CEDR Transnational Road Research Programme
Call 2016: Invasive Species and Biodiversity

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

State of the art of legislation, guidelines and best practices in road construction and maintenance for the control of invasive species

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CEDR Call 2016: Invasive Species and Biodiversity

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

Short title: Best practice guide based on current practises

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Authors of this deliverable:
Alexander Fürdös, AANTA AB, Sweden
Herbert Seelmann, Consultant, Czech Republic
Friederike Trognitz, AIT Austrian Institute of Technology, Austria
Swen Follak, AGES, Austria
Matthias Eberius, Zasso, Germany
Norbert Sedlacek, Herry Consult, Austria
Angela Sessitsch, AIT Austrian Institute of Technology, Austria

PEB Project contact: Pia Bartels

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Change history

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- v 1.0

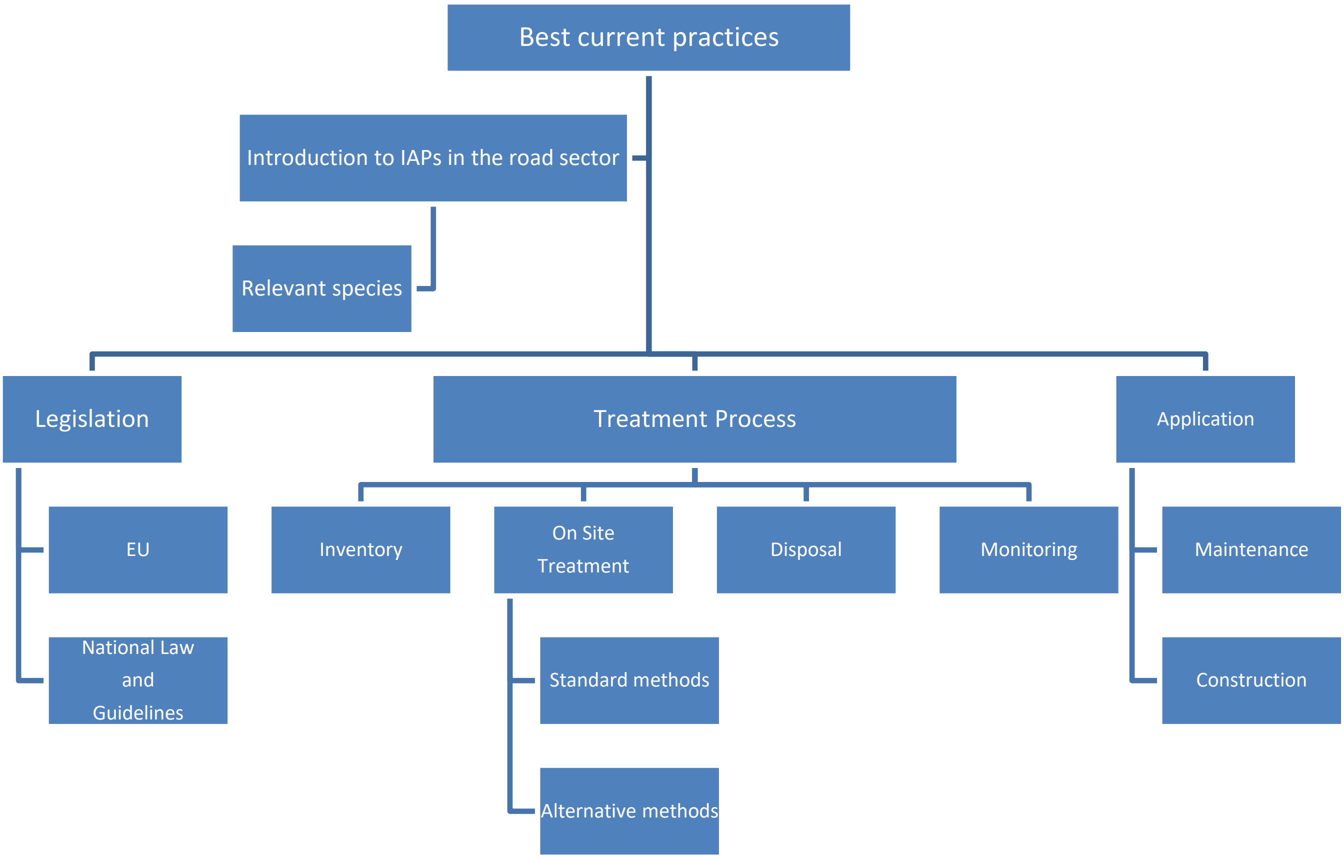
This document was revised according to reviews from:

- Letter from Riikswaterstaat to AIT
- Comments from Pia Bartels (via mail to Friederike Trognitz)
- Comments in document v1.0
- Offer to CEDR (2017)
- Discussions within the project team

1 Executive summary

This document aims at giving the readers a **comprehensive overview of currently applied measures** to control invasive alien plants (IAPs) in the road sector.

The document describes current best practices in the following structure:



Awareness

Invasive Alien Plants (IAPs) generally have been identified by the EU as a problem, and adequate legislative measures have been developed. Nevertheless, the degree of relevance of IAPs for the road sector varies from country to country. The main reasons for this are the different climatic and soil conditions in the varying regions which lead to different population sizes or different species compositions of IAPs. Thus, the awareness, the knowledge and the availability of governmental guidelines and measures vary substantially. Ireland, the Netherlands, Germany, Switzerland and partially Austria are countries in which the awareness regarding IAPs is high. In these countries, legislation and guidelines regarding IAPs are available.

Many stakeholders who participated in the comprehensive survey which was conducted in frame of ControlInRoad stated that road authorities should intensify their contact with IAP experts to gain more knowledge on IAPs and effective treatment methods.

Legislation

At the EU level, legislation regarding some IAPs has been developed (European Union Regulation No. 1143/2014). It is now up to the Member States to implement this legislation in national and federal law and simultaneously to develop their own legislation and guidelines for the treatment of IAPs. The majority of stakeholders who participated in the survey stated that national legislation is very important.

A good example regarding the development of legislation is Austria. Here, the EU legislation has already been transposed into national law (source: https://www.neobiota-austria.at/ms/neobiota-austria/neobiota_recht/nat-bestimmungen/). National legislation and guidelines are also well developed in Ireland.

BEST CURRENT PRACTICE - **LEGAL**	
NATIONAL LAW	• EU call about new emerging pest and disease which also includes weeds (https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/sfs-05-2018-2019-2020). • The national law usually does not describe how the treatment of these IAPs shall be done.
STANDARDS & GUIDELINES	• Treatment procedures and methods shall be described as standards and guidelines relevant for the road sector, both at the national and international level. • In Austria for example, the national guidelines RVS (Richtlinien für Straßenverkehr) should be updated also to include IAPs.
TENDER DOCUMENTS	• The adequate treatment of IAPs shall be incorporated in tender procedures of road authorities. • Country-specific requirements for IAP treatment shall be developed both for maintenance as well as for construction services.
BEST PRACTICE	• Austria has started to develop national laws and guidelines • Germany has guidelines at the federal level, but not at the national level • In Ireland, applicable guidelines are already very well developed and could be used as a model. Ireland is also highly experienced with the treatment of IAPs in tender procedures.

Treatment

Treatment of IAPs along roads is not solely the application of one certain method. If the goal is to sustainably treat IAPs and avoid their spread, thus being effective and cost-efficient in the end, multiple measures has to be applied.

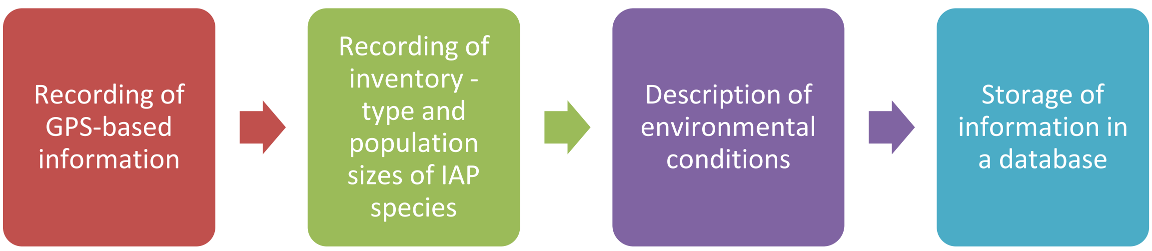
<u>These measures include the following steps:</u>

These measures can be applied during normal road maintenance and during road construction.

IAP INVENTORY

A **comprehensive inventory** of IAPs is a prerequisite for success. Only when knowledge about the exact location, the plant species and the population size of IAPs is available, adequate measures can be defined.

Today several countries have started inventory projects, as for example the Netherlands, Norway, Sweden and Ireland. Also, there are different smartphone-based Apps available to facilitate inventories performed by the public. It cannot be stated which system in use is the best, as each individual system is designed according to specific needs and requirements. The underlying basic functionalities are however, mainly the same:



We recommend the development of a reference European system for the inventory of IAPs. With such a system, uniform inventory methods can be applied facilitating the comparability of the data collected. A regular inventory would allow for the analysis of the status quo as well as the monitoring of the spread of IAPs at the European level. The development of an inventory system and a database would represent a rather moderate investment with a large benefit.

BEST CURRENT PRACTICE - **INVENTORY**	
MEASURES	ONE COMMON SYSTEM for the INVENTORY of IAPs along roads (and other traffic routes) shall be developed to: • be able to record the status quo of IAP occurrence at the European level • be able to follow up effectiveness of treatments and thus the development/spread of IAPs along roads in Europe
TECHNOLOGY	Basic functionalities of an inventory system for IAPs would be: • GPS-supported determination of exact location (incl. altitude) of IAPs • Selection possibilities of IAP species/types for different countries/regions • Possibility to describe the environment (e.g. soil...) in which IAPs occur • Storage and administration in a central database • Access through several device types (smartphones, PCs)
BEST PRACTICE	• Ireland • The Netherlands • Austria • Australia • Norway • Sweden • Several Apps, available for Android devices

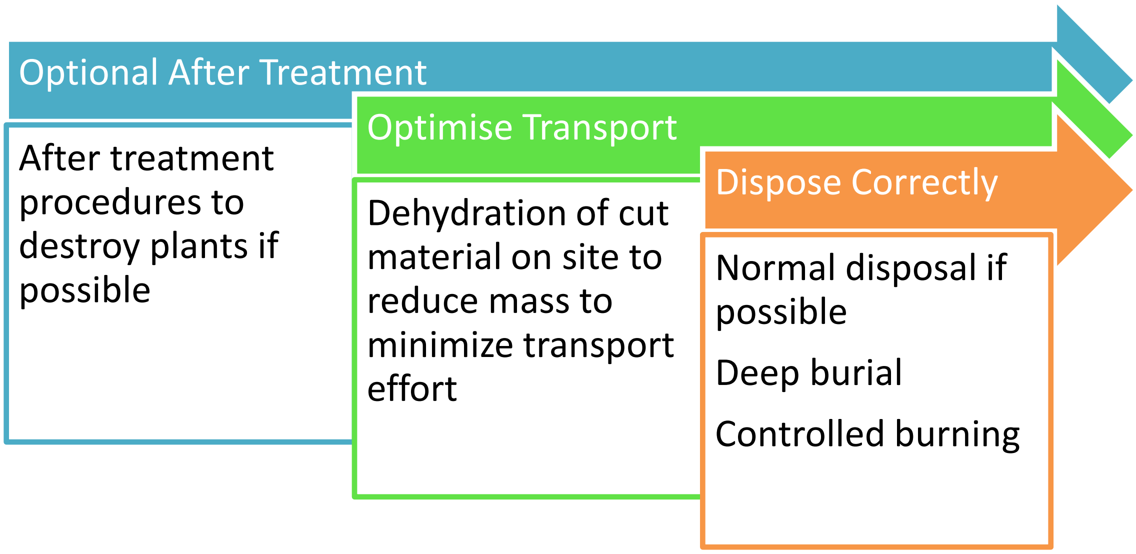
TREATMENT ON SITE

Currently, different methods are commonly used for **on-site treatment** of IAPs. The most common methods are mowing/mulching and the use of herbicides, as these methods can be rather easily used in regular road maintenance. However, herbicides will likely be widely banned in the future, thus, alternative methods must be found. Also, hand removal and digging are commonly used methods, though they are very labour-intensive and thus costly. Some alternative methods have been tested in several projects, also in frame of ControlInRoad, but they mostly need further research and development before being ready for broad application. In road construction, additional technical methods can be used. Besides the use of non-IAP-contaminated soil, plant barriers (e.g. geotextile membranes, root barrier membranes) can be set up.

BEST CURRENT PRACTICE -**TREATMENT**	
MEASURES	• MOWING/MULCHING of IAPs during ordinary road maintenance is the most common treatment of IAPs on site. Singularly, IAPs are removed by hand. Sometimes, special disposal procedures to avoid spread apply. • The success of different treatment methods depends on the IAP species. Detailed treatment methods for different IAPs are described in the Deliverable "Booklet".
MOST IMPORTANT	• A common best practice which always shall be applied during and after treatment on site is CLEANLINESS. (e.g. all equipment, clothes, shoes must be cleaned to avoid spread of IAPs). These biosecurity measures could be implemented in a "biosecurity plan" for road maintenance. • Another method that may be used in the future is BIOCONTROL (use of living organisms, such as insects, to control pest populations).
ROAD CONSTRUCTION	• During road construction, special measures like stronger subconstruction (like macadam see https://en.wikipedia.org/wiki/Macadam), plant barriers and special seed mixtures shall be applied.
BEST PRACTICE	• In Ireland, expert companies, specialised on treatment of IAPs along roads, support the local road authorities. A good practice, which could be easily adopted in other countries.

DISPOSAL

Correct disposal of mowing or cutting waste is important to avoid the spread of IAPs, especially if the treatment method applied involves only cutting the plants without destroying them. Also, non-destroyed roots can lead to further spread of IAPs. If it cannot be ensured that the plant waste is no longer viable, it should be treated like hazardous waste. Reasonable treatments in such cases could be deep burial or burning (if allowed).



Dumping, mowing or cutting waste into waterbodies is not an option for disposing IAPs as this is likely to spread the plants and further exacerbate the problem.

CURRENT BEST PRACTICE – **DISPOSAL (depending on the waste legislation in each member state)**	
MEASURES	• DISPOSAL of IAPs, which are still viable and thus able to spread after treatment, is a very critical issue, because correct disposal of IAPs is costly. • As disposal is such a critical issue, clear rules shall be defined. • General rules shall be implemented in national laws (e.g. ban to spread specific IAPs). • Rules for disposal of IAPs shall preferably be defined in national standards and guidelines.
BEST PRACTICE	• Currently only a few examples (e.g. Ireland, the federal state of Vorarlberg in Austria) are known, where disposal with awareness of IAPs is undertaken.

IAP MONITORING

Even after successful treatment, regular monitoring of any occurrence of IAPs is necessary to reach a sustainable effect and to save on costs in the long term. It is recommended to remove re-growing IAPs plants directly during inspection. With this step, the loop is closed in terms of the IAP inventory and it is assured that IAPs are sufficiently controlled.

BEST CURRENT PRACTICE - **MONITORING**	
MEASURES	• As a measure of quality control, monitoring the effectiveness of the treatment on site shall be controlled by regular visual inspections during the growing season, at least for ten years. • For this post-monitoring, the same procedures and technologies used to create the inventory shall be utilised. • The (post)monitoring of IAPs could be integrated in regular maintenance procedures for road infrastructure. • Thus, the effectiveness of the treatment can be judged and the long-term development of IAPs can be monitored in a controlled way.
MOST IMPORTANT	• If during monitoring IAPs are detected (i.e. regrowth), these shall be removed by digging (or other appropriate method depending on the plant species) to make sure that the roots are removed.
BEST PRACTICE	• Ireland

2 Purpose of this document

This document summarizes current best practices regarding the management of IAPs in road construction and maintenance.

Cost aspects are not considered, as they are part of a separate work package (Deliverable 5.2 - Cost-Benefit Analysis).

Relevant sources for this deliverable are:

- Deliverable 4.1.2 (Results of the Questionnaire)
- Personal interviews
- Site visits (Ireland, Italy, Switzerland, Austria, Sweden)
- Laws, Standards, Best Practice procedures
- Literature review
- Internet search

Specific technical methods for the treatment of IAPs with focus on specific plant species are described in the following documents:

- Deliverable 3.1: Evaluation of alternative methods
- Deliverable 2.2: Booklet with description of most relevant Invasive Alien Plants (IAPs) and related treatment methods

Goals of this document:

- to provide a basis for the development of deliverables 5.1/5.2/5.3
- to give an overview on available legislation, routines and procedures
- to provide an overview on best available awareness information material
- to give an overview on currently applied methods and their general effectiveness against IAPs

Out of scope:

- Description of costs
- Description of regional effectiveness (e.g. regional characteristics like climate, micro climate, soil, etc…)
- Description of sectoral differences (road / rail sector)
- Description of functional differences (primary / secondary roads)
- Detailed description treatment methods
- Detailed descriptions of how to use treatment methods (e.g. Working Procedures)
- Alternative treatment methods

3 Introduction to Invasive Alien Plants (IAPs) in the road sector

3.1 Introduction

IAP means Invasive Alien Plants, a subgroup of Invasive Alien Species (IAS).
The general EU policy is to control, if possible eradicate, and prevent the establishment and spread of IAS. Therefore, corresponding guidelines/regulations have been issued by the EU, which must be implemented in national laws by the Member States. The **EU Regulation 1143/2014 on Invasive Alien Species (IAS)** which became effective on 1 January 2015 contains relevant information, why IAPs shall be controlled and accordingly defines strategies and measures. This Regulation contains rules to prevent, minimise and mitigate the adverse effects of invasive alien species on biodiversity and related ecosystem services, on human health and safety as well as to reduce their social and economic impact.
EU Directives are immediately effective in all EU Member States.
Some of the IAPs that are included in the EU regulations are relevant for the infrastructure sector. At the same time, the EU has issued regulations with the purpose to limit the usage of pesticides/herbicides, one of the most effective weapons against IAPs.

3.2 IAPs relevant for the road sector

In this project, the most relevant IAPs for the road infrastructure sector are described in the following documents:

- **Deliverable 2.2: Booklet describing the most relevant IAPs and related treatment methods**

In simplified terms, IAPs are plants, which have their origin and habitat in other countries/climate zones than those in the project area (= outside EU). Furthermore, IAPs

- are very competitive and difficult to control,
- suppress domestic plants,
- prefer disturbed sites or sites with unfavourable conditions,
- spread easily.

<u>IAPs can cause severe impacts such as:</u>

- Allergies (=health costs)
- Damage to infrastructure (e.g.: destroying buildings, roads)
- Increased efforts and thus costs for infrastructure planning and construction
- Increased efforts and thus costs for infrastructure maintenance

- Health issues caused by the usage of pesticides/herbicides
- Outcompete native vegetation and damage habitat for native wildlife

List of IAPs relevant for the Road Sector

In total, 89 IAPs related to roadsides have been compiled (Deliverable 2.1 – List of invasive alien plants along roadsides). The following numbers of species have been identified for each country: Austria (19), Germany (14), Ireland (12), the Netherlands (21), Norway (45), Slovenia (29), and Sweden (24). The majority of the species occurs only in one or two countries, while thirteen species (14%) are currently known to occur along roadsides in more than four of the seven countries.

The most frequently reported IAPs along roadsides in the selected countries were *Fallopia* species (*F. japonica*, *F. x bohemica*, *F. sachalinensis*), *Solidago* species (*S. canadensis, S. gigantea*) and *Heracleum* species (*H. mantegazzianum*, *H. persicum*) as well as *Impatiens glandulifera*. Notable invasive tree and shrub species along roadsides are *Ailanthus altissima* and *Robinia pseudoacacia* and *Rosa rugosa*. Moreover, the dwarf shrub *Senecio inaequidens* was mentioned in all selected countries, except in Ireland. The annual herbaceous *Ambrosia artemisiifolia* and the perennial herbaceous *Lupinus polyphyllus* is found in four (Germany, Norway, Sweden, Slovenia) out of seven countries. Six of the assembled species are on the List of Invasive Alien Species of Union concern (EU) and including: *Ailanthus altissima*, *Asclepias syriaca, Gunnera tinctoria, Heracleum mantegazzianum, Heracleum persicum* and *Impatiens glandulifera*.

Table 1 outlines the most problematic IAPs that occur along roadsides in the seven European countries (Deliverable 2.1 – List of invasive alien plants along roadsides). Further classification, according to the EU (= "have serious adverse impact on biodiversity and related ecosystem services, as well as have other social and economic impact", EU Regulation 1143/2014) and EPPO lists (IAP List = List of invasive alien plants, A2 List = pests recommended for regulation as quarantine pests, Observation List = present a medium risk or for which information currently available is not sufficient to make an accurate assessment), was added. As the presence of IAPs along roadsides in the countries has not been studied in detail so far, a monitoring program (i.e. a systematic collection, recording and analysis of observations over time) would be required for in depth knowledge on the occurrence of IAPs in Europe.

A booklet was prepared to help the operating personnel to identify IAPs along roadsides (Deliverable 2.2). The plants included in the booklet represent many of the most problematic IAPs in Europe (= priority IAPs), i.e. twelve important IAPs including *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 *Solidago* species (goldenrots).

Table 1: Most problematic IAPs along roadsides and their classification based on Deliverable 2.1

Species	English name	EU[2], EPPO[3]
Ailanthus altissima	Tree of heaven	EU, IAP List
Ambrosia artemisiifolia	Ragweed	IAP List
Amelanchier spicata	Low juneberry	IAP List
Asclepias syriaca	Common milkweed	EU
Bidens frondosa	Devil's beggarticks	Obs. List
Buddleja davidii	Summer lilac	IAP List
Cornus sericea	Red osier	IAP List
Fallopia japonica	Japanese knotweed	IAP List
Fallopia sachalinensis	Sakhalin knotweed	IAP List
Fallopia x bohemica	Knotweed	IAP List
Gunnera tinctoria	Giant rhubarb	EU
Helinathus tuberosus	Jerusalem artichoke	IAP List
Heracleum mantegazzianum	Giant hogweed	EU, IAP List
Heracleum persicum	Persian hogweed	EU, A2 List
Impatiens glandulifera	Himalayan balsam	EU, IAP List
Lupinus polyphyllus	Garden lupin	Obs. List
Prunus serotina	Black cherry	IAP List
Senecio inaequidens	Narrow-leaved ragwort	IAP List
Solidago canadensis	Canadian goldenrod	IAP List
Solidago gigantea	Giant goldenrod	IAP List

[2] see http://ec.europa.eu/environment/nature/invasivealien/list/index_en.htm; [3] EPPO classification see https://www.eppo.int/

3.3 Regional, sectoral and functional views on IAPs

IAPs may occur differently on roads and transport infrastructure. Depending on regional, functional or sectoral circumstances, different species of IAPs may be problematical regarding various characteristics, influencing the effectiveness of the treatment methods. It is out of scope of this project to consider this aspect in detail, however, a short summary on potential preconditions is given below:

Regional differences (not handled in this document):

- What are regional differences?
  - Climate & micro-climate
  - Soil
  - Geographical location (e.g. altitude)
- Not handled in this document because
  - Not in the scope of ControlInRoad

Functional differences (not handled in this document):

- What are functional differences?
  - Primary roads (highways, motorways)
  - Secondary roads (country roads, rural roads)
- Level of service requirements for roads
- Not handled in this document because
  - Functional differences lay mainly in the responsibility of the national road operators and organisations responsible for the road sector in each country
  - Problems with IAPs are similar, the differences lay mainly in the size and layout of roads

Sectoral differences (road and rail):

- What are sectoral differences?
  - Road
  - Rail
  - Waterways
  - Seaports and airports
- Not handled in this document because
  - Not in the scope of ControlInRoad
  - Problems with IAPs are similar, the differences lay mainly in the size and layout of the infrastructure but can also manifest in environmental differences characteristic for the type of infrastructure (e.g. commonly local environmental conditions along railways are drier than along waterways)
  - The main difference is on how control measures can be applied (e.g. spraying of trains, required vehicle speed for application, accessibility…)

3.4 *Where do IAPs occur in road infrastructure?*

- **Road accompanying green areas** along paved road infrastructure
    - Usually IAPs do not represent a problem on paved surfaces if these are in regular use
    - Cracks beside and within paved surfaces may be occupied by IAPs
    - The central reserve (also called medial or median strip) may need special attention as trees and shrubs may occur and as these areas are difficult to access

- **Hot Spot Areas**, which are green areas belonging to road infrastructure (e.g. around service areas)

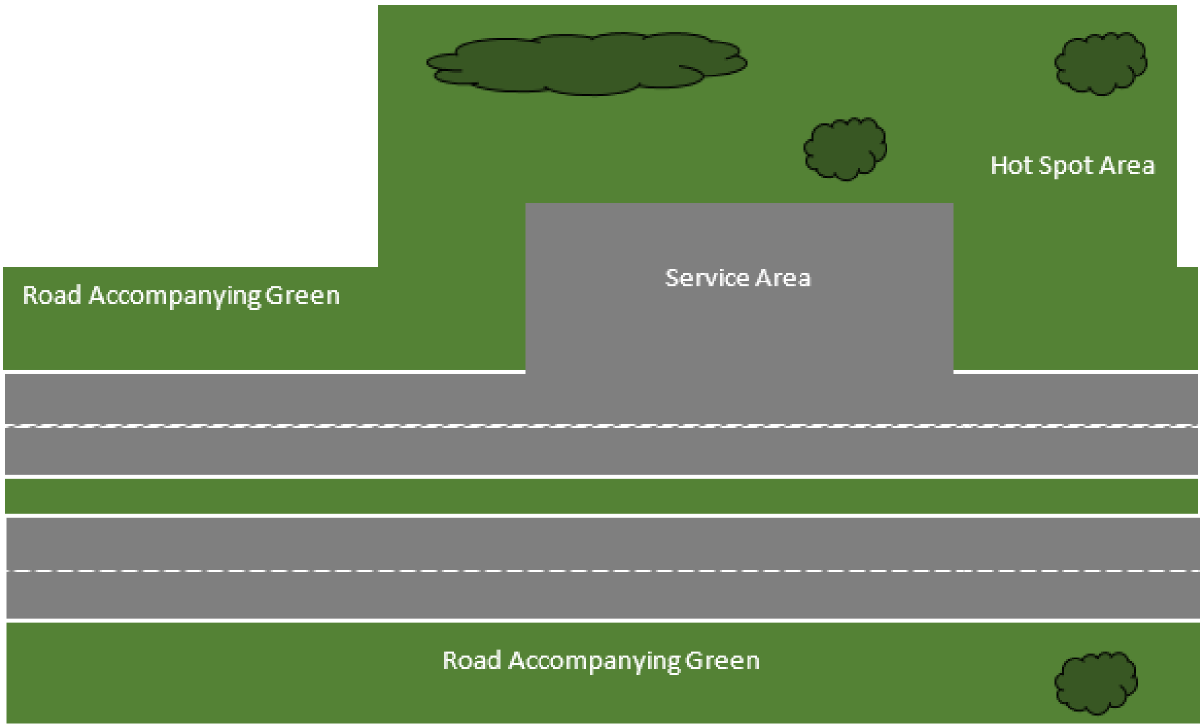


Figure 1: Areas related to road infrastructure where IAPs can occur

4 Legislation and guidelines

BEST CURRENT PRACTICE - **LEGAL**	
NATIONAL LAW	• Based on EU legislation, national law shall be developed in each country. • The national law must state rules (e.g. growth, spread) for each IAP. • The national law usually does not describe how the treatment of IAPs shall be done.
STANDARDS & GUIDELINES	• Treatment procedures and methods shall be described in standards and guidelines relevant for the road sector, both at the national and international level. • In Austria for example, the national guidelines RVS (Richtlinien für Straßenverkehr) should be updated accordingly.
TENDER DOCUMENTS	• The correct treatment of IAPs shall be regarded in tender procedures of road authorities. • Country-specific requirements for IAP treatment shall be developed both for maintenance as well as for construction services.
BEST PRACTICE	• Austria has started to develop national laws and guidelines • Germany has guidelines on federal level, but not on national level • In Ireland, applicable guidelines are already very well developed and could be used as a model. Ireland has also good experience with the treatment of IAPs in tender procedures.

4.1 EU Legislation

4.1.1 EU Legislation dealing with Invasive Alien Species

The **EU Regulation 1143/2014 on Invasive Alien Species (IAS)** which became effective on 1 January 2015, contains relevant information, why IAPs shall be controlled and accordingly defines strategies and measures. This Regulation contains rules to prevent, minimise and mitigate the adverse effects of invasive alien species on biodiversity and related ecosystem services, and on human health and safety as well as to reduce their social and economic impact. The most important statements and issues are as follows:

Scope (Article 2):
The regulation applies to all invasive alien species. However, it does not apply to species that change their distribution area without human intervention, e.g. due to climate change. It also does not apply to pathogens of animal diseases or plant pests listed in the Plant Protection Directive 2000/29/EC.

Definition of IAS (Article 3):

"Invasive alien species" means a non-resident species whose introduction or spread endangers or adversely affects biodiversity and related ecosystem services.
'Invasive alien species of Union concern' means an invasive alien species whose adverse effects have been considered to be so significant to require concerted action at Union level in accordance with Article 4 (List of invasive alien species of Union concern), section 3.

Risk assessment (Article 5):
This article describes the minimum criteria for a risk assessment in order to be considered sufficient. There are numerous risk assessment methods which differ in detail. In the study *"Invasive alien species - framework for the identification of invasive alien species of EU concern"*, the Commission has compared these methods and checked their compatibility. Member States may at any time submit applications for the inclusion of a species in the Union list. These applications must include such a risk assessment.

Restrictions (Article 7):
Among other things, species of the Union list must not be deliberately introduced into the territory of the Union, they must not be kept or bred and they must not be placed on the market or released into the environment. These restrictions shall be enforced and controlled by competent national authorities.

Action Plans (Article 13):
Within 18 months after the adoption of the Union list, i.e. until January 2018 for the IAPs of the first listing, effective management measures have to be implemented against those species that are widely distributed. This should minimize their adverse effects on biodiversity. After 3 years, until August 2019, an action plan has to be set up which includes appropriate timetables and concrete measures to prohibit wilful introduction and as a result the spread of such species.

Monitoring system (Article 14):
Within 18 months after the adoption of the Union list, until January 2018, a system for monitoring these species should be established or integrated into existing systems. This is to document the distribution of the species in the sovereign territory and their increase or decrease.

Official controls (Article 15):
Official controls of the corresponding categories shall be carried out, referred to each species on the Union list.

Notification of early detection (Article 16):

Where species of the Union list are identified during official controls or through the monitoring system, the Commission shall be informed without delay. This also applies to the occurrence of species that are not already widely distributed in parts of the territory from which the species were previously unknown and for the recurrence of species that had been reported as eliminated.

Immediate removal (Article 17):
Within three months of the notification of early detection, appropriate control measures must be applied and their effectiveness monitored.

Exemptions from immediate disposal (Article 18):
Within two months of the identification of a species from the Union list, the Member State may decide not to apply control measures, for example by demonstrating that such removal is not technically feasible, that the costs are disproportionately high, or that serious adverse effects on human health or the environment would occur. Evidence to substantiate this decision must be submitted to the Commission. If the Commission rejects the decision, measures under Article 17 shall apply. If the Commission approves the decision, measures under Article 19 shall apply.

Management measures (Article 19):
Within 18 months of the adoption of the Union list, until January 2018, effective management measures should be implemented against those species that are widespread in the sovereign territory. This should minimize their adverse effects on biodiversity. The measures should be appropriate and prioritize their effectiveness. If possible, recovery measures have to be included.

Reporting (Article 24):
A report shall be sent to the Commission by 1 June 2019 and every six years thereafter, providing, inter alia, information on the monitoring system, the distribution of the Union list species in the sovereign territory, the action plans, the disposal measures, authorizations and official controls.

Information support system (Article 25):
The Commission has established an information support system at the JRC (Joint Research Centre):
https://easin.jrc.ec.europa.eu/easin

The entire document can be downloaded here:
https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1417443504720&uri=CELEX:32014R1143

4.2 National Legislation and guidelines

4.2.1 Austria

In Austria there are no road standards or guidelines concerning the control of invasive alien plant species. The standard **RVS 12.05.11 only chapter 5.3** (Conservation of lawn and meadow areas) and the appendix (chapter 7: Mowing equipment, Work calendar) refers to "mowing“, however, the problem of invasive plant species is not mentioned.

There is no systematic survey done by ASFINAG. In the federal state Burgenland, currently tests on the removal of invasive alien plants are being carried out. In addition, in further federal states (sporadically) surveys take place, especially on ragweed. Partially it is also very well known on which roads invasive plants occur (for example in Tyrol). The federal state Vorarlberg (Department Environmental Protection) has published the **document "Aktionsprogramm Neophyten und Kreuzkräuter in Vorarlberg" ("Action Program Neophytes and *Senecio* in Vorarlberg")**, which also gives recommendations for the containment and removal of various invasive plant species along roads.
Reference: Amt der Vorarlberger Landesregierung, Abteilung IVe Umweltschutz, Aktionsprogramm Neophyten und Kreuzkräuter in Vorarlberg (2013)

In this document, the following measures are set to control invasive alien plant species:

- Mowing, pulling out of individual stocks (manual removal)
- Mechanical, thermal, physical and chemical measures

Moreover, in some Federal States like Upper Austria and Styria, EU regulations have been incorporated into the law.

It should also be mentioned that the EU Biodiversity Strategy provides the basis for the "Biodiversity Strategy Austria 2020+". Proposed measures for dealing with IAS are among others:

- Implementation of EU Regulation No. 1143/2014
- Promoting prevention by raising awareness among sectors and people involved
- Adapting existing surveillance systems and examining the possibilities of citizen science activities
- Exchange of information and experience on the success and failure of control measures
- Intensification of research investigating invasive species, in particular on the ecological, economic and health effects of the species

More information about the regulations in Austria can be found on the website **"Neobiota in Österreich"**:
https://www.neobiota-austria.at/ms/neobiota-austria/neobiota_recht/nat-bestimmungen/

Furthermore, it should be noted that the federal agency AGES has the task of controlling the import and export of IAPs.

4.2.2 Germany

The federal law on nature protection (Bundesnaturschutzgesetz) was updated to include the management of invasive species of Union concern (§ 40 a-f). The execution of the management measures generally falls to nature conservation authorities, not to road authorities. The update of the law also prohibits the use of non-native seeds and woody plants in open nature (which also includes roadsides outside of urban areas) after 1. March 2020 (§ 40). Although exceptions apply regarding functional interference or safety in traffic, road authorities are thus legally obligated to use native seed mixtures and woody plants in construction and landscaping along roadsides outside of urban areas.
Only in a few federal states or regions/districts there exist documents in which the problem of measures against neophytes associated with roads is described. A comprehensive document is for instance the guide **"Leitfaden zur Verwendung gebietseigener Pflanzen bei Straßenbaumaßnahmen in Rheinland-Pfalz" ("Guide for the Use of Territory-own Plants in Road Construction in Rheinland-Pfalz").**
Reference: Mobilität Rheinland – Pfalz (2011): Leitfaden zur Verwendung gebietseigener Pflanzen bei Straßenbaumaßnahmen in Rheinland - Pfalz, Koblenz
In this guide the following measures are proposed to control invasive alien plant species:

- Regular mowing of giant hogweed (*Heracleum mantegazzianum*) before flowering
- Pulling out of ragweed (*Ambrosia artemisiifolia*)
- Removal of Japanese knotweed (*Fallopia japonica*) by different mechanical measures
- In nature reserves: Purely mechanical measures including digging, clearing of black locust (*Robinia pseudoacacia*) are allowed, in individual cases also mitigation with herbicides (Garlon 4, glyphosate) is possible

Furthermore the **"Bundesamt für Naturschutz" ("**Federal Agency for Nature Conservation") runs the website Neobiota.de (https://neobiota.bfn.de/) on alien and invasive species in Germany. Here a compilation of documents dealing with IAS in Germany, Europe and worldwide (although not dealing with IAPs in road construction or maintenance) can be found at: https://neobiota.bfn.de/grundlagen/linkliste.html

4.2.3 Ireland

In Ireland there exists the document „**Guidelines on the Management of Noxious Weeds and Non-Native Invasive Plant Species on National Roads**“ (prepared in 2008, revised in 2010).

The control of invasive plant species already starts during the construction of roads. The most important statements are:

- *Roads are a major source of invasive plant spread.*
- *It is essential to detect invasive plant spread at the earliest stage possible.*
- *The approach must be applicable to all development sites.*
- *A management plan is required.*
- *There exist clear responsibilities and awareness for each organisation/company dealing with road construction.*
- *Effective control and disposal as well as ongoing monitoring and follow-up is mandatory.*

The following most important steps/measures are addressed in the guidelines:

<u>Step 1: Assessing the presence/risks of noxious weeds and non-native invasive species at pre-construction phase of national road schemes</u>

In this step the presence of noxious weeds or non-native invasive species is recorded on data recording sheets with the location of each species and the extent of infestation plotted on a map at a scale of 1:5,000 or less. Large infestations should be identified as requiring specific treatment (during the site clearance and topsoil-stripping phase of construction), because if left unattended, they have the potential to cause significant problems in the future.

Here the following activities are very important:

- the area requiring treatment
- the type of treatment required
- an assessment of the risk of re-infestation from surrounding land.

The management plan should set out a clear process for eradicating, controlling and containing these species, including:

- an implementation schedule;
- records of treatments undertaken;

- locations where materials are disposed

__Step 2: Control and management of noxious weeds and non-native invasive species during site clearance and construction of roads__

Here, care should be taken to choose the most appropriate method for the specific circumstances at each site. Where chemical treatment is required, the use of such chemicals should be undertaken in accordance with the product label and Good Plant Protection Practices. The use of herbicides should be minimised, and application should be limited to a minimum. Those involved in the application of herbicides must be competent to do so and, consequently, must have sufficient training, experience and knowledge in the area of herbicides/pesticides application.

Soil management and storage

If noxious weeds or non-native invasive species are found during the construction of the road, the soil should not be translocated to another location due to the risk of spreading these species. At sites where Japanese knotweed is identified it may not be possible to use stores due to potential contamination. It must be treated or disposed of immediately.

Landscaping and landscape contractor maintenance

The landscape contractor will generally be required to maintain and manage the landscape treatments during the weed disinfestation (usually three years), once all landscaping works have been completed. All vehicles and equipment that have been used in control operations should be cleaned once control work in that section has been completed. This also includes footwear, tools, etc. It is also important to remove soil which may contain seeds and plant fragments which otherwise could be transported along the road corridor as works are being undertaken.

Disposal of material

Where cut, pulled or mown noxious weed or non-native invasive plant material arises, its disposal should not lead to a risk of further spread or poisoning livestock (the latter in the case of ragwort). Material that contains flower heads or seeds should be disposed either by composting or burial at a depth of no less than 0.5 m in the case of noxious weeds, or by incineration or disposal to a licensed landfill in the case of non-native invasive species. It should be noted that particular care is required in relation to the disposal of non-native invasive species and, in particular, to the disposal of Japanese knotweed (and other knotweed species). Where burial is being used to dispose knotweeds, the material should be buried to a depth of 5 m and overlaid with a suitable geotextile membrane. All disposals should be carried out in accordance with any Waste Management Act in place.

The control of noxious weeds and non-native invasive species should be undertaken in three distinct phases:

Assessment

An assessment of the presence of noxious weeds or non-native invasive species should be undertaken to guide the selection of control measures and the appropriate risk management requirements. This assessment will provide data on the species present, scale of infestation, age of plants and physical site conditions which will facilitate the identification of the most appropriate control measure. All previous measures should also be recorded. The assessment should also take account of the presence and location of any planting or landscaping on the section of the road in question, as well as any sensitive ecological receptors (e.g. water courses, species-rich grassland, designated conservation areas, etc.) that may be in the immediate vicinity.

Implementation of appropriate control measures

The decision to use a particular type of treatment to control noxious weeds and non-native invasive species will always be made on a case-by-case basis. Whilst generally there should be a preference for physical control methods, chemical control may in some cases be more appropriate. As the flowering period for most species is from June onwards, control measures should optimally be initiated during spring (late February to late May) to prevent plants flowering and thus producing seeds.

Post-control monitoring

Monitoring of the control measures should be undertaken approximately six to eight weeks after treatment to determine the success of the measures used. Further follow-up may be needed to ensure complete eradication. Follow-up treatment for several years (around five years) will be required for Japanese knotweed and giant hogweed due to the soil seed bank in the case of giant hogweed and the extensive underground rhizome of Japanese knotweed not fully taking up the herbicide resulting in re-growth.

<u>Step 3: Identification, ecology and control measures of noxious weeds and non-native invasive species</u>

The choice of control will depend on the scale of infestation, the age of the plants, their location and accessibility on the road, their proximity to sensitive neighbouring vegetation or habitat and the time of year. The guidelines precisely describe the identification, ecology and control measures of the following plants:

Noxious weeds:

• Spear Thistle *(Cirsium vulgare)*

• Creeping or Field Thistle *(Cirsium arvense)*
• Common Ragwort *(Senecio jacobea)*
• Curled Dock *(Rumex crispus)*
• Broad-Leaved Dock *(Rumex obtusifolius)*

Non-native invasive species:
• Japanese Knotweed (*Fallopia japonica*)
• Giant Hogweed (*Heracleum mantegazzianum*)
• Indian or Himalayan Balsam (*Impatiens glandulifera*)
• Giant Rhubarb (*Gunnera tinctoria*)
• Montbretia (*Crocosmia x crocosmiflora*)
• Winter Heliotrope (*Petasites fragrans*)
• Old Man's Beard (*Clematis vitalba*)
• Rhododendron (*Rhododendron ponticum*)
• Buddleia *(Buddleja davidii)*

The entire document can be downloaded here:
https://www.tii.ie/technical-services/environment/construction/Management-of-Noxious-Weeds-and-Non-Native-Invasive-Plant-Species-on-National-Road-Schemes.pdf
Please note that these guidelines are currently reviewed and a new IAPs Standard will be published in the next few months.

5 Best Practice for the Control of IAPs on Roads

This section describes the most common treatment methods known to control IAPs in the road sector. To be efficient and sustainable, the treatment shall always follow this basic process:

This basic process is valid **for both road construction (incl. the planning process) and road maintenance**.

During **road construction, methods** such as horizontal and vertical plant barriers can be utilised, to combat IAPs. Furthermore, the type and amount of sub-construction material may be important to avoid the growth and establishment of IAPs.

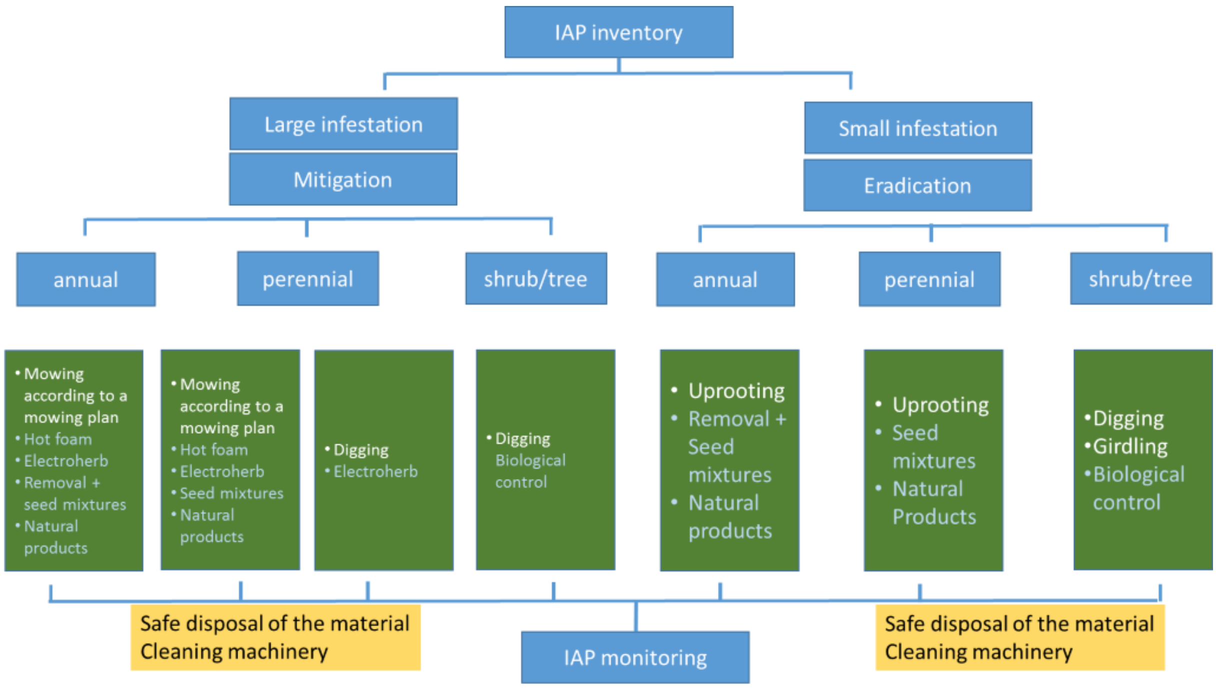


Figure 2: Basic decision process for choosing treatment methods against IAPs

5.1 IAP Inventory

BEST CURRENT PRACTICE - **INVENTORY**	
MEASURES	ONE COMMON SYSTEM for the INVENTORY of IAPs along roads shall be developed to: • be able to collect the Status Quo of IAP spread on the European level • be able to track the effectiveness of treatments and thus the development/spread of IAPs along roads in Europe
TECHNOLOGY	Basic functionalities of an inventory system for IAPs are: • GPS supported determination of exact location (incl. altitude) of IAPs • Selected possibilities of IAP species/types for different countries/regions • Possibility to describe surroundings of IAPs (soil quality...) • Storage and administration in a central database • Access through several device types (smart phones, PCs)
BEST PRACTICE	• Ireland • The Netherlands • Austria • Australia • Norway • Sweden • Several Apps, available for Android devices

Monitoring, i.e. systematic collection, recording and analysis of observations over time is a pre-requisite of success in the control of IAPs. If adequate information is available, it is possible to define, where and when measures against IAPs shall take place. Monitoring must be done continuously (repetitively) and comprehensively. This is important to be able to strategically control the spread of IAPs and to gain knowledge on the effectiveness of control methods over time.

Goals:

- to find and systematically record IAPs on site
- to use recorded data to manage and prevent the further spread of IAPs

Methods:

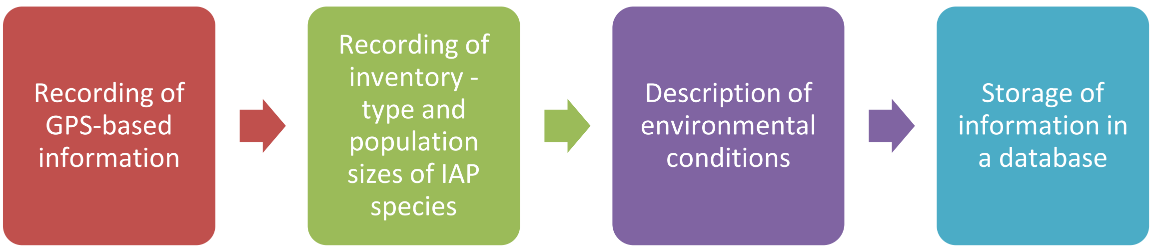
- Site visits with experts
- “Citizen science” (scientific research conducted, in whole or in part, by amateur or nonprofessional scientists)
- Notification requirement for species that cause health risks
- Software applications for detailed recording of the occurrence of IAPs and accessing relevant databases

Systematic monitoring of IAPs and connecting this information with other external data can also provide important knowledge regarding specific local conditions (e.g. soil, weather) and how these conditions affect IAPs (e.g. extensive growth).

In our survey nearly half of the stakeholders answered, that they do not have a system in place for systematically recording the occurrence of IAPs. Only 31% of the stakeholders responding in our survey have a system in use. The remaining 22% said that they only partially have a system in place, or that it is only used to a small extent. The stakeholders from Hungary, Czech Republic, Poland, Norway, Luxembourg, Italy, France and Belgium answered that they are not aware of suitable systems being used in their countries or of ongoing projects regarding the systematic recording of invasive plants.

Today several countries have started inventory projects, as for example the Netherlands, Norway, Sweden and Ireland. In addition, there are different smartphone-based Apps available to facilitate inventories performed by the public. It cannot be stated which system in use is the best, as each individual system is designed according to the different needs and requirements.

The underlying basic functionalities are though mainly the same:



5.1.1 Examples for IAP inventory from different countries

5.1.1.1 Ireland

In Ireland the "Guidelines on the Management of Noxious Weeds and Non-Native Invasive Plant Species on National Roads" (see 7.4 of this deliverable) are in place.

Some important statements dealing with post-control monitoring of IAPs are:

- Monitoring of the control measures should be undertaken approximately six to eight weeks after treatment to determine the success of the measures used
- Further follow-up may be needed to ensure complete eradication
- Some types of noxious weeds – in particular ragwort – can be difficult to control, particularly where it has not been managed for a number of years. As a result, it may be necessary to use a variety of control methods over an extended period to reduce populations
- Similarly, follow-up treatment for several years (around five years) will be required for Japanese knotweed and giant hogweed due to the soil seed bank of giant hogweed and the extensive underground rhizome of Japanese knotweed not fully taking up the herbicide resulting in re-growth.
- Repeated treatments or other means of controlling seedling germination will be required for a period of five or more years.
- Monitoring of the site will be required in mid-spring and mid-summer to assess the occurrence of seedlings and determine appropriate control.

Another document dealing with the spread of IAPs is the dataset "Irish Vascular Plant Data - Paul Green" (https://maps.biodiversityireland.ie/Dataset/178). Terrestrial maps on the flora of Britain and Ireland can be found in this document.

5.1.1.2 The Netherlands

In the Netherlands, the **„Verspreidingsatlas"** of the Dutch National Database Flora and Fauna (NDFF) informs about the spread of invasive alien plant species. This atlas describes the allocation of all plant and animal species in the Netherlands, including their growth and spread over the years. The whole document can be accessed here: https://www.verspreidingsatlas.nl/

Note: This database is not yet filled with sufficient and actual area covering information, but RWS (Rijkswaterstaat, Directorate-General for Public Works and Water Management) has started in 2019 to add requirements to investigate the presence of IAS on a project base. This is done in frame of regular monitoring in anticipation of management measures (like mowing) of road verges. These areas alongside the national roads are not accessible for the general public like in other countries. Therefore, the monitoring can only be done by professional agencies that meet the safety requirements for entry.

The Ministry of Agriculture, Nature Management and Fisheries is primarily responsible for the development of a national approach to meet the EU Regulation. A steering committee has been established to fulfil this task and develop an approach. This committee consists of different stakeholders like the National Food and Consumer Authority, Customs, Union of Water Authorities, The Provinces, Ministry of Economic Affairs and the Ministry of Infrastructure and Water Management. It has established a master program for the extermination and control of Union List species in 2017. The main aims of this program are that provinces are responsible for the policy for the Union List Species. Furthermore, there are specific tasks for Rijkswaterstaat (Rijkswaterstaat Ministry for Infrastructure and Water Management) to take care of the core tasks according to road and water safety and the conservation of roads and infrastructure network. In any case spread of IAS has to be prevented by appropriate management measures.

In 2019 The Netherlands have started to obtain data on the actual spread of IAS in the whole country and information on the most appropriate methods to control IAS by researchers of the Stichting Bargerveen. These insights will lead to an effective policy approach and will be transferred later to the standards and procedures for work processes in construction and maintenance of main roads. The following measures are set to control invasive alien plant species:

- grazing by sheep/pig (wherever suitable) or repeated mowing (especially in case of *Heracleum mantegazzianum*),
- glyphosate application and
- sometimes hot water or steam (especially in the case of *Fallopia* spp.).

5.1.1.3 Austria (Tirol/Tyrol)

The Federal State of Tyrol developed an online platform, in which the public can enter any observation of IAPs. These data help to obtain the distribution of IAPs in Tyrol as complete as possible.
The webpage can be seen here:
https://orawww.uibk.ac.at/apex/prod/f?p=20121119:1:0::NO

5.1.1.4 Germany

Here, the website www.korina.info was launched in Saxony-Anhalt. Furthermore, several federal states have registration offices for *Ambrosia* (http://www.ambrosia.de/ambrosia-meldestellen.html).

5.1.1.5 Australia

Although not from Europe, but an interesting document "Guidelines for Monitoring Weed Control and Recovery of Native Vegetation" has been developed in Australia. This document contains guidelines, which are written in a concise form and comprise the following chapters:

- Monitoring (definition, procedures)
- Photography (how to make a good photo documentation)
- Mapping (how to make correct mapping)
- Measuring of plant populations (how they have to be taken out, what to measure)
- Recording (how a recording system has to be set up)
- Conclusions and Acknowledgements

The entire document can be downloaded here:
https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/299360/Guidelines-for-monitoring-weed-control-and-recovery-of-native-vegetation.pdf

5.1.1.6 Norway

There are no systematic surveys in Norway. **However, surveys are conducted (by car) along roads every 5th year for some species**. The report **"Fremmede skadelige arter" (Invasive alien species) was published by the Norwegian Public Roads Administration (Statensvegwesen**) and describes how the Norwegian Public Roads Administration will implement the regulations regarding invasive alien species (website: https://www.miljostatus.no/fremmede-arter).

Furthermore, there exists a report which informs about the spread of invasive alien species: **„Invasive Alien Species – Pathway Analysis and Horizon Scanning for Countries in Northern Europe"**. This report is the product of a collaboration between the Nordic Council of Ministers and ten participating countries and territories (Denmark, Estonia, Finland, the Faroe Islands, Iceland, Latvia, Lithuania, Norway, Svalbard and Sweden), which are all part of the so called NOBANIS network. The following measures are set to control invasive alien plant species: Cutting, hot water (only on trial basis), chemical measures, removing soil.

The entire document can be downloaded here:
https://www.nobanis.org/globalassets/nobanis-projects/invasive-alien-species---pathway-analysis-and-horizon-scanning-for-countries-in-northern-europe.pdf

5.1.1.7 Sweden

Sweden has started systematic monitoring programs. It will take several years for a complete recording of invasive alien plant species along roads.

Until now there exist few publications dealing with IAPs and infrastructure:

"Invasiva arter i infrastruktur" ("IAPs and infrastructure") from 2015.
https://www.slu.se/globalassets/ew/org/centrb/cbm/dokument/publikationer-cbm/cbm-skriftserie/invasiva-arter-i-infrastruktur.pdf

The Swedish National Road and Transport Research Institute (VTI) has, on behalf of the Swedish Transport Administration, produced a report which is a compilation of the international state of knowledge in infrastructure environments concerning IAS (Tschan , 2018). Mainly performed in 2015-2016. The report also aims to identify national research needs and recommend strategies to counter the spread of invasive species in Sweden.

VTI Report (2016)

Tschan, G. F. (2018). Invasiva arter och transportinfrastruktur - En internationell kunskapsöversikt med fokus på vägar och växter. VTI, Statens väg- och transportforskningsinstitut.

https://www.vti.se/sv/Publikationer/Publikation/invasiva-arter-och-transportinfrastruktur_1201716

There is also a database in which individual occurrences can be displayed cartographically based on GIS (Art Databanken / The Swedish Species Information Center), however, this is not specific to invasive alien plants.

Furthermore, there exists as well as in Norway the already mentioned report which informs about the spread of invasive alien plant species: **„Invasive Alien Species – Pathway Analysis and Horizon Scanning for Countries in Northern Europe".**

During the last two years there are escalating activities in recording and combating IAPs along the Swedish road infrastructure. Giant hogweed (*Heracleum mantegazzianum*) has during many years, with shifting intensity, been a major problem. There are some municipalities that recently installed a notification office for the occurrence of giant hogweed (e.g. Uppsala-Län). The garden lupin (*Lupinus polyphyllus*) is considered a major threat to the biodiversity along roadsides, and many activities have started to combat this IAP. Japanese knotweed (*Fallopia japonica*) is also observed, especially in the Southwest.

5.1.2 *Examples for monitoring Apps for Android-based systems*

Modern technologies make it easy to design adequate technical systems for monitoring IAPs. A good example is software in the form of “Apps” for smartphones and tablets. Such Apps can be designed according to the specific needs and requirements of the user and allow exact localisation of IAPs as GPS functionality is available. The data collected can easily be stored in databases and shared with others.

Examples for Apps which are currently available:

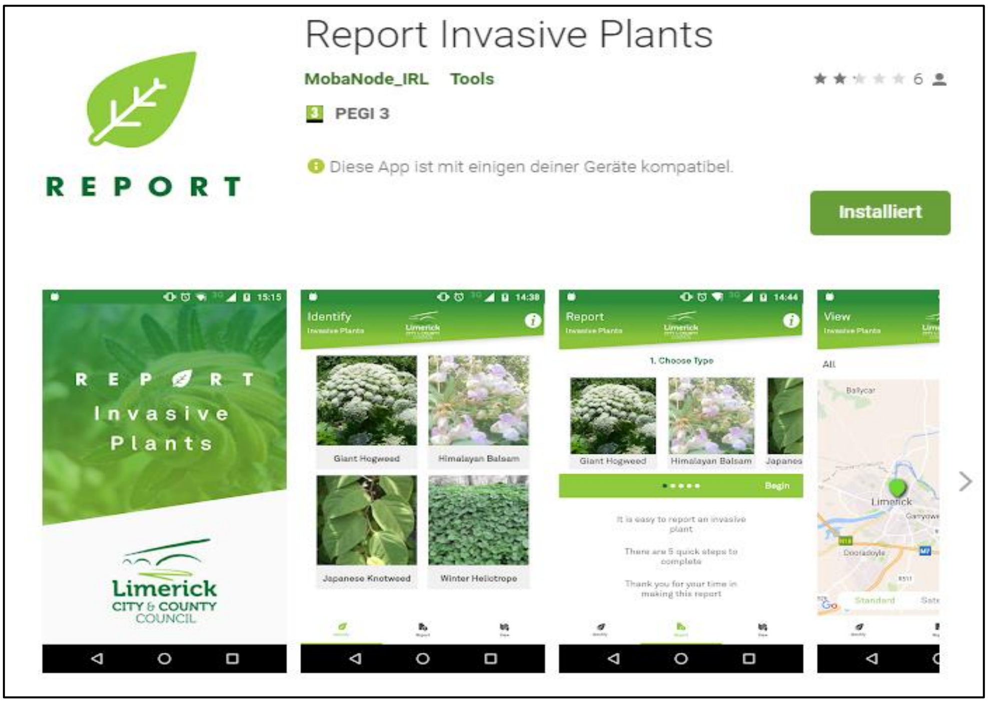


Figure 3: App “Report Invasive Plants” (source:https://play.google.com/store/apps/details?id=com.mobanode.invasivespecies&hl=de)

Figure 4: App “Invasive Species Mapper”(source: https://play.google.com/store/apps/details?id=com.servir.invasivespecies&hl=de)

Figure 5: App "Alien Species Reporter"(source: https://play.google.com/store/apps/details?id=com.chkraten.jstp4&hl=de)

5.2 On Site Treatment

BEST CURRENT PRACTICE -**TREATMENT**	
MEASURES	• MOWING/MULCHING of IAPs during ordinary road maintenance is the most common treatment of IAPs on site. Singularly, IAPs are removed by hand. Sometimes, special disposal procedures to avoid spread apply. • The success of different treatment methods depends on the IAP species. Detailed treatment methods for different IAPs are described in Deliverable “Booklet”.
MOST IMPORTANT	• A common best practice which always shall be applied during and after treatment on site is CLEANLINESS. • All equipment, clothes, shoes must be cleaned to avoid spread of IAPs
ROAD CONSTRUCTION	• During road construction, special measures like stronger sub-construction (see https://en.wikipedia.org/wiki/Macadam), plant barriers and special seed mixtures shall be applied.
BEST PRACTICE	• In Ireland, expert companies, specialised on treatment of IAPs along roads, support the local road authorities. A good practice, which could be adopted in other countries.

This chapter describes the most common treatment methods against IAPs. It distinguishes between “standard” methods, with are commonly used today and “alternative” methods, which have a certain potential to replace “standard” methods.

Goals:

- to control/manage IAPs growth and spread long term

Methods:

- standard and alternative methods
- various combinations of methods are possible

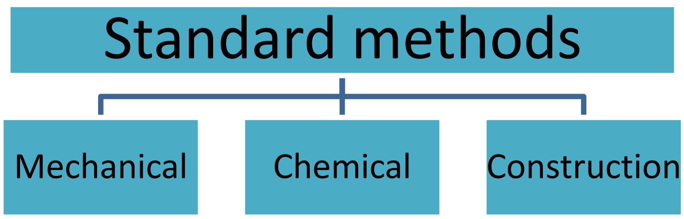


Figure 6: Major standard approaches to treat IAPs

5.2.1 Standard methods

There is an increasing impetus to reduce the use of herbicides to control IAPs. Currently there are countries where herbicides are not allowed to be used on roadsides or special permits are required where their use is unavoidable. In countries where herbicides are permissible, their use is often the most affordable with regard to cost and effectiveness. However, the extensive use of herbicides can cause increased resistances against the herbicides. If using herbicides, the success has to be controlled and often more than one treatment is required. Using herbicides against *Fallopia* spp. for several years with at least two treatments per year should be considered (Jones et al. 2018). Standard methods for IAP control principally involve mulching, mowing, and hand removal. Another standard nature management method is “grazing” (by goats or sheep), a measure applicable only under certain conditions if suitable preconditions are available and road safety is guaranteed. This would be a viable option for specific right of way situations (e.g. reclaiming overgrown roadside sites). However, this method cannot be applied to major roads but might be applied to small roads or roads with a very low traffic volume. There are many restrictions such as high costs (e.g. for fencing) and safety concerns (Popay & Field 1996, Willard 2016). Thus, the applicability of grazing measures is highly limited in the road sector although it might be useful in other areas of infrastructure (e.g. along waterways).

5.2.1.1 Mechanical methods

Mowing and mulching are the most widely used methods for vegetation management on road sides. Both methods can be effective but several considerations have to be made. In general, annual plants should be cut at the ground level and before flowering to avoid the dispersal of propagules, e.g. seeds. Timing and frequency of cutting is crucial for some species as they are able to re-sprout fast. For a few IAPs, mowing regimes are available (e.g. *Ambrosia artemisiifolia*, *Lupinus polyphyllus*; Milakovic et al. 2014, Brobäck 2015).

For perennial plants, mowing should be done during the appropriate growing season and at the adequate cutting height. Mowing of perennial plants should be done twice a year, at the beginning of the growing stage (May/June) and before resources are transported to the storage organs (i.e. generally September/October) to weaken the plants. After the treatment, the equipment must be cleaned before working on other sites and adequate biosecurity measures must be put in place on-site. Hand removal of certain species may be an effective method for small infestation sites. In this case costs will be high in the first year of management but in the following years, less work will be needed and costs will be lower.

Table 2: Overview of standard, mechanical methods

Standard methods - Mechanical						
Method	**Advantage**	**Disadvantage**	**Plant species**	**IAPs (selection)**	**Main references**	**Practicable and effective method for the control of IAPs**
Mowing/Mulching	Low cost in comparison to other mechanical control options, for medium to large-sized populations, standard measure	High frequency needed. To prevent seed production the timing is very important. Some IAPs (*Fallopia* spp.) sprout from stem fragments which rapidly re-sprout, therefore mowing is not a suitable option for such species.	Annuals, perennials	*A. artemisiifolia*, *L. polyphyllus*, *A. syriaca*, *H. mantegazzianum*, *I.glandulifera*	Pyšek et al. (2007), Brobäck (2015), Zalai et al. (2017), Lommen et al. (2017) G. Gebhard (road maintenance unit, Burgenland, Austria), pers. comm.	*
Hand removal (uprooting)	Effective, highly targeted, surrounding native species remain unaffected	High cost, labour intensive, only suitable in areas with low infestation (small stands)	Annuals	*I.glandulifera*, *A.artemisiifolia*	Howell (2002), D. Fischer (Zürich), pers. com	*
Digging/Excavation	Effective, highly targeted, surrounding native species remain largely unaffected	High cost, labour- intensive, only suitable in areas with low infestation, requires good access	Annuals, perennials	*Fallopia* spp., *A. syriaca*, *G. tinctoria*, *H. mantegazzianum*	Pyšek et al. (2007), D. Fischer (Zürich), pers. comm.	*
Brushing	Effective	Only used on hard surfaces, negative effect on the pavement	Annuals, perennials	Experimental and/or field tests available, not yet tested on relevant IAPs	Rask & Kristoffersen (2007)	

5.2.1.2 Chemical methods

Table 3: Overview of standard, chemical methods

Standard methods – Chemical						
Method	**Advantage**	**Disadvantage**	**Plant species**	**IAPs (selection)**	**Main references**	**Practicable and effective method for the control of IAPs**
Herbicides	Effective, flexible	Environmental problems, herbicide resistance, legal constrains in some countries	Annuals, perennials, shrubs, trees	Experimental and/or field tests available, tested on relevant IAPs	Jones et al. (2018)	*

5.2.1.3 Constructional methods

Table 4: Overview of standard, constructional methods

Standard methods – Constructional						
Method	**Advantage**	**Disadvantage**	**Plant species**	**IAPs**	**Main references**	**Practicable and effective method for the control of IAPs**
Usage of non-contaminated, suitable material for sub-construction	Effective	Additional effort	All	All	HERBIE — GUIDELINES, STATE OF THE ART AND INTEGRATED ASSESSMENT OF WEED CONTROL AND MANAGEMENT FOR RAILWAYS Preparation: Fundamental Values Department, Sustainable Development Unit Publication: U I C-ETF	*
Plant barriers	Effective	Additional effort	All	All	HERBIE — GUIDELINES, STATE OF THE ART AND INTEGRATED ASSESSMENT OF WEED CONTROL AND MANAGEMENT FOR RAILWAYS Preparation: Fundamental Values Department, Sustainable Development Unit Publication: U I C-ETF	*
Usage of special seed mixtures	Reduces establishment of IAPs	Additional effort	All	All	HERBIE — GUIDELINES, STATE OF THE ART AND INTEGRATED ASSESSMENT OF WEED CONTROL AND MANAGEMENT FOR RAILWAYS Preparation: Fundamental Values Department, Sustainable Development Unit Publication: U I C-ETF	*

5.2.2 *Alternative methods*

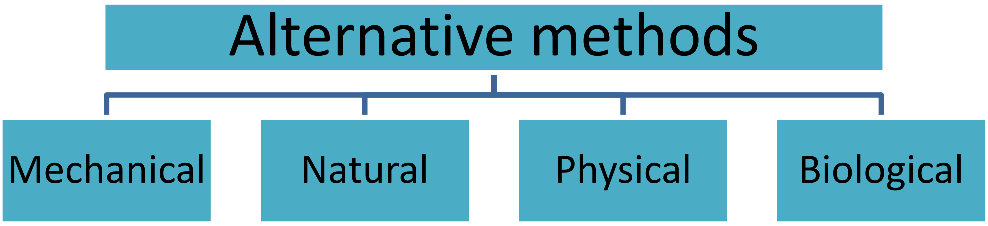


Figure 7: Major alternative approaches to treat IAPs

5.2.2.1 Mechanical methods

Stem girdling can be effective on invasive trees, but it is quite labour intensive. The use of geotextiles to prevent the regrowth of plants can be done on constructions sites. Mowing and mulching with the use of competitive seed mixtures can be done for plants with low competition abilities like ragweed. The objective is to restore the native vegetation.

Table 5: Overview of alternative, mechanical methods

Alternative methods - Mechanical						
Method	**Advantage**	**Disadvantage**	**Plant species**	**IAPs (selection)**	**Main references**	**Practicable and effective method for the control of IAPs**
Mowing (removal), competitive seed mixture	Sustainable method	Restoration of native vegetation is critical	Annuals and biannuals	*A.artemisiifolia*	Schuster et al. (2018)	*
Stem girdling (ring-barking)	Effective to prevent re-sprouting, surrounding native species unaffected	High cost, labour intensive, only suitable in areas with low infestation	Shrubs and trees	*R. pseudoacacia*, *A. altissima* *A. negundo*	Böcker & Dirk (2008) Merceron et al. (2016)	*
Suffocation/Smothering (Geofabrics, CuTex Root Barrier, Knotblock)	Effective (inhibits germination and budding). Prevent the spread into neighbouring sites, used during road construction	Less effective against rhizome perennials (e.g. *F. japonica*), maintenance effort, difficulty of removal, disposal management Alternative: biodegradable mulch film	Annual, perennials	Practical use in agriculture (vegetables), experimental and/or field tests available, tested on relevant IAPs (e.g. *F. japonica, H. mantegazzianum, I.glandulifera*)	Jones et al. (2018), http://www.geosyn.co.uk/product/knotblock-knotweed-barrier	*

5.2.2.2 Methods based on natural products

The use of organic acids like pelargonic acid as an alternative to herbicides is under investigation and will be evaluated in the field trial 2019 on ragweed. Pelargonic acid, acetic acid and caprylic acid are allowed for the use in urban areas of pesticide free cities. Natural products based on essential oils are too cost intensive and are not suitable for road infrastructure management. Organic acids need more frequent applications compared to herbicides.

The use of allelopathic plants for greening the road verges should be implemented during road construction. This is a cost-effective way to outcompete some IAPs.

Table 6: Overview of alternative methods using natural products

Alternative methods – Natural products						
Method	**Advantage**	**Disadvantage**	**Plant species**	**IAPs (selection)**	**Main references**	**Practicable and effective method for the control of IAPs**
Organic acids (e.g. acetic acid, pelargonic acid, caprylic acid ,capric acid)	Effective against (young) annual broadleaf plants	Not very effective against grass species and perennials, only “burndown effect” (i.e. active ingredient has contact activity), high dosages needed, high costs	Annuals	Experimental and/or field tests available (along roadsides), not yet tested on relevant IAPs	Young (2004), Abouziena et al. (2009), Barker & Prostak (2014), Crmaric et al. (2018)	*
Essential oils (e.g. clove oil, pine oil, citrus oil)	Effective against (young) annual broadleaf plants, positive image of the product (“natural”)	Not very effective against grass species and perennials, only “burndown effect”, high dosages needed, high costs	Annuals	Experimental and/or field tests available (along roadsides), not yet tested on relevant IAPs	Young (2004), Boyd et al. (2006), Abouziena et al. (2009), Barker & Prostak (2014)	
Plant oils (rape oil, sunflower oil)	Reduces biomass of plants, environmentally friendly	Herbicidal activity appears low (depends on plant species), more treatments necessary, quantities required may not be economically viable	Annuals, perennials	Experimental and/or field tests available, not yet tested on relevant IAPs	Hodge et al. (2018)	
Iron chelate solution	Selective, for broadleaf plants, no residuals	Repeated treatments necessary, product not available in Europe yet	Annuals, perennials	Not yet tested on IAPs	Fiesta™ Weed Control (https://www.nutrilawn.com/fiesta-weed-control), Smith-Fiola & Gill (2014)	
Corn gluten meal (crude botanical product)	Pre-emergence herbicidal activity, positive image of the product (“natural”)	Grasses and perennial weeds are less sensitive, applicability along roadsides questionable (e.g. high quantities needed)	Annuals	Experimental and/or field tests available (along roadsides), not yet tested on relevant IAPs	Barker & Prostak (2014), Dayan & Duke (2015)	

Alternative methods – Natural products (Table continued)						
Method	**Advantage**	**Disadvantage**	**Plant species**	**IAPs (selection)**	**Main references**	**Practicable and effective method for the control of IAPs**
Plant allelopathy (*F. rubra*, *F. arundinacea straw/mulch* (crude botanical product)	Can be effective	Effectiveness depends largely on the weed spectrum, applicability along roadsides questionable (e.g. high quantities needed), more experiments necessary	Annuals, perennials	Experimental and/or field tests available, not yet tested on relevant IAPs	Bertin et al. (2007), Recasens et al. (2018)	*

5.2.2.3 Physical methods

The methods listed in the table below is a summary. Some of the methods are not suitable for road infrastructure like brushing, direct flames, freezing or high cold-water pressure. Other methods are still in the development like microwaves, but no equipment is available. Hot water is a widely used method in urban application for hard surfaces. The method is quite effective against small weeds. If the weeds are bigger, the method is not successful.

The use of hot foam or infrared radiation is under investigation and the effect will be evaluated in the field test in 2019. The use of electric power is still being evaluated. All these methods need to be applied several times during the vegetation period.

Table 7: Overview of alternative, physical methods

Alternative methods- Physical						
Method	**Advantage**	**Disadvantage**	**Plant species**	**IAPs (selection)**	**Main references**	**Practicable and effective method for the control of IAPs**
Direct flame	Can be effective (on a hard surface 100% reduction of weed cover)	Effectiveness depends on plant age and species, weather conditions; less effect on perennials; high energy consumption (6.82 kg/h, working width 1 m), fire hazard	Annuals	Experimental and/or field tests available (along roadsides), not yet tested on relevant IAPs	Ascard (1995), Rask & Kristoffersen (2007), Barker & Prostak (2014)	
Hot water	Can be effective, moderate environmental impact	Effectiveness depends in particular on plant age and species, weather conditions, less effect on perennials	Annuals	Experimental and/or field tests available, not yet tested on relevant IAPs	Kurfess & Kleisinger (2000), Rask & Kristoffersen (2007) HEATWEED Technology (http://heatweed.com/about-the-company/)	
Hot foam made from plant oils and sugar	Can be used on any surface, low energy consumption, due to the foam, the heat stays longer on the plant	Very high impact on environment because palm oil and avocado oil is used.	Annuals	Experimentally tested	Foamsteam available at the US market (https://www.benziecd.org/uploads/1/1/5/2/11522077/invasive_plant_treatments_alt_to_herb.pdf)	*
Steaming	Can be effective, less water use as for hot water, higher heat transmission	Effectiveness depends in particular on plant age and species, weather conditions, less effect on perennials; high	Annuals	*E. annuus*, *Senecio* spp. Experimental and/or field tests available, not yet tested on relevant IAPs	Rask & Kristoffersen (2007)	

		risk of energy loss during application				

Alternative methods- Physical (Table continued)						
Method	**Advantage**	**Disadvantage**	**Plant species**	**IAPs (selection)**	**Main references**	**Practicable and effective method for the control of IAPs**
Hot air	Effect similar to other thermal control methods	Effectiveness depends in particular on plant age and species, weather conditions, less effect on perennials; High energy needed, only small machines are available	Annuals	Experimental and/or field tests available, not yet tested on relevant IAPs	Rask & Kristoffersen (2007)	
Cold water (under high pressure)	Can be effective, machine for practical use available	Cost intensive	Annuals	Experimental and/or field tests (orchards) available, not yet tested on relevant IAPs	Bravin & Kuster (2016)	
Infrared radiation	Can be effective	Effectiveness depends in particular on plant age and species, weather conditions, less effect on perennials; high cost, low area output, *no machine available*	Annuals	Experimental and/or field tests available, not yet tested on relevant IAPs	Ascard (1995), Rask & Kristoffersen (2007)	

Microwaves	-	High energy consumption (1000 to 3400 kg diesel/ha), no machine for practical use available, experimental stage	Annuals	Experimental and/or field tests available, not yet tested on relevant IAPs	Sartorato et al. (2006), Rask & Kristoffersen (2007)	
Laser radiation	Lower energy cost compared to other thermal control	Does not kill plants, only retards plant growth, no machine for practical use available, experimental stage for direct targeting the specific plant species	Annuals	Experimental and/or field tests available, not yet tested on relevant IAPs	Rask & Kristoffersen (2007) Mathaissen et al 2006 Kaierle et al 2013	

Alternative methods- Physical (Table continued)						
Method	**Advantage**	**Disadvantage**	**Plant species**	**IAPs (selection)**	**Main references**	**Practicable and effective method for the control of IAPs**
Freezing (i.e. liquid nitrogen and carbon dioxide)	-	Only destroys upper part of the plants, no machine for practical use available. Treatment is time and cost intensive, can damage road infrastructure	Annuals, perennials	Experimental and/or field tests available, not yet tested on relevant IAPs, except *Fallopia* sp.	Rask & Kristoffersen (2007), Report LIFE12 NAT/AT/000321	
Electroherb	Effective against (young) annual grass and broadleaf plants	The deep root system of perennials is not sufficiently affected, experimental stage	Annuals (perennials)	*Ambrosia artemisiifolia*		*

5.2.2.4 Biological methods

Biological control can be applied for specific IAPs. The usage depends on the registered product. The best results are obtained on trees, because other methods are mostly not allowed or available. The development of specific bioherbicides requires more investment in research and development to evaluate effects on non-target species.

Table 8: Overview of alternative, biological methods

Alternative methods- Biological						
Method	**Advantage**	**Disadvantage**	**Plant species**	**IAPs (selection)**	**Main references**	**Practicable and effective method for the control of IAPs**
Chondrostereum purpureum	Effective	Cultivated and native *Prunus* sp. are also affected, commercially developed (BioChon), but not on the market	Trees (*Prunus* sp.)	*P. serotina*	De Jong (2000), Hamberg et al. 2017 https://neobiota.bfn.de/handbuch/gefaesspflanzen/prunus-serotina.html	*
Verticillium nonalfalfae	Effective, commercially developed (Ailantex) and temporarily authorized (in AT),	Labour intensive (stem inoculation), follow-up host range studies are needed	Trees (*A. altissima*)	*A. altissima*	Maschek & Halmschlager (2017), Maschek & Halmschlager (2018)	*
Puccinia komarovii var. *glanduliferae*	Effective, already released in the UK, (establishment phase)	Biotypes of *Impatiens glandulifera* seem to be less sensitive	Annuals (*I. glandulifera*)	*I. glandulifera*	Varia et al. (2016)	*

5.3 *Disposal of IAPs*

BEST CURRENT PRACTICE - **DISPOSAL**	
MEASURES	• DISPOSAL of IAPs, which are still able to spread after treatment, is a very critical issue, because appropriate disposal of IAPs is costly. • Because disposal is such a critical issue, clear rules shall be defined. • General rules shall be issued in national laws (e.g. ban to spread specific IAPs). • Rules for disposal of IAPs shall preferably be defined in national standards and guidelines.
BEST PRACTICE	• Today only a few examples (e.g. Ireland, the federal state of Vorarlberg in Austria) are known, where disposal with awareness of IAPs is undertaken.

<u>Goals:</u>

- to avoid spread of IAPs

The question if and how IAPs shall be disposed is closely connected with, sometimes even integrated in, the method of treatment.

Correct disposal of mowing or cutting waste is important to avoid spread of IAPs, especially if the treatment method applied only cutting the plants without destroying them. Also, non-destroyed roots can spread IAPs. If it cannot be ensured that the plant waste is no longer viable, it should be treated like hazardous waste. Reasonable treatments in such cases could be deep burial or burning (if allowed).

<u>Important questions in connection with the disposal of IAPs are:</u>

- Which plants must be specifically disposed?
- How must the waste be disposed?
- Which quantities must be disposed?
- Can the waste be dried on site before being transported (to reduce the transport volume)?
- Can the disposal be integrated in existing processes?

The biology of the IAPs will determine the most appropriate method of disposal. Plants which cannot regrow from cut material do not need to be disposed as is the case for ragweed, *Heracleum mantegazzianum*, lupin etc. Other plants which can easily re-grow from cut stems like *Fallopia* spp., Himalayan balsam etc. need to be safely removed from the site to prevent their spread.

Disposal of waste may cause huge additional costs, as transport and controlled disposal in a licenced facility is necessary. Transport cost could be reduced, if plants can be dehydrated on site (less biomass and weight to transport). Nowadays, because of the required efforts mentioned above, controlled disposal of IAPs is rarely carried out. An exception is the construction of new infrastructure in Ireland.

When planning and building new road/rail infrastructure, it may be easier to dispose IAPs than in regular road/rail maintenance.

Dumping, mowing or cutting waste into or near waterbodies is not an option for disposing IAPs due to the likelihood of further spread.

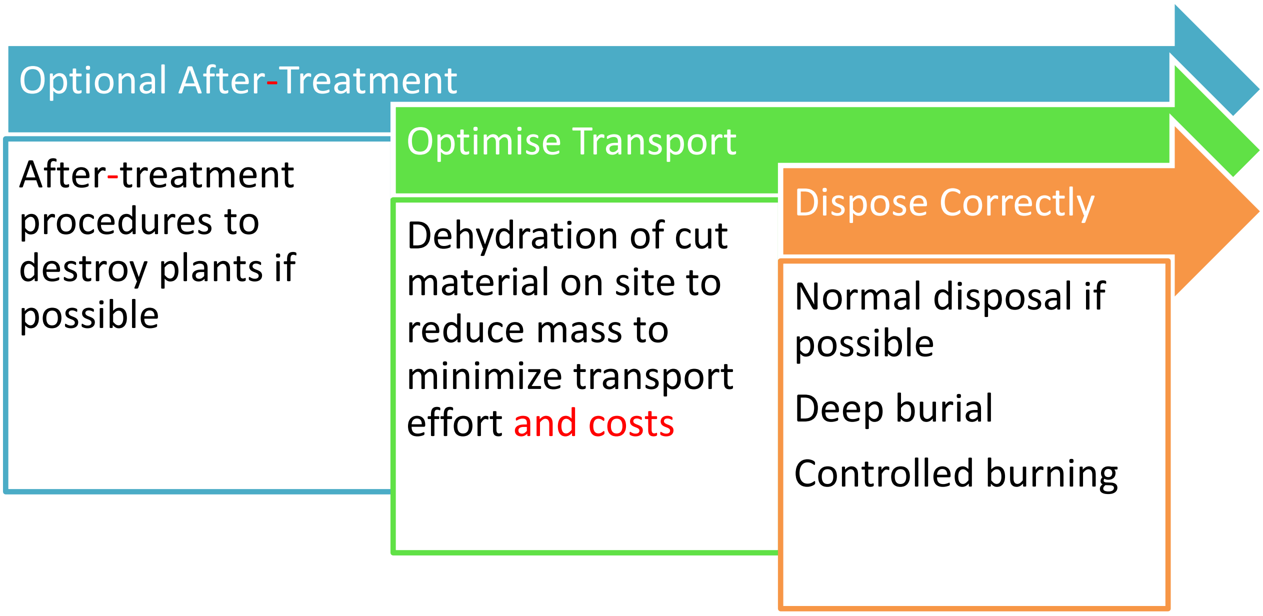


Figure 8: Fundamental decisions regarding disposal of IAPs

5.4 *IAP monitoring*

BEST CURRENT PRACTICE - **MONITORING**	
MEASURES	• As a measure of quality control, the monitoring of the effectiveness of the treatment on-site shall be controlled by visual inspections. • For this post-monitoring, the same procedures and technologies as for the inventory shall be used. • Thus, the effectiveness of the treatment can be judged and the long-term management of IAPs can be monitored in a controlled way.
MOST IMPORTANT	• If during monitoring (re-grown) IAPs are detected, these shall be removed by an appropriate method to make sure that the roots are removed.
BEST PRACTICE	• Ireland

Even after successful treatment, regular monitoring of any occurrence of IAPs is necessary in order to be able to successfully manage a site and save costs in the long term. It is recommended to remove any re-growth of IAPs directly during monitoring.

With this step, the loop is closed to the IAP inventory and it is assured that IAPs are sufficiently controlled.

<u>Goals:</u>

- To avoid re-growth of IAPs
- To identify IAPs hot spots after treatment

<u>Methods:</u>

- Site visits (visual inspection during regular or occasional maintenance) for at least 10 years
- Immediate removal of IAPs if observed (preferred: manual weeding/digging/removal)
- Recording of critical hot spots

6 Best practice in road maintenance and road construction

To successfully control IAPs, appropriate processes must be followed during the planning and construction (or the general renovation) of roads as well as during regular maintenance activities.

It does not matter if the construction or maintenance of the roads is carried out internally (by the road authorities and their associated internal organizations) or if external service providers are involved.

In this document ("Best Practice") we report on the status quo of these processes. Detailed recommendations, which measures should be carried out, are described in deliverable 5.1.

In the first survey, only about half of the participants (about 100 replies) were able to identify the processes (both for construction and maintenance) regarding IAPs in their organization.

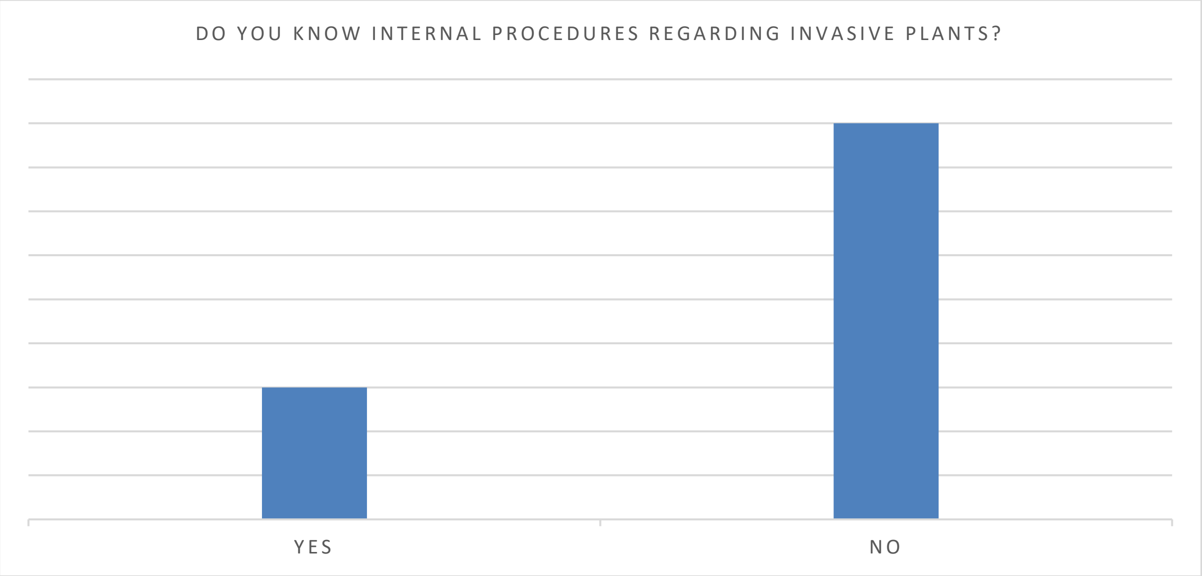


Figure 9: Do you know internal procedures regarding invasive plants?

When asked whether they were aware of tenders for road construction with any specific requirements regarding IAPs, only a third could answer with yes.

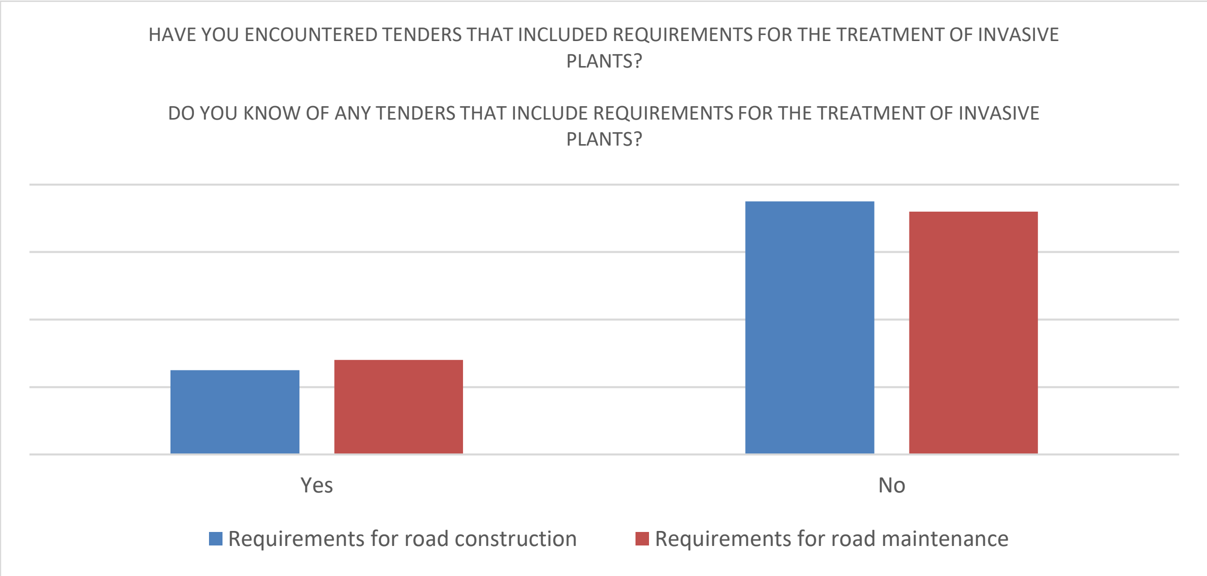


Figure 10: Have you encountered tenders that included requirements for the treatment of invasive plants/Do you know of any tenders that include requirements for the treatment of invasive plants?

Similarly, national guidelines and standards regarding IAPs are largely unknown. The main reason for this is that such national guidelines and standards are until now hardly available.

However, the existence of national guidelines and standards is essential in order to be able to develop internal processes for road construction and maintenance and to be able to integrate corresponding requirements in tenders.

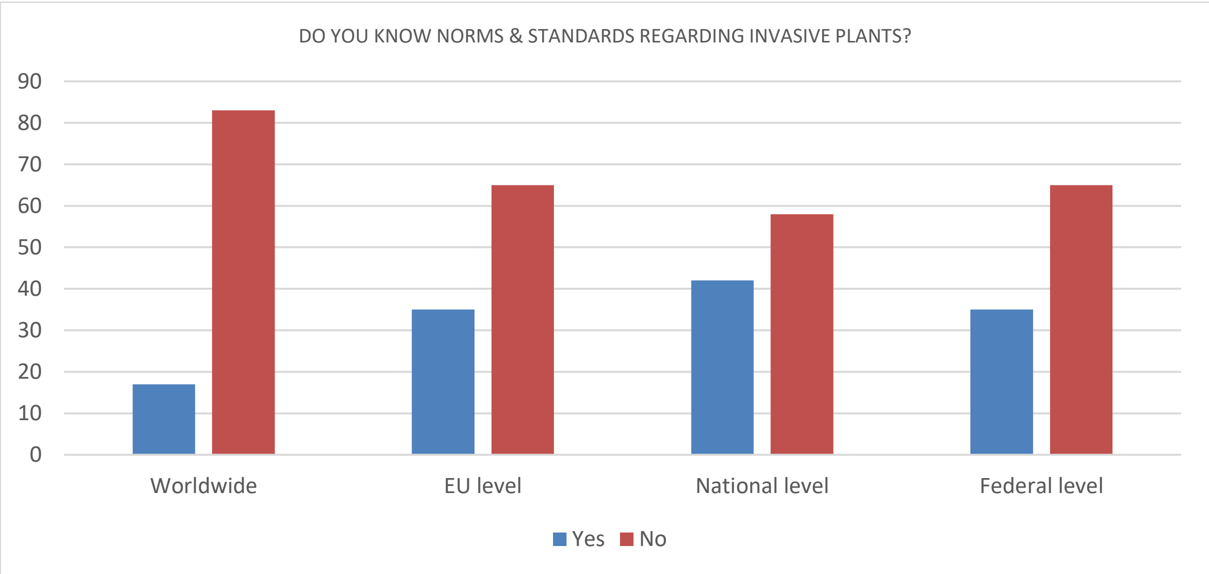


Figure 11: Do you know NORMS & STANDARDS regarding invasive plants?

6.1 IAPs in road infrastructure maintenance

Mechanical, chemical or alternative treatment of IAPs is frequently carried out during regular road maintenance''.

Important to consider:

- Time of year
- Weather conditions
- Plant growth stage (flowering stage)
- Size of infestation
- Goal of treatment (mitigation/eradication)
- Avoid the spread of IAPs (cleaning of the machinery and clothes!) i.e. biosecurity measures
- Minimize the use of resources and costs
- Ensure maximum user health and environmental protection (humans/animals/plants)
- Prevention of spread of IAPs

6.1.1 Examples for treatment of IAPs in road maintenance from different countries

6.1.1.1 Ireland

Again, the„ Guidelines on the Management of Noxious Weeds and Non-Native Invasive Plant Species on National Roads" can be mentioned as a good example. In Ireland local road authorities are effectively supported by the central road authority. Because the local road authorities do not have the resources required for the effective and adequate treatment of IAPs, the central road authority decided to issue a tender for IAPs expert services. This tender resulted in a framework agreement with 15 expert companies for IAP control in Ireland, which support the local authorities on their request.

Criteria relevant for the evaluation of tenders have been:

- 70% tender quality (no evaluation of proposed methods)
- 30% costs

The local authorities may choose freely between 15 expert companies, despite their location. Payment is connected to the success of the treatment. The payment scheme expects that successful treatment will take several years, and the payment is scheduled accordingly. The final rate is paid after a quality control procedure assuring that the treatment is sustainable.

6.1.1.2 United Kingdom

In the UK the "Best Practice Guidance Notes - Control of Weeds" are in place. The guidance document is for local authorities involved in the control of weeds on hard surfaces and has a focus on integrated and non-chemical weed control, including the development of management plans and tools to monitor the effectiveness of the chosen treatment regime. The document also references to corresponding acts, directives and regulations in the UK and the EU.

The entire document can be downloaded here:
http://www.emr.ac.uk/wp-content/uploads/2015/03/BPWeeds2015web1.pdf

6.1.1.3 Norway

Road maintenance in Norway is contracted to external service providers on long term (5 years) contracts.
No detailed information is available on how IAPs are treated in tenders or contracts. Depending on the size of the population and where it is situated the number of treatments amounts to a maximum of 2 times a year (in Norway IAPs are not very common).

6.1.1.4 Slovenia

The maintenance of national roads in Slovenia varies between the maintenance of motorways and the maintenance of major and regional roads.

The Slovenian Infrastructure Agency is responsible for the management, maintenance and development of major and regional roads and the national cycling network. Maintenance is assigned to a concessionaire (private company) who obtains a concession for the management of roads (public-private-partnership) for 7 years.

IAPs are treated as follows:
The actual number of treatments per year with different standard methods amounts from three times a year (*Fallopia spp.)* to 3-4 times a year *(Ambrosia artemisiifolia*).

6.1.1.5 Austria

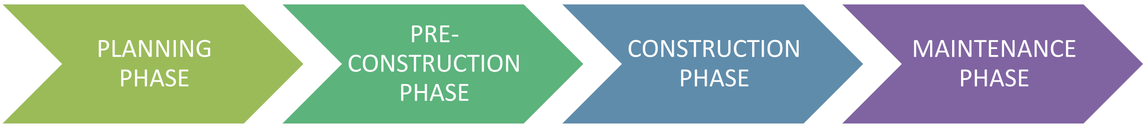
Road maintenance in Austria is performed by internal organisations.
IAPs are treated as follows:

In the federal state of Upper Austria the actual number of treatments per year with different standard methods varies from 5 times a year (*Ambrosia artemisiifolia)* to 50 times a year *(Fallopia* spp.).

6.2 IAPs in road infrastructure construction

During construction of new road or road re-construction constructional measures can be undertaken to avoid the growth of IAPs. Thus, extended maintenance costs (internally or claimed by contractors) can be avoided.

<u>Basic treatment process of IAPs in road construction:</u>



<u>Planning Phase:</u>

- **IAP Inventory** (survey and recording of IAPs)
- **Description of potential measures**. If relevant IAPs occur, it is recommended to describe them in an environmental review report. The responsible authorities may prescribe measures against IAPs and issue them as constraints/burdens
- **Special road design** which helps to avoid IAPs, shall be considered

<u>Pre-construction Phase:</u>

- Pre-treatment on site (e.g. mowing, usage of herbicides)
- Removal of IAPs and correct disposal
- Excavated material shall be stored and treated in such a way that growth and spread of IAPs is avoided (e.g.: cleaning, covering)
- **Waste/excavated material must be disposed according to local legislation**

<u>Construction Phase:</u>

- Usage of **non-contaminated, suitable material for sub-construction** in sufficient strength. If available material on site is not suitable, the material shall be replaced by clean material.
- Construction of vertical and horizontal **physical barriers** against IAPs to prevent the re-sprouting of root and rhizomes.
- Usage of **special seed mixtures** for greening containing domestic plants species suitable for the specific climate to avoid establishment of any incoming IAPs.

Maintenance Phase (see also chapter "road maintenance")

- Regular monitoring and immediate removal of IAPs if they are observed
- Recording of IAPs hotspots

6.2.1 *Examples regarding treatment of IAPs in road infrastructure construction from different countries*

6.2.1.1 Ireland

In Ireland there are the "Guidelines on the Management of Noxious Weeds and Non-Native Invasive Plant Species on National Roads" in place. According to these guidelines, before and also during the construction of a road IAPs have to be considered. It is required to perform a detailed assessment prior to the construction, i.e. species, location, scale and extent of infestation, growth stage, sensitivity of the local environment, etc. have to be recorded. A management plan has to be in place prior to any site works and all contractors have to be notified. The priority is placed on the reduction of any risk regarding the transfer of seed or disseminative material and activities in infested zones are not allowed.

6.2.1.2 Germany

In Germany there exists the concise but informative guideline "Invasive Neophyten auf Baustellen" ("Invasive neophytes on construction sites"). These guidelines deal with:

- Dangers that emanate from invasive neophytes
- Occurrence of invasive neophytes
- List of occupational groups and institutions that have a special responsibility to prevent the further spread of invasive neophytes
- Guidelines for dealing with neophytes in construction projects
  - Preventive measures, immediate measures and control
  - Professional disposal and landfilling
- Risk for the contractor in case of non-compliance

The entire document can be downloaded here:
https://www.siegen-wittgenstein.de/media/custom/2170_1185_1.PDF?1443432785

6.2.1.3 Switzerland

In Switzerland, the City of Lucerne and the Canton of Lucerne have published the concise but informative guideline "Invasive Neophyten auf Baustellen" ("Invasive neophytes on construction sites"). These guidelines deal with:

- Procedures related to construction projects
- Obligatory principles related to construction projects with invasive neophytes
- The main problematic plants
- Measures to be planned in frame of the construction phase

The entire document can be downloaded here:
https://vif.lu.ch/-/media/VIF/Dokumente/Download/Fachordner/Naturgefahren/938_001_neophytenbaustelle.pdf?la=de-CH

6.2.1.4 Sweden

In Sweden, surveys on IAPs were carried out for isolated road projects and appropriate measures proposed for their handling.

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