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ControlinRoad Controlling the spread of invasive species with innovative methods in road construction and maintenance

Booklet with IAP and Description 12.2018

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CEDR Call 2016: Conflicts along the Road: Invasive Species and Biodiversity

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Controlling the spread of invasive species with innovative methods in road construction and maintenance

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Author(s) of this deliverable:

Swen Follak, AGES, Austria Matthias Eberius, Zasso GmbH, Germany Alexander Fürdös, AANTA AB, Sweden Norbert Sedlacek, HERRY Consult, Austria Friederike Trognitz, AIT, Austria

PEB Project contact: Pia Bartels, BASt, Germany

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1 Introduction

This report summarizes the results of task 3 (Preparation of a booklet for IAS) of work package 2 ("List invasive plants related to transport infrastructure habitat"). A booklet has been produced to help the operating personal to identify invasive alien plants (IAPs) along roadsides. The booklet includes a description and photos of the plants species as well as general control options.

The plants included in this booklet represent many of the most problematic IAPs in Europe (= priority IAPs). Twelve important IAPs are portrayed in this booklet and it includes the following species: *Asclepias syriaca* (common milkweed), *Ambrosia artemisiifolia* (ragweed), *Ailanthus altissima* (tree-of-heaven), *Fallopia* species (knotweeds), *Gunnera tinctoria* (giant rhubarb), *Heracleum* species (hogweeds), *Impatiens glandulifera* (Himalayan balsam), *Lupinus polyphyllus* (garden lupin), *Robinia pseudacacia* (black locust), *Rosa rugosa* (Japanese rose), *Senecio inaequidens* (narrow-leaved ragwort) and the *Solidago* species (goldenrots).

The selection is based on the national lists of invasive alien plants from seven European countries (Austria, Germany, Ireland, Norway, the Netherlands, Slovenia Sweden) and the List of Invasive Alien Species of Union concern (Follak et al. 2018, EU Regulation 1143/2014¹). The complete list of IAPs along roadsides and details on the selection process can be found on the website http://www.controlinroad.org and in Follak et al. (2018).

Current control options were briefly listed and were taken from the results of Task 1 (Search for new and alternative methods in controlling IAS, literature cited therein) of work package 3 (Alternative methods in road construction, operation and maintenance for IAS) and from the literature (see chapter "background sources" of the booklet, p. 30; only main references are listed).

It should be highlighted that in this booklet general control options are presented and that their feasibility (e.g. due to the availability of certain active substances, regulations) can vary nationally. The applicability (and effectiveness) of the control options can also differ because of specific site conditions and thus, adaptions may be necessary (i.e. change of frequency, time and duration of a certain treatment) on a local and/or regional level.

¹ Follak et al. (2018), EPPO Bulletin 48, 256–265, EU (2014), EU Regulation 1143/2014, https://eurlex.europa.eu/legal-content/en/TXT/?uri=CELEX:32014R1143



2 Booklet – Booklet with IAP and Description Priority Roadside Invasive Alien Plants



Identification and Management Guide







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Invasive Alien Plants Along Roadsides

Invasive alien plants have the capacity to establish quickly and easily and can cause widespread negative economic, social and environmental impacts. Morover, invasive alien plants can degrade and destabilize slopes, reduce sight lines, increase fire hazards, and in some cases have the potential to cause damage to the motorway infrastructure.

In this respect, roadsides have an an important role in facilitating the spread of invasive alien plants by providing habitat for their establishment as well as serving as corridors which allow them to spread. The spread of invasive alien plants from roadsides into natural habitats is a cause of great concern.

Decision-makers involved in road construction and maintenance need to be aware of the potential impacts of the establishment and spread of invasive alien plants. This *Identification and Management Guide* should help to recognize and detect *Priority Roadside Invasive Alien Plants* in Europe and it also gives a brief overview about general direct control options. Thus, this guide can be used to prepare monitoring activities and can help to select appropriate control options.

Note: It has to be taken in mind that listed active substances (herbicides) should be used following the instructions on the label and in line with the relevant plant protection product regulations in each country.

Priority Roadside Invasive Alien Plants

The plants included in this *Identification and Management Guide* represent many of the most problematic roadside invasive alien plants in Europe.

The selection is based on the national lists of invasive alien plants from seven European countries (Austria, Germany, Ireland, Norway, the Netherlands, Slovenia Sweden) and the List of Invasive Alien Species of Union concern (EU Regulation 1143/2014).

Twelve invasive alien plants species are portrayed in this guide. Please see the website http://www.controlinroad.org for a complete list of invasive alien plants along roadsides and details on the selection process.



Asclepias syriaca (common milkweed)



List of Invasive Alien Species of Union Concern

DESCRIPTION: Perennial herb.

FLOWERS: Pink to white, in large, many-flowered axillary and apical bell-like clusters, flowering from June to August.

LEAVES: Opposite, smooth margined, oblong, 10-20 cm long and 5-11 cm wide, with prominent veins, leathery.

STEMS: Erect, up to 1.50 m in height, short downy hairs and milky juice.

OTHER ID TIPS: Forms follicles with many seeds that are brown, flat with a tuft of silky white hairs.



Few experiments (along roadsides) have been carried out to investigate the effect of control measures upon stands of *Asclepias syriaca* yet.

Population size	Control options	Instruction
Individuals, small populations	Uprooting, digging	Removal of individual plants. Incomplete controlled individuals are able to re-sprout. Dispose plant material to a designated disposal site. During the growing season.
	Cutting	Usually performed several times (e.g. early June and early August) with a scythe, brush cutter or a trimmer. Should be done as close to the ground as possible. Plants are more susceptible to cutting before flowering. Dispose plant material to a designated disposal site.
	Spot treatment with herbicides	Knapsack sprayer. Glyphosate is effective at the pre-flowering stage (early- to late-bud stage). Sequential applications may be necessary.
Large populations	Mowing/mulching	Should be done as close to the ground as possible, e.g. twice in early June and early August, respectively. Plants are more susceptible to mowing before flowering. Occasional mowing can worsen infestations by stimulating re-sprouting.
	Herbicides	Broadcast application. Glyphosate is effective at the pre-flowering stage (early- to late-bud stage). Sequential applications may be necessary.



Ambrosia artemisiifolia (ragweed)



The pollen produced is highly allergenic and can induce allergic rhinitis, fever, or dermatitis

DESCRIPTION: Annual herb.

FLOWERS: Inflorescences of two kinds: male capitula short stalked in dense, elongating spike-like ebracteate racemes and female capitula in axillary clusters immediately below the male.

LEAVES: Mostly opposite, alternate above, deltate to lanceolata or elliptic in outline, deeply pinnatifid.

STEMS: Hairy, erect, bluntly four-angled, ridged and leafy, with several branches, green to light pinkish red, height from 0.1 to 2.5 m depending on the environmental conditions.

NOTES: It can be easily confused with other roadsides species like *Artemisia vulgaris* (perennial, witish hair on the upper side of the leaves) or *Achillea milleflorum* (perennial, finely dissected leaves, white flowers).



Population size	Control options	Instruction
Few to less than 100 individuals, small populations	Uprooting	Removal should be done before flowering (+ root system). Incomplete controlled plants are able to re-sprout and to produce seeds. Spring to autumn. Dispose plant material to a designated disposal site.
	Cutting	Usually performed with a trimmer (before flowering). Incomplete controlled plants are able to re- sprout and to produce seed. Dispose plant material to a designated disposal site (post- ripening of seeds).
Large populations	Mowing/mulching	Cutting along roadsides should be done as close to the ground and as late as possible: first cut shortly before male flowering (mid-July) followed by subsequent cuts before the onset of new flowers on re-sprouted lateral shoots.
	Herbicides	Many effective active substances are available (e.g. glyphosate, clopyralid). Best applied at an early growth stage (< 4 leaf stage).



Ailanthus altissima (tree-of-heaven)



It propagates easily by seed and root suckers and is an aggressive pioneer species

DESCRIPTION: Medium-sized tree.

FLOWERS: Small and yellow, in large panicles.

LEAVES: Large, odd-pinnately compound, pubescent or nearly glabrous.

STEMS: Usually only 6-10 m tall, but sometimes growing up to 30 m high. The bark is smooth with pale stripes.

NOTES: It is believed to be one of the fastest-growing trees due to a rapid stem elongation.



Control of Ailanthus altissima is difficult due to its ability to produce root suckers.

Population size	Control options	Instruction
Individuals, small colonies, large colonies	Digging, uprooting	For young individuals. Incomplete controlled individuals are able to re-sprout. All year.
	Cutting	Mechanical treatments (e.g. chainsaw) alone are effective at temporarily removing the top growth of the species. Growing season of the tree.
	Girdling	It involves removing about a 5 cm wide band of bark around the tree trunk, using tools such a chisel. Growing season of the tree.
	Herbicides (+ mechanical options)	Broadcast and spot application (full canopy development – from mid-June on), cutting + stump treatment, stem injection (root suckers may develop). Main active substances: e.g. glyphosate, triclopyr
	Ailantex (Verticillium nonalfalfae)	Biological control option with a mycoherbicide. Stem inoculation: late spring after leaf development. Availability is currently limited to Austria.



Fallopia species (knotweeds)



Fallopia species are considered to be extremely invasive, outcompeting and displacing native species in particular in riparian zones

DESCRIPTION*: Vigorous growing, rhizomatous perennial geophyte.

FLOWERS: Off white, in ochreate clusters of 3 to 6 on terminal and axillary panicles, with the main axis up to 10 cm long and with slender branches 5-9 cm long.

LEAVES: Broadly ovate, cuspidate at the tip and truncate at the base.

STEMS: Light green often with reddish flecks, branched and reach up to 3 m in height. Stems arise from strong rhizomes.

NOTES: *Fallopia* species include *F. japonica* (Japanese Knotweed), *F. sachalinensis* (giant knotweed: leaf rounded acuminate forming a heart shape) and *F. x bohemica* (Bohemian knotweed: intermediate leaf base shape). Bohemian knotweed is a hybrid of giant and Japanese knotweed. Species can be confused with each other.



*refers to Fallopia japonica

Effective control of *Fallopia* species is very difficult and no control treatment deliveres complete eradication.

Population size	Control options	Instruction
Individuals, small populations, large populations	Pulling	Removal of individual stems after shoot emergence, throughout the growing season. Individuals may re-sprout. Dispose plant material to a designated disposal site.
	Digging	Removal of individual plants, throughout the growing season (best: spring, summer), incomplete controlled individuals are able to re-sprout. Dispose plant material to a designated disposal site.
	Excavation	Using a backhoe loader, spring, and soil depth > 2m. Dispose plant and soil material to a designated disposal site. It is a less effective (and costly) measure and may be useful only under specific conditions.
	Cutting	Usually, trimmer, brush cutter and/or flail mower can be used, throughout the growing season (as required, > four times a year). Dispose plant material to a designated disposal site.
	Covering	Using barrier membranes (geotextiles), all year, covering should be maintained for at least one growing season. Emerging stems around the covering should be hand pulled. It is a less effective (and costly) measure and may be useful only under specific conditions.
	Herbicides	Principal active substances employed: glyphosate solo or in combination with synthetic auxins (e.g. 2,4-D), ALS inhibitors (Flazasulfuron). Regrowth



	possible, several years of
Broadcast treatment	treatment (> 4 years) necessary.
	Using large volume sprayer (for
Spot treatment	large populations).
Cut and stem fill	Using a knapsack sprayer.
Stem injection	Stem is cut and herbicide is filled directly into stem cavity (several methods available).
	Application is directly into the stem cavity using an injection device (several methods available).
	<u>Most effective</u> : foliar (biannual) application of glyphosate in summer and autumn or annual application using stem injection in autumn.
Cutting + herbicide	Usually, trimmer and/or flail mower can be used before herbicide application, summer (July/August). Application of herbicide (autumn) at approx. 0.5 to 1.0 m height.



Gunnera tinctoria (giant rhubarb)



List of Invasive Alien Species of Union Concern

DESCRIPTION: Perennial, polycarpic, hemicryptophyte herb.

FLOWERS: Robust panicle, three to four per plant, up to 100 cm, predominantly hermaphrodite near the apex and female at the base.

LEAVES: Deciduous, 30-200 cm in diameter, orbicular and palmately lobed.

STEMS: Up to 2 m in height.

NOTES: Vegetative propagation is the main means of expansion leading to dense clonal stands.



Few experiments (along roadsides) have been carried out to investigate the effect of control measures upon stands of *Gunnera tinctoria* yet.

Population size	Control options	Instruction
Individuals, small populations, large populations	Removal (uprooting, digging, excavation)	Spades can be used for small plants and appropriate machinery for larger infestations. The entire rhizome system has to be removed together with standing biomass to prevent any re- sprouting. Plant material may be deep buried or dried out.
	Herbicides	Main active substance: glyphosate. Using a knapsack sprayer. Treatment later in the season (August-September) is to be preferred. Regrowth may occur. It is necessary to repeat applications over several years.
	Cut and paint	It involves cutting the petioles and inflorescences and applying glyphosate to cut surfaces using a sponge. Regrowth may occur.
	Cut and injection	It involves the removal of petioles and inflorescences and excavating one or more wells in the rhizomes, into which of glyphosate is injected. Regrowth may occur.



Heracleum species (hogweeds)



List of Invasive Alien Species of Union Concern. Its sap can cause severe skin irritations, burns, and even blindness

DESCRIPTION*: Monocarpic perennial (biennial) with a thick taproot.

FLOWERS: Terminal compound umbel, white or pinkish, Ø up to 50 cm (with 50-150 rays).

LEAVES: Large pinnate leaves, pointed and with curved spines at the margin, lowermost eventually up to 3 m long, upper leaves on the flowering stem are progressively smaller.

STEMS: Ridged, with purple blotches, and covered in pustulate bristle, flowering stem up to 2-5 m in height.

NOTES: *Heracleum* species include *H. mantegazzianum* (giant hogweed), *H. persicum* (Persian hogweed) and *H. sosnowskyi* (Sosnowsky's hogweed). Species can easily be confused with each other. *Heracleum* species can be confused with native *Heracleum* sphondylium (common hogweed). This species is considerably smaller (< 1.5 m in height) and umbels are 10-20 cm in diameter (with 12 to 45 rays).

* refers to Heracleum mantegazzianum



Population size	Control options	Instruction
Few to less than 100 individuals, small populations	Root cutting	Usually performed with a spade with a sharpened blade in early spring and mid-summer. The root should be cut at least 10 (15) cm below soil level.
	Cutting	Usually performed with a scythe or a trimmer. Should be repeated 2-3 times or more during the growing season (mid-flowering stage).
	Removal of umbels	Should be done when terminal umbels start to flower. The cut umbels must be collected and destroyed. Beware of regeneration.
	Spot treatment with herbicides	Glyphosate, auxin herbicides like triclopyr (post-emergence in summer during bud stage, plant is actively growing).
Large populations	Ploughing	Taproot is cut.
	Mowing	Usually performed with a flail mower. Should be repeated 2-3 times or more during the growing season (mid-flowering stage, before seed set).
	Herbicides	Glyphosate, auxin herbicides (triclopyr) are effective. See above.
	Herbicides + mowing	Early glyphosate application followed by an additional treatment of mowing or cutting. See above.



Impatiens glandulifera (Himalayan balsam)



List of Invasive Alien Species of Union Concern

DESCRIPTION: Annual herb.

FLOWERS: White, pink, or reddish.

LEAVES: Smooth, egg-shaped leaves are clustered in groups of three to five. Leaf edges are toothed.

STEMS: Hollow, smooth and purple-tinged, up to 2 m in height.

OTHER ID TIPS: Seed capsules explode at maturity.

NOTES: Widely present and colonizes mainly moist roadsides and ditches.



Population size	Control options	Instruction
Individuals, small populations	Uprooting	Can be easily hand-pulled. From May/June on to the beginning of seed set. Sites should be checked and newly emerged individuals should be removed.
	Cutting	Usually performed with a strimmer. From May/June on to the beginning of seed set Should be done several times in the growing season.
Large populations	Mowing	Plants should be mowed below the lowest node to stop regeneration. From May/June on to the beginning of seed set. More treatments per year are necessary.



Lupinus polyphyllus (garden lupin)



May outcompete native plant species

DESCRIPTION: Perennial herb.

FLOWERS: Flowers in one terminal, erect raceme, there are three flower colour morphs (blue, pink, and white).

LEAVES: Palmate leaves with long petioles and 10-15 narrowly oblong (lanceolate), 1-2 cm broad leaflets.

STEMS: Unbranched stems, 0.5-1.5 m in height.

NOTES: It grows in symbiosis with a nitrogen-fixing bacterium, soils where the species grows are enriched with nitrogen.



Population size	Control options	Instruction
Individuals, small populations	Uprooting, digging	Spades can be used for small plants or they can be hand-pulled. The entire root system has to be removed. Dispose plant material to a designated disposal site.
Large populations	Mowing	It is best to cut the species along roadsides as early as possible, in the flowering stage (plants are in bloom), when seeds are not produced.
		Cutting should be done as close to the ground as possible to reduce the risk of re-sprouted flower stalks and leafs that may help plants to gain resources for the next season.



Robinia pseudacacia (black locust)



It propagates easily by seed and root suckers and is an aggressive, thorny pioneer species

DESCRIPTION: Medium-sized tree, open, irregular crown.

FLOWERS: Whitish, pods contain 4-8 hard-coated seeds.

LEAVES: Alternate, deciduous, compound and imparipinnate, 20-45 cm long and consist of 7-19 small, oval, alternate leaflets.

STEMS: Generally 12-18 m tall and 30-76 cm in stem diameter

NOTES: *R. pseudacacia* as an ornamental, forestry, shelter and land reclamation species and has been widely planted. It grows in symbiosis with a nitrogen-fixing bacterium, soils where the species grows are enriched with nitrogen.



Control of *Robinia pseudacacia* is very difficult due to its ability to produce root suckers especially when damaged. In particular, (improper) cutting can cause an increase in root suckering and sprouting.

Population size	Control options	Instruction
Individual trees (young and old)	Digging, uprooting	For seedlings and young trees. Incomplete controlled individuals are able to re-sprout and form root suckers. Dispose plant material to a designated disposal site. Throughout the growing season.
	Girdling	For older trees. It involves removing about a 5 (10) cm wide band of bark around the tree trunk (cut should go beyond the cambium), using tools such a chisel or chainsaw. Can stimulate root suckering. Combination with a herbicide treatment is possible.
	Herbicides	Main active substances: e.g. aminopyralid, clopyralid, triclopyr, glyphosate.
	Foliar application	Application on individual plants when actively growing and fully leafed.
	Cut stem	Cut stem near the base and apply herbicides on the cut surface. Growing season of the tree.
	Hack and squirt	Make a few cuts with an axe around the trunk and apply the herbicides solution into the cut. Growing season of the tree.
	Basal bark	Wetting the bottom (approx. 30 to 50 cm) of bark around the whole trunk with a herbicide solution.
		Trees may re-sprout and form root suckers.



Rosa rugosa (Japanese rose)



It forms dense multi-stemmed deciduous thickets through rhizomatous sprouting

DESCRIPTION: Deciduous shrub.

FLOWERS: Usually solitary or few together, five petals, bright purplish-pink, sometimes white.

LEAVES: Alternate, leaflets, nearly equally sized, leathery and robust.

STEMS: Erect, sometimes arching (1.5 m), often much branched, tomentose when young, densely prickly.



Few experiments (along roadsides) have been carried out to investigate the effect of control measures upon stands of *Rosa rugosa* yet.

Population size	Control options	Instruction
Individuals, small populations, large populations	Digging, uprooting	Spades can be used for small plants and appropriate machinery for larger infestation. The entire rhizome system has to be removed to prevent any re- sprouting. Dispose plant and soil material to a designated disposal site.
	Cutting	Cutting as close to ground level as possible twice or three times a year (reduces plant vitality). Repeated cutting over several years is needed.
	Excavation	Using a backhoe loader. Requires subsequent digging of re-sprouts from root fragments. Dispose plant and soil material to a designated disposal site.
	Herbicides	Using knapsack sprayer or large volume sprayer (for large populations). Main active substance: glyphosate. It is most effective when applied after flowering (early summer). Cut + stump treatments also provide control.



Senecio inaequidens (narrow-leaved ragwort)



It is a prolific seed producer, has a vigorous growth and is toxic

DESCRIPTION: Herbaceous, woody (at base) short-lived perennial.

FLOWERS: Terminal or axillary, corymbose panicle, bright yellow

LEAVES: Alternate, bright green, linear-lanceolate, upper leaves occasionally pinnately lobed, shortly petiolate.

STEMS: Stems are erect, glabrous, often much branched from the base, up to 1 m in height.

NOTES: *S. inaequidens* is an opportunistic species with the ability to colonize a wide range of habitats.



Few experiments (along roadsides) have been carried out to investigate the effect of control measures upon stands of *Senecio inaequidens* yet.

Population size	Control options	Instruction
Individuals, small populations	Uprooting	Removal should be done before flowering (+ root system). Incomplete controlled plants are able to re-sprout and to produce seeds. June to November, best date: late autumn (November). Several years (> 3 years) are necessary.
Large populations	Mowing/mulching	Repeated cutting (every 6 weeks) as close to the ground as possible. Several years (> 3 years) are necessary.



Solidago species (goldenrots)



It is an aggressive invader due to its vigorous growth which may lead to changes in the native vegetation

DESCRIPTION: Perennial herb.

FLOWERS: Inflorescences form broad pyramidal panicles with recurving branches and a central axis, *Soidago canadensis:* lemon yellow, pappus is silvery whitish, *Solidago gigantea*: flowers bright yellow, pappus is brownish-white.

LEAVES: Triple-nerved, pubescent beneath, lanceolate.

STEMS: Ercet, up to 0.25-2.5 m (mean 1.5 m) tall, weakly hairy, branched only in the inflorescence, *Solidago canadensis*: weakly hairy, *Solidago gigantea*: stem glabrous.



Population size	Control options	Instruction
Individuals, small populations	Uprooting	Removal should be done before flowering (+ root system). Incomplete controlled plants are able to re-sprout and to produce seeds. At the latest: October (before seed set).
Large populations	Mowing/mulching	Repeated cutting (twice) as close to the ground as possible and before seed set: 1. (May) June 2. Middle of August. Consequent mowing is necessary over several years.



Background Sources

CABI datasheets, https://www.cabi.org/.

- EPPO Global Database, https://gd.eppo.int/.
- Forman RTT, Sperling D, Bissonette JA, Clevenger AP, Cutshall CD, Dale VH et al. (2003): Road Ecology. Science and Solutions. Island Press, Washington, D.C. (US).

Acknowledgements

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