FIELD HANDBOOK for the Implementation of Freshwater Ecosystem Conservation Measures

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Zagreb, November 2022

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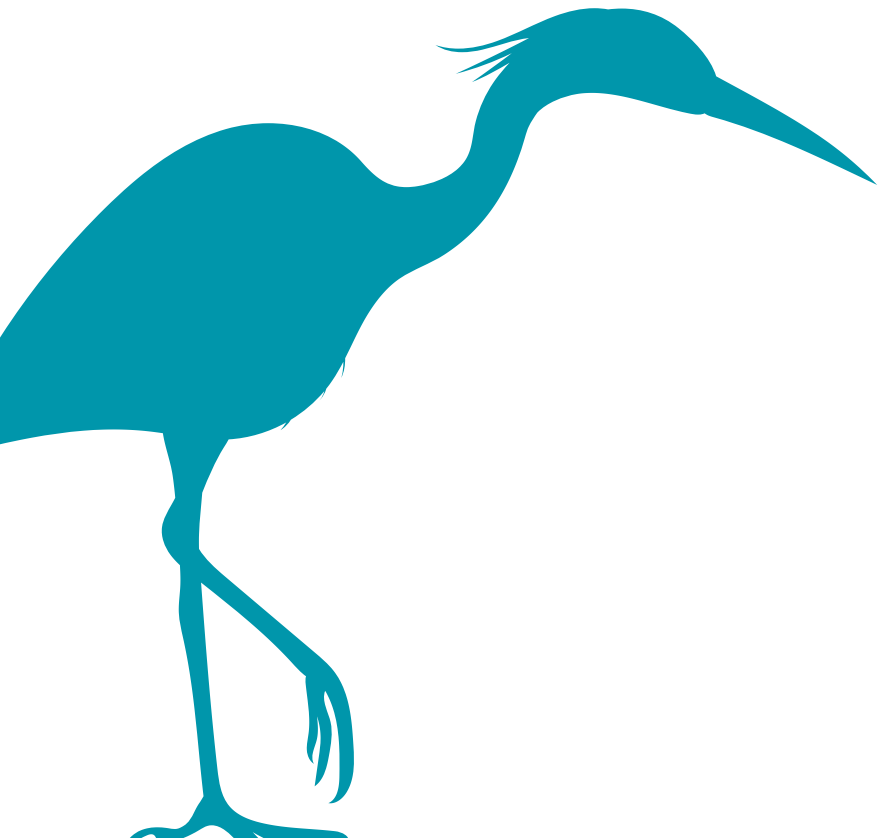
LIST OF ACRONYMS

EU	European Union
IAS	Invasive Alien Species
MESD, cro. MINGOR	Ministry of Economy and Sustainable Development
OG[1]	Official Gazette
AA[2], cro. OPEM	Appropriate Assessment “Assessment of acceptability (of a project/plan) considering the implications for the ecological network”

1 In Croatian: Narodne novine (NN)

2 In Croatian: Ocjena prihvatljivosti za ekološku mrežu (OPEM)



FIELD HANDBOOK for the Implementation of Freshwater Ecosystem Conservation Measures

INTRODUCTION

This *Field Handbook for the Implementation of Freshwater Ecosystem Conservation Measures* has been prepared as part of the *Development of Natura 2000 Management Framework* project, co-funded under the *Competitiveness and Cohesion Operational Programme 2014 – 2020*. As one of the project components, monitoring of the effectiveness of freshwater ecosystem conservation measures was conducted, which has resulted in the preparation of the *Handbook for the Implementation of Freshwater Ecosystem Conservation Measures* on which this Field Handbook is based.

This Field Handbook, and the associated Handbook, have been prepared based on the analyses made by different experts (biologists, hydrotechnical engineers, experts on different taxonomic groups), results of the research on plant and animal taxonomic groups undertaken in connection with the execution of standardised mowing, cutting and woody debris removal works, and the previous experience of all stakeholders involved in the execution of different steps of the appropriate assessment procedure (hereinafter referred to as "the AA procedure") in respect of a programme of maintenance works prepared with the aim of ensuring protection from the harmful effects of water (hereinafter referred to as "the water maintenance programme", as defined in the Water Act, OG No. 66/19, 84/21) and the implementation of the nature protection requirements prescribed as a result of that procedure (more precisely, the implementation of freshwater ecosystem conservation measures) on the territory of the Republic of Croatia. The measures presented in the Handbook are also based on the outcomes of interdisciplinary work meetings with all stakeholders, including expert institutions and bodies responsible for the appropriate assessment, implementation and monitoring of the implementation of water maintenance programmes, the analysis of expert opinions and decisions, and on the experiences of other EU Member States in this regard. Project stakeholders also include the legal persons authorised to perform the relevant water maintenance works on site (hereinafter referred to as "the contractors"), as they are key to the implementation of freshwater ecosystem conservation measures.

This Field Handbook presents the freshwater ecosystem conservation measures that may be prescribed in connection with the following types of standardised water maintenance works (groups of activities) undertaken with the aim of ensuring protection from the harmful effects of water:

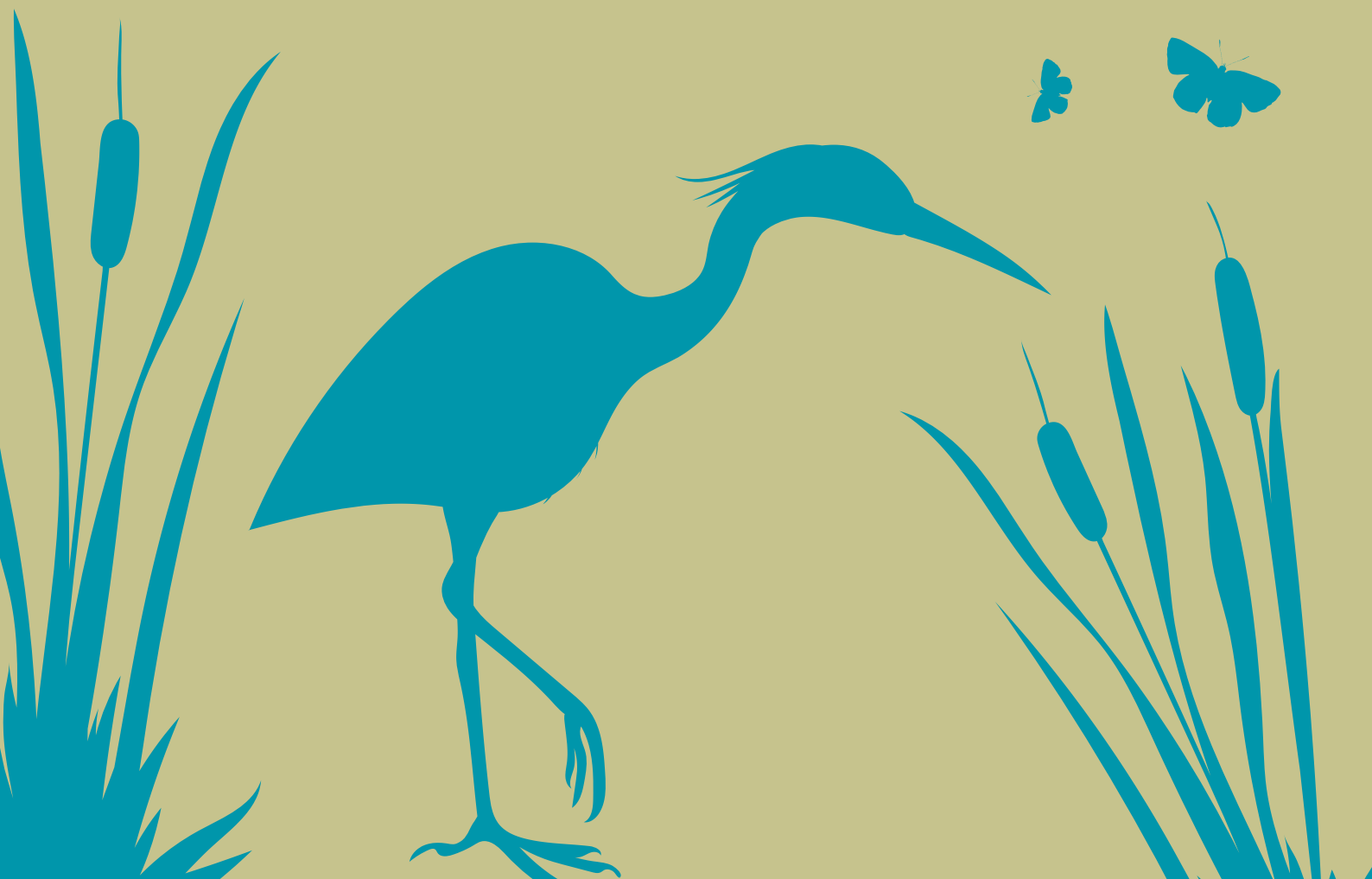
1. waste removal,
2. debris removal,
3. sediment removal,
4. removal of vegetation by mowing (of grass and/or sedge and/or reed) and/or by clearing (of small brush Ø < 5 cm and/or shrubs),
5. selective cutting of brush Ø > 5 cm and/or trees Ø > 10 cm (with or without the removal and disposal of stumps),
6. establishing vegetation by seeding and planting,
7. maintenance, i.e. repair of damage to existing water and other types of structures without changing the dimensions of the structure(s) concerned,
8. establishing protection from the harmful effects of erosion through renovation of regulation structures in watercourse beds (renovation of existing structures without changing the dimensions of the structure(s) concerned)
9. establishing the functional status of waters through renovation of small and simple water and other types of structures.

This Field Handbook has been prepared and is intended to ensure better performance of all stakeholders involved in the implementation and monitoring of the implementation of freshwater ecosystem conservation measures prescribed as a result of the AA procedure conducted in respect of a particular water maintenance programme.

By presenting examples of good practice, this Field Handbook aims to show how different standardised water maintenance works should be properly executed with the implementation of freshwater ecosystem conservation measures.

Considering that this Field Manual is primarily intended to be used when preparing and undertaking the maintenance works, it focuses on the presentation of those freshwater ecosystem conservation measures that refer to the proper execution of standardised works. In this Field Handbook, the users of the associated Handbook can find additional information regarding the general freshwater ecosystem conservation measures which might, when implemented on site, affect the planned schedule (i.e. dynamics) of works.

Undertaking Standardised Works with the Implementation of Freshwater Ecosystem Conservation Measures



1. Waste Removal

No specific conservation measures are generally prescribed with regard to standardised waste removal works. In cases where conservation measures in connection with this type of standardised work are prescribed with regard to a particular site, they usually refer to the conservation of sensitive species and habitats.

2. Woody Debris Removal

Woody debris refers to dead trees (logs), branches (sticks), and trees that are felled and laid down as well as other organic matter of natural origin that can be transported by water through the riverbed. This group of standardised works **does not include sediment removal. An overview of the conservation measures prescribed in connection with this type of standardised work is provided below.**

MEASURE A.1.

Woody debris comprising dead wood (logs and sticks) and trees that have been felled or laid down should be left in watercourses. If they obstruct the water flow, they should be either relocated or turned in the direction of the water flow. Woody debris should be removed from watercourses only if and where necessary to ensure flood protection.

← FIGURE 2.1
An example of the implementation of Measure A.1.: woody debris is removed only if and where necessary to ensure flood and infrastructure protection; the figure shows an accumulation of woody debris stuck against a column of a bridge (Source: Oikon Ltd.)

(!) NOTES REGARDING THE IMPLEMENTATION OF MEASURE A.1.

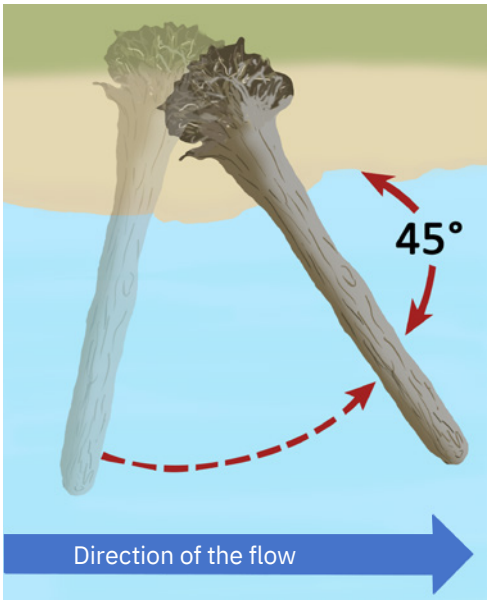
If standardised work of this type is necessary, localised execution **approach should be applied whenever possible, or execution should be limited to small stretches only.**

When preparing a watercourse maintenance programme, next to each worksite named in it there should be an indication as to whether the execution will be localised or the removal of woody debris will be undertaken on small watercourse stretches.

The decision concerning the need to remove woody debris is made by the competent employee of Croatian Waters on site, depending on the site-specific circumstances (watercourse characteristics, flood protection risks).

If they obstruct the water flow, woody debris (in particular, felled/fallen trees) should be **turned in the direction of the flow**, ideally in parallel with the bank or at an angle in relation to the bank. The possibility of placing felled/fallen trees (logs) at an angle in relation to the bank depends on the type of the watercourse and its size. The recommended angle for large rivers (e.g. Sava River, Drava River, etc.) is 45°.

Where stable positioning of a log in a watercourse cannot be secured, due to its weight and shape structure, then the "anchoring" method should be used to stabilise it. Depending on the situation on site (the type and size of the watercourse, structure of the banks and the bottom, flow volume, etc.), several methods can be used (see Figures 2.2 and 2.3).



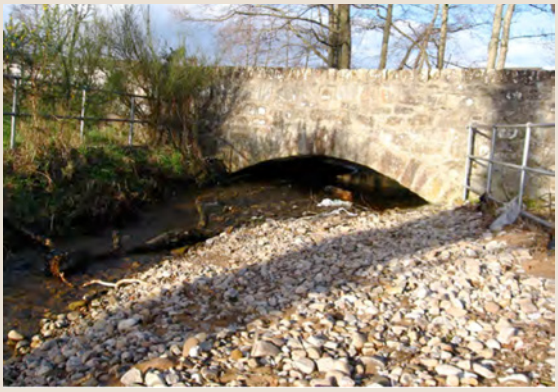
↑ FIGURE 2.2
Turning woody debris (a log) in the direction of the flow at an angle in relation to the bank (the recommended angle for large rivers, e.g. the Sava and Drava rivers, is 45°)
(Author: Matej Kopecki, according to: Macomb County Public Works Office, n.d.)

↑ FIGURE 2.3
An example of the practice of fixing logs using steel wire rope slings
(Source: Paulus 2015)

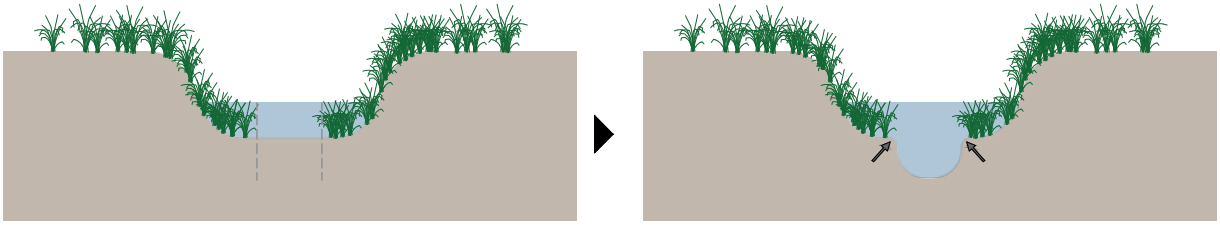
3. Sediment Removal

MEASURE A.2.

Sediment may be removed only if and where necessary, i.e. sporadically on such watercourse sections where it obstructs the flow and thus presents a risk of harm to the health and property of people. Otherwise, the bed should be left in its natural state.



← FIGURE 3.1
An example of the implementation of Measure A.2.: sediment is removed only if and where necessary, i.e. where it obstructs the flow and thus presents a risk of harm to the health and property of people; sediment deposits found next to a bridge may increase the risk of flooding
(Source: Scottish Environment Protection Agency 2010)



REMOVING THE SEDIMENT ALONG THE CENTRAL BED LINE

A LATERAL ELEVATION IS FORMED IN THE BED THAT HELPS PRESERVE AQUATIC HABITATS AND BANK VEGETATION

↗ FIGURE 3.2 *An example of good practice in removing sediment from artificial watercourses (canals)*
(Author: Beatrica Perkec, according to: Scottish Environment Protection Agency 2009)

(!) NOTES REGARDING THE IMPLEMENTATION OF MEASURE A.2.

The decision concerning the need to remove sediment is made by the competent employee of Croatian Waters on site, depending on the site-specific circumstances (watercourse characteristics, flood protection risks).

When preparing a watercourse maintenance programme, next to each worksite named in the programme there should be an indication:

- as to whether the execution will be localised or the removal of sediment will be undertaken on small longitudinal watercourse stretches, and
- in the case of temporarily flowing torrential watercourses and intermittent watercourses, that the works will be performed in the period of the year when the bed is dry.

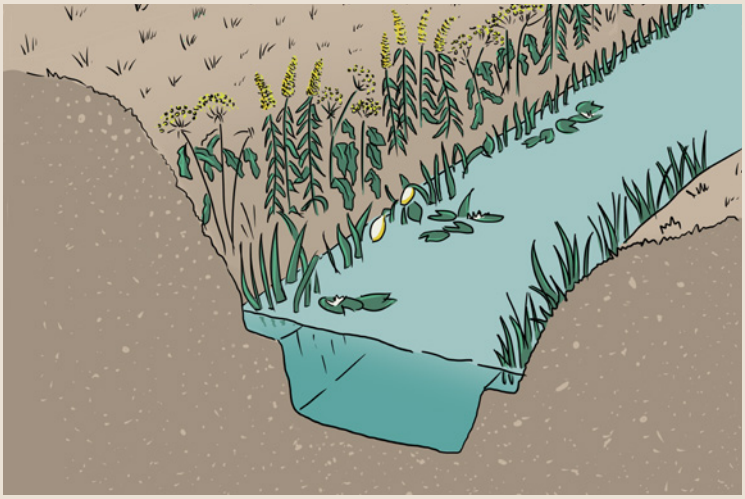
4. Removal of vegetation by mowing (of grass and/or sedge and/or reed) and/or by clearing (of small brush Ø < 5 cm and/or shrubs)

MEASURE B.1.

Amphibious vegetation (vegetation that spends part of the year submerged in water and part of the year above the water surface) should not be mown.

MEASURE B.2.

A strip of riparian vegetation of at least 2 m in width should be left unmown/uncleared on both sides of a watercourse. In the case of watercourses where a 2 m wide strip of riparian vegetation cannot be left and removal is necessary, care must be taken to ensure that such strip is as wide as possible considering the circumstances, and Measure B.3. should be implemented. In order to prevent the washing out of nutrients and pollutants, a 2 m wide strip of riparian vegetation should, whenever possible, be left between watercourses and agricultural land.

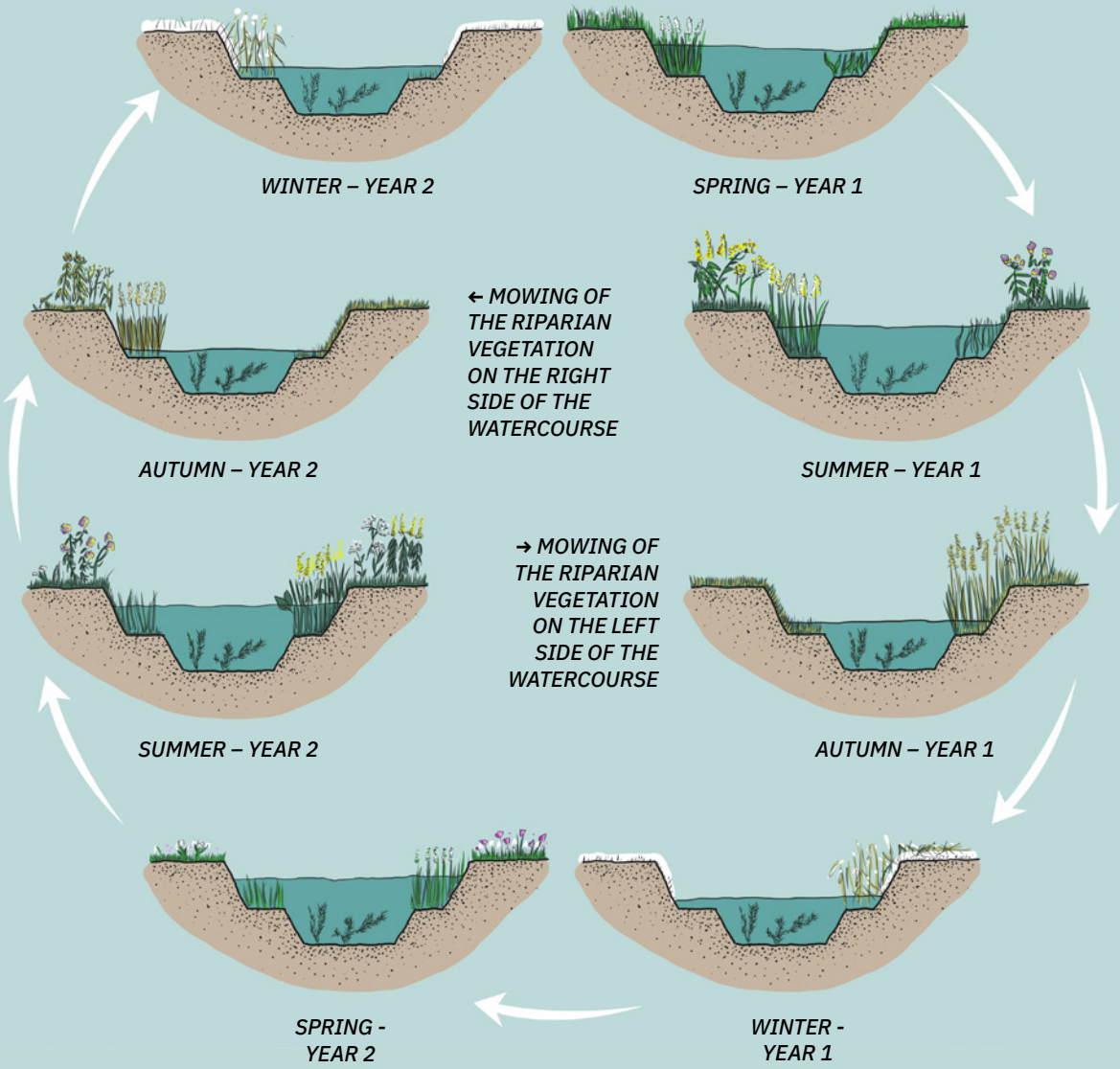


← FIGURE 4.1
An illustration of the implementation of Conservation Measure B.2.
(Author: Matej Kopecki, according to Buisson et al. 2008)

← FIGURE 4.2
An example of good practice in implementing Measure B.2., i.e. a strip of unmown riparian vegetation is left next to agricultural land to prevent the washing out of nutrients and pollutants (Tomašnica watercourse)
(Source: Elektroprojekt JSC)

MEASURE B.3.

If both riparian and amphibious vegetation must be mown on a particular section of a watercourse, the mowing carried out during a single vegetative period (i.e. a year) should be limited to one bank, while the vegetation on the other bank should be left intact. On the bank where the clearing of brush and shrubs is performed, care must be taken to avoid removing the firmly established shrubs as much as possible (as they contribute to bank stabilisation, provide shade, etc.).



↑ FIGURE 4.3. *An example of the implementation of Measure B.3. – a 2-year riparian vegetation maintenance cycle – mowing*
(Author: Matej Kopecki, according to: Buisson et al. 2008)

MEASURE B.4.

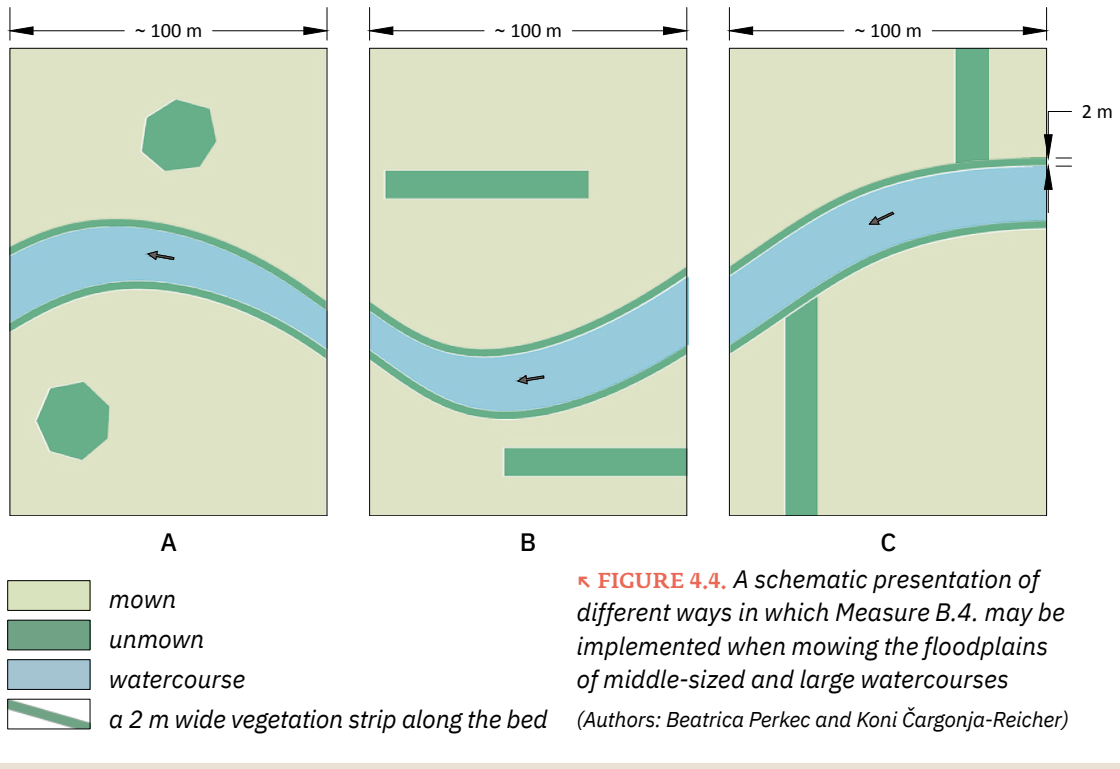
When mowing a section of a floodplain, rotational (mosaic) mowing and/or clearing method should be applied, i.e. different segments should be mown/cleared at different intervals. More precisely, it must be ensured that, at every 100 m stretch, approx. 10% of the vegetation-covered area (in the shape of small strips or patches) is left unmown/uncleared. During the next mowing cycle, those strips/patches should be mown/cleared, while some other 10% of the relevant 100 m stretch should be left intact. When undertaking clearing works, care must be taken that trees and well-established shrubs are preserved as much as possible.

(!) NOTES REGARDING THE IMPLEMENTATION OF MEASURE B.4.

MEASURE B.4. is implemented on middle-sized and large watercourses where the floodplain is wide enough to permit such approach.

A schematic presentation of different ways in which Measure B.4. may be implemented (Figure 4.4.)

At every stretch of approx. 100 m in length that is mown, at least 10% of the area in the shape of patches (implementation method A) or short strips of vegetation should be left unmown. The selected strips may be either parallel (implementation method B) or perpendicular in relation to the bed (implementation method C). During the next mowing cycle, those patches/strips should be mown, while some other 10% of the relevant 100 m stretch should be left intact.



↖ FIGURE 4.4. *A schematic presentation of different ways in which Measure B.4. may be implemented when mowing the floodplains of middle-sized and large watercourses*

(Authors: Beatrica Perkec and Koni Čargonja-Reicher)

MEASURE B.5.

The mowing/clearing works in built-up urban settings and areas used for tourism or sporting and recreational purposes may, if needed, be undertaken several times a year. During each mowing/clearing cycle, at least 10% of the area, i.e. strips or patches of vegetation, should be left unmown/uncleared.

(!) NOTES REGARDING THE IMPLEMENTATION OF MEASURE B.5.

When preparing a watercourse maintenance programme, next to each worksite there should be an indication as to whether the relevant section of the watercourse is located within a built-up urban area or not. If that is the case, only and specifically Measure B.5. may be prescribed for such a site.

MEASURE B.6.*

The mowing of floodplains and banks of watercourses and canals (managed by Croatian Waters) in areas where corncrakes nest should be carried out in the period from 15 August until 15 March.

MEASURE B.7.

Measures B.1., B.2., B.3., B.4., and Measures P.1., P.2., P.3. do not refer to the mowing and clearing of stands of the common ragweed (*Ambrosia artemisiifolia*), japanese knotweed (*Reynoutria* spp.) or false indigo bushes (*Amorpha fruticosa*), or the stands of other invasive alien species that must, if needed, be mown/cleared several times a year. After the mowing/clearing works are completed, the cuttings must be properly disposed of.

MEASURE B.8.

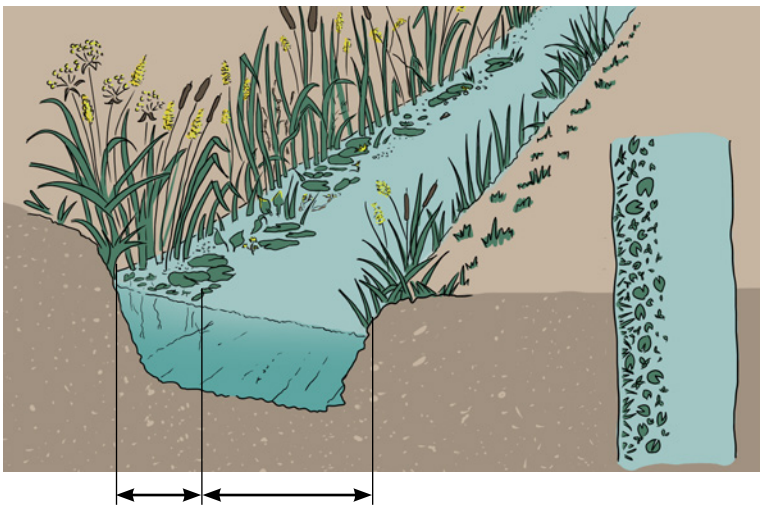
Aquatic vegetation should only be removed if the watercourse flow continuity is compromised and therefore presents a risk of harm to the health and property of people.

* Measures prescribed with regard to specific sites where deemed necessary.

MEASURE B.9.

If mowing/clearing of aquatic vegetation in a particular section of the watercourse bed is necessary, such works should be undertaken on an area equal in size to no more than 2/3 of the watercourse width, while leaving the substrate and the aquatic and wetland vegetation growing along the banks intact. In exceptional cases, i.e. if it significantly obstructs the flow or disrupts the functioning of the pumping stations, removal of aquatic and wetland vegetation growing in the bed may be allowed. As regards channelised watercourses, the area within the bed should be mown in such manner so as to form sinusoidal (meandering) swaths.

→ FIGURE 4.5.
An illustration of the implementation of Conservation Measure B.9.
(Author: Matej Kopecki, according to: Buisson et al. 2008)



→ FIGURE 4.6
An example of good practice in implementing Measure B.9.: a sinusoidal aquatic vegetation mowing pattern in channelised watercourses
(Source: Wasserverbandstag 2015)

MEASURE B.10.

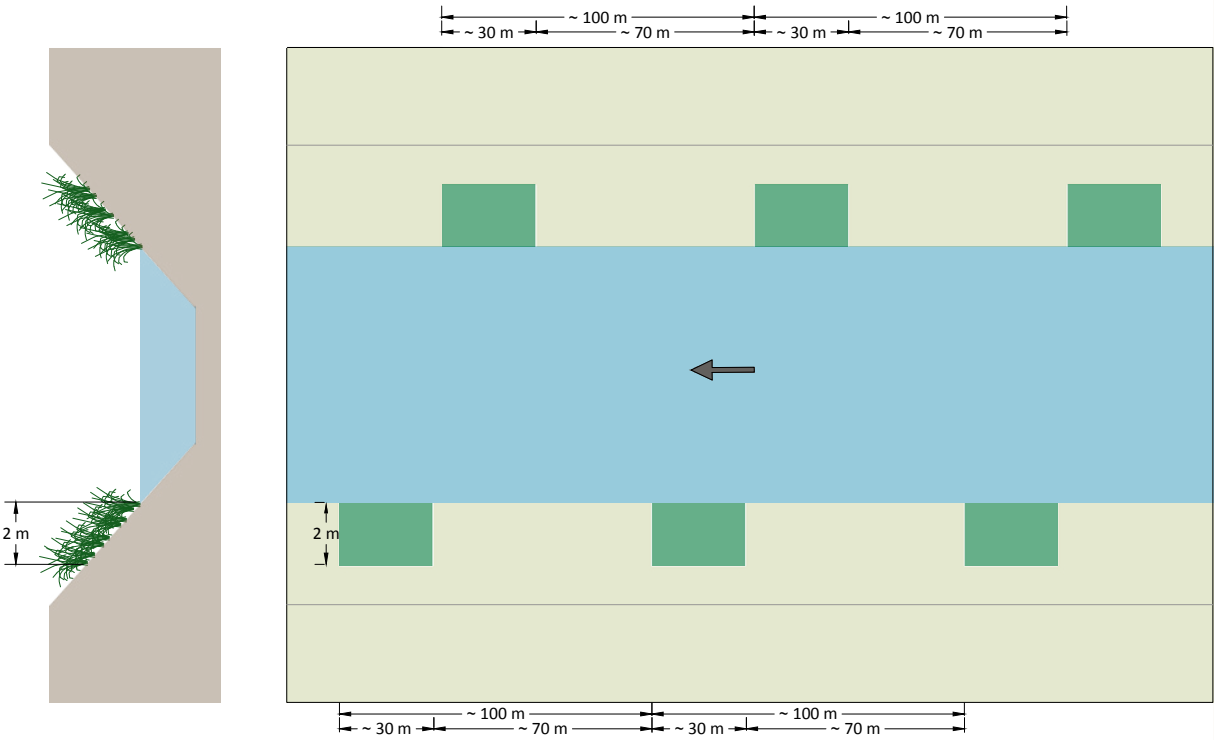
All vegetation clippings and cuttings left after mowing must be removed from the watercourses to prevent the lowering of oxygen levels in the water, or obstructions affecting downstream structures.

MEASURE B.11.*

If aquatic vegetation classified under *Habitat Type A.3.3.2 Rooted submerged communities of flowing waters* (alliance: *Ranunculion fluitantis*) is established in the watercourse affected by the works, at least 1/3 – 1/2 of such vegetation should be left intact across the watercourse width.

MEASURE B.12.*

In exceptional cases, when mowing of the riparian vegetation on both sides of a watercourse section is required,different segments should be mown at different intervals. Care should be taken that on each 100 m stretch of the relevant watercourse section at least 30% of the riparian vegetation, i.e. strips extending at least 2 m in width from the edge of the watercou rse, is left unmown at all times.



↑ FIGURE 4.7
A schematic presentation of one of the ways in which Conservation Measure B.12. may be implemented
(Authors: Beatrica Perkec and Koni Čargonja-Reicher)

* Measures prescribed with regard to specific sites where deemed necessary.

To ensure proper implementation of conservation measures when undertaking mowing activities, the difference between mulching and mowing of grass must be explained and understood. **Mulching** (carried out using the so-called "mulchers") refers to the cutting and grinding of vegetation to the ground level and leaving it as such on the surface to decompose. Depending on the power of the machine, the mulching method may also be used to cut and grind small brush and shrubs. **Mowing** is however performed using mowers, and the grass is cut to a certain height from the ground. Grass cuttings are collected either immediately or after they dry (hay). If grass cuttings are left on the ground or if the mulched particles are too big, they may block the sunlight and prevent moisture from penetrating the soil on which the grass grows, which results in the so-called "suffocation" (or drying out) of grassland vegetation. Finally, **if vegetation cuttings are left in the affected watercourse, the natural organic matter decomposition process will result in reduced concentration of oxygen diluted in the water**, which may lead to suffocation of fish and other aquatic fauna, and may also affect water quality.

← FIGURE 4.8
An example of poor practice: vegetation growing along a watercourse mown with a mulcher, at some places even all the way to the ground (location: Gliboki Stream)
(Author: Martina Šašić Kljajo)

← FIGURE 4.9
An example of good practice: mowing performed with a sickle-bar mower, ensuring the appropriate cutting height
(Source: Briliant Ltd., website 2021)

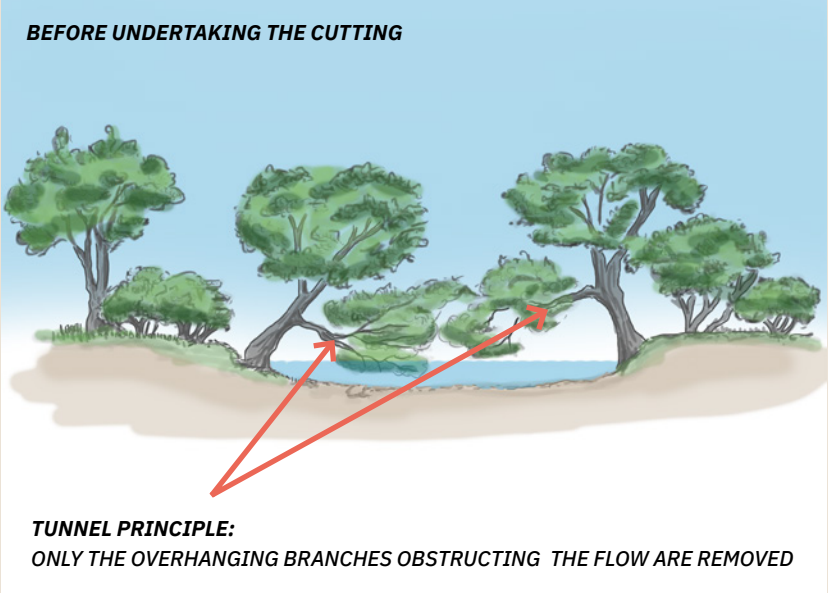
5. Selective cutting of brush Ø > 5 cm and/or trees Ø > 10 cm (with or without removal and disposal of stumps)

MEASURE C.1.

The trees and brush should be removed only if they obstruct the continuity of the water-course flow to that extent that they cause a risk of harm to the health and property of people. Otherwise, the vegetation should be left in its natural state, intact.

MEASURE C.2.

Whenever possible, the required flow continuity should be ensured by removing the overhanging branches reaching the highest water level (the so-called "tunnel principle"), and individual trees obstructing the flow.



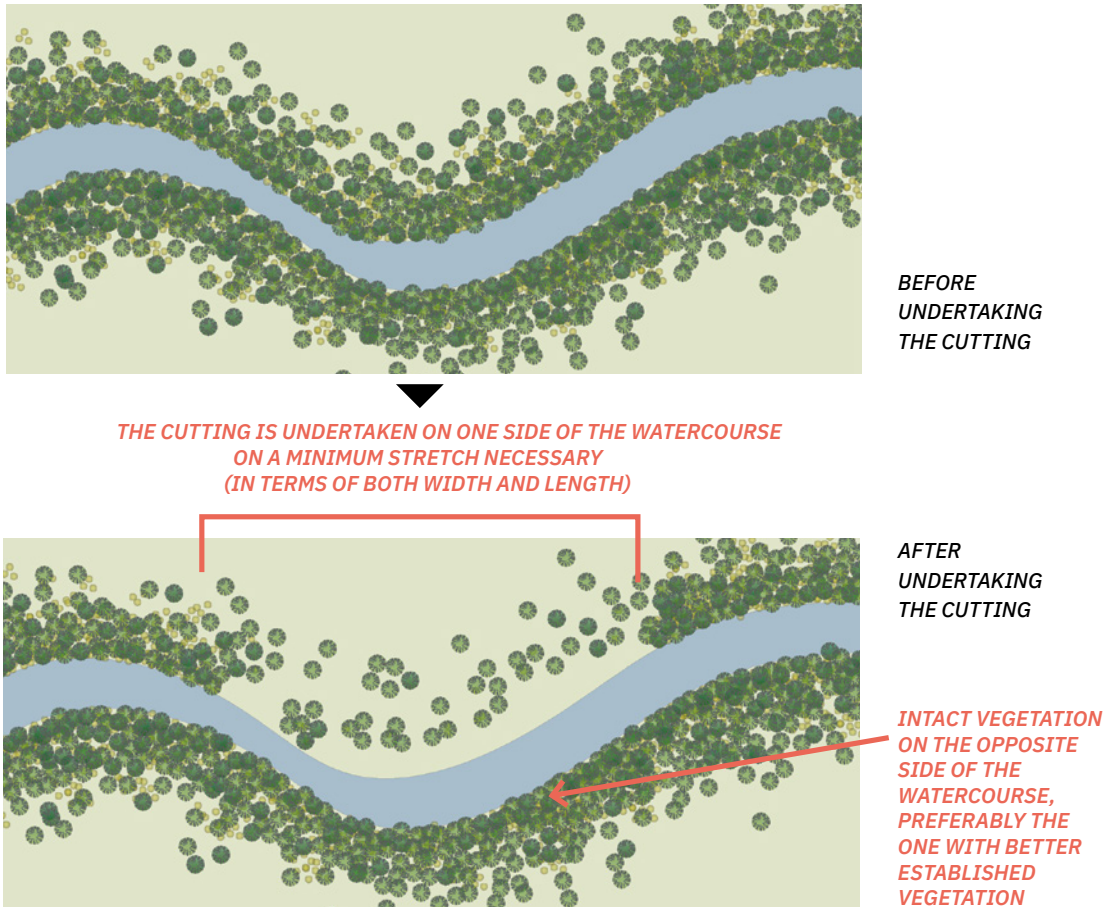
↖ FIGURE 5.1
An illustration of the implementation of Conservation Measure C.2. (↖ up: condition before; ← left: condition after undertaking the selective cutting by implementing Measure C.2.)
(Author: Matej Kopecki, according to Derigonand Dechavann 2013)

MEASURE C.3.

If Measures C.1. and C.2. are not sufficient to ensure the required flow continuity, the trees and brush should be removed, but only on one side of the watercourse (i.e. the bank with less firmly established trees and brush), while the vegetation strip on the opposite bank should be left intact. Removal works should be undertaken only on such stretch which is limited in both length and width to what is minimally necessary to ensure the required flow continuity, while the trees and brush which do not disrupt the flow should, whenever possible, be left intact in order to preserve some of the favourable habitats on that side (bank) of the watercourse as well.

(!) NOTES REGARDING THE IMPLEMENTATION OF MEASURE C.3.

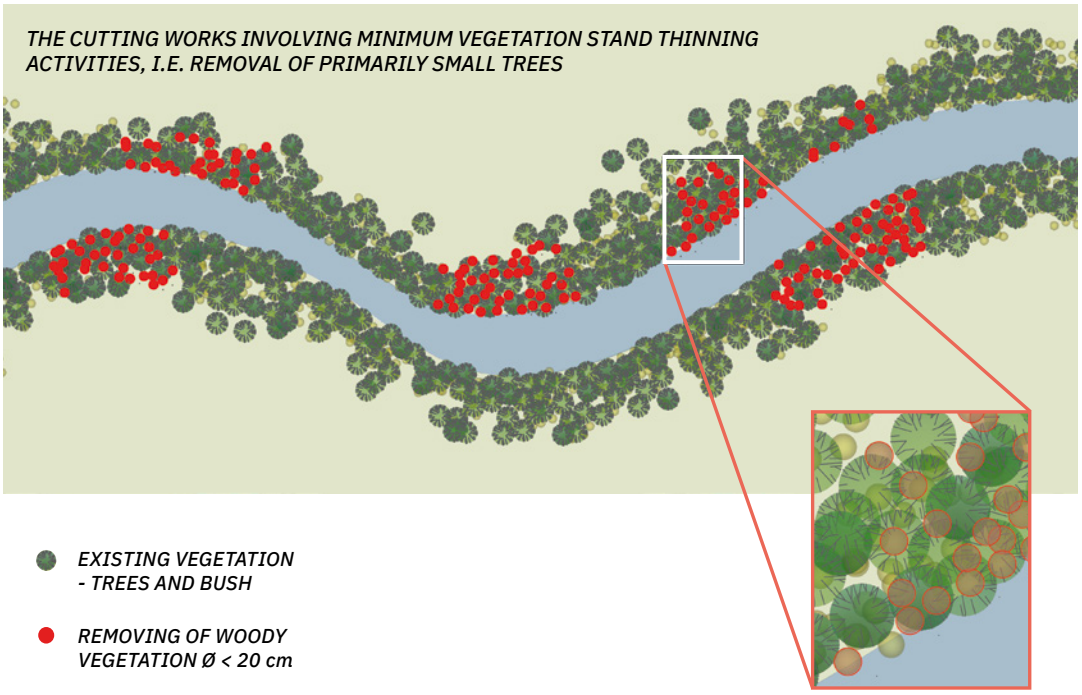
The manner in which Measure C.3. will be implemented depends on the situation on site (watercourse characteristics, possibilities of accessing the watercourse and achieving flow continuity). The decision regarding the manner in which the measure will be implemented is made by the competent employee of Croatian Waters present on site.



↑ FIGURE 5.2
An illustration of one of the ways in which Measure C.3. may be implemented, where selective cutting is undertaken on one side of the watercourse only, in strips which are as short as possible and minimally wide *(Authors: Beatrica Perkec and Koni Čargonja-Reicher)*

MEASURE C.4.

If Measures C.1., C.2. and C.3. are not sufficient to ensure the required flow continuity, the minimum scope of clearing and cutting works should be undertaken for the purpose of thinning the vegetation stand. In that process, the woody vegetation with a diameter of less than 20 cm should be removed first, while the groups of large trees should be left intact as much as possible. Care must be taken that the removal works be limited to what is minimally necessary to ensure the required flow, and that the trees and brush which do not obstruct the flow are left intact, as much as and whenever possible, in order to help preserve the existing bank habitats.



↑ FIGURE 5.3 *An illustration of the implementation of Conservation Measure C.4.: selective cutting by thinning a bank vegetation stand through removal of trees with a diameter of less than 20 cm, while leaving groups of large trees intact* (Authors: Beatrica Perkec and Koni Čargonja-Reicher)

MEASURE C.5.

Removal of woody vegetation should only be carried out in the period from 15 August until 31 March in order to avoid the nesting season of most bird species.

MEASURE C.6.*

If presence of the common kingfisher on a wider area is determined, the riparian vegetation should be preserved as much as possible, and the removal of trees and shrubs should be carried out only in the period from 1 September until 31 January.

* Measures prescribed with regard to specific sites where deemed necessary.

MEASURE C.7.

Old trees with crevices and cavities that may potentially be habitats of strictly protected species (e.g. bats and burrowing birds) should be left uncut whenever possible. If strictly protected species are found, the competent public institutions for the management of protected areas and ecological network sites and the Ministry should be immediately notified, and all further steps should be taken in agreement with those institutions.

MEASURE C.8.

After cutting/felling mature trees, the logs should be left resting in place for a period of 24 hours prior to removal in order to allow the potentially present bats and other fauna to leave the tree.

MEASURE C.9.

The areas covered with invasive alien species of woody plants (e.g. false indigo, *Amorpha fruticosa*) may, if necessary, be cleared several times a year, provided the cuttings are properly disposed of.

EXAMPLES OF UNDERTAKING SELECTIVE CUTTING WITH THE IMPLEMENTATION OF CONSERVATION MEASURES

→ FIGURE 5.4 *An example of selective cutting undertaken in combination with partial implementation of Conservation Measure C.3. – the vegetation on one watercourse bank is left entirely intact, while no trees are left on the other*
(Source: Institute for Environment and Nature, MESD)

→ FIGURE 5.5 *An example of good practice in undertaking the necessary selective cutting works to ensure watercourse flow continuity (Slakovec lateral canal)*
(Source: Elektroprojekt JSC)

6. Establishing vegetation by seeding and planting

MEASURE D.1.

Mineral fertilisers and other chemical substances used to stimulate revegetation should not be applied, i.e. care must be taken to avoid the washing out of harmful substances into watercourses and prevent eutrophication.

MEASURE D.2.

After completing the works that result in the creation of bare soil on the slopes of watercourses or in the adjacent floodplains, revegetation of the affected area must be stimulated exclusively by seeding and planting the species native to the (relevant) regional area.

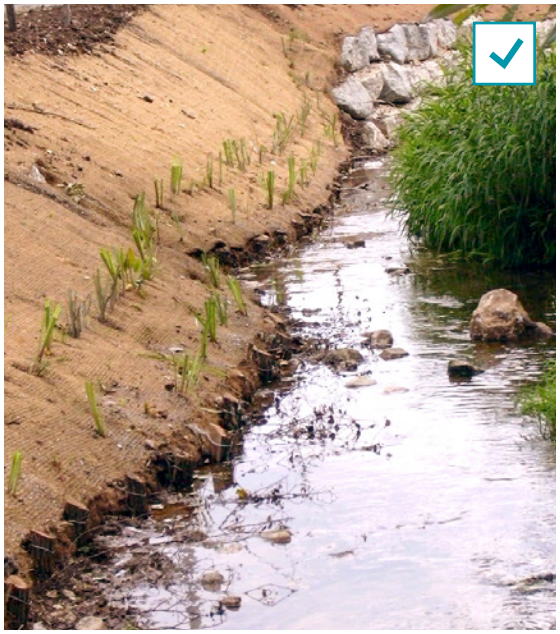
The seeding and planting should be undertaken as soon as possible after the execution of works resulting in strips of bare soil on the banks or the floodplain. In doing so, the risk of bank erosion and spread of invasive alien plant species is reduced.

The recommended tree species native to the regional area which may be planted alongside watercourses are: willows (*Salix* sp., e.g. *S. alba*, *S. x fragilis*), poplars (*Populus* sp., e.g. *P. alba, P. nigra*), alders (*Alnus* sp., e.g. *A. incana, A. glutinosa*). In selecting individual species, care should be taken that they are native to the specific site where the works are undertaken.

Where better erosion resistance is required, biodegradable geotextiles may be used as an underlay before seeding or planting (Figure 6.2).

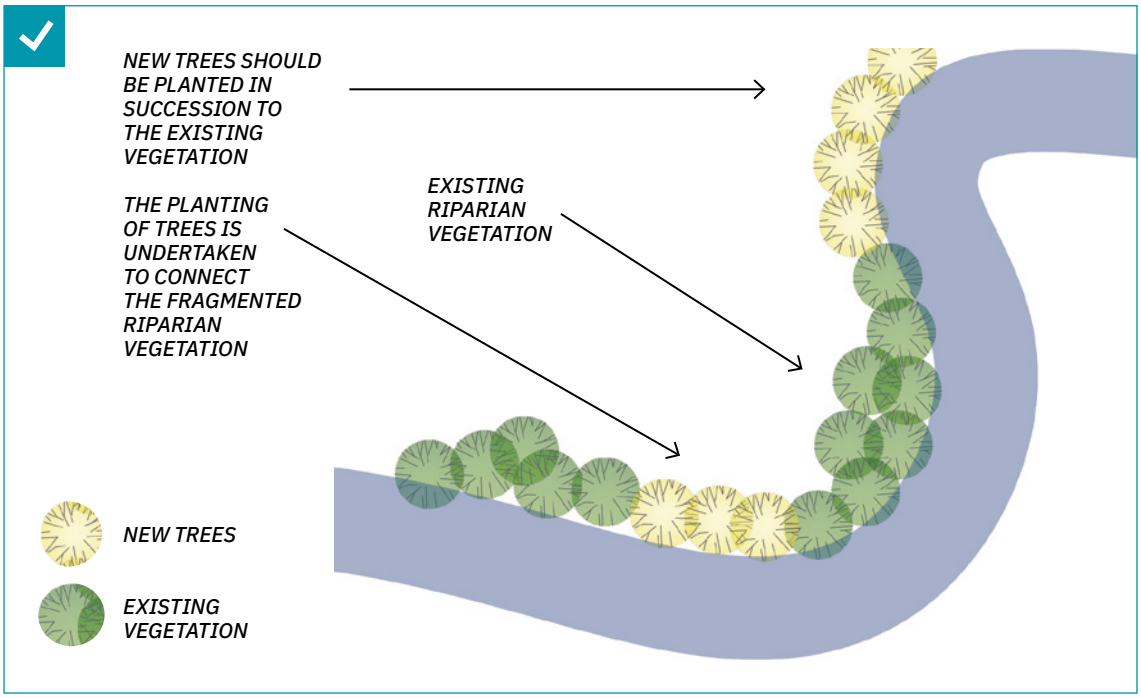
After the planting, **the progress and development of the planted vegetation should be regularly monitored, the native vegetation should be maintained and, where necessary, measures should be taken to eliminate potential invasive alien plant species.**

↑ FIGURE 6.1
An example of poor practice: failure to implement Measure D.2. after completing works on the bank, thus compromising its stability due to increased exposure to erosion
(Source: Kathy Dale, in: Scottish Environment Protection Agency 2009)



↑ FIGURE 6.2
An example of good practice: planting of vegetation on the slope using biodegradable geotextile as an underlay to increase erosion resistance
(Source: AquaTerra Solutions, website 2021)

↘ FIGURE 6.3 *An example of good practice in planning the planting of woody species for the purpose of establishing new vegetation covered areas and thus connect the small fragmented sections into a continuous strip of woody riparian vegetation*
(Author: Beatrica Perkec, according to: Scottish Environment Protection Agency 2009).



7. **Maintenance, i.e. repair of damage to existing water and other types of structures without changing the dimensions of the structure(s) concerned**

8. **Establishing protection from the harmful effects of erosion through renovation of regulation structures in watercourse beds (renovation of existing structures without changing the dimensions of the structure(s) concerned)**

9. **Establishing the functional status of waters through renovation of small and simple water and other types of structures**

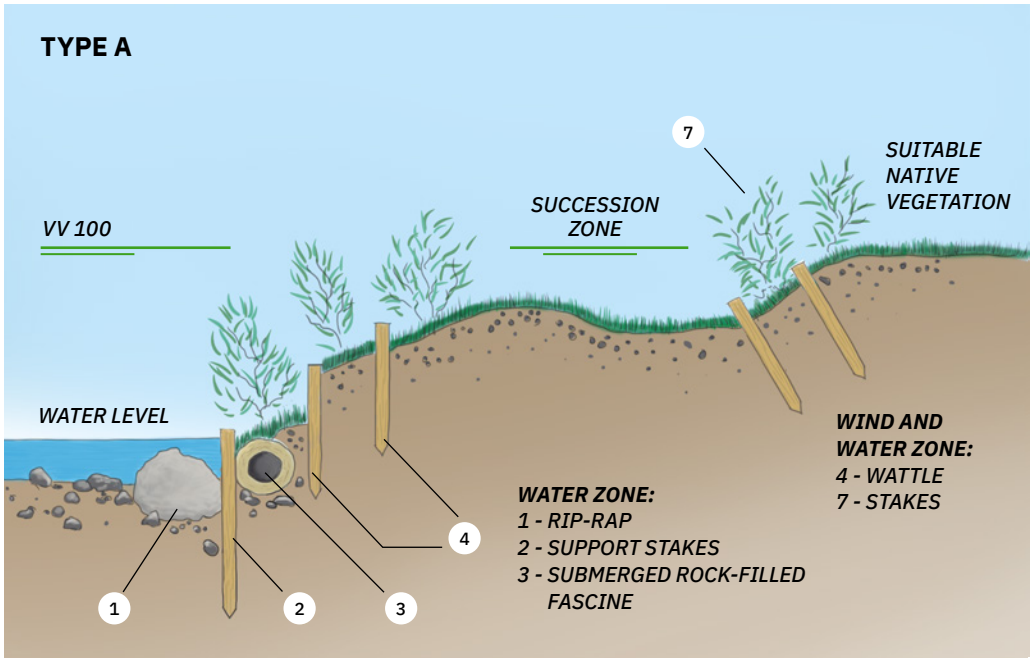
MEASURE E.1.

The possibility of using other bank reinforcement and erosion protection methods besides those based on the use of rocks and concrete (bioengineering methods) should be considered. Additionally, when undertaking works of this type, it should be ensured that the bank stretches to be rock armoured or reinforced with some other material are as small as possible. If the floodplain is wide enough, the possibility of installing a trench fill revetment on the land section up to the cut-off line should be considered as a method to be used instead of bank lining.

EXAMPLES OF IMPLEMENTATION OF MEASURE E.1.

The figures below present several ways in which Measure E.1. can be implemented. Two of the examples (i.e. Type A and Type B) refer to a bank which is prone to erosion, while the third example (Type C) refers to a bank which is not prone to erosion.

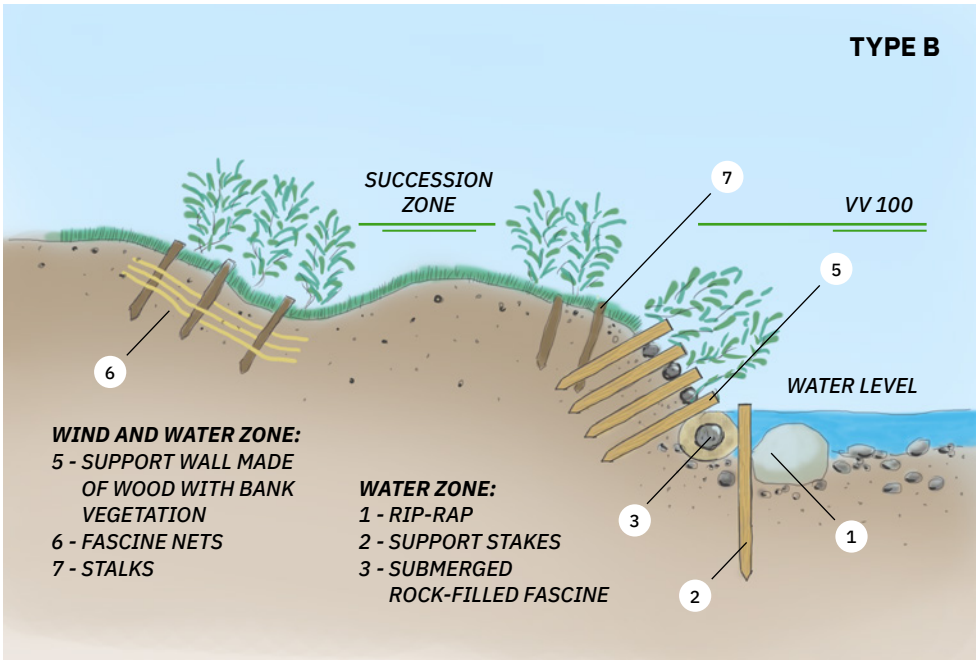
Type A (Figure 7.1) – to armour a bank prone to erosion, the bank slope is reinforced, up to the height representing the low to medium water level ("water zone"), by installing **rip-rap, support stakes and an underwater rock-filled fascine**. The **fascines** are usually wrapped in brushwood (which forms a 10 cm thick cover) and are **filled** with crushed stone or large gravel. The full diameter of a filled fascine depends on the aggregate. More precisely, if large aggregate is used, the fascines may range in diameter from 1.1 to 1.2 m, and if small aggregate is used, from 0.7 to 1.6 m. In the zone that extends up to the height representing the high water level, which is exposed to the effects of winds as well ("the wind and water zone"), the bank slope is armoured with **wattles**, while the remaining bank area, in the high water level zone (marked in the figures as "VV 100"), is reinforced with stakes.



↑ FIGURE 7.1
An example of the implementation of Measure E.1. –a schematic presentation of a method of managing a bank prone to erosion (Type A)
(Author: Matej Kopecki, according to Elektroprojekt JSC)

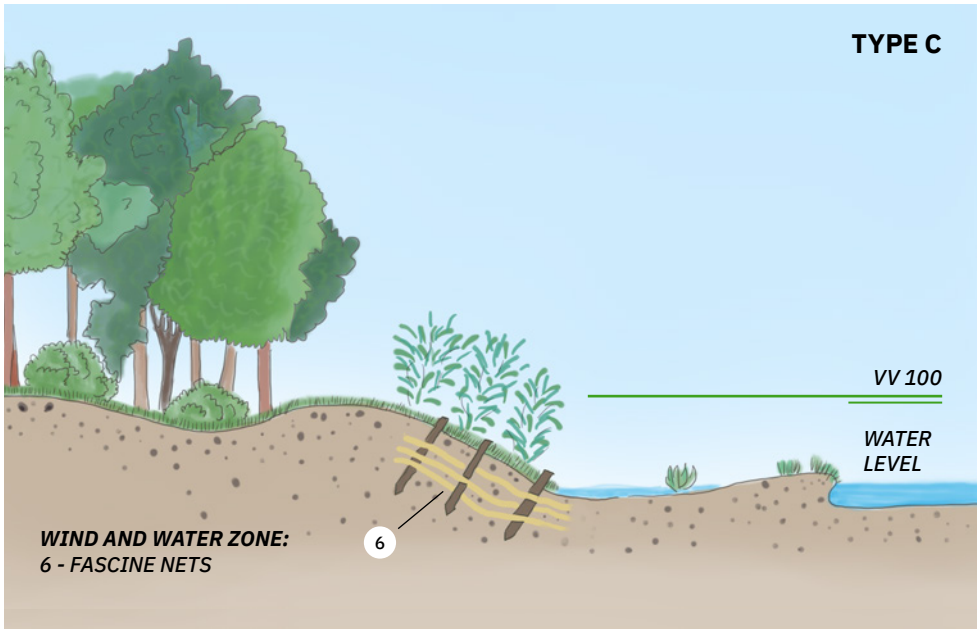
The **wattles** are usually made using willow stakes and sticks, and are arranged in rows, approx. 0.5 to 1.0 m apart from each other, parallel to the bank. To make an ordinary wattle, 1.5 m long stakes with a diameter of 6 – 15 cm are used. They are stuck into the bank so that they partly protrude from the ground, i.e. up to the height of 50 – 60 cm. To ensure growth, live stakes with seedlings must be used. The installed stakes are then interlaced with fresh willow sticks of 2 cm in diameter. The area between the lines where the stakes and the wattles are installed is the so-called "succession zone" where natural bank revegetation and progressive vegetation processes are expected to occur (the establishment of herbaceous plants, then shrubs and, finally, woody vegetation).

Type B (Figure 7.2) – to armour a bank prone to erosion, the bank slope is, in this case too, reinforced, up to the height representing the low to medium water level ("**water zone**"), by installing **rip-rap, support stakes and an underwater rock-filled fascine. In the "wind and water zone"**, however, **a support wall made of wood** is used to reinforce the slope, while the bank is covered with vegetation. The stakes are stuck in the ground at the point where the wall of wood ends. At the height representing the high water level, **fascine nets are installed**. Fascine nets are made from bundles of brushwood tied by a wire, and may vary in size. Humus with grass seeds can be used to fill the space between net openings. The area between the lines where stakes and the fascine net are installed is the so-called "succession zone", where natural bank revegetation processes are expected to occur, i.e. where woody vegetation is expected to develop.



↑ FIGURE 7.2
An example of the implementation of Measure E.1. – a schematic presentation of a method of managing a bank prone to erosion (Type B)
(Author: Matej Kopecki, according to: Elektroprojekt JSC)

Type C (Figure 7.3) – a bank which is not prone to erosion is left intact up to the height representing the low to medium water level ("water zone"). **In the "wind and water zone", however, fascine nets are used to reinforce the bank slope.**



↑ FIGURE 7.3
An example of the implementation of Measure E.1. – a schematic presentation of a method of managing a bank which is not prone to erosion (Type C)
(Author: Matej Kopecki, according to: Elektroprojekt JSC)

↑ FIGURE 7.4
An example of good practice in implementing bioengineering methods to stabilise a slope of a small watercourse (location: Međimurje)
(Source: Međimurska priroda – Public Institution for Nature Protection)

↑ FIGURE 7.5
An example of good practice in implementing bioengineering methods to stabilise a slope of a small watercourse at a site in Međimurje; using fascines to stabilise the slope **(left)**; *at a site in Nespeš, Sv. Ivan Zelina; using fir tree boards and stakes to stabilise the slope* **(right)**
(Source: Croatian Waters)

In addition to the conservation measure described above, the following **measures from Group E.** are also implemented in connection with the maintenance and repair works undertaken on regulation structures:

MEASURE E.3.

After the works on a regulation structure are completed, the area must be rehabilitated, i.e. earthfilled and seeded.

← FIGURE 7.6
A new earthfill revetment (location: Mala Neretva)
(Source: Institute for Environment and Nature, MESD)

MEASURE E.5.

If invasive alien plant species are identified during the revegetation period, they must be actively removed (and properly disposed of) until the natural woody vegetation is reestablished.

MEASURE E.6.

When undertaking maintenance works on dams and other structures in the area surrounding the barrier, which structures obstruct the upstream and/or downstream passage of freshwater fauna, i.e. compromise the continuity of the ecological system, such structures should be permanently adjusted to allow free movement/passage of freshwater fauna. If technically feasible, when executing major repairs or renovating such structures, works aimed at making them more environmentally-friendly should also be planned (e.g. building cascades below dams, developing special fish passes, and executing similar technical projects).

EXAMPLE OF IMPLEMENTATION OF MEASURE E.6.

The figure below shows a change that occurred after the step, which had been the cause of disruption in longitudinal connectivity, was removed to mitigate the impact on the migration of the biota and sediment. Once the barrier was removed, the river continuity was restored, allowing the fish to migrate freely, and rest areas have developed, contributing to the increase in the variety of microhabitats at the site.

↑ FIGURE 7.7
An example of the implementation of Measure E.6. – mitigating the impact of a weir in a watercourse bed (up: the state before and down: the state after removing the step; Hučava River, Slovakia)
(Source: Rob Kleinjans, Dam Removal Europe 2022)

MEASURE E.7.

When renovating culverts and crossings over watercourses within the range of otters and beavers, free passage across the banks must be ensured for the said species (i.e. a dry animal passage/corridor must be secured). Culvert renovation projects may not be executed in a manner that causes a disruption in watercourse continuity, i.e. a disruption in the migration of fish and other fauna (e.g. only semi-circular culverts and culverts in the shape of a bridge, which do not affect the watercourse bed, may be planned). It must also be ensured that the bottom of the culvert is below or at the level of the watercourse bottom slope.

← FIGURE 7.8
An example of the implementation of Measure E.7.: a passage for otters built under a bridge with a lateral bank superelevation to ensure dry conditions for safe animal passage
(Source: Z. Chabadová, in: Hahn 2015)

← FIGURE 7.9
An example of the implementation of Measure E.7.: an example of a culvert, where the load-bearing structure of the bridge does not disturb the bank or the bed of the watercourse
(Source: Scottish Environment Protection Agency 2010)

Implementation of Measures Aimed at Conserving the Favourable Habitat Conditions for Species

INVERTEBRATES

/ butterflies, decapods, molluscs, coleopters, dragonflies /

MEASURE F.19.*

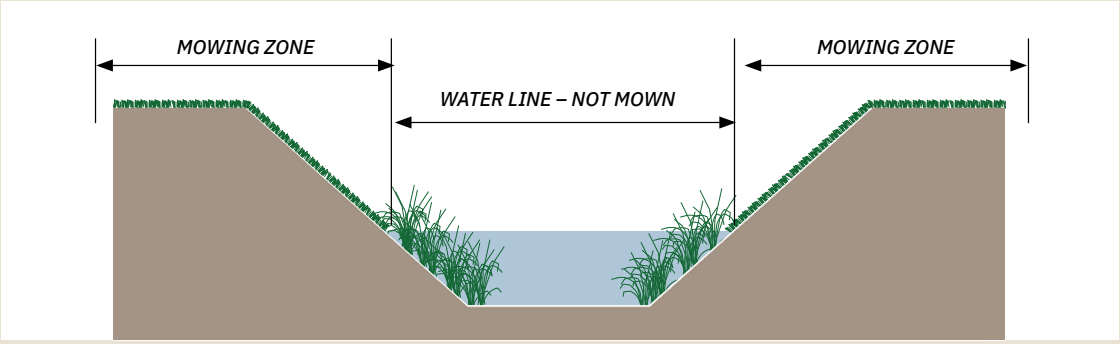
At sites where presence of freshwater decapods is determined, care should be taken that as much as possible woody debris, riparian and aquatic vegetation, trees and brush be preserved along the edges of watercourses in order to conserve or create favourable habitats and provide shadow above the water.

From the four freshwater decapod species native to Croatia, three are strictly protected, namely the white-clawed crayfish (*Austropotamobius pallipes*), the stone crayfish (*Austropotamobius torrentium*) and the noble crayfish (*Astacus astacus*).

↑ FIGURE 8.1
The stone crayfish (left) and an example of a watercourse with a typical habitat for the stone crayfish – Velika Belica Stream (right)
(Author: Matej Faller)

MEASURE F.30.*

Where the presence of populations of the thick-shelled river mussel (*Unio crassus*), a strictly protected shellfish species, is determined, only the area up to the water line should be mown (the bottom of the watercourse bed should be left intact).



↑ FIGURE 8.2 *An illustration of the implementation of Measure F.30. – the riparian vegetation is mown up to the water line, while the bottom of the watercourse bed is left intact*
(Authors: Beatrica Perkec and Koni Čargonja-Reicher)

MEASURE F.31.*

Where the presence of populations of the thick shelled river mussel (*Unio crassus*), a strictly protected shellfish species, is determined, the works in the watercourse bed must be limited to what is strictly necessary, and care should be taken to leave the sediment deposited at the bottom of the watercourse bed as undisturbed as possible.

→ FIGURE 8.3 *The thick-shelled river mussel (Unio crassus) in a watercourse*
(Source: Alexander Mrkvicka, Creative Commons License 2009)

MEASURE F.37.*

Where potential or actual presence of populations of the beetle species *Carabus variolosus* is determined, the existing alder forests growing alongside watercourses must be preserved.

→ FIGURE 8.4 *The Carabus variolosus beetle*
(Source: Jacek Proszyk, Creative Commons License 2018)

* Measures prescribed with regard to specific sites where deemed necessary.

With the aim of ensuring **conservation of strictly protected and endangered butterfly species**, works must be scheduled in accordance with the periods when undertaking of works is permitted, i.e. in accordance with Measures F.20., F.23. and F.25. – F. 28.

With the aim of ensuring **conservation of strictly protected and endangered dragonfly species**, conservation measures defining the periods when the execution of works is permitted and/or the manner in which works should be executed may be prescribed in respect of specific sites: F.43. – F.46.

FISH, AMPHIBIANS AND REPTILES

The conservation measures designed specifically to ensure conservation of fish, amphibians and reptiles refer primarily to the definition of periods when undertaking of works is permitted. The purpose of such measures is to ensure an undisturbed environment during their spawning and reproduction season as well as in other sensitive periods of the life cycle of those species. The measures include: Measure F.11. for the fish, Measures F.15. – F.18. and F.29.1 and F.29.2 for the amphibians and reptiles. General Measure P.7. is also usually prescribed for amphibians.

Where amphibians and reptiles are concerned, it is important that the measures aimed at conserving the favourable microhabitat conditions (i.e. **preservation of pools/ponds and other small water surfaces at the site, use of the existing access routes, formation of a mild-sloped watercourse bank**) are implemented appropriately depending on the specific species to which they refer.

← FIGURE 8.5 *An example of the implementation of Measure F.29.2.: Jasenova canal – the mild-sloped canal bank and the aquatic and wetland vegetation inside the canal have been preserved*
(Source: Hyla Association)

↗ FIGURE 8.6 *An example of the implementation of Measure F.18. along the Sirotići torrential stream: photo to the left: selective mowing and clearing with strips left intact; photo to the right: in one section of the watercourse, riparian vegetation, which provides shade, and aquatic vegetation and branches in the bed, which help conserve the microhabitats where amphibians spawn, have been preserved*
(Source: Hyla Association)

BIRDS

With regard to birds, specific conservation measures are prescribed for the purpose of conserving the favourable aquatic ecosystem habitat conditions for strictly protected bird species, as well as for the purpose of preventing the disturbance, injury or dying of individuals in the nesting season. The relevant measures include: Measures C.5. and P.9. (in connection with most birds), B.6. (in connection with the common kingfisher), C.6. (in connection with the corncrake) and F.12. (in connection with the European roller). Most of the works are also subject to Measure F.7.

MEASURE F.7.

If colonies (clusters of active nests) of strictly protected bird species (e.g. sand martins, bee-eaters, and others) are found at a particular worksite, the works must be discontinued and a quiet, undisturbed zone extending within the radius of 250 m upstream and downstream of the site must be secured until the end of the nesting season. In that case, it is also required to notify the competent public institutions for the management of protected areas and ecological network sites, the nature protection inspection and the Ministry, and all further actions should be taken in agreement with those institutions.

With the aim of preventing disturbance during the nesting season of the white-tailed eagle, the obligation to ensure a complete movement restriction within the radius of 500 m from the eagle's nest in the period from 1 January until 15 July must be rigorously enforced. In the quiet zone, works can be carried out only outside the nesting season and they must be carried out in a way that does not result in deterioration of habitat conditions within the radius of 100 m upstream and downstream of the bird colony, and the radius of 200 m from the nest of the white-tailed eagle.

FIGURE 8.7

↖ **up left:** *the white-tailed eagle (Haliaeetus albicilla)*
(Author: Ksenija Hocenski);

↗ **up right:** *the common kingfisher (Alcedo atthis)*
(Author: Matej Kopecki);

← **down:** *a colony of sand martins (Riparia riparia) on a steep eroded river bank*
(Source: Shkumbin Saneja, Creative Commons License 2008)

MAMMALS – BEAVERS AND OTTERS

With regard to mammals, specific conservation measures are prescribed for the purpose of conserving the favourable aquatic ecosystem habitat conditions for beavers and otters, as well as for the purpose of preventing disturbance, injury or dying of individuals (Measures F.5. and F.6.).

MEASURE F.5.

If an active lodge or dam built by a beaver is found, the works must be discontinued within the area that extends 200 m upstream and downstream of the lodge/barrier.

If an activity which is not allowed to be carried out at sites where strictly protected species are found (e.g. deliberate disturbance, activities by which the breeding or resting areas are deliberately damaged or destroyed) must be performed in order to continue the works, a permission from the competent authority for nature protection must be obtained and complied with.

Heavy mechanical equipment may not be used in the vicinity of an actively used lodge, and only small groups of workers are allowed to pass near it.

MEASURE F.6.

If an actively used otter's holt is found, the works must be discontinued within the area that extends 100 m upstream and downstream of the holt.

If an activity which is not allowed to be carried out at sites where strictly protected species are found (e.g. deliberate disturbance, activities by which the breeding or resting areas are deliberately damaged or destroyed) must be performed in order to continue the works, a permission from the competent authority for nature protection must be obtained and complied with.

Heavy mechanical equipment may not be used in the vicinity of an actively used den, and only small groups of workers are allowed to pass near it.

OTTER

↑ FIGURE 8.8 *An otter's paw print*
(Author: Vedran Slijepčević)

↑ FIGURE 8.9 *Entrance into an otter's holt*
(Source: Oikon Ltd.)

↑ FIGURE 8.10 *Entrance into an otter's holt*
(Source: Oikon Ltd.)

↑ FIGURE 8.11 *An otter's droppings (spraint)*
(Source: Oikon Ltd.)

recognising the signs of presence in the habitat

BEAVER

↑ FIGURE 8.12 *A dam built by a beaver*
(Author: Vedran Slijepčević)

↑ FIGURE 8.13
An illustration of a beaver's paw printe
(Author: Matej Kopecki)

↑ FIGURE 8.14 *A beaver's lodge (mound)*
(Source: Oikon Ltd.)

↑ FIGURE 8.15 *A beaver's droppings*
(Source: Oikon Ltd.)

↑ FIGURE 8.16
Evidence of a beaver's activity on a tree
(Source: Oikon Ltd.)

INVASIVE ALIEN SPECIES

https://invazivnevrste.hr

MEASURE F.12.1*

Alien species must be actively removed.

The list and information about the distribution of invasive alien species (IAS) is available on: https://invazivnevrste.hr/.

Invasive alien species, including:

- common milkweed (*Asclepias syriaca*),
- IAS from the genus Impatiens: Himalayan balsam (*Impatiens glandulifera*), Balfour's touch-me-not (*I. balfourii* Hooker f.), small balsam (*I. parviflora* DC.),
- velvetleaf (*Abutilon theophrasti* Medik),
- IAS from the genus Amaranthus: common tumbleweed (*Amaranthus albus* L.), low amaranth (*A. deflexus L.*), green amaranth (*A. hybridus* L.), red-rooted amaranth (A. *retroflexus L.),*
- common ragweed (*Ambrosia artemisiifolia* L.),
- Chinese mugwort (*Artemisia verlotiorum* Lamotte),
- devil's beggarticks (*Bidens frondosa* L.),
- paper-milberry (*Broussonetia papyrifera* (L.) Vent.),
- butterfly-bush (*Buddleja davidii* Franch.),
- rounded chamomile (*Chamomilla suaveolens* (Pursh) Rydb.),
- Mexican tea (*Chenopodium ambrosioides* L.),
- IAS from the genus Conyza: Canadian fleabane (*Conyza canadensis* (L.) Cronquist), tall fleabane (*C. sumatrensis* (Retz.) E.Walker),
- field dodder (*Cuscuta campestris Yuncker*),
- thorn apple (*Datura stramonium L.*),
- wild cucumber (*Echinocystis lobata* (Michx.) Torr. et Gray),
- Indian goosegrass (*Eleusine indica* (L.) Gaertn.),
- fringed willow-herb (*Epilobium ciliatum* Raf.),
- annual fleabane (*Erigeron annuus* (L.) Pers.),
- IAS from the genus Euphorbia: spotted sandmat (*Euphorbia maculata* L.), prostrate sandmat (E. *prostrata Aiton*),

- IAS from the genus Galinsoga: common quickweed (*Galinsoga ciliata (Raf.) S.F.Blake*), lesser quickweed (*G. parviflora Cav.*),
- Jerusalem artichoke (*Helianthus tuberosus* L.),
- path rush (Juncus *tenuis Willd.*),
- Virginia pepperweed (*Lepidium virginicum* L.),
- common evening-primrose (*Oenothera biennis* L.),
- witchgrass (*Panicum capillare* L.),
- fall panicgrass (*Panicum dichotomiflorum* Michx.),
- Virginia creeper (*Parthenocissus quinquefolia* (L.) Planchon),
- American pokeweed (*Phytolacca americana* L.),
- cutleaf coneflower (*Rudbeckia laciniata* L.),
- IAS from the Solidago genus: Canadian goldenrod (*Solidago canadensis* L.), giant goldenrod (*S. gigantea* Aiton),
- Johnson grass (*Sorghum halepense* (L.) Pers.),
- bird's eye speedwell (*Veronica persica* Poir.),
- IAS from the genus Xanthium: spiny cocklebur (*Xanthium spinosum* L.) and common cocklebur (*X. strumarium* L. ssp. italicum (Moretti) D. Löve)

must be removed **by mowing** the invaded area during springtime, i.e. in the period from **15 May until 15 June**, and late summer, i.e. in the period from **15 August until 15 September.**

MEASURE F.12.2*

If the mechanical equipment used to perform works in the bed of a watercourse where invasive alien species have been identified (the list and distribution of invasive alien species are available on: https://invazivnevrste.hr/)**) is to be relocated and used on other watercourses or sections of the same watercourse where such invasive alien species have not been identified, the following precautionary measures should be taken:

1. the equipment used in the execution of maintenance works must be cleaned from silt and vegetation,
2. the machines and other equipment must be checked in order to determine whether there are any animals and/or vegetation (shellfish, snails, etc.) left and, if there are, they must be removed,
3. the equipment must be kept in a dry location for at least four weeks before being transported to some other watercourse (if this is not possible, the

* Measures prescribed with regard to specific sites where deemed necessary.

contaminated equipment must be thoroughly washed using hot pressurized steam),

4. the equipment used in such watercourses where presence of invasive alien decapods has been determined (e.g. the spiny-cheek crayfish (*Orconectes limosus*), the signal crayfish (*Pacifastacus leniusculus*), the marbled crayfish (*Procambarus fallax f. virginalis*)) must be thoroughly dried after use in order to prevent the spread of crayfish plague into other watercourses in which alien crustaceans are not present.

If alien and/or invasive alien species have been identified in a water body, work execution should be scheduled so that the planned activities are first performed on the furthest upstream section moving downstream to the furthest downstream section of the relevant water body in order to prevent upstream spreading.

The list of invasive alien freshwater species of invertebrates and aquatic plants (to which Measures F.12.1.* and F.12.2* refer), and their known distribution are provided in Annex 1 to this Field Handbook (see Annex 1). More information is available via the invasive alien species portal (https://invazivnevrste.hr).

Measures B.1. – B.4. and Measures P.1. - P.3., which are generally prescribed in connection with mowing and cutting of brush, **do not refer to the mowing and clearing of stands of** the common ragweed (*Ambrosia artemisiifolia*), japanese knotweed (*Reynoutria* spp.) or false indigo bushes (*Amorpha fruticosa*), or the stands of other invasive alien species that must, if needed, be mown/cleared several times a year. After the mowing/clearing works are completed, the cuttings must be properly disposed of (Measure B.7.).

When selective cutting is undertaken, the areas covered with woody invasive alien species (e.g. false indigo, *Amorpha fruticosa*) are exempt from the implementation of conservation measures and may be removed, if necessary, several times a year, provided they are properly disposed of (Measure C.9.).

If invasive alien plant species are identified while monitoring the progress of revegetation after the execution of maintenance works, including repair and renovation of existing water structures, such plants should be actively removed (and properly disposed of) until reestablishment of the natural woody vegetation (Measure E.5.).

Invasive alien plant species frequently found along watercourse banks, in the floodplains and/or in the transitional zones extending towards agricultural areas: **false indigo** (*Amorpha fruticosa*), **knotweeds** (*Reynoutria japonica, R. sachalinensis*, *R. x bohemica*), **goldenrods** (giant goldenrod (*Solidago gigantean*) and Canadian goldenrod (*S. canadensis*)), **common milkweed** (*Asclepias syriaca*), **ash-leaved maple** (*Acer negundo*), **common ragweed** (*Ambrosia artemisiifolia*), **wild cucumber** (*Echinocystis lobata*), **annual fleabane** (*Erigeron annus*), **Jerusalem artichoke** (*Helianthus tuberosus*), **Himalayan balsam** (*Impatiens glandulifera*), American pokeweed (*Phytolacca americana*), **cutleaf coneflower** (*Rudbeckia laciniata*), and **spiny cocklebur** (*Xanthium spinosum*).

Important invasive alien aquatic plants that frequently form thick clusters in the water: **Canadian waterweed** (*Elodea canadensis*), **floating primrose-willow** (*Ludwigia peploides*), **Nuttall's waterweed** (*Elodea nuttallii*), **Brazilian waterweed** (*Egeria densa*), and **water lettuce** (*Pistia stratiotes*).

Important invasive alien species of invertebrates that can be relatively easily noticed macroscopically: **spiny-cheek crayfish** (*Orconectes limosus*), **marbled crayfish** (*Procambarus virginalis*), **signal crayfish** (*Pacifastacus leniusculus*), **zebra mussel** (*Dreissena polymorpha*), **Asian freshwater clam** (*Corbicula fluminea*), and **Chinese pond mussel** (*Sinanodonta woodiana*).

Other **invasive alien invertebrates**, i.e. species from the following orders: Amphipoda (*Echinogammarus ischnus, Dikerogammarus villosus, Dikerogammarus bispinosus, Dikerogammarus haemobaphes, Chelicorophium curvispinum*), Mysidacea (*Hemimysis anomala, Katamysis warpachowskyi, Limnomysis benedeni*), and Isopoda (*Jaera istri*).

Important invasive alien fish species, i.e. the invasive Ponto-Caspian gobies: **monkey goby** (*Neogobius fluviatilis*), **round goby** (*Neogobius melanostomus*), (big-head) **Kessler's goby** (*Ponticola kessleri*), and **racer goby** (*Babka gymnotrachelus*). In Croatia, these species are spreading upstream along large lowland rivers belonging to the Danube River Basin.

ADVICE

More information about the invasive alien species, their characteristics and distribution is available via the **invasive alien species portal** in Croatia:

https://invazivne vrste.hr.

In 2020, the Ministry of Economy and Sustainable Development introduced a system for reporting new invasive alien species via a mobile application, i.e. **Invazivne vrste u Hrvatskoj** (Invasive Species in Croatia), which is available for IOS and Android devices, and can be downloaded for free from *App Store* and *Google Play*.

If possible, the invasive plant species should be removed from the worksite before commencing work.

Considering that different invasive alien plant species have different ecological and biological needs, successful removal must be ensured by implementing the methods deemed suitable taking into account the specific needs of each individual species (see Annex 2).

MOBILE APPLICATION

Invazivne vrste u Hrvatskoj (Invasive species in Croatia)

Google Play

App Store

PORTAL

https://invazivnevrste.hr

False indigo is a deciduous shrub that grows from 1 to 2 m in height. It has odd-pinnate feather-like leaves with 5 to 12 (sometimes up to 17) pairs of ovate to elliptical leaflets. **The flowers are clustered into long, dark purple inflorescences. The fruit is a short (6 – 9 mm) bean.** Besides through seeds, it can quickly spread vegetatively through suckers.

FIGURE 8.17 *The false indigo (indigo bush, Amorpha, false indigo bush, bastard indigo (Amorpha fruticosa):*↖ up left *the inflorescence and leaves,* ↗ up righ *a stand (Source: Oikon Ltd.)*

Bohemian knotweed is a perennial herbaceous plant that usually grows up to 3 (5) m in height. The stem can be up to several centimetres thick and it is hollow with visible nodes, dark red at the beginning, later turning blue-green. It is an alternate-leaved plant with large, ovate-triangular leaves on short stalks. **The creamy-white flowers form a large loose and branched cluster** (the so-called "panicle"). The Bohemian knotweed is a fertile hybrid offspring of two other alien species from the genus Reynoutria (namely, the Japanese knotweed, *R. japonicus* and the giant knotweed, *R. sachalinensis*).

FIGURE 8.18 *The Bohemian knotweed (lat. Reynoutria x bohemica)::* ↖ up left *a stand,* ↗up right *leaves (Source: Oikon Ltd.)*

INVASIVE ALIEN SPECIES

recognising the most frequently encountered terrestrial invasive alien plants

ASH-LEAVED MAPLE | COMMON MILKWEED

ASH-LEAVED MAPLE is a deciduous tree. It is an opposite-leaved plant with odd-pinnate feather-like leaves composed of 3 to 5 (9) ovate or elliptical-lanceolate leaflets with entire or irregularly toothed margins. **The terminal leaflet sometimes has three lobes.** The female flowers are located in long, hanging clusters from which fin-winged fruits, similar to those of our native maple trees, develop. The plant blooms before leafing.

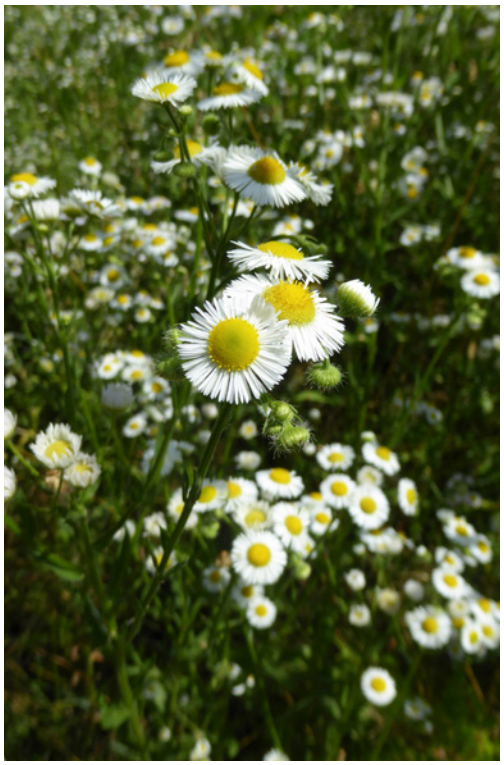
↑ FIGURE 8.19 *The ash-leaved maple (boxelder maple, lat. Acer negundo)*
(Source: Oikon d. o. o.)

↑ FIGURE 8.20 *The common milkweed (Asclepias syriaca)*
(Source: Oikon d. o. o.)

Common milkweed is a perennial herbaceous plant that grows from 1 to 2 m in height. It has an upright, hollow stem. **It is an opposite-leaved plant with approx. 20 cm long, ovate-oblong leaves with entire edges,** and a short stalk. The flowers are small, clustered in umbels, and have a strong, sweet smell. In early autumn, it develops ripe elongated, silver-grey, **bubble-like fruits covered with spiny and warty hairs** containing **numerous seed pods distinguished by their long, thin silky hairs.** All parts of the plant contain sap.

Wild cucumber is an annual climber plant with branched bines that grows from 5 to 8 m in height. Its leaves are approx. 5 cm long and lobed almost up to the mid-point. They have serrate (saw-like) margins, and grow on long stalks. Stamens are located in terminal umbels, while pistils are separate. All flowers are greenish-white. The plant is recognisable **by its ovate (egg-shaped) fruits, from 3 to 5 cm in size, covered with long, thin prickles.**

↑ FIGURE 8.21 *The wild cucumber (Echinocystis lobata)*
(Source: Oikon Ltd.)



↑ FIGURE 8.22 *The annual fleabane (Erigeron anuus)*
(Source: Oikon Ltd.)

Annual fleabane is a herbaceous plant that grows approx. 30 cm in height (up to 150 cm). The stem supports the leaves, and at its tip, where it supports inflorescences, it is branched. **The flowers form heads with radially arranged tongue-shaped white or light-blue flowers, while the tube-shaped flowers growing in the middle are yellow.**

Devil's beggarticks is an annual plant that grows from 10 to 100 cm in height. The stem supports the plant's oppositely arranged leaves. The leaves have stalks and a feather-like structure, with a larger terminal leaflet on an elongated stalk. **The flowers form yellow heads** up to 2 cm in size. Its fruit is a cypsela which may be 5 to 8 mm long with two distinctive "hook barbs" that serve to accommodate the spreader. It is similar to the three-lobed beggarticks (*Bidens tripartita*) that has leaves with a terminal leaflet without an elongated stalk.

↑ FIGURE 8.23
The devil's beggarticks (Bidens frondosa)
(Source: Oikon Ltd.)

↑ FIGURE 8.24
Giant goldenrod (Solidago gigantea)
(Source: Oikon Ltd.)

Giant goldenrod is a perennial plant that grows from 0.5 to 2.5 m in height. It has lanceolate and toothed leaves that diminish in size towards the tip of the stem. **The flowers grow from yellow heads arrayed in a pyramidal inflorescence** of protruding sprigs. The species *Solidago gigantea* is similar to *Solidago canadensis*, another invasive alien species (the Canadian goldenrod). They differ in that the Canadian goldenrod has a hairy stem (the upper part, mainly) and less toothed leaves (with almost entire margins).

Himalayan balsam is a large and strong annual plant that usually grows from 1 to 2 m in height. It may have oppositely-arranged leaves or by 3 in a whorl. The leaves are either lancelolate or elliptical, long (up to 18 cm), with a serrate (saw-like) margins. **The flowers are irregular, large (up to 4 cm), pink, sometimes white, clustered in racemose inflorescences** located in the axillary buds of the leaves. The fruit is a smooth surface capsule of 1.5 to 3 cm in length.

← FIGURE 8.25 *The Himalayan balsam (Impatiens glandulifera) (Source: Oikon Ltd.)*

← FIGURE 8.26 *The American pokeweed (Phytolacca americana) (Source: Oikon Ltd.)*

American pokeweed is a perennial herbaceous plant that grows from 1 to 2 m in height. It has large leaves with entire margins and short stalks. The flowers are small and unsightly. Numerous small flowers are clustered in **racemose inflorescences. Its fruits are round juicy berries, which are green at first, then turn dark red, and finally black, grouped in attractive hanging clusters.**

Jerusalem artichoke is a perennial plant that grows up to 2 m in height, it is related and similar to the sunflower, and has an edible tuber. It has an upright stem, which is branched in its upper part. The leaves are ovate-oblong with serrate (saw-like) margins. **The flowers form separate, upright yellow heads (4-8 cm in width) at the ends of the sprigs.** The plant blooms late, in the period from September to November. For that reason it often fails to develop inflorescences in cold regions.

← FIGURE 8.27 *The Jerusalem artichoke (Helianthus tuberosus) (Source: Oikon Ltd.)*

INVASIVE ALIEN SPECIES

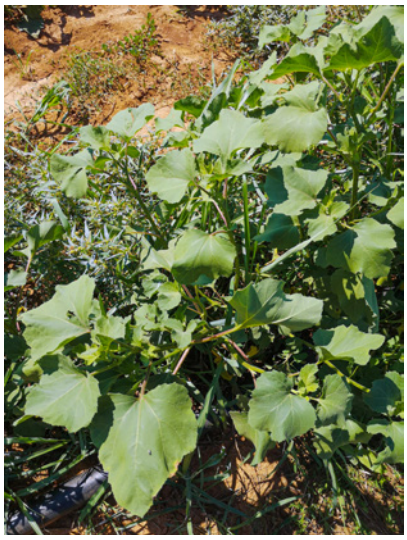
recognising the most frequently encountered terrestrial invasive alien plants

CUTLEAF CONEFLOWER

COMMON COCKLEBUR

Cutleaf coneflower is a perennial that may be up to 3 m tall. **The lower leaves are bipinnate and have stalks**; the middle leaves have 2 – 3 deeply cut in lobes; the upper leaves are sessile, simple, ovate, and have no stalks (petiole); leaf edges are entire or roughly toothed. **The inflorescence is a big head (up to approx. 6 cm in size) growing on a long stem, and the outer flowers (petals), which develop on the head, are yellow and very quickly bend backwards.** The inner flowers are yellow-green.

← FIGURE 8.28 *The cutleaf coneflower (Rudbeckia laciniata)*
(Source: Oikon Ltd.)

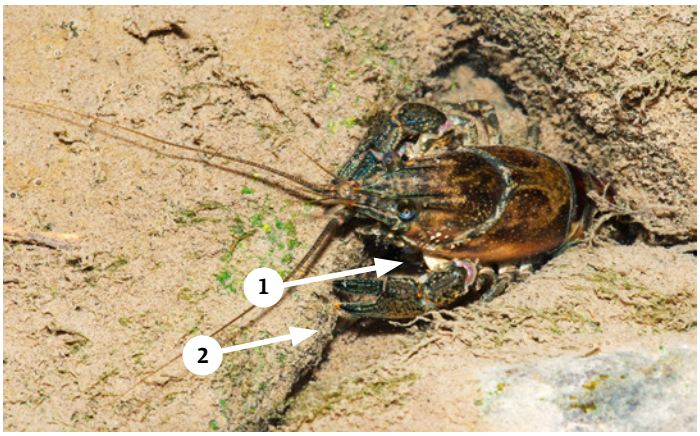


↑ FIGURE 8.29
The common cocklebur (Xanthium strumarium ssp. *italicum)*
(Source: Oikon Ltd.)

The common cocklebur is an annual, usually branched herbaceous, opposite-leaved plant that grows from 20 to 120 cm in height, and looks like a bush. **The stem and branches are usually marked by purple or brownish stripes or dots.** The leaves grow on a long stalk (up to 15 cm), the blade has a broad ovate-triangular shape and a lobed base. The leaves have either entire margins or 3 to 5 wide lobes. The flowers are borne in heads that develop in big clusters, sometimes in terminal inflorescences without leaves. **The fruit is covered with strong, hook-like spines with two stout "beaks" on its tip.** The fruit is an ovate bur with no pappus. The plant is aromatic. It resembles its typical subspecies (*X. strumarium* L. ssp. *strumarium*), which is not an aromatic plant, has a green stem and branches, and its leaves are heart-shaped at the base, while the beaks on the fruit are flat.

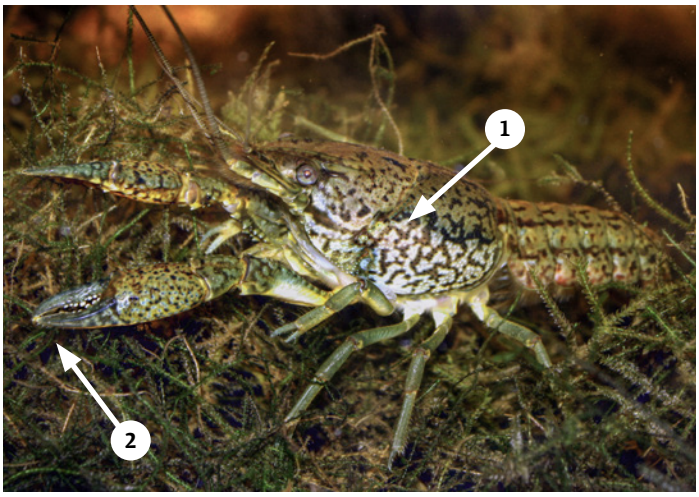
DECAPODS

SPINY-CHEEK CRAYFISH is a freshwater decapod with an elongated body that may reach up to 12 cm in length. It is specific in that it has dark-red bands on its abdominal segments (rump or "tail"). It has about ten up to 1 mm long prominent spines on each side of its carapace (cheeks) (1). The claws are relatively small, and their tips are orange with black bands (2).



← FIGURE 8.30
The spiny-cheek crayfish (Faxonius limosus, former Orconectes limosus)
(Source: Magnus Hagdorn, Creative Commons License 2014)

MARBLED CRAYFISH is a freshwater decapod with an elongated body that may reach up to 10 cm in length. It has a special marble colour pattern on its body (1). Its claws are relatively small in relation to the body, and have the same colour. Its movable part of claws is somewhat longer than its fixed part (2).



← FIGURE 8.31
The marbled crayfish (Procambarus virginalis, former Procambarus fallax f. virginalis)
(Source: Chucholl C., Creative Commons License 2012)

INVASIVE ALIEN SPECIES

recognising the most frequently encountered freshwater macroscopic invasive alien invertebrates

SIGNAL CRAYFISH

BLUE CRAB

SIGNAL CRAYFISH is a freshwater decapod with an elongated body that may reach up to 16 cm in length. A pearly-white coloured patch at the base of each claw joint is distinctive to the species (1). The shell (exoskeleton) of the upper part of the body and the claws are relatively smooth. The lower part of the claws is intensive red.

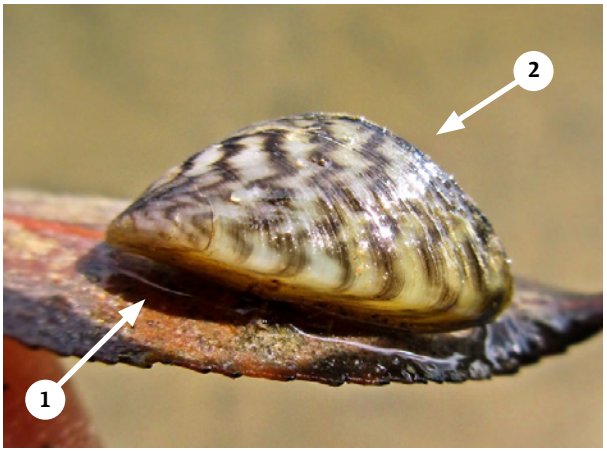
← FIGURE 8.32
The signal crayfish (Pacifastacus leniusculus)
(Author: Matej Faller)

BLUE CRAB is a marine species that chooses brackish waters to spawn. The width of its shell (exoskeleton), reaching approx. 20 cm in adult specimens, is double in size in relation to its length (7 to 9 cm in adult species). It is recognisable by its olive-coloured shell (exoskeleton) and blue legs and claws (1). Its fifth leg is shaped as an oar, its claws are not robust, and its shell is thin and light.

← FIGURE 8.33
The blue crab (Callinectes sapidus)
(Source: LoriLee, The Children's Museum of Indianapolis, Creative Commons License 2011)

MOLLUSCS

ZEBRA MUSSEL is a freshwater shellfish of 1 to 5 cm in size. It has a triangular shell with a flat ventral surface (1) and a sharp dorsal surface (2). It has a recognisable striped pattern on its shell (hence the name: "zebra mussel"). It secretes a byssus (a bundle of filaments) which it uses to attach itself to the surface where it usually grows in thick clusters.



← FIGURE 8.34
The zebra mussel (Dreissena polymorpha)
(Source: Bj.schoenmakers, Creative Commons License 2016)

ASIAN FRESHWATER CLAM is a small freshwater clam. It has an inflated shell, slightly round to triangular in shape. It can be recognised by conspicuous concentric ridges on its shell (growth layer zones) (1). The shell is usually pale brown or yellowish brown, olive-coloured, and may even be black. It can grow from 5 to 6.5 cm in size, although the usual size of its shell is less than 2.5 cm.

← FIGURE 8.35
The Asian freshwater clam (Corbicula fluminea)
(Source: Björn S., Creative Commons License 2018)

INVASIVE ALIEN SPECIES

recognising the most frequently encountered freshwater macroscopic invasive alien invertebrates

CHINESE POND MUSSEL

CHINESE POND MUSSEL is the largest representative of the family Unionidae. It is usually 12 to 20 cm long, but can also reach 30 cm in size. It is bigger than any of our native freshwater mussels. It has two symmetrical shells with a smooth or rough surface, depending on the habitat in which it grows.

↑ FIGURE 8.36
The chinese pond mussel (Sinanodonta woodiana)
(Source: Albarubescens, Creative Commons License 2019)

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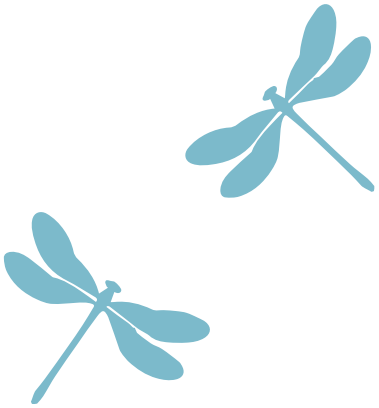


Annexes

1 Freshwater Invasive Alien Invertebrate and Aquatic Plant Species Present in Croatia

TAXONOMIC GROUP	SPECIES	KNOWN DISTRIBUTION IN CROATIA
Invertebrates (decapods)	The spiny-cheek crayfish (*Orconectes limosus= Faxonius limosus*) The marbled crayfish (*Procambarus virginalis*) The signal crayfish (*Pacifastacus leniusculus*)	Mura, Korana, Radonja, Bednja, Plitvica and Drava rivers (almost the entire watercourse) and downstream sections of their tributaries, canals, reservoirs and gravel pits; the Vuka, Karašica and Dunube rivers, the Kopački rit area, the Šoderica Lake (near Koprivnica, only the marbled crayfish)
	The blue crab (*Callinectes sapidus*)	Neretva River delta, surroundings of Split and Trogir, Krk Island, Vransko Lake near Biograd
Invertebrates (molluscs, shellfish)	The zebra mussel (*Dreissena polymorpha*)	he entire course of the Danube and Sava rivers and its small tributaries, the entire course of the Drava River and the associated reservoirs, gravel pits, tributaries and derivation canals; Mura River, Lake Jarun in Zagreb, Dobra River, Lešće Reservoir, Bukovnik and Sabljaci Reservoirs
	The Asian freshwater clam (*Corbicula fluminea*)	The entire course of the Danube River and its small tributaries, the entire course of the Sava River and its small tributaries and lakes, the entire course of the Kupa, Una and Glina rivers and their tributaries, the entire course of the Drava River and the associated reservoirs, gravel pits and tributaries (Karašica, Vučica, Županijski kanal rivers), Savica Lake in Zagreb, Tribalj Reservoir, Lika River and Krušćica Reservoir, Butoniga Reservoir
	The Chinese pond mussel (*Sinanodonta woodiana*)	Danube River and its small tributaries, Sava River and its small tributaries and lakes, Drava River and the associated reservoirs and tributaries, Draganići River and Konopljište Fishpond, Ilova River, Vransko Lake near Biograd, Karašica, Spačva, Vuka, Vučica, Mrsunja, Londža, Županijski kanal, Orljava, Česma, Pakra and Tolica (Daruvar) rivers, Voćin-Drava canal, Kopački rit, Lapovac Lake (Našice), Vidrenjak Lake, Bajer Fishpond (Novi Marof), Borza River (Topolje), Bistra Spring (Kaptol), Mali Strug canal (Gornji Varoš), and Tribalj Reservoir

TAXONOMIC GROUP	SPECIES	KNOWN DISTRIBUTION IN CROATIA
Invertebrates (molluscs, gastropods)	The New Zealand mudsnail (*Potamopyrgus antipodarium*)	The entire course of the Drava River, reservoirs on the Drava River, Bednja River, the course of the Mirna River, including the Boljunčica and Pazinski potok streams, Butoniga Reservoir, Arđile stream, Raša River, Rečina River, Dragonja River
	Physella acuta	Raša River, Dubračina Stream, Njivice Reservoir, Muškovci Reservoir, Zrmanja River, Ličanka Stream, Bajer Reservoir, Lepenica River, Omladinsko jezero Lake, Lokvarka Stream, Lika River, Štikada Lake, Ričica Stream, Prološko Blato, Ričice Reservoir, Cetina River, Peruča Reservoir, Visovac Lake, Brljansko Lake, Kozjak Laka, Prošćansko Lake, Drava River with its tributaries and reservoirs, Sava River with its tributaries, Bednja River, Plitvica River, Lepenica Reservoir, Krapina River
Invertebrates (Amphipoda –crustaceans)	*Echinogammarus ischnus*	Drava River downstream from Terezino polje, Danube River (Batina, Borovo, Ilok)
	Dikerogammarus villosus	Drava River with the associated canals, tributaries and reservoirs; Danube River and its small tributaries, Sava River (entire course in Croatia),Odra River, Sutla River
Invertebrates (Mysidacea)	*Hemimysis anomala*	Drava River, Danube River and its small tributaries
Invertebrates (Amphipoda – crustaceans)	*Dikerogammarus bispinosus* *Obesogammarus obesus*	Danube River and its small tributaries
Invertebrates (Isopoda)	*Jaera istri*	Sava River downstream from the Una River estuary, Drava River and Karašica River, Danube River and its small tributaries
Invertebrates (Mysidacea))	*Katamysis warpachowskyi*	Danube River and its small tributarie
	Lmnomysis benedeni	Županijski kanal River, Drava River estuary, Danube River and its small tributaries
Invertebrates Amphipoda – crustaceans)	*Dikerogammarus haemobaphes*	Danube River and its small tributaries, Sava River downstream from Bobovac
Invertebrates Amphipoda – crustaceans)	*Chelicoropihnum curvispinum*	Drava River with its tributaries and the Šoderica gravel pit, Mura River and its tributaries, Danube River and its small tributaries, Sava River and Una River

TAXONOMIC GROUP	SPECIES	KNOWN DISTRIBUTION IN CROATIA
Aquatic plants	The broadleaf watermil (*Myriophyllum heterophyllum*)	The records so far refer only to the Neretva River Delta (Desne Lake, Bijeli vir), with only one mention in literature of its presence on the Krk Island
	The Canadian pondweed (*Elodea canadensis*))	Sava, Mura, Drava, Lonja and Odra rivers and small standing and running waters of Northern and Eastern Croatia
	Nuttall's waterweed (*Elodea nuttallii*)	So far, the presence of this species has been recorded in several location in Continental Croatia, the Drava and Danube regions, Kopački rit, Drava River near Varaždin and Čakovec, the surroundings of Virovitica
	The floating primrose-willow (*Ludwigia peploides*)	Three locations in Central Croatia have been identified: one sighting in the Ilova River and two in the Česma River (Obedišće and Sišćani)
	The Brazilian waterweed (*Egeria densa*)	So far, the species has only been recorded in the Neretva River Delta (Modro oko, Bijeli vir, Metković)
	The water lettuce (*Pistia stratiotes*)	So far, the presence of this species has only been confirmed in lakes within the Sava – Strmec Special Ornithological Reserve (the surroundings of Zagreb)

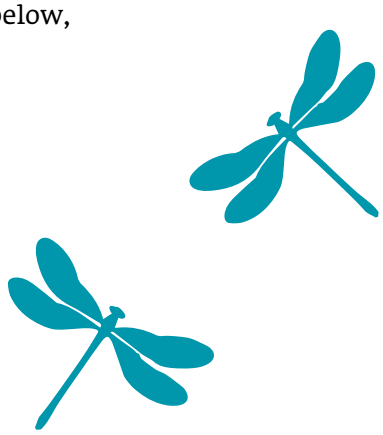
2 Recommended Methods for Removing the Most Frequently Encountered Invasive Alien Plant Species in Croatia

Most invasive alien plant species should be removed before they start producing fruit (seeds). All invasive alien species can be mown or cleared several times a year. It is, however, recommended that most of such plant species be mown at least two times a year, i.e. in spring and in autumn, in accordance with the time frames defined by Measure F.12.1.*.

In addition to removing invasive alien plant species by mowing or clearing, the relevant conservation measures also include the requirement of "proper disposal". This means that the biomass left after mowing/cutting or clearing, which contains invasive alien plant cuttings, should be removed from the site and transported on a tarpaulin or in thick plastic bags to a suitable landfill or composting area. The vegetative parts of the plants and those that have not yet flowered may be composted on site, i.e. they may be left to dry in the air or covered. However, if the species which is being removed reproduces vegetatively, the collected biomass must be placed on a tarpaulin, or some other impermeable base material, so that it does not touch the ground. Before leaving the site, the mechanical equipment must be thoroughly cleaned, i.e. there may not be any soil left on it which could contain seeds and parts of the removed plants. If possible, all remaining dirt should be washed out.

Considering that the fruits and vegetative parts of some species may be spread by water, it should be envisaged that the mown or cleared biomass be disposed of as far away from the watercourse and the floodplain as possible.

An overview of invasive alien plant species that are most frequently found alongside watercourses, in the floodplains and/or in the transitional zone, which extends towards the agricultural areas, is provided below, along with the recommended methods of removal.



The **false indigo bush** (***Amorpha fruticosa***) should be removed **mechanically** (**by cutting**) before the fruit (seed) development phase (i.e. **before 1 August**). Once removed, the parts that have been cut or pulled out must be disposed of safely (i.e. in a location where it can be ensured that the vegetative parts of the plant are physically separated from the soil and removed outside the floodplain) considering that the uprooted plants are still able to reproduce vegetatively for some time and, if disposed of in the vicinity of a watercourse, they may be transported downstream where new populations may consequently be established.

Although one-time removal is not sufficient to completely eradicate this species, considering that it can grow from the remaining underground parts, repeated localised removal efforts may eventually lead to permanent removal.

Where applicable, it is also recommended, after removing this invasive plant and disposing of the resulting biomass, that the affected area be grazed by animals in order to maintain it and prevent reestablishment..

The spread of the **common cocklebur** (***Xanthium strumarium* ssp. *italicum*)** should be controlled by employing mechanical methods (mowing). More precisely, it should be mechanically removed before the fruit development phase.

The common milkweed (***Asclepias syriaca***) is mainly found in habitats along river embankments. The recommended control method is repeated cutting of aboveground parts before pollination. It can also be mown and uprooted.

Besides through a combination of mechanical and chemical methods, this species can also be effectively eradicated mechanically, i.e. by repeated mowing every 2 to 3 weeks during its vegetative season.

Considering its capacity for vegetative reproduction, the cuttings of the common milkweed must be disposed of safely, i.e. in a safe location, to prevent further spread by water and consequently the development of roots (propagation).

The recommended method for controlling the spread of the **ash-leaved maple** (***Acer negundo***) is to mow the seedlings and young plants before fruit (seed) development phase (i.e. before 15 August), or to cut mature trees.

One of the ways in which the species from the genus **Reynoutria** (***Reynoutria japonica, R. sachalinensis, R. x bohemica***) could be effectively removed is by cutting the thick clone stands of those species several times during the season in combination with the uprooting, i.e. pulling out the shoots immediately after cutting. To ensure eradication, this method would have to be implemented systematically over a period of several years.

Just as in the case of the **false indigo** (***Amorpha fruticosa***), small fragments of underground stems (rhizomes) left in the soil after the plant is pulled out present a problem in the efforts to control the spread of this species, as very soon such small parts can develop into new, vital plants. The knotweeds which reproduce in Europe primarily vegetatively present an even bigger problem in that regard. This is precisely why uprooting instead of mulching is recommended as the best control method for this species.

The resulting biomass must be disposed of properly, i.e. outside the floodplain, and it may not get into direct contact with the soil.

The spread of the **wild cucumber** (***Echinocystis lobata***) can be effectively controlled by employing mechanical methods over several consecutive seasons, while taking care that removal is undertaken before the plant starts developing fruit, as the seeds may be successfully transported by water.

Considering that the blooming period of this species lasts from June to October, the first mowing cycle should already be carried out in June, or even earlier (15 May – 15 June).

The spread of the **cutleaf coneflower (*Rudbeckia laciniata***) may be controlled employing the mechanical method of removing the plant's shoots from the ground. However, this method is effective only on small areas because it stimulates the germination of the achenes resting on the ground. In any case, removal must be performed repeatedly before the fruit development phase.

To control the spread of herbaceous plants: **the annual fleabane** (***Erigeron annuus***), **the devil's beggarticks** (***Bidens frondosa***), **the common ragweed** (***Ambrosia artemisiifolia***), **and the goldenrods** (***Solidago gigantea, Solidago canadensis***), care must be taken that they are regularly mown before the fruit development phase. The first mowing cycle should be carried out already in June or even earlier (in the period from 15 May until 15 June).

The Jerusalem artichoke (***Helianthus tuberosus***) can be effectively controlled if mown two times a year during summer for several years in a row. In addition to this method, it is also advisable to remove young plants in their early sprouting phases (by mulching).

This species spreads only through its vegetative propagule, i.e. the bulb, particularly when the water level is high and during floods. Therefore, when implementing control measures in relation to this species, it should be checked whether the bulb may have been left in the ground.

The Himalayan balsam (***Impatiens glandulifera***) spreads through seeds that are successfully distributed by flowing waters. It is therefore recommended that the spread of this species be controlled by mowing or other mechanical removal methods of specimens before the fruit development phase.

It blooms during July and August. It is therefore recommended that the first mowing or clearing cycle be undertaken before the blooming season.

The recommended method for controlling the spread of the **American pokeweed** (***Phytolacca Americana***) is uprooting, i.e. pulling out the plants from the ground together with their roots (mulching) consecutively during the period of 1 to 2 years.

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