Improving degree of conservation of Natura 2000 target species and habitat types through improvement of river connectivity

Project number:
LIFE22-NAT-HR-Improve River LIFE/
101114250

PROTOCOL FOR RESTORATION AND MAINTENANCE OF RIPARIAN VEGETATION

Co-funded by the European Union

REPUBLIC OF CROATIA
Ministry of Environmental Protection and Green Transition

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them. This document was made with the financial support of the Environmental Protection and Energy Efficiency Fund (EPEEF). The content of this document is the sole responsibility of the Ministry of Environmental Protection and Green Transition and under no circumstances can it be considered as a reflection of the views and opinions of the EPEEF.

Project name	Improve River LIFE - Improving the conservation status of target Natura 2000 species and habitat types through improved river connectivity
Project number	LIFE22-NAT-HR-Improve River LIFE/101114250
Title	Protocol for restoration and maintenance of riparian vegetation
Authors	Tomislav Milas (Public Institution Sea and Karst) Vida Posavec Vukelić (Ministry of Environmental Protection and Green Transition, Institute for Environmental and Nature Protection) Ivana Sučić (Ministry of Environmental Protection and Green Transition, State Institute for Environmental and Nature Protection)
Document date	February 18, 2025
Delivery number and name	Deliverable D2.1 – Protocol for the renovation and maintenance of riparian vegetation

Co-funded by the European Union

NATURA 2000

ENVIRONMENTAL PROTECTION AND ENERGY EFFICIENCY FUND

REPUBLIC OF CROATIA
Ministry of Environmental Protection and Green Transition

HRVATSKE VODE

PMF

PUBLIC INSTITUTION SEA AND KARST

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them. This document was made with the financial support of the Environmental Protection and Energy Efficiency Fund (EPEEF). The content of this document is the sole responsibility of the Ministry of Environmental Protection and Green Transition and under no circumstances can it be considered as a reflection of the views and opinions of the EPEEF.

Contents

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them. This document was made with the financial support of the Environmental Protection and Energy Efficiency Fund (EPEEF). The content of this document is the sole responsibility of the Ministry of Environmental Protection and Green Transition and under no circumstances can it be considered as a reflection of the views and opinions of the EPEEF.

INTRODUCTION

As part of the project “Improving the conservation status of Natura 2000 target species and habitat types through improved river connectivity” - Improve river LIFE (101114250 — LIFE22-NAT-HR-Improve River LIFE), the restoration of coastal (hereinafter referred to as: riparian) vegetation with native species is planned. Local conditions, vegetation cover at individual locations and the presence of certain plant species will be taken into account. The restoration of the population of softmouth trout (*Salmo obtusirostris*), an endemic trout species that inhabits the rivers of the Adriatic basin, largely depends on the health of their natural habitat, and riparian vegetation plays a key role in this. Riparian vegetation, i.e. the plant cover along the banks of rivers, has several important functions that directly affect the conditions necessary for the survival and reproduction of this sensitive freshwater fish species.

Riparian vegetation is important for a variety of ecosystem functions, including providing food, shelter, and spawning ground for animal species, regulating water temperature through shading and evapotranspiration, providing corridors for the movement of organisms, and creating a buffer zone to control and filter sediments and nutrients from floodplains. Riparian vegetation provides shade, which regulates water temperature. Softmouthed trout requires cool, oxygen-rich water, and rising temperatures due to lack of shade can threaten its survival, especially in the summer months when high temperatures further deteriorate habitat conditions. Dense vegetation prevents watercourses from overheating.

Moreover, riparian vegetation as a hydromorphological qualitative element plays an important role in the processes of erosion and sedimentation in the river, the control of bank erosion and the preservation of habitat diversity. The creation of a buffer zone is particularly important in areas near agricultural areas, where it can have a positive effect on reducing pollutant dispersion and potentially improving water quality. Planting indigenous riparian vegetation species helps prevent the growth and spread of invasive alien plant species, which often spread uncontrollably in disturbed habitats without the presence of indigenous plants. Furthermore, well-developed riparian vegetation also affects the diversity of microhabitats in the watercourse itself. By creating shade, riparian vegetation affects the aquatic vegetation abundance (macrophytes) that will develop in the riverbed – in darker, shaded areas, macrophytes will be less abundant, while in more open and illuminated areas, macrophyte vegetation will be more abundant. Extensively developed macrophyte vegetation reduces the velocity of water flow and contributes to increased sedimentation, i.e. the accumulation and deposition of fine sediment and detritus, while the absence of macrophytes contributes to increased water flow. In this way, the diversity of microhabitats of the watercourse itself depends on the degree of development of riparian vegetation.

Riparian vegetation stabilizes river banks. Plant roots prevent soil erosion from the banks, reducing the input of sediment into the watercourse. Clean, gravelly river bottoms, which are natural habitats for softmouth spawning, depend on this natural "shield" provided by plants. Planting riparian

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them. This document was made with the financial support of the Environmental Protection and Energy Efficiency Fund (EPEEF). The content of this document is the sole responsibility of the Ministry of Environmental Protection and Green Transition and under no circumstances can it be considered as a reflection of the views and opinions of the EPEEF.

vegetation contributes to the biodiversity of the habitat. It attracts insects that fall into the water and serve as natural food for trout, especially in the early stages of the fish life cycle. Without a diverse ecosystem that supports this food web, the survival of young individuals would be seriously endangered. Likewise, vegetation helps to purify water by absorbing nutrients and pollutants from nearby agricultural areas (nitrates) or settlements (especially in the Vrljika area), thereby reducing eutrophication and maintaining good water quality. Therefore, without the restoration of riparian vegetation, rivers lose the natural balance that is necessary for the restoration of the softmouth population. Activities carried out as part of the project "Improve River LIFE", for the aforementioned reasons, includes the planting and restoration of riparian vegetation as part of a broader project strategy to preserve this endangered species of fish in Jadro and Vrljika River.

This task is aligned with the conservation measures and the method of implementing conservation measures for target habitat types and species for the Jadro and Vrljika rivers prescribed by the Ordinance on conservation objectives and conservation measures for target species and habitat types in ecological network areas (OG 111/2022), and includes the restoration and maintenance of areas with aquatic vegetation and a strip of riparian vegetation at least 2 meters wide. It is planned that a total of 34,800 m² of riparian vegetation will be restored and maintained (4,500 m² on the Jadro River and 30,300 m² on the Vrljika River). The restoration and maintenance of riparian vegetation will be carried out on the strip along the banks of the rivers and on the banks belonging to the water resource or public water resource managed by Hrvatske vode ltd., and there are no obstacles to restoration.

LOCATIONS OF RESTORATION OF RIPARIAN VEGETATION

As part of the project, the restoration of riparian vegetation on the Jadro and Vrljika rivers is planned on a total area of 34,800 m^2, namely:

1) Restoration of vegetation along a 5,300 m long strip of the Vrljika banks, which corresponds to an area of 30,300 m^2
2) Restoration of vegetation along an 800 m long strip of the Jadro coast, which corresponds to an area of 4,500 m^2.

The locations where riparian vegetation restoration activities are planned to be carried out are shown in yellow in Figures 1 and 2. The final selection of locations will be in line with the prescribed nature protection conditions specified in the Decision of the Ministry of Environmental Protection and Green Transition based on the request of Hrvatske vode ltd. to conduct an acceptability assessment for the ecological network and determine nature protection conditions for the maintenance work program in the Area of Protection from Harmful Effects of Water 2023-2026 for the area of the Water Management Department for the Southern Adriatic Basins (CLASS: UP/I 352-03/22-05/110 REG. NUMBER: 517 -10 -2-1-23 -8 of 17 August 2023). In addition, the project partners, the Public Institution Sea and Karst and Hrvatske vode - the Water Management Office for the Small Basin "Central

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them. This document was made with the financial support of the Environmental Protection and Energy Efficiency Fund (EPEEF). The content of this document is the sole responsibility of the Ministry of Environmental Protection and Green Transition and under no circumstances can it be considered as a reflection of the views and opinions of the EPEEF.

Dalmatian Coast and Islands" and the Water Management Office for the Small Basin "Vrljika", will consider and agree on the selection of locations with regard to the planned areas and activities and the conditions prescribed by the Decision.

Restoration of riparian vegetation on the river Vrljika (Figure 1) is needed along the middle and lower reaches, downstream from the junction with the Sija canal, towards barrier number 4 (Đogića brana) and all the way behind barrier number 6 (Runovićki most). Restoration of riparian vegetation on the Jadro River is needed around the first barrier (Most Voljak) and again on the stretch between the second barrier (Cemex) and the third barrier (Vodovod 1 and 2) all the way to the fourth barrier (Šljukica Most). The expected result is a restored and maintained riparian vegetation belt with native species on 34,800 m^2. The rivers Jadro and Vrljika are part of the ecological network Natura 2000 in Croatia. One of the conservation measures on both rivers is the measure to maintain coastal and aquatic vegetation in a favorable condition: “Maintain areas with aquatic vegetation and a strip of coastal vegetation at least 2m wide, and if it does not exist, allow natural vegetation regeneration or restore vegetation by planting native species (restoration and maintenance).” The implementation of activities to restore and maintain riparian vegetation on the Jadro and Vrljika rivers will contribute to the establishment of defined conservation measures for the Natura 2000 ecological network areas on both rivers.

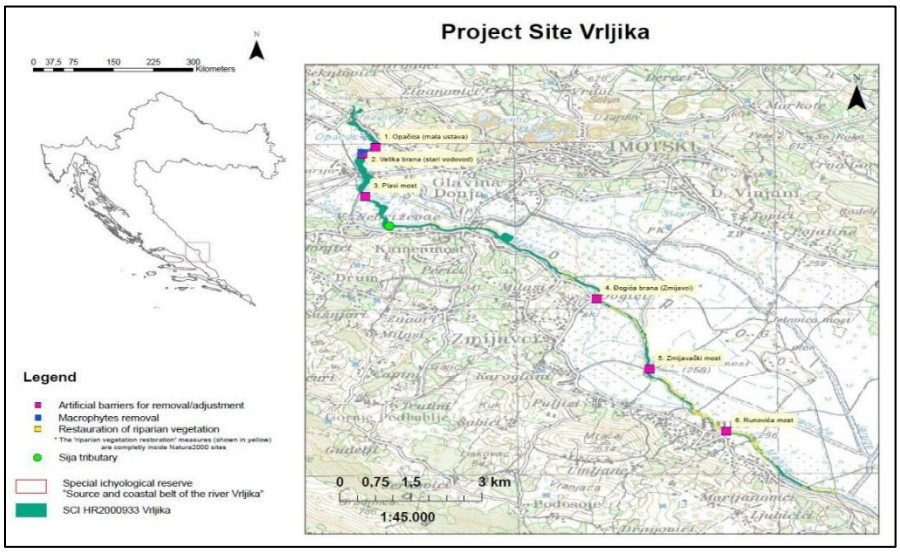

Figure 1. Map of project locations on the Vrljika River.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them. This document was made with the financial support of the Environmental Protection and Energy Efficiency Fund (EPEEF). The content of this document is the sole responsibility of the Ministry of Environmental Protection and Green Transition and under no circumstances can it be considered as a reflection of the views and opinions of the EPEEF.

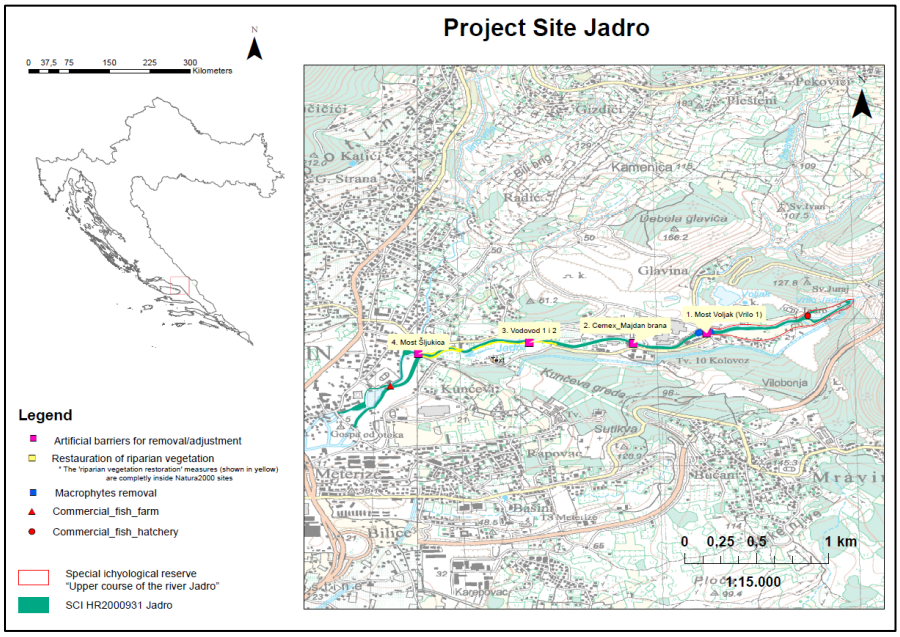

Figure 2. Map of project locations on the Jadro River.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them. This document was made with the financial support of the Environmental Protection and Energy Efficiency Fund (EPEEF). The content of this document is the sole responsibility of the Ministry of Environmental Protection and Green Transition and under no circumstances can it be considered as a reflection of the views and opinions of the EPEEF.

DESCRIPTION OF THE CURRENT HABITAT AND SPECIES CONDITION

The project is being implemented on two rivers of the Adriatic basin in Split-Dalmatia County, included in Natura 2000 protected areas – the Jadro (HR2000931) and Vrljika (HR2000933) rivers, which are one of the last remaining habitats of the softmouthed trout (*Salmo obtusirostris*).

Jadro River

On the banks of the lower Jadro River, there are reed beds of common reed (As. *Scirpo-Phragmitetum* Koch 1926 – Inc. As. *Phragmitetum australis* ("vulgaris") Soó 1927) – one of the most significant communities of reed vegetation, which in places occupies large floodplains. The floristic composition is completely dominated by *Phragmites australis*, while all other species are represented with low degree of coverage.

According to the Habitat Map of the Republic of Croatia from 2004, the Jadro river is included in the habitat type middle and lower reaches of slow-moving watercourses (NKS A.2.3.2.2. – www.bioportal.hr). According to the revision of the habitat map for non-forest habitats of the Republic of Croatia (2016), the Jadro River is included in the primary habitat type - permanent watercourses (NKS A.2.3. – www.bioportal.hr) (11,282 ha) with occasional occurrences of the habitat type - reed beds, sedges, tall sedges and tall sedges (NKS A.4.1. – bioportal.hr) (15,708 ha) and forests (NKS E. – bioportal.hr). In the largest part of the stream, the sediment is dominated by finer or coarser gravel and stones.

In terms of vegetation, the Jadro River in its source area is dominated by a typical *Berula-Nasturtium* type of vegetation with the dominant species being the lesser water-parsnip (*Berula erecta*) and watercress (*Nasturtium officinale*). Other characteristics of the habitat are the prevalence of finer or coarser gravel and stones in the sediment where deeper and shallower parts alternate. In the upper reaches of the river, the dominant species are floating hydrophytes (plants rooted in the bottom of a water body with leaves that float on the surface of the water) such as longleaf pondweed (*Potamogeton nodosus* Poir., *Potamogeton* sp.) and the threadleaf crowfoot (*Ranunculus trichophyllus),* which dominate in the middle of the stream. Towards the middle of the stream with deeper water, the submersible form of the species *Berula erecta* becomes dominant. The marginal parts of the watercourse are inhabited by tall emergent vegetation dominated by common bulrush (*Typha latifolia*), bur reed (*Sparganium* sp.) and lakeshore bulrush (*Scirpus lacustris*). At low water levels, the macrophyte vegetation throughout the water column is extremely dense and lush, leaving relatively few open, free water surfaces. The riparian vegetation is also typical for watercourses of this type. It consists of stands of willow (*Salix* sp., *Salix alba*) and poplar (*Populus* sp., *Populus alba*, *Populus*

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them. This document was made with the financial support of the Environmental Protection and Energy Efficiency Fund (EPEEF). The content of this document is the sole responsibility of the Ministry of Environmental Protection and Green Transition and under no circumstances can it be considered as a reflection of the views and opinions of the EPEEF.

pyramidalis = *P. nigra* var. *pyramidalis*) and purple loosestrife (*Lythrum salicaria*) (Habdija et al., 2008). The coastal vegetation is unevenly developed, and significant anthropogenic influence is noticeable throughout the entire course.

Vrljika River

The floodplain forest of willows and poplars (Ass. Salici-Populetum nigrae (Tx. 1931) Meyer Drees 1936) dominates the watercourse of the Vrljika River - stands in which, in addition to the species *Salix alba*, *Salix fragilis*, there are also *Populus alba*, *Populus nigra* and *Fraxinus angustifolia*, and sometimes *Morus alba*. This association already has a slightly richer floristic composition, so *Cornus sanguinea* predominates in the shrub layer and in the final stage of community development, also *Rubus caesius*, *Viburnum opulus*, *Clematis viticella* are present. In the ground layer, in more flooded positions of the community, the species *Polygonum hydropiper*, *Galium palustre*, *Potentilla reptans*, *Ranunculus repens*, *Urtica dioica*, *Scutellaria galericulata*, *Phalaris arundinacea* and others are found, while in higher, more drained and less flooded positions, *Glechoma hederacea*, *Agrostis stolonifera*, *Lycopus europaeus*, *Lysimachia nummularia* and others. However, often this rule cannot be observed on the ground because the elevation of the terrain and hydrographic conditions change faster than the composition of the ground growth can be stabilized.

The banks of the Vrljika are mostly covered with woody species typical of the river's marginal belt. The most dominant are willows, accompanied by privet (*Ligustrum vulgare*), common dogwood (*Cornus sanguinea*) and poplars (*Populus* sp.). Other woody species are present either singly or in smaller numbers. However, human activity is also present in the coastal zone, which is primarily manifested in the fortification and arrangement of the banks. In places where natural vegetation is developed in its typical composition, the banks are gently sloping and overgrown with vegetation typical of the riparian zone (Figures 3a and 3b). However, in places the banks are arranged and are of an extremely steep character, in some places almost vertical, and here both woody coastal vegetation and macrophyte vegetation are absent (Figure 4). Consequently, in these places the riverbed itself is deeper and the water flow is faster, which additionally hinders, even completely prevents, the development of macrophyte vegetation typical of this type of watercourse.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them. This document was made with the financial support of the Environmental Protection and Energy Efficiency Fund (EPEEF). The content of this document is the sole responsibility of the Ministry of Environmental Protection and Green Transition and under no circumstances can it be considered as a reflection of the views and opinions of the EPEEF.

Figure 3a. Typically developed, lush riparian vegetation on a section of the river with minimal anthropogenic impact.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them. This document was made with the financial support of the Environmental Protection and Energy Efficiency Fund (EPEEF). The content of this document is the sole responsibility of the Ministry of Environmental Protection and Green Transition and under no circumstances can it be considered as a reflection of the views and opinions of the EPEEF.

Figure 3b. The appearance of riparian vegetation that is to be achieved through restoration activities.

Figure 4. The steep banks of rivers prevent the development of riparian vegetation.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them. This document was made with the financial support of the Environmental Protection and Energy Efficiency Fund (EPEEF). The content of this document is the sole responsibility of the Ministry of Environmental Protection and Green Transition and under no circumstances can it be considered as a reflection of the views and opinions of the EPEEF.

CRITERIA FOR SELECTING SPECIES FOR PLANTING

As part of the restoration of riparian vegetation, an attempt will be made to restore species that are no longer present or are becoming less common. This is narrow-leaved ash *(Fraxinus angustifolia),* which is often a victim of illegal logging, and the field elm (*Ulmus minor*) whose population is in decline due to the Dutch elm disease that has been present for decades. Unfortunately, nursery production of these species in Croatia is almost non-existent. Field ash production has mostly stopped due to a fungal disease caused by a fungal disease *Hymenoscyphus fraxineus*. If available, seedlings will be purchased from the Croatian Forests nursery due to the known provenance and origin of the seedlings, since commercial nurseries mostly import seedlings from other countries.

If it is possible to obtain healthy seedlings, willow, field ash and field elm will be planted. If it is not possible to obtain ash and elm from nursery production, the area will be filled with willows because other species such as alder or pedunculate oak are not indigenous to these rivers, and an attempt will be made to propagate ash and elm with locally collected seeds.

As for willows, the most available is the white willow (*Salix alba*) which can be propagated by cuttings, directly cutting from neighboring trees. Since the Jadro and Vrljika rivers have relatively good vegetation and the lack of vegetation is manifested in spots, this will be the planting plan, i.e. by planting in open spaces and surfaces that will be "filled" in order to achieve a continuous belt of woody riparian vegetation. We will plant seedlings and cuttings from neighboring trees along the entire course, at each intersection where necessary. For propagation by cuttings, in addition to white willow, brittle willow (*Salix fragilis*), and in the shrub layer there is: purple willow (*Salix purpurea*). If seedlings are available, dogwood *(Cornus sanguinea)* and common privet *(Ligustrum vulgaris)* will be planted in the shrub layer.

The proposed planting plan is outlined as follows.

JADRO

Willows (*Salix* sp.):

Propagation: Taking cuttings from surrounding trees
Method: Direct cutting and planting of cuttings.
Location: Along river banks where the soil is moist or with a high groundwater level and suitable for rapid rooting.

Field elm (*Ulmus minor*):

Propagation: Sowing local seeds
Method: Local seed collection, pre-sowing preparation and then sowing.
Location: In areas with slightly firmer soil, but still close to water for optimal growth.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them. This document was made with the financial support of the Environmental Protection and Energy Efficiency Fund (EPEEF). The content of this document is the sole responsibility of the Ministry of Environmental Protection and Green Transition and under no circumstances can it be considered as a reflection of the views and opinions of the EPEEF.

Narrow-leaved ash (*Fraxinus angustifolia*):

Propagation: Sowing local seeds
Method: Local seed collection, pre-sowing preparation and then sowing.
Location: In places where it is possible to ensure sufficient light and water, as well as soil stability.

VRLJIKA

Willows (*Salix* sp.):

Propagation: Taking cuttings from surrounding trees
Method: Direct cutting and planting of cuttings.
Location: On riverbanks where high water levels or high groundwater levels can be expected, to take advantage of the willow's natural ability to stabilize banks.

Field elm (*Ulmus minor*):

Propagation: Sowing local seeds
Method: Local seed collection, pre-sowing preparation and then sowing.
Location: In areas with slightly firmer soil , but still close to water for optimal growth.

Narrow-leaved ash (*Fraxinus angustifolia*):

Propagation: Sowing local seeds
Method: Local seed collection, pre-sowing preparation and then sowing.
Location: In places where it is possible to ensure sufficient light and water, as well as soil stability.

The main mechanism for the restoration of woody riparian vegetation will be the propagation of local populations of white and brittle willow (*Salix fragilis*) by cuttings. These species tolerate moist and wet conditions very well and are perfectly adapted to grow in the immediate vicinity to rivers, and their roots grow in water where they form so-called aerial roots. Also, both species have a high rooting potential through cuttings, so it is not necessary to use rooting hormones. The cuttings are pushed into the soil in an area that is almost always moist.

Cuttings will be taken from local trees in the immediate vicinity to ensure the maintenance of the local genotype, without importing seedlings or cuttings from nurseries that most often import planting material from abroad.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them. This document was made with the financial support of the Environmental Protection and Energy Efficiency Fund (EPEEF). The content of this document is the sole responsibility of the Ministry of Environmental Protection and Green Transition and under no circumstances can it be considered as a reflection of the views and opinions of the EPEEF.

SELECTING PLANTING LOCATIONS

The planting locations will be selected in accordance with the project. Figures 1 and 2 above show the entire areas to be planted, however, within the areas planned for restoration it is necessary to look for canopy gaps that provide quality ecological conditions for the growth of the selected species. A field visit of the area has determined that there are favorable locations along the aforementioned areas, examples of which are shown in the figures below.

Figure 5. Example of a location without woody vegetation, suitable for planting.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them. This document was made with the financial support of the Environmental Protection and Energy Efficiency Fund (EPEEF). The content of this document is the sole responsibility of the Ministry of Environmental Protection and Green Transition and under no circumstances can it be considered as a reflection of the views and opinions of the EPEEF.

Figure 6. Example of a location without woody vegetation, suitable for planting.

Riparian vegetation restoration work should begin at the most upstream location and continue downstream. Examples of good riparian vegetation restoration practice from the available literature suggest this approach, so that propagules of potentially unwanted species, such as invasive plants, do not spread downstream due to the works and nullify any previous efforts to restore these parts. Also, when preparing locations for riparian vegetation restoration, invasive plant species should be removed.

It is important to note that during the restoration of riparian vegetation, no mineral fertilizers or other chemical substances may be used to promote the restoration of vegetation cover, with the aim of preventing the leakage of harmful substances into the watercourse and eutrophication.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them. This document was made with the financial support of the Environmental Protection and Energy Efficiency Fund (EPEEF). The content of this document is the sole responsibility of the Ministry of Environmental Protection and Green Transition and under no circumstances can it be considered as a reflection of the views and opinions of the EPEEF.

COLLECTION OF PLANTING MATERIAL

Collecting cuttings

Equipment needed for collecting cuttings:

To collect cuttings, scissors will be used, two-handed for thicker cuttings, and hand-held vine shears for thinner cuttings. A telescopic chainsaw is suitable for cutting inaccessible branches. A hammer is used to drive thicker cuttings into previously dug holes in the ground.

Method:

Cuttings are cut with two-handed or hand shears, depending on the thickness (Figure 7). Cuttings should be approximately 50 cm long, then planted in moist soil (Figure 8). Thicker and thinner cuttings will be used to avoid unnecessary waste. After the cutting has been taken, the thicker end must be cut sharply at a 45° angle so that it can be pushed into the soil more easily; if it is a thicker cutting, then the upper end is cut straight, so that it can be pushed into the soil by hitting it with a hammer if the

Figure 7. Collecting cuttings.

Figure 8. Manual planting into moist soil.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them. This document was made with the financial support of the Environmental Protection and Energy Efficiency Fund (EPEEF). The content of this document is the sole responsibility of the Ministry of Environmental Protection and Green Transition and under no circumstances can it be considered as a reflection of the views and opinions of the EPEEF.

soil is harder (Figure 9). If the upper part of the cutting is damaged when hitting it with a hammer, the damaged part can be cut off with scissors.

Figure 9. Planting cuttings using a hammer.

Seed collection

Narrow leaved ash (*Fraxinus angustifolia)* and field elm (*Ulmus minor*) of local provenance will be sown, if the seeds are available. The fruits of the field ash ripen in September, while those of the field elm ripen in April and May, which is when they would be collected.

After collection, the seeds will be stored in a suitable location and conditions, and before sowing, pre-sowing preparation will be carried out to remove seed dormancy. Then the sowing would be carried out. The locations where sowing would be carried out are clearings, gaps and places where old trees have collapsed or dried up.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them. This document was made with the financial support of the Environmental Protection and Energy Efficiency Fund (EPEEF). The content of this document is the sole responsibility of the Ministry of Environmental Protection and Green Transition and under no circumstances can it be considered as a reflection of the views and opinions of the EPEEF.

Pre-sowing preparation of field ash seeds (*Fraxinus angustifolia*) and field elm (*Ulmus minor*) involves processes such as stratification and scarification to ensure successful germination. These methods mimic the natural conditions needed to overcome seed dormancy, which is also characteristic of many other tree species.

Narrow leaved ash seeds often have a deeper dormancy due to physiological inhibitors and a hard seed coat, which requires a combination of stratification and in some cases, scarification.

Field ash seeds need to undergo cold stratification to break down germination inhibitors. The process usually involves:

- Collecting seeds in the fall, after which they are cleaned of the scales (wings).
- Soaking seeds in water for 24–48 hours to soften the seed coat and promote moisture absorption.
- Mixing the seeds with moist sand or peat and placing them in a refrigerator at 2–4 °C for 2–3 months (depending on the degree of dormancy). This period of cold and moisture simulates winter, which is essential for activating germination. After stratification, the seeds are sown in the spring when frosts have passed.

Field elm seeds have a shorter and less pronounced dormancy period compared to field ash, but still require some preparation for optimal germination.

The seeds are collected in late spring or early summer, when the winged fruits ripen and begin to fall.

In late autumn or early winter (e.g. November or December), the stratification process begins. The seeds are mixed with a moist substrate (sand, peat or even a damp paper towel) and placed in a refrigerator at 2–4 °C. This cold and moist treatment lasts 4–6 weeks, which means that stratification started in December would be finished by the end of January or the beginning of February. It is necessary to check the moisture of the substrate from time to time – it should be moist, but not wet.

After stratification, the seeds are ready for sowing in early spring, optimally in March or early April, depending on the conditions in the field. The seeds are sown to a depth of about 1cm in prepared soil, preferably in a sunny or semi-shady place with good drainage.

Restoration of herbaceous plants

It is anticipated that local herbaceous will spontaneously spread to the restoration sites by propagules and no additional efforts are needed to plant it. The key point is to regularly monitor the condition of riparian vegetation and urgently intervene if invasive alien species appear, or to proceed with their removal.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them. This document was made with the financial support of the Environmental Protection and Energy Efficiency Fund (EPEEF). The content of this document is the sole responsibility of the Ministry of Environmental Protection and Green Transition and under no circumstances can it be considered as a reflection of the views and opinions of the EPEEF.

MONITORING AND MAINTENANCE OF YOUNG PLANTS

Monitoring will be conducted every 2 weeks by the project partner - Public Institution Sea and Karst, including a nature guard and professional service staff. Monitoring will include:

- **Visual inspection of vegetation** – checking the health of plants, the presence of damage or disease.
- **Photo documentation** – taking reference photos for comparison over time.
- **Monitoring the impact of environmental factors** – drought, floods, soil erosion.
- **Removal of invasive plant species** – if they appear, removal will be carried out manually or mechanically.

Specific maintenance activities

- **Watering** – will not be necessary except in the event of **extreme drought** during the summer.
- **Weeding and mowing** – will **only be carried out if naturally occurring herbaceous vegetation interferes with the growth of young trees.** Mowing will be carried out **with motorized trimmers** if needed.
- **Protection from herbivores and human activity** – installing protective nets or other measures is not necessary because there are no herbivores near Vrljika and Jadro that would damage these plants.

Evaluation of the success of the renovation

In addition to regular monitoring, **a detailed evaluation** of the success of the renovation will be carried out:

- **Comparison with non-restored locations** – analysis of differences in vegetation cover and structure between restored and non-restored areas.
- **Control of selected "reference" locations** - comparison with areas where riparian vegetation is already developed in a representative state.
- **Biomass and fauna monitoring –** the presence of new plant and animal species that depend on riparian vegetation will be analyzed.

Successful restoration of riparian vegetation should include a zone where a layer of low and tall herbaceous plants, semi-shrubs and shrubs, and a layer of trees are present. Therefore, monitoring in a later phase should also include monitoring the success of restoration - not only of woody individuals, but also of the phytocenosis itself, i.e. the entire vegetation, but also the restoration of biomass and fauna. Also, a comparison should be made with the conditions at locations that have not been restored, as well as with "control" locations - locations that are already in good condition and

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them. This document was made with the financial support of the Environmental Protection and Energy Efficiency Fund (EPEEF). The content of this document is the sole responsibility of the Ministry of Environmental Protection and Green Transition and under no circumstances can it be considered as a reflection of the views and opinions of the EPEEF.

where riparian vegetation has developed in a representative state. It is also necessary to foresee the removal of invasive species if they appear.

For successful restoration, it is necessary to ensure the survival of planted vegetation, i.e. to prevent its subsequent removal, either by herbivores or human activity.

LITERATURE

Bardi , A., Papini, P., Quaglino , E., Biondi, E., Topić, J., Milović , M., Pandža, M., Kaligarič , M. , Oriolo , G., Roland, V., Batina, A., Kirin, T. (2016): Map of natural and semi-natural non-forest terrestrial and freshwater habitats of the Republic of Croatia. AGRISTUDIO srl ., TEMI srl ., TIMESIS srl ., HAOP.

Department of planning, industry & environment and natural resources commission (2020): Good practices in riparian rehabilitation. (www.environment.nsw.gov.au)

Eubanks, E. (2004.): Riparian Restoration. United States Department of Agriculture.

Gashaw, T., Terefe, H., Soromessa, T., Ahmed, S. and Megersa, T. (2015): Riparian areas rehabilitation and restoration: An overview. Point J. Agric. Biotechnol. Res. 1(2): 037-045.

Ministry of Environmental Protection and Green Transition, Institute for Environmental and Nature Protection (2021): National classification of habitats, V. amended version (http://www.haop.hr/sites/default/files/uploads/dokumenti/03_prirodne/stanista/NKS_2018_opisi_ver5.pdf).

Ministry of Environmental Protection and Green Transition (2022): Manual for the implementation of measures to preserve freshwater ecosystems. Zagreb.

Ministry of Economy and Sustainable Development (2022): Rulebook on conservation goals and conservation measures of target species and habitat types in ecological network areas . NN 111/2022. Zagreb.

Oikon doo for the Ministry of Environmental Protection and Physical Planning: Habitat Map of the Republic of Croatia, 2004.

Vukelić, J., Rauš Đ., (1998): Forest phytocenology and forest communities in Croatia

Bioportal Web Service: http://www.bioportal.hr/gis/ (accessed: March 2025)

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them. This document was made with the financial support of the Environmental Protection and Energy Efficiency Fund (EPEEF). The content of this document is the sole responsibility of the Ministry of Environmental Protection and Green Transition and under no circumstances can it be considered as a reflection of the views and opinions of the EPEEF.