



Appendix A

## Harmonia<sup>+PL</sup> – procedure for negative impact risk assessment for invasive alien species and potentially invasive alien species in Poland

### QUESTIONNAIRE

#### A0 | Context

Questions from this module identify the assessor and the biological, geographical & social context of the assessment.

##### a01. Name(s) of the assessor(s):

first name and family name

1. Bogdan Jackowiak
2. Przemysław Bąbelewski – external expert
3. Barbara Tokarska-Guzik

acomment01.	Comments:		
	degree	affiliation	assessment date
(1)	prof. dr hab.	Department of Plant Taxonomy, Institute of Environmental Biology, Faculty of Biology, Adam Mickiewicz University in Poznań	23-01-2018
(2)	dr inż.,	Wrocław University of Environmental and Life Sciences	28-01-2018
(3)	prof. dr hab.	Faculty of Biology and Environmental Protection, University of Silesia in Katowice	29-01-2018

##### a02. Name(s) of *the species* under assessment:

Polish name: Bożodrzew gruczołowaty  
Latin name: ***Ailanthus altissima*** (Mill.) Swingle  
English name: Tree of heaven

acomm02.

Comments:

The Latin name of the species was adopted according to The Plant List (2012 - B). This name is also accepted in Polish sources (Mirek et al. 2002, Seneta i Dolatowski 2002, 2012- P, Vascular Plants of Poland, A Checklist - B) with the synonym *A. glandulosa* Desf.; the Polish name given in these papers is tree of heaven and ailanthus.

Synonyms collected in the work of Kowarik and Säumel (2007 - P): *Ailanthus glandulosa* Desf. 1786, *A. procera* Salisb. 1796, *A. giraldii* Dode 1907, *A. vilmoriniana* Dode 1904, *A. peregrina* (Buc'hoz) F.A. Barkley 1937, *A. cacodendron* (Ehrh.) Schinz & Thell. in Thell. 1912, *A. procera* Salisb. 1796, nom. illeg., *A. rhodoptera* F. Mueller 1863, *A. sutchuensis* Dode 1907, *Albonia peregrina* Buc'hoz nom. illeg. 1783 sine descr., *Pongelion cacodendron* (Ehrh.) Degen, *P. glandulosum* (Desf.) Pierre, *Rhus cacodendron* Ehrh. 1783, *R. hypselodendron* Moench, *R. sinense* Ellis 1757, *R. peregrina* (Buc'hoz) Stapf 1929, *Toxicodendron altissimum* Mill. 1768.

More common English synonyms are: China sumac; copal tree; tree of heaven; varnish tree (CABI 2017 - B).

Taxonomic differentiation of the genus *Ailanthus* acc. Nooteboom (1962 - P). In addition to *A. altissima*, there are four species: *A. excelsa* Roxb., *A. integrifolia* Lam. (incl. *A. calycina* Pierre), *A. triphys* (Dennst.) Alston and *A. fordii* Nooteboom.

Taxonomic problems within the genus are related to *A. altissima*. Sometimes, *A. vilmoriniana* and *A. giraldi* (Fu and Hong 2001 - P) are distinguished as separate species, but this is not recognized by other authors; e.g. Geerinck (1990 - P), who treated both species as identical, belonging to *A. altissima*. There are about a dozen subspecies within *A. altissima* native range; a similar number of cultivars was described (Kowarik and Säumel 2007 - P).

Polish name (synonym I)

Ajlant gruczołowaty

Latin name (synonym I)

*Ailanthus glandulosa*

English name (synonym I)

Copal tree

Polish name (synonym II)

Ajlant wyniosły

Latin name (synonym II)

*Toxicodendron altissima*

English name (synonym II)

Tree-of-heaven

**a03. Area under assessment:**

**Poland**

acomm03.

Comments:

-

**a04. Status of the species in Poland. The species is:**

<input type="checkbox"/>	native to Poland
<input type="checkbox"/>	alien, absent from Poland
<input type="checkbox"/>	alien, present in Poland only in cultivation or captivity
<input type="checkbox"/>	alien, present in Poland in the environment, not established
<input checked="" type="checkbox"/>	alien, present in Poland in the environment, established

aconf01.

Answer provided with a

low	medium	high
		<b>X</b>

level of confidence

acomm04.

Comments:

The native range of *Ailanthus altissima* covers the eastern regions of China and northern Vietnam, where it is a component of deciduous forests (Kowarik and Säumel 2007 - P). Its non-native range includes all continents except the Antarctic region. It is widely distributed in Europe and North America (DAISIE 2006, CABI 2017 - B). In addition, it occurs in Central America (Mexico), South America (Argentina), Africa (North coast and South Africa), Australia (south-east part), Central and Eastern Asia (Kowarik and Säumel 2007 - P); in many regions of the world, it has the status of an invasive species (including EPPO 2014,

CABI 2017 - B). It was brought to Europe in 1740 (Hu 1979 - P). Currently, it is common in southern, western and central Europe, both cultivated and spontaneously growing. Tree of heaven is an urbanophilic species strongly associated with the central zones of large cities, which is particularly evident in the northern part of its European range (Sudnik-Wójcikowska 1998 a and b, Tokarska-Guzik 2005 a and b, Kowarik and Säumel 2007 - P). The area of established occurrence in Poland is smaller than the area of potential cultivation of the species. The latter goes further to the east (among others, Sudnik-Wójcikowska 1998 a and b, Bąbelewski 2005, Bąbelewski 2006, Bąbelewski and Czekałski 2005, Tokarska-Guzik 2005 a and b, Kowarik and Säumel 2007 - P; Jackowiak 2015-2017 - A). Individual localities of this species were recorded in environments similar in nature to the outskirts of Wrocław, Poznań, Kraków, Warsaw and Łódź (Bąbelewski 2015-2017 - A). *Ailanthus altissima* is also kept in collections of several botanical gardens and arboreta in Poland (Pracownicy ogrodów... 2018 - N).

**a05.** The impact of *the species* on major domains. *The species* may have an impact on:

<input checked="" type="checkbox"/>	the environmental domain
<input checked="" type="checkbox"/>	the cultivated plants domain
<input type="checkbox"/>	the domesticated animals domain
<input checked="" type="checkbox"/>	the human domain
<input checked="" type="checkbox"/>	the other domains

acomm05.

Comments:

Tree of heaven significantly affects the natural environment in which it occurs. These are both cultivated trees or their clusters, as well as individuals and populations formed spontaneously (Udvardy 2008 - P, CABI 2017 - B). In Poland, the impact of this species on the natural environment has been so far described quite generally (including Bąbelewski and Czekałski 2005 - P). The destructive influence on other objects is mentioned by, among others, Świerkosz (1993 - P) and in some garden guides. This is confirmed by the observations of the authors of this study, indicating a very strong influence on the construction, transport and road infrastructure (Bąbelewski 2015-2017, Jackowiak 2015-2017 - A). The literature data from outside Poland indicate that tree of heaven significantly changes the chemical (Medina-Villar et al. 2015 - P) and biotic conditions in the ground - especially the microbiological composition (Medina-Villar et al. 2016 - P) and the structure of arthropod communities (Gutiérrez-López et al. 2014 - P). In addition, the allelopathic effects on plants occurring in the zone of influence of this tree were observed (Gómez-Aparicio 2008, Udvardy 2008 - P). In Poland, the negative impact of *A. altissima* was found on ornamental plants planted in cities (Jackowiak 2015-2017 - A). So far, the negative impact of this species on fruit plants, which is known, for example, in Moravia (Bąbelewski 2015-2017 - A), has not been confirmed. There is no information about the influence of *A. altissima* on animal husbandry, as well as on people. In the latter case, however, possible allergenic effects should be taken into account.

## A1 | Introduction

Questions from this module assess the risk for *the species* to overcome geographical barriers and – if applicable – subsequent barriers of captivity or cultivation. This leads to *introduction*, defined as the entry of *the organism* to within the limits of *the area* and subsequently into the wild.

**a06.** The probability for *the species* to expand into Poland's natural environments, as a result of self-propelled expansion after its earlier introduction outside of the Polish territory is:

<input type="checkbox"/>	low
<input type="checkbox"/>	medium
<input checked="" type="checkbox"/>	high

aconf02.	Answer provided with a	low	medium	high <b>X</b>	level of confidence
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acommm06. Comments:  
*Ailanthus altissima* is already established in Poland, so the probability of its appearance as a result of independent expansion should be recognized as high, with a high degree of certainty (see the Harmonia +PL survey instruction). Tree of heaven reproduces mainly generatively, and the winged seeds produced in a large number can be transferred to relatively long distances by wind and water (Kowarik and Lippe 2006, 2011, Kaproth and McGraw 2008 - P).  
 Although the main source of the spread of *A. altissima* in Poland is the cultivation of communities of this tree, it cannot be ruled out that at least part of the wild population in Western Poland is the result of a completely independent expansion of tree of heaven to the east. The most probable sources of diaspores outside of Poland are the areas of such cities as Berlin and Leipzig, where this species has been present for many years in the form of compact, wild tree stands. Thus, migration of *A. altissima* from these areas to Poland cannot be excluded. The Odra valley is an important barrier of expansion of *A. altissima* to the east. In this context, attention should be paid to two aspects of the question: formal and cognitive. First of all, the border of Poland has changed over time. Until the end of World War II, a large part of western Poland, i.e., the area with the most numerous occurrence of *A. altissima*, was situated outside the state border of Poland. Secondly, distinguishing populations coming from outside Poland would require very complex genetic tests, and their result would not necessarily have to answer the question asked. *Ailanthus altissima* also occurs in the Czech Republic and Slovakia, where it has the status of an invasive species (CABI 2017 - B), including the areas of cities near the border with Poland.

a07. The probability for *the species* to be introduced into Poland's natural environments by **unintentional human actions** is:

<input type="checkbox"/>	low
<input type="checkbox"/>	medium
<input checked="" type="checkbox"/>	high

aconf03.	Answer provided with a	low	medium	high <b>X</b>	level of confidence
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acommm07. Comments:  
 Tree of heaven was introduced into the natural environment of Poland mainly due to intentional human actions consisting in planting this tree in urban areas (Bąbelewski 2007 - P). It spreads spontaneously from cultivated places to anthropogenic habitats and further (though not yet so often) to natural habitats. The possibilities of unintentional dragging (e.g. with transport) are definitely smaller and unexplored, but highly probable, hence the "high" rating, in accordance with the instruction in *Harmonia*<sup>+PL</sup> protocol. Vehicle transport (seeds) and bringing diaspores (seeds, vegetative parts) with other plants (Kowarik and Lippe 2006, 2011, Kowarik and Säumel 2007 - P) are mentioned as a frequent way of transferring the diaspores of species from other non-native areas.

a08. The probability for *the species* to be introduced into Poland's natural environments by **intentional human actions** is:

<input type="checkbox"/>	low
<input type="checkbox"/>	medium
<input checked="" type="checkbox"/>	high

aconf04.	Answer provided with a	low	medium	high <b>X</b>	level of confidence
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acommm08. Comments:  
*Ailanthus altissima* has been deliberately introduced in many regions of Europe, including Poland, primarily as a decorative tree (planted mainly in cities), but also for soil protection

against erosion and due to economic and therapeutic properties (Udvardy 2008 - P , CABI 2017 - B).

Tree of heaven is not a species deliberately introduced into forests. It is planted mainly in cities without the intention of introducing it to commercial environments (forests), but generally considered to be close to natural ones (not transformed by humans). Treating the natural environment in a narrow sense, the likelihood of introducing this species should be assessed as low. Treating the natural environment widely (i.e., considering all natural and by man transformed environments), the probability is high (as in question a07). Due to climatic conditions, the species was planted primarily in Western Poland - here the probability of "escapes" is high; different situation is in the eastern part of the country, where it was introduced sporadically, therefore the probability of introducing the species to the environment is low (Tokarska-Guzik 2005a - P). Therefore, we recommend a medium grade of assessment with a medium degree of certainty resulting from interpretation doubts. It should be mentioned that *Ailanthus altissima* is found in the collections of botanical gardens and arboretums in Poland (see question a04), in which the oldest documented specimens come from 1948. In the case of some gardens, spontaneous propagation by means of numerous seeds and root growths was confirmed (Botanical Gardens employees... 2018 - N).

## A2 | Establishment

Questions from this module assess the likelihood for *the species* to overcome survival and reproduction barriers. This leads to *establishment*, defined as the growth of a population to sufficient levels such that natural extinction within *the area* becomes highly unlikely.

a09. Poland provides **climate** that is:

<input type="checkbox"/>	non-optimal
<input type="checkbox"/>	sub-optimal
<input checked="" type="checkbox"/>	optimal for establishment of <i>the species</i>

aconf05.	Answer provided with a	low	medium	high	level of confidence
				<b>X</b>	

acomm09.	Comments:
	<p>Climatic conditions for the establishment of <i>Ailanthus altissima</i> in Poland vary, but generally they are moderately favorable. Regional diversity results from climate differences. In Poland, tree of heaven has been introduced into cultivation. The species is seeding and forms new tree generations in Western Poland, Pomerania, western part of Central Poland and in Southern Poland (Sub-carpathian region). In eastern Poland and in the mountain areas, tree of heaven does not grow, because in eastern part prevails a harsh continental climate, while in mountains – the mountain climate. In Central Europe, climate is the main factor affecting the distribution, while the factor related to the fertility of habitats plays a more important role in the Mediterranean zone. Preferred average annual temperatures are between 7-18°C, but the plant can tolerate even strong frosts (seedlings are mainly destroyed by frost). In recent years, the mean annual temperatures in Poland exceed the limit of 7°C by 1-2°C. <i>A. altissima</i> is indicated as an interesting example of a species that has become invasive outside its natural climate zone, i.e., its native range is associated with subtropical/warm temperate climate, but it is able to colonize areas located in tropical to moderately cool climate zones (Cronk and Fuller 2001, Kowarik and Säumel 2007 - P). At the same time, <i>A. altissima</i> is mentioned among species that use the so-called "urban heat islands" to enlarge their range, especially in Central and Northern Europe, (Sukopp and Werner 1983, Jackowiak 1998 a and b, 2000, Sudnik-Wójcikowska 1998 a and b, Sukopp and Wurzel 2003, Tokarska-Guzik 2005a - P). It can be assumed that the thermal factor had a dominant influence on its distribution (Udvardy 2008 - P). Tree of heaven is a typical thermoindicator, strongly attached to the warmest zones of Central European cities and highly industrialized places, such as Cologne, Duisburg, Berlin, Leipzig, Halle and Zürich and</p>

the western part of the Ruhr area (Kowarik 1983 a and b, Kowarik and Böcker 1984, Kunick 1984, Landolt 1991, Sudnik-Wójcikowska 1986, 1998a, Sudnik-Wójcikowska and Moraczewski 1993 - P). In Poland, cartographic data on the distribution of tree of heaven in cities (Warsaw, Łódź, Wrocław) was provided by Sudnik-Wójcikowska (1998b - P), Bąbelewski and Czekalski (2004, 2005 - P). Quoted data and guidelines of the Harmonia<sup>+PL</sup> iprotocol authorise for the evaluation of climatic conditions in Poland as optimum for establishment of the species.

**a10.** Poland provides **habitat** that is

- non-optimal
- sub-optimal
- optimal for establishment of *the species*

aconf06.	Answer provided with a	low	medium	high <b>X</b>	level of confidence
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acomm10. Comments:  
 In Poland, the habitat conditions for *Ailanthus altissima* are optimal for the species establishment. It occurs mainly in urbanized areas, where it is most often associated with the zones with the elevated temperature, not only of air, but also soil (Sudnik-Wójcikowska 1998b, Bąbelewski and Czekalski 2004, 2005, Bąbelewski 2014a and b - P). It is also found at roadside sites and railway areas, and appears in riverside habitats (Tokarska-Guzik 2003-2017 - A). Regarding soil, tree of heaven has modest requirements. It grows well on dry soils, transformed anthropogenically, and on rubble. The research carried out by Brogowski et al. (1977 - P) regarding salt resistance (NaCl) suggest that the tree tolerates saline soils. However, this species is not suitable for the recultivation of energy ash landfills (Kluczyński 1973, 1979 - P).  
 In other areas of secondary range (South Africa), tree of heaven inhabits the banks of forests, rivers and roads (Henderson 2001 - P). In the USA, it is a widespread tree species of the foreign origin in forest areas (Luken and Thieret 1996 - P). In Europe, especially in the Mediterranean region, *A. altissima*, apart from urban habitats, colonized habitats along roads and ditches, but also successfully inhabited other types of habitats, e.g., unused fields, thickets and pine, oak and riparian forests (Kowarik 1983b, Lepart and Debussche 1991, Kowarik and Säumel 2007, Constán-Nava 2012 - P).

### A3 | Spread

Questions from this module assess the risk of *the species* to overcoming dispersal barriers and (new) environmental barriers within Poland. This would lead to spread, in which vacant patches of suitable habitat become increasingly occupied from (an) already-established population(s) within Poland.

Note that spread is considered to be different from range expansions that stem from new introductions (covered by the Introduction module).

**a11.** The capacity of *the species* to disperse within Poland by natural means, **with no human assistance**, is:

- very low
- low
- medium
- high
- very high

aconf07.	Answer provided with a	low	medium	high <b>X</b>	level of confidence
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acomm11. Comments:  
 Dispersion from a single source (data type A): Winged fruits (nuts) of *Ailanthus altissima* can cover anemochorically (spread by wind) short distances, while hydrochorically (spread by

water) even a distance of 1200 m, floating on the water (Säumel and Kowarik 2010).

Estimate (C-type data): tree of heaven has a potentially high dispersal capacity, primarily through generative diaspores - a single tree can produce about 1 million seeds per year (Weber 2003 - P), as well as vegetative. These abilities are revealed to varying degrees: strongly in the areas where the species has already adapted well, less in regions and places disadvantageous for climatic and/or edaphic reasons, i.e., connected with nutritional soil properties. Therefore, locally, especially in urban areas in the western part of Polish lowland, the capacity of spread is even very high. In some cities it is an invasive species, e.g. in Wrocław (Bąbelewski 2009 a and b, 2014 a and b - P), in others, it is less frequent but definitely expansive, e.g. in Warsaw (Sudnik-Wójcikowska 1998 a and b - P), Łódź (Witośławski 2006 - P), Kraków, Poznań and Toruń (Jackowiak 2015-2017 - A), and in the cities of the Katowice agglomeration (Tokarska-Guzik 2003-2017 - A). Taking into account this differentiation, "medium invasive capacity" was indicated.

**a12.** The frequency of the dispersal of *the species* within Poland by **human actions** is:

<input type="checkbox"/>	low
<input checked="" type="checkbox"/>	medium
<input type="checkbox"/>	high

aconf08.	Answer provided with a	low	medium	high	level of confidence
				<input checked="" type="checkbox"/>	

acommm12.	Comments:
	<p>Although tree of heaven was planted very rarely in Poland, the places where it was cultivated still are the main sources of its dispersion in many cities. Previous observations show that even single trees, after reaching generative abilities, become sources of expansion. Until recently, it was easily available in commerce, recommended and promoted for urban areas, as a species of a tree that is very effective, grows quickly, and at the same time is resistant to industrial and transport pollution. In many textbooks and guides it is considered to be a species recommended for planting in cities. Tree of heaven according to the "selection of trees" is well suited for forestation, alleys, boulevards, promenades, squares and green areas and for planting along wide streets (35-50 m) (Bojarczuk and Bugała 1980, Bugała et al. 1984 - P). This ornamental tree is planted singly or in groups (Łukasiewicz 1995, Seneta and Dolatowski 2002 - P). The order of the Minister of the Environment (2011 - P) formally blocked the possibility of selling seedlings, but this species still remains in cultivation in many places (including botanical gardens and arboretums, see question a04, a08) and poses a serious threat to the natural environment and infrastructure. The frequency of displacement of an individual or its diaspores to a distance greater than 50 km does not seem to be large, rather the process of concentration of new populations is observed in close proximity to mother plants. Hence, the distinct "island" range structure in Poland.</p>

## A4a | Impact on the environmental domain

Questions from this module qualify the consequences of *the species* on wild animals and plants, habitats and ecosystems.

Impacts are linked to the conservation concern of targets. Native species that are of conservation concern refer to keystone species, protected and/or threatened species. See, for example, Red Lists, protected species lists, or Annex II of the 92/43/EWG Directive. Ecosystems that are of conservation concern refer to natural systems that are the habitat of many threatened species. These include natural forests, dry grasslands, natural rock outcrops, sand dunes, heathlands, peat bogs, marshes, rivers & ponds that have natural banks, and estuaries (Annex I of the 92/43/EWG Directive).

Native species population declines are considered at a local scale: limited decline is considered as a (mere) drop in numbers; severe decline is considered as (near) extinction. Similarly, limited ecosystem change is considered as transient and easily reversible; severe change is considered as persistent and hardly reversible.

a13. The effect of *the species* on native species, through **predation, parasitism or herbivory** is:

- inapplicable
- low
- medium
- high

aconf09. Answer provided with a 

low	medium	high
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 level of confidence

acomm13. Comments:  
The species does not show such interactions - it is an autotrophic, photosynthetic plant.

a14. The effect of *the species* on native species, through **competition** is:

- low
- medium
- high

aconf10. Answer provided with a 

low	medium	high <b>X</b>
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 level of confidence

acomm14. Comments:  
*Ailanthus altissima* occurs mainly in urban areas in Poland, growing in habitats without native species from the "special care" group (small impact). These species can be endangered in natural habitats (e.g. river valleys), where *A. altissima* is only sporadically encountered.  
It must be stressed, however, that *A. altissima* may affect other plants, e.g. allelopathically, but in Poland these are usually communities of synanthropic plants and most often so-called impoverished communities, or poorly developed. At high densities, *A. altissima* can eliminate native species of shrubs (e.g. *Sambucus nigra*) or herbaceous plants growing in urban habitats.  
Assuming that in the future it can spread and establish in natural ecosystems, we can predict an increase of competitive impact on native plants to the medium level.  
The negative impact on other non-native regions has been documented, e.g., the USA or the Mediterranean basin, especially in river valleys, where the fast-growing young *A. altissima* individuals compete with native plants for light and space, and form dense thickets to replace/displace local vegetation (Constán-Nava 2012 - P).

a15. The effect of *the species* on native species, through **interbreeding** is:

- no / very low
- low
- medium
- high
- very high

aconf11. Answer provided with a 

low	medium	high <b>X</b>
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 level of confidence

acomm15. Comments:  
There are no species in Poland with which *Ailanthus altissima* could potentially cross.

a16. The effect of *the species* on native species by **hosting pathogens or parasites** that are harmful to them is:

- very low
- low
- medium
- high
- very high



aconf12.	Answer provided with a	low <b>X</b>	medium	high	level of confidence
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acom16. Comments:  
46 species of insect pests, 16 species of fungi and 1 virus have been demonstrated in the natural range of *Ailanthus altissima* associated with the species, some of which can cause serious damage to plants (Ding et al. 2006 - P). In Europe, the individuals of tree of heaven were not affected by serious diseases or pests. There was no transmission of pathogens or parasites that attack other plants (Udvardy 2008 - P, CABI 2017 - B). This issue requires further research.

**a17.** The effect of *the species* on ecosystem integrity, by **affecting its abiotic properties** is:

<input type="checkbox"/>	low
<input checked="" type="checkbox"/>	medium
<input type="checkbox"/>	high

aconf13.	Answer provided with a	low	medium	high <b>X</b>	level of confidence
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acom17. Comments:  
Data from North America and Western Europe - e.g. from Spain (Castro-Díez et al. 2015 - P), indicate a very large influence of *A. altissima* on the integrity of ecosystems by disturbing their abiotic factors, particularly, because of plant toxins produced in shoots and leaves accumulate in soil and change its chemical properties. We do not have such information from Poland, because in this phase of the invasion of *A. altissima*, it finds its place mainly in urbanized ecosystems, which are very strongly transformed. Its environmental impact (including abiotic factors) is significant, but these are ecosystems with a very low degree of integration. Assuming that the further invasive process will also spread to habitats of a natural character, the average impact on abiotic conditions should be taken into account.

**a18.** The effect of *the species* on ecosystem integrity, by **affecting its biotic properties** is:

<input type="checkbox"/>	low
<input checked="" type="checkbox"/>	medium
<input type="checkbox"/>	high

aconf14.	Answer provided with a	low	medium	high <b>X</b>	level of confidence
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acom18. Comments:  
As in the case of abiotic factors, data from North America and Western Europe - e.g. from Spain (Castro-Díez et al. 2015 - P), indicate a very large influence of *A. altissima* on the integrity of the ecosystem by disrupting its biotic factors. Toxins produced in shoots and leaves accumulate in the soil and limit germination and growth of other plant species (Udvardy 2008 - P, CABI 2017 - B). We do not have such information from Poland, because in this phase of the invasion of *A. altissima*, it finds its place mainly in urbanized ecosystems, which are very strongly transformed. Its environmental impact (including biotic factors) is significant, but these are ecosystems with a very low degree of integration. Assuming that the further invasive process will also spread to habitats of a natural character, the average impact on biotic conditions should be taken into account.

## A4b | Impact on the cultivated plants domain

Questions from this module qualify the consequences of *the species* for cultivated plants (e.g. crops, pastures, horticultural stock).

For the questions from this module, consequence is considered 'low' when presence of *the species* in (or on) a population of target plants is sporadic and/or causes little damage. Harm is considered 'medium' when *the organism's* development causes local yield (or plant) losses below 20%, and 'high' when losses range >20%.

**a19.** The effect of *the species* on cultivated plant targets through **herbivory or parasitism** is:

- inapplicable
- very low
- low
- medium
- high
- very high

aconf15. Answer provided with a 

low	medium	high <b>X</b>
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 level of confidence

acomm19. Comments:  
The species is a non-parasitic plant.

**a20.** The effect of *the species* on cultivated plant targets through **competition** is:

- inapplicable
- very low
- low
- medium
- high
- very high

aconf16. Answer provided with a 

low	medium	high <b>X</b>
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 level of confidence

acomm20. Comments:  
*Alianthus altissima* does not affect typical crops. Individual *A. altissima* localities are located in the vicinity of allotment gardens and home gardens, then a large mass of greenery and rapid growth can shade crops and compete for light, water and mineral salts. The root system releases allelopathic compounds that inhibit the growth of plants (Bąbelewski 2015-2017 - A). In addition, in the areas of increased occurrence, tree of heaven worsens condition and displaces or even eliminates decorative shrubs grown in urban areas (Jackowiak 2015-2017 - A).

**a21.** The effect of *the species* on cultivated plant targets through **interbreeding** with related species, including the plants themselves is:

- inapplicable
- no / very low
- low
- medium
- high
- very high

aconf17. Answer provided with a 

low	medium	high <b>X</b>
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 level of confidence

acomm21. Comments:  
In Poland, apart from *A. altissima*, a single locality of *Ailanthus giraldii* var. *duclouxii* Dode was noticed. This is theoretically the only potential species with which *A. altissima* could interbreed. Currently, this locality does not exist anymore and there is no information about other closely related species.

**a22.** The effect of *the species* on cultivated plant targets by **affecting the cultivation system's integrity** is:

<input checked="" type="checkbox"/>	very low
<input type="checkbox"/>	low
<input type="checkbox"/>	medium
<input type="checkbox"/>	high
<input type="checkbox"/>	very high

aconf18.	Answer provided with a	low	medium	high <b>X</b>	level of confidence
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a22. Comments:  
In the areas of increased occurrence, tree of heaven worsens the condition, displaces or even eliminates ornamental shrubs grown in urbanized areas. In this way, it destroys their integrity (Jackowiak 2015-2017 - A). Occasionally, this species was also observed in the strawberry plantation in the Psie Pole district in Wrocław (Bąbelewski 2015-2017 - A).

**a23.** The effect of *the species* on cultivated plant targets by hosting **pathogens or parasites** that are harmful to them is:

<input checked="" type="checkbox"/>	very low
<input type="checkbox"/>	low
<input type="checkbox"/>	medium
<input type="checkbox"/>	high
<input type="checkbox"/>	very high

aconf19.	Answer provided with a	low	medium <b>X</b>	high	level of confidence
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a23. Comments:  
Tree of heaven is not a carrier or intermediate host for pathogens or parasites of crop plants. Individual trees in the urban green of Wrocław were attacked by a parasitic fungus of the genus *Verticillioza*. Infected trees can be a source of pathogens for other cultivated trees (Bąbelewski 2015-2017 - A).

## A4c | Impact on the domesticated animals domain

Questions from this module qualify the consequences of *the organism* on domesticated animals (e.g. production animals, companion animals). It deals with both the well-being of individual animals and the productivity of animal populations.

**a24.** The effect of *the species* on individual animal health or animal production, through **predation or parasitism** is:

<input checked="" type="checkbox"/>	inapplicable
<input type="checkbox"/>	very low
<input type="checkbox"/>	low
<input type="checkbox"/>	medium
<input type="checkbox"/>	high
<input type="checkbox"/>	very high

aconf20.	Answer provided with a	low	medium	high	level of confidence
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a24. Comments:  
The species is a non-parasitic plant.

**a25.** The effect of *the species* on individual animal health or animal production, by having properties that are hazardous upon **contact**, is:

- very low
- low
- medium
- high
- very high

aconf21. Answer provided with a 

low	medium <b>X</b>	high
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 level of confidence

acomm25. Comments:  
Animals having the direct contact with tree of heaven do not show negative reactions being a sign of the negative impact on their health or breeding (Bąbelewski 2015-2017 - A). The rutin content may have an irritating effect on mucous membranes. Compounds extracted from tree of heaven have an insecticidal and fungicidal action and can be used as rodent and insect repellents (Lawrence et al. 1991, Heisey 1996, 1997, Ostfeld et al. 1997 - P).

**a26.** The effect of *the species* on individual animal health or animal production, by hosting **pathogens or parasites** that are harmful to them, is:

- inapplicable
- very low
- low
- medium
- high
- very high

aconf22. Answer provided with a 

low	medium	high
-----	--------	------

 level of confidence

acomm26. Comments:  
Tree of heaven does not carry pathogens or parasites that affect animals.

### A4d | Impact on the human domain

Questions from this module qualify the consequences of *the organism* on humans. It deals with human health, being defined as a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity (definition adopted from the World Health Organization).

**a27.** The effect of *the species* on human health through **parasitism** is:

- inapplicable
- very low
- low
- medium
- high
- vert high

aconf23. Answer provided with a 

low	medium	high
-----	--------	------

 level of confidence

acomm27. Comments:  
The species is a non-parasitic plant.

**a28.** The effect of *the species* on human health, by having properties that are hazardous upon **contact**, is:

- very low
- low
- medium

- high
- very high

aconf24. Answer provided with a 

low	medium <b>X</b>	high
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 level of confidence

acomm28. Comments:  
 Tree of heaven has allergic properties. Allergic reactions in humans are caused by pollen grains and as a result of direct contact with the plant. Inhalation allergies are most often called cross-reactions and are caused by pollen grains of ailanthus and pollen of other species. They were shown, among others in Sardinia (Ballero et al. 2003 - P). Dermatological lesions appear as a result of direct contact with the plant (Derrick and Darley 1994 - P).  
 Based on oral information (discussion at an international scientific conference), it appears that this phenomenon is observed on a large scale in Berlin. This is also confirmed by the field experience of one of the authors of this study (Bąbelewski 2015-2017 - A). The scale of the phenomenon is poorly recognized.

a29. The effect of *the species* on human health, by hosting **pathogens or parasites** that are harmful to humans, is:

- inapplicable
- very low
- low
- medium
- high
- very high

aconf25. Answer provided with a 

low	medium	high
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 level of confidence

acomm29. Comments:  
 No transmission of pathogens or parasites to humans was observed via tree of heaven.

### A4e | Impact on other domains

Questions from this module qualify the consequences of *the species* on targets not considered in modules A4a-d.

a30. The effect of *the species* on causing damage to **infrastructure** is:

- very low
- low
- medium
- high
- very high

aconf26. Answer provided with a 

low	medium	high <b>X</b>
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 level of confidence

acomm30. Comments:  
 Based on many years of authors' observations (Bąbelewski 2015-2017, Jackowiak 2015-2017 - A) and literature (Branquart et al. 2007 – B, Kowarik and Säumel 2007, Udvardy 2008 - P), it appears that tree of heaven strongly influences the construction and transport infrastructure as well as roads and communication paths, both through its strong root system, root suckers and stem growths, and the direct impact of above-ground shoots (among others, it destroys the walls of buildings, including historical, and foundation of fences, it causes the lifting of pavement slabs and concrete and asphalt pavements).

## A5a | Impact on ecosystem services

Questions from this module qualify the consequences of *the organism* on ecosystem services. Ecosystem services are classified according to the Common International Classification of Ecosystem Services, which also includes many examples (CICES Version 4.3). Note that the answers to these questions are not used in the calculation of the overall risk score (which deals with ecosystems in a different way), but can be considered when decisions are made about management of *the species*.

**a31.** The effect of *the species* on **provisioning services** is:

- |                                     |                        |
|-------------------------------------|------------------------|
| <input type="checkbox"/>            | significantly negative |
| <input type="checkbox"/>            | moderately negative    |
| <input type="checkbox"/>            | neutral                |
| <input checked="" type="checkbox"/> | moderately positive    |
| <input type="checkbox"/>            | significantly positive |

aconf27.	Answer provided with a	low	medium	high <b>X</b>	level of confidence
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acomm31.	Comments: In the regions of massive occurrence, it may be a source of wood (for the production of furniture, paper and fuel). Leaves can be food for silkworms. Parts of the plant (roots, leaves) are used in medicine (CABI 2017 - B). The species is described as a nectar source tree (Udvardy 2008 - P).
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**a32.** The effect of *the species* on **regulation and maintenance services** is:

- |                                     |                        |
|-------------------------------------|------------------------|
| <input type="checkbox"/>            | significantly negative |
| <input type="checkbox"/>            | moderately negative    |
| <input type="checkbox"/>            | neutral                |
| <input checked="" type="checkbox"/> | moderately positive    |
| <input type="checkbox"/>            | significantly positive |

aconf28.	Answer provided with a	low	medium	high <b>X</b>	level of confidence
----------	------------------------	-----	--------	------------------	---------------------

acomm32.	Comments: Potential regulatory services (expert opinion not based on specific research): - regulation of air quality (dust retention, absorption of pollutants, such as: sulfur and nitrogen oxides, carbon dioxide, vapor of sulfuric, hydrochloric and nitric acid, heavy metals - enrichment of air and soil in moisture - air exchange (enrichment of horizontal and vertical convection movements) - protection against wind (depends on the width and height of the green belt and its distance from the sheltered object) - creation of "islands of coldness and moisture", especially in summer - regulation of the degree of shading - noise reduction - "Biological field" ( advantageous electric charges emitted by green communities, positively affecting human health) - disturbance of natural ecosystem integrity in case of the species spread in river valleys - changes of physical and chemical conditions of soil, among others through the output of a lot of leaves containing toxins (Branquart ah Ave. 2007 - B, Udvardy 2008, Medina-Villar ah Ave. 2015, 2016 - P).
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**a33.** The effect of *the species* on **cultural services** is:

- |                          |                        |
|--------------------------|------------------------|
| <input type="checkbox"/> | significantly negative |
| <input type="checkbox"/> | moderately negative    |

<input type="checkbox"/>	neutral
<input checked="" type="checkbox"/>	moderately positive
<input type="checkbox"/>	significantly positive

aconf29.	Answer provided with a	low	medium	high <b>X</b>	level of confidence
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acommm33.	<p>Comments:</p> <p>Potential cultural services (expert opinion not based on specific research):</p> <ul style="list-style-type: none"> <li>- impact on the aesthetics of space (masking unsightly elements, emphasizing the beauty of architectural elements);</li> <li>- on the other hand, a negative affect on recreational infrastructure is possible;</li> <li>- positive impact on health;</li> <li>- cultural inspiration for artists (painting, photography);</li> <li>- strengthening of interpersonal relationships (especially in the case of joint care for them);</li> <li>- improving the quality of recreational places;</li> <li>- the psychological bond between people and trees with which they grew;</li> <li>- witnesses of history, in the case of trees of several decades;</li> <li>- potential research objects;</li> <li>- business benefits and loss (e.g. a correlation between the level of sales in commercial districts and the presence of such impressive trees) and simultaneously an adverse impact of quickly growing trees is confirmed to the infrastructure; cf. a30).</li> </ul>
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## A5b | Effect of climate change on the risk assessment of the negative impact of the species

Below, each of the Harmonia<sup>+PL</sup> modules is revisited under the premise of the future climate. The proposed time horizon is the mid-21st century. We suggest taking into account the reports of the Intergovernmental Panel on Climate Change. Specifically, the expected changes in atmospheric variables listed in its 2013 report on the physical science basis may be used for this purpose. The global temperature is expected to rise by 1 to 2°C by 2046-2065.

Note that the answers to these questions are not used in the calculation of the overall risk score, but can be but can be considered when decisions are made about management of *the species*.

**a34. INTRODUCTION** – Due to climate change, the probability for *the species* to overcome geographical barriers and – if applicable – subsequent barriers of captivity or cultivation in Poland will:

<input type="checkbox"/>	decrease significantly
<input type="checkbox"/>	decrease moderately
<input type="checkbox"/>	not change
<input type="checkbox"/>	increase moderately
<input checked="" type="checkbox"/>	increase significantly

aconf30.	Answer provided with a	low	medium	high <b>X</b>	level of confidence
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acommm34.	<p>Comments:</p> <p>In the case of <i>Ailanthus altissima</i>, which is the species already present in Poland, global warming will favor its introduction into the areas within its current range in our country and expansion to the east, to an area previously free of this species.</p> <p>Tree of heaven is a thermophilic species, with the eastern limit of its non-native range in Europe determined by an isotherm of an annual average of about 8.5°C (Gutte et al. 1987 - P). This is consistent with the thermal data from Wrocław, where the average annual temperature is 8.5°C (Dubicka 1994, Bąbalewski 2014c - P). The factor favoring spread of the species is also the appropriately high total temperature in the growing season (Kowarik and Böcker 1984 - P). The forecast presented by Jäger (Kowarik and Säumel 2007 - P) shows</p>
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that the average annual increase in air temperature, even from 1-2 °C, will cause further expansion of *A. altissima* towards the east.

**a35. ESTABLISHMENT** – Due to climate change, the probability for *the species* to overcome barriers that have prevented its survival and reproduction in Poland will:

- decrease significantly
- decrease moderately
- not change
- increase moderately
- increase significantly

aconf31. Answer provided with a 

low	medium <b>X</b>	high
-----	--------------------	------

 level of confidence

acomment35. Comments:  
The history of colonization of new areas in the United States and Western Europe shows that this species is found in the regions with particularly favorable climatic conditions, including natural habitats (e.g. river valleys). On this basis, it can be assumed that when the climate warms up and the population density increases, tree of heaven will cross further ecological barriers that have prevented its spread into natural ecosystems so far.

**a36. SPREAD** – Due to climate change, the probability for *the species* to overcome barriers that have prevented its spread in Poland will:

- decrease significantly
- decrease moderately
- not change
- increase moderately
- increase significantly

aconf32. Answer provided with a 

low	medium	high <b>X</b>
-----	--------	------------------

 level of confidence

acomment36. Comments:  
The history of colonizing new areas in the United States and Western Europe shows that this species is spreading in regions with particularly favorable climatic conditions, including natural habitats (e.g. river valleys). On this basis, it can be assumed that when the climate warms up and the population density increases, tree of heaven will cross further spatial barriers that have prevented its spread into natural ecosystems so far.

**a37. IMPACT ON THE ENVIRONMENTAL DOMAIN** – Due to climate change, the consequences of *the species* on wild animals and plants, habitats and ecosystems in Poland will:

- decrease significantly
- decrease moderately
- not change
- increase moderately
- increase significantly

aconf33. Answer provided with a 

low	medium	high <b>X</b>
-----	--------	------------------

 level of confidence

acomment37. Comments:  
The history of colonization of new areas in the United States and Western Europe shows that this species is found in regions with particularly favorable climatic conditions, including natural habitats (e.g. river valleys). On this basis, it can be assumed that when the climate warms up and the population density increases, tree of heaven will cross further ecological barriers that have prevented its spread into natural ecosystems so far. As this process



develops, the competitive strength of *A. altissima* and its negative impact on the species structure and functioning of these ecosystems will undoubtedly increase.

**a38. IMPACT ON THE CULTIVATED PLANTS DOMAIN** – Due to climate change, the consequences of *the species* on cultivated plants and plant domain in Poland will:

- decrease significantly
- decrease moderately
- not change
- increase moderately
- increase significantly

aconf34. Answer provided with a 

low	medium	high
-----	--------	------

 level of confidence  
**X**

acomm38. Comments:  
As the climate warms up, the influence of *A. altissima* on plants cultivated for ornamental purposes (parks, green areas) will increase. It can also affect the production of plants grown in gardens and orchards.

**a39. IMPACT ON THE DOMESTICATED ANIMALS DOMAIN** – Due to climate change, the consequences of *the species* on domesticated animals and animal production in Poland will:

- decrease significantly
- decrease moderately
- not change
- increase moderately
- increase significantly

aconf35. Answer provided with a 

low	medium	high
-----	--------	------

 level of confidence  
**X**

acomm39. Comments:  
Based on the experience of countries in which *A. altissima* is more widely spread, it appears that its impact on animal husbandry is quite limited or poorly recognized. It seems that the species also in Poland will not pose a direct threat to breeding animals.

**a40. IMPACT ON THE HUMAN DOMAIN** – Due to climate change, the consequences of *the species* on human in Poland will:

- decrease significantly
- decrease moderately
- not change
- increase moderately
- increase significantly

aconf36. Answer provided with a 

low	medium	high
-----	--------	------

 level of confidence  
**X**

acomm40. Comments:  
An increase in *A. altissima* population, resulting from the climate change, may contribute to the elevated risk to humans due to the effects of allergenic pollen (inhalation allergies), as well as direct influence (skin allergies).

**a41. IMPACT ON OTHER DOMAINS** – Due to climate change, the consequences of *the species* on other domains in Poland will:

- decrease significantly
- decrease moderately
- not change

- increase moderately
- increase significantly

aconf37. Answer provided with a 

low	medium	high <b>X</b>
-----	--------	------------------

 level of confidence

acomm41. Comments:  
The destructive impact on the construction, transport and road infrastructure will certainly increase.

## Summary

Module	Score	Confidence
Introduction (questions: a06-a08)	1.00	1.00
Establishment (questions: a09-a10)	1.00	1.00
Spread (questions: a11-a12)	0.50	1.00
Environmental impact (questions: a13-a18)	0.30	0.80
Cultivated plants impact (questions: a19-a23)	0.05	0.90
Domesticated animals impact (questions: a24-a26)	0.00	0.50
Human impact (questions: a27-a29)	0.25	0.50
Other impact (questions: a30)	1.00	1.00
Invasion (questions: a06-a12)	0.83	1.00
Impact (questions: a13-a30)	1.00	0.74
Overall risk score	0.83	
Category of invasiveness	very invasive alien species	

## A6 | Comments

This assessment is based on information available at the time of its completion. It has to be taken into account. However, that biological invasions are, by definition, very dynamic and unpredictable. This unpredictability includes assessing the consequences of introductions of new alien species and detecting their negative impact. As a result, the assessment of the species may change in time. For this reason it is recommended that it regularly repeated.

acomm42. Comments:  
*Ailanthus altissima* is considered one of the more serious invasive species in Europe (DAISIE 2006 - B, Vila et al. 2006, Rodrigues et al. 2015, Thalmann et al. 2015, Medina-Villar et al. 2016 - P), America Northern (NISIC, USDA 2014 - B) and other countries of the world.  
Based on the assessment, it was classified as a "very invasive species" with the highest negative impact on other objects (1.00) and the natural environment (0.30). The result should be associated primarily with the current, still limited spread throughout the country. It should be emphasized that the forecasted climate changes may increase the negative impact of the species on the indicated domains.

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## 2. Databases (B)

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## 3. Unpublished data (N)

Pracownicy ogrodów botanicznych i arboretów 2018 Ankieta dotycząca utrzymywania inwazyjnych gatunków roślin obcego pochodzenia w uprawie

## 4. Other (I)

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## 5. Author's own data (A)

Bąbelewski P. 2015-2017 obserwacje własne

Jackowiak B. 2015-2017 obserwacje własne

Tokarska-Guzik B. 2003-2017 obserwacje własne