Information on measures and related costs in relation to species considered for inclusion on the Union list

This document shall be cited as:
Brundu, G. 2017. Information on measures and related costs in relation to species considered for inclusion on the Union list: *Ailanthus altissima*. Technical note prepared by IUCN for the European Commission.

This technical note provides information on the effectiveness of measures, alongside the required effort and resources, used to prevent the introduction, and to undertake early detection, rapid eradication, and management for the invasive alien species under review. Each table represents a separate measure. Date of completion: 06/11/2017

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Species (scientific name)	*Ailanthus altissima* (Mill.) Swingle
Species (common name)	Tree-of-heaven
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Date Completed	23/09/2017
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Summary

Highlight of measures that provide the most cost-effective options to prevent the introduction, achieve early detection, rapidly eradicate and manage the species, including significant gaps in information or knowledge to identify cost-effective measures.

Ailanthus altissima (tree of heaven), Simaroubaceae, is an early successional tree, native to China and North Vietnam, introduced as ornamental and for other uses which has become invasive in Europe and on all other continents except Antarctica. It is most abundant in urban habitats and along transportation corridors, but can also invade natural habitats. The measure that can prevent intentional introductions of the species is a ban on keeping, importing, selling, breeding and growing. To evaluate the acceptability of such a ban on keeping, importing, selling, breeding and growing *Ailanthus*, it is important to take into account the actual purposes for *Ailanthus* voluntary introduction and use in the European Union.

To prevent unintentional introduction and spread, the following measures are recommended: (1) identification of large trees (female or male) for eradication; (2) applying best construction and management practice for roads and railways; (3) applying best management practices (e.g. limiting disturbance) in habitats and land uses that are at risk of invasion; and (4) awareness campaigns to prevent mislabeling, dumping of garden waste, soil movements from infested sites. As for most of the invasive alien species that have many unintentional pathways of accidental introduction and secondary spread, all the possible measures should be included in a single action plan.

Early detection could be achieved by surveying the highest priority roads and railroads, urban and peri-urban areas, historical and archaeological buildings, riparian network, and natural and semi natural areas crossed or in close proximity. Surveys can be done scouting on foot, by car, by aerial vehicle (helicopter) and assisted with distal or proximal remote sensing tools such as unmanned aerial vehicles or systems. The measures to achieve rapid eradication of *Ailanthus* are the same as for the species Management, i.e. rapid eradication should follow an integrated control methodology.

The management of *Ailanthus* needs to make use of an integrated control strategy within a dedicated management plan. In the case of *Ailanthus* integrated control, specific tactics can include any combination of the following: herbicide rotation and herbicide mixtures, herbicide application rate and timing, precision application (e.g., "drill-fill" or stem injection), selection and integration of different methods according to the location and site accessibility, age, size, and the sex of the targeted Ailanthus plant (e.g., hand pulling can be an option, even if in very few cases), seed bank management, habitat manipulation (both for prevention and control) which can include several management and silvicultural options and disturbance mitigation. Importantly, as studied in the US, rodents can have a significant effect on the survival of tree seeds and seedlings invading old fields.

A variety of insects and diseases affect tree-of-heaven with varying success; however, there are no biological control agents currently approved for use in the United States. In addition, the release of macro-organisms as biological control agents is currently not regulated at EU level. Nevertheless national/regional laws are to be respected. Before any release of an alien species as a biological control agent an appropriate risk assessment should be made.

Prevention – measures for preventing the species being introduced, intentionally and unintentionally. **This table is repeated for each of the prevention measures identified.**	
Measure description Provide a description of the measure	The measure that can prevent **intentional introduction** is a **ban on keeping, importing, selling, breeding and growing**
Effectiveness of measure e.g. has the measure previously worked, failed	When addressing an alien plant species that is introduced mostly intentionally (e.g. ornamentals) and not yet present in the territory of the European Union, a ban on keeping, importing, selling, breeding, and growing the species is expected to be an effective measure against invasion.

	However, *Ailanthus* is already present in most of the Countries of the European Union, therefore such a measure is likely to only limit further spread and re-invasion in sites where removal or control intervention are taking place. In addition, *Ailanthus* spread also occurs unintentionally (*cf.* the following Prevention tables).
Effort required e.g. period of time over which measure need to be applied to have results	To be effective, these restrictions and trade bans must be enforced indefinitely.
Resources required [1] e.g. cost, staff, equipment etc.	Evaluations of the costs associated with the implementation of a ban on keeping, importing, selling, breeding and growing for *Ailanthus* are not available. However, if the ban for *Ailanthus* will be part of general biosecurity policy and biosecurity strategy, resources and costs will be reduced. For example, if there will be a unique biosecurity strategy for all the invasive alien plants of Union Concern this will produce general beneficial effects and economies of scale, including for the training of staff and application of custom controls as some pathways are responsible for the introduction of more than on taxa. However, the costs of compliance with such measures are often asymmetrical because compliance depends on technical know-how, production facilities, vectors safety and an infrastructural base that, while usually available in developed and emerging markets, is often lacking in many low-income countries (Murina and Nicita, 2017). As a result, the cost of compliance and the resource required might be different across EU Member States, for example in relation to the existing organisational framework, the total number of points of entry (unpacking facilities, car import yards and industrial premises where machinery is unloaded), the size of the borders, the size of the country, the total number of islands, the biogeographical region, and the trade routes.
Side effects (incl. potential) i.e. positive or negative side effects of the measure on public health, environment, non-targeted species, etc.	The pollen of *Ailanthus* is considered as a possible allergenic source (e.g., Ballero *et al.*, 2003) so that a ban on keeping, importing, selling, breeding and growing *Ailanthus* is likely to have a positive effect on human health.
Acceptability to stakeholders e.g. impacted economic activities, animal welfare considerations, public perception, etc.	To evaluate the acceptability of a ban on keeping, importing, selling, breeding and growing *Ailanthus*, it is important to take into account the many purposes for *Ailanthus* intentional introduction and use in the European Union. *Ailanthus* was originally introduced in Europe (18th century) as an amenity tree and as forage for silk worms. Its use as an ornamental and shade tree however continues today in Europe. Further uses include plantations for erosion control on slopes, verges of traffic lanes, dunes on the coast,

afforestation or reforestation, for the reclamation of landfill sites and mine spoils (Kowarik and Säumel, 2007, and references cited therein). It grows on a wide range of soils, from poor to rich and from dry to moist. *Ailanthus* tolerates relatively high levels of air pollution and may be able to sequester some pollutants. For this reason, it has been widely planted in urban areas worldwide to reduce environmental pollution (Baptista et al., 2014). *Ailanthus* has been used also for biomass production for fuel wood and for the production of fodder for goats and cattle (Feret, 1985; Baptista *et al.*, 2014).

In order to meet future demand and to overcome the wood shortages, studies have been conducted worldwide to evaluate the potential of new or alternative resources as raw material components for pulp and paper production. Thus, the use of fast growing species such as *Ailanthus* is considered as a promising alternative. The results achieved by Baptista *et al.* (2014) showed that the properties of the paper obtained from *Ailanthus* are close to those of the reference ones (*Eucalyptus globulus*).

Moreover, *Ailanthus* has been studied from the point of view of its biological activities and pharmacological applications, proving its use in traditional Chinese medicine and its potential application in modern medicine (Baptista *et al.*, 2014, and references cited therein; Peng *et al.*, 2017). However, *Ailanthus* is traditionally used also in the invaded range, e.g. flower tips for vermifuge and antiseptic properties in Sicily, Italy (Napoli, 2008).
The extract or semi-purified fractions of *Ailanthus* are strong plant growth inhibitors, therefore good candidates as potential environmentally safe and effective agricultural pest management agents (Tsao *et al.*, 2002). In addition, *Ailanthus* functions as food for honeybees; the honey is tasty but initially bad smelling (Kowarik and Säumel, 2007, and references cited therein).

However, most of the uses and benefits provided by *Ailanthus* described above can be provided by alternative native woody species, such as in the case of slope stabilisation and reduction of soil erosion risk, shade and other landscaping uses. The economic impact on the ornamental plant industry is likely to be low, as only small volumes of the species are traded. In addition, in the invaded range, the negative effects of *Ailanthus* on ecosystem services are generally considered far greater than positive effects (e.g., Andreu *et al.*, 2009; Conedera *et al.*, 2014). It is important to take into account the potential role of *Ailanthus* in urban systems in providing cultural ecosystem services. As it often grows well in harsh urban-industrial environments where native species may be limited, regulating ecosystem services might be also relevant (see, e.g. Kowarik and Säumel, 2007). However, conflicting opinions do exist and would need further clarifications, so that further

	research and an adequate informative action may convince stakeholders. Importantly, in some European countries or regions, the legislation in force pose limitations to the use of *Ailanthus*. For example, In Italy, *Ailanthus* is included in a black list for two regions, Lombardy and Piedmont (respectively on the basis of the Lombardy regional law 31 March 2008, No. 10; Piedmont DGR n. 23-2975/2016). In addition, the presence of *Ailanthus* outside cultivation, is generally perceived as negative by many stakeholders (as explained in the table on unintentional introduction and spread).
Additional cost information [1] When not already included above, or in the species Risk Assessment. - implementation cost for Member States - the cost of inaction - the cost-effectiveness - the socio-economic aspects	The exact costs are unknown. However, it is widely accepted that prevention (a ban on keeping, importing, selling, breeding and growing *Ailanthus*) would be highly cost effective, being much cheaper than early detection, rapid eradication or management measures (cost of inaction). General information (not specifically concerning *Ailanthus*) can be achieved through the documents and reports of those Countries that have national biosecurity policies in force, such as Australia[1] and New Zealand. Another source of general information on prevention cost is the study of Epanchin-Niell (2017).
Level of confidence [2] See guidance section	**High.** *Ailanthus* is unlikely to be confused with other species**.** When a ban on keeping, importing, selling, breeding and growing an alien species not yet present in the territory of the European Union is addressing an alien plant species that would be introduced mostly intentional such as *Ailanthus*, it can be expected to be an effective measure against invasion. In conclusions, a ban on keeping, importing, selling, breeding and growing will be very effective (with a high level of confidence) to limit the intentional introductions of Ailanthus to areas of the EU where the species is presently absent (e.g. Denmark), where it has been locally eradicated or were eradication attempts are occurring (e.g. in the framework of LIFE projects).

Prevention – measures for preventing the species being introduced, intentionally and unintentionally. **This table is repeated for each of the prevention measures identified.**	
Measure description Provide a description of the measure	General considerations on the preventive measures for **unintentional introduction and spread.** The measures that can prevent unintentional introduction and spread, should be based on a comprehensive analysis of the pathways of unintentional introduction and spread of *Ailanthus* within the territory of the European Union, and identify the pathways which require priority action.

[1] http://www.parliament.wa.gov.au/publications/tabledpapers.nsf/displaypaper/4010213a4c3d7d22ffde7bb64825812300165804/$file/213.pdf
http://www.gia.org.nz/Portals/79/Content/Documents/Resource-Library/GIA%20Annual%20Report%202016-web.pdf?ver=2016-11-21-145322-423

	This section reviews the available knowledge on measures that could prevent or reduce the unintentional introduction and spread of *Ailanthus*. These preventive measures include the application of best management practices for the construction and management of roads and railways, and for habitats and land uses that are at risk of invasion (discussed in this table). In addition, awareness campaigns to prevent mislabeling, dumping of garden waste, soil and seed movements from infested sites and targeting key stakeholder groups will be needed (discussed in the following Prevention table). When it comes to control and management measures it is generally agreed (e.g., USDA, 2014) that large female individuals should be considered a priority for control, aiming to reduce the risk of further unintentional spread of *Ailanthus* from infested areas to uninvaded areas through seed rain. It is important to note that all these measures addressing unintentional introductions and secondary spread, need to be addressed within **a single action plan.** **Unintentional introductions - Applying best management practice for construction and maintenance of roads and railways, and for habitats and land uses that are at a high risk of invasion.** *Ailanthus* can disperse at the local scale by seeds and vegetatively. Long-distance dispersal of seeds and clonal ramets is mediated by natural corridors (rivers, see Kowarik and Säumel, 2008; Cabra-Rivas *et al.*, 2014), and by road/rail transport and other human activities and infrastructures. In southern France, Kowarik (1983) observed clonal roadside populations of *Ailanthus* up to a length of 120 m. Clonal growth starting on roadsides encroached into evergreen shrub communities out to a distance of 25 m, and arable fields up to 45 m (Kowarik and Säumel, 2007, and references cited therein). Wind moves samaras both individually as well as aggregated in clusters. Wind was shown to move samaras at least 200 m over a hayfield, with four 18-m-tall trees as seed sources (Landenberger *et al.*, 2007). In urban habitats, sealed surfaces of pavements or streets may facilitate secondary dispersal of samaras by wind along linear habitats (Kowarik and Säumel, 2007 and references cited therein). The seed shadow from an 8-m tall tree extended for 456 m along the sidewalk in an urban transportation corridor, as a combined function of primary and secondary wind dispersal (Kowarik and von der Lippe, 2011). Outside of cities, *Ailanthus* preferentially colonizes transportation corridors, and among these mostly road and railroad verges and medians of motorways. Samaras can be attached to vehicles, and are also dispersed by the airflow of cars (von der Lippe *et al.*, 2013). Mainly starting from

	roadside verges, *Ailanthus* can invade borders of agricultural fields, meadows, vineyards, olive oil grooves and old fields (Kowarik and Säumel, 2007 and references cited therein). Merriam (2003) suggested that the reason that *Ailanthus* is most closely associated with railroad rights of-way in North Carolina (USA) is because winds from passing trains carry seeds along the tracks more effectively than in other edge habitats. Hydrochory is a secondary dispersal vector in Ailanthus as supported by a study by Kowarik and Säumel (2008). They demonstrated that samaras were able to drift for at least 20 days on water. Both floating and submerged seeds were able to germinate after differing periods of exposure to water. In addition, a significant portion of buried stem fragments developed both adventitious shoots and roots after a stay of 3 or 10 days in water. In a river, water moved a quarter of exposed samaras over 1,200 m in 3 hours (Säumel and Kowarik, 2010). Agricultural machinery accidental transport of *Ailanthus* seeds has also been documented (e.g., Fryer, 2010). Rodents may occasionally act as dispersal agents by padding out their dens with collected samaras. In Texas, several bird species feed on *Ailanthus* seeds (Kowarik and Säumel, 2007, and references cited therein). However, in the family *Simaroubaceae* we can expect the presence of andromonoecious (male and hermaphrodite flowers occur separately on the same plant), functionally dioecious, or distinctly dioecious plants (male and female reproductive structures on separate plants.). *Ailanthus* is a dioecious tree. Female flowers may have stamina, but these do not contain pollen. Other authors suggested that flowers might also be bisexual or the trees monoecious (male and female reproductive structure are found on the same plant but in different flowers), but empirical data on the occurrence and proportion of flower types in populations are scarce. Possibly, some authors address female flowers with sterile stamina as bisexual or 'hermaphrodite' (Kowarik and Säumel, 2007, and references cited therein). Importantly, in the city of Prague (Czech Republic), 614 mature individuals were examined: 50% of them were male plants with staminate flowers only, 48.5% were female plants bearing pistillate flowers and 1.5% of the trees were bisexual individuals classified as andromonoecious (poster communication at the 2014 NeoBiota Conference, Holec *et al.*, 2014). There are many guidelines available for **best management practices** in road and railway building and maintenance that help prevent the spread of invasive plants on roadsides and into agricultural or natural areas (e.g., Pennsylvania Department of Transportation, 2014; Graziano and Clayton, 2017; USDA Forest Service San Dimas Technology, 2017; For railway see: ÖBB-Infrastruktur AG

	Guidelines, Austria[2]). Importantly, activities such as mowing, grading, ditching and construction can work to either exacerbate or prevent the spread of invasive plants, including *Ailanthus* Those habitats and land uses that are more prone to be invaded by *Ailanthus* should be managed according to **specific guidelines** that should indicate adequate forest management measures, maintenance interventions for transport corridors and urban-forest interfaces, management of riparian networks (Cabra-Rivas *et al.*, 2014), measures to reduce or to contrast land abandon in agricultural and forest areas. This is particularly important as *Ailanthus* is already present and established in many MSs, so that there is a higher risk of accidental introduction and spread into these habitats from infested areas. Importantly, forest disturbance may provide greater opportunity for invasion of *Ailanthus*, thereby altering the successional trajectory of native plant communities. Forest disturbance is typically characterized by biomass removal that creates new growing space, such as fires, removal of litter, clear cuttings, coppicing, and opening of roads. Rapid establishment and growth, and vegetative reproduction in high light environments make disturbed areas such as timber harvests particularly prone to invasion by *Ailanthus* (Kota *et al.*, 2007; Radtke *et al.*, 2013; Wunder *et al.*, 2016; Wickert *et al*., 2017). In forest and natural areas, one additional important prevention measure is to wash vehicles before they enter a "weed-free" area or when they leave an *Ailanthus* infested area. A prototype of portable vehicle washer is described in the web site of USDA Forest Invasive Species Program (https://www.fs.fed.us/invasivespecies/prevention/). This measure is of course advisable to reduce the accidental transport of many other weeds. In addition, *Ailanthus* colonizes a broad array of urban habitats ranging from walls, fence rows, cracks of sidewalks, and road and railroad embankments to abandoned lots and urban parks (Kowarik and Säumel, 2007, and references cited therein), archaeological sites (Celesti-Grapow and Blasi, 2004). The abandonment of these habitats/land, or an inadequate intensity of maintenance interventions, will very likely promote the colonisation by *Ailanthus* and the establishment of large clones. In Southern Europe, *Ailanthus* can frequently colonise abandoned agricultural fields (Marco *et al.*, 2010), such as abandoned olive groves and vineyards, particularly on limestone areas. The

[2] http://events.uic.org/IMG/pdf/session_7b_-thomas_schuh_-_obb_-_invasive_alien_plants_.pdf - http://botany.uibk.ac.at/neophyten/download/05_OeBB_Schuh_Broschuere.pdf

	colonisation of abandoned chestnut orchards by *Ailanthus* in Switzerland is reported by Knüsel *et al.* (2015). In general, any intervention in archaeological site management[3] (including exclusion of domestic herbivores) can enhance the risk of invasions by weeds including *Ailanthus*.
Effectiveness of measure e.g. has the measure previously worked, failed	To be effective, the different preventive measures must be integrated into a single action plan and enforced addressing all possible unintentional pathways.
Effort required e.g. period of time over which measure need to be applied to have results	The measures need to be maintained indefinitely.
Resources required [1] e.g. cost, staff, equipment etc.	No information available. However, general information on the cost of awareness raising campaigns for invasive alien plants can be found in LIFE projects on invasive alien plants.
Side effects (incl. potential) i.e. positive or negative side effects of the measure on public health, environment, non-targeted species, etc.	*Ailanthus* can have negative effects on human infrastructures, including those building of historical and cultural importance, so that preventing its spread is likely to have a positive effect on local and national economies. The pollen of *Ailanthus* is considered as a possible allergenic source (e.g., Ballero *et al*., 2003) so that preventing its spread is likely to have a positive effect on human health. Applying best construction and management practice for roads and railways will also limit the spread of other invasive alien species with similar ecological requirement and pathways of spread. In addition it has been remarked for the south of Italy that road-side removal of *Ailanthus* might improve road safety due to enhanced visibility of road signals (Casella and Vurro, 2012).
Acceptability to stakeholders e.g. impacted economic activities, animal welfare considerations, public perception, etc.	Please see the table on preventive measures for intentional introduction. Applying best construction and management practice for roads and railways, may incur costs for those sectors required to undertake the measures. However, measures to prevent accidental introduction and secondary spread are more likely to be accepted by stakeholders and to be less conflictual, as *Ailanthus* invasions are generally perceived as a problem in the habitats and land uses where *Ailanthus* stands are established and costly control intervention are often occurring. Importantly, in some European countries or regions, the legislation in force pose limitations to the use of *Ailanthus* and some funding for the control of *Ailanthus* in agricultural areas are available through the EU's

[3] http://excellence.minedu.gov.gr/thales/en/thalesprojects/380237
http://www.doc.govt.nz/documents/science-and-technical/sap243entire.pdf

	rural development policy 2014-2020.
Additional cost information [1] When not already included above, or in the species Risk Assessment. - implementation cost for Member States - the cost of inaction - the cost-effectiveness - the socio-economic aspects	No information available.
Level of confidence [2] See guidance section	**High.** There are a number of best practice guidance documents published. Prevention is the first and most cost-effective line of defence against invasive alien species. In conclusions, the preventive measure summarised in the present table and described in the following tables (with a high level of confidence due to the fact that *Ailanthus* is quite a well-studied species) are very likely to limit the spread of *Ailanthus* to areas of the EU where the species is presently absent or where it has been locally eradicated. Road and railways are very well-known transport corridors for *Ailanthus* accidental spread.

Prevention – measures for preventing the species being introduced, intentionally and unintentionally. **This table is repeated for each of the prevention measures identified.**	
Measure description Provide a description of the measure	**Awareness campaigns to promote nursery best practices, prevent mislabelling, dumping of garden waste, contaminated soil or seeds movements from infested sites**. This set of preventive measures can be adopted by EU MSs making use of specific national legislation tools or can be included in more general biosecurity policy and biosecurity strategy for larger groups of invasive alien species. However, in addition to regulations MSs or single stakeholders' categories may consider and use a voluntary code of conduct as an effective alternative or complementary approach (e.g., EPPO Phytosanitary Procedures, PP 3/74 (1); EPPO, 2009). Additional information can be found in the EPPO Guidelines for the management of plant health risks of bio-waste of plant origin (EPPO, 2008). Concerning the cleaning of machinery or of other vectors, useful information can be found from the guidelines prepared by Biosecurity

	Queensland, part of the Department of Agriculture, Fisheries and Forestry, in Australia (Biosecurity Queensland, 2014) and similar documents[4]. Simple measures, such as cleaning of agricultural machinery cannot be considered as "stand alone" measures but must be integrated in more general action plans and codes of conduct, and widely disseminated and integrated with other general biosecurity measures (e.g., quality of forest and horticultural reproductive materials and nursery plants weed-free).
Effectiveness of measure e.g. has the measure previously worked, failed	To be effective, preventive measures must be enforced addressing all possible unintentional pathways.
Effort required e.g. period of time over which measure need to be applied to have results	The measures need to be maintained indefinitely, to prevent further spread of this alien plant within the EU.
Resources required [1] e.g. cost, staff, equipment etc.	No information available. However, there are many LIFE projects that can provide information on awareness campaign concerning other invasive alien plants. Examples of LIFE projects specifically dealing with *Ailanthus* are reported in the Management section below.
Side effects (incl. potential) i.e. positive or negative side effects of the measure on public health, environment, non-targeted species, etc.	No information available.
Acceptability to stakeholders e.g. impacted economic activities, animal welfare considerations, public perception, etc.	See the table on the preventive measures for unintentional introduction and spread. The overall objective of the LIFE AlterIAS project was to reduce the introduction of invasive plants at source, by raising awareness about their environmental risks amongst the whole ornamental horticulture supply chain in Belgium. The project aimed to promote best practices for preventing the release and spread of invasive alien species through a voluntary Code of Conduct produced with the involvement of the horticultural sector (Halford *et al.*, 2014).
Additional cost information [1] When not already included above, or in the species Risk Assessment.	No information available.

[4] See also:
http://dpipwe.tas.gov.au/Documents/Washdown-Guidelines-Edition-1.pdf
https://www.boprc.govt.nz/media/395661/keepitclean.pdf

- implementation cost for Member States - the cost of inaction - the cost-effectiveness - the socio-economic aspects	
Level of confidence [2] See guidance section	**High.** A number of public awareness campaigns have been ran and codes of conducts published. Prevention is the first and most cost-effective line of defence against invasive alien species.

Early detection - Measures to run an effective surveillance system for achieving an early detection of a new occurrence (cf. Article 16 of the IAS Regulation). This section assumes that the species is not currently present in a Member State, or part of a Member State's territory. **This table is repeated for each of the early detection measures identified.**	
Measure description Provide a description of the surveillance method	The measures to achieve early detection and run an effective surveillance system for achieving an early detection of a new occurrence of *Ailanthus* should take into account the pathways of introduction and spread, the location and distribution of existing infested areas, the susceptibility to be invaded by the diverse habitats and land uses. Early detection and rapid eradication (EDRE) are critical for preventing establishment of *Ailanthus*. Coordination efforts should be made between land managers, the local public (citizen science), and road crews, etc., on identification of *Ailanthus* so suspected infestations can be reported. There is not a single method that can be used, so it is advisable to frame the available measures and options in a dedicate **action plan**. Early detection can be achieved by **surveying the highest priority roads and railroads, urban and peri urban areas, historical and archaeological buildings, riparian network, and natural and semi natural areas crossed or in close proximity** (at least within 2 km of known locations of *Ailanthus* according to USDA, 2014). Surveys can be done on foot, by car (see McAvoy *et al.*, 2012) or aerial vehicle (helicopter) and assisted with distal or proximal remote sensing tools such as unmanned aerial vehicles or systems (UAV, UAS, drones).

	An example of road survey ('windshield survey') methodology is found in McAvoy *et al.* (2012) for Virginia (USA). The authors state that "young tree-of-heaven stems quickly exceed heights over 1 m and are easily identified by their long compound leaves. The number of living tree-of-heaven stems up to 25 m from the edge of both sides of the road and in the median, if present, were counted and recorded in 1.6-km road segments. At the end of each 1.6-km road segment the total number of tree-of-heaven was recorded and a new count was begun for the next 1.6-km road segment. To determine the amount of error in the windshield counts 10 1.6-km road segments infested with tree-of-heaven were surveyed from the vehicle. At the end of each 1.6-km segment, both sides of the road were walked and the number of tree-of-heaven stems was counted." Although not specifically planned for *Ailanthus*, Harris *et al*. (2001) provide guidance and a model for New Zealand on time intervals for active weed and invasive alien plants surveillance and they distinguish active surveillance from fortuitous surveillance. Several factors determine site invasiveness and probability of detection: rate of spread of the invasive alien plant, ability to find the new weed. The rate of arrival of an alien plant at a site varies with the proximity of the site to roads, towns and adjoining land use. Once an alien plant has arrived, its rate of spread depends on the habitat, the growth form, and its inherent biological capacity for spread. The visibility of an alien plant or small population, and hence the probability of finding it, varies with its growth stage, growth form and the location of the infestation. The ability to find an alien is also a function of our search effort (Harris *et al.*, 2001). In the Czech Republic, a research project (www.invaznirostliny.cz/en) aimed at developing an innovative method of mapping *Ailanthus* and other invasive plant species featuring a dedicated unmanned aerial system (UAS). This project aims to develop an unmanned aircraft system and methodological workflow enabling fast and precise monitoring of invasions. Different approaches to image pre-processing are tested, choosing the best methods for the data acquisition and their geometric and radiometric correction. In the USA, Rebbeck *et al.* (2015) tested a digital aerial sketch-mapping system (DASM - https://www.fs.fed.us/eng/rsac/invasivespecies/documents/DASM.pdf) run on a laptop computer with a touch screen display and stylus, allowing the manual recording of sketched features onto a base map. The goal of this method was to capitalize on conspicuous seed clusters of *Ailanthus* and test whether application of DASM technology from helicopters could be used as a fast and cost-effective tool to map seed-bearing *Ailanthus* in forested landscapes. These tests were conducted across 289,000 acres of public and private forestlands. Field crews assessed the accuracy of the

	aerial surveys through ground reference data collection. Crews also conducted aerial surveys during the leaf-on season to determine whether Ailanthus foliage and seed clusters were distinguishable from those of other species. Finally, a mapping protocol was developed for use by the forest management community. The georeferenced data could be used as a management strategy to identify high priority areas to target the removal of *Ailanth*us seed sources to minimize its dispersal and slow its spread (cf. also, http://www.edc.uri.edu/atmt-dss/report_forecast/toh_habitat.html). **Citizen science** can also play a role in the early detection, for example the Invaders of Texas Citizen Scientist Program (USA) is designed to train volunteer citizen scientists to detect invasive plants in their area and report them to a state-wide detection and mapping database housed on the www.Texasinvasives.org website (including *Ailanthus*). Another example, is the SISSI citizen science project in Italy (http://sissi.divulgando.eu/specie/dettaglio/3) and the LIFE project CSMON (http://www.csmon-life.eu/pagina/dettaglio_specie/35).
Effectiveness of the surveillance e.g. has the surveillance previously worked, failed	*Ailanthus* can be easily identified in all the stages of its life cycle, so that surveillance is expected to be effective. However, surveillance measures must address all possible areas where *Ailanthus* entry, establishment and spread may occur, giving priority to habitats and land uses more prone to invasion. Data collected through citizen science need to be carefully screened to avoid false-positives. In addition, surveillance will be facilitated whenever access to private properties will be necessary. There is not a single method or tool that can be used "stand alone", so it is advisable to frame the available measures and options in a dedicate action plan. For example, UAV operation in urban and inhabited areas might be prohibited or limited in some areas/MSs, limiting the application especially for invasive species like *Ailanthus* that spread into man-made habitats. Despites its limits, drones still provide a reasonable alternative to satellite imagery especially in vegetation mapping, where often data of high spatial and temporal resolution are required. In addition, they might be of great help in areas that cannot be surveyed on foot.
Effort required e.g. required intensity of surveillance (in time and space) to be sufficiently rapid to allow rapid eradication	The measures need to be maintained indefinitely. Early detection of *Ailanthus* in the EU needs availability of well trained staff, to conduct surveillance by vehicle, by helicopter, on foot or by boat. The surveillance done by the trained staff could be supported by non-governmental organisations and "citizen science" activities. In addition, remote sensing techniques, including

	drones and GIS modelling, may greatly help surveillance. The road or 'windshield' survey undertaken by McAvoy *et al.* (2012) took place along the secondary, primary, and interstate roads from May to September in 2004, 2005, 2010 and 2011. The authors state that "to maintain consistent counts the majority of observations were made by the first author; a few observations were performed by three others in the vehicle with the first author and 12% of the observations were done by the second author after extensive travel with the first author".
Resources required [1] e.g. cost, staff, equipment etc.	In general, trained staff are the key resource needs to undertake the surveys on foot, boat and by vehicle. The additional costs of vehicles, including boats and helicopters may also need to be considered depending upon the geography, habitats and size of the areas invaded. If remote sensing is being adopted then drones and computer software are also needed, along with staff with the relevant skills. For the digital aerial sketch-mapping system (DASM) detailed above, Rebbeck *et al.* (2015) report for the USA that approximately 12,000 acres were surveyed per day at an average of 2,000 acres/hour. They remark that there is a distinct cost advantage to their sketch-mapping technique over ground-based detection only. Their survey costs were estimated at $0.40/acres ($1/ha). Additional populations of non-seed-producing *Ailanthus* were often found during ground searches of seed-bearing Ailanthus for chemical treatments. This suggests that a multistage approach of conducting local ground searches near aerially detected seed-bearing *Ailanthus* may be even more cost-effective. Rebbeck *et al.* (2015) based the cost estimation on a commercial rate of $960/hour, which included helicopter rental ($800/hour) and hourly wages for the pilot ($60/hour) and two sketch-mappers ($100/hour) for an average 8-hour day. This estimate included round-trip flight time to and from the airport and survey area (1–2 hours/day), as well as a midday aircraft refuelling and crew break at the closest airport. Additional costs for training, setup, and post data processing time were minimal since they retooled an existing methodology currently used by the Division of Forestry. However, they estimated that an additional 16 hours ($50/hour) is required annually. Estimates of coverage ranged from 2,000 to 7,000 acres/hour, depending on the level of *Ailanthus* infestation and flight altitude. If more Ailanthus was present, then more time per acre was required for mapping (McAvoy *et al.*, 2012).
Side effects (incl. potential) i.e. positive or negative side effects of the method on public health, environment, non-targeted species, etc.	There will be no side effects in relation to early detection measures applied to tackle *Ailanthus*. However, if there were common biosecurity strategy for a number of invasive alien plants this will of course produce general beneficial effects as some vectors and corridors are responsible for the spread of more than on taxa, so that land surveillance in the same localities or along the same

	routes will tackle more than one alien taxa.
Acceptability to stakeholders e.g. impacted economic activities, animal welfare considerations, public perception, etc.	See the table on Preventive measures for unintentional introduction and spread. As generally agreed, public participation in detecting invasive species can increase the available "eyes and ears" searching for identified targets. A potential area of conflict is the access to private land to undertake the survey work.
Additional cost information [1] When not already included above, or in the species Risk Assessment. - implementation cost for Member States - the cost of inaction - the cost-effectiveness - the socio-economic aspects	As *Ailanthus* is already present in many EU Member States, a lack of surveillance would certainly promote further spread. Early detection and rapid eradication of incipient populations of *Ailanthus* before they have a chance to become widely established, will eliminate the need for costly and resource-intensive control programs.
Level of confidence [2] See guidance section	**Level of confidence: HIGH** There is plenty of literature and practical cases supporting the fact that Early Detection, followed by Rapid Eradication (EDRE) would be a very effective strategy to limit further spread of *Ailanthus* within the EU. However, there is not enough information to calculate the total cost for the EU for such a strategic option. Several measures do exist and would be very effective if included in a dedicated plan. However, such a dedicated plan should be based also on the knowledge of the actual distribution and abundance at MS level, at least with the resolution of a 10 x 10 km grid map (or even lower for some priority sites). Such important baseline mapping dataset is presently not available, so that the precise evaluation of efforts and resources required for ED in areas not yet invaded by *Ailanthus* in the EU is not possible.

Rapid eradication - Measures to achieve rapid eradication after an early detection of a new occurrence (cf. Article 17). This section assumes that the species is not currently present in a Member State, or part of a Member State's territory. **This table is repeated for each of the eradication measures identified.**	
Measure description Provide a description of the measure	Early Detection, followed by Rapid Eradication (EDRE), can detect and eradicate incipient populations of *Ailanthus* before they have a chance to become widely established, thus eliminating the need for costly and resource-intensive control programs. If prevention fails, early detection and rapid response are the next and most cost-effective line of defence against invasive alien species. The measures to achieve rapid eradication of *Ailanthus* are the same as described in the section on Management, i.e. rapid eradication should follow an **integrated control methodology**.

	In the very first phase of an invasion where only seedlings are present (before the tap root develops) **hand pulling** can be applied in combination with monitoring of the site and control follow ups. In the case of larger infestations, vegetative propagation from adult individuals, rapid eradication should be conducted according to integrated control methodology in the framework of a management plan (see Management measures table below). If rapid eradication occurs on a relative large area (e.g. more than 10 m^2), it is advisable to adopt specific measure for vegetation recovering of the eradicated areas. These might include the planting or sowing of local plant species of the temporary protection from grazing. For these reasons, rapid eradication cannot be applied without considering an integrated control methodology.
Effectiveness of measure e.g. has the measure previously worked, failed	Rapid eradication is expected to be very effective. Rejmánek and Pitcairn (2002) reports some of the numerous examples where small infestations of invasive plant species have been eradicated by hand pulling. According to the study the same authors conducted in California, professional eradication of exotic weed infestations smaller than one hectare are usually possible. Efforts in eradicating first establishment stages of *Ailanthus* are likely more challenging than in many other species as young plants, rather quickly, develop a tap-root and respond with vegetative reproduction to disturbance. Thus, control for root suckers may be vital for a period of time longer than 2 years.
Effort required e.g. period of time over which measure need to be applied to achieve rapid eradication	Manpower and simple tools. As a result of the presence of an *Ailanthus* seed bank, the removal by hand may need to be repeated several times in a 2-year period. Seedlings will need to be monitored and removed thereafter (by hand pulling). According to Rebbeck *et al*. (2010) persistence of *Ailanthus* seeds in soil seed banks is underreported. It appears that seeds are short-lived, typically 1 to 2 years, but germination rates are very high (80 to 100 percent) in disturbed forest stands.
Resources required [1] e.g. cost, staff, equipment etc.	The resources required will be related to the extent of the invaded area, the land accessibility, the need to repeat the interventions. When *Ailanthus* hand pulling is planned, it is important to use gloves to prevent skin irritation. DGE-BIODIV (2013)[5] give costs in Switzerland for manual pulling at 3-7 CHF/m^2/year.
Side effects (incl. potential) i.e. positive or negative side effects of the measure on public health, environment, non-targeted species, etc.	Eradication actions need to be planned carefully and restoration actions are always necessary as disturbance during interventions might promote invasion by other generalist invasive alien plants and *Ailanthus* vegetative spread. Restoration of undisturbed native vegetation might be a way to

[5] http://www.vd.ch/fileadmin/user_upload/themes/environnement/faune_nature/fichiers_pdf/Flore_et_Champignons/Recommandations_de_lutte_VD_F4-1_-_Ailante.pdf

	limit further spread of *Ailanthus*. Hand pulling of young seedlings and suckers should be avoided (or carefully performed) from historical (or archaeological) buildings to prevent further damages on the structures (Vidotto, 2015).
Acceptability to stakeholders e.g. impacted economic activities, animal welfare considerations, public perception, etc.	See the table on preventive measures for unintentional introduction and spread. Public perception of localised control of *Ailanthus* seedlings and young plants is generally positive when found outside cultivation and in land-uses where it is considered a weed. On the contrary, the removal of large trees can be conflictual in some cases. To promote acceptability, it can be useful to identify and promote replacement plant species for *Ailanthus* after its eradication from private or public gardens and urban green areas.
Additional cost information [1] When not already included above, or in the species Risk Assessment. - implementation cost for Member States - the cost of inaction - the cost-effectiveness - the socio-economic aspects	As *Ailanthus* is already present in many EU Member States, a lack of intervention, in particular local eradication of new outbreaks, would certainly promote a further spread. Eradication of incipient populations of invasive plant species before they have a chance to become widely established, will eliminate the need for costly and resource-intensive control programs. In addition, it is generally agreed that "doing nothing" or waiting for more research violates precautionary principles (Underwood, 1997). Thus, local authorities and land managers should plan programs to detect and facilitate the eradication of small, incipient *Ailanthus* populations to attempt, in accordance with precautionary principles, to preclude additional widespread infestations.
Level of confidence [2] See guidance section	**High**. There is plenty of literature and practical cases supporting the fact that Early Detection, followed by Rapid Eradication (EDRE) would be a very effective strategy to limit further spread of *Ailanthus* within the EU.

Management - Measures to achieve management (cf. Article 19). This section assumes that the species is already established in a Member State, or part of a Member State's territory. **This table is repeated for each of the management measures identified.**	
Measure description Provide a description of the measure	**The control of *Ailanthus* needs to make use of an integrated control strategy within a dedicated management plan.** Different measures may be required at an individual site, and management should be frequently site-specific. Conceptually, the management of *Ailanthus* needs to include a range of technologies and tools rather than only plant protection products (herbicides) and/or mechanical interventions alone.

	Different types of habitats and land uses are invaded by *Ailanthus* in the European Union, and within a single country or region. The idea of an **integrated control** originates from the agricultural sector but can be very effectively applied to many of invasive alien plants that impact the environment. This is often referred as IPM 'integrated pest management', IWM 'integrated weed management', IVM 'integrated vegetation management' or also as best management practices (BMPs). Numerous reviews describing IWM can be referenced for specific details (Thill et al., 1991; van Wilgen et al., 2001; Owen et al., 2015). The key principle to an IVM program is to preserve as much desirable vegetation as practical while removing the undesirable vegetation and the Pennsylvania Department of Transportation have proposed one for managing *Ailanthus* on roadsides (Gover et al., 2004). Integrated control has been suggested also for Switzerland[6], Hungary and Slovakia[7]. In the case of *Ailanthus* **integrated control**, specific tactics can include any combination of the following: herbicide rotation and herbicide mixtures, herbicide application rate and timing, precision application (e.g., "drill-fill" or stem injection), selection and integration of different methods according to the location and site accessibility, age, size, and the sex of the targeted *Ailanthus* plant (e.g., hand pulling can be an option, even if in very few cases), seed bank management, habitat manipulation (both for prevention and control) which can include several management and silvicultural options and disturbance mitigation. Importantly, as studied in the US, even rodents can have a significant effect on the survival of tree seeds and seedlings invading old fields (Ostfeld *et al.*, 1997). Mechanical and chemical control are short-term activities, whereas rigorous and disciplined follow-up and rehabilitation are usually necessary in the medium term (van Wilgen *et al.*, 2001). In addition, control interventions are often likely to be upset by stochastic events such as fires, floods, annual climate variation on control outcomes or other events. While an approach of **adaptive management**, based on trial, error and continual improvement is a logical way in which to progress (van Wilgen *et al.*, 2001; Kettenring and Adams, 2011; Williams and Brown, 2016), integrated control should be always included in a dedicated **management plan** (site or habitat specific) to cope with stakeholders' issues, the need of monitoring, control follow ups, and prevention of new invasions (by other taxa) or re-invasion (by *Ailanthus*). Useful information can be achieved in the work of Leffler and Sheley (2012) describing how adaptive management could be included in an

[6] http://www4.ti.ch/fileadmin/GENERALE/organismi/rapporti_studi/Ailanto_Oikos_2008.pdf
[7] https://www.dunaipoly.hu/uploads/2016-02/20160202200313-rosalia-handbook-ver2-6xtoafsq.pdf

	ecologically based invasive plant management strategy (EBIPM). EU/national/local legislation on the use of plant protection products and biocides needs to be always respected. In many types of invaded sites mechanical and chemical control for *Ailanthus* are more effective when used in combination, therefore the two methods are often combined and are here treated as a single management measure. *Ailanthus* is very difficult or impossible to control by simple cutting or by other mechanical means alone. Not only do trees re-sprout with tremendous vigour, but massive root suckering also occurs, which usually results in many more new stems spreading over a wider area (USDA, 2014). There are several practical techniques that can help make **mechanical control** of tree-of-heaven more effective. These include: (1) cutting trees before they become too large; (2) cutting trees in early summer when root reserves are lowest; (3) cutting regrowth repeatedly and frequently, and applying Plant Protection Products to cut surfaces; and (4) providing shade from competitive native plants after control efforts (USDA, 2014). After larger trees have been cut to ground level, re-sprouting wood is soft enough to be mowed at regular intervals which can stress root reserves and lead to fewer root suckers. However, an infrequent mowing cycle may allow the sprouts to spread and become too tall to mow. It is important to stress that using mechanical treatment alone risks the measure being ineffective, as if one sprout survives it can be the source for establishing abundant populations again. Therefore, mowing – similarly to the other mechanical methods - is more effective when followed up with a chemical treatment (USDA, 2014). **Plant protection products (PPP)** can be applied in a variety of ways including: (1) foliage application, (2) topical application to cut stems and stumps, (3) injection into the trunk, and (4) basal spraying. Although aboveground portions of *Ailanthus* are relatively easy to suppress or kill with herbicide treatment, it is also important to control the root system. Therefore, special attention should be paid to selection of the correct PPP, optimal application rate, and appropriate time to get good results. Care should always be taken when spraying any PPP near non-target plants. It is important to read and carefully follow all instructions and warnings provided on the PPP label (USDA, 2014). To reduce risk related to the use of PPP, the main principle of **targeted chemical control methods** (TCCM) should be followed. This means to apply the herbicides directly, and only, on specific plant individuals selected for control. TCCM were originally developed in order to remove specific invasive alien plant taxa from natural and protected areas without harming native species and sensitive habitats (Tu et al., 2001; Burn, 2003). Targeted chemical control methods suggested for *Ailanthus* in Cyprus include 3 different techniques: drill-fill (stem injection), cut-stump, and frilling (Dufour-Dror, 2013). Drill-fill (stem injection) is considered the method that gives the best results for invasive tree such *Ailanthus* characterized by a high resilience and re-

	sprouting ability. Because drilling represents a localized wound in the tree structure, it is less likely to trigger intense root sucker's development as that happens when the main trunk is cut down. The cut-stump is the second type of TCCM widely used in order to control alien invasive trees. With the cut-stump technique the trunks are cut down prior to herbicide application (herbicide is applied directly to the cambial regions of the newly cut stem). Herbicides are not injected into the sapwood as it is with drill-fill but applied onto the stump (Dufour-Dror, 2013). Frilling is a TCCM suited for young saplings and seedlings (BD<5cm) that are too small to be drilled, and whose exposed cut surface is too limited in order to apply enough herbicide (Burn, 2003; Dufour-Dror, 2013). Drill-fill techniques were tested also in Island of Sicily (Italy) as described by Badalamenti and La Mantia (2013) and on the island of Montecristo (Italy). Integrated control strategy within a dedicated management plan for *Ailanthus* can also include **grazing.** *Ailanthus* usually has low palatability for grazers; however, livestock (cattle, sheep, and goats) and deer will consume it during certain times of the year under specific circumstances. Goats will eat leaves and bark. Deer will browse leaves during the summer - especially in shady, forested areas. Under heavy grazing pressure, livestock will remove new suckers and sprouts. Use of grazing in combination with other techniques may be effective in certain situations (USDA, 2014). However, grazing alone is unlikely to control large infestations. In addition, grazing cannot be proposed in some types of infested land uses, such as road verges or urban areas. Furthermore, grazing has to be completely avoided from sites where vegetation recovering is planned after a removal/eradication intervention against *Ailanthus*.
Effectiveness of measure e.g. has the measure previously worked, failed	The control of *Ailanthus* by integrated control strategy within a dedicated management plan is an effective measure. Examples of effective control are reported by Brunel *et al.* (2013). On the contrary, single and non-integrated measures alone both mechanical (e.g. sapling removal, cutting) and chemical (e.g. foliar sprays, basal bark application) have met with limited success and are costly, time-consuming, and can pose a risk of serious non-target effects (Swearingen and Pannill, 2009; Erdős *et al.*, 2015). The LIFE project Montecristo 2010 (Montecristo 2010: eradication of invasive plant and animal aliens and conservation of species/habitats in the Tuscan Archipelago, Italy, LIFE08 NAT/IT/000353) aimed to eradicate *Ailanthus* from the Italian islands of Montecristo and Pianosa (about 10 km^2). The topography of Montecristo makes this intervention very difficult and costly, while on Pianosa the topography of the island is less a problem. So far, the abundance of *Ailanthus* has been significantly reduced on both islands, mostly on Pianosa and activities will continue until the full

	eradication of *Ailanthus* from both islands (http://www.montecristo2010.it/stealthV3_pubblica/0840425A0S1345033092.pdf).
Effort required e.g. period of time over which measure need to be applied to have results	The measures need to be maintained indefinitely.
Resources required [1] e.g. cost, staff, equipment etc.	The resources needed for an integrated control strategy within a dedicated management plan will be dependent upon specific circumstances, but in general will included trained staff, access to necessary tools and equipment to undertake physical control, the purchasing and application of PPP, and the disposal costs for the removed plants/trees. See DGE-BIODIV (2013) for details of the recommended resources required for the different individual control methods. There is only little information on the cost for applying an integrated control strategy within a dedicated management plan for *Ailanthus*. For example, for the control of *Ailanthus* scattered on a surface of about 180 ha on the Island of Montecristo (Italy) the dedicated LIFE Project (LIFE08 NAT/IT/000353)[8] allocated a budget of about 380,000 Euro, 19,000 Euro for the action plan, and an additional budget of about 40,000 Euro for mapping *Ailanthus* distribution from helicopter and land survey. Management itself can incur direct, indirect, and opportunity costs where opportunity costs are the values that are forgone by implementing a particular management strategy (e.g. lost trade values from implementing a ban, or forgone profits from delaying timber harvest in infested woods). While direct expenditures on invasive species management are often straightforward to quantify and readily considered, opportunity costs are more often overlooked (Epanchin-Niell, 2017). However, there are example of costs for single actions of an integrated control strategy, e.g. for Swiss, Germany, Italy (DGE-BIODIV, 2013 – Ailante. *Ailanthus altissima* (Mill.) Swingle. F4-1 Recommandations de lutte[9]). DGE-BIODIV (2013) provide annual costs in Switzerland for different control methods: - Manual pulling, once per year = 3-7 CHF/m^2/year - Repeated mowing, 5-6 rimes per year = 1.5-3 CHF/m^2/year - Chemical treatment on leaves and stem, once per year = 1-5 CHF/m^2/year

[8] http://www.montecristo2010.it/stealthV3_pubblica/0810372AOO7595000015.pdf

[9] http://www.vd.ch/fileadmin/user_upload/themes/environnement/faune_nature/fichiers_pdf/Flore_et_Champignons/Recommandations_de_lutte_VD_F4-1_-_Ailante.pdf

	- Removing the plant/tree along with root system, once per year = 40-80 CHF/m^2/year - Felling of shrubs and trees and chemical treatment of the stumps, once per year = 15-60 CHF/m^2/year - Ring-barking, once per year = 15-30 CHF/m^2/year - Chemical impregnation of the bark, once per year = 6-15 CHF/m^2/year - Notching of the bark followed by chemical treatment, once per year = 25-30 CHF/m^2/year - Felling followed by repeated mowing, 5-6 rimes per year = 15-60 CHF/m^2/year - Felling followed by chemical treatment on leaves and stem, once per year = 15-60 CHF/m^2/year.
Side effects (incl. potential) i.e. positive or negative side effects of the measure on public health, environment, non-targeted species, etc.	*Ailanthus* can have negative effects on human infrastructures and archaeological and historical buildings, so that reducing its abundance with management is likely to have a positive effect on the local economy. The control of *Ailanthus* with an integrated control strategy within a dedicated management plan will minimise all possible negative effects of mechanical treatment of *Ailanthus* alone (expensive and often not successful) or due to the use of PPP (herbicides) alone
Acceptability to stakeholders e.g. impacted economic activities, animal welfare considerations, public perception, etc.	See the table on general considerations on the preventive measures for unintentional introduction and spread. The successful implementation of any management plan and action is dependent, at least in part, on its acceptability to a wide range of stakeholders. Management actions can be accepted by stakeholders if well communicated, however this cannot be easily predicted as there are always very diverse perceptions among stakeholders' groups, with special concern to alien trees that can have multiple uses, or cultural or ornamental value. However, the Spanish environmental managers surveyed by Andreu et al. (2009) identified the following taxa as noxious: *Carpobrotus* spp., *Eucalyptus* spp., *Ailanthus altissima*, and *Robinia pseudoacacia*. In regards to the application of PPP's it is important to note that EU/national/local legislation on the use of plant protection products and biocides needs to be respected. Importantly, the European Commission has decided on the 10th January 2017 to register a European Citizens Initiative (ECI) inviting the Commission "to propose to Member States a ban on glyphosate, to reform the pesticide approval procedure, and to set EU-wide mandatory reduction targets for pesticide use" (http://europa.eu/rapid/press-release_IP-17-28_en.htm). In Italy, the National Action Plan for the sustainable use of plant protection products (D.M. January 22, 2014 - *Decreto 22 gennaio 2014, Piano di azione nazionale per l'uso sostenibile dei prodotti fitosanitari*) is leading to limitations in the use of chemical pesticides on roads (Action A.5.5) and in

	population centres (Action A.5.6) (Lorenzini, 2016), i.e. in land use types very commonly invaded by *Ailanthus*. Very recently, Kissane and Shephard (2017) have examined the published literature to evaluate the extent to which glyphosate based herbicides can cause toxic effects in wildlife and people and the implications of chronic exposure. The main principle of targeted chemical control methods (TCCM) i.e. to apply the herbicides directly, and only, on specific plant individuals selected for control are therefore always suggested whenever the use of PPP is planned.
Additional cost information [1] When not already included above, or in the species Risk Assessment. - implementation cost for Member States - the cost of inaction - the cost-effectiveness - the socio-economic aspects	No information available. However, it should be taken into consideration that additional cost could be required for the management of those plants or *Ailanthus* that have been intentionally planted as single plants or in plantations, and that may have a particular historical, cultural, economic or ornamental value, such as monumental trees (Zapponi *et al.*, 2017) or tree individuals introduced for the first time in a Botanic Garden.
Level of confidence [2] See guidance section	**Level of confidence: HIGH** There is significant scientific literature and practical evidence to support the content of this section with concern to the types of measure that can be applied and their effectiveness. Several management options do exist and would be very effective if included in a dedicated strategic management plan. However, such a dedicated management plan should be based on the knowledge of the actual distribution and abundance at MS level, at least with the resolution of a 10 x 10 km grid map (or even lower for some priority sites). Such important baseline mapping dataset is presently not available, so that the precise evaluation of efforts and resources required for managing *Ailanthus* in the EU is not possible.

Management - Measures to achieve management (cf. Article 19). This section assumes that the species is already established in a Member State, or part of a Member State's territory. **This table is repeated for each of the management measures identified.**	
Measure description Provide a description of the measure	**Classical biological control** A variety of insects and diseases affect *Ailanthus* with varying success; however, there are no biological control agents currently approved for use in the United States (USDA, 2014). In addition, it should be borne in mind that the release of macro-organisms as biological control agents is

	currently not regulated at EU level. Nevertheless national/regional laws are to be respected. Before any release of an alien species as a biological control agent an appropriate risk assessment should be made. Among biological agents currently being researched in the USA, there are three fungal pathogens, two weevils, and a moth. Approval for one of the weevil species, *Eucryptorrhynchus brandti* (Coleoptera: Curculionidae), is anticipated in the near future (Ding *et al*., 2006; USDA, 2014). Importantly, the biological control of *Ailanthus* using the wilt-inducing fungi in the genus *Verticillium* spp. as "mycoherbicides" could be a promising alternative in Europe (Maschek and Halmschlager, 2017). A strain of *Verticillium albo-atrum* found in southern Pennsylvania by Don Davis and colleagues has been found to cause near complete mortality of *Ailanthus* in artificially infected stands (Harris *et al*., 2013). However, recent phylogenetic and taxonomic studies by revealed five new *Verticillium* species. Two of these, *V. alfalfae* Inderb. et al. and *V. nonalfalfae* Inderb. et al., resembled the distantly related *V. albo-atrum* s.s. in morphology. Thus, all prior morphology-based identifications and assigned host ranges of *V. albo-atrum* s.l. are to be questioned. Currently, only *V. nonalfalfae* and *V. dahliae* have been reported from wilting *Ailanthus* in Europe (Maschek and Halmschlager, 2017). In Europe, an Austrian isolate of *V. nonalfalfae*, which is considered the most effective *Verticillium* species as biocontrol agent against *Ailanthus*, were tested in field inoculations studies. Results revealed that disease progression on *Ailanthus* is negatively influenced by high temperatures in summer. Therefore, inoculation in spring turned out to be the most effective to combat *Ailanthus*. However, due to the common occurrence of *V. dahliae* in Austria, this pathogen might be considered as alternative biocontrol agent of *Ailanthus* on sites in warmer climates. For that purpose, further investigations of the host range and non-target effects of selected *V. dahliae* strains should be carried out according to Maschek and Halmschlager (2017).
Effectiveness of measure e.g. has the measure previously worked, failed	The biological control of *Ailanthus* using the wilt-inducing fungi in the genus *Verticillium* spp. as "mycoherbicides" could be a promising alternative to other control measures (Maschek and Halmschlager, 2017). The huge potential of selected strains of *V. nonalfalfae* as biocontrol agents against *Ailanthus* already has been demonstrated in the United States (Maschek and Halmschlager, 2017 and reference cited therein) and Europe. *Verticillium dahlia* might serve as alternative biocontrol agent of *Ailanthus* on sites in warmer climates, however, further investigations concerning host range and non-target effects of selected *V. dahlia* strains have to be carried out (Maschek and Halmschlager, 2017).

Effort required e.g. period of time over which measure need to be applied to have results	No information available.
Resources required [1] e.g. cost, staff, equipment etc.	No information available.
Side effects (incl. potential) i.e. positive or negative side effects of the measure on public health, environment, non-targeted species, etc.	The application of a pathogen such as a Verticillium species bears the risk of non-target effects, particularly if it has a broad host range.
Acceptability to stakeholders e.g. impacted economic activities, animal welfare considerations, public perception, etc.	The release of macro-organisms as biological control agents is currently not regulated at EU level. Nevertheless national/regional laws are to be respected. Before any release of an alien species as a biological control agent an appropriate risk assessment should be made.
Additional cost information [1] When not already included above, or in the species Risk Assessment. - implementation cost for Member States - the cost of inaction - the cost-effectiveness - the socio-economic aspects	No information available.
Level of confidence [2] See guidance section	**HIGH.** Classical biological control could be a very useful methodology for long term management of invasive weeds.

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WEB sites

LIFE Montecristo:
http://www.minambiente.it/sites/default/files/archivio/allegati/life/life_progetto_montecristo_action_plan.pdf

LIFE Alta Murgia
http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPageandn_proj_id=4566anddocType=pdf

LIFE RI.CO.PR.I
http://www.pdc.minambiente.it/sites/default/files/progetti/ricopri_linee-guida-azione-c2.pdf

Modelling Ailanthus distribution
http://www.gissmox.ethz.ch/en/showcases/projects/ailanthus.html

Ailanthus control methods

Swiss (protected area)
http://www.gissmox.ethz.ch/en/showcases/projects/ailanthus.html

Swiss (forest)
https://www.bafu.admin.ch/bafu/it/home/temi/bosco/pubblicazioni-studi/pubblicazioni/guida-relativa-alla-gestione-dell-ailanto.html
http://www4.ti.ch/fileadmin/GENERALE/organismi/rapporti_studi/Ailanto_Oikos_2008.pdf

Italy (historical site, page 6 of the PDF document)

http://www.isaitalia.org/images/stories/arbor/rivista_elettronica/2016/2/Arbor_n._2_2016-ilovepdf-compressed1.pdf
https://iris.unito.it/retrieve/handle/2318/1589122/206577/Vidotto_etal_ailanto_arbor_postprint_4aperto.pdf

Italy
http://www.regione.piemonte.it/ambiente/tutela_amb/dwd/esoticheInvasive/schede_complete/ailanto_althissima_2016.pdf

France
http://www.codeplantesenvahissantes.fr/fileadmin/PEE_Ressources/TELECHARGEMENT/Ailanthus_altissima__Mill__Swingle.pdf

Spain
http://www.mapama.gob.es/es/biodiversidad/temas/conservacion-de-especies/ailanthus_altissima_2013_tcm7-306916.pdf
http://www.lifemedwetrivers.eu/sites/default/files/documentos/25_ailanthus_altissima.pdf

Notes

1. Costs information. The cost information depends on the information available.

2. Level of confidence provides an overall assessment of the confidence that can be applied to the information provided for this method.

- **High**: Information comes from published material, or current practices based on expert experience applied in one of the EU countries or third country with similar environmental, economic and social conditions.
- **Medium**: Information comes from published data or expert opinion, but it is not commonly applied, or it is applied in regions that may be too different from Europe (e.g. tropical regions) to guarantee that the results will be transposable.
- **Low**: data are not published in reliable information sources and methods are not commonly practiced or are based soley on opinion; This is for example the case of a novel situation where there is little evidence on which to base an assessment.

3. Citations and bibliography. The APA formatting style for citing references in the text and in the bibliography is used.
e.g. Peer review papers will be written as follows:
In text citation: (Author & Author, Year)
In bibliography: Author, A. A., & Author, B. B. (Publication Year). Article title. *Periodical Title*, Volume(Issue), pp.-pp.

(see http://www.waikato.ac.nz/library/study/referencing/styles/apa)