from the team to convince them to attend the workshop, especially when this entailed cross-border travel. The reason for this is twofold. Firstly, state functionaries and some other stakeholders need permits to be able to attend events across the border (which take effort to arrange). Secondly, state actors need to obtain approval from their superiors about what to say at public events. Consequently, they usually prefer to stick to standard statements to avoid the risk of saying something their superiors may see as problematic. In this context, in its stakeholder engagement strategy the demo will assess the importance of building a closer and more open relationship with state representatives and will propose approaches to engagement directed at enabling this relationship.

Finally, in the stakeholder engagement strategy the demo will pitch ways of reaching out to private landowners. Such actors are few in the area and are not directly relevant to the demo territory, which is state owned. Hence, they were underrepresented during the workshop. However, private landowners will be crucial for the promoting the upscaling of the demo's

solutions to the wider area at later stages in the project and after its end. Therefore, ideas on their gradual engagement would need to be developed beforehand.

5.2 Restoration goals based on stakeholder workshop

Following the first stakeholder workshop, the surveys on ecosystem targets were responded by 20 stakeholders. These have described the target ecosystems as structurally diverse, uneven-aged, close to natural forest stands. Regarding their composition, there is a strong preference among stakeholders for autochthonous species, and for species that are adapted to current and future climate conditions. A mixed-species composition is also preferred. In concrete, there are a few species that are frequently mentioned by stakeholders as part of the target ecosystems, which are portrayed in Figure 5.1 Preferred tree species to be used as part of the restored ecosystems, according to stakeholders.

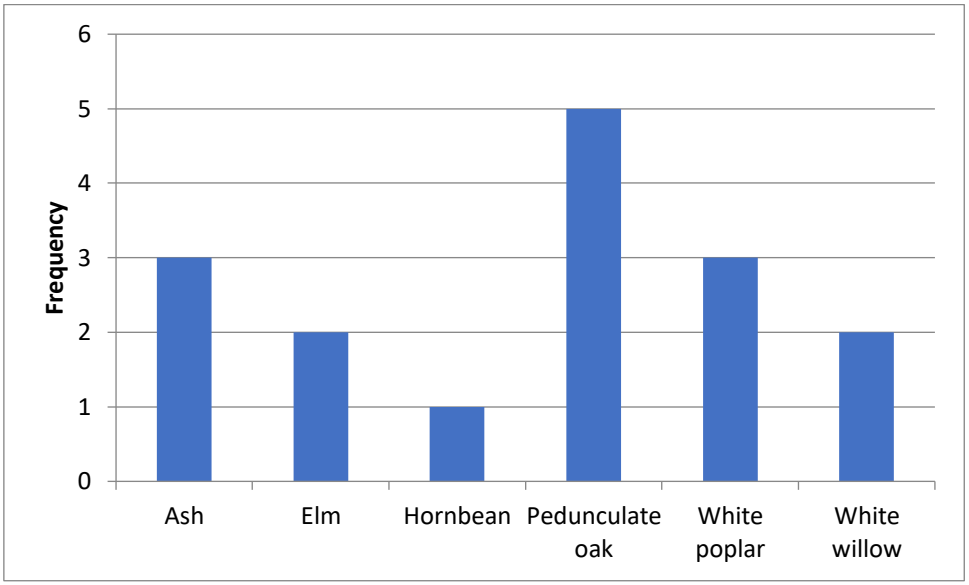

Figure 5.1 Preferred tree species to be used as part of the restored ecosystems, according to stakeholders.

Monocultures are most frequently mentioned as an unacceptable ecosystem condition (6 times), which apparently is seen as highly incompatible with the view of the restored forests in the demo-region. A low vitality of trees is also mentioned relatively often as inadequate with this view (3 times), whereas other features, such as a low biodiversity, dominance or a significant presence of allochthonous species, coppice-based regeneration, harvesting next to water streams, and converting to non-forest land uses, also seem to be unwanted (Figure 5.2).

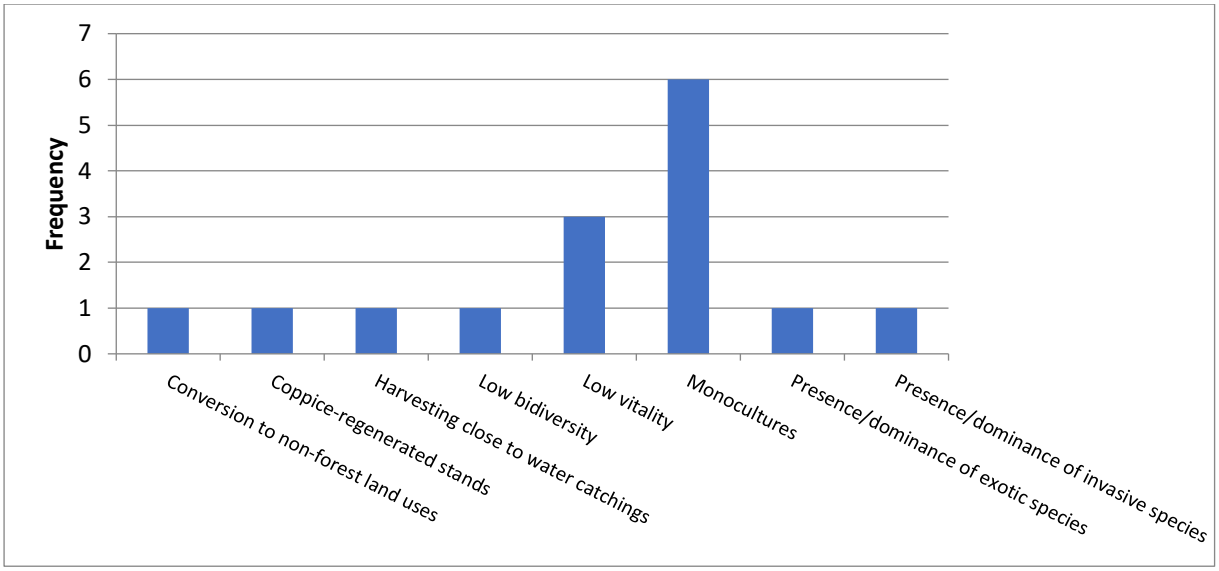

Figure 5.2 Ecosystem characteristics or conditions that are dimmed as unacceptable by stakeholders, according to the responses retrieved from the surveys.

In general, (1) increasing the presence of climate-adapted and of autochthonous species, (2) promoting the development of mixed forest stands, and (3) conducting a careful and integral selection of species and planting material, are frequently mentioned as adequate measures for making local forests more adaptive to global change. Other measures, such as selecting local provenances for establishing or enriching a stand, improving soil water retention, increasing the diversity of forest landscape through zoning, are also mentioned as adequate (

Figure 5.3 Adequate measures to make local forests more adaptive to global change, according to the responses retrieved from the surveys.

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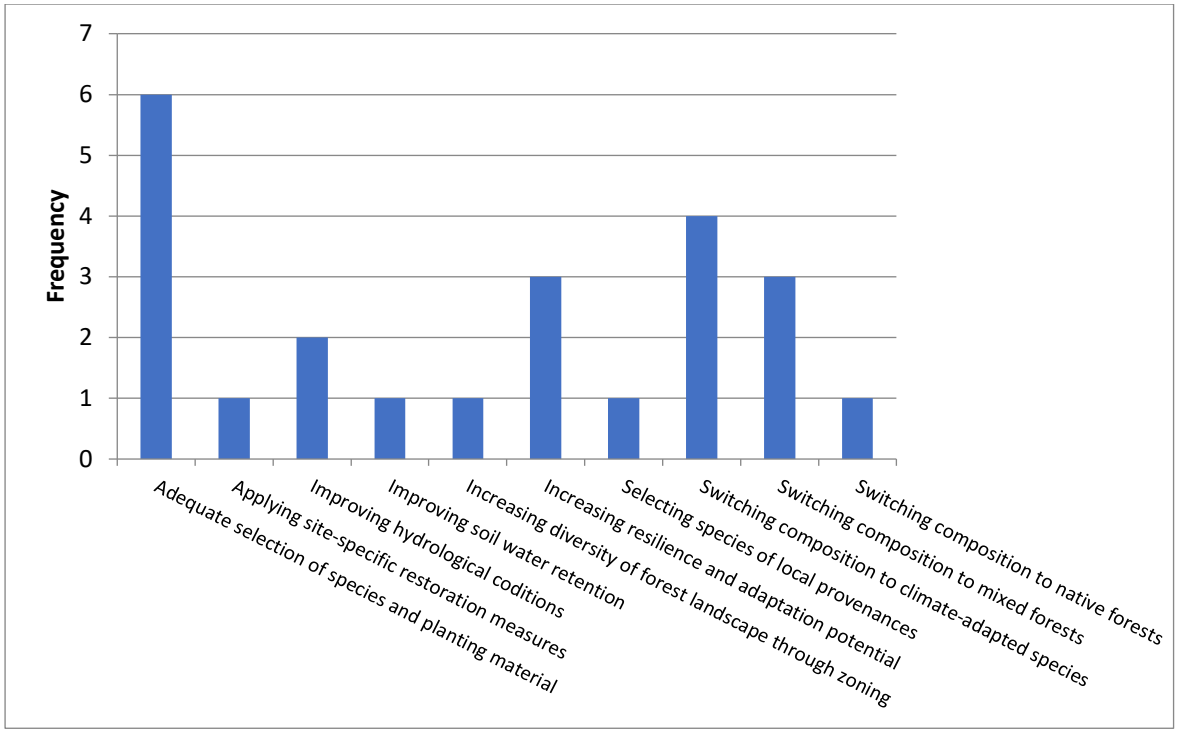


Figure 5.3 Adequate measures to make local forests more adaptive to global change, according to the responses retrieved from the surveys.

The key stakeholders are Croatian Forest Research Institute, Croatian Forests Ltd., public institutions local authorities and local community will be involved in Croatia. In Serbia it will be public company in charge of the forest and the protected area management, regional institute of nature protection, hunting association, local community.

Demo forest area encompasses economically important forests. Main drivers for forest rehabilitation and reforestation is widely shared awareness among forest owners, forest managers and governments of the need to secure wood production for the future and enhancement of forest-related biodiversity. This area is under intense pressure of depopulation caused by ageing of the population and by lack of the quality jobs.

Local communities will mainly benefit from increased economic activity in the recreational sector and wood production as well as a more pleasant living environment. On a regional scale, water boards will benefit from improved hydrological conditions and the society as a whole from improved water supply (quantity and quality) in dry periods and improved retention capacity in flood events. The community would also benefit trough potential higher positive impact on human health and well-being within restored forests. Primarily local food producers and indirectly local community through enlargement of whole scale of forest ecosystem services.

Significant forest damages (forest loss) area has to be sufficiently restored in the next three consecutive years. If not, additional planting should be done. Furthermore, restoration in terms of replacement of non-native poplar plantations to native climax tree species composition is prescribed by management plans in Croatia after first/second rotation period, especially when site changes are observed (progression to more dry site conditions suitable for oak and ash). On the area where and restoration sites are managed by Croatian Forests Ltd. there is a plenty of space for upscaling. Nevertheless, Croatian forests are managing the demo area and its surroundings according to existing restoration principles (low application of mechanisation,

different planting design, no additional tree species included), so this restoration project can be used as an enhanced example for future forest restoration in both state owned and private forests and have a potential to be implemented in future restoration plans.

6 Planning

6.1 Planning in Serbian part

Table 6.1 Planning by year Serbia

Action	2022	2023	2024	2025
Planning and preparing restoration	Selection of plots for restoration has been done. Department 39e: Clear cut of poplar tree species, extraction and shipment of trees	Department 39 e: Removal of shrubs.		
Restoration		Planting and fencing.	Planting	
Monitoring t=0	Initial assessment and first measurements on monitoring plots	Initial assessment and monitoring		
Monitoring t=1		The soil sampling for carbon and biological activity will be collect according to the plans of WP6 request.		
Stakeholders	1st stakeholders' workshop: Vision and design		2nd stakeholders' workshop: Restoration implementation	3rd stakeholders' workshop: Review and upscaling; Dissemination campaigns

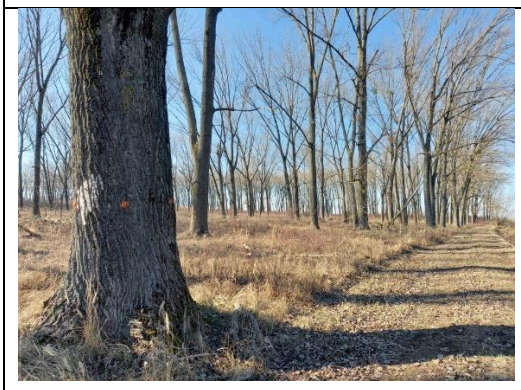
6.2 Planning in Croatian part

Table 6.2 Planning by year Croatia

Action	2022	2023	2024	2025
Planning and preparing restoration	Selection of plots for restoration has been done. Department 1a: Removal of shrubs, clear cut of poplar tree species, extraction and shipment of trees	Department 95b : Removal of shrubs, clear cut of poplar trees, extraction and shipment of trees.		
Restoration		Planting of pedunculate oak, sorbus spp. and wild cherry species. Fencing	Planting of pedunculate oak, sorbus spp. and wild cherry species. Fencing	
Monitoring t=0	Initial assessment and first measurements on monitoring plots	Initial assessment and monitoring		
Monitoring t=1		The soil sampling for carbon and biological activity will be collect according to the plans of WP6 request.		
Stakeholders	1st stakeholders workshop: Vision and design		2nd stakeholders workshop: Restoration implementation	3rd stakeholders workshop: Review and upscaling; Dissemination campaigns

7 Photos of initial situation

Table 7.1 Photos of the demo area

Croatian restoration site	**Serbian restoration site**
	
Croatian restoration site 95b showing a stand of poplar monoculture that is overmatured.	SER/CRO 4 (15 l) Restored stand. Young *Quercus robur* stand established after cut of the *P. euramericana* plantation. The stand is 6 years old and it grows on fluvisol.
Croatian restoration site 1a consisting of low vitality poplar clone plantation	SER/CRO 7 (39 e) Degraded stand. Poplar plantation (*P.euramericana*) of low quality and vitality – clear cutted this year.
Poplar plantation in the demo area	Poplar plantation in the demo area

Unmanaged stand of poplar plantation	Mixed forest of *Q. robur*
Young poplar plantation	River Drava and Danube
Young restored *quercus robur* stand	One of the numeorus Danube backwaters in the area