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. Karolina Mazurska
2. Wojciech Solarz
3. Henryk Okarma

acomm01. Comments:

	degree	affiliation	assessment date
(1)	mgr	Institute of Nature Conservation, Polish Academy of Sciences in Cracow	23-01-2018
(2)	dr	Institute of Nature Conservation, Polish Academy of Sciences in Cracow	14-03-2018
(3)	prof. dr hab.	Institute of Nature Conservation, Polish Academy of Sciences in Cracow	11-03-2018

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

Polish name: Bernikla kanadyjska

Latin name: ***Branta canadensis*** L. 1758

English name: Canada goose

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acomm02. Comments:

Polish name (synonym I)	Polish name (synonym II)
Gęś kanadyjska	–
Latin name (synonym I)	**Latin name (synonym II)**
Anas canadensis	–
English name (synonym I)	**English name (synonym II)**
Canadian snow goose	–

a03. **Area** under assessment:

Poland

acomm03. Comments:
–

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

	native to Poland
	alien, absent from Poland
	alien, present in Poland only in cultivation or captivity
	alien, present in Poland in the environment, not established
X	alien, present in Poland in the environment, established

aconf01. Answer provided with a

low	medium	high
		X

level of confidence

acomm04. Comments:

The first occurrence of the Canada goose was recorded in Poland in ca. 1935 in Pomerania, while single specimens and small flocks have been noted since 1982 (Tomiałojć and Stawarczyk 2003 – P). Since winter of the turn of 1988, the Canadian snow geese have wintered annually in large numbers (up to 1400 specimens) in the Elbląska Bay and other parts of the Vistula Lagoon. In 2004, near the mouth of the Rewa, the breeding of greylag goose *Anser* and a hybrid of the Canada goose (Półtorak and Sikora 2007, Meissner and Bzoma 2009 – P) was found. In the same year in the Ronald Reagan Municipal Park in Gdańsk-Przymorze, there was the first attempt of breeding the Canada goose in Poland. The Canadian snow geese were from the local zoo: They had escaped from the zoo and came back in winter. In 2005, the first successful breeding was recorded in Gdańsk (Głowaciński and Solarz 2011 – P, Non-native species in Poland 2018 – B). Since then, the number of breeding specimens has increased, and it has been accompanied by the growth in the number of observed individuals from this species Poland (127 observations in 2017 – Ornitho.pl 2018 – B). In Poland, this species is considered as extremely difficult in breeding, and only 1-6 pairs Canadian snow geese attempt to breed annually (Stawarczyk et al. 2017 – P, Faunistic Committee 2018 – I).

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

X	the environmental domain
X	the cultivated plants domain
X	the domesticated animals domain
X	the human domain
X	the other domains

acomm05. Comments:

The Canada goose has a negative impact on all domains under assessment. The impact on the natural environment is reflected above all by the hybridization with other species from Anatidae (Jansson et al. 2008, Gyimesi and Lensink 2010, Głowaciński and Solarz 2011 – P) and by the transfer of a large number of pathogens, including those causing diseases listed on the World Animal Health Organization (OIE), and by the contamination of water

reservoirs with faeces that lead to their eutrophication (Watola et al. 1996, Kirby and Sjöberg 1997, Allan 1999, Dzięciołowski 2005, McLaughlan et al. 2014 – P). The impact on husbandry and humans is connected mainly with transferring numerous pathogens by this species. The impact on plant cultivations is related to the eating cultivated crops by Canadian snow geese (Allan et al. 1995, Gebhardt 1996, Allan 1999 – P) and the trampling and contamination of crops with faeces (Pimentel 2002, Spurr and Coleman 2005 – P). The contamination of water reservoirs, beaches, parks and golf courses (Jansson et al. 2008, GBNNRA 2011, Głowaciński and Solarz 2011 – P), and a threat airplane disasters caused by crashes with the birds (French and Parkhurst 2001, Dolbeer and Seubert 2006, Jansson et al. 2008, GBNNRA 2011 – P, CABI 2018 – B) are a symptom of the negative impact of this species on other domains.

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:

	low
	medium
X	high

aconf02.	Answer provided with a	low	medium	high **X**	level of confidence

acomm06. Comments:

This species is domesticated in Poland (Głowaciński and Solarz 2011, Stawarczyk et al. 2017 – P, non-native species in Poland 2018, NOBANIS 2018 – B, Faunistic Committee 2018 – I); The methods of assessment applied by the Harmonia^{+PL} Procedure of negative impact risk assessment for invasive alien species and potentially invasive alien species in Poland (called hereinafter: Harmonia^{+PL}) indicates the selection of the following replies: high probability, with a high degree of certainty. The species has been observed in Poland since about 1935 (Tomiałojć and Stawarczyk 2003 – P). Since the winter of the turn of 1987 and 1988, a large number (up to 1400 specimens) of Canadian snow geese annually winter in the Elbląska and other parts of the Wiślana Lagoon. In 2005, in Gdańsk, the first successful breeding of the Canada goose took place (Głowaciński and Solarz 2011 – P, Non-native species in Poland 2018 – B). Since then, the number of observations of this species (127 observations in 2017 – Ornitho.pl 2018 – B) has increased annually in Poland.

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

	low
	medium
X	high

aconf03.	Answer provided with a	low	medium	high **X**	level of confidence

acomm07. Comments:

This species is domesticated in Poland (Głowaciński and Solarz 2011, Stawarczyk et al. 2017 – P, Native species in Poland 2018, NOBANIS 2018 – B, Faunistic Committee 2018 – I), and the assessment methods of Harmonia^{+PL} indicates the following replies: high probability, with a high degree of certainty. The probability that the introduction of the Canada goose to the natural environment in Poland occurred or could occur in the future as a result of

	unintentional human activity (e.g., as a contaminant in imported goods or as "stowaway" in the transport means or in hand baggage), is practically null.

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

	low
	medium
X	high

aconf04.	Answer provided with a	low	medium	high **X**	level of confidence

acomm08. Comments:

The species is domesticated in Poland (Głowaciński and Solarz 2011, Stawarczyk et al. 2017 – P, Non-native species in Poland 2018, NOBANIS 2018 – B, Faunistic Committee 2018 – I),),and the assessment methods of Harmonia^{+PL} indicates the following replies: high probability, with a high degree of certainty. In 1665, Canadian snow geese were for the first time introduced in Great Britain (London) (Kirby 1999 – P); in 1928, in Germany (Geiter et al. 2002 – P); in 1929 in Sweden (Andersson et al. 1999 – P); in 1930, in Denmark (Jansson et al. 2008 – P); and in 1936, in Norway (Andersson et al. 1999 – P). Initially, they were brought as decorative species, later their use as game prevailed (Jansson et al. 2008 – P). Additionally, escapes from zoos and parks have contributed to the development of this species in the natural environment (Jansson et al. 2008, Głowaciński and Solarz 2011 – P). Since 2004 onwards, escapes of the Canada goose from the zoo in Gdańsk (Poland) occurred for several subsequent years, which has led to the domestication of this species in Poland (Głowaciński and Solarz 2011, Stawarczyk et al. 2017 – P). The Canadian snow geese are increasingly bred as decorative species in semi-open private raising; although, this species is listed in the Regulation of the Minister of the Environment of 9 September 2011 on the list of plants and animals of alien species that could be a threat to native species or natural habitats in case of their release into the natural environment – P (e.g. OLX 2018a, OLX 2018b – I). Despite the fact that a portion of these birds are able to fly, fugitives from the raisings are likely to be a part of specimens observed in the wild (Głowaciński and Solarz 2011 – P).

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
X	optimal for establishment of *the species*

aconf05.	Answer provided with a	low	medium	high **X**	level of confidence

acomm09. Comments:

The species is domesticated in Poland (Głowaciński and Solarz 2011, Stawarczyk et al. 2017 – P, Non-native species in Poland 2018, NOBANIS 2018 – B, Faunistic Committee 2018 – I), and the assessment methods of Harmonia^{+PL} indicates the following replies: high probability, with the high degree of certainty. The Canada goose prefers a moderate warm climate (Mediterranean and subtropical), continental (with dry summer), and polar (tundra) (CABI 2018 – B). Its spread and domestication in such countries as Italy, France, the Netherlands, and Belgium, Finland, Sweden and Norway (CABI 2018 – B) indicates an easy adaptation to diverse

	climatic conditions, including the Polish humid continental climate. It should be noted that the Canada goose avoids areas with summer temperatures above 25°C (Gallardo 2014 – P).

a10. Poland provides **habitat** that is

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

aconf06.	Answer provided with a	low	medium	high **X**	level of confidence

acomm10. Comments:

The species is domesticated in Poland (Głowaciński and Solarz 2011, Stawarczyk et al. 2017 – P, Non-native species in Poland 2018, NOBANIS 2018 – B, Faunistic Committee 2018 – I),and the assessment methods of Harmonia^{+PL} indicates the following replies: high probability, with a high degree of certainty. The Canada goose occupies similar habitats with the natural and secondary ranges. It prefers open, grassy habitats, inhabits lakes, other water reservoirs and surrounding areas, marshes, coastal planes, prairie tundra and arable land (Long 1981, Głowaciński and Solarz 2011 – P). This species is also common in urbanized areas and habitats made by man, including urban parks, golf courses, and airports (Jansson et al. 2008 – P). The Canadian snow geese adapt very easily to new conditions and can occur everywhere where basic conditions are met, i.e. access to water and food. Usually, it prefers habitats near freshwater (CABI 2018 – B).

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
X	very high

aconf07.	Answer provided with a	low	medium **X**	high	level of confidence

acomm11. Comments:

Assessment (Data type: C)
The ability of the Canadian snow geese to spread in the natural environment independently, without human impact, is very high, and its rate is more than 10kilometres/year. It is exemplified by Great Britain where in study areas (10 km^2) in 1968-1972 and 1988-1991, the number of specimens of this species nearly doubled (from 681 to 1196 specimens) (Gibbons et al. 1993 – P). The maximum number of 56,486 specimens (ca. a half of the assessed population) found in Great Britain in December in 2006 by Austin et al. (2008 – P) indicates that the rate of population growth was similar to that in the previous years (GBNNRA 2011 – P). In the beginning of this century, this population was assessed in Sweden at 43,500 specimens (Nilsson 2006 – P). This population combined with the British population are focal points for the spread of Canadian snow geese in Europe (Kirby and Sjöberg 1997 – P). The specimens flying to Poland and wintering here are probably from the Swedish population (Głowaciński and Solarz 2011 – P).

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

	low
	medium
X	high

aconf08.	Answer provided with a	low	medium **X**	high	level of confidence

acomm12. Comments:

The Canadian snow geese are increasingly bred as decorative species in semi-open private locations; although, this species is listed in the Regulation of the Minister of the Environment of 9 September 2011 on the list of plants and animals of alien species that could be a threat to native species or natural habitats in case of their release into the natural environment – P, e.g., OLX 2018a, OLX 2018b – I. There is no data on the number of this species living in captivity, although some locations contain several dozen specimens. Despite the fact that a fraction of these birds are not deprived of their ability to fly, the fugitives from these locations must be a portion of those observed in the wild (Głowaciński and Solarz 2011 – P). Due to the high interest in breeding this species, specimens from populations living in the wild can be caught, transported, and bred. As a result of the of Canadian snow geese to fly and improper security of aviaries, the birds can escape and spread to new areas. It is also probable that birds caught in the wild are transferred to animal rehabilitation centres and zoos, and they can also escape from these facilities (what has been described in question a04 and a08). The specimens of the Canada goose can be also intentionally released from animal rehabilitation centres, where they were treated by vets. Due to above the frequency of the man-made spread of this species, it can be estimated as high (the assessment of accidental and intentional releases to the natural environment exceeds at most 10 cases per decade).

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
X	medium
	high

aconf09.	Answer provided with a	low	medium **X**	high	level of confidence

acomm13. Comments:

This species feeds almost exclusively on plant food collected on land in open areas near water and in green areas and cultivations (Głowaciński and Solarz 2011 – P, CABI 2018, Non-native species in Poland 2018 – B). It eats roots, rhizomes, tubercles, stems, leaves, fruit,

and seeds (CABI 2018 – B). The herbivory of the Canadian snow geese can have a negative impact on aquatic ecosystems, and feeding this species on natural vegetation may cause serious damage along the bank line and shallow water reservoirs (Gebhardt 1996 – P). Excessive feeding on terrestrial plants and trampling them can have a negative impact on the condition of natural habitats used in this manner. The destruction of habitats may be also caused by their contamination with faeces (Watola et al. 1996, French and Parkhurst 2001, McLaughlan et al. 2014 – P). The feeding of the Canada goose on land can uncover soil which then can erode (French and Parkhurst 2001 – P). Assuming the future spread of the Canada goose in Poland, the impact due to feeding on plants can locally reduce slightly, at most, the population size of native special care species or diminish seriously the population sizes of the remaining native species.

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

	low
X	medium
	high

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

acomm14. Comments:

The Canadian snow geese may be aggressive towards waterfowl and can drive them away during competition for breeding grounds and food (Andersson et al. 1999 – P). This species is a trophic competitor for native waterfowl and wetland birds such as common moorhen *Gallinula chloropus* and Eurasian coot *Fulica atra* (Głowaciński and Solarz 2011 – P). There is also evidence on the competition for food between the Canada goose and the mute swan *Cygnus olor* in winter (Allan et al. 1995 – P). Aggressive behaviour was also observed in competition between Canadian snow geese and greylag geese for food and breeding grounds (Blair et al. 2000, Dzięciołowski 2005 – P), among others, in Sweden (Andersson et al. 1999 – P). Assuming the future spread of the Canada goose in Poland, the impact due to competition can locally reduce slightly, at most, the population size of native special care species or diminish seriously the population sizes of the remaining native species.

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

	no / very low
	low
	medium
X	high
	very high

aconf11.	Answer provided with a	low	medium	high **X**	level of confidence

acomm15. Comments:

Similarly to other goose species, the Canada goose show intra- and interspecies nesting parasitism (taking over nests together with eggs), and combined breeding (adaptation of newly hatched birds) (Söderholm 2005 – P). The interspecies parasitism or taking over broods is the possible imprinting of the improper behaviour in the hatchling, which can result to the selection of a partner from the species of foster parents and thus lead to hybridization (Fabricius 1991 – P). The Canadian snow geese mostly crosses with the greylag goose, hybridization with the barnacle goose *Branta leucopsis*, the brant *B. bernicla*, lesser white-fronted goose *Anser erythropus*, taiga bean goose *A. fabalis*, greater white-fronted goose*A. albifrons*, snow goose *A. caerulescens*, bar-headed goose *A. indicus* (Jansson et al. 2008 – P) and Egyptian goose *Alopochen aegyptiacus* (Gyimesi i Lensink 2010 – P). There are also reports on crossing the Canada goose with the domestic goose (All About Birds 2006 – B). Only hybrids of the Canada goose with other species from *Branta* genus, i.e. the barnacle goose and brant goose are fertile (to limited extent) (Głowaciński i Solarz 2011 – P). Hybrids

between the Canada goose and greylag goose were recorded in Germany (Gebhardt 1996 – P), Sweeden (Söderholm 2005 – P), Iceland and sheep Islands (Weidema 2000 – P). The above mentioned species are game (greylag goose, taiga bean goose, greater white-fronted goose) and non-native species (snow goose bar-headed goose, Egyptian goose). Only three species are covered by strict protection: lesser white-fronted goose, lesser white-fronted goose, barnacle goose and brant. Currently, hybridization of the Canada goose with lesser white-fronted goose (Ruokonen et al. 2000 – P), which is a species that is exposed to extinction (VU) according to IUCN (2017 – B), is the biggest problem. Assuming that the Canada goose is a widely spread species, it should be assumed that its impact on native species via crossing will be big, i.e. the probability is high, (such cases of crossing of this species are known in the wild, but in Poland, there are native species which can cross with this species), with medium effect (the species causes a serious loss in genetic coherence in native species which are not special care species or the species cause a small loss of genetic coherence in native special care species).

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
X	very high

aconf12. Answer provided with a

low	medium	high	level of confidence
		X	

acomm16. Comments:

The Canada goose is a vector for at least 27 following pathogens: avian influenza (strains: H5N1 i H5N8), salmonellosis, the Newcastle disease, avian cholera, botulism, chlamydiosis, viral intestinal inflammation in ducks (DVE/duck plague), aspergillosis, west Nile fever, eastern and western equine encephalitis, bornaviruses (ABV), poxoviruses, parwoviruses, *Escherichii coli*, *Cryptosporidium parvum*, *Chlamydia psittaci*, *Campylobacter jejuni*, *Listeria monocytogenes*, *Helicobacter canadensis*, *Arcobacter* spp., *Giardia lamblii*, *Bordetella avium*, *Plasmodium relictum* (causing avian malaria), *Toxoplasma gondii* and a host for at least 4 mosquito species: *Culex pipiens*, *Culex restuans*, *Culex salinarius* (Cox 1980, Graczyk et al. 1997, Graczyk et al. 1998, French and Parkhurst 2001, Kullas et al. 2002, Raffel et al. 2002, Dubey et al. 2004, Ellis et al. 2004, Kassa et al. 2004, Molaei et al. 2006, Jansson et al. 2007, Jansson et al. 2008, Fraser 2010, Piepenbring 2012, Dickx et al. 2013, Gorham and Lee 2016 – P, USGS 2016 – I, CABI 2018 – B). There were studies in Germany in which eggs of the Canada goose were investigated in terms of pathogens that can be hazardous to waterfowl and poultry. In these studies, antibodies against Newcastle disease, avian influenza and duck plague (Bönner et al. 2004 – P). The pathogens survive and reproduce in faeces of the Canada goose for a period up to one month after defecation (Feare et al. 1999 – P). In studies conducted in the United States, the following pathogens were identified in the faeces of this species: coli bacteria, including pathogenic forms such as enterotoxigenic (ETEC) and enterohemorrhagic (EHEC), forms of *Escherichia coli* (Kullas et al. 2002 – P) and protozoa of *Giardia* and *Cryptosporidium* (Kassa et al. 2004 – P), including oocysts of *Cryptosporidium parvum* (Graczyk et al. 1997, Graczyk et al. 1998 – P). The Canada goose is a host to the following diseases listed by the World Animal Health Organization which entails the obligation do report the following diseases: the avian influenza (including the most hazardous strain H5N1 that is fatal to birds to birds, Ellis et al. 2004 – P, USGS 2016 – I), eastern and western equine encephalitis, West Nile fever, chlamydiosis, and the Newcastle disease.

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

	low
	medium
X	high

aconf13.	Answer provided with a	low	medium	high **X**	level of confidence

acomm17. Comments:

Nesting and remaining specimens of the Canada goose in lakes and small ponds leads to the contamination of these reservoirs with faeces. One species of the Canada goose can produce daily up to 0.7 kg of faeces (French and Parkhurst 2001 – P), which means that 10 specimens may produce annually 2.5 ton of faeces. It can deteriorate water quality, among other things, by introducing bacteria, nitrogen, and phosphorus. Such an inflow of elements may contribute to the eutrophication of water reservoirs, especially if they have limited circulation and flow (Watola et al. 1996, Kirby and Sjöberg 1997, Allan 1999, Dzięciołowski 2005, McLaughlan et al. 2014 – P). The increased level of biophylic elements can, in term, favour water weeds and algae. In the US, this species is responsible for the introduction up to 70% of phosphorus to small lakes and in ponds (Manny et al. 1994 – P). In studies carried out in lakes in Scania (Sweden), the assessed share of the Canada goose after the introduction of phosphorus to water reservoirs is considerably lower, and it fluctuated from less than 1% to 6% (Lerner 2006 – P). Assuming that this species is spread all over the country, it is estimated that its impact on the integrity ecosystems by disturbing abiotic factors will be big. This impact can be hardly reversible and it will regard both habitats not classified as special care habitats, as well as those classified as special care habitats. This impact can be hardly reversible, and it will regarded both non-special care habitats as well as special care ones, including, among others, habitats 3150 (old river beds and natural eutrophic water reservoirs).

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

	low
	medium
X	high

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

acomm18. Comments:

Significant changes in element circulation can be caused by producing large amount of faces by the Canada goose can result in a cascade and hardly reversible changes in the trophic network of ecosystems (Banks et al. 2008 – P). They can include significant disturbances in the dynamics of cycles of producer occurrence (phytoplankton – both consumers feeding on dead organic matter (Hessen et al. 2017 – P). Additionally, mass feeding of the Canada goose can cause hardly reversible disturbances in the trophic network. If the Canada goose spreads in Poland, this impact will include both non-special care habitats and special care habitats, including habitats 3150 (old river beds and natural eutrophic water reservoirs).

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
X	very high

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

acomm19. Comments:

The Canada goose feeds in arable land, which causes large and expensive losses in agrocenoses (Allan et al. 1995 – P). Locally, where it occurs in larger flocks, is considered a pest to cultivations (Gebhardt 1996, Allan 1999 – P). Especially large losses are reported in areas located near water reservoirs (Allan et al. 1995 – P). Green areas are also affected by the negative impact of the herbivory (Jansson et al. 2008 – P). In Scandinavia, considerable damages to agricultural landscape have been reported in winter, which have been caused by grazing and contamination with faeces by large goose flocks (Canadian snow geese together with native species), and these include cultivated potatoes, beets, and winter crop (rape, wheat, rye) (Svensson 1992 – P). Damage caused by grazing and trampling cultivated land can be serious. In Germany, assessed annual loses were estimated at DM 1-3 (0,5-1,5 €) million (Gebhardt 1996 – P). In Sweden, there have been more reports on damage to cultivations, but the actual scope and related costs have been poorly documented (Jansson et al. 2008 – P). In Great Britain, losses in winter crops brought about by the Canada goose are ca. 20% (Allan et al. 1995, Pimentel 2002 – P). Data from North America indicated that the grazing season and the type of crop and growth conditions have an impact on arable land as regards the Canada goose. Crop losses reaching 70% have been recorded in cultivations of germinating winter wheat and rye (GBNNRA 2011 – P). Conducted studies have indicated diversified losses in crops, between 5% and 19%, depending on the time, intensity, and the range of grazing by this species (Borman et al. 2002 – P). Grazing can also lead to the formation of bare land which is more susceptible to erosion (French and Parkhurst 2001 – P).

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

X	inapplicable
	very low
	low
	medium
	high
	very high

aconf16.	Answer provided with a	low	medium	high	level of confidence

acomm20. Comments:

The species is not a plant.

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

X	inapplicable
	no / very low
	low
	medium
	high
	very high

aconf17.	Answer provided with a	low	medium	high	level of confidence

acomm21. Comments:

The species is not a plant.

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

	very low
	low
X	medium
	high
	very high

aconf18.	Answer provided with a	low	medium **X**	high	level of confidence

acomm22. Comments:

The Canada goose has a negative impact on plant cultivations mainly by herbivory (cf. question a19). Grazing can also lead to the creation of bare areas that are more susceptible to erosion (French and Parkhurst 2001 – P). Adverse effects of this species also include trampling cultivations, which causes considerable and to a wide extent irreversible damage to plants, irreversible to a great extent (Pimentel 2002 – P). Trampling by large bird flocks can compact soil and, at the same time, prevent new plants from growing (Jansson et al. 2008 – P). Other damage is the contamination of cultivations with faeces. In New Zealand, introduced populations contaminate the pastoral land to such an extent that grazing cattle and sheep is impossible. The damage to the pastoral land correlates directly with the number of birds staying there. The losses are estimated at the level from USD 1.375 USD to USD 47,500 per farm (Spurr and Coleman 2005 – P). Assuming that the Canada goose is a species widely spread in Poland, it is estimated that the probability of the occurrence of such events would be medium (the impact will affect from 1/3 to 2/3 of cultivations) and the effect would be medium (in the worst case the condition of plants or yield from a single crop will diminish from ca. 5% to ca. 20%); therefore, in the considered case, therefore the impact would be also medium.

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

X	very low
	low
	medium
	high
	very high

aconf19.	Answer provided with a	low	medium	high **X**	level of confidence

acomm23. Comments:

So far, the transfer of pathogens or parasites harmful to cultivars by the Canada goose has not been recorded. There are also notions that such an impact can be discovered as research progresses.

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
X	very low
	low
	medium

	high
	very high

aconf20.	Answer provided with a	low	medium	high **X**	level of confidence

acomm24. Comments:

This species is mostly herbivorous. Adult specimens feed on plants, while young birds require a diet rich in protein and they eat insects, small crustaceans and mollusc related to aquatic plants (French and Parkhurst 2001 – P). So far, no impact of the Canada goose on bred animals via predation or parasitism has been recorded.

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

	very low
X	low
	medium
	high
	very high

aconf21.	Answer provided with a	low	medium **X**	high	level of confidence

acomm25. Comments:

So far, no impact of the properties of the Canada goose posing a threat by direct contact on the health of a single animal or animal production has been recorded. However, assuming that the species spreads all over the country and considering its aggression (Andersson et al. 1999 – P), it should be stated that such an impact, mainly hitting with beak or wings could occur (the probability: 1-100 cases of direct contact per 100,000 bred animals or pets), but its effects would be totally reversible. Due to the above, the impact has been classified as 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
X	very high

aconf22.	Answer provided with a	low	medium	high **X**	level of confidence

acomm26. Comments:

The Canada goose is a vector for at least 27 pathogens (cf. question a16): avian flu (strains: H5N1 and H5N8, OIE list), salmonellosis, the Newcastle disease (OIE list), avian cholera, botulism, chlamydiosis (OIE list), duck viral enteritis (DVE/duck plague), aspergillosis, West Nile fever (OIE list), eastern and western equine encephalitis (OIE list), bornaviruses (ABV), Poxviruses, parvoviruses, *Escherichia coli*, *Cryptosporidium parvum*, *Chlamydia psittaci*, *Campylobacter jejuni*, *Listeria monocytogenes*, *Helicobacter canadensis*, *Arcobacter* spp., *Giardia lambli*, *Bordetella avium*, *Plasmodium relictum* (causing avian malaria), *Toxoplasma gondi* and a host for at least 3 mosquito species: *Culex pipiens*, *Culex restuans*, *Culex salinarius* (Cox 1980, Graczyk et al. 1997, Graczyk et al. 1998, French and Parkhurst 2001, Kullas et al. 2002, Raffel et al. 2002, Dubey et al. 2004, Ellis et al. 2004, Kassa et al. 2004, Molaei et al. 2006, Jansson et al. 2007, Jansson et al. 2008, Fraser 2010, Piepenbring 2012, Dickx et al. 2013, Gorham and Lee 2016 – P, USGS 2016 – I, CABI 2018 – B). Virus H5N1 causes high morbidity and mortality in poultry and in swine. In turn, eastern and western

	equine encephalitis and West Nile fever are very dangerous to horses (Fraser 2010 – P). In eastern equine encephalitis, the symptoms include, among others, considerable brain hyperaemia and disseminated neurodegenerative changes. Severe cases of this infection last less than a day, while the average mortality is ca. 50%. The west Nile fever in horses leads to fatalities, and this disease also brings down dogs and cats. The Newcastle disease is a highly infectious and fatal disease in hens, turkeys, and other gallinaceous poultry.

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:

X	inapplicable
	very low
	low
	medium
	high
	vert high

aconf23.	Answer provided with a	low	medium	high	level of confidence

acomm27.	Comments: This 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
X	low
	medium
	high
	very high

aconf24.	Answer provided with a	low	medium **X**	high	level of confidence

acomm28.	Comments: The Canada goose is known for its aggressive behaviours towards people (Conover and Chasko 1985 – P). For example, people were attacked by aggressive birds (hit with the beak and wings) on US beaches in the breeding season. This behaviour and high levels of bacteria coli in the faeces of the Canada goose caused some beaches to be closed. Aggressive behaviours towards people also occur near water reservoirs in urban parks. All these problems have been aggravated by the population increase of the Canadian snow geese in the US (GBNNRA 2011 – P). Assuming that the species will spread all over Poland, it should be stated that the probability of such an impact would be medium (1-100 cases of direct contact per 100,000 people per year), and its impact is low small (absence of permanent impairments, low stress level). Due to the above, the impact was classified as low.

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
X	very high

aconf25.	Answer provided with a	low	medium	high X	level of confidence

acomm29. Comments:

The Canada goose is a vector for at least 27 various pathogens (cf. questions a16 and a26), including avian influenza (strains: H5N1 and H5N8, OIE), salmonellosis, the Newcastle disease (OIE litst), chlamydiosis (OIE list), the West Nile fever (OIE list), eastern and western equine encephalitis (OIE list), *Escherichia coli*, *Cryptosporidium parvum*, *Chlamydia psittaci, Campylobacter jejuni*, and *Giardia lamblia* (Graczyk et al. 1997, Graczyk et al. 1998, Kullas et al. 2002, Ellis et al. 2004, Kassa et al. 2004, Jansson et al. 2008 – P, USGS 2016 – I, CABI 2018 – B). In studies conducted in the US, bacteria coli were identified in the faeces of this species, including such pathogenic forms as enterotoxigenic (ETEC) and enterohemorrhagic (EHEC) forms of *Escherichia coli* (Kullas et al. 2002 – P). Several American states had to close beaches because high coli bacteria in the faeces of this species were recorded (GBNNRA 2011 – P). The avian influenza (strain H5N1) is a fatal disease to humans. One can be infected with this disease via contact with ill animals or objects contaminated with faeces of ill animals. According to the World Health Organisation, the mortality of people infected with H5N1 virus in 2003-2009 was ca. 60% (WHO 2009 – I). Infection with *Escherichia coli*, *Giardia lamblia*, *Cryptosporidium parvum*, *Campylobacter jejuni*, *Chlamydia psittaci,* salmonellosis, West Nile fever, and eastern and western equine encephalitis are also hazardous to humans. The West Nile fever is classified as a haemorrhagic fever, which can cause nausea, vomiting, difficulty with swallowing, torticollis, weakening muscles, difficulty in walking, coordination disturbances, confusion, and parkinsonism. Some cases may be fatal. There are various forms of the infection with *Escherichia coli*, from food poisoning to sepsis that can end up with death. *Giardia lamblia* causes giardiasis, small intestine disease; *Cryptosporidium parvum* – cryptosporidiosis, as well intestinal disease. *Campylobacter jejuni* causes acute gastritis and intestinal inflammation which can flare and lead to ulceration. The disease usually takes several days. Sometimes, especially in persons with immune system impairments, systemic infection (sepsis) occurs. *Chlamydia psittaci* causes ornitosis (parrot disease), which attacks mostly lungs, the heart, the liver, and central nervous system. Currently, this disease is mostly treatable. Salmonellosis is a disease occurring mainly in the alimentary tract, hazardous to man, but fully treatable. The threat posed by the Canada goose is high, because these birds live in the wild, but they are hardly skittish and concentrate in areas visited by people, such as urban parks or beaches.

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
X	very high

aconf26.	Answer provided with a	low	medium	high X	level of confidence

acomm30. Comments:

The species contaminates water reservoirs with its faeces, and this includes parks, golf courses, and areas used for recreation, thus reducing their attractiveness (Jansson et al. 2008, GBNNRA 2011, Głowaciński and Solarz 2011 – P). It should be noted that one

specimen of the Canada goose can produce up to 0.7 kg faeces per day (French and Parkhurst 2001 – P), which means that 10 specimens may produce up to 2.5 tons of faeces per year. Furthermore, aggressive behaviour of this species, especially in the breeding period, can discourage people from using water reservoirs and beaches (GBNNRA 2011 – P). Faeces of this species are a serious sanitary threat due to the high content of pathogens and parasites, including the avian influenza that is fatal to people (H5N1) (CABI 2018 – B). Furthermore, faeces may contribute to water eutrophication (Watola et al. 1996, Kirby and Sjöberg 1997, Allan 1999, Dzięciołowski 2005, McLaughlan et al. 2014 – P). For example, in the US, this species is responsible for introducing up to 70% of phosphorus to small lakes and ponds (Manny et al. 1994 – P). Another very grave problem related to this species is a threat to aviation, because birds can collide with airplanes. Due to their large size, flocking behaviour, and attraction to airports as breeding and resting grounds, Canadian snow geese can pose an extremely serious hazard to aircraft (Dolbeer and Seubert 2006 – P). According to the British Civil Aviation Authority (CAA), the combination of very fast development of gregarious bird populations, such as Canadian snow geese, and the progress in aviation poses a considerable problem for the air safety. Growing populations of non-migrating goose species near conurbations raise particular concerns, because existing requirements on aviation safety are not adapted to such big birds (Jansson et al. 2008, GBRRNA 2011 – P). This species is probably responsible for financial losses at the amount of USD 1.2 billion caused by damage and delayed flights all over the world (Allan 2000 – P). But fatalities related with these events are much more severe (CABI 2018 – B). In 1995 in the US, there was an airplane disaster caused by 13 specimens of the Canadian snow geese that were drawn into aircraft engines. Then, there were 24 fatalities and losses were estimated at ca USD 190 million (French and Parkhurst 2001, Dolbeer and Seubert 2006, GBNNRA 2011 – P). In 2009, collision with this species in New York caused serious damage to an Airbus A320 jet. Although there were no casualties, financial losses were very significant (GBNNRA 2011 – P). In Great Britain, this species is one of frequent causes of airplane crashes. It was estimated that the Canada goose are the cause of ca 40% of all collisions with birds leading to damage to aircraft (GBRRNA 2011 – P).

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:

X	significantly negative
	moderately negative
	neutral
	moderately positive
	significantly positive

aconf27. Answer provided with a

low	medium	high
		X

level of confidence

acomm31. Comments:

The impact of the Canadian snow geese on supply services has been determined as very negative, because this species affect adversely cultivars, mainly crops, by eating plants, trampling vegetation, and contaminating it with faeces (cf. a 19 and a22); moreover, it has also a negative effect on husbandry, because it transfers at least 27 pathogens, including diseases listed by the World Animal Health Organization (OIE) including the following: the avian influenza (H5N1), eastern and western equine encephalitis, West Nile fever, and chlamydiosis, and Newcastle disease (cf. a26). Additionally, Canadian snow geese

contaminate water reservoirs with faeces, which deteriorates water quality by the introduction of bacteria, nitrogen, phosphorus, and other components into water, and the reservoirs are subject to eutrophication (cf. questions a17 and a30); consequently, it affects the availability of drinking water (Solarz and Josefsson 2014 – P).

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

X	significantly negative
	moderately negative
	neutral
	moderately positive
	significantly positive

aconf28.	Answer provided with a	low	medium	high **X**	level of confidence

acomm32. Comments:

The impact of this species on control services has been indicated as very negative, because it adversely affects biological control – controlling zoonoses, and this species transfers at least 27 pathogens, including diseases listed by the World Animal Health Organization (OIE) (OIE), avian influenza (H5N1), eastern and western equine encephalitis, West Nile fever, chlamydiosis, and the Newcastle disease (cf. question a16 and a26). Faeces of this species pose a serious sanitary threat to people (cf. question a29). Additionally, the Canada goose may cause eutrophication of the water reservoir (cf. question a17, a18 and a30) and disturb trophic networks (cf. question a18).

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

	significantly negative
X	moderately negative
	neutral
	moderately positive
	significantly positive

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

acomm33. Comments:

The impact of the Canada goose on cultural services has been determined as moderately negative, because the specimens of this species contaminate water reservoirs used for recreation and rest with their faeces, thus reducing the attractiveness of such areas (Solarz and Josefsson 2014 – P). Trampling, contamination with faeces, and aggressive behaviour can be arduous in other recreational areas, such as beaches, parks, and golf courses (cf. question a30) (Conover and Chasko 1985, Solarz and Josefsson 2014 – P). For example, there are reports from the US that people staying on the beach were attacked by the Canadian snow geese (by hitting with beak and wings)). This species is still bred as a decorative bird and in zoos, and that is why it can be perceived by a part of the public as a desired element of the ecosystem. On the other hand, due to the fact that the presence of the Canada goose may have a negative impact on native species, it can be considered adverse. The Canada goose is also a game species in such countries like Germany, Denmark, Finland, Norway, Sweden, and hunting was one of the reasons for reintroduction of this species (Jansson et al. 2008 – P).

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:

	decrease significantly
	decrease moderately
X	not change
	increase significantly
	increase moderately

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

acomm34. Comments:

The Canada goose prefers a moderate warm climate; (Mediterranean and subtropical and subtropical); continental (with dry summer), and polar (tundra) (CABI 2018 – B). Its spreading and domestication in many European countries (CABI 2018 – B) indicates an easy adaptation to very diverse conditions, and it also adopts to the humid continental climate occurring in Poland. Simulations on the future distribution of this species indicate that it can move or expand its range northward, as far as the northernmost parts of Scotland and Fennoscandia and then the Kola Peninsula (Huntley et al. 2007 – P). The Canada goose spread to the north, because this species avoids areas where summer temperatures exceed 25°C (Gallardo 2014 – P). The Canada goose has already overcome geographical barriers, and it occurs in the natural environment in Poland. Therefore, it seems that predicted climate changes will not affect overcoming subsequent barriers related to introduction by this species. The existing population is likely to develop regardless of climate changes.

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
X	not change
	increase moderately
	increase significantly

aconf31.	Answer provided with a	low	medium **X**	high	level of confidence

acomm35. Comments:

Climate changes are likely to affect the shifting or expansion of this species to the north (cf. questions a34, Huntley et al. 2007 – P). The snow goose has already overcome barriers which hampered domestication in Poland. It seems that predicted climate changes will not affect the existing population, and it will likely develop, regardless of climate changes.

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
X	not change
	increase moderately
	increase significantly

aconf32.	Answer provided with a	low	medium	high **X**	level of confidence

acomm36. Comments:

It is most probable that climate changes will shift or extend the range of this species to the north (cf. questions a34, Huntley et al. 2007 – P). The Canada goose has already overcome barriers that were hampering the spread of this species in Poland. It seems that predicted climate changes will not affect the existing population, and it will likely develop regardless of climate changes.

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
X	not change
	increase moderately
	increase significantly

aconf33.	Answer provided with a	low	medium	high **X**	level of confidence

acomm37. Comments:

The Canada goose has a negative impact on the natural environment, because it transfers pathogens, disturbs abiotic and biotic factors in ecosystems, and it is a competitor and crosses with other native species; in addition, it is also herbivorous (cf. questions a13-a18). The predicted climate changes do not seem to contribute to the aggravation of this negative impact. The existing population is likely to develop, and the impact on the natural environment also will increase, but it will be regardless of climate changes.

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
X	not change
	increase moderately
	increase significantly

aconf34.	Answer provided with a	low	medium	high **X**	level of confidence

acomm38. Comments:

The species has a negative impact on cultivations due to herbivory and disturbing the integrity of cultivations (cf. questions a19 and a22). Predicted climate changes seem not to contribute to the aggravation of this negative impact. The existing population is likely to develop, and impact on the natural environment also will increase, but it will be regardless of climate changes.

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
X	not change
	increase moderately
	increase significantly

aconf35.	Answer provided with a	low	medium	high **X**	level of confidence

acomm39. Comments:

The Canada goose has a negative impact on husbandry due to the transfer of pathogens and properties which pose a danger during the direct contact (cf. questions a25 and a26).). Predicted climate changes seem to not contribute to the aggravation of this negative impact. The existing population is likely to develop, and impact on the natural environment also will grow, but it will be regardless of climate changes.

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

	decrease significantly
	decrease moderately
X	not change
	increase moderately
	increase significantly

aconf36.	Answer provided with a	low	medium	high **X**	level of confidence

acomm40. Comments:

This species has a negative impact on humans due to the transfer of pathogens and properties which pose a danger during the direct contact (cf. questions a28 and a29). Predicted climate changes seem not to increase the negative impact. The existing population will probably develop, and its impact on humans will grow, but it will be regardless of climate changes.

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

	decrease significantly
	decrease moderately
X	not change
	increase moderately
	increase significantly

aconf37.	Answer provided with a	low	medium	high **X**	level of confidence

acomm41. Comments:

The Canada goose has a negative impact on other objects, mainly by contamination of water reservoirs, beaches, parks and golf courses with faeces, and there is also hazard of collision of birds with airplanes. Predicted climate changes seem to affect the growth of the negative impact. The existing population will probably develop, and impact on other objects will increase, but it will be regardless of climate changes.

Summary

Module	Score	Confidence
Introduction (questions: a06-a08)	1.00	1.00
Establishment (questions: a09-a10)	1.00	1.00
Spread (questions: a11-a12)	1.00	0.50
Environmental impact (questions: a13-a18)	0.79	0.83
Cultivated plants impact (questions: a19-a23)	0.50	0.83
Domesticated animals impact (questions: a24-a26)	0.42	0.83
Human impact (questions: a27-a29)	0.63	0.75
Other impact (questions: a30)	1.00	1.00
Invasion (questions: a06-a12)	1.00	0.83
Impact (questions: a13-a30)	1.00	0.85
Overall risk score	1.00	
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:

The Canada goose is the only species that ranked first in three summaries issued in several years which indicated species having the most negative impact on the environment and economy. In the analysis carried out by Nentwig et al. (2017 – P) 149 non-native species were studied, including 54 plants, 49 invertebrates, 40 vertebrates, and 6 fungi. Among the species with the highest negative impact, there was 1 bird (the Canada goose with the highest final score of 38), 4 mammals (the brown rat *Rattus norvegicus* (37), the muskrat *Ondatra zibethicus* (32), the sika deer *Cervus nippon* (31), the muntjac *Muntiacus reevesi* (30), one crayfish (the Louisiana crawfish *Procambarus clarkii* (34)), 1 mite (*Varroa destructor* (31), and 4 plants (the silver wattle *Acacia dealbata* (31), the big-sage *Lantana camara* (31), the kudzu *Pueraria lobata* (29), common water hyacinth *Eichhornia crassipes* (29)). Kumschick and Nentwig (2010 – P) have analysed 26 non-native birds domesticated in Europe. It was found that the Canada goose is a species with the most negative environmental impact (the final score of 15). The next position is held by the African sacred ibis (*Threskiornis aethiopicus* (9)) and the ruddy duck (*Oxyura jamaicensis* (8)). No other species had such a considerable negative impact on the economic domain (the final score of 21), and the following species ranked next in the list: Rose-ringed parakeet (*Psittacula krameri* (11)), monk parakeet (*Myiopsitta monachus* (6)), and the sacred ibis (5). Kumschick et al. (2015 – P). The researchers selected for studies 300 non-native species introduced after 1500 and domesticated in Europe, including 26 birds, 34 mammals, 35 fish, 77 terrestrial arthropods, and 28 plants. Again, among these species, the Canada goose ranked first with the final score of 38 (environmental impact: 17/economic impact: 21), equally placed with the brown rat that has a bigger negative environmental impact, (19/19), preceding among the fallow deer *Dama dama* (33:17/16), the sika deer (33:16/17), and muskrat (32:18/14).

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