Invasive plant control in habitats of Ormánság

Oak Protection

Hungary-Croatia
Cross-border Co-operation Programme

Interreg
European Regional Development Fund

EUROPEAN UNION





INVASIVE PLANT CONTROL IN HABITATS OF ORMÁNSÁG

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Methodological guide

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Oak Protection

Interreg
European Regional Development Fund
A cross-border region where rivers connect, not divide

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MECSEKERDŐ
természetes úton

HRVATSKE ŠUME

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1. INTRODUCTION

The rapid spread of invasive species is one of the most significant factors that threaten our biodiversity. Tis phenomenon is becoming more and more well-known to the present day: we see new plant and animal species appearing in the landscape that becoming dominant within a few years. In addition to endangering our natural values and causing economic problems, biological invasion also has serious human health consequences. Everybody knows the pollen allergy caused by North American common ragweed, which affects every fifth person in Hungary, but there are also toxic species and those that can cause severe skin irritation or even blindness. The economic damage caused by invasive species is also very significant. Control of invasive plant and animal species in the European Union – according to data from 2009 – is estimated at approx. EUR 12 billion, which is increasing year by year. It is worth mentioning that this amount does not include any loss of incomings and additional costs that may result from the appearance of an invasive species. Farmers feel these burdens on their own skin, for example, in the cost increase spent on nursing of young stands, in the inferior quality of hay harvested from a meadow infected with goldenrods, or in the destruction of horticultural crop caused by a non-native pest. All this shows that the problem caused by invasive species is far from being a "private matter" for nature conservation, and it can be said that it affects almost all sectors of agriculture.

In order to manage this problem successfully, it is essential to prevent the new introductions, to detect the newcomer species early and response rapidly to already introduced species to prevent their further spread. The importance of the problem has also been recognized by the European Union, and to address this problem entered into force on 1 January 2015 the "Regulation (EU) No 1143/2014 of the European Parliament and of the Council on the prevention and management of the introduction and spread of invasive alien species".

EU legislation on invasive species has made it necessary to harmonize several laws in Hungary as well. Nature Conservation, Hunting and Forest Laws have been amended, and a new government decree has been adopted to prevent or treat the introduction and spread of invasive alien species. These laws came into force on 1 January 2017.

Definitions used in the EU Regulation:

'biodiversity' means the variability among living organisms from all sources, including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystem;
'ecosystem services' means the direct and indirect contributions of ecosystems to human wellbeing;
'introduction' means the movement, as a consequence of human intervention, of a species outside its natural range;
'alien species' means any live specimen of a species, subspecies or lower taxon of animals, plants, fungi or micro- organisms introduced outside its natural range; it includes any part, gametes, seeds, eggs or propagules of such species, as well as any hybrids, varieties or breeds that might survive and subsequently reproduce;
'invasive alien species' means an alien species whose introduction or spread has been found to threaten or adversely impact upon biodiversity and related ecosystem services;
'invasive alien species of Union concern' means an invasive alien species whose adverse impact has been deemed such as to require concerted action at Union level pursuant to Article 4(3);
'invasive alien species of Member State concern' means an invasive alien species other than an invasive alien species of Union concern, for which a Member State considers on the basis of scientific evidence that the adverse impact of its release and spread, even where not fully ascertained, is of significance for its territory, or part of it, and requires action at the level of that Member State.

Nowadays, invasion biology has become a separate discipline that is constantly evolving. We have a constantly expanding knowledge for the spread, effects and control of invasive species. However, this knowledge is far from complete, and it is likely that it will never be due to the new, constantly appearing alien species. Anyway, we must strive to make the research, monitoring and surveillance activities as complete and effective as possible, which efforts are also supported by the European Union.

Among others, Mecsekerdő Forestry and Našice Forestry wanted to participate actively in the achievement of these latter objectives by establishing international cooperation with Oak Protection, supported by the European Union.
In our publication, we report on the results achieved in the implementation of the project on invasive plant control.

Drava, the river that connects, not divides (Photo: Márton Korda)

2. EXECUTIVE SUMMARY

Drava Plain is no exception to the damage caused by invasive plant species that threaten our natural heritage. Their presence and spread threaten the long-term conservation of most important natural values of the region, the wildlife of Illyrian oak-hornbeam forests (91L0), hardwood floodplain forests (91F0) and softwood floodplain forests (91E0) and various treeless habitats. Recognizing this, Mecsekerdő Zrt. and Našice Forestry decided to try solving the problem together. For this purpose, an international project called Oak protection has been created and its results on invasive species are summarized in this volume.

Nature conservation significance of the area affected by the project

The project area is mosaic and affects several distinctly different landscapes in the southern part of Southern Transdanubia (Fig. 1). Project activities were carried out on wetlands in the Drava, mesophilous habitats in Ormánság, and in meso- and xerophilous habitats the Villány Mountains. Five of the Natura 2000 sites designated under the Habitats Directive are affected by the project interventions and some of the natural areas protected by Hungarian legislation, such as a part of the Danube-Drava National Park, the nature conservation areas of Szársomlyó and Szentegát forest.

The diverse habitat characteristics provide living conditions for diverse wildlife. Habitats along the Drava are basically formed by excess water, so the seaweed and sludge vegetation of the river and oxbows, mesophilous grasslands, and soft- and hardwood floodplain forests are characteristic. In Ormánság, besides the mesophilous grasslands and forests, the Illyrian oak – hornbeam forests also appear. In the Natura 2000 areas of the Villány Mountains, among the forest habitats of Community interest the Illyrian oak-hornbeam forests cover the largest area, but there are also Illyrian beeches, Pannonian Turkey oak forests and Pannonian pubescent oak forests-steppe mosaics, and even forests of slopes and screes fragmentary. The extent of dry grasslands characteristic to the Pannonian region is also very significant.

The diverse habitat structure provides habitats for a number of plant and animal species of Com-

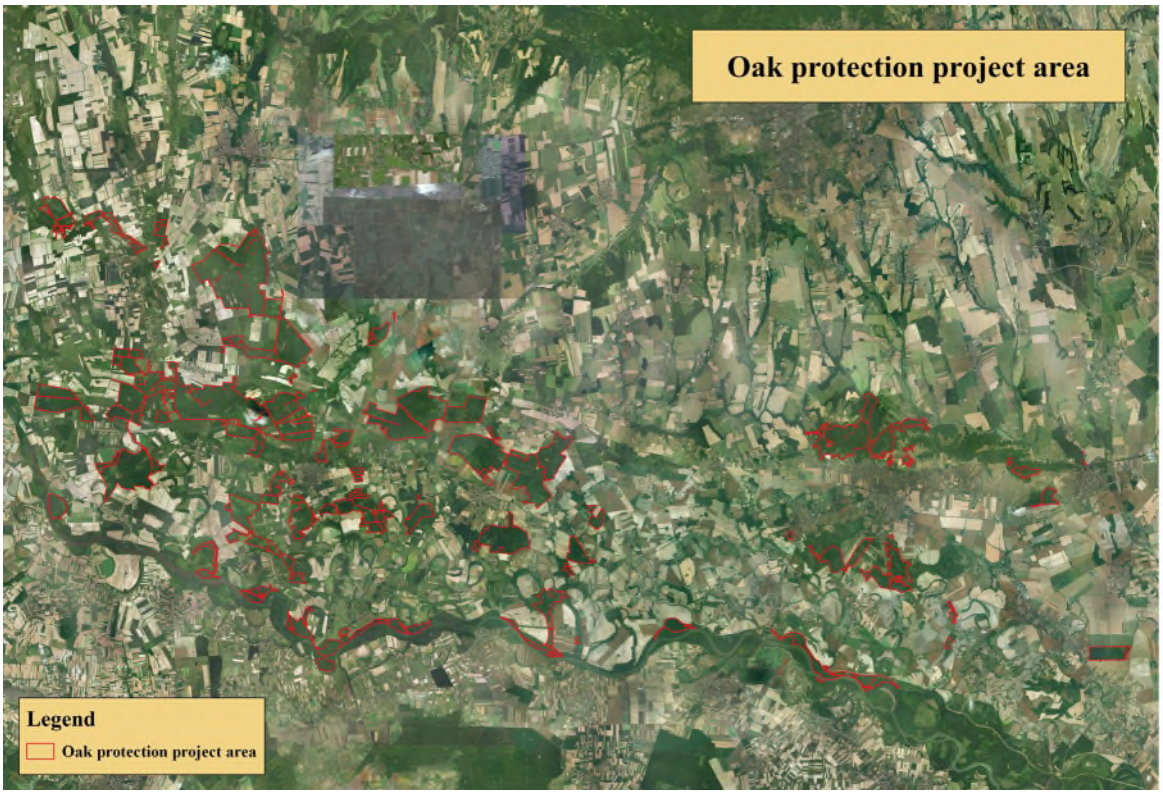

Figure 1. The Oak protection project area

munity interest. Among them, it is worth highlighting *Himantoglossum jankae*, *Pulsatilla grandis*, *Isophya costata* and *Bolbelasmus unicornis* living in dry grasslands and pubescent oak scrubs. Among the invertebrates of Community interest, *Cerambyx cerdo*, *Morimus funereus*, *Lucanus cervus* and *Euphydryas maturna* live in the forest habitats. In the mesophilous grasslands live the populations of *Lycaena dispar* and *Maculinea teleius*. Szársomlyó deserves special emphasis as a very important bat habitat, so it is not surprising that Natura 2000 species such as *Miniopterus schreibersii, Myotis blythii, Myotis dasycneme, Myotis myotis, Rhinolophus ferrumequinum, Rhinolophus hipposideros* live here. Also worth mentioning in connection with Szársomlyó the highly protected *Colchicum hungaricum* (Fig. 2) with its Mediterranean character and *Trigonella gladiata* and *Medicago orbicularis* respectively.

One of the comprehensive objectives of the project is the significant control of invasive plants causing problems in the area, and thus to protect the diverse natural values.

Figure 2. *Colchicum hungaricum* lives only in Szársomlyó in Hungary (Photo: Márton Korda)

The results of the invasive plant species detection and control

As a first step in the project activity related to invasive plant species, the occurrence of invasive species was detected on the Croatian and Hungarian side by the coordination of Mecsekerdő Zrt. During the survey, the coordinates of the areas infected with alien plant species were recorded by field GPS, photographic documentation was prepared and then displayed on the map using GIS software after being included in the database. The survey showed that the most problematic woody species in the area are the green ash, the tree of heaven, the box elder, the black locust, the honey locust and the false indigo. Among the herbaceous species, the presence of common milkweed, giant and Canadian goldenrods, wild cucumber, knotweed species, American pokeweed and annual fleabane were detected.

According to the survey, the biggest problem in the project area is caused by false indigo, which are present on 127.34 hectares. This is followed by tree of heaven with a presence of 22.57 ha, and finally the black locust with 5.26 hectares.

The aim of the project was to suppress these three woody species; this activity also covered external infection sources near the infected areas. Invasive plant control can only be successful if all seed producing individuals and infection centres are eliminated within the given area, across administrative and other boundaries. There are a number of other areas related to the project area, where owners or managers are unable to address the problem due to lack of resources or expertise. Therefore, with the support and approval of these managers, these areas got into the part of the project area for the long-term sustainability of the project results. Otherwise, uncontrolled invasive individuals would disperse their seeds and spread again in the area. The project was implemented in close cooperation with managers of external areas. As a result of all of these, the three species were eradicated at 155.17 ha.

It is important to emphasize that 65.1 ha of this area is such treeless habitat (e.g. clearing), which could serve as a potential habitat for *Lycaena dispar* and *Maculinea teleius* associated with mesophilous grasslands, but due to the invasion of false indigo, this role could not be filled. During the project, the false indigo control has begun in

these areas, which will result in the regeneration of grassland vegetation, which may lead to the return of the two Natura 2000 butterfly species in the long term.

In addition to eradication of invasive plants, the project also aims to develop an internationally applicable methodology to summarize the practical experiences in invasive plant control to expand the knowledge base. The planned methodology aims to present the possibilities of nature conservation treatments based on the experiences gathered in areas with different characteristics. It is important to emphasize this, because the selection of the given control technology is determined by the habitat characteristics. The effectiveness of the treatment can be significantly influenced by the duration of treatment, the way of execution, the circumstances and the current weather conditions. Details of these (baseline, methods used, chemicals, results, or even the negative experiences) are important to demonstrate with the aim of providing background support for researchers, conservationists and farmers dealing with invasive plant control day-to-day.

A further aim of the project is to develop new solutions in addition to the technologies used in the past, especially in the field of false indigo control. Experience gained from invasive plant control is presented in detailed in this volume.

Development of deadwood supply

Providing sufficient quantity and quality of deadwood and decaying trees are essential condition for the long-term conservation of *Cerambyx cerdo, Morimus funereus* and *Lucanus cervus* as the invertebrates of Community interest occurring in the project area (Fig. 3). For this purpose, the assessment of the deadwood supply and the detection of every deadwood position has been carried out in the designated areas of the project, which also provide opportunity to monitor and evaluate the changes occurring in the longer term.

Figure 3. The conservation of various deadwood supply is a key condition for preserving forest biodiversity (Photo: Márton Korda)

3. SITUATION ANALYSES

In the following we briefly describe the most important natural values of the project area, with special attention to the priority values and the values of Community interest. We briefly introduce the Natura 2000 sites established for the conservation of these values. Finally, we review the invasive plant species that threaten the natural values of the area.

3.1. Forest habitats of Community interest and priority forest habitats in the area

Illyrian Beech forests

Natura 2000: 91K0 Illyrian beech forests (*Aremonio-Fagion*) (habitat of Community interest)

In the Villány Mountains - due to its small size and low mountains - the Illyrian beech forests (Helleboro odori-Fagetum) occur only extraregionally, in the lower third and deeper valleys of cool, humid northern sides, often with fragmented appearance. The Jurassic limestone has loess cover at these sites, with clay-lined brown forest soil, rarely brown earth. The largest beech forests are located from Tenkes to Csukma Mountain, but smaller spots can be discovered in the Siklós Valley, as well as on the Fekete Mountain and the northern side of Szársomlyó. The canopy layer of plant community is dominated by beech, but silver lime appears sometimes in larger proportions too. A typical shrub species - unlike the Mecsek beech forests - is the Jericho honeysuckle. The herb layer is occasionally nudum, species reflecting sub-Mediterranean-Illyrian effect are in the early spring aspect Helleborus odorus, Lathyrus venetus, Allium ursinum, and later *Tamus communis*, *Ruscus aculeatus* and *R. hypoglossum* (Kevey 1985-1986, Kevey and Csete 2008a, 2008c, Erdős et al. 2017).

Illyrian oak-hornbeam forests

Natura 2000: 91L0 Illyrian oak-hornbeam forests (*Erythronio-Carpinion*) (habitat of Community interest)

Illyrian sessile oak-hornbeam forests (*Asperulo taurinae-Carpinetum*) in the Villány Mountains – like the beech forests there - appear in the northern region in extra-regional position, and in some cases they descend down to the footsteps of mountains. The bedrock is Jurassic limestone or less often (Villánykövesd: Fekete Mountain) dolomite, which was covered mostly loess, formed clay-lined

Figure 4. The hornbeam-pedunculate oak forests of Ormánság represent an outstanding value from a conservation and economic point of view (Photo: Márton Korda)

brown forest soil, and slope sedimentary soil at the footsteps. In the upper canopy layer, the dominant species is the sessile oak, which is often mixed with Turkey oak, partly because of anthropogenic effect. In the wetter stands of the valley bottom, the sessile oak is replaced by pedunculate oak. In the sub-canopy layer, the manna ash can play an important role in addition to the hornbeam. The silver lime consociations are very extensive, which are the products of the previous improper forest management. The shrub layer is characterized by field rose and Jericho honeysuckle reflecting sub-Mediterranean effect. Similar effect show in the herb layer the *Polystichum setiferum*, *Primula vulgaris*, *Ruscus aculeatus*, *R. hypoglossum*, *Scrophularia vernalis*, *Scutellaria altissima* and *Tamus communis*.

The pedunculate oak-hornbeam forests (*Veronico montanae-Carpinetum*) (Fig. 4) of Ormánság (Drava Plain of Baranya) occur between 96-123 m above sea level from southeast to northwest. The bedrock is made up from young sediment sand, on which forest soils are formed with sedimentary origin. The watercourses crossing the landscape and the high groundwater level produce a periodic water effect accompanied by a humid, cool microclimate. Several of its stands make a transition to hardwood floodplain forests. The closure of canopy layer is high, where the dominant species is pedunculate oak, often accompanied by the narrow-leaved ash. In the sub-canopy layer besides the typical hornbeam occurs often the field maple, in Southern Transdanubia the Tatarian maple is not rare, and the small-leaved lime and the field elm too. In the low-to-medium-cover shrub layer are dominant the common hazel, common dogwood, wild privet and common ivy. The cover of herb layer may vary from sub-nudum to full cover, with many submountainous elements found in shelter, and some sub-Mediterranean species (e.g. *Carex strigosa*, *Knautia drymeia*, *Primula vulgaris*, *Ruscus aculeatus*, *Polystichum setiferum*). Number of protected plant species are 17 (Horvát and Kevey 1983, 1984, Dénes et al.1996–1997, Kevey 2007a, 2013, Kevey and Csete 2008b, 2008d, Erdős et al. 2017).

Forests of slopes, screes and ravines

Natura 2000: 9180 Forests of slopes and screes (*Tilio-Acerion*-forests) (habitat of Community interest)

There are forests of slopes and screes (*Tilio tomentosae-Fraxinetum orni*) in the Villány Mountains, in Szársomlyó, Fekete Mountain and Tenkes, except these locations the plant community occurs only in the Mecsek Mountains. The stands are located in cool, humid microclimate, northern exposure, steep (30–45 degrees) slopes, at 250–380 m above sea level, on the limestone or rarely dolomite (Fekete Mountain), in rocky debris rendzina soil. The stands are smalls, fragmented and usually inserted between oak-hornbeam forest stands. The height of canopy layer is up to 20 meters and generally consist of silver lime, broad-leaved lime, field maple, Norway maple, manna ash, wych elm, and other non-dominant tree species. Among the shrub species, the Cornelian cherry is dominant. The special values of the plant community are the submediterranean and Illyrian species in the herb layer as *Polystichum setiferum*, *Helleborus odorus*, *Ruscus aculeatus*, *Scutellaria altissima*, *Doronicum orientale*, *Asperula taurina*, T*amus communis*, *Lathyrus venetus*, *Lunaria annua*. Most important invasive species in the plant community are the black locust and to a lesser extent the tree of heaven.

While there are typical ravine forest (*Scutellario altissimae-Aceretum*) stands in the Mecsek, only fragments can be found in the Villány Mountains and the surrounding hills (Völgység, Geresdi Hills, (Bisse: Remete, Kistótfalu: Áta Mountain, Nagytótfalu: Császár Mountain, Villánykövesd: Fekete Mountain, Diósviszló: Viszló Mountain). These stands are located in narrow, erosion valleys with northern exposure, embedded in Jurassic limestone. Typical ravines are missing or only small in size due to the loess cover here, so the necessary cool, steamy, wet microclimate is not expressed here either. Ravine forest fragments were formed where the loess blanket was devastated as a result of erosion. In the canopy layer the beech, hornbeam, Norway maple, wych elm, silver lime and manna ash are characteristic, but the sycamore is missing. In the shrub layer, the characteristic species are the European bladdernut and common ivy; in the herb layer beyond the typical beech forest species occur the *Phyllitis scolopendrium* and the *Polystichum setiferum* (Kevey 1984, 2018, Erdős et al. 2012).

Pannonian pubescent oak forests

Natura 2000: 91H0 Pannonian pubescent oak forests (habitat of Community interest)

In the Villány Mountains (karst) pubescent oak forests (*Inulo spiraeifoliae-Quercetum pubescentis*) are located on the southern side and the ridge of the higher lines (Tenkes, Csukma Mountain, Fekete Mountain, Szársomlyó), and they can slide to the northern side of the narrow ridges. The stands are mostly on limestone, rarely (Villánykövesd: Fekete Mountain) on dolomite, on black rendzina or rocky soil. These pubescent oak forests often appear in scattered, fragmented, rocky mosaic patches (e.g. Szársomlyó), which is caused by the steep, graded structure of the bedrock. As a result of the long lasting and vigorous grazing, secondary scrub forests (e.g. Tenkes, Csukma Mountain) were formed by the opening of basifilous oak stands. The height of the woody patches of the mosaic-like plant community does not exceed 10 meters, the typical species is the pubescent oak and the manna ash, but the silver lime is not uncommon either. The members of shrub layer are the often tree statured Cornelian cherry, warted spindle tree, common hawthorn and wild privet, which form belt at the forest edges. It is characteristic the frequent presence of Jericho honeysuckle and the absence of common barberry and European smoketree. In the grassland, besides *Dictamnus albus*, *Galium lucidum*, there are also characteristic the *Iris variegata*, *Silene nemoralis*, *Ceterach officinarum*, *Inula spiraeifolia*, *Tamus communis*, *Ruscus aculeatus*, and numerous grassland species in open areas. The number of protected plant species is close to 30.

The basifilous oak forests (*Tamo-Quercetum virgilianae*) with a non-mosaic but low-to-medium closed canopy layer also occur in southern exposure, but on less steep slopes and deeper soil than the pubescent oak forests. The height of the canopy layer does not exceed 15 meters; the permanent species are the manna ash, pubescent oak and silver lime. Its associate trees are the field maple, European ash, Turkey oak and wild service tree. In the well-developed shrub layer occur the Cornelian cherry, common hawthorn, warted spindle tree, wayfarer, wild privet, Jericho honeysuckle and field rose. The herb layer is dominated by dry oak forest species; sub-Mediterranean character aspect show the *Luzula forsteri*, *Tamus communis* and *Scutellaria altissima*. The number of protected plant species is around 30. In the disturbed stands the black locust and tree of heaven appear as invasive species (Dénes 1994, Kevey 2008, 2012).

Pannonian Turkey oak forests

Natura 2000: 91M0 Pannonian Turkey oak forests (habitat of Community interest)

In the mountains and hills of southeastern Transdanubia, the Turkey oak forests (*Potentillo micranthae-Quercetum dalechampii*) (Fig. 5) appears regionally as a result of the macroclimate. The stands are on plateaus, but they can also be seen on mild southern and northern slopes as well, as on flattening southern foothills. In the Villány Mountains, the bedrock is limestone or loess, on which a deep brown layer of rendzina or brown soil was formed. Compared to the other Turkey oak forests in the country, it is a striking feature that the silver lime is a constant attendant beside the dominant Dalechamps oak and Turkey oak in the canopy layer. Depending on the site characteristics, the

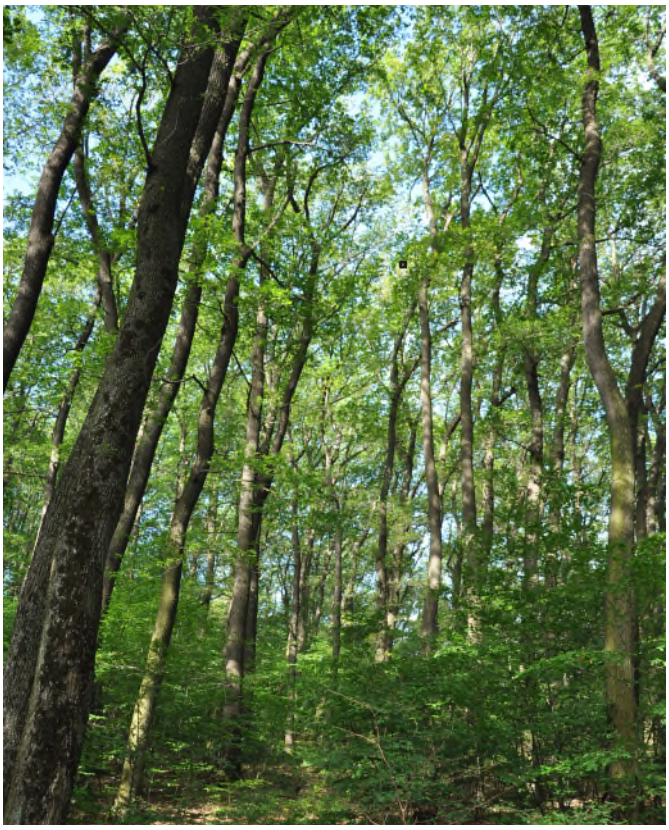

Figure 5. The sub-Mediterranean elements in the herb layer are typical of the Turkey oak forests of the region (Photo: Márton Korda)

development of the shrub layer may vary, but it mostly has a high cover. Its characteristic species are the Jericho honeysuckle, the field rose and service tree. There are also several sub-Mediterranean plant species in the diverse grassland, such as *Doronicum orientale*, *Genista ovata* subsp. *nervata*, *Helleborus odorus*, *Luzula forsteri*, *Potentilla micrantha*, *Ruscus aculeatus* and *Tamus communis* (Haraszthy 2014).

Softwood floodplain forests

Natura 2000: 91E0 Common alder (*Alnus glutinosa*) and European ash (*Fraxinus excelsior*) formed floodplain forests (*Alno-Padion*, *Alnion incanae*, *Salicion albae*) (habitat of Community interest)

At the lower level of Drava floodplain stand the softwood floodplain forests (*Salicetum albae-fragilis*). The crude or humic alluvial soils are wet to the soil surface. The transformation of the sites and the loss of the area of softwood floodplain forests are also prominent here. The canopy closure is medium or high, dominated by white willow and associated by crack willow and the rare black poplar. In slightly higher areas, white poplar consociation can develop, which are already a transition to hardwood floodplain forests. In the poorly developed sub-canopy layer, the European white elm is the most typical, and grey alder is the dealpine specialty. The shrub layer is well-developed with a mass of common dogwood and / or blackberry, sometimes black elder. The herb layer is dominated by floodplain forest and marsh species, with former uses and site transformations resulting in high levels of disturbance tolerant species. There are few species of sub-Mediterranean character (e.g. *Carex strigosa*, *Carpesium abrotanoides*, *Fritillaria meleagris*, *Peucedanum verticillare*). Number of protected plant species is 15 (Kevey and Tóth 2006, Kevey et al. 2008).

Hardwood floodplain forests

Natura 2000: 91F0 Hardwood floodplain forests along the large rivers with species *Quercus robur*, *Ulmus laevis* and *Ulmus minor*, *Fraxinus excelsior* or *Fraxinus angustifolia* (*Ulmenion minoris*) (habitat of Community interest)

Figure 6. Due to water management and barrage construction, the hardwood floodplain forests are flooded only in exceptional cases nowadays (Photo: Márton Korda)

The hardwood floodplain forests (*Fraxino pannonicae-Ulmetum*) (Fig. 6) on the Drava River (Baranya) are at 93-115 above sea level, with plain or only slightly uneven relief. The bedrock is young alluvial sand, where alluvial forest soils have been formed. Due to the proximity of the groundwater level, the habitats are periodic or permanent water balanced, although in the recent period - due to water management and barrage construction - there is a tendency to dry out, only a few stands (e.g. Drávakeresztúr: Lóka, Zokoga, Kisszentmárton: Atak Forest) receive regular flooding. The height of the canopy layer can exceed 35 meters, with high closure. In the upper canopy layer, the pedunculate oak and the narrow-leaved ash are dominant, their rate are very variable due to the site conditions and forest management, and sometimes their consociations occur. The associate species of the upper canopy layer is the white poplar; in the sub-canopy layer occur the field elm, European white elm, field maple, small-leaved lime and hornbeam. The cover of the shrub layer varies, mostly depending on the forest management; the common dogwood, common hazel, common hawthorn, English hawthorn are dominant and common ivy is frequent. The composition of herb layer is similar to that of the hornbeam-pedunculate oak forests, although the proportion of floodplain forest species is higher here. The transition between the two plant communities is not uncommon. In the herb layer, in addition to the many submountainous species, the sub-Mediterranean species (e.g. *Carex strigosa*, *Carpesium abrotanoides*, *C. cernuum*, *Erythronium dens-canis*, *Knautia drymeia*, *Primula vulgaris*, *Ruscus aculeatus*, *Tamus communis*) provide a special character of these hardwood floodplain forests. There are 17 protected plant species in this plant community (Kevey 2007b, Kevey et al. 2008).

3.2. Plant and animal species of Community interest and priority species associated with forest habitats of the area

Great capricorn beetle (*Cerambyx cerdo*) and stag beetle (*Lucanus cervus*)

Booth species habitat preference and lifestyle are similar, so they will be presented together. They are associated with old oak-dominated stands; their larvae develop for years in decaying trees, so shelter wood trees and groups, and thick deadwood of different decaying phase are essential to them. Particularly important is the conservation of oaks standing alone, in forest edges or sunny hillsides (Fig. 7).

Figure 7. Conservation of the stag beetle populations is only possible with the care of the deadwood (Photo: Márton Korda)

Longhorn beetle (*Morimus funereus*)

It is a flightless, warm-preferring species and therefore lives in southern exposure in sunny habitats. Larvae live in larger stumps and near surface root system of more tree species, especially oaks, hornbeam and beech trees, at least two years long. The requirements of its survival are the preservation of old, decaying trees, the abandonment of thick stumps and the prohibition of stump removal in lowland areas.

Flat bark beetle (*Cucujus cinnaberinus*)

This saproxylophagous beetle is a good indicator of forests with high naturalness, and lives mainly in older stands. Its conservation can be ensured by the continuous presence of thick tree specimens and dead woods.

Unicorn scarab (*Bolbelasmus unicornis*)

Its larvae develop in underground mushroom species (e.g. truffles). Due to its special life cycle, the conservation of mycorrhiza system is of paramount importance, so the avoidance of rough soil disturbance and chemicals. The wild boar rummage and thus the consumption of mushroom fruiting bodies are also important threatening factors.

Scarce fritillary (*Euphydryas maturna*)

Larvae feed on native ash trees and wild privet, while imagines feed on nectars of *Asteraceae* and *Apiaceae* species. Its population size is highly unsteady, the strongest population is found in the Lankóc forest. The requirements of its conservation are the maintenance of diversity and shrub layer, as well as the preservation of the forest edges with nectar source providing plant species.

Janka's lizard orchid (*Himantoglossum jankae*) [Crimean lizard orchid (*H. caprinum*)]

This thermophilous and basiphilous speciesprefers hilly and mountainous habitats with forests and grasslands mosaic. The main threatening factors of its habitats are the spontaneous shrub succession, the invasion of black locust and tree of heaven, and the rummage of the tuber by wild boar (Dénes et al.1993).

Pannonian swallow-wort (*Vincetoxicum pannonicum*)

Our super-endemic plant species, apart from Szársomlyó, lives only in the Buda Mountains, in the opening of pubescent oak scrubs, rocky steppes and grasslands. It is threatened by trampling furthermore, the spreading and shading of tree of heaven (Fig. 8).

Figure 8. Pannonian swallow-wort is the endemic plant species of the Buda Mountains and the Villány Mountains (Photo: Márton Korda)

Greater pasque flower (*Pulsatilla grandis*)

The species lives in dry grasslands and in openings of dry oak forests with forest-grassland mosaic. The invasion of black locust and tree of heaven narrows its living space, and it hardly tolerates the trampling as well (Fig. 9).

Figure 9. The habitat of the greater pasque flower – which is a species of Community interest – is threatened by the invasion of black locust and tree of heaven (Photo: Márton Korda)

Table 1 shows the habitat preferences for plant and invertebrate species of Community interest and priority species occurring in the area.

Table 1. Habitat preferences for plant and invertebrate species of Community interest and priority species occurring in the area

Species	Habitats						
	Illyrian beech forest	Illyrian oak-hornbeam forest	Forests of slopes, screes and ravines	Pannonian Turkey oak forest	Pannonian pubescent oak forest	Softwood floodplain forest	Hardwood floodplain forest
Great capricorn beetle *Cerambyx cerdo*		•		•	•		•
Longhorn beetle *Morimus funereus*	•	•	•	•	•		•
Stag beetle *Lucanus cervus*	•	•		•	•		•
Flat bark beetle *Cucujus cinnaberinus*	•	•	•	•	•	•	•
Unicorn scarab *Bolbelasmus unicornis*				•	•		
Scarce fritillary *Euphydryas maturna*				•	•		•
Janka's lizard orchid *Himantoglossum jankae*				•	•		
Pannonian swallow-wort *Vincetoxicum pannonicum*					•		
Greater pasque flower *Pulsatilla grandis*					•		

Bat species

Only *Myotis dasycneme* reproduces in forests, therefore to this species it is essential to have a large presence of elder, decaying trees, where they can develop their maternity colonies. The other bat species visit the forests for feeding, and for them, the greatest threat is the clear-cuts. Table 2 shows the habitat use patterns of Natura 2000 bat species occurring in the project area (Haraszthy 2014).

Table 2. Habitat use of bat species occurring in the project area based on Estók and Görföl (2016)

Species	Habitat use		Comment
	Feeding	Maternity colony	
Schreibers's long-fingered bat *Miniopterus schreibersii*	•		
Lesser mouse-eared bat *Myotis blythii*	•		
Pond bat *Myotis dasycneme*	(•)	•	Softwood and hardwood floodplain forests
Greater mouse-eared bat *Myotis myotis*	•		
Greater horseshoe bat *Rhinolophus ferrumequinum*	•		
Lesser horseshoe bat *Rhinolophus hipposideros*	•		

3.3. Short introduction to the Natura 2000 areas affected by the project

Tenkes Special Area of Conservation (HUDD20001)

The nearly 1,560 ha Tenkes Natura 2000 site preserves the rich mosaic of Pannonian habitats with Illyrian and sub-Mediterranean influences. Approximately two thirds of the area is covered by forest habitats of Community interest. In the greatest extent, the Illyrian oak-hornbeam and Illyrian beech forests occur, but the area of the Pannonian pubescent oak forests mixed with dry grasslands is also significant. In smaller extent, there are mixed forests of slopes and screes and Pannonian Turkey oak forests. The diverse habitat structure provides territories for many protected plants and animals and species of Community interest. Among them, *Himantoglossum jankae*, *Pulsatilla grandis, Isophya costata* and *Bolbelasmus unicornis* living in dry grasslands and pubescent oak scrubs, deserve special mention. In the forest habitats occur *Cucujus cinnaberinus, Cerambyx cerdo, Morimus funereus* and *Lucanus cervus* as species of Community interest.

Villánykövesdi Fekete-hegy Special Area of Conservation (HUDD20003)

The 290 ha Villánykövesdi Fekete-hegy Natura 2000 site contains in relatively small extent habitats of Community interest (approx. 50 ha), which are in great majority forests. The largest expanse is represented by the Illyrian oak-hornbeam forests, but the Pannonian pubescent oak forests are also worth mentioning. The dry grasslands typical of the Pannonian region occur in a few acres of patches; therefore, the species of Community interest are also linked to forests. An exception to

this is *Himantoglossum jankae*, which lives in the grasslands too. In the forests occur *Cucujus cinnaberinus, Cerambyx cerdo, Morimus funereus, Lucanus cervus* and *Euphydryas maturna*.

Szársomlyó Special Area of Conservation (HUDD20006)

Most of habitats of Community interest in the 270 hectare Szársomlyó Natura 2000 area are Pannonian grasslands, but there are about 80 ha forest habitats as well. The majority of these are Illyrian oak-hornbeam forests, but it is worth mentioning the expansion of the Pannonian Turkey oak and the Pannonian pubescent oak forests too. Among the species of Community interest, the Pannonian endemic *Vincetoxicum pannonicum* deserve to be highlighted, which lives in the dry grasslands and pubescent oak scrubs. The area is a very important bat habitat, so it is not surprising that from the Natura 2000 species live here the *Miniopterus schreibersii, Myotis blythii, Myotis dasycneme, Myotis myotis, Rhinolophus ferrumequinum* and *Rhinolophus hipposideros.* Forests-related arthropod species of Community interest are also present in wide variety, including *Cucujus cinnaberinus, Cerambyx cerdo, Lucanus cervus* and *Euphydryas maturna*. Of the Natura 2000 species, special emphasis is placed on the highly protected endemic butterfly *Polymixis rufocincta*, which lives in the open rocky grasslands on the southern side of Szársomlyó. Although these are not species of Community interest, but definitely worth mentioning the Mediterranean, only here living, highly protected *Colchicum hungaricum*, and the protected *Trigonella gladiata* and *Medicago orbicularis*.

Since 1944, Szársomlyó has been protected as nature conservation area.

Kelet-Dráva Special Area of Conservation (HUDD20007)

In the area of approximately 6,623 ha Kelet-Dráva Natura 2000 area occur on nearly 400–400 ha treeless and forest habitats of Community interest. In the case of treeless habitats, seaweed and mud vegetation and mesophilous grasslands occur, while softwood floodplain forests (330 ha) and hardwood floodplain forests (66 ha) are included in the list of forest habitats. Most of the species of Community interest (11 species) are fish, but the list includes *Lutra lutra, Emys orbicularis, Graphoderus bilineatus* and *Lycaena dispar*. *Euphydryas maturna* living here is specifically a forest species that associated with hardwood floodplain forests.

The area is the part of Duna-Drava National Park.

Ormánsági erdők Special Area of Conservation (HUDD20008)

In the 10,532 ha of Ormánsági erdők Natura 2000 area occur about 130 hectares of treeless habitats of Community interest. It refers to the mosaic characteristic of area, that these habitats include seaweed vegetation, mesic and wet grasslands and dry grasslands as well. Among the forest habitats of Community interest, there are very significant (more than 5,700 ha) Illyrian oak-hornbeam forests and hardwood floodplain forests (more than 2,700 ha), but the 263 hectares of softwood floodplain forests also represent an important natural value. From the species of Community interest *Lycaena dispar* and *Maculina teleius* are associated with wet grasslands, while *Lucanus cervus* and *Cerambyx cerdo* live in forest habitats.

In the area is located the Szentegáti-erdő Nature Conservation Area too, which since 1993 has been designated as a priority conservation area of 250.16 ha.

3.4. Invasive herbaceous plant species occurring in the project area

Common milkweed (*Asclepias syriaca*)

The common milkweed is originated from North America; its Hungarian spread was supported considerably by its intensive cultivation between 1870-1950. The reason of cultivation was the supposed multitudinous utilization of species: volatile oil, syrup and wine had been made from flowers, paper and wallpaper from stem fibres; gum from milk, silk from seed hairs furthermore stems had been eaten like asparagus. Today, however, its importance only as honey plant has been proven; therefore the plantation were abandoned and milkweed started to spread rapidly through its hairy seeds and root suckers. The colonization of new areas are promoted by the anemochor seeds (Fig. 10), prolonged seed longevity, strong competitive ability, allelopathy and drought tolerance of species. Through roots suckering the species can form extended colonies. Some of thick roots run horizontally near the soil surface while others can reach up to 1-1.5 m depth in soil. Flowering period lasts from June to August, pollinators are bees and several other insect species. The complicated flower system could serve as a trap and sometimes causes the damage of flower visitors. Common milkweed is a thermophilous, xerophilous and light demanding species. Its spread is more intense in disturbed, loose soil habitats, from dry open grasslands to wet floodplain habitats. The species can tolerate the temperate shading, hence in habitats with loose canopy layer as gallery forests, black locust, poplar and pine plantations can reach significant cover. Its spread also occurs in orchards and vineyards, furthermore its importance as agricultural weed has been increased nowadays. Beside its damage in agriculture the damage in nature conservation is very considerable by suppressing native plants. According to our current knowledge, it is practically impossible to control by non-chemical methods, since every disturbance and mechanical injury results vigorous sprouting and the increase of colony. Practical experiences show that spot spraying and applying herbicide on leaves result the eradication of stands within one-three years (Bagi 2008, Bagi and Bakacsy 2012).

Figure 10. The hairy seeds of common milkweed are dispersed very efficiently by the wind (Photo: Márton Korda)

In the area of Mecsekerdő Zrt., common milkweed occurs in 190 hectares and two hectares are affected by the invasion of species. It spreads along the watercourses and forest edges especially in the area of Našice Forestry. It occurs in young oak forest of Koška Forestry; however, with the closure of the forest, the species is declining.

Giant and Canadian goldenrod (*Solidago gigantea, S. canadensis*)

The giant and Canadian goldenrods were introduced to Hungary in the middle of 1800s as ornamental plants, later beside their use in horticulture use as medicinal plants became widespread. Both species are productive honey plants and medicinal plants with several pharmacological effects, but their pollen can cause allergy. Due to their imposing stature, golden yellow bloom (Fig. 11) and effective reproductive capacity, these spe-

Figure 11. Goldenrod species planted as ornamentals escaped from the gardens and became dangerous invasive species (Photo: Márton Korda)

cies have been widely planted, but have escaped from the gardens by wind dispersed cypselae and established in many habitats. Of the two species, the giant goldenrod spreads more intensively and occurs in larger part of Hungary: it is common is in most part of Transdanubia and along the watercourses of Middle Mountain and Great Hungarian Plain. Canadian goldenrod occurs rarely, reaches higher dominance along the Transdanubian- and North Mountains, especially near to larger settlements. Both species are geophytes; the rhizomes of giant goldenrod are shorter but longer-lived so their stands are smaller and denser. The wind disperses the fruits of goldenrods for long distances so they can establish in new areas easily creating dense network of rhizomes and monodominant stands. In addition to the nature conservation problem they cause, goldenrods can spread in seed orchards and forestation as well inhibiting the natural or artificial renewal of forests. In treeless habitats, the change of management and abandon of reaping and grazing promote their invasion considerably. The closed stands of goldenrods can lead to the suppression of former vegetation and the decline of diversity of flora, invertebrate and vertebrate fauna. Dense, tall goldenrod stands increase the habitats of ground-nesting birds and are impermeable to certain vertebrate species as well. The control of goldenrod species are usually non-chemical. Goldenrod shoots are grazed by several animal species, some of them graze only before the flowering period. The most applied control method are reaping and mechanical mowing, which eradicates the stands successfully using twice a year. Chemical control of these species are not widespread, and it is applied only supplementary (Botta-Dukát and Dancza 2008, 2012).

In the area of Mecsekerdő Zrt., the giant goldenrod occurs frequently, while Canadian goldenrod rarely. In the area of Našice Forestry, both species spread in open habitats, establishing from the surrounding agricultural lands and cause problems in forestation sometimes.

Wild cucumber (*Echinocystis lobata*)

This species was named after its prickly pepo fruit. In North America, where this species is native, wild cucumber was considered as panacea (greatest of all medicines), furthermore its decorative seeds was used as button, pearl and toy. Wild cucumber was introduced to Hungary probably as ornamental plant and it started to spread escaping from gardens along the watercourses. The species has naturalized in western and south-western Transdanubia and Hungarian Mountains by 1950s, recently it has occurred throughout the country but only sporadically in Little Hungarian Plan and Danube–Tisza interfluve. Wild cucumber reach higher dominance especially in floodplain habitats, floodplain gallery forests, alluvial willow scrubs and herbaceous riparian vegetation. Beside the above mentioned plant communities it also occurs in streamside tall-herb vegetation of hills and mountains and semi-humid or wet forest habitats. Seeds and fruits are dispersed by water for long distances, its seed dormancy is broken by winter temperature; therefore seeds can germinate substantially on wet, nutrient-rich soil surface, but seedlings are sensitive to late frost. Both seedlings and mature plants are light demanding, so they climb up to 7–8 m height by tendrils and shades the other plants leaned on. Plant material of wild cucumber shoots can be so considerable that it is able to weigh down even the smaller tree saplings.

Figure 12. Wild cucumber is an annual invasive species with climbing shoots that spreads along the watercourses throughout the country (Photo: Márton Korda)

Flowers are unisexual; female flowers are axillary and not conspicuous while male flowers bloom in white, fragrant racemes (Fig. 12). Wild cucumber tolerates the habitat disturbance; it is common in nutrient-rich wet or humid soils even with changing water regimes as well as alluvial clay and cob soils. Due to its climbing shoots it influences the species composition and richness of native plant communities unfavourably. The species is the host plant of several pathogen organisms, mostly viruses, which can infect the native and cultivated plants too. The selectivity of chemical treatments is practically impossible to ensure during the wild cucumber control because of its climbing life form and near water habitats. Control activities targeting wild cucumber exclusively are rare; successful eradication of species was implemented by inundation during a habitat reconstruction (Bagi and Böszörményi 2008, 2012).

In the area of Našice Forestry, wild cucumber spreads along the watercourses and forest edges mostly, but floodplain areas, reeds and poplar stands are also threatened by its invasion.

Knotweed species

Bohemian knotweed (*Fallopia* × *bohemica*), Japanese knotweed (*Fallopia japonica*), Sakhalin knotweed (*Fallopia sachalinensis*)

The Asian Japanese knotweed and Sakhalin knotweed were introduced into Europe as ornamentals in 1800s. The hybridization of these species evolved the Bohemian knotweed, which was discovered in Czech Republic. The Sakhalin knotweed occurs in botanical gardens from where escapes very rarely. Both Japanese and Bohemian knotweed are planted in gardens and can escape, but Bohemian knotweed considerably frequently. Former data referring the occurrence of Japanese knotweed are most likely refer to hybrid species. In Hungary, the specimens of Bohemian knotweed occurs more frequently, which have functionally male flowers and do not produce viable seeds. Bohemian knotweed exists near to settlements, in disturbed and ruderal habitats as well; but considerable damage caused by the species occurs along the rivers, streams, canals, floodplains and forest edges (Fig. 13). Rhizomes encompass the soil forming extensive, unmixed stands. The competitive ability of species is very high. Due to its rapid growth, 2–3 m tall stature, deep penetrating and extensive rhizome system; except of early spring plants every other species disappeared from its stands. Dense and highly shading knotweed stands inhibit the natural succession, the renewal of native plants and decline the floral and animal diversity. Regenerative ability of species is also very effective; it spread mostly vegetatively by the dispersion of rhizomes and sometimes the shoot fragments. Rhizome fragments dispersed by watercourses can establish and form new stands. Knotweed growing along the watercourses can

encumber the flood control activities and damage the flood protection structures. Specimens growing in settlements can impair the buildings and cracking the pavements. Control of knotweed is very difficult and time-consuming activity since the species can regenerate rapidly through the dormant buds of rhizomes. Eradication is implemented usually by the combination of chemical and non-chemical methods and lasts several years. Mechanical mowing and cutting result in usually strong sprouting activity therefore the increase of stand size. Since the species lives mostly near to watercourses, the chemical treatments requires special regard. Recent experiences have shown that it can be suppressed chemically by stem injection (Balogh 2008, 2012).

In the area of Mecsekerdő Zrt., 49 ha are affected by the occurrence of species and one ha with its invasion.

Figure 13. The Bohemian knotweed spreads very aggressively along watercourses and floodplains (Photo: Márton Korda)

American pokeweed (*Phytolacca americana*)

The American pokeweed is native in North America and Mexico. Its Hungarian name derives from its red pigment which is like the dye produced by kermes insect. American pokeweed has been planted in Europe especially in wine-growing areas since the middle of 1600s as dyeing plant. It was used throughout Europe to colour wines, syrups, and candies until the toxic effect of the paint was found out. All parts of plant are toxic but mainly its root and fruit. The raw consumption of shoots can lead to vomiting, diarrhoea and convulsions; the root contains abnormal cell proliferation inducing chemicals. Dizziness, somnolence, hypotension, urticaria, and some cases of more severe poisoning may occur when consuming a larger amount. American pokeweed and the relative Chinese pokeweed were planted because of their tall statue, white or pinkish inflorescence (Fig. 14) and black berries as ornamentals. It has also been grown as dyeing and ornamental plant in Hungary, and knowledge of its escaping has been available since the early 1800s. The birds are eager to eat the pokeweed berries, especially the black

Figure 14. The juicy fruit of the American pokeweed is eaten and dispersed by birds (Photo: Márton Korda)

and singer thrush, which is why the American pokeweed established in more and more loose, disturbed, semi-shaded habitats. Seeds can retain its germination ability for decades, and individuals can reach 30–40 years old age. Larger stands are found mainly in black locust, pine and row crops plantations, abandoned vineyards and grasslands. It occurs in forest plantations, and recently in natural forests as well; where can cause problems in afforestation and natural regeneration. Since the species is not able to spread vegetatively, it can be controlled by regular mowing, pulling out the young ones, and later by digging out the storage root. Among the livestock, sheep and goat are eager to feed pokeweed shoots, so grazing by sheep or goat can be recommended as control method in the case of more specimens or larger stands. Although the species does not propagate vegetatively, we cannot prevent its dispersion by birds, and therefore American pokeweed is not recommended for planting as ornamental plant (Balogh and Juhász 2008, 2012).

In the area of Mecsekerdő Zrt., 10 ha are affected by the occurrence of species and five ha with its invasion.

Annual fleabane (*Erigeron annuus*)

Annual fleabane is native in North America, it was introduced to Europe in 17th century as ornamental plant. By the end of 1700s, the species had been spread in the ruderal habitats of Europe considerably, while it became common weed in the second half of 1800s in Hungary. It occurred especially in roadsides, railway embankments and vineyards initially, and then it was mentioned more and more frequently from different forests, clear cuttings, seed orchards, disturbed anthropogenic habitats and agricultural lands. This species establishes rapidly in bare soil and open habitats due to the huge amount of cypselae with pappus. Much of its seedlings appear in August and survive the winter in the form of leaf rosette. Its capitula (head inflorescences) with white and light violet ray florets flourish usually between June and September, but can bloom from April until November as well (Fig. 15). The flowers are self-pollinated; therefore, the cypselae are ripening and dispersing continuously by the wind from the 1.5 m tall plants. The newcomer specimens establish and start to spread rapidly in disturbed, open or less covered sites and can reach high dominance in humid, sunny or semi-shaded habitats. Annual fleabane has wide soil tolerance. The species does not spread vegetatively; its spread is promoted by rapid growth and effective seed dispersal: various pollination, high seed production, rapid seed maturity and germination, and high germination rate. High dominance of annual fleabane can decrease the diversity of habitat, but due to its low competition ability the species disappears from the plant community during the succession. The species could be problematic in agricultural lands, vineyards or orchards; in forestation it can became dominant only in first years with other annual species such as Canadian fleabane. It can be controlled by regular mowing or will be suppressed by the competition of perennials spontaneously (Pál 2012).

In the area of Našice Forestry the species occurs in open habitats, forests, forest edges, clear cuttings abundantly.

Figure 15. The annual fleabane can quickly become dominant in disturbed and open habitats (Photo: Ágnes Csiszár)

3.5. Invasive woody plant species occurring in the project area

Green ash (*Fraxinus pennsylvanica*)

The North American green ash (Fig. 16) was already present in Hungary at the end of the 1700s as a rare park tree. Its forestry utilization in Hungary has been significant through one hundred years since the 1870s. At first, a greater role was also given to this species in forest utilization of sand and floodplain, and later of saline sites. The species did not bring the hopes attached to it, mainly due to its unfavourable timber properties. Nowadays, green ash has become widespread in the lowlands of Hungary, especially along the rivers and in the saline areas. Due to its rapid growth, the relative independence from site characteristics, allelopathic effect and the low number of consumers and pests, the green ash has become an invasive species. The invasive success of species is promoted due to its regular and abundant production of seeds, which are both water and wind spread and germinate for 2–3 years, furthermore its good trunk sprouting ability. Green ash tolerates the extremity of the continental climate, its water resistance is excellent; and although being a light-demanding species, its juvenile shade tolerance lasts longer than that of European ash and narrow-leafed ash. Its shoot has significant coumarin content, therefore, the foliage consumers damage less than native ash; its bark become rough sooner, so it suffers from bark stripping only at a younger age. Due to its earlier large-scale planting and good spreading ability, green ash appears along the rivers, in floodplain areas throughout the country. Its massive renewal creates dense shrub and second canopy layers, which makes the regeneration of indigenous species in many cases completely impossible, and may cause the decline of natural forests in the future. Its control takes a long time because of the continuous propagule supply dispersed by watercourses, and requires a river basin planning. Chemical-free control can be implemented successfully by pulling out the thinner saplings and bark girdling with chainsaw of larger trees. Chemical eradication can generally be effectively performed by methods commonly used by other woody species (Csiszár and Bartha 2008, Bartha and Csiszár 2012).

Figure 16. The green ash is one of the most common invasive tree in our riverside habitats (Photo: Márton Korda)

The presence and spread of species can be observed in lowland mesic forests and floodplain habitats along the Drava river.

Tree of heaven (*Ailanthus altissima*)

Tree of heaven (Fig. 17) is native in China and Korea and it was already present in Hungary at the beginning of the 1800s. The species was used for forestry purposes in Hungary in the 1820s and 1960s, but it was planted primarily not for timber production. Its extraordinary toughness soon made it a major species for the cultivation under extreme climatic and soil conditions, especially in the area of running sand and mountain barrens. Its use in forestry in the second half of the 1900s was eventually abandoned because of its generative and vegetative proliferation, which was also impossible to manage. By that time it had become naturalized in the Great Hungarian Plain due to its spontaneous spread. Nowadays tree of heaven is found all over the country, but abundantly occurs in areas of dry, warm climates. It has become one of the invasive species causing considerable damage in nature conservation, and it is an increasingly important problem in economy. This is mainly due to its highly intensive generative and vegetative reproduction, but many of other features contribute to its success. Among others, good drought toler-

Figure 17. The tree of heaven is one of the most aggressive invasive tree in Hungary, which can be recognized from far in its lavishly blooming flowers with unpleasant smell (Photo: Márton Korda)

ance, strong competitive and allelopathic effects on many plant species, and the almost complete absence of pests and pathogens promoting its spread. Tree of heaven not only colonize the new area, but transforms its structure, species composition and ecological characteristics due to its competition, shading, allelopathy and the significant amount of leaf litter falling year by year. Considering its introduction history, it is not surprising that the species causes the biggest problem in dry grasslands and forests today, but it is worrying that it is appearing more and more in mesic sites as well. In addition to our natural environment, it is a problem in the built environment. Tree of heaven can roots into the facades of buildings and the cracks of roads easily, and can grow into a surprisingly large tree causing serious damage by its roots. The control of the species is encumbered strongly its extreme sprouting ability. According to our current knowledge, an effective chemical-free method does not exist for a large-scale reduction of the species. It can be said that mechanical control usually results in steep stand increase due to inducing of vigorous sprouting activity. Because tree of heaven is one of our most problematic invasive trees, several chemical control technologies have been developed in recent years, and many of them can be applied successfully. In the case of young specimens and sprouts, spraying and wiping herbicide are the most commonly used method. For younger, thinner-barked individuals, bark wiping by herbicide is the most widespread technology, which was previously combined with bark stripping, but nowadays the technology without stripping is more widespread. In older specimens, trunk injection is the best practice. After removing the trees, the seeds in the soil can germinate massively, which must be taken into account when planning the control (Udvardy

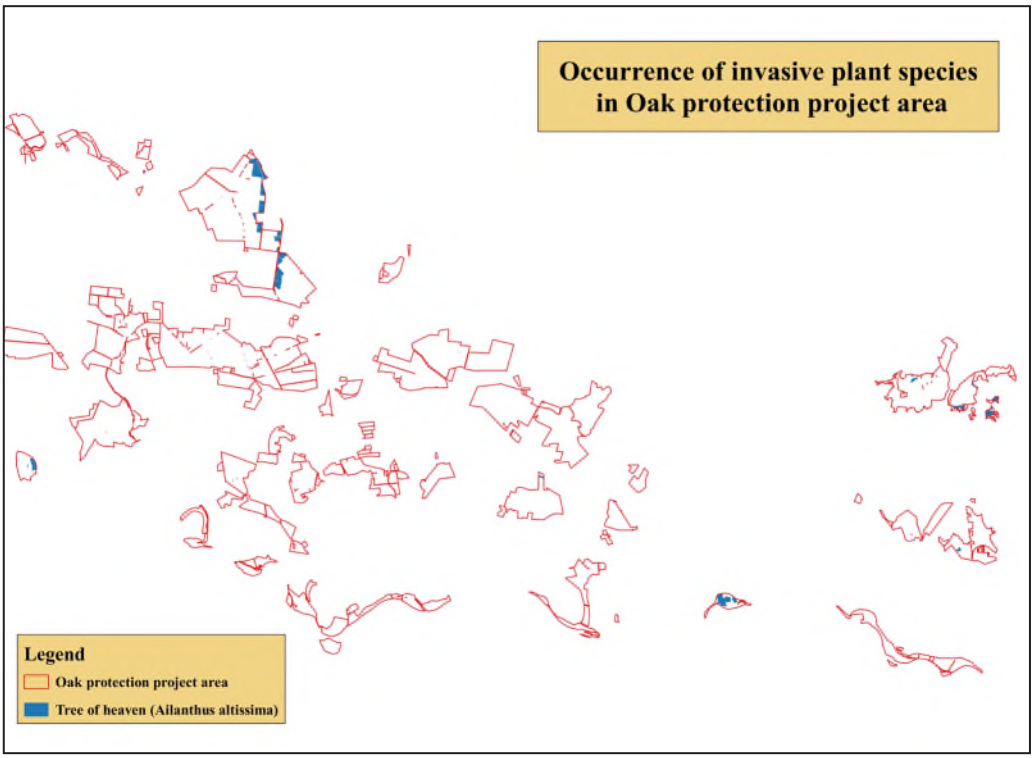

Figure 18. The occurrence of tree of heaven in the project area

2008, Udvardy and Zagyvai 2012, Korda 2018).

The species has a very long history in the Villány Mountains affected by the project, as we know, the first large-scale horticulture plantation took place here in the first decade of the 1800s. Its occurrence on the Drava Plain is well known in many areas, but its damage is particularly noticeable in drier habitats. During the project, the species has been removed from nearly 23 ha (Fig. 18).

Box elder (*Acer negundo*)

The North American box elder was introduced into Hungary in the 1770s as an ornamental tree. It was already used for forestry purposes at the end of the 1820s, but its considerable utilization began only in the 1880s with sand afforestation. Box elder began to be used around the turn of the century in floodplain areas, sometimes in significant quantities. Its use in forestry has ceased by the 1970s because of its valueless timber and spontaneous renewal that encumbered the forest management as well. Although it has become a widespread species in our lowlands and hilly areas, it is present mostly in our floodplains, with no exception of Drava as well. Its abundant reproduction is primarily due to its fruits dispersed by both wind and water (Fig. 19). In case of injury or cut-out, it regenerates quickly with trunk sprouts, but it does not form root suckers. Its seeds can germinate from April to September. Box elder is a pioneer tree species, characterized by very rapid growth at young age. The species is essentially light-demanding, but at a young age it tolerates the shade longer. It has a very high tolerance to the nutrient and water balance of the sites, tolerates drier periods and flooding, but finds its optimum on alluvial soil. Box elder causes the most significant problem in grasslands and forests in our floodplains, both from conservation and economic point of view. Its abundant regrowth and younger specimens in shrub and second canopy layers prohibit the renewal of native species. In a few years, box elder forms completely closed shrub and tree stands in grasslands, resulting in the complete disappearance of the grassland community. In addition to the above-mentioned habitats, it spreads in drier, open and disturbed habitats as well, in settlements or around them, along roads, railways. Its control aggravates the continuous propagule supply dispersed by wind and water, which is why the removal of the fruiting individuals is extremely important. Several experiments have been made to its control chemical-free, which have produced favourable initial results. In the case of thinner barked saplings the manual removal, by the thicker ones uprooting by mattock can be successful. Larger trees can be controlled by chainsaw girdling and root collar cut-off on loose soil. Chemical eradication can generally be effectively performed by commonly used methods (Udvardy 2008, Udvardy and Nótári 2012, Korda 2018).

Box elder is a common species in Drava Plain, it spreads especially in floodplain forests and grasslands abundantly, but in mesic forests too.

Figure 19. Both wind and water disperse efficiently the winged fruits of the box elder (Photo: Márton Korda)

Black locust (*Robinia pseudoacacia*)

Black locust occurs in the largest area of Hungary among the tree species; it covers 24.8% of all forested area. It is a species of outstanding economic importance, which is excellent for firewood and timber industry, but also plays a significant role in horticulture and beekeeping (Fig. 20). Black locust can be easily cultivated fast-growing species, which has drought tolerance, relative low nutrient

demand and excellent vegetative regeneration capacity. Because of these features, it has been widely used in the past for sandy and sedimentary soil binding, afforestation of bare mountain and hillside, and has recently been involved in the recultivation of dumps and industrial depots. Features helping its growing and renewal are the major threat to nature conservation too. Where it has been planted or established spontaneously, it is very difficult to remove from, thanks to its excellent root- and trunk sprouting ability and its long term persistent seed bank. The seeds remaining in the pods are spread by the wind far. Its seeds maintain germination ability for several decades, and their dormancy is often broken by human activities (such as burning, trampling, plowing or stump removal). As a result of all these effects, the colonization of the species is increasing. The characteristic ecological problem of black locust stands is the enrichment of soil nitrogen content due to bacteria living in the root nodules, which results in the spreading of weeds and the characterization loss of herb layer. Rapid nutrient deplete of soil and allelopathic effect of fallen leaf litter also contribute to these phenomena. Another problem in the invaded habitats is the very strong competitive ability of black locust, which manifests in the low tolerance of other tree or shrub species. Planning its control, it should also be taken into account its

Figure 20. The black locust is well-known from its honey, but it is a highly aggressive invasive tree that can appear anywhere from dry to mesic habitats (Photo: Márton Korda)

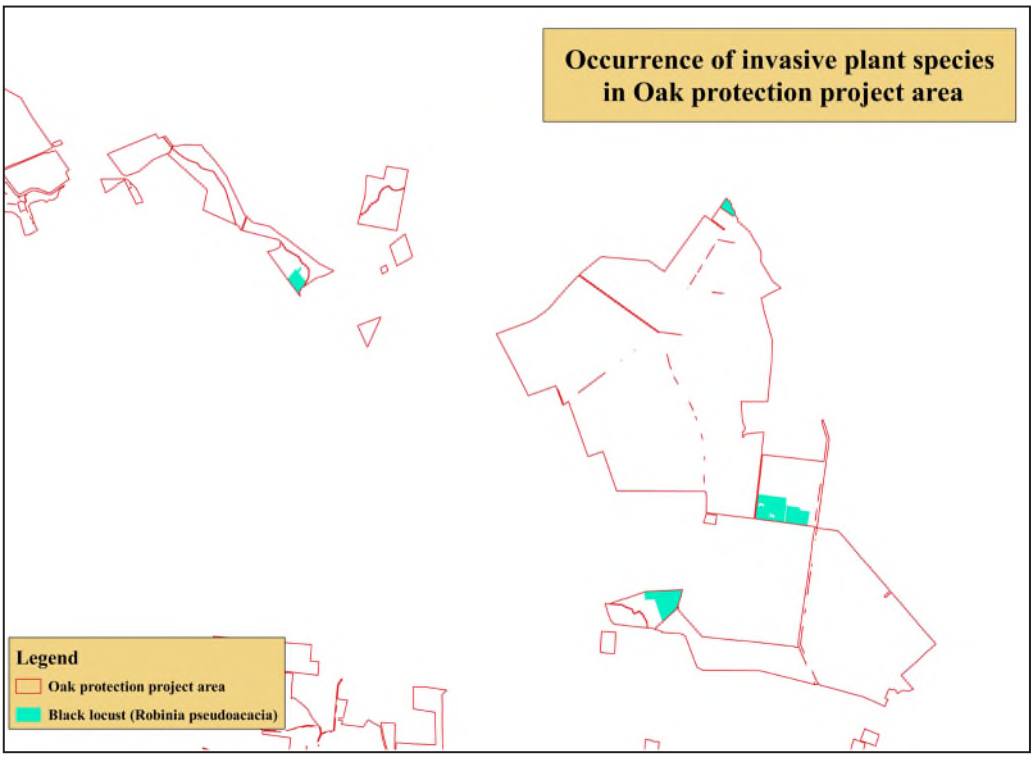

Figure 21. The occurrence of black locust in the project area

sprouting activity for years, and seeds retain their germination ability for decades. In most cases, mechanical treatments do not alone control the species or can only be successful over a long time. If the grazing of young (not yet thorny) shoots after the cut is feasable, this can provide a chemical-free solution, as well as regular removal of the sprouts. Chemical control can be done successfully with the generally used methods of woody species, most effectively by trunk in-

jection (Bartha et al 2008, 2012).

In the area of Mecsekerdő Zrt. 3226 ha are affected by the presence of black locust, of which 716 ha occur in natural forests. The species is also common in the Drava Plain, its larger cover occurs in the drier areas, but it is not rare in hardwood floodplain or mesic forests or in their former place. During the project, the species has been removed from over five ha (Fig. 21).

Honey locust (*Gleditsia triacanthos*)

Honey locust was introduced from America to Europe at the beginning of the 1700s, it was basically used as park or hedge tree and is still used today. The species played significant forestry role only in non-forest plantations (field-protecting forest strips, alleys). Its unmixed stands are very rare, and they have been planted for experimental purposes only. Honey locust has never served a meaningful timber production purpose; however, there are many planted individuals or smaller groups, especially in lowland forests.

Figure 22. The honey locust is not a serious problem nowadays, but its more and more often occurring spontaneous renewal is a cause for concern (Photo: Márton Korda)

It already blooms at an early age of 8–10 years regularly, and produces fruits at 3 to 5 year intervals abundantly (Fig. 22). Although honey locust can be characterized by hardseededness and persistent seedbank, but nowadays we are increasingly experiencing the presence of seed-borne, often multi-year-old specimens around the mother-trees. This is not a problematic issue today but a cautionary sign for the future. Learning from the history of many invasive trees, it would be important to prevent the spread of honey locust and to remove individuals present in the forest environment (Gencsi and Vancsura 1992, Simkó and Csontos 2009).

We are not aware of its control from nature conservation point of view; but considering its good stump sprouting ability; it can certainly be controlled by chemical methods effectively.

False indigo (*Amorpha fruticosa*)

The first data of the North American false indigo come from the mid-1800s from Hungary. It was planted for both horticultural and forestry purposes to bind slopes, to form forest edge or shrub layer, and also for soil protection. The species was used to the greatest extent in our lowlands, especially in the floodplains. At the end of the 1910s, there was a rapid spread of false indigo along the Danube and the Tisza, which was further exacerbated by the abandonment of agricultural lands and grazing of grasslands. Nowadays, it is abundant mainly in lowlands: along watercourses, canals, in floodplain forests and grasslands, poplar plantations and fallows. Its planted stands occur in drier areas, in sandy and saline sites, but the species spreads only moderately in these habitats. The long-term viability and effective dispersal of seeds – especially by water, sediments and animals – contribute to its establishment and spread. False indigo is a relatively short-lived but quick-producing shrub species. Flowers are insect pollinated, good honey producers (Fig. 23). Its regenerative ability is very good, it forms trunk sprouts intensively and lying shoots can root into the soil. The optimal site of species is nutrient-rich, loose soils, which sometimes affected by flooding, but it survives on sandy, saline and rocky sites as well. False indigo is high light-demanding species, and there-

Figure 23. The false indigo in the floodplains of Hungary is a growing problem, it can create homogeneous stands in forests and grasslands alike (Photo: Márton Korda)

fore spreads in the largest masses of open habitats (floodplain grasslands, fallows, poplar plantations, forest edges). It is not able to create contiguous stands in forests with higher closure of two canopy layers. The greatest damage to nature conservation caused by false indigo is in our floodplains, which is particularly noticeable in treeless habitats. After the germination of seeds transported by the water massively, false indigo forms a high, imperviously dense stand within a few years. Besides the shading its strong allelopathic and nitrogen enrichment effects promote the habitat transformation considerably. Chemical control is complicated by the fact that the areas affected by its invasion are often found near living waters. Several chemical-free methods are used in practice, of these, grazing and mowing are the most common. Many livestock, especially the grey cattle feed their foliage and younger shoots, and open the denser false indigo stands by trampling. Areas followed by grazing are occasionally worth flail mowing. The emerging young sprouts can be grazed and mowed as well. It should be emphasized, that these treatments must be carried out regularly (Szigetvári and Tóth 2008, 2012).

To the west of the Danube, false indigo is not as widespread as in Tiszántúl, but the increasingly evident its invasion is clearly seen along the rivers in Transdanubia. False indigo becomes increasingly common in the Drava Plain, its largest populations occur in gallery forests, grasslands and forest edges. During the project, the species has been removed from nearly 130 ha (Fig. 24).

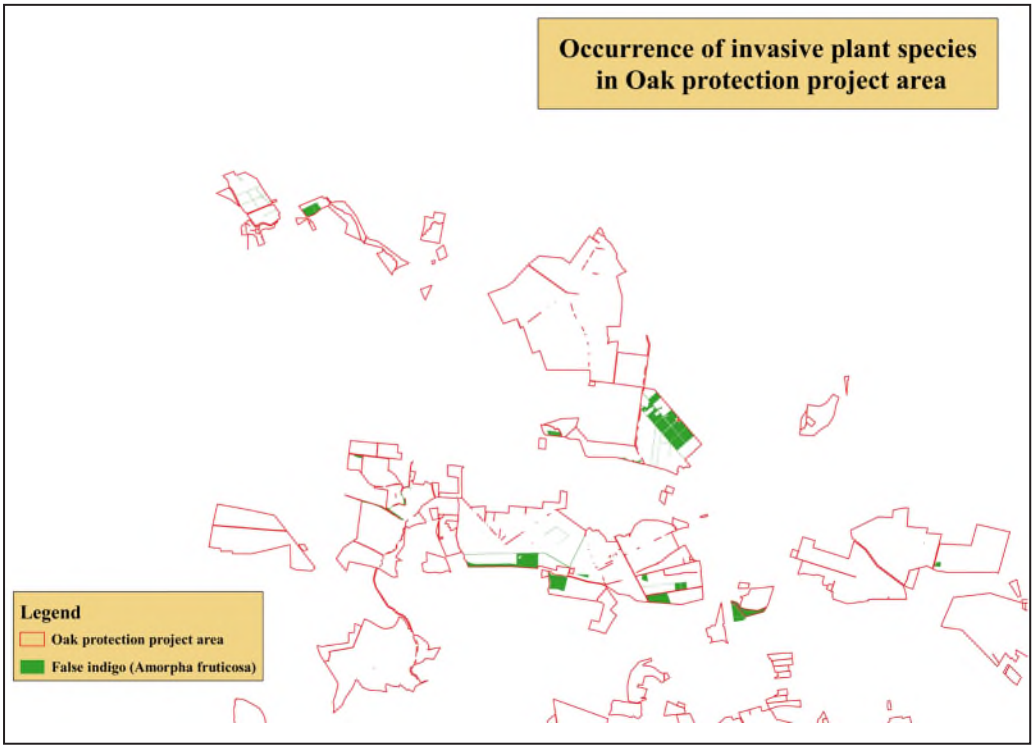

Figure 21. The occurrence of false indigo in the project area

4. PRESENTATION OF PROJECT GOALS AND IMPLEMENTATION

To protect the native ecosystem in the "Oak protection" project, the project owners have set targets for invasive plant control. In the framework of the project, according to the previous studies, the basis was the mechanical and chemical control of black locust (*Robinia pseudoacacia*), false indigo (*Amorpha fruticosa*) and tree of heaven (*Ailanthus altissima*), which are the most threatening invasive species in the Drava Plain and Villány Mountains. Since the survey had previously been concerned only the Hungarian parts, the sites in the area of Našice Forestry were surveyed by the assistance of the external experts of Hrvatski Šumarski Institut. In 2018, a detailed survey was carried out by the colleages of Institute on the Našice lowland forest area (cca 20000 ha). In the survey of 41 sites potentially infected with invasive species, the occurrence of invasive species was recorded. As a result of the survey, Croatian specialists recorded the occurrence of additional invasive species such as boxelder (*Acer negundo*), green ash (*Fraxinus pennsylvanica*), common milkweed (*Asclepias syriaca*), giant goldenrod (*Solidago gigantea*), annual fleabane (*Erigeron annuus*), wild cucumber (*Echinocystis lobata*), knotweed species (*Fallopia* spp.) and American pokeberry (*Phytolacca americana*). According to their experience, invasive species are mostly spread in the forest edges and reforestations. In Croatia, the work concerned only to the detection of invasive plant occurrence, control activites were not carried out within the project.
As an integral part of the project, the lead partner has also undertaken to develop a methodology for false indigo control. The goal was to develop procedures and technology lines that can be adapted to international practice and minimize the environmental impact. The work had to be done in protected, highly protected and Natura 2000 areas, which required a high degree of professional and technological discipline. (Further details on the experiments are given below).
In addition to the experiments, a total of 155.17 hectares of woody invasive plants were suppressed on the Hungarian side in Sellyei and Szigetvár Forestry of Mecsekerdő Foresrtry Co. These works were carried out in reforestation, forest edges and forest gaps, so the total size of the affected project area was close to 700 hectares. Among the plant protection works, the project was subjected to mechanical control (flail mowing, stoning, manual removal, grazing) and chemical control (stump and bark lubrication, trunk injection, full area mechanical and manual chemical control). A detailed description of the methods used is provided in the following section. Works began in the autumn of 2017 and were completed in spring 2019 after the necessary repetition numbers were completed.

4.1. The legislative background of chemical control in Hungary and Croatia

Legislative background in Hungary

In Hungary, the regulations on the pesticide use are set out in 43/2010. FVM Decree (hereinafter: Decree).

Also in the EU, following a general statute, according to Article 5. § (2) of the Regulation: *Plant protection products may be used in accordance with the requirements of the authorization and marketing authorization for the plant protection product (hereafter referred to as "authorization document") and its instructions for the prevention of risks to man and the environment, as well as its use and plant protection technology*.

An important problem with forest plant protection practice is that most of the pesticides are only allowed in agricultural and horticultural crops, as the low volume of forest use does not cover the significant costs of licensing. Therefore, most of the plant protection products to be used in forestry are subject to special prescriptions. Pursuant to Article 6. § (1) of the Decree, a *plant protection product may be used in accordance with the provisions of the Emergency and Pilot License issued pur-*

suant to the European Parliament and Council Regulation (EC) No 1107/2009 contrary to the Article 5. § (2).

In Hungary, the Department of Food Chain Safety, Land Registry, Plant Protection and Forestry of the Pest County Government Office is responsible for issuing pilot licenses. Before starting the experiment, it is necessary to submit a license application on a form downloadable from the Internet[1]. The license fee is 15.000 Ft for the applied preparation. Pilot licenses for experiments used in the project were issued by the Authority.

Emergency permits for plant management are issued by the Directorate for Plant, Soil and Agri-Environment Protection of the National Food Chain Safety Agency. As with the application for a pilot license, the procedure can be requested on a form downloadable from the Internet[1]. The license must be requested annually and issued for 120 days of use. The use can be divided into more utilization periods, but the number of days of use should not exceed 120 days. Medallon Mezzo (BFA+ tank mix) and other Garlon 4E herbicides were used for experimental and plant management purposes in the project, have been applied under this authorization. The fee for an emergency authorization of a plant protection product is HUF 150,000.

The plant protection products in protected natural areas may only be used with the permission of the Nature Conservation Authority in accordance with LIII. of 1996. Article 38. § (1) (g) Tv.

Legislative background in Croatia

The rules on the use of plant protection products in Croatia are laid down in the Law on the Sustainable Use of Pesticides (odluku o proglašenju zakona o održivoj uporabi pesticida[2]).

Chemical use in Croatian forestry practice

After planning and purchasing the chemical requirement all herbicides to be used must be approved by the Ministry of Agriculture and the products must be registered for forestry use. Reducing undesirable species with herbicides is primarily a feature of reforestion with direct oak seeding. All machines used for herbicide application should be regularly checked by authorized companies. Anyone who deals with herbicides (and other pesticides) must have a valid herbicide authorization (contractors, responsible personnel in the forest management unit, and administrative staff). The amount of herbicide used in the forest and the place of use should be recorded in the appropriate database. Compliance with the rules on chemical use is controlled by the inspectors.

In order to control invasive species, the use of glyphosate-active chemicals is typical. The chemicals used in forestry are registered in Croatia under the name „Total" and „Ouragan". Currently, Ouragan is used, which is allowed at 5 liters / ha.

The invasive species are controlled by a variety of methods.

- After cutting undesirable tree species, the cutting surface is treated with a mixture of water and Ouragan.
- In reforestations, invasive herbaceous plants are treated by spot spraying if the woody regrowth is not yet present.
- Chemical-free methods are often used to control invasive species – unwanted specimens are removed manually and mechanically.

[1] http://portal.nebih.gov.hu/-/szukseghelyzeti-engedely-kerelem

[2] https://www.zakon.hr/z/703/Zakon-o-odr%C5%BEivoj-uporabi-pesticida

4.2. Presentation of applied technologies

4.2.1. Non-chemical and combined control methods

Flail mowing

By the activity we mean the shredding, crushing and spreading of the parts of the plant to be crushed.

With regard to forestry, only the most powerful machines can be used, as the areas to be treated are mixed with non-lignified shrub size and multi-year old, lignified specimens of false indigo. These machines have a horizontal shaft rotary swing or fixed milling cutters. The flail mowers can be connected to a wide variety of power machines, so they can be assigned to the most appropriate tool carrier for fieldwork. Our most important goal in false indigo crushing is to prevent the crushed stock from resprouting. Contrary to agricultural practice, the amount of broken material will generally not be collected, utilized. This operation allows us to handle the subsequent sprouting by overall spraying. In the project we used a FAE type horizontal flail mower driven by a Valtra T234 tractor.

Figure 25. Stand before flail mowing (left) and the result of activity (right) (Photos: Mecsekerdő Zrt.)

Advantages

- The dense, strong, multi-year old, 2 to 2.5 meter high, already lignified false indigo can be cut off more efficiently than manual work (Fig. 25).
- Crushed plant parts are recycled in the soil, and the area will be completely clean and free from plant residues in one pass. Depending on the condition of the stand to be removed, the flail mower may have an efficiency of 1 to 1.5 ha per day.

Disadvantages

- Extremely expensive
- Exercised operator is necessary

On uneven surface, technology is not effective. It can be used well for false indigo control. The efficiency of the machine can only be evaluated with the chemical treatment. It spreads the resulting chips. After the shredding, the thickness of the chips remaining in the area influences the rate of sprouting. These young shoots can be handled easily with timely applied full-scale treatment for further utilization of the area. Multiple repetitions of treatments may be necessary, as the shoots may develop at different times from the root and the seed.

Stem shredding

If we want to use the plant material to be mowed in a given area for feeding purposes, it is important that the nutrient value of the mowed mass is preserved as much as possible. The mowing machine should also be suitable for shredding, because the mowed false indigo represents a large and juicy green mass, the drying process of which is positively influenced by the stem shredding. As the stem is capable of drying on its entire surface, there is less chance of it becoming stuffy. The sprouts that grows in the area can then be treated with overall spraying. In the project, we used an agricultural chain stem shredder driven by a MTZ type 82 agricultural tractor for the shredding of young, non-lignified false indigo (Fig. 26).

Advantages
- Provides quick working in areas that are covered with non-lignified false indigo.
- Specific costs are low.

Disadvantages
- Not effective on uneven surface.
- Not to be used in denser, already lignified, false indigo stands.
- The false indigo will resprout very soon, so the process should be repeated 4-5 times during vegetation.

The effectiveness of the method can only be evaluated with chemical treatment.

Figure 26. Stand before stem shredding and the result of activity (Photo: Mecsekerdő Zrt.)

4.2.2. Chemical control methods

Overall (full-field) machine spraying

Full-field spraying can be used if the area is well-suited to spraying equipment (towed or suspended) connected to an agricultural machine, and the spraying frames can follow the unevenness of the soil without damage, furthermore does not contain any protected natural value which may be damaged by treatment. In general, these areas are nursery parcels, afforestations carried out on agricultural lands, wildlands, openings, and flat-landed forest renewals after stump removal. Depending on the culture to be treated, the chemicals used are total (Garlon 4E, Mezzo, glyphosate) or selective (Lontrel 300, Banvel 480 S, Galera) herbicides.

With this technology, some resprouting is unavoidable, so posttreatment is necessary.

Advantages
- Great area performance
- Even spray coverage

Disadvantages
- For reforestation, it is useable only after stump removal
- High water demand
- Resprouting is possible

Manual spot spraying

If the invasive plants appear in patches or by specimens, it is suggested the use of backpack sprayer to protect the surrounding vegetation and avoid unnecessary environmental pollution. It is recommended to use a conical protector on the application device that prevents the spray droplets from drifting outside the target area.

Advantages
- Chemical saving
- Environmentally friendly

Disadvantages
- Non-uniform application
- Small area performance

Basal bark treatment

During this activity, a herbicide solution is applied to the trunk of the treated plant species (tree of heaven, black locust, older, lignified false indigo, etc.), taking care not to drop the product. The condition of applicability is the thin bark through which the chemical is readily absorbed. Applied chemicals: Garlon 4E and 1:4 gas oil blend or BFA+. It is advisable to incorporate pigment into the former mixture for the visibility of treatments, the latter chemical is pigment containing (Fig. 27).

This activity is carried out during the vegetation period, typically from late April to late September, as it would be ineffective because of the pause of

Figure 27. Tree of heaven sprouts after basal bark treatment (Photo: Ferenc Kele)

assimilation during the winter.

The bark should be lubricated with a high-quality radiator brush 30-40 cm long for the unbranched part of the trunk, covering the entire circumference. There should only be as much material as the brush does not drop. Typical mistake in application is that a thin strip is not exposed on the opposite side of the operator, and it is sufficient for tree of heaven to survive the treatment.

If there are trees to be protected near to the controled invasive plants, it is forbidden to intervene at temperatures above 25°C, because the vaporization of the chemical can cause phytotoxicity (poisoning symptoms)!

Depending on the effectiveness of the absorption, some posttreatment may be needed.

Advantages
- useable in a wide time interval, less exposed to weather conditions (wind, rain, etc.),
- due to the paint mixed with the plant protection product, the activity performed can be clearly seen and well controlled,
- has a small investment requirement (bucket, brush, safety equipment),
- area performance for 0.3 to 1 ha / 4 people / 1 working day.

Disadvantages
- much more expensive technology than spraying
- requires a lot of handwork
- resprouting is possible

Cut stump treatment

In addition to basal bark treatment, the cut stump treatment can also be mentioned, during which, after separating the treated specimen from the ground, the surface of the stump remaining in the soil is brushed down to a diameter of 10-20 cm by treating the entire cutting surface and the bark. In case of larger diameters, the treatment should be applied from the bark to the thickness of sapwood. The applied product is a mixture of Garlon 4E and 1:4 gas oil. For this operation, it is important to keep in mind the time factor, and within 20 to 30 minutes after cutting, the stump must be handled before the cell lines on the cutting surface become dry. Late treatment significatly worsens the effectiveness of technology.

Advantages
- Can be used in a wide time interval, even outside vegetation period, but in frost-free weather
- less exposed to the weather (wind, rain, etc.),
- visible, verifiable, due to paint mixed with the plant protection product,
- has a small investment requirement (bucket, brush, safety equipment),
- area performance for 0.3 to 1 ha / 4 people / 1 working day

Disadvantages
- much more expensive technology than spraying
- requires a lot of handwork
- the cutted material must be removed from the stumps, this is extra work,
- resprouting is possible

Trunk injection

For invasive plants thicker than 8 to 10 cm in diameter, basal bark treatment brings no longer satisfactory solution. During the trunk injection a concentrated, 1–2 ml amount of chemical (Medallon, Mezzo mixture, BFA+) is injected directly into the sapwood, into a 5 to 6 mm diameter 5–15 mm long hole by a syringe. The chemical is absorbed in the transport vessels of the plant due to the pressure drop in the transpiration and the capillary effect. The drilled holes are clogged to prevent leaching and evaporation (Fig. 28).

The activity is usually carried out during vegetation period, typically from late April to late September, but winter treatments for black locust also produce satisfactory results.

The number of drilled holes depends on the thickness of the trunk, and the hole should be placed horizontally 5–10 centimeters around the circumference of the trunk. It is meaningless to inject into a dead or decayed part, in which case a body containing a living tissue must be sought.

It is important that the treated tree specimen should be only thrown away after the complete destruction in order to avoid resprouting!

Advantages

- The advantage of injection is that it can be used during the vegetation period with the exception of very rainy or heat-wave periods.
- Area performance varies from about 0.2 to 0.6 ha, depending on site and stand conditions.
- However, it greatly reduces the number of post-treatments of the areas, as the roots suckers develop at least in this technology.

Disadvantages

- The investment needs are relatively high due to the use of high capacity cordless drills and their charging.
- Cost demand is the highest among the applied technologies, and it requires well-assembled and careful implementers.

There were no false indigo stands in the project areas, which consisted of old and more than 8-10 cm diameter at breast height specimens, which would justify the use of this technology. Stands that included specimens with such thick diameters, because of the expanse of sprouts, contained an extra amount of injectable specimens that would have induced additional cost increases. Therefore, for these stands, it was more expedient the shredding of area and then to spray it entirely.

Trunk injection technology was only used on tree of heaven specimens.

Figure 28. The trunk injection of tree of heaven (Photo: Ferenc Kele)

4.3. Demonstration of false indigo experiments: applied methods, chemicals, experiences, results, necessary posttreatments

In Hungary, the number of plant protection products authorized in forest management is low, their exclusive application did not allow to achieve the goals set in the project. Therefore, products that are known to be effective in the targeted plant control have been included. Most of the experiments such products were used that are suitable for treating small and large areas, by machine and hand tools, and in the case of grazing too.

Techniques and conditions of application of the chemical vary from technology to technology. Machine Overall Spraying can be used to treat larger areas in full, while invasive specimens occurring patches are expedient to treat by hand-spraying. The treatment of the specimens per thread can be accomplished by protective funnel.

For areas where the distribution of invasive species is mosaic, it is advisable to carry out the intervention with a backpack motor sprayer, as this technology makes it easier to track irregularly shaped, small areas of 100 m^2 to 0.2 ha. We treat large areaa only in cases with backpack motor sprayer where the field conditions do not allow for machine spraying. The disadvantage of backpack motor spraying is that in the treated area overlaps are often uneven, untreated strips, patches may remain, so usually a couple of weeks later a check-in is necessary to correct the defects.

Where only the treatment of one stand is needed, local point treatment is recommended. The experiments were carried out with a pressurized backpack sprayer of type STIHL SG 51 at a pressure of 2 to 4 bar.

Applying basal bark treatment is recommended for the management of areas under forest stand, as spraying and relocating are difficult in the dense stand.

Presentation of chemicals used in experiments

Galera

Active substance: 267 g/l clopyralid, 67 g/l picloram.

Mechanism of action: both active ingredients in the formulation have a systemic, absorbent action. Clopyralid is one of the pyridyloxycarboxylic acids (O herbicide group) and causes hormone-like symptoms. Picloram (O herbicide group) belonging to the pyridine carboxylic acid also causes hormone-like symptoms. Due to their effect, sensitive weeds are twisted, distorted, and gradually turn yellow, and then die within 2–3 weeks depending on the temperature and weather. It is mainly absorbed by leaf and has a limited soil effect with a rain resistance of 2 hours. During the treatment is necessary at least 12 °C, is not advisable to spray before the expected frost. In willow and poplar energy plantations, the authorized dose is 0.3–0.6 l/ha.

Banvel 480 S

Active substance: 480 g/l dicamba

Mechanism of action: this product with hormonal effect is an aromatic carboxylic acid derivative that influences the growth control of the plant and the resulting disturbances cause the plant to die. Due to its systemic effect it also transports to the root system.

It is authorized in meadows, in grazing cultures in doses of 0.5 to 0.6 l/ha. Grazing is prohibited for 14 days in the treated area.

Lontrel 300

Active substance: 300 g/l clopyralid

Mechanism of action: clopyralid, a picolinic acid derivative, is a pyridyloxycarboxylic acid (O herbicide group). It exerts its effects on the germinated plant, in the coleoptile and hypocotyl, and then on the shoot- and root apex, cambium, axial buds and meristematic regions of the nodes. Hormone-type preparations work best when the plant is in an intensive growth phase. It inhibits longitudinal growth, bud differentiation and flowering. It already inhibits auxin transport in low concentrations irreversibly, and destroys the transport tissues.

Authorized plant protection product in willow and poplar energy plantations at a dose of 0.4–0.8 l/ha.

Mezzo

Active substance: 200 g/kg of metsulfuron-methyl

Mechanism of action: sulphonylurea-type herbicide, by blocking the function of ALS enzymes,

blocks protein synthesis. The composition affects through both the leaf and the root. In combination with a glyphosate-active agent, a total herbicide-authorized chemical for the weed control of railway tracks at a dose of 60–100 g/ha.

Taltos 450 WG

Active substance: 355 g/kg aminopyralid + 150 g/kg florasulam

Mechanism of action: The Taltos 450 WG contains two active ingredients. Florasulam belongs to the sulphonyl anilide family, and it is a so-called ALS inhibitory. However, unlike classical sulfonylureas, it acts on other interfaces. The aminopyralidic active ingredient belongs to the pyridine carboxylic acids and is related to the active ingredients of the Starane 250 EC and Lontrel 300 herbicides, but it is much more active (dose only 10 grams per hectare). In terms of its mode of action, it is a growth regulator and transported very effectively by xylem and floem transport; it accumulates in the shoot apex and reaches the root system in high concentrations (e.g. in the roots of creeping thistle).

It is authorized in autumn wheat, barley, rye, triticale and oat crop at a dose of 33 g/ha.

Garlon 4E

Active substance: 480 g/l tryklopir

Mechanism of action: product with hormone effect, it belongs to the heterocyclic oxyacetic acid derivatives. Systemic leaf and root herbicide, mainly against dicotyledonous weeds, but it is also used in shrub control. Garlon 4E is the only oil-soluble herbicide that can absorb through the thin bark of the 1–3-meter-high (no longer sprayable) sprouts or the cutting surface of the stumps and prevent resprouting. It is not authorized in the European Union, but its active substance is included in the list of active substances supported by the EU. This plant protection product can be used in the control of invasive alien plants nder emergency authorization.

BFA+ tank mix

Active subtance: Medallon Premium (360 g/l glyphosate) and Mezzo (200 g/kg metsulfuron-methyl) oil emulsion

Mechanism of action: In early injection experiments, the synergistic effect of the active ingredients of the tank mix was shown in the tree of heaven. In the combination of glyphosate and metsulfuron-methyl, fewer root suckers were developed by injecting tree of heaven in the following years than using the active ingredients separately. It can be clearly established that the basal translocation of the two active ingredients is strong, and therefore reaches the dormant buds in the horizontal root system, which die with the root part. Several international publications refer to the synergistic effect of glyphosates and metsulfuron-methyl (Kudsk and Mathiassen 2004, Singh 2009).

In this tank mix, a low surface tensioned, pigment-painted suspoemulsion was developed that absorbed through the bark of thin-bark tree species. After absorption, the emulsion exhibits a strong basal translocation similar to the active ingredient combination injected. In the tank mix, 33% Medallon Premium and 0.3% Mezzo herbicides are mixed. The licensing documentation of adjuvant in the tank mix has been compiled and it licensing begin in spring 2019. The use of Medallon and Mezzo at such doses is subject to emergency authorization.

Dates of experiment implementations

In order to be able to evaluate the autumn treatments well before the project was completed, the experiments had to be carried out already in autumn 2017, before the complete outage of the vegetation.

- autumn 2017, full-field spraying with machine application
- end of May 2018, early June, treatments of subareas with manual application

The purpose of autumn treatments is to determine the absorbtion success of applied herbicides into the roots of false indigo in the late autumn period; and how much is the rate of resprouting in the next vegetation period, in the meadow and pasture farmed Bogdása 10 TI. Interventions should be carried out with the greatest possible care for grassland vegetation.

In summer treatments, we were curious about the reactions of false indigo to the basal bark treatments in the period of intense growth, which have been used effectively during the summer. Our further question concerned to the rate of survival and repsouting activity of false indigo after treatment at a higher temperature.

A summary evaluation table for experimental

treatments is provided in the appendix to this publication. The table evaluates the results recorded in each parcel by the treatment types specified in the experimental thematics.

4.4. Summary of experimental results

4.4.1. Non-chemical control methods

Mechanical cutting – grazing posttreatment

Location: Bogdása 10 TI
Following the use of the agricultural chain stem shredding by the agricultural tractor MTZ 82 in Bogdása 10 TI area, the resprouting false indigo have been grazed by cows in the designated and fenced area (Fig. 29). During their feeding, the cows tear the young seedling out of the ground, and they are also eager to consume the leaves and fresh shoots of false indigo. Based on the spring 2019 evaluation, it can be seen that 1.5 vegetation years are not sufficient to reduce the number of false indigo. A significant reduction of the specimen number, based on available literature (Csiszár and Korda 2017), requires much more time (3–5 years). The use of this environmentally friendly treatment method should in any case be considered in continuous areas where regular grazing or mechanical suppression can be achieved. However, it should also be emphasized that the treatment of areas, edges, trenches and buffer zones that cannot be folded by the electric fence or which are not accessible to the machine must be solved by some other technology. Further examination of the treatment method and annual assessment of the specimen number is recommended.

Figure 29. Grazed area in the spring of the second year (Photo: István Szidonya)

Mechanical cutting – mechanical posttreatment

Location: Teklafalu topographic number 0131
In the area of treated trench, we cut the false indigo specimens with a cleaning saw. The area must be returned several times during vegetation and the resprouting vegetation must be cut off again. According to our current experience, mechanical cutting is not suitable for the complete eradication of false indigo, and it is expected that the species will not disappear after several years, only partial suppression can be achieved.

4.4.2. Chemical control methods

Basal bark treatments without mechanical pretreatment

Location: Lakócsa 5TN and Teklafalu 7CE
Date: May 31, 2018.

Garlon 4E and gas oil mix 1:4
As a result of basal bark treatment (Teklafalu 7CE), the treated approx. 5 m high, 4–5 years old false indigo stand has dried up around 100% (Fig. 30) with the undergrowth. The effect refers to the high degree of gassing of Garlon 4E at high temperatures, which is a known adverse side effect of previous treatments. After the cutting of the stand, in the next vegetation period these specimens were completely died away, and there was no resprou-

ting. Treatment can be considered highly successful and recommended, but given that the license for Garlon 4E has expired in the European Union, purchasing is only possible outside the EU with an emergency permit, so organizing this treatment may be problematic.

BFA+ tank mix

In the Lakócsa 5 TN forest subcompartment, the basal bark treatment of 2–3-year-old fals indigo stands resulted in a 70% solution (Fig. 31).

After the treatment, some of the upper branches of the thicker-trunked specimens remained alive, but the thinner, branch-free shoots were dry.

According to the evaluation performed during the posttreatment period, the treatment was successful, the treated speciemens were died away, and resprouting was not experienced. The authorization procedure for the herbicide used has begun, and hopefully will be successful. The formulation contains glyphosate, so the ban on glyphosates may compromise the applicability of the technology after 3 to 4 years.

Experiments on bark treatment without mechanical pretreatment of false indigo were successful with the Garlon 4E and Diesel 1:4 mixture and the BFA+ tank mix as well (Fig. 32–33). Thus, this method is recommended for suppressing 1 to 2 meter high, 1 to 2 year old, non-branched specimens that have not formed sprout bunches because of previous mechanical cut.

Figures 30–31. The result of basal bark treatment with Garlon 4E (left) and BFA+ (right) in the year of treatment (Photos: Ferenc Kele)

Figures 32–33. The result of basal bark treatment with Garlon 4E (left) and BFA+ (right) in the year after treatment (dried branches were cut down after the expression of effect) (Photos: Ferenc Kele)

Mechanical cut and chemical stump treatment

Location: Bogdása 10G
Date: June 06, 2018.
In 25 to 30-year-old, closed oak forestation, under the stand, at the knee height, false indigo stumps were treated chemically on the cut surface and in the bark below it, after cut back with Stihl FS 490 clearing saw and Göhler scissors.

Garlon 4E and gas oil mix 1:4
About 100% of the treated specimens dried up (Fig. 34). No resprouting at the time of evaluation was observed. At the site of lubrication, the loss of leaves and shoots from gassing was also observed, up to a height of about 2.5 m. This good results were also confirmed by the next year evaluation. In spite of the emergence of a single seedling or root sucker, it can be stated that the treatment eradicated the treated false indigo stand (Fig. 36). There was no phytotoxicity in 2019. Treatment can be recommended for treating branched older specimens in the open field or, due to the risk of phytotoxicity from evaporation, under older forest stands.

BFA+ tank mix
The treated specimens dried up, but there was significant resprouting at the time of first evaluation on the treated stand (Fig. 35). However, these sprouts died away during the year of treatment. In the next year's assessment, there was only a small-scale root suckering, so the treatment was successful (Fig. 37). Besides the sprouts, some hornbeam seedlings showed mild phytotoxic symptoms.

Figures 34–35. The result of stump treatment with Garlon 4E (left) and BFA+ (right) in the year of treatment (Photos: Ferenc Kele)

Figures 36–37. The result of stump treatment with Garlon 4E (left) and BFA+ (right) in the year after treatment (Photos: István Szidonya)

Manual spraying – spotspraying

Location: Teklafalu 8D
Date: July 31, 2018.

Lontrel 300 at a dose of 1.5 l/ha

The location of the treatment is the designated area of strong false indigo group in the forest edge of 20 years old oak forestation, with a height of 1.2 to 1.8 m of false indigo (Fig. 40).

In the treated areas, the upper part of the false indigo is blackened, extending towards the lower shoot parts. The lower shoot parts, close to the root collar were drooping in a large proportion, but in a small proportion they still seemed viable.

As a result of the treatment, oak saplings under the previous false indigo stands have emerged without any phytotoxic symptoms (Fig. 38–39). The phytotoxic symptoms resulting from the treatment did not appear on forest stands near the treatment.

No resprouting was seen in the year after treatment, so treatment can be considered excellent (Fig. 41). The main problem with the applicability of the treatment is that the effective dose is twice the authorized dose, so it is only possible to use the technology when an emergency permit is available. Providing emergency authorization – given that environmental risk assessments have been tested at a lower dose during the authorization procedure – it is questionable or the authority may require these tests. Another downside to treatment is the high cost of herbicides. Treatment can be recommended for efficient treatment of open areas, escarpes, and forest edges.

Figures 38–39. Living oak sapling due to treatment selectivity (left) and the boundary of untreated and treated area (right) (Photos: Ferenc Kele)

Figures 40–41. The result of treatment with Lontrel 300 in the year of treatment (left) and in the year after treatment (right) (Photos: Ferenc Kele and István Szidonya)

Location: Bogdása 10TI

The site is a meadow, a pasture-treated forest area (Fig. 42), where has previously been mechanical mowed and then treated chemically. About 15–20% of the sites were infected with false indigo sprouts.

Figure 42. Bogdása 10TI untreated control area (Photo: Ferenc Kele)

Banvel 480 S 1,0 l /ha

The upper part of the directly sprayed specimens is blackened, but then resprouted in combination with twisting symptoms (Fig. 43). Larger specimens that did not have the entire surface of the spray liquid, distorted but survived the treatment.

In the immediate surroundings of the point spraying, the vegetation was completely burned. From the human health point of view, the feasibility of manual treatments is doubtful due to the penetrating smell and irritant effect of the mucosa.

In the 2019 evaluation, significant resprouting was observed in the treated area (Fig. 44), so treatment cannot be considered successful.

Figure 43. The result of spot spraying with Banvel 480 S in the year of treatment (Photo: Ferenc Kele)

Figure 44. The result of spot spraying with Banvel 480 S in the year after treatment (Photo: István Szidonya)

Galera 0,6 l/ha

Smaller specimens drooped completely black in the treated area, the larger specimens leaning to the ground due to strong twisting symptoms (Fig. 45). From a human health point of view, due to the penetrating smell and mucosa irritating effect of the spray liquid, the feasibility of the manual treatments is doubtful. In the 2019 evaluation, significant resprouting was observed in the treated area (Fig. 46), so treatment cannot be considered successful.

Taltos 450 WG 66 g/ha

Treated specimens were curved, distorted, drooping shoots, stopped growing, and the development of the surrounding vegetation also stopped, so the phytotoxic symptoms are less pronounced (Fig. 47). In the 2019 evaluation, significant resprouting was observed in the treated area (Fig. 48), so treatment cannot be considered successful.

Figure 45. The result of spot spraying with Galera in the year of treatment (Photo: Ferenc Kele)

Figure 47. The result of spot spraying with Taltos 450 WG in the year of treatment (Photo: Ferenc Kele)

Figure 46. The result of spot spraying with Galera in the year after treatment (Photo: István Szidonya)

Figure 48. The result of spot spraying with Taltos 450 WG in the year after treatment (Photo: István Szidonya)

5. CONCLUSIONS, ADAPTABILITY

In the project, several significant results have been achieved with the problems caused by invasive plant species. An important practical result in the project area is the survey of areas affected by invasive species and specific invasive plant control carried out about 155 hectares. The result beyond the boundaries of the project area is the different technologies developed to control of false indigo. Its importance lies in the fact that – as opposed to tree of heaven and black locust – only a few examples are known for successful control of false indigo (Csiszár and Korda 2017), so there are only a limited number of "recipes" available of successful control of the species. The main objective of the project was to fill this gap and develop control methods that allow the different types of false indigo stands to be suppressed (e.g., patchy, homogeneous, continuous, under tree stand, etc.). Here developed control methods can be applied outside the project area for false indigo control.

Successful control technologies developed for false indigo control are presented below.

Non-chemical methods

According to the experience of the project, the false indigo control by mechanical methods (flail mowing, stem shredding) and combining them with grazing during the 1.5 vegetation period – due to intensive resprouting – did not produce satisfactory results. However, according to the experience from the Tisza and Körös rivers, the species can be successfully control by grazing after flail mowing over a longer period of time, as cattle are eager to graze the false indigo (Sipos 2017). Regular mowing of sprouts can be successful too. Accordingly, if the area to be cleared (clearing, meadow, pasture) can be grazed or regularly mowed, this can be the most environmentally friendly option for false indigo control.

Combined control methods

If grazing or mowing of the area cannot be ensured, it is advisable to use a combination of mechanical and chemical methods to eradicate the large, over 1 meter tall specimens consisting (infected for several years) false indigo stands in clearings, meadows or pastures.

Flail mowing in summer, then machine spraying at the end of August – at the beginning of September is recommended with an increased (1.5 fold) dose of Lontrel 300, with possession of an emergency permit. For successful treatment, it is advisable to use other factors too (400 l/ha spray, 0.025% Silwet Star and 1 l/ha Catane spray oil). If the field features do not allow machine spraying, the application of the chemical should be done by spot spraying. In such stands, bark treatment would be feasible in practice.

Chemical methods

It is advisable to schedule chemical treatments for the early autumn period, when the great summer warmth disappear and the maximum daily temperature does not reach 25°C. In the vegetation to be treated, the nutrient transport reverses towards the root zone, so the effect of the herbicide is stronger, and it can destroy most of the root system.

For hormone-sensitive forestation, forest stands, edges, areas with sensitive tree species (such as black locust) and with machine passable oak afforestation, the use of Lontrel 300 herbicides is required at 1.6 l/ha. In the case of large false indigo stands, treatments should be done after early summer shredding in early autumn, after the night temperature fall around 10 degrees. Lontrel 300 can not be absorbed through the wax layer of oak leaves without adjuvant, so it can be applied. Further experiments are expedient to possible reduce the dose.

In the case of small, low-closure false indigo sprouts, manual spot spraying with a hydraulic drop-shaped backpack sprayer can be recommended in both forestation and meadow. During the implementation, the use of Lontrel 300 herbicide at a dose of 1.6 l/ha is recommended with the parameters given in the machine spraying. Treatment should be carried out in the waxy state of oak leaves to avoid any loss of growth due to phytotoxicity.

Bark and stump treatment technologies have proved to be effective. At places where there is a need for gentle treatment due to protected species or other species to be preserved, it is strongly recommended while minimizing habitat disturbance. This procedure is also recommended when treatment of trenches, forest edges, buffer zones, or starting colonization.

If the control work is delayed and / or there is a need to reduce the multi-year old sprouts under the stand, the basal bark treatments should be performed in the late autumn or early spring with a mixture of Garlon 4E and gas oil 1: 4. In the case of high and densely branching stands, it is advisable to cut of the specimens with a higher stump and to apply herbicide on the cut surface and the cortex below.

Spraying is not recommended in black locust forestation because of the increased chemical sensitivity of the species. Here beyond the vegetation period (late autumn to next spring budburst), it is recommended basal bark treatment or stump treatment using long-stemmed brush with BFA+ tank mix or 1: 4 mixture of Garlon 4E and gas oil, depending on the size of false indigo stands.

6. NATURE CONSERVATION BENEFITS OF THE PROJECT

According to a survey conducted in 2017, the most significant threat in Hungarian protected and Natura 2000 areas is the spread of invasive alien plant species (Kézdy et al. 2017). Accordingly, the number of nature conservation projects that place a strong emphasis on invasive plant control has been increasing in recent years. Oak Protection is one of these project coordinated by Mecsekerdő Zrt. and Našice Forestry, whose strategic objective is the invasive species control in order to protect the native species and the habitats of the Pannonian Biogeographical Region. At the international level, the main conservation benefit of the project is the expansion of knowledge about the invasive plant control (detailed in Chapter 6), and the clearing of 155.17 ha area from invasive woody species on local level. Invasive plant control can only be successful if all seed producing trees and infection focal points in the given area will be abolished crossing administrative and other borders. There are several neighbouring areas that are in foreign management (Table 3), and are untreated due to lack of source or expertise. Therefore, with the support and approval of the owners / trustees, these areas have become part of the project area for the long-term sustainability of the project results. Otherwise, the abandoned invasive specimens would spread in the project area again due to their seed or fruit dispersal.

We will review in more detail below how the project contributed to maintain or improve the favourable conservation status of habitats and species of Community interest and priority species and habitats.

Table 3. The extent of areas affected by invasive species according to managers and species

Owner / Manager	Area affected by invasive species [ha]			
	Black locust	Tree of heaven	False indigo	Total
Mecsekerdő Zrt.	2.91	22.57	118.18	143.66
Other areas	2.35	-	9.16	11.51
Total	**5.26**	**22.57**	**127.34**	**155.17**

Habitats

During the project, three invasive woody species – namely, the false indigo (*Amorpha fruticosa*), tree of heaven (*Ailanthus altissima*) and black locust (*Robinia pseudoacacia*) – have been suppressed in a total area of 155.17 ha (Table 3).

The most problematic species in the project area is the false indigo, which occurs on some 127.34 hectares. It has appeared primarily along roads and watercourses, from which it spreads very quickly and aggressively. In addition, it is also present in forest rides, forest edge shrubberies and forests with low canopy closure. The most affected habitats are non Community interest, secondary habitats (roadsides, watercourses), but through them the species can reach other forest and treeless habitats successfully and spread widely. For this reason, it is of the utmost importance that the species control should not be limited to the habitats of Community interest, but also to these secondary habitats, so that regular reinfection can be prevented too.

The tree of heaven causes problems in 22.57 ha of the treated area. Experience shows that infections start from secondary, disturbed habitats (railway embankments, watercourses, neglected

private areas), from where the species can reach valuable habitats due to its winged fruits, and create large stands in a short time.

Compared to the above-mentioned species, the black locust occurs in smaller but not negligible area (5.26 ha) as undesirable, invasive species. Based on experience – as a light-demanding and drought-tolerant tree species – typically appears after the end-use of native forest stands. During the reforestation, black locust hinders the development of native, initially slowly growing tree species and can suppressed them. In addition, it is spreading along the roads, forest rides, forest edges, but it also appears in the second canopy of native forests in many places. The control of three invasive species mentioned above affected directly the stands of Illyrian sessile oak-hornbeam forests (91L0) and hardwood floodplain forests (91F0) from the forest habitat types of Community interest. The extent of the Illyrian sessile oak-hornbeam forests treated in the project is 30 ha. The total area affected by these invasive species was 10 ha. In the case of the 248 ha hardwood floodplain forest involved in the project, the infected area was 35 ha in total. The favourable conservation status of these habitats has been improved by interventions.

In addition, it is important to mention the indirect conservation benefits of the interventions. The control of these species by eradication of infection foci relieves many treeless Natura 2000 areas from the potential threat of invasive species.

Species

Invasive plant control during the project not only improves the favourable conservation status of habitats of Community interest, but also the species associated with the habitats concerned. The interventions were not affected Natura 2000 species directly, but through invasive plant control the long-term conservation of their habitats may be ensured more likely, which is the key to the survival of these species. In addition to invasive plant control, an important aim of the project is to increase the deadwood supply, which is also a vital habitat element for many beetle species of Community interest.

a. Plant species

Greater pasque flower (*Pulsatilla grandis*)
It is a protected and community plant species of open, dry habitats, which can be found in the opening of scrubs and dry grasslands. Its habitat is most threatened by the spread of the shrub species during the natural succession and by invasive species. Among the latter, the spread of black locust and the tree of heaven causes problems in the project area. Interventions were preventive, targeting invasive tree species around the known habitat of *Pulsatilla grandis*, thus preventing the invasion of its habitat.

b. Forest beetle species of Community interest associated with decaying wood and deadwood

Three protected beetle species and species of Community interest occur in the area affected by the project. The essential condition for their long-term conservation is the provision of a sufficient quantity and quality of deadwood and decaying trees.

The **great capricorn beetle (*Cerambyx cerdo*)** binds to the still alive but already decaying old oak trees – most often to the pedunculate oak. Its larvae develop in sunny thicker branches or trunks. Because larvae are large and require a large amount of food, thinner branches are not suitable for their development. For this species, the oldest decaying trees standing in openings, forest gaps or forest edges are the most favourable. In the forest stand, only the larger, thicker, sunny branches of the large oaks at the upper canopy are suitable for the development of larvae. The essential condition for the long-term conservation of the species is the welfare of the elderly, decaying oaks in the habitats of beetle, and the continuous development of these, i.e. the creation of a network of so-called biotope trees (Hegyessy and Merkl, 2014a, Magos 2018).

The development of **stag beetle (*Lucanus cervus*)** larvae requires the presence of deadwood under the soil surface. In most cases, this means dead stumps or dead roots of still living trees, but thicker, partly in the soil embedded lying trunks are also suitable. The species is associated mostly with oaks, but the expansion of its food spectrum has recently been observed, e.g. it also develops on

willow and fruit trees. The key of long-term conservation of the species is the saving of old, decaying or dead, but still standing trees, the total avoidance of stump removal furthermore the presence and undisturbance of the thicker deadwood. The most significant predator of the beetle is the wild boar, whose population regulation – along with many other conservation and economic benefits – would also help to preserve the species (Merkl, 2014, Magos, 2018).

The **longhorn beetle (*Morimus funereus*)** develops in thicker stumps or dead roots. The larvae are large, therefore the thinner deadwood is not suitable for them. Its development is mainly known in oaks, but several other tree species proved to be served as its host plant. The long-term conservation of the species requires the preservation of old decaying or dead but still standing trees, as well as the avoidance of stump removal and total site preparation (Hegyessy and Merkl 2014b, Magos 2018).

For all of the species discussed, their survival is greatly enhanced by continuous cover forestry, the creation of mixed aged forest stands, the conservation of seed trees and witness trees (so-called 'biotope trees'), and the creation of an appropriate network of these.

In connection with the development of the deadwood supply, one of the forest stands of the project area, the Szentegát forest block deserves special attention. This area represents high natural value, and a part of it is protected by nature conservation area of national importance under the name of Szentegát forest Nature Conservation Area. In the area, the hornbeam-oak forest is the dominant habitat, in which transformed beech forests and in smaller extent hardwood floodplain forests are found. These beech forests are already rare in this area. The value of the area is indicated by the occurrence of a number of protected plant species (e.g. *Dryopteris carthusiana, Polystichum setiferum, Polystichum aculeatum, Neottia nidus-avis, Platanthera bifolia, Neottia ovata, Epipactis helleborine* and *Daphne mezereum*, which is rare in the flatlands), as well as bird species associated with older beech trees, e.g. the cavity excavator *Dryocopus martius* and the cavity nesting *Columba oenas*. Many other bird species are nesting in the forest, e.g. *Milvus milvus, Milvus migrans, Haliaeetus albicilla, Pernis apivorus* and *Turdus viscivorus.* It is not surprising, as it is an old forest block, that a large population of *Lucanus cervus* lives in the area associated with deadwood. The oldest stands of the forest block are 140–145 year old sessile oak-hornbeam forests mixed with ash. In these forests, Mecsekerdő Zrt. carries out a special management aimed at protecting both natural and economic values of the old forests. The management activities are based on regular measurements and monitoring. The company also incorporates state-of-the-art tools into this work, e.g. the area's lying deadwood supply was surveyed by remote sensing and drone. Records made by drone (Fig. 49) provide an opportunity to record the unique position of deadwood, and in the longer term to monitor and evaluate the changes occurring. In addition to estimating the deadwood amount, invasive plant control was implemented in the infected area of 7.26 ha of the protected forest block. Tree of heaven occurred in 6.15 ha was controlled by bark treatment, while

Figure 49. Drone record for the registering the deadwood supply of the forest (Photo: Mecsekerdő Zrt.)

black locust occurred in 1.11 ha was controlled by cut stump treatment, followed by full-scale manual herbicide apply for both species.

c. Butterfly species of Community interest associated with forests

Scarce fritillary (*Euphydryas maturna*)
It is a very special life-style butterfly species that requires native ash species or common privet rich shrub layer, and sunny openings or clearings rich in *Veronica* species and dicotyledonous herbs (mainly *Asteraceae* and *Apiaceae* species) to survive (Ábrahám and Sum 2014, Korompai 2018). The spread of false indigo endangers mostly these latter habitats, resulted in disappearance of an important element of habitat mosaic essential for butterfly species. False indigo control allows the regeneration of these open habitats, which significantly improves the conservation status of the butterfly species.

d. Butterfly species associated with open habitats

The **large copper (*Lycaena dispar*)** and **scarce large blue (*Maculinea teleius*)** are protected butterfly species and species of Community interest, which are associated with wet meadows (Bálint 2014, Bálint és Ambrus 2014). Conservation of their populations is essential to maintain the traditional land use of their habitats. Treeless habitats (e.g. opening, shrubbery, wildland) occurred at 15 locations, with a total of 65.1 ha of project area, could serve as potentially suitable habitat for these butterflies, but due to the false indigo invasion this role could not be filled. During the project, the false indigo control has begun in these areas, which has resulted in a significant reduction in cover of species and its eradication in some places. It is planned to maintain and further improve the favourable conservation situation in the long term by grazing the areas. As a result of these treatments, regeneration of the meadow is expected, which in the long run may result in the return of the two Natura 2000 butterfly species.

Hardwood floodplain forest with high naturalness along the Drava. Its conservation is in our common interest (Photo: Márton Korda)

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APPENDIX

Results of 2018 treatments

Treatment success was evaluated on a 5-grade scale, with 5 being successful treatment.

Field treatments with field sprayer

Bogdása 10 Tl		Treatment: 29 Sept 2017		Culture: meadow, pasture with strong infestation of false indigo		Date of recording: 22 May 2018	Culture: meadow, pasture with strong infestation of false indigo		Date of 2nd recording: 12 June 2018
Parcel	Chemical	Concentrations	Method of application	Success of treatment	Evaluation of treatment	Phytotoxicity	Success of treatment	Evaluation of treatment	Phytotoxicity
1	Galera	1,2 l/ha	Field sprayer, 400 l/ha spray, 0.025% Silwet-Star as adhesive + 1 l / ha spraying technological Catane white oil	5	There is no seedling in the area. On the treated plots an average of about 90 cm height of plants have sprouted.	n.a.	5	Most of the sprout bunches died away, the rate of resprouting is about 5 %.	It is not experienced in the oak saplings occurring in the area.
2	Banvel 480 S-Mezzo	1 l/ha + 50g/ha		5	There is no seedling in the area. On the treated plots an average of about 45 cm height of plants have sprouted.	n.a.	4,5	Most of the sprout bunches died away, the rate of resprouting is about 5 %.	It is not experienced in the oak saplings occurring in the area.
3	Banvel 480 S-Mezzo	1 l/ha		5	There is no seedling in the area. On the treated plots an average of about 85 cm height of plants have sprouted. We have found specimens that have completely dried. We think of an application error (double sprayed specimens).	n.a.	4,5	Most of the sprout bunches died away, the rate of resprouting is about 5 %.	–
4	Lontrel 300 - Banvel	0,8 l/ha + 1l/ha		5	There is no seedling in the area. On the treated plots an average of about 50 cm height of plants have sprouted. There is an application error, the area have not covered everywhere.	n.a.	5	Most of the sprout bunches died away, the rate of resprouting is about 5 %.	–
5	Lontrel 300 - Banvel 480 S	1,6 l/ha		5	There are many seedlings in the area. On the treated plots an average of about 50 cm height of plants have sprouted, but there are plants about 90 cm height too. There is an application error, the area have not covered everywhere.	n.a.	5	Most of the sprout bunches died away, the rate of resprouting is about 5 %.	It is not experienced in the oak saplings occurring in the area.
6	Taltos 450 WG	66g/ha		3	Several knots have started and sprouted. There are many seedlings in the area. On the treated plots an average of about 40 cm height of plants have sprouted. There is an application error, the area have not covered everywhere.	n.a.	1	The resprouting is significant from the sprout bunches.	–

Mechanical treatment

Teklafalu topographical number 0131		Culture: trench with strong infestation of false indigo		Date of recording: 04 Sept 2018		Culture: trench with strong infestation of false indigo		Date of recording: 06 June 2019	
Parcel	Treatment	Success of treatment	Evaluation of treatment	Phytotoxicity	Comments	Success of treatment	Evaluation of treatment	Phytotoxicity	Comments
1	Mechanical – mechanical post-treatments	2	A case-by-case solution. It does not solve the problem.	–	Re-sprouting should be evaluated		Thin 50-60 cm sprouts are growing in sprout bunches.	No	The treatment is unsuccessful or longer continuous mechanical treatment is necessary to reduce the number of specimens.

Mechanical treatment

Bogdása 10 TI		Culture: meadow, pasture with strong infestation of false indigo		Date of recording: 04 Sept 2018		Culture: meadow, pasture with strong infestation of false indigo		Date of recording: 06 June 2019	
Parcel	Treatment	Success of treatment	Evaluation of treatment	Phytotoxicity	Comments	Success of treatment	Evaluation of treatment	Phytotoxicity	Comments
1	Mechanical cut – grazing posttreatments	3	Effect after several years visible only. The area can be clean after multi-annual treading and the removal of the sprout bunches.	–	Resprouting should be evaluated		Cannot be evaluated	No	Cannot be evaluated due to a short time interval after treatment.

Mechanical pretreatment and cut stump treatment

Bogdása 10G		Treatment: 06 June 2018		Culture: young oak forestation with strong infestation of false indigo		Date of recording: 04 Sept 2018		Culture: meadow, pasture with strong infestation of false indigo		Date of 2nd recording: 06 June 2019	
Parcel	Chemical	Concentration	Method of application	Success of treatment	Evaluation of treatment	Phytotoxicity	Comments	Success of treatment	Evaluation of treatment	Phytotoxicity	Comments
1–4.	Garlon 4E - gas oil	1:4	Cut stump treatment +bark treatment	5	Treated stumps have 100% dried away, without trace of resprouting.	Damage due to dripping is not, but due to gassing leaf drying up to a height of 1.5-2.5 m was observed.	Resprouting should be evaluated	5	Stumps of dead specimens are visible, stumps are dead, some root suckers or seedlings are found in the area.	Not visible	Treatment is recommended
5–8.	BFA+	Ready for use	Cut stump treatment +bark treatment	2	Treated stumps have 100% dried away, but significant resprouting occurred.	–	Resprouting should be evaluated	4	Stumps of dead specimens are visible, stumps are dead, some root suckers or seedlings are found in the area.	Not visible	Treatment is recommended

Spot spraying

Bogdása 10TI (Lontrel Teklafalu 8D)		Treatment: 31 July 2018		Culture: meadow, pasture with strong infestation of false indigo		Date of recording: 04 Sept 2018		Culture: meadow, pasture with strong infestation of false indigo		Date of 2nd recording: May - June 2019	
Parcel	Chemical	Concentration	Method of application	Success of treatment	Evaluation of treatment	Phytotoxicity	Comments	Success of treatment	Evaluation of treatment	Phytotoxicity	Comments
1–4.	Banvel 480 S	1l/ha	Spot spraying	3	The upper part of the directly sprayed specimens is blackened and dried away, but the resprouting can be seen in combination with twisting symptoms. Larger specimens, whose incomplete surfaces received spray, were distorted, but survived the treatment.	In the immediate surroundings of the spot spraying, the vegetation is burnt out.	Resprouting should be evaluated next year.	1	The sprout bunches in the area are lively, with a significant number of fresh shoots.	It has not been tested.	–
5–8.	Galera	0,6 l/ha	Spot spraying	5	In the treated area, the smaller specimens drooped completely black, the larger individuals lean on the ground due to strong twisting symptoms.	In the immediate surroundings of the spot spraying, the vegetation is burnt out.	Resprouting should be evaluated next year.	2	The sprout bunches in the area are lively, with a few fresh shoots without phytotoxic symptoms, some dry stumps found.	It has not been tested.	It is possible to have multiple „fatigue" or "shared treatments" would have a better effect.
9–12.	Taltos 450 WG	66 g/ha	Spot sprayings	5	Treated specimens are curved, distorted, showed drooping shoots, their growth rates stopped, and the development of the surrounding vegetation stopped too.	Less pronounced phytotoxic symptoms occurred in the environment	Resprouting should be evaluated next year.	1	From the sprout bunches intact shoots develop.	It has not been tested.	–
13–16.	Lontrel 300 (Teklafalu 8 D)	1,6 l /ha	Spot spraying	5	In the treated areas, the upper part of the false indigo is blackened, extending towards the lower fold parts. The lower shoot parts near to the root collar have dried in a large proportion, but still appear viable in a small proportion. During treatment, the size of the false indigo was 1.2-1.8 m high.	Oak saplings appeared in the treated area!	Resprouting should be evaluated next year.	5	The treated area is occupied by monocotyledons, a false indigo is not found in the area. Treatment is proved to be completely successful.	It has not been tested.	The technology is recommended for false indigo control.

Results of 2019 treatments

Mechanical treatment					
Bogdása 10TI and Teklafalu 0116		Culture: meadow, pasture with strong infestation of false indigo		Date of 1st recording: 06 June 2019	
Parcel	Treatments	Success of treatment	Evaluation of treatment	Phytotoxicity	Comments
1	Mechanical cut – grazing posttreatments	?	The effect cannot be evaluated.	No	Due to the fresh grazing sprouts have not appeared yet.
2	Mechanical – mechanical posttreatments	?	The effect cannot be evaluated.	No	Due to the fresh grazing sprouts have not appeared yet.

Mechanical pretreatment and cut stump treatment							
Bogdása 10ÚT		Treatment: 02 May 2018		Culture: young oak forestation with strong infestation of false indigo		Date of 1st recording: 06 June 2019	
Parcel	Chemical	Concentration	Method of application	Success of treatment	Evaluation of treatment	Phytotoxicity	Comments
1–4.	Garlon 4E - gas oil	1:4	Lubrication	3	The treated specimens have dried away.	Due to the gassing of Garlon 4E phytotoxic symptoms occurred on sprouts developed later near to the treatment.	New sprouts have developed since the implementation, probably not seen at the time of treatment. Due to the continuous sprouting, spring treatment is not recommended.
5–8	BFA+	Ready for use	Lubrication	4	The treated specimens have dried away.	Not visible	

Basal bark treatment							
Teklafalu 7 CE (Garlon 4A), Lakócsa 5 TN (BFA+)		Treatment: 31 May 2018		Culture: meadow, pasture with strong infestation of false indigo		Date of 1st recording: 12 June 2018	
Parcel	Chemical	Concentration	Method of application	Success of treatment	Evaluation of treatment	Phytotoxicity	Comments
1–4	Garlon 4E - gas oil	1:4	Lubrication	5	Most of the branches have dried, leaves subsisted on some branches.	No	–
5–8	BFA+	Ready for use	Lubrication	3	Leaves on the branches are withered, the effect is cannot be evaluated yet.	No	Due to the different action mechanism of the chemical, the effect may be longer.

Basal bark treatment (continue of the table)							
Date of 2nd recording: 31 July 2018				Culture: meadow, pasture with strong infestation of false indigo		Date of 3rd recording: 06 June 2019	
Success of treatment	Evaluation of treatment	Phytotoxicity	Comments	Success of treatment	Evaluation of treatment	Phytotoxicity	Comments
5	Treated specimens are almost completely dried, the undergrowth has dried under the treated specimens (avoid dripping!)	No	In 2019, it is recommended to evaluate the cut stumps and the re-sprouting	5	There are no living specimens in the area, the dead specimens have been cut, and the stumps have died.	Leaf curl is observed in the nettle groups close to the treatment.	Treatment is recommended. The specimens living next to the treated area are likely to be root suckers of untreated specimens of the outside area.
3,5	The treated specimens were largely dried, but live branches were left at the lateral branches (older specimens). In the case of sprout bunches, it is not enough to treat the main specimens, all stems must be treated.	No	In 2019, it is recommended to evaluate the cut stumps and the re-sprouting.	5	There are no living specimens in the area, the dead specimens have been cut, and the stumps have died.	Not visible	Treatment is recommended. The specimens living next to the treated area are likely to be root suckers of untreated specimens of the outside area.

Basal bark treatment							
Bogdása 9NY		Treatment: 02 May 2018		Culture: meadow, pasture with strong infestation of false indigo		Date of 1st recording: 06 June 2019	
Parcel	Chemical	Concentration	Method of application	Success of treatment	Evaluation of treatment	Phytotoxicity	Comments
1–4.	Garlon 4E - gas oil	1:4	Lubrication	5	There are no living specimens in the area, the dead specimens have been cut, and the stumps have died.	Leaf curl is observed in the nettle groups close to the treatment.	Treatment is recommended. The specimens living next to the treated area are likely to be root suckers of untreated specimens of the outside area.
5–8.	BFA+	Ready for use	Lubrication	5	There are no living specimens in the area, the dead specimens have been cut, and the stumps have died.	Not visible	Treatment is recommended. The specimens living next to the treated area are likely to be root suckers of untreated specimens of the outside area.

Spot spraying							
Bogdása 10TI (Lontrel - Banvel) Teklafalu 8TI2 (Táltos) Teklafalu 8TI3 (Galera)		Treatment: 24 May 2019		Culture: meadow, pasture with strong infestation of false indigo		Date of 1st recording: 06 June 2019	
Parcel	Chemical	Concentration	Method of application	Success of treatment	Evaluation of treatment	Phytotoxicity	Comments
1–4.	Banvel	1l/ha	Spot spraying	5	In the treated areas, the upper part of the false indigo is withered, and the leaves are drying.	There is shoot curl on herbaceous dicotyledons occurring near to the treatment.	Resprouting should be evaluated next year.
5–8.	Galera	0,6 l/ha	Spot spraying	4	Treated specimens are curved, their shoot apex is distorted, specimens are brown.	Dicotyledonous herbs are turning yellow; the leaves of nettle and blackberry are curling.	
9–12.	Taltos	66 g/ha	Spot spraying	3	Treated specimens are curved, their shoot apex is distorted. Some low specimens are intact, produce no or small-scale symptoms.	Dicotyledonous herbs are turning yellow; their stems are distorted.	The intact specimens were likely to have reached the soil surface around or after the treatment, so they were not treated. The plots 11 and 12 are mechanicaly-ly controlled and therefore cannot be evaluated.
13–16.	Lontrel	1,6 l /ha	Spot spraying	5	In the treated areas, the upper part of the false indigo is withered, and the leaves are drying.	There is shoot curl on herbaceous dicotyledons occurring near to the treatment.	Resprouting should be evaluated next year.

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