



Appendix A

Harmonia^{+PL} – 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. Wojciech Solarz
2. Henryk Okarma
3. Karolina Mazurska

acomment01.	Comments:	degree	affiliation	assessment date
		(1) dr	Institute of Nature Conservation, Polish Academy of Sciences in Cracow	04-03-2018
		(2) prof. dr hab.	Institute of Nature Conservation, Polish Academy of Sciences in Cracow	20-01-2018
		(3) mgr	Institute of Nature Conservation, Polish Academy of Sciences in Cracow	30-01-2018

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

Polish name: Jeleń sika (jeleń wschodni)
Latin name: ***Cervus nippon*** Temminck, 1838
English name: Sika deer

acommm02.	Comments:	
	Polish name (synonym I)	Polish name (synonym II)
	Jeleń wschodni	Sika
	Latin name (synonym I)	Latin name (synonym II)
	–	–
	English name (synonym I)	English name (synonym II)
	Japanese sika deer	Sika

a03. Area under assessment:

Poland

acommm03.	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

aconff01.	Answer provided with a	low	medium	high	level of confidence
				X	

acommm04.	Comment:
	The natural range of the species includes the Far East: Japan, Korea, Manchuria, the Ussuri Country, and the Primorsky Krai (Feldhamer 1980 – P). The species was introduced to Poland at the turn of the 19 th and 20 th centuries to the present Forest Inspectorate of Kobiór near Pszczyna (Cenkier 1938, Sumiński 1963, 1965, Cenkier 1966, Caboń-Raczyńska 1983, Kamieniarz 1993 – P) and to the area of the current Kadyny Forest Inspectorate near the Vistula Lagoon (Sumiński 1963, 1965, Caboń-Raczyńska 1983, Grzegorzczuk 1987, Kamieniarz 1993 – P). These populations remain in these areas to this day. In recent years, the size of the Pszczyna population ranges between 30-45 individuals, and the population from the Vistula Lagoon area – within 150-225 individuals (Solarz and Okarma 2014 – 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 checked="" type="checkbox"/>	the domesticated animals domain
<input checked="" type="checkbox"/>	the human domain
<input checked="" type="checkbox"/>	the other domains

acommm05.	Comment:
	Sika deer have strong negative effect on plants through herbivory (Díaz et al. 2005, Takatsuki 2009b, Takatsuki and Ito 2009 – P). They cause significant damage to crops (Putmann and Moore 1998, Tsukada et al. 2013 - P) and forest stands (Larner 1977, Carter 1984, Ratcliffe 1989 – P, Lowe 1994 – N, Chadwick et al. 1996 – P). Bovine tuberculosis and avian tuberculosis have been found in sika deer - both in free-living populations and in captivity - which can be infecting both animals, as well as humans (Dodd 1984, Itoh et al. 1992, Mirsky et al. 1992, Rhyhan and Saari 1995 – P). This species also plays an important role in the epidemiology of the <i>Ashworthius sidemi</i> nematode of Asiatic origin, which can infect <i>Bison bonasus</i> European bison, <i>Capreolus capreolus</i> European roe deer, <i>Cervus elaphus</i> red deer, <i>Alces alces</i> elk (Drózdź et al. 2003, Demiaszkiewicz et al. 2009,

Demiaszkiewicz et al. 2013 - P), as well as cattle (Moskwa et al. 2015 – P). The presence of sika deer in the natural environment increases the risk of transport collisions (Onoyama et al. 1997, Kawata 2011 – P).

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	level of confidence
				X	

acomm06. Comment:
The species has been established in Poland for over 100 years (Solarz and Okarma 2014 – N). It occurs in all countries neighbouring Poland, except from Belarus. Dispersal capacity of the species allows immigration of individuals from abroad, particularly from the Czech Republic and Kaliningrad Oblast. Records from the northern Poland suggest that there could be immigration in the past – single individuals could have dispersed from the Kaliningrad Oblast to the area of the Kadyń population occurrence. Some of them may belong to the subspecies of *C. nippon hortulorum* Dybowski's sika (Solarz and Okarma 2014 – N).

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	level of confidence
				X	

acomm07. Comment:
The probability of introducing the species to the natural environment of Poland due to unintentional human actions is very low. However, because it has been established in Poland for over 100 years (Solarz i Okarma 2014 – N), according to the risk assessment methodology included in the Harmonia ^{+PL} document, it was assessed that the probability of such events is high.

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	level of confidence
				X	

acomm08.

Comment:

The species has been established in Poland for over 100 years (Solarz and Okarma 2014 – N). Since 1965, it has the status of game species. This means that its introductions ("establishments") are possible in accordance with the Law of October 13, 1995, Hunting Law (The Act of 13 October 1995. Hunting Law – I). There are numerous opinions among the hunters that sika deer could enrich the local fauna, especially in forest complexes that are too small to maintain red deer. So far there is no information about cases of intended introduction of species for hunting purposes. This species is, however, kept in zoological gardens, as well as on deer farms, agritourism farms and minizoo; the number of farm deer may exceed 1000 individuals (Solarz and Okarma 2014 – N). There are cases of sika deer escapes from farms and minizoo (Solarz and Okarma 2014 - N). As sika deer is an established species in Poland, according to the risk assessment methodology, the probability of such events is high.

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:

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

aconf05.

Answer provided with a

low	medium	high X
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level of confidence

acomm09.

Comment:

In Europe, populations of the species currently occur e.g. England, Ireland, France, Switzerland, Austria, Germany, Denmark, the Czech Republic and Russia (Bartoš 2009 – P). The values of climatic similarity of these regions to Poland are in the range of 45-94% (moderately favorable) or 94-100% (optimal). In Poland, sika deer have been established for over 100 years, but they do not demonstrate tendency to expand their range of presence (Solarz and Okarma 2014 – N). Perhaps low temperatures in winter and the depth of snow cover are limiting factors. In Japan, it has been demonstrated that sika deer prefer areas with snow depths less than 50 cm, and extremely rarely populate areas where the snow has more than 100 cm (Takatsuki 1992 – P). As sika deer is an established species in Poland, according to the risk assessment methodology, it was assessed that the climatic conditions in Poland are optimal for the 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 X
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level of confidence

acomm10.

Comment:

The preferred habitat for sika deer includes forest habitats, mainly coniferous or mixed forests. They also obtain food (grasses, herbs and young shoots of trees and shrubs) in open mid-forest spaces, heaths, meadows near the forest border (Feldhamer et al. 1978, Takatsuki 2009b – P). Such habitats are common in Poland, and the species is established in the country, which is why the habitat conditions for the species in Poland were assessed as optimal.

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:

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

aconf07.	Answer provided with a	low	medium X	high	level of confidence
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acomm11.	Comment: Population expansion (Data type: B) In the United Kingdom, it was estimated that the area of the species occurrence increased by 5.3% in between 1972 and 2002 (Ward 2005 – P) and the range increased by 7.3% between 2002 and 2007 (Ward et al. 2008 – P). It seems that two processes affect the expansion of the species range: slow natural expansion and accidental escapes from parks and farms (Ward et al. 2008 – P). In addition, in Ireland, a significant expansion of the species population range was found between 1978-2008. The annual rate of range increase was estimated at 5%, and throughout the entire period the range increased by 353% (Carden et al. 2011 – P). However, in Poland, although the sika deer was introduced at the turn of the 19 th and the 20 th century (Sumiński 1963, 1965, Cenkier 1938, 1966 - P), it has only survived since then in places where it was established (perhaps due to harsher climate). Therefore, even assuming that the species is found throughout Poland, its ability to spread in our country was rated as very small.
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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 X	high	level of confidence
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acomm12.	Comment: The sika deer is established in Poland, and it has the game species status since 1965. Some hunters are interested in introducing sika deer primarily in locations where there are no large forest complexes suitable for the red deer, which is why there is some risk of introducing this species in new areas. However, relocations from the two existing populations in Poland to new areas have not yet taken place (Solarz and Okarma 2014 – N). In addition, the current legislation prohibits the introduction of this species (The Act of 16 April 2004 on Nature Conservation – I). Therefore, its ability to spread by human actions in Poland should be assessed as average, even assuming that the species is present in the entire country – more than one case is expected over a decade, but no more than 10 cases of transporting individuals from free-living populations over distance of more than 50 km.
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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:

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

aconf09.	Answer provided with a	low	medium X	high	level of confidence
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a13.	Comment:
	In its natural range, in places where their density is high, sika deer demonstrate strong negative effect on vegetation (Takatsuki 2009b, Takatsuki and Ito 2009 – P). The species composition of plant communities is changing, the strongly eaten species are disappearing, and the species that are not eaten, such as <i>Arisaema</i> spp. (Araceae), <i>Rubus</i> spp. (Rosaceae), rose <i>Rosa</i> spp. (Rosaceae), Eagle fern <i>Pteridium aquilinum</i> , Japanese primrose <i>Primula japonica</i> (Takatsuki 2009b, Takatsuki and Ito 2009 – P) dominate. In Europe, introduced sika deer can achieve locally high density and cause severe damage to vegetation as a result of excessive browsing. It has been observed that they can cause severe and permanent changes in the structure and composition of vegetation in semi-natural forests, heaths and wetlands (Díaz et al. 2005, Hannaford et al. 2006, Perrin et al. 2006 – P). Excessive sika deer herbivory caused a local decrease in the number of numerous plant species in Ireland and the United Kingdom, such as spartina <i>Spartina anglica</i> in salt marshes (Hannaford et al. 2006 - P), and many forest species, such as holly <i>Ilex aquifolium</i> , common ivy <i>Hedera helix</i> , honeysuckle <i>Lonicera periclymenum</i> , greater wood-rush <i>Luzula sylvatica</i> , true blackberry <i>Rubus fruticosus</i> , yew <i>Taxus baccata</i> , and European blueberry <i>Vaccinium myrtillus</i> . Chronic excessive browsing in forest habitats suppresses the natural regeneration of most tree species, with the exception of a few not eaten by sika deer, such as European beech <i>Fagus sylvatica</i> , and favors domination in the treetops of long-life species that grew before the onset of strong deer pressure (Stokes et al. 2004 – N, Perrin et al. 2006, 2011 – P). There is no data from Poland on food preferences of sika deer, therefore, based on data from other areas, the species effect on native species by herbivory was estimated as medium: assuming that the species is widespread, it may at most cause small drops in population size of species of special concern or serious decreases in the size of the population of other native species.

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

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

aconf10.	Answer provided with a	low	medium X	high	level of confidence
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acommm14.

Comment:

There is no direct evidence in the scientific literature about competition between sika deer and other deer species, although there are opinions that the population numbers of both red deer and roe deer decrease in habitats occupied by sika deer, and some data indicate that the density of these species is lower than expected in forest complexes not inhabited by sika deer (Chadwick et al. 1996 – P). Unconfirmed reports indicate reduction in the productivity or spatial displacement of red deer by sika deer, but no real competition has been proven (McKelvey 1959, Dzięciołowski 1979 - P). Sika deer are aggressive and less tolerant than other deer species, even bigger, such as red deer, and can drive them away from feeding places (Takatsuki 1988, Bartoš 2009, Feldhamer and Demarais 2009 – P). Sika deer may also disturb the rut of the red deer, because male sika deer are very aggressive at that time, can attack young male deer (Matuszewski and Sumiński 1984 – P) and reproduce with female red deer in the presence of males of this species (Pérez-Espona et al. 2009 – P). Perhaps this is the reason for the time shift for rut of the red deer and the sika deer described in the Czech Republic. After spreading of sika deer in the habitat previously dominated by the red deer, there was a delay in the start of the native deer comparing to the sika deer rut (Macháček et al. 2014 – P). Sika deer have a strong effect on herbaceous vegetation, so it can be assumed that they may limit the feeding base of European bison (wisent) *Bison bonasus*, but it is difficult to clearly state to what extent the food niche of these two species would overlap, due to lack of research on the interaction between bison and sika deer. It seems that, assuming a wide spread of sika deer in Poland, it could cause slight decreases in the population size of native species of special concern (European bison) or serious decreases in the size of the population of other native species; therefore, its potential effect as a result of competition should be considered as medium.

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

<input type="checkbox"/>	no / very low
<input type="checkbox"/>	low
<input type="checkbox"/>	medium
<input type="checkbox"/>	high
<input checked="" type="checkbox"/>	very high

aconf11.

Answer provided with a

low	medium X	high
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level of confidence

acommm15.

Comment:

Sika deer hybridise with red deer, producing fertile offspring. The first generation of hybrids shows the characteristics of both species, while the next hybrid generations are definitely more difficult to identify under natural conditions. Crossbreeding between these species has been demonstrated both where sika deer were introduced and in the natural range of the species along the border between Russia and China (Stokes et al. 2004 – N, Bartoš 2009, Pérez-Espona et al. 2009 – P). In Europe, hybridisation between sika deer and deer occurs both in farm conditions and in nature, in Ireland (Harrington 1982, McDevitt et al. 2009, Smith et al. 2014 – P), the United Kingdom (Lowe and Gardiner 1975, Harrington 1982, Abernethy 1994, Diaz et al. 2006, Pemberton et al. 2006, Senn et al. 2010 – P), the Czech Republic (Bartos et al. 1981, Zima et al. 1990 – P), Germany (Gehle et al. 1998 – P), Lithuania (Baleisis et al. 2002 – P), France (Pascal et al. 2003 – I) and Poland (Biedrzycka et al. 2012 – P). Usually, the extent of introgression (share of genes of one species in the other species' genome) is small, about 10% of hybrids (Diaz et al. 2006, Pemberton et al. 2006, Pérez-Espona et al. 2009, Carden et al. 2011 – P), yet in some extremely strongly hybridised populations in Ireland and England, it can reach as much as 45%. According to the methodology of evaluation, in case of wide spread in Poland, the effect of sika deer due to hybridization should be considered high (high probability, medium effect). However, in this case, it seems reasonable to use the expert method, admissible in the adopted risk assessment methodology: assuming that the sika deer is widely spread in Poland, hybridization may lead to a complete and permanent loss of genetic coherence of the entire native deer population. Progressing introgression would trigger protection of

red deer, thus granting it status of a species of a special concern. This, however, would not guarantee that in case of sika deer becoming widespread, even active protection would not prevent „pure” red deer from complete extinction. For these reasons, although currently it is not a species of special concern, the effect of sika deer through hybridisation should be considered very high in such a case.

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

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

aconf12.	Answer provided with a	low	medium	high X	level of confidence
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acommm16. Comment:
 Bovine tuberculosis and avian tuberculosis have been found in sika deer - both in free-living populations and in farm conditions (Dodd 1984, Itoh et al. 1992, Mirsky et al. 1992, Rhyan and Saari 1995 – P). Bovine tuberculosis is one of the notifiable diseases included on the list of the World Organization for Animal Health (OIE), and thus - subject to reporting. In addition to the fact that it may cause the death of animals, in Poland it is necessary to cull infected European bison is an additional consequence. In Eastern and Central Europe, sika deer play an important role in transmission of *Ashworthius sidemi*, Asiatic nematode attacking stomach and gastrointestinal system, which can infect European bison, roe deer, deer and elk (Drózdź et al. 2003, Böhm et al. 2006, Demiaszkiewicz et al. 2009, Osińska et al. 2010, Demiaszkiewicz et al. 2013 - P) and also cattle (Moskwa et al. 2015 – P). This parasite is highly pathogenic and causes pneumothorax, hyperaemia, exudates from the mucous membrane of the abomasum and duodenum, chronic diarrhea, weakness and even death of young animals (Demiaszkiewicz et al. 2009 – P). Nematodes are widely distributed in central Europe, and local cervid populations demonstrate high infection rates and a very large number of nematodes in one host (Drózdź et al. 2003, Demiaszkiewicz et al. 2008, Kuzmina et al. 2010 – P). In Poland, this parasite was found in 100% of all studied bison (Drózdź et al. 2003, Osińska et al. 2010 – P). The effect of this parasite on the health of native deer and European bison is difficult to assess. There has been no case of death caused by this nematode, but it is likely that it may reduce the condition of bison and lead to death, especially of young animals (Ferte et al. 2000 – P).

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

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

aconf13.	Answer provided with a	low	medium X	high	level of confidence
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acommm17. Comment:
 In the United Kingdom, it was shown that at high density, sika deer, through very strong herbivory of vegetation and uncovering the soil and by intensive trampling (the species may aggregate in large herds), can trigger soil erosion processes on heaths and salt marshes (Díaz et al. 2005 – P). The degradation of water quality in streams and creeks has also been documented (Kelly 2002, Swanson and Putman 2009, Perrin et al. 2011 – P). In Japan, even at low densities in subalpine areas, sika deer cause destruction of rhizomes of the buckbean *Menyanthes trifoliata* growing in mud of watercourses and, as a result, reduction of water flow and destruction of other mud species (Takatsuki 2009b – P). The potential effect of ungulates, including sika deer on the nitrogen cycle has been also suggested, by adding readily available N to upper levels of the soil in urine and feces. As a

result of these additions, natural heterogeneity in the spatial distribution of N within landscapes is amplified by ungulate selection of habitats and patches (Hobbs 1996 - P). Assuming a wide spread of the sika deer in Poland, it cannot be ruled out that, in the worst case scenario, the species will cause hardly reversible changes in the processes occurring in habitats of special concern, such as marsh forests and moorlands. Having considered the foregoing, the effect of the species on the integrity of the ecosystem by disturbing its abiotic factors should be considered as high.

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

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

aconf14.	Answer provided with a	low	medium	high	level of confidence
			X		

acomm18. Comment:
 Both in the native range and the introduction sites, sika deer have a very strong negative effect on vegetation, causing significant changes in the structure and species composition of plant communities (Díaz et al. 2005 – P, Takatsuki and Ito 2009 – P). Through these changes and the treading of the soil while in high densities, sika deer cause cascade effects in the ecosystem that affect populations of forest animal species, particularly soil invertebrates, birds nesting on the ground and in shrubs, small rodents and their predators (Fuller 2001, Côté i in . 2004, Miyashita et al. 2004, Gill and Fuller 2007, Takatsuki 2009b, Seki and Koganezawa 2013, Seki et al. 2014 – P). Assuming a wide spread of the sika deer in Poland, it cannot be ruled out that, in the worst case scenario, the species will cause hardly reversible changes in the processes occurring in habitats of special concern, such as marsh forests and moorlands. Therefore, the potential effect of the species on the integrity of the ecosystem by disturbing its biotic factors should be considered as high.

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:

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

aconf15.	Answer provided with a	low	medium	high	level of confidence
			X		

acomm19. Comment:
 Sika deer are forest animals, mainly associated with coniferous and mixed forests. In the natural range, in Japan, sika deer cause significant damage to crops, estimated at around USD 1.4 million in 2010, and the damage caused by these animals was demonstrated in 36% of farms and homesteads (Tsukada et al. 2013 – P). In Europe, sika deer can also cause some damage to crops, located close to forest habitats in which this species is present, though they are relatively small (Putmann and Moore 1998 - P). A definitely more serious

problem includes damage to forest stands, which are caused in the entire range of the species, if only the deer population would reach sufficiently high density. The damage mainly concerns coniferous species and younger stages of forest stands, and includes chewing the shoots, but also bark stripping during heavy winters. Economic losses can be very substantial locally, e.g. in Scotland (Ratcliffe 1989, Chadwick et al. 1996 – P), Ireland (Lowe 1994 - N). Large trees may also be damaged, as during the breeding season for male sika deer, characteristic behavior includes marking the territory by gouging deep vertical grooves with antlers in the bark of tree trunks, especially coniferous tree trunks (the bole-scoring, Larner 1977, Carter 1984 - P). As a result, sika deer, already at the density of several individuals/km², can simplify the vertical structure of tree stands, severely inhibiting the development of shrubs and young trees. At a density higher than 20 individuals/km², tree disappearance is often observed, large open spaces in forests appear, without any tree regeneration (Swanson and Putman 2009, Takatsuki 2009a, 2009b, Akashi et al. 2011 – P). Assuming a wide spread in Poland, the potential effect of sika deer on plant cultivation through herbivory should be considered as large: the effect could affect 1/3 to 2/3 of crop plants subject to invasion, worst case scenario: yield of a single crop could be reduced by more than 20 %.

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
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 level of confidence

acomm20. Comment:
The species is an animal.

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
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 level of confidence

acomm20. Comment:
The species is an animal.

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

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

aconf18. Answer provided with a

low	medium X	high
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 level of confidence

acomm22.

Comment:

There are no published study results on the effect of the species on the condition or yield of crops by changing the properties of the agroecosystem, including the circulation of elements, hydrology, physical properties, and trophic networks. Sika deer may feed on crops, but in places where they are introduced in Europe, damage to crops is low (Putmann and Moore 1998 – P). Therefore, it is predicted that in case of the of sika deer spread in Poland, its effect on crops by disturbing integrity would be mostly average: it would affect 1/3 to 2/3 of crops, and in the worst case, the condition of plants or single crop yield would be reduced by approx. 5% to approx. 20%.

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

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

aconf19.

Answer provided with a

low	medium	high
		X

level of confidence

acomm23.

Comment:

There are no published scientific studies on the transmission of pathogens or parasites harmful to arable crops by deer.

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:

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

aconf20.

Answer provided with a

low	medium	high

level of confidence

acomm24.

Comment:

The species is not a predator or a parasite.

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	high X
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 level of confidence

acomment25. Comment:
There is no available information suggesting that the species has biological, physical and/or chemical properties that are harmful when in contact with farm animals and pets or on animal production (e.g., toxins or allergens). The sika deer is a medium-sized animal, so it cannot be ruled out that in the event of direct physical contact with farm animals, interactions could occur (kicking, injuring with antlers). It has been estimated that even in case of wide spread of the species in Poland, the probability of direct contact would be low and the effect would be small.

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 X
-----	--------	------------------

 level of confidence

acomment26. Comment:
Bovine tuberculosis (a notifiable disease, included in the OIE list) and avian tuberculosis have been found in sika deer - both in free-living populations and in breeding (Dodd 1984, Itoh et al. 1992, Mirsky et al. 1992, Rhyan and Saari 1995 – P). Bovine tuberculosis is chronic and highly contagious. Cattle infected with tuberculosis shall be slaughtered *ex officio*. In eastern and central Europe, sika deer play an important role in the epidemiology of *Ashworthius sidemi* gastrointestinal nematode originating from Asia, which can infect all deer species found in Poland and European bison, but the presence of these parasites in cattle was also noted (Moskwa et al. 2015 – P). This parasite is highly pathogenic and causes pneumothorax, hyperaemia, exudates from the mucous membrane of the abomasum and duodenum, chronic diarrhea, weakness and even death of young animals (Demiaszkiewicz et al. 2009 – P).

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

acomment27. Comment:
The species is not a parasite.

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	high X
-----	--------	------------------

 level of confidence

acomm28. Comment:
There is no available information suggesting that the species has biological, physical and/or chemical properties that are harmful when in contact with human (e.g., toxins or allergens). It cannot be ruled out that because of sika deer size, there may be cases of hitting with legs or antlers in the event of trying to catch an animal or bring it to a high stress situation. It has been estimated that even in case of wide spread of the species in Poland, the probability of direct contact would be low and the effect would be small.

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 X
-----	--------	------------------

 level of confidence

acomm29. Comment:
Bovine tuberculosis (a notifiable disease included in the OIE list) and avian tuberculosis have been found in sika deer - both in free-living populations and in breeding (Dodd 1984, Itoh et al. 1992, Mirsky et al. 1992, Rhyan and Saari 1995 – P). Human can become infected with these diseases from sika deer, these diseases can result in death.

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 X	high
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 level of confidence

acomm30. Comment:
In Japan, on Hokkaido, with the increase in the population of deer sika since the early 1970s, the number of road accidents involving these animals increased from 293 in 1993 to 1,823 in 2009 (Kawata 2011 - P). The amount of compensation paid by insurance companies increased to approximately USD 3 million in 2014 (General Insurance Association of Japan 2015 – I). In the eastern part of Hokkaido, there were 696 train

collisions involving sika deer recorded between 1987 and 1995, on a 330 km railway section (Onoyama et al. 1998 – P). In the event of a wide spread of the species in Poland, the frequency with which it would cause measurable damage to the infrastructure within one year should be considered as medium and the effect as partially reversible. Because of that, the total effect of the species on infrastructure should be considered as medium.

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:

- significantly negative
- moderately negative
- neutral
- moderately positive
- significantly positive

aconf27. Answer provided with a

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

 level of confidence

acomm31. Comment:
The species may cause some losses in crops (Putmann and Moore 1998, Tsukada et al. 2013 – P). However, first and foremost, the strongly negative effect of this species on forest ecosystems, especially on younger forest stand classes and crops, which may affect the efficiency of forest management (Larner 1977, Carter 1984, Ratcliffe 1989 – P, Lowe 1994 - N, Chadwick et al. 1996 – P). The spreading of diseases (bovine and avian tuberculosis) and *Ashworthius sidemi* nematode can reduce both the efficiency of farm animal breeding, and the hunting economy (Dodd 1984, Itoh et al. 1992, Mirsky et al. 1992, Rhyan i Saari 1995, Demiaszkiewicz et al. 2009, Moskwa et al. 2015 – P). The positive effect of the species on supply services is related to the fact that it is a game species and a source of venison. It is still also bred on farms to produce meat. Because of that, the effect of the species on supply services was assessed as moderately negative.

a32. The effect of *the species* on **regulation and maintenance services** is:

- significantly negative
- moderately negative
- neutral
- moderately positive
- significantly positive

aconf28. Answer provided with a

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

 level of confidence

acomm32. Comment:
The species may have a negative effect on the ecosystem function. The presence of the species has a very negative effect on biological regulation due to the increased risk of zoonotic diseases spread. Bovine tuberculosis (notifiable disease included in the OIE list) and avian tuberculosis have been found in sika deer (Dodd 1984, Itoh et al. 1992, Mirsky et al. 1992, Rhyan and Saari 1995 – P). This species also plays an important role in the epidemiology of *Ashworthius sidemi* - a dangerous nematode (Demiaszkiewicz et al. 2009, Moskwa et al. 2015 – P).

a33. The effect of *the species* on **cultural services** is:

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

aconf29.	Answer provided with a	low	medium	high	level of confidence
			X		

acommm33. Comment:
 The sika deer is a game species and therefore influences hunting culture. It is kept in zoological gardens, and due to its aesthetic value, its presence in the environment can also be positively perceived by a part of the society. On the other hand, in the event of spreading in Poland, sika deer may pose a threat, e.g. for European bison, which is a charismatic species, which should be considered a negative effect on cultural services. The total effect of this species on cultural services was therefore considered neutral.

A5b | Effect of climate change on the risk assessment of the negative impact of the species

Below, each of the Harmonia^{PL} 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 checked="" type="checkbox"/>	not change
<input type="checkbox"/>	increase moderately
<input type="checkbox"/>	increase significantly

aconf30.	Answer provided with a	low	medium	high	level of confidence
				X	

acommm34. Comment:
 The sika deer has been brought to Poland over 100 years ago. Climate change, expected in this scenario (1-2°C) will not affect the likelihood of its introduction into our country as a result of increased immigration, or higher number of animals in farms.

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

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

aconf31. Answer provided with a

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

 level of confidence

acomment35. Comment:
The species has already been established in Poland for over 100 years. Climate change will not affect the probability of its establishment in our country.

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 X	high
-----	--------------------	------

 level of confidence

acomment36. Comment:
Despite the fact that the sika deer has been established in Poland for more than 100 years, it is not widely spread – its populations occur only in introduction sites. It seems that low temperatures in winter and the depth of the snow cover may be factors limiting the species spread in Poland. It can therefore be assumed that due to the forecasted global warming, the probability of sika deer spread will moderately increase.

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 X	high
-----	--------------------	------

 level of confidence

acomment37. Comment:
In case of wider spread as a result of global warming and increase in the number of local populations, one should expect that the effect on wild plants and animals as well as habitats and ecosystems in Poland will increase moderately.

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 X	high
-----	--------------------	------

 level of confidence

acomment38. Comment:
The species does not have a significant effect on crops in Europe. However, in case of wider spread as a result of global warming and increase in the number of local populations, it should be expected that the effect on crops or plant production in Poland will increase moderately.

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 X	high
-----	--------------------	------

 level of confidence

acomm39. Comment:
In the event of a wider spread as a result of global warming and increase in the number of local populations in Poland, one should expect that the effect of sika deer on farm animals and pets, as well as on animal production will increase moderately, mainly due to a higher transmission risk concerning bovine and avian tuberculosis, as well as *Ashworthius sidemi* nematode to farm 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 X	high
-----	--------------------	------

 level of confidence

acomm40. Comment:
In case of a wider spread as a result of global warming and increase in the number of local populations in Poland, one should expect that the effect of deer will increase moderately as a result of increased transmission risk for bovine and avian tuberculosis, which may be fatal to humans.

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 X	high
-----	--------------------	------

 level of confidence

acomm41. Comment:
In case of wider spread as a result of global warming and increase in the number of local deer population in Poland, an increase in the number of road collisions of the species with vehicles can be expected.

Summary

Module	Score	Confidence
Introduction (questions: a06-a08)	1.00	1.00
Establishment (questions: a09-a10)	1.00	1.00
Spread (questions: a11-a12)	0.25	0.50
Environmental impact (questions: a13-a18)	0.83	0.58
Cultivated plants impact (questions: a19-a23)	0.42	0.67
Domesticated animals impact (questions: a24-a26)	0.50	1.00
Human impact (questions: a27-a29)	0.50	1.00
Other impact (questions: a30)	0.50	0.50
Invasion (questions: a06-a12)	0.75	0.83
Impact (questions: a13-a30)	0.83	0.75
Overall risk score	0.62	
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 is regularly repeated.

acomm42.

Comments:

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