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

Recommendations and best practice guide based on outcomes of WP3 and WP4

controlinroad

CEDR Call 2016: Three applied research programmes covering the topics safety, biodiversity and water quality alongside roads

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1 Executive summary

In some countries, the problem of invasive alien species IAPs in the road sector is not seen as important as it should be (in politics and society) (Questionnaire D4.2, Brunel et al., 2013). It is well known and evident that IAPs pose a threat to the natural environment and that some can cause problems to human health,and cause economic costs (for instance damage road infrastructure). Nevertheless, IAPs expand (Wang et al., 2019) and the problems they cause are likely to increase sharply in the future. Therefore, it is important to develop suitable strategies for a sustainable management of IAPs in the road sector and to get them into broad application.

Due to different organizational forms, responsibilities, local infrastructures and environments, it is hardly possible to make recommendations which suit all countries or regions. Therefore, this document will only recommend generally applicable principles for measures to be implemented by the individual countries.

Basic measures for most European countries (with just a few exceptions like e.g. Ireland) are:

1. **Clear competencies and responsibilities**

It is important that there are clear competencies and responsibilities for IAPs management in the respective road administrations. Responsible bodies with appropriate knowledge and organizational authority should be installed at national and regional/local levels. Overall, the issue of IAPs control requires a higher-level national coordination. It is recommended that the responsible national body (e.g. ministry) is responsible for preparing the basic principles for the management of IAPs at a national level and also actively supports the regional road administrations. A good example of this is Ireland, where the national road authority has taken the lead for IAPs management and supports the local authorities with knowledge and external resources.

2. **Adequate, sustainable budgeting**

In addition to clear competencies, responsibilities and appropriate knowledge in road administrations, sufficient budget funds must also be made available for the management of IAPs. Regular budgets for inventory, treatment, disposal and control have to be provided. Furthermore, financial resources are required for raising awareness and training. In frame of the management of IAPs a national survey and documentation system (Survey & Documentation Tool) has to be implemented and also needs to be considered in the annual budget.

3. **National survey and documentation system (Survey & Documentation Tool)**

The foundation (basic tool) for successful IAPs management is a national survey and documentation system. With the help of this uniform tool, IAPs can be widely recorded. Treatments and post-treatments can also be documented facilitating the control of IAPs. Such a tool can be also used to document the effectiveness of control methods. Based on this information, spatial and temporal treatment strategies can be developed.

4. National guideline for the management of IAPs in the road sector

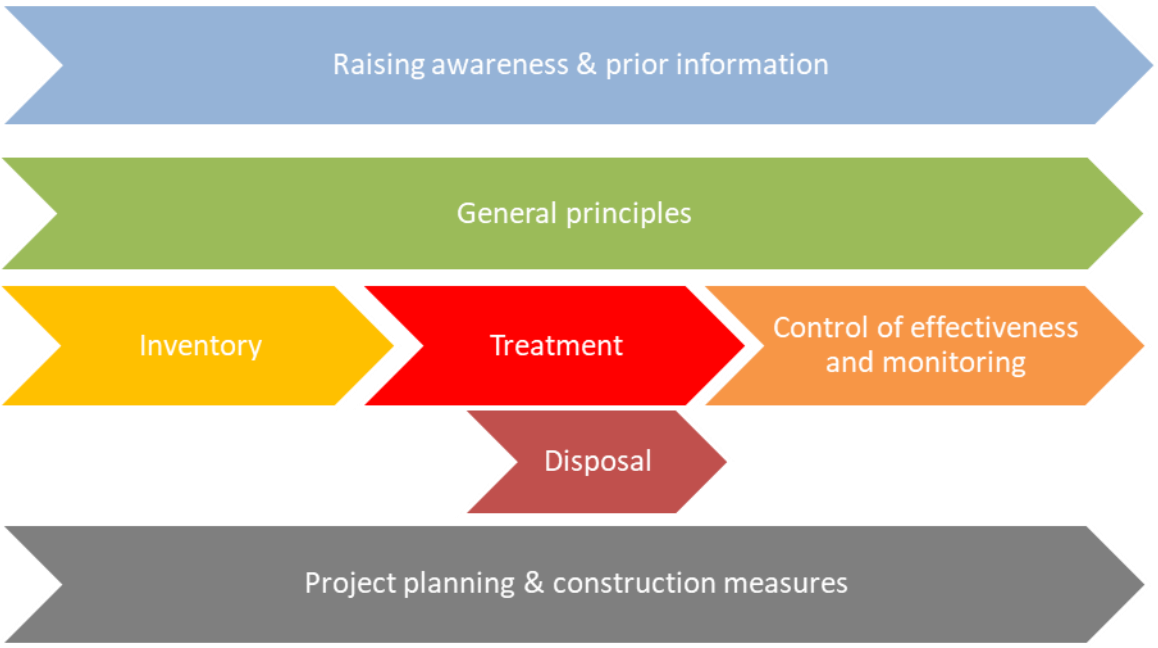
National guidelines are an established instrument for the definition of processes and measures in the road sector. It is therefore recommended to develop corresponding national guidelines for IAPs management in this sector.

These national guidelines for IAPs management in the road sector should include:

- Description of the national survey and documentation system
- Process flows for inventory, treatment, disposal and monitoring
- Description of control methods
- Cost-benefit considerations

5. Main processes for the management of IAPs in the road sector

Successful management of IAPs requires a holistic approach and shall follow some basic principles. The following scheme describes the main steps, which should be followed in frame of a comprehensive, uniform IAPs management.



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The most important statements of the individual process steps are:

Raising awareness & prior information

In most countries the problem of "IAPs in the road sector" is not given a high priority. In addition, some IAPs are used for afforestation, whereas other IAPs are still available as ornamental plants. To prevent further spread of IAPs, it is highly important to raise awareness among the general public and decision-makers.

It is also useful to collect/collate important information (such as legislation, guidelines, mapping, descriptions of plants, experience with control methods, etc.) that are already available in the project countries.

General principles

The most important common principles are:

Working and traffic safety:

Working and traffic safety are important aspects when treating IAPs along roads. If measures have to be carried out during normal road operation, the protection of the personnel employed must have top priority. Depending on the choice of the treatment method and depending on the target plant further specific protective measures might be necessary (e.g. special clothing, suitable respiratory protection). Some methods furthermore require special knowledge and training (e.g. for specific machines such as Electroherb™).

Regardless of which treatment method is used, it is essential to define basic rules of behaviour to ensure working and traffic safety.

Cleanliness/Biosecurity:

To avoid the spread of plant parts and seeds, equipment (like cleaning tools) and clothing/shoes have to be carefully cleaned. This must be done before this equipment or clothing/shoes are used again elsewhere (implementation of biosafety plan).

Uniform documentation tools:

In order to be able to control IAPs successfully, it is essential that the documentation (e.g. of inventory, treatment, etc.) is as comprehensive and uniform as possible. Modern technologies shall be used (e.g. to be developed using professional Apps, real-time connection to a central database, GPS coordinates etc.).

Inventory

It is recommended that country-specific strategic plans are developed to maintain an inventory of IAPs (where, when, how much) in order to get an overview of relevant IAP occurrences near road infrastructures. Important goals are to establish a long-term, comprehensive, centralized-controlled (which is part of the uniform documentation tools) database which includes the identification of IAPs and their quantitative inventory along roads in order to be able to document the development and spread of IAPs over time.

Treatment and disposal

To actively control IAPs in road infrastructure, a variety of mechanical, chemical and biological methods is available for treatment on site. In general, an eradication of IAPs is difficult to achieve, so when choosing the control method, the primary goal should be to prevent the growth and spread of IAPs. Here a distinction must be made between "standard methods" and “alternative methods”. In any case a treatment has to ensure sustainable removal of IAPs, avoid the spread of IAPs and – so far as possible – to do so by avoiding the use of herbicides. An important role in this context also includes the appropriate disposal of plant material. It has to be clarified whether the disposal of plant material is necessary after treatment or not. If so, clear rules must be followed (e.g. prohibition for dumping of mowing/cutting waste into waterbodies, rules for composting and burning or removal to authorized landfill sites).

Control of effectiveness and monitoring

The objectives of monitoring are the systematic collection, recording and analysis of observations over time which must be done continuously (repeatedly) and comprehensively. The effectiveness must be checked after the treatment for several years (depending on the IAPs and the control method). If individual IAPs are found during the follow-up inspection, it is recommended to remove them immediately and dispose them properly.

Project planning & construction measures

When constructing new road infrastructure preventive measures must be taken to prevent uncontrolled or unconscious dissemination of IAPs. Construction measures, e.g. (thicker beds of gravel, growth locks / plant barriers, special seed mixtures) should abe considered on planned and existing roads where IAPs hotspots already appear. This is important in order to prevent or minimize additional costs for construction. An inventory of IAPs along the planned route should therefore be carried out during project planning and building preparation. Since it can generally be expected that viable IAPs material can be found in the excavated material, special attention must be paid when handling such material (disposal as hazardous waste).

Overall, the cost-benefit analysis (CBA) takes into account all above mentioned points providing the basis for the decision process.

It is recommended to develop a **Regulatory Guideline** for each country. The main chapters of such a guideline may follow at the end of this deliverable (see chapter 6).

2 Introduction

IAPs are rapidly spreading and the sustainable removal of these plants is becoming increasingly more difficult. Since uniform rules do not exist in Europe, it is necessary to make appropriate recommendations. Roadsides play an important role in facilitating the spread of IAPs by providing habitat for their establishment. Therefore, European countries should take appropriate measures to control their further spread.

It is well known that herbicides harm our environment and their use is highly debated by the general public. Because of these concerns the registration of herbicides is also discussed by the European Commission and other public bodies and it is very likely that some active ingredients will be withdrawn from the market over the next few years. Some European countries have already regulated the use of herbicides along roadsides. Furthermore, the most widespread standard methods (i.e. mowing and mulching) for the vegetation management along roadsides are often not suitable to achieve adequate control of IAPs. Therefore, there is also an urgent need for alternative methods or practices to deal with the control of IAPs.

The vegetation control methods differ from each other in many points (e.g. mode of action on plant species, costs, availability, applicability in practice, influences on health and the environment, etc.). The control methods assessed by ControlInRoad are summarized in Table 1.

Table 1: Summary of control methods discussed by ControlInRoad

Name of method	Group of method	Description of method	Advantage	Disadvantage	Suitable for IAPs
Mulching	Standard Mechanical	Mulching is the standard method for reducing the height of plants and keeping the plant material on site to avoid disposal costs. At the same time, the equipment used is very robust and readily available	Low cost compared to other mechanical control options, for medium to large-sized populations	High frequency needed, to prevent seed production the timing is very important, high rate of re-sprouting, only short-term effect	**Common milkweed** *(Asclepias syriaca)*, **Garden lupin** *(Lupinus polyphyllus)*, **Giant hogweed** *(Heracleum mantegazzianum)*, **Himalayan balsam** *(Impatiens glandulifera)*, **Ragweed** *(Ambrosia artemisiifolia)*
Mowing	Standard Mechanical	In contrast to mulching, the biomass is	Low cost compared to other mechanical	High frequency needed, to prevent seed production the	**Common milkweed** *(Asclepias syriaca)*, **Garden**

		usually removed	control options, for medium to large-sized populations	timing is very important, high rate of re-sprouting, only short-term effect	**lupin** *(Lupinus polyphyllus)*, **Giant hogweed** *(Heracleum mantegazzianum)*, **Himalayan balsam** *(Impatiens glandulifera)*, **Ragweed** *(Ambrosia artemisiifolia)*
Hand removal	Standard Mechanical	Removal of biomass by hand (uprooting)	Effective, highly targeted, surrounding native species unaffected	High cost, labour intensive, only suitable in areas with low infestation (small stands)	**Himalayan balsam** *(Impatiens glandulifera)*, **Ragweed** *(Ambrosia artemisiifolia)*
Digging	Standard Mechanical	Removal of biomass by shovel, spade or bulldozer	Effective, highly targeted, surrounding native species remains largely unaffected	High cost, labour intensive, only suitable in areas with low infestation, requires good access.	**Common milkweed** *(Asclepias syriaca)*, **Giant hogweed** *(Heracleum mantegazzianum)*, G**iant rhubarb** *(Gunnera tinctoria)*, **Sakhalin knotweed** *(Fallopia sachalinensis)*
Herbicides	Standard Chemical	Chemical substances used to control unwanted plants	Effective, flexible, low costs	Environmental problems, herbicide resistance	**All**
Pelargonic acid	Alternative-natural	This is an organic compound (nine-carbon fatty acid)	Effective against (young) annual broadleaf plants.	Not very effective against grass species and perennials, only “burndown effect”, high dosages needed, high costs	Experimental and/or field tests available (along roadsides), not yet tested on relevant IAPs.
Hot foam	Alternative-physical	The method uses hot water in combination with foam made from natural, non-toxic ingredients	Can be used on any surface, low energy consumption, keeps heat on the plant	Very high impact on environment because palm oil and avocado oil is used	Experimentally tested

		including plant oils and sugars.			
Infrared	Alternative-physical	Electromagnetic radiation (EMR) with wavelengths longer than those of visible light	Can be effective	Effectiveness depends in particular on plant age and species, weather conditions, less effect on perennials; high cost, low area output	Experimental and/or field tests available, not yet tested on relevant IAPs.
Electroherb ™ (Zasso)	Alternative-physical	The Zasso Electroherb™ process is an electro-technical process for weed control	Effective against (young) annual grass and broadleaf plants	The deep root system of perennials seems to be not affected sufficiently, experimental stage	**Ragweed** *(Ambrosia artemisiifolia)*
Removal + seed mixture	Alternative-mechanical	Removal of IAPs and subsequent sowing of a mixtures of plant species in order to outcompete the IAPs	Sustainable method	Restoration of native vegetation is critical	**Ragweed** *(Ambrosia artemisiifolia)*

The ControlInRoad project has shown (see deliverables 3.1, 4.2 and 5.2) that there is no universal highly efficient method with a comparable effectiveness as herbicides to control IAPs. Rather individual IAPs management plans have to be developed considering the respective circumstances (e.g. IAPs species to be controlled, available budget, available resources, local conditions, organizational forms, time restrictions, road maintenance, new road construction, legal requirements, etc.). Overall, a holistic approach which takes account of all aspects (e.g. inventory, treatment, post-control) of IAPs management is important. The holistic process approach will be explained in more detail in the following sections.

3 Main process steps for IAPs management

Successful management of IAPs requires a holistic approach as said above and thus includes several sub-processes, which are described in the following sections. Despite the need to choose appropriate management practises, there are several accompanying issues, which are important to take into account, and which are prerequisites for being able to efficiently manage further spread of IAPs.

Clear competencies and responsibilities

It is highly important to have assigned personnel with clear competencies and responsibilities for IAPs management in the respective road administrations. Responsible bodies with appropriate knowledge and organizational authority should be installed at national and regional/local levels. Furthermore, the management of IAPs requires a higher-level national coordination. It is recommended that the responsible national body (e.g. ministry) is responsible for preparing the basic principles for the management of IAPs at national level and also actively supports regional road administrations. A good example of this is Ireland, where the national road authority has taken the lead for IAPs management and supports local authorities with knowledge and external resources.

Adequate, sustainable budgeting

It is evident that the management of IAPs requires financial resources, which must also be made available. Initially, resources are required for the development of a national survey and documentation system (Survey & Documentation Tool) and for the creation of national guidelines for IAPs management. It should be considered that, in addition to regular annual budgets required for the inventory, treatment, disposal and control of IAPs, resources should be allocated to raise the awareness in the general public and e.g. the agricultural sector. Furthermore, training should be provided to responsible public bodies and staff being involved in the control of IAPs.

Figure 1 provides an overview of the different recommended steps of IAPs management. Recommendations are based on the outcomes of Deliverable 3.1, Deliverable 4.2 and Deliverable 5.2. These different steps are outlined in more detail below.

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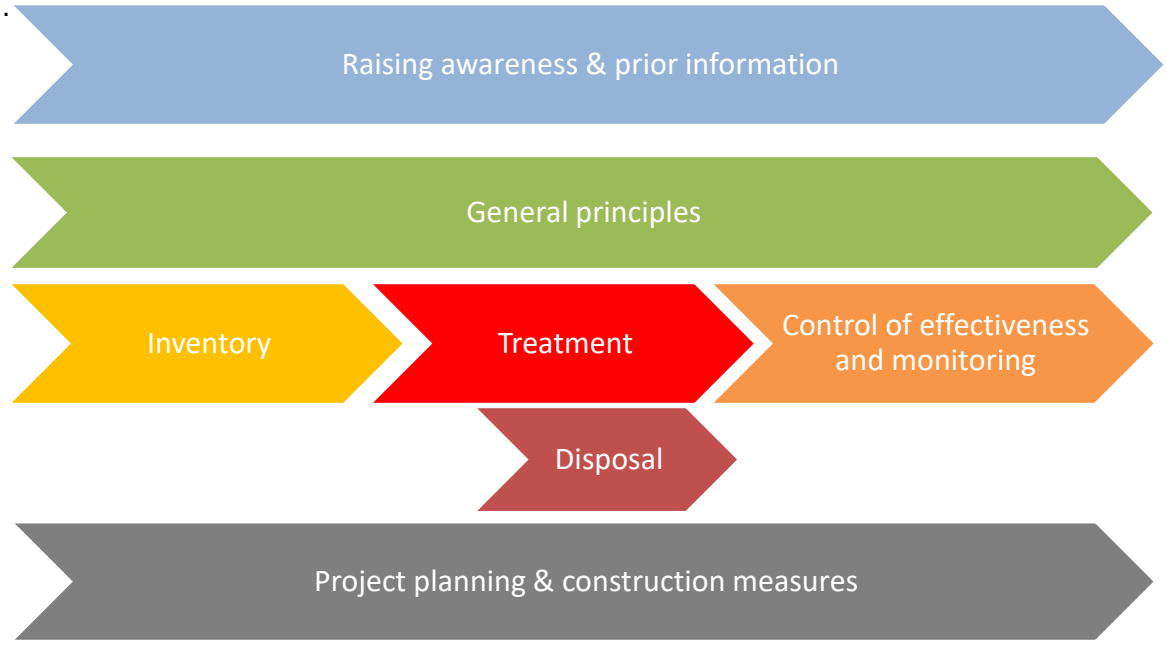

Fig. 1: Overview of the recommended steps in the management of IAPs.

3.1 Raising awareness & prior information

Raising awareness & prior information

In many countries the problem of "IAPs in the road sector" is not given a high priority. Moreover, in some cases invasive plants are used for afforestation, e.g. fast-growing IAPs like black locust, with the aim to reduce CO_2. However, besides the proliferation of IAPs, such afforestation areas are often close to roads. So, while everything is done along roads to control IAPs, it can happen that the same IAPs or other IAPs are planted intentionally in the immediate vicinity. Furthermore, IAPs are often considered beautiful and are therefore collected and planted in private gardens. Many IAPs are also still available in commercial garden centres (e,g. summer lilac, garden lupin, common milkweed etc.). If the problem of “IAPs in the road sector” is to be given a higher priority, it is essential to raise awareness among the general public and among decision-makers.

It is recommended that important information (e.g. legislation, guidelines, mapping, descriptions of plants, experience with control methods, etc.) on IAPs that is already available is collected, processed and constantly updated. Furthermore, we recommend enabling a broad, common knowledge base for IAPs in each country, which can be used for different purposes like creating awareness, education and training. Both, the general public and experts, can be addressed with the following actions:

- Public campaigns (e.g. participation in plant fairs, advertisements in newspapers, commercials, etc.) to inform about the negative impacts of IAPs;
- Lectures at professional events;
- Creation of brochures for employees in the road sector (such as the brochure from the Austrian Federal Railways);
- Training measures for employees in the road sector (e.g. recognition of important IAPs);
- Basis for a national mapping and reporting system for IAPs;
- Develop a broad accepted certification for contractors that work for national and regional public organisations on road construction and management to ensure that they are able to work according to certain standard procedures and requirements necessary for controlling IAPs. The certification should refer to the safety of the employees and the environment. The local authorities may choose freely between expert companies, despite their location. Payment should be 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;

- Informing respective organisations and staff in the infrastructure sector of local IAPs locations (above and below ground where material may have been deep buried).

3.2 General principles

General principles

3.2.1 Working and traffic safety

When treating IAPs, it is important to pay attention to working safety. In particular, if measures (e.g. inventory, treatment of IAPs) have to be carried out during normal road operation, special appropriate safeguards must be taken to protect the personnel employed during the daily work along road sides (accidents with other road users). General and labour law regulations for the protection of road operators have to be followed.

Depending on the choice of treatment method and for certain plants (e.g. giant hogweed), further specific protective measures are necessary. Special clothing may be necessary to prevent direct contact with plants. If chemical methods are used, suitable respiratory protection must also be provided. Some methods (e.g. Electroherb™) require special knowledge on the use of machines. It is equally important to follow the instructions of manufacturers of machines and of chemicals for the different control methods.

Regardless of which treatment method is used, it is essential to define basic rules of behaviour for road workers along the above described issues.

Basic rules of conduct to enable human and environmental safety should address the following issues:

- Generally applicable regulations regarding work safety / workers' protection
- Road sector-specific, national safety regulations
- Instructions for protective equipment (clothing, masks, etc.) for specific methods or plants (e.g. giant hogweed)
- Training, particularly on specific methods
- Securing/marking of IAPs locations
- Traffic Safety: Rules and regulations for the safety of personnel and third parties on the road when the road is full in operation

3.2.2 Biosecurity (biosafety policy)

A frequent cause of spread of IAPs is poor cleanliness. Equipment and clothing are often not cleaned, which means that viable plant parts and seeds that can reproduce are easily spread. This also applies to carelessly left clippings from mowing. As a result, reproductive plant parts and seeds can easily be spread by whirling up vehicles. In addition, clippings which are not disposed of are an excellent fertilizer for the growth of plants.

Essentially, it must be ensured that after every physical activity (inventory, treatment, follow-up inspection) at an IAPs infestation, a corresponding cleaning takes place:

- cleaning the shoes and clothing,
- cleaning tools and machines.

This must be done immediately after the treatment of IAPs.

3.2.3 Uniform documentation tools (APPs, database) – European standard (control database)

In order to be able to control IAPs successfully, it is essential that the documentation is comprehensive. Appropriate documentation makes it possible to describe the current state or baseline scenario to assess the effectiveness of different control methods and to continuously monitor the spread of IAPs. By including additional information (e.g. costs), it is possible to perform well-founded analyses (e.g. on costs/benefits) and to develop strategic programs to control IAPs.

Tools for collection and data storage

The standardized collection of the data should be carried out with a uniform "documentation App" to be developed or to be taken over and adapted from existing Apps such as the KORINA-App for Android (see: https://www.korina.info/funde/app/), which is used for inventory, as well as for the documentation of treatments and monitoring (effectiveness check/after-treatment). The collected data are stored in a national IAPs database to be established in all countries.

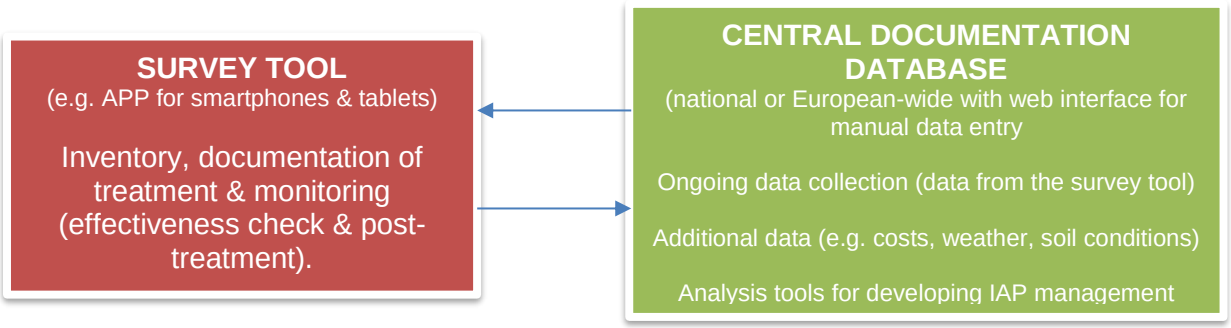

Fig. 2: Tools for collection and data storage

Basically, a uniform European-wide standard should be aimed for, so that European-wide control of IAPs can be ensured. However, it is recommended to provide “national” versions in

the respective national language in order to facilitate broad use. The country-specific most important IAPs can also be prioritized in a national version of the survey tools.

Functional description of a universal survey tool

Technologies

- Professional APP based on Android (alternatively iPhone) for trained specialist users (general plant identification apps are already available)
- Real-time connection to the central database (storage and retrieval of information), but must also work offline
- Automated: Location detection (GPS coordinates, service life, identification of survey staff)
- Optional: Version for the public to report IAPs in public street spaces (this will need to be monitored and the records verified by suitably qualified personnel)

Application areas

- Simple and accurate inventory
- Documentation of the treatments
- Documentation of the effectiveness of treatment and post-treatment re-growth

Basic functions

- IAP lexicon (description of the specific IAPs with pictures to facilitate manual recognition)
    - Optional: Automated detection of IAPs using image analysis
        - Note: The technical feasibility must be checked
- Information and instructions on safety & cleanliness
- Information on existing IAPs deposits (with map)
- Automatic storage of the geographic location (GPS position with maps)
- Inputs for inventory: Information on the IAPs found (species, status of flowering, size, additional information as free text, etc.)
- Inputs for treatment: Location of treatment (automatically collected), method used (selection), free text
- Inputs for monitoring (effectiveness check, post-treatment carried out): Location, photo documentation, description of the post-treatment, free text
- Inputs for construction measures: Location, description of construction measures, free text

Manual fall-back solutions

As there may be technical failures (e.g. battery failure) of the survey tool, it is recommended to also issue survey/documentation forms in paper form. These can be filled in by the survey

staff on site. The data collected can then be transferred to the central database via the web interface.

Example: see figure 3

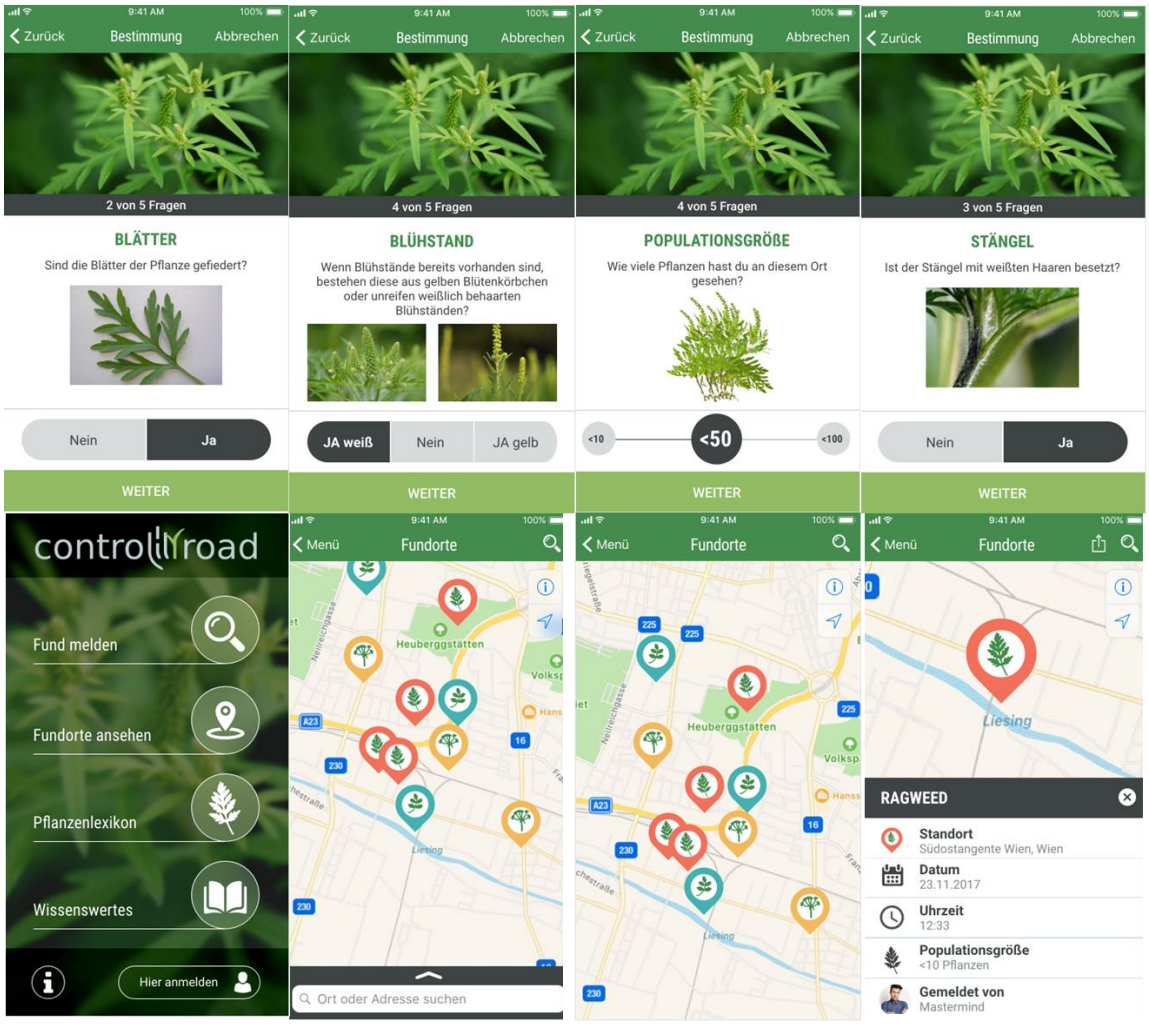

Fig. 3: Graphic overview of an APP for the record of IAPs

Functional structure of a national central database ("control database") for IAPs in road engineering:

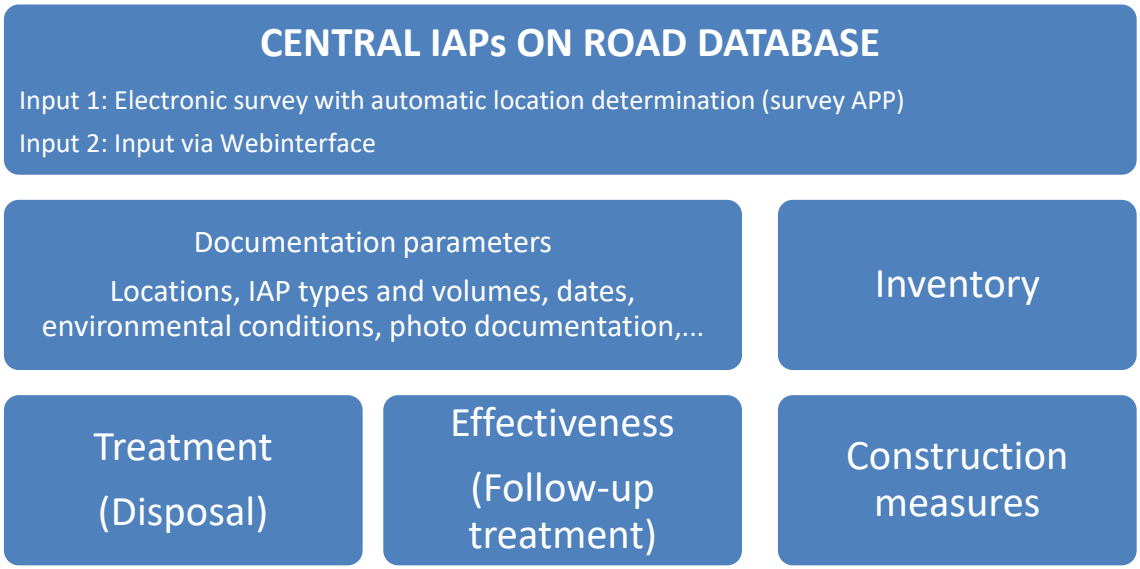

Fig. 4: Functional structure of a national central database ("control database") for IAPs in road engineering

3.3 Inventory

The inventory of IAPs along roads is essential to be able to develop appropriate treatment strategies and management plans. For such an inventory, it is recommended to develop country-specific strategic plans (where, when, how much) for performing an inventory in order to get a complete picture of relevant IAP occurrences near road infrastructures. Important goals are to establish a long-term, comprehensive, centralized-controlled (which is part of the uniform documentation tools) database which includes the identification of IAPs and their quantitative inventory along roads in order to be able to document the development and spread of IAPs over time.

The inventory can be done either by

- internal personnel with the appropriate knowledge regarding IAPs or
- external specialists.

It has to be noted that IAPs are generally difficult to recognize by amateurs. Experiences from road administrations show that initial IAP training as well as refresher trainings are very demanding for the staff and take a long time. As new IAPs are frequently reported regular training has to be provided.

When planning and preparing new roads or before general repairs, a detailed inventory of IAPs along the new routes should be carried out. Furthermore, to carry out the inventory, the standardized survey tool recommended in chapter 3.2.3 should be used.

A fully or partially automated inventory would be desirable (e.g. camera-based during inspections, drone surveys, evaluation of orthophotos and satellite images). However, no reliable methods for automating the inventory process are currently known although there are promising developments in the area of automatic plant recognition.

3.3.1 Objectives of the inventory

- Precise collection of critical IAPs and their quantitative occurrence along roads
- Long-term, complete collection of IAPs in the road network
- Collection of data in a central database in order to be able to document the development over time

3.3.2 General planning of the inventory

- Location of the inventory (e.g. continuously, define prioritized areas)
- Time & authorized person
    - Professional inventory by experts
    - During normal road maintenance by own, specially trained staff
    - During the planning phase / preparation for road construction sites by own staff or external experts
    - Consideration of seasons, flowering, etc.
- Notes on general principles:
    - Safety
    - Biosecurity

3.3.3 Tools for inventory

- See chapter 3.2.3 (survey tools and central documentation database)

3.4 Treatment on site and disposal

A variety of mechanical, chemical and biological methods are available to actively combat IAPs on or along roads (treatment on site). Some methods have been "standard" for many years, other methods are still in the developmental stage (alternative methods). The recommended methods are examined in more detail in the chapter Cost-effectiveness analysis (chapter 4).

There is currently no alternative universal method available that helps against every type of IAPs. In general, an eradication of IAPs is difficult to achieve, so when choosing the control method, the primary goal should be to prevent the growth and spread of IAPs.

For each application, it is necessary to choose the treatment method individually and to plan the implementation of the treatment individually, since the effectiveness can depend heavily on the time of use (growth period, flowering time etc.).In addition, some measures require special training and safety precautions.

When choosing the control methods, it should therefore be carefully considered whether it makes sense to use own staff (e.g. road operators) or whether it is more appropriate to contract external service providers for the treatment. It should be expected that an external service provider would guarantee some level of success of control in the terms of the contract. If there are enough external specialist companies for IAP management in the country, we recommend following the example of Ireland where the National Road Administration has established framework contracts with suitable specialist companies. These specialist companies can be commissioned by the local road authorities to control IAPs as required. This allows a separation of the IAPs control measures from the "usual" activities for the care of the vegetation along roads and thus to implement a targeted approach to IAPs. In any case, the following should be considered when choosing the individual treatment method:

3.4.1 Objectives of treatment

- Sustainable removal of IAPs (e.g. when building lots are ready for construction)
- Avoiding the spread of IAPs (e.g. during normal maintenance)
- Avoiding the use of herbicides (e.g. glyphosate) in order not to harm personnel, third parties and the environment or to meet legal requirements

3.4.2 General planning of treatment

- Location of treatment (e.g. define priority areas)
    - Inclusion of the results of the inventory
- Type of treatment method
    - Which IAPs should be treated?
        - Is the plant made unviable (unable to reproduce) as a result of the treatment?
    - Cost / Benefit (see chapter 4)

  - Availability of the method (standard method / alternative method), is the method permitted?
  - Comprehensive training of personnel
  - Treatment rate
  - Practicability (applicability on hillsides, consideration of installations like cables, ducts, etc.)
  - Risks for personnel, third parties, environment
  - Legal restrictions
  - Period of use: consideration for seasons, flowering, etc.
- Notes on general principles:
  - Safety
  - Biosecurity

3.4.3 Disposal

When implementing specific control methods, it is important to clarify whether the disposal of plant material is necessary after treatment or not. This depends on how the plants are treated: for those control methods that destroy plants more or less completely and do not leave viable parts of plants behind disposal is not necessary, for all other control methods disposal is essential to reduce the further spread of invasive plants.

Plant material accumulates particularly when implying the control methods

- mowing,
- hand removal and
- excavation/digging.

In these cases, professional disposal is essential to avoid further spread of IAPs caused by not appropriately disposing of viable plant material. In order to achieve this, the following steps are suggested:

<u>Definition of clear rules</u>, e.g.:

- Strict prohibition for dumping of mowing/cutting waste into waterbodies.
- Three-Step Plan:
  a. After treatment plants should be destroyed (e.g. plant material should be torn up or crashed).
  b. Dehydration of cut material on site to reduce mass to minimize transport effort.
  c. Disposal (composting, burial, burning).
- For (industrial/commercial) composting, the plant material is maintained in heaps (‘windrows’) for several weeks to allow the decomposing organisms to break down the organic material (i.e. seeds and other propagules). It is an aerobic and exothermic process where the temperature rises >55°C for several weeks or months. The temperatures reached should principally destroy seeds and seedlings of most IAPs.

- Plant material or soils containing seeds or fragments of IAPs can also be buried (at a minimum depth of 2 m, plant material of *Fallopia* spp. is recommended to be sealed by a geotextile membrane or deeper burial: min. 5 m – source Guidance Treatment and disposal of invasive non-native plants: RPS 178) on an authorized landfill site. It is also possible to bury plant material on the site where it came from.
- Burning of plant material is another option that should be done by an industrial/commercial incineration facility.
- The choice of the method depends on the plant category (e.g. annual, perennial, woody species) and the developmental stage (prior/after flowering). In general, IAPs should be managed before they reach the generative phase (flowering, seed set). However, other factors including the availability of (professional) disposal facilities, the amount of plant material to be disposed and site characteristics (e.g. space required for on-site deep burial) should be taken into consideration.

  It is recommended that
  - annual and perennial herbaceous IAPs can be composted in industrial/commercial facilities, deep buried (on-site, landfill) or burned;
  - specific IAPs (e.g. *Fallopia* spp.) should normally not be composted because they have vegetative parts (rhizomes, corms) that may survive in compost and spread to new locations when the compost is distributed. The plant material should be disposed of by deep burial or controlled burning;
  - woody IAPs should be chipped and used as mulch on-site or added to compost once fully dead and dried. Incineration of material may also be a viable option.

<u>Issue of general rules in national laws</u> (e.g. ban to spread specific IAPs).
Rules for disposal of IAPs shall preferably be defined in national standards and guidelines. Here, it should also be considered that disposal causes high costs (storage, transport, destruction costs). Legal regulations (e.g. water laws, waste laws) must be followed; in the worst case, IAPs material may have to be handled as special waste.

It should be noted:

- Professional storage of plant waste on site (for drying and volume/weight reduction)
  - Protection against disturbance (e.g. wind and water) must be provided
  - Water pollution (including groundwater!) must be avoided
- Shortest possible transport routes
  - The nearest landfill / disposal site should be selected
- Professional destruction / permanent storage
  - Determine the conditions under which burning is possible
  - Disposal in water is prohibited

- Storage in appropriately secured landfills (e.g. deep disposal) is recommended, possibility of distribution by winds must be prevented

3.4.4 Tools for documentation of treatment and disposal

- See chapter 3.2.3 (survey tools and central documentation database)

3.5 Monitoring of treated sites

Control of effectiveness and monitoring

3.5.1 Objectives of monitoring

- Systematic collection, recording and analysis of observations over time
- Must be done continuously (repeatedly) and comprehensively

3.5.2 General planning of monitoring

The effectiveness must be checked after the treatment and for several years (depending on the specific IAPs). If individual IAPs are found during the follow-up inspection, we recommend removing them immediately and dispose of them properly. The effectiveness check should be taken into account already at the planning stage of the treatment.

Same as inventory, the effectiveness check / monitoring can be carried out by internal staff or by external specialists. The documentation is provided by the national survey tool, the results are stored in the central database.

3.5.3 Tools for documenting effectiveness and monitoring

- See chapter 3.2.3 (survey tools and central documentation database)

3.6 Project planning & construction measures

Project planning & construction measures

Steps to be undertaken when planning and building new roads, or during general repairs (upgrading) of roads.

3.6.1 Objectives

- Avoid additional efforts and costs for IAPs treatment during future road maintenance
- Avoid additional claims of contractors
- Prevent future spread of IAPs
    -
    -

3.6.2 General planning

Preventive measures must be taken to prevent the uncontrolled or unconscious distribution of IAPs when new roads are built or when roads are being upgraded. Construction measures should also be considered at special IAPs hotspots. This is important, amongst other things, in order to prevent or minimize additional costs for construction (e.g. removal of strong roots) and road maintenance.

An inventory of IAPs along the planned route should therefore be carried out during project planning and building preparation. The same process steps apply as described in the "Inventory" chapter (see 3.3). IAPs should also be marked on site (e.g. by fencing). If this is not possible, appropriate treatment of IAPs must be carried out. If necessary, plant residue material must be properly disposed of. The same steps apply as described in the chapter "Treatment and disposal" (see 3.4).Since it can generally be expected that viable IAPs material can be found everywhere in the excavated soil, special attention must be paid to the handling of excavated material.

3.6.3 Handling of excavated material

- Safe storage (avoiding spread by wind!) on site should be a routine process in the construction sector to avoid expensive mass transports.
- Covering excavated material to prevent plant growth.
- No sale of excavated material (especially topsoil) to third parties (other entrepreneurs, farmers, private individuals) to prevent unwanted spreading.

In the case of new construction or upgrade of roads, it is also possible to take constructive measures to prevent the growth or uncontrolled spread of IAPs (root barriers).

3.6.4 Constructional and other measures for new road construction

- Reinforcement of the road substructure (thicker beds of gravel)
- Installation of plant barriers
- Use of special seed mixtures to prevent the growth of IAPs.

It is recommended to document the measures carried out (inventory, treatment, construction measures) with the recommended survey tool and to store the results in the central database.

3.6.5 Tools for the documentation of effectiveness and post-treatment

- See chapter 3.2.3 (survey tools and central documentation database)

4 Assessment of control methods based on the valuation of costs and benefits

As pointed out in chapter 3.4.2 it is recommended to include a cost-benefit assessment of the different IAPs control methods in order to select the most appropriate approach. By using the valuation of costs and benefits of the implementation of control measures it is possible to compare the costs of the use of different control methods with the benefits that can be reached using the different control methods.

4.1 Selection of valuation methods

Different assessment methods exist to compare costs and benefits of measures. In many European countries guidelines are available for the analysis of constructional, operational and organisational measures in the transport sector. Examples for such guidelines are:

- Austria: FSV: RVS 02.01.22 - Decision Making Support | Cost-Benefit-Trials in Traffic and Transport (2010)
- Germany: FGSV: Evidence on usage of methods for decision making in transport planning (2010)
- Switzerland: Schweizerischer Verband der Strassen- und Verkehrsfachleute: Swiss norm SN 641 820 – Cost-Benefit-Trials in theroadsector (2013) (2013)
- Strukturfonds-ERDF, Kohäsionsfonds und ISPA: Guidance to Cost Benefit Trails for investment projects (2003)

The aim of these guidelines is to give advice in cost-benefit-observations in order to determine the economic viability of the applied measure and to justify the use of public money. These guidelines distinguish between different methods of cost-benefit analysis. The Austria RVS 02.01.22 presents the following methods:

- Impact analysis (or Effect analysis) (IA)
  The impact analysis describes all ascertainable qualitative and quantitative impacts systematically but without a formal value synthesis. A formal value synthesis aggregates the different impact dimensions. With this step an absolute (dimensionless) measure, the decision calculus, is derived. This is done in an intuitive pragmatic way.
- Cost benefit analysis (CBA)
  Based on the impact analysis the CBA describes all impacts in money values und adds all monetized impacts (costs and benefits) of a measure to one value. Benefits are usually described as cost reductions due to the impact of the measure. The decision calculus is a measure value with the dimension monetary units per monetary unit (generalised ratio test).
- Value benefit analysis (VBA)
  The value benefit analysis brings all different impact characteristics (with their different dimensions) to a comparable dimensionless measure value via transformation (using a benefit function). This measure value is the standardised target achievement rate.

Such a rate has to be weighted along their relative relevance of the impact and has to be added to the dimensionless benefit value. The costs of a project/treatment are measured as every other impact category and added to the benefit value in the same way. The decision calculus is a measure value without dimension and is called benefit value.

- Cost-effectiveness analysis (CEA)
  The cost-effectiveness analysis derives the benefit value for all impacts except the costs of the measure in the same way as for the value benefit analysis. This benefit value has to be connected with the costs of the measure (that are calculated in the same way as for the CBA and exist therefore as monetised values). The decision calculus is a measure value with the dimension “benefit points per money unit”. For this case at least two comparable measures have to be calculated to be able to compare them. It is not possible to compare a single measure with a scenario that does not apply a measure.

Cost-benefit observation should help to select or pre-select those IAP control measures that reach the highest cost/benefit ratio. From this point of view all valuation methods except the single impact analysis are useable methods. The impact analysis is not recommended because it is only useable for the evaluation of ecological impacts. Therefore, a final selection of one of the three potential methods depends on the data availability regarding costs and benefits. The following table (Table 2) shows the potential use of the three remaining valuation methods depending on the data situation.

Table 2: Relevance of cost-benefit observation by quality of valuation data

Monetary values for	**Qualitative values (ordinal ranking) for**	**CBA**	**VBA**	**CEA**
Costs and benefits	-	X		
Costs	Benefits			X
-	Costs and benefits		X	

4.2 Costs to be considered

To be able to compare costs and benefits for different measures it is necessary to calculate those values that exist as monetary values as an actual cash value for a certain time period. Rajmis et al (2016) suggested a time period of 10 years to validate different methods for controlling *H. mantegazzianum* and a social discount rate between 1% and 3%, based on Florio and Sirtori (2013) and Drupp et al. (2015). Based on this, it is suggested to calculate the

actual cash values of control methods for ten years with an average social discount rate of 2%. The discount rate has to be adopted to the actual discount situation.

Relevant cost components for all control methods are:

- Investment costs for material that is needed for carrying out the different control measures.
  Costs have to be calculated as yearly cost values (for the suggested period of 10 years). Investment costs are not used directly but have to be depreciated depending on their economic life span.
- Running costs for the use of required machines (energy, machine maintenance and similar)
- Additional costs depending on the method (transport, disposal, chemicals, seeds and similar)
- Personnel costs for operating the method
- Personnel costs for monitoring

To be able to compare the different costs of the different control methods it is necessary to express all costs with the same unit. One possible unit is EUR/h of treatment. For this information it is necessary to have information on area definition such as treatment width and working speed (depending on plant density and possible work load in terms of plants treated per hour) as well as information on necessary treatment deepness into the ground to be able to re-calculated compiled prices with different units (EUR/area, EUR/volume) to EUR/hour.

Possible sources on cost information are:

- information on costs from manufacturers
- labour treaties
- cost database of KTBL (Kuratorium für Technik und Bauwesen in der Landwirtschaft)

In addition to the cost information it is necessary to define for each control method and each IAPs

- how often treatments have to be done per year (and also at which time period of the year)
- how many years these treatments have to be done
- how many years monitoring has to be done.

4.3 Benefits to be considered

The benefits of controlling/eradicating IAPs can be defined as the benefit to the relevant stakeholder compared to the situation without controlling/eradicating IAPs (do nothing scenario). That means that damage costs when doing nothing are defined as the benefits of

doing 100% of eradication. Therefore, it is necessary to identify different categories of damages that occur due to the appearance and spread of IAPs.

The different damage categories have to be linked to the stakeholders / parties / persons, who are potentially affected by IAPs. They can be broken down into the following categories:

- Road operators (main focus of this project)
- Agricultural sector
- Humans
- Environment

When IAPs are controlled/eradicated along roadsides direct effects appear only along roads, because anywhere else plants are not directly treated. Therefore, it is mainly road operators that profit directly from such control measures. All other parties may only be indirectly affected due to the reduction of spread.

The main damage categories for the affected parties (see chapter 6.1) have been identified:

- Road operators (main focus of this project) (results of discussion with road operators)
    - Damage to road surface / pavements
    - Damage to road signs (incl. reduction of sight due to overgrowing)
    - Damage to road embankments and curbs
    - Health issues (e.g. allergic diseases, skin irritation) for road workers

  One main benefit for road operators of eradicating IAPs is the reduction of costs for vegetation management. This benefit is not be taken into account on the benefit side, since the costs for managing IAPs with the different control methods are considered on the cost side (costs of applying control measures). The lower the efforts for controlling IAPs are, the lower the costs for special vegetation management for IAPs are.
- Agriculture (Reinhardt et al. 2003)
    - Reduction of crops
    - Reduction of livestock
- Humans (Reinhardt et al. 2003, Rajmis et al. 2016)
    - Allergic disease
    - Skin irritations, burns by direct contact
- Environment (Säumel et al. 2016)
    - Reduction of biodiversity and native plants
    - Reduction of ecosystem services (noise protection, air quality, temperature regulation, shielding function etc.)

Benefits (respective damages) can be presented in monetary values (quantitative, cardinal ranking) or in qualitative values (ordinal ranking).For the calculation of a CBA (see chapter 4.1)

it is necessary to have monetary values for all benefit categories. This enables a direct comparison with costs and the derivation of a cost-benefit ratio. However, in many cases it is not possible to monetize all damages caused by IAPs along roads. In this case an ordinal ranking of the damages has to be conducted. This leads to the use of the cost-effectiveness analysis (see chapter 4.1).

To evaluate the benefits of the different control methods the damages have to be linked to the effectiveness of the different methods. Again, an ordinal scale should be used for valuing the effectiveness of the different methods (after 10 years of method implementation). It is suggested to use the following scale for the assessment of effectiveness (based on information described in Deliverable 5.2, chapter 7 - Cost benefit comparison):

- “High”: 90%-100% effectiveness of eradication, if the particular strategy is used under "optimal" conditions: The particular strategy is highly effective and leads to a more or less complete controlof the respective IAPs within the managed area.
- “Medium”: 50-89% effectiveness of eradication, if the particular strategy is used under "optimal" conditions: The particular strategy is effective and leads to a decrease of the respective IAPs within the managed area.
- “Low”: Below 51% effectiveness of eradication, if the particular strategy is used under "optimal" conditions: The particular strategy is poorly effective, and it is likely that the respective IAPs is not sufficiently controlled and do not decrease or even spreads further after treatment within the managed area.

4.4 Cost Benefit Observation for three IAPs

A detailed valuation of the costs and benefits regarding the use of the different methods to control the spread of three selected invasive plants along roads has been worked out in D5.2. This valuation aimed at suggesting those measures for the control/eradication of IAPs along roads that provide the highest cost/benefit ratio for the relevant stakeholders (especially road operators).Based on available data regarding costs a monetarisation of costs for the use of different methods was worked out. Due to data availability regarding benefits only a qualitative valuation along an ordinal scale based on the description of effects and the effectiveness of different methods to reduce the spread of IAPs was possible. Therefore, the direct connection of benefit values and monetary costs by calculating the cost effectiveness (division of benefit values with monetary cost values) was chosen as an appropriate valuation method. Results of the cost-effectiveness analysis are benefit values per costs. These values enable the comparison of control methods and a ranking of control methods.

The following pictures (Fig. 5, 6 and 7) show an overview of the calculated benefit values per 1.000 EUR for the three in the following defined scenarios:

- Minimum scenario: low plant density, 1 m treatment width, upper value of effectiveness range (regarding effectiveness range between 90% and 100%)

- Main scenario: medium plant density, 3 m treatment width, medium value of effectiveness range (regarding effectiveness range between 50% and 90%)
- Maximum scenario: high plant density, 10 m treatment width, lower value of effectiveness range (regarding effectiveness range up to 50%)

and the three selected IAPs (*H. mantegazzianum, Fallopia* spp*., A. artemisiifolia)*. The higher the benefit value per costs, the better is the control method compared to other control methods.

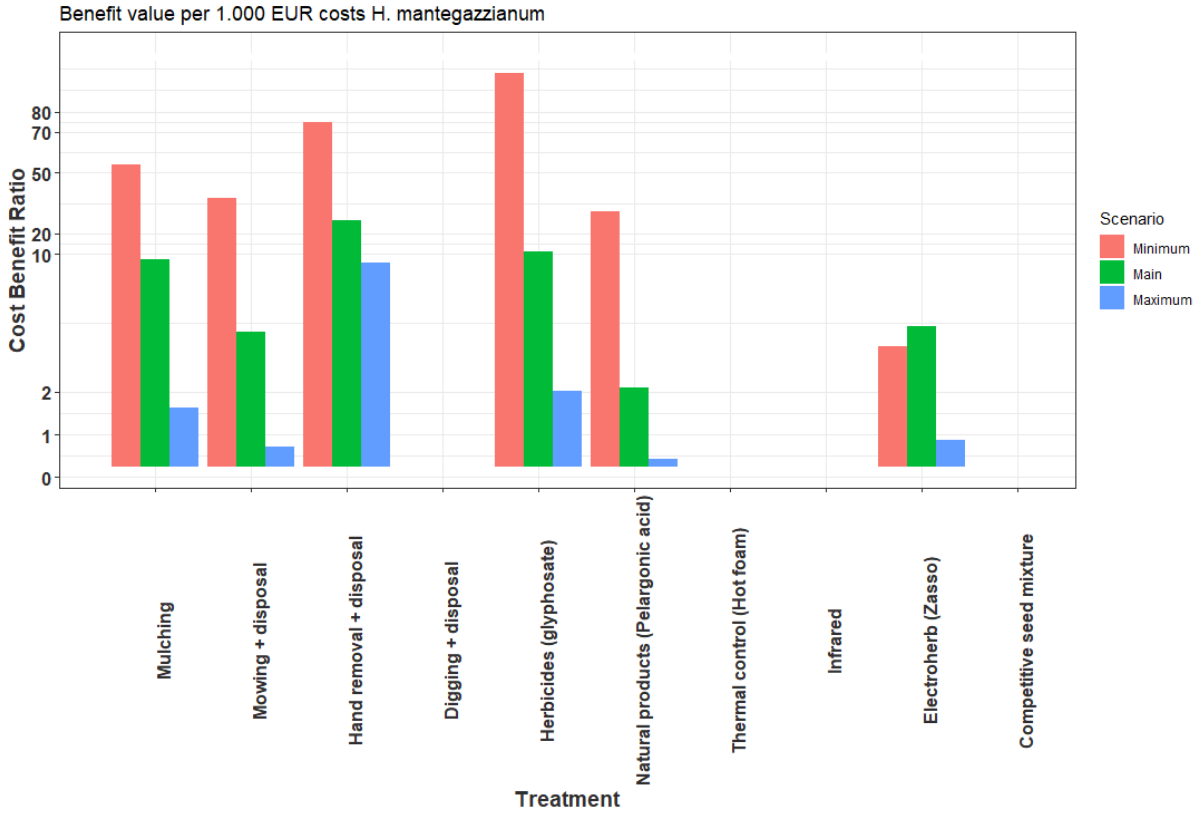

Fig. 5: Overview of the benefit value for the control of H. mantegazzianum in different scenarios

As shown in Fig. 5 for ***H. mantegazzianum,*** the hand removal method is the best alternative to the application of herbicides independent of the scenario (described by treatment width, plant density and effectiveness range of methods). The usage of alternative methods (natural products, Electroherb™) leads to a degradation of the cost-benefit ratio compared to the standard methods “herbicide use” and “hand removal (including disposal)”.

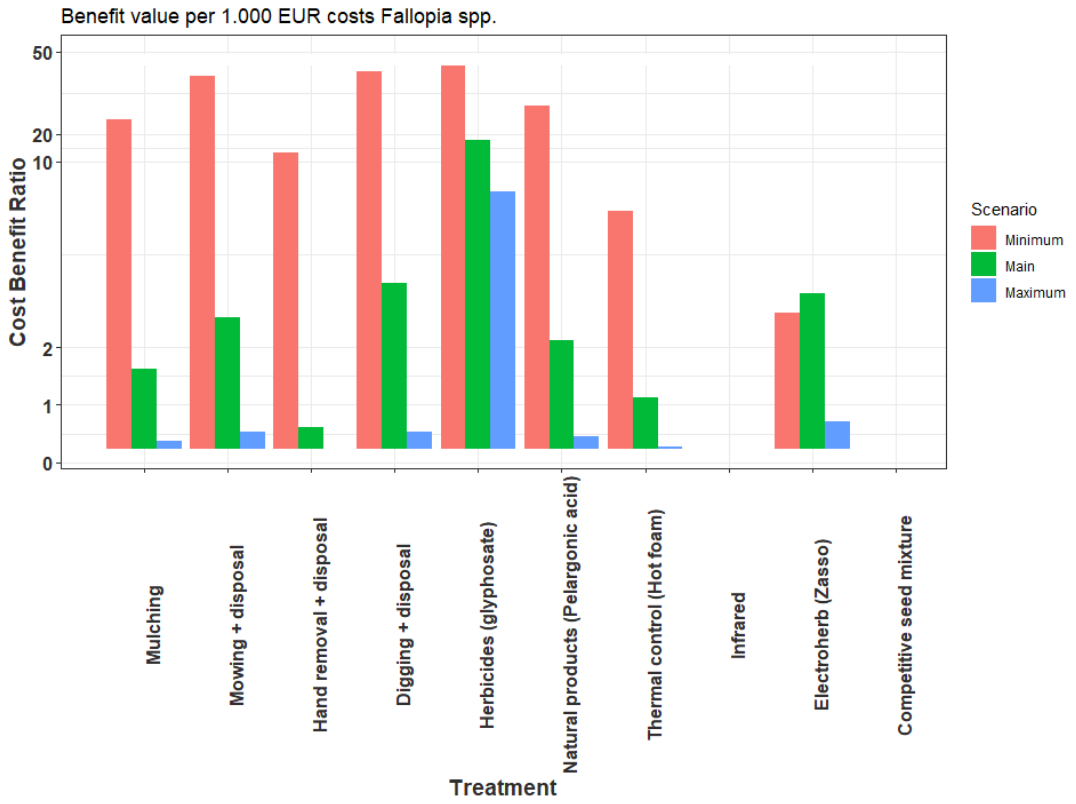

Fig. 6: Overview of the benefit values for the control Fallopia spp. in different scenarios

For ***Fallopia* spp.** (Fig. 6) the control method with the best cost-benefit ratio is for all scenarios the use of herbicides. Looking at the best alternative instead of the use of herbicides in case of the minimum and main scenario the control method “digging and disposal” has the best cost benefit ratio. Only in the maximum scenario Electroherb™ is identified as the control method with the best cost-benefit ratio besides the use of herbicides.

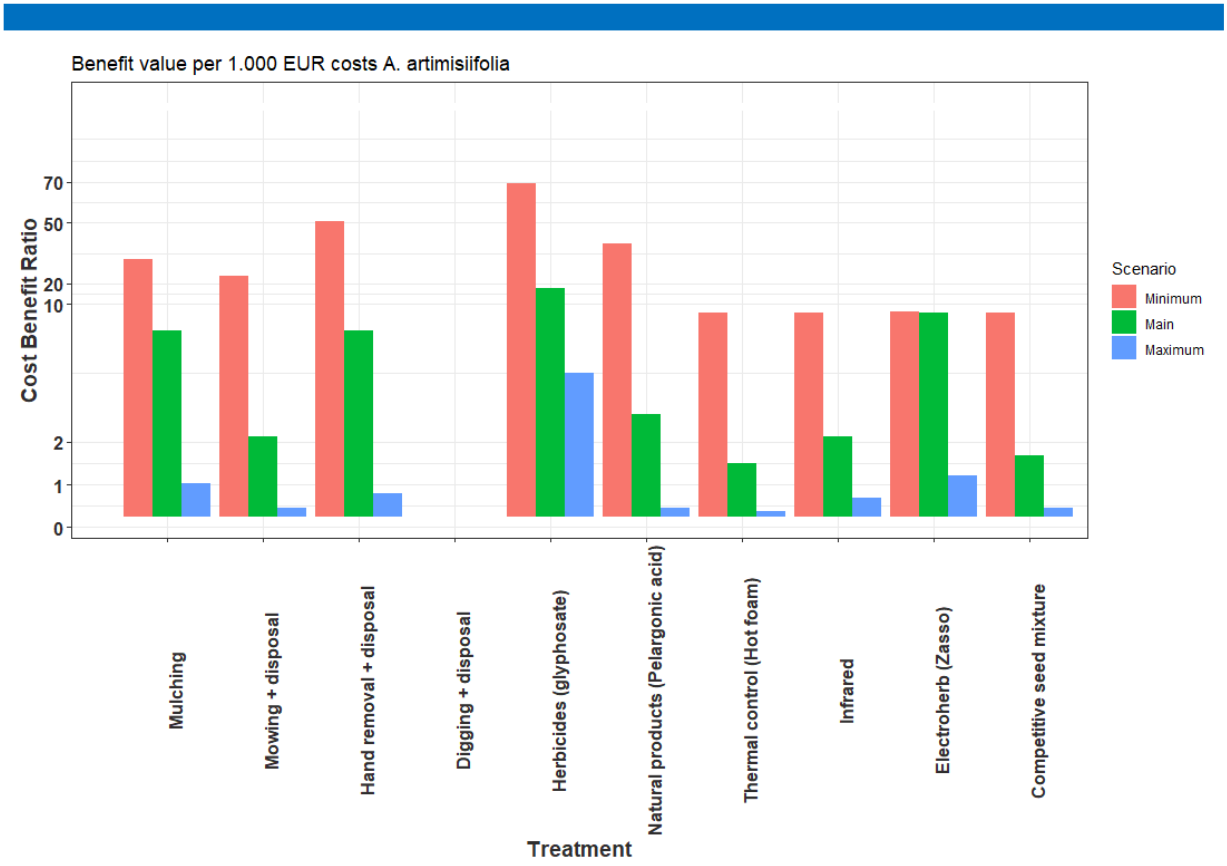

Fig. 7: Overview of the benefit values for the control A. artemisiifolia in different scenarios.

For ***A. artemisiifolia*** (Fig. 7) the standard method of herbicide application has the best cost-benefit ratio for all scenarios. The selection of the best alternative depends on the scenario: For the minimum scenario hand removal (and disposal) is the best alternative. For all other scenarios Electroherb™ is the best alternative to the use of herbicides.

These results lead to the recommendations laid out in Table 3 regarding the selection of control methods for the three selected IAPs instead the use of glyphosate:

Table 3: Recommendation of control methods for the selected IAP and the three different scenarios

Recommendation of control method to be used instead of herbicides (glyphosate) Based on the calulation of a cost benefit ratio (by using a cost effectiviness analysis)			
	Scenario		
	Minimum	Main	Maximum
	Low plant density, 1m treatment width, upper value of effectiveness range (regarding effectiveness range between 90% and 100%)	Medium plant density, 3m treatment width, medium value of effectiveness range (regarding effectiveness range between 50% and 90%)	High plant density, 10m treatment width, lower value of effectiveness range (regarding effectiveness range up to 50%)
H. mante-gazzianum	1. Hand removal (+disposal)	1. Hand removal (+disposal)	1. Hand removal (+disposal)
	2. Mulching	2. Mulching	2. Mulching
Fallopia spp.	1. Digging (+disposal)	1. Digging (+disposal)	1. Electroherb
	2. Mowing + dispoal	2. Electroherb	2. Digging (+disposal)
A. arte-misiifolia	1. Hand removal (+disposal)	1. Electroherb	1. Electroherb
	2. Natural products	2. Mulching	2. Mulching

When working with the results of the cost-benefit assessment, it should be noted that long-term field trials regarding the effects of different control methods on different IAPs are required under various conditions in order to increase the quality and reliability of the assessment results and the informative value of the cost-benefit assessment. Nevertheless, the results presented here provide a first good indication of which control methods are better than others under certain circumstances (scenarios). They can serve as a starting point for detailed location-specific assessments (using location-specific input data).

5 Transferability to other IAPs along roads

Besides the target IAPs addressed by ControlInRoad - *H. mantegazzianum*, *Fallopia* spp. and *A. artemisiifolia,* many other IAPs occur along roadsides. These are in particular the annual *Impatiens glandulifera*, the perennials *Asclepias syriaca*, *Gunnera tinctoria* and *Lupinus polyphyllus* as well as the woody species *Ailanthus altissima* (Deliverabe 3.1). Standard methods for the control of these five IAPs are outlined in Deliverable 2.2 and 3.1. It is assumed that proposed alternative methods (Deliverable 5.2) can also be used largely in the same way for the control of these species except for *A. altissima* (see Table 4 below).

Table 4: Overview of the transferability of control methods to other IAPs, not studied in Deliverable 3.3

	Standard methods					Alternative methods				
	Mulching	Mowing + disposal	Hand removal + disposal	Digging + disposal	Herbicides (Gyphosphate)	Natural products (Pelagronic acid)	Thermal control (Hot foam)	Thermal control (Infrared)	Electroherb (Zasso)	Removal + seed mixture
I. glandulifera	x	x	x		x	x	x	x	x	x
L. polyphyllus	x	x	x		x	x			x	
G. tinctoria			x	x	x	x			x	
A. syriaca	x	x	x		x	x			x	

Lupinus spp. are supposed to be sensitive to pelargonic acid (Young 2003), and this may also apply due to its non-selective behaviour to *A. syriaca* and *G. tinctoria*, however no studies are currently available for these two species. Similar to *Fallopia* spp. and *H. mantegazzianum*, multiple treatments may be necessary to contain the species with pelargonic acid. This may also apply to Electroherb™, where two to three treatments in the growing season should be sufficient to control and reduce populations of all three perennials.

The control of the perennial *Fallopia* spp. by hot foam was quite promising (Deliverable 3.3). However, the transferability of this approach to other perennials (*L. polyphyllus*, *G. tinctoria*, and *A. syriaca*) is fairly difficult (also due to the absence of any studies), since the efficacy depends e.g. on the location of the vegetation cone, leaf structure, characteristics of the root system (Deliverable 3.1) which differs between the respective plant species.

From a biological point of view, *A. artemisiifolia* and *I. glandulifera* are largely comparable (both are annual, dicotyl herbaceous plants). Therefore, it can be assumed that the effects of the alternative methods (natural products, thermal option, Electroherb™) on *I. Glandulifera* are about the same as for *A. artemisiifolia*. Again, no data on the efficacy of these methods on *I. glandulifera* is available in the literature. For *I. glandulifera*, essentially mechanical methods (uprooting) are recommended.

A. altissima is a woody species. Standard control methods for woody species include girdling, cutting and herbicide use. Electroherb™ and thermal options are assumed to be not suitable for the control of woody species (Deliverable 3.3) except juvenile individuals and seedlings. One alternative method is the application of a wilt-inducing fungus of the genus *Verticillium* (Maschek & Halmschlager 2017). The biological control agent is only effective against *A. altissima* and cannot be transferred to other woody species. It has not been evaluated within the project as this method has become available only very recently (until now it is only approved temporary for use in Austria).

6 Recommendations for Regulatory Framework

6.1 Proposal for normative measures

6.1.1 Purpose of this chapter

This chapter describes how the knowledge gained from the project can be implemented in normative measures for sustainable control of IAPs in the road sector (road maintenance, road construction or reconstruction). Considering the differences in the countries involved in the project (e.g. organizational structures in the road sector, involvement of external service providers) and regardless of which invasive plants mainly occur in the respective countries, the recommendations are kept as applicable as possible.

6.1.2 What are normative measures?

Normative measures can be divided in legislation, i.e. legally binding bans/demands and legally not directly binding measures such as guidelines or standards.

Guidelines or standards have no legal quality in themselves (i.e. you do not have to abide by them), but they can be given a binding position, e.g. by reference in a law or in tender documents. This means that all persons and institutions for whom the respective law is to be applied to or who would like to participate in a tender must then adhere to the referenced guidelines or standards.

6.1.2.1 Binding legislation

Basically, it is very difficult to enact binding laws (bans/demands) for plants, because plants cannot be banned themselves. At best, the possession, use of the plant or its fruit (e.g. from a certain ripeness) or a ban on its spread can be regulated by law. It is also difficult to define suitable sanctions and to determine whether the respective law should be generally applicable, or e.g. only for certain groups of society (e.g. companies, public administrations).

Creating binding legislation for IAPs treatment along roads is therefore difficult both in terms of content (technical) but also politically. Since there is little chance of successfully creating binding laws, this solution is not recommended.

6.1.2.2 Law-like norms = national guidelines and standards

National guidelines and standards are a good alternative to binding legislation to establish controlled technologies, processes and methods in the road sector.

National guidelines and standards have been tried and tested in the road sector for decades. This means that they are almost binding, even though they do not have an independent legal quality (i.e. the nature of a ban or demand). In addition, these guidelines, which are generally valid nationwide, have the advantage that they can be easily adapted to regional conditions,

which is particularly advantageous in federally-organized states. Good examples are the RVS (guidelines for road traffic) in Austria, or the guidelines for road construction in Germany.

The results of the first stakeholder survey have also shown that most stakeholders demand national guidelines for the management of IAPs.

We therefore recommend the development of national guidelines for the management of IAPs, as these:

- are flexible, i.e. can be adapted relatively quickly to new circumstances (new problems, new technical methods);
- if necessary, can be made legally binding by references.
- are able to form binding requirements and contract elements in project tenders;
- are regionally easily adaptable, e.g. to the organizational forms of road administrators (work instructions, requirements for tenders).

6.2 Proposal for the structure of a national guideline for the management of IAPs in road traffic

Objectives of this proposal

In this subchapter a template structure of a national guideline for the management of IAPs in the road sector is presented in the form of possible chapters and subchapters of such a guideline. The relevant content with which this structure can be filled can be found in the previous parts of the report (see chapters 3 to 5).

Proposed structure of contents for a national guidline

1. Title, date, numbering, authors
2. Statement of obligation
3. Table of contents
4. Scope of application
5. General
6. Definitions (Glossary - definitions)
7. Management strategy
8. Raising of awareness and prior information
9. General principles

9.1 Working and traffic safety

9.2 Cleanliness (Biosafety policy)

9.3 Standardized survey and documentation for effectiveness and development control

9.4 Cost-benefit considerations

10. Inventory

10.1 Methods of inventory

10.2 Planning of inventory

10.3 Collection of environmental parameters

10.4 Carrying out the inventory

10.5 Documentation of the inventory

11. Treatment on site

11.1 Goals

11.2 Selection of suitable control methods

11.2.1 Taking into account the results of the inventory

11.2.2 Consideration of disposal requirements,

11.2.3 Consideration of availability / feasibility over time

11.2.4 Consideration of costs, benefits and effectiveness

11.3 Planning of treatment

11.4 Execution of treatment

11.5 Documentation of treatment

12. Disposal

12.1 Goals

12.2 Consideration of dependencies

12.3 Legal regulations

12.4 Methods of treatment

12.5 Execution of disposal

12.6 Documentation of disposal

13. Effectiveness control and monitoring

13.1 Goals

13.2 Methods of effectiveness control and monitoring

13.3 Planning the effectiveness check and monitoring

13.4 Carrying out the effectiveness check

13.5 Execution of monitoring (if necessary)

13.6 Documentation

14. Project planning and construction measures

14.1 Goals

14.2 Consideration of IAPs in planning and projecting

14.3 Taking IAPs into account when preparing for construction

14.4 Taking IAPs into account during construction

14.5 Documentation of constructive measures

14.6 Effectiveness control and monitoring

15. Attachments

15.1 List of national IAPs and where (regions) they mainly occur

15.2 Collection and documentation tools (APPs, database) - European standard

15.3 List of control methods

15.4 Description of constructive (structural) measures

15.5 List of national experts

7 References

7.1 Deliverables

Deliverable 2.2 – List of invasive alien plants along roadsides

Deliverable 2.2 – Booklet with IAP and Description

Deliverable 3.1 – Alternative methods in road construction, operation and maintenance in relation to Invasive Alien Plants (IAPs)

Deliverable 3.2 – Greenhouse assays

Deliverable 3.3 – Field trial

Deliverable 4.2 – State of the art of legislation, guidelines and best practices in road construction and maintenance for the control of invasive species

Deliverable 5.2 – Cost Benefit Analysis

7.2 References

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