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. Andrzej Czech
2. Paweł Janiszewski – external expert
3. Wojciech Solarz

acomm01. Comments:

	degree	affiliation	assessment date
(1)	dr	Ursa Maior Sp. z o.o. S.K.A.	27-01-2018
(2)	dr hab.	University of Warmia and Mazury in Olsztyn	25-01-2018
(3)	dr	Institute of Nature Conservation, Polish Academy of Sciences in Cracow	16-02-2018

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

Polish name: Bóbr kanadyjski

Latin name: ***Castor canadensis*** Kuhl, 1820

English name: Canadian beaver

Współfinansowano w ramach projektu nr POIS.02.04.00-00-0100/16 pn. *Opracowanie zasad kontroli i zwalczania inwazyjnych gatunków obcych wraz z przeprowadzeniem pilotażowych działań i edukacją społeczną* ze środków Unii Europejskiej w ramach Programu Infrastruktura i Środowisko 2014-2020

acomm02.	Comments:

Polish name (synonym I) Bóbr amerykański	Polish name (synonym II) –
Latin name (synonym I) –	Latin name (synonym II) –
English name (synonym I) American beaver	English name (synonym II) North American beaver

a03. **Area** under assessment:

Poland

acomm03.	Comments: –

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

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

aconf01.	Answer provided with a	low	medium	high **X**	level of confidence

acomm04.	Comments: There is no evidence on the presence of this species in the natural environment in Poland (Parker et al. 2012 – P). According to data from literature, the Canadian beaver probably appeared in the natural environment in Poland in the first half of the 20th century. They were individuals who in 1932 escaped from farm breeding taking place in the present-day Warmian-Masurian Voivodeship, near the town of Morąg. Probably together with the European beaver, these animals could have settled over the Pasłęka river. However, genetic research published in 1980 (Sysa and Żurowski 1980 – P) showed that only the native species of the European beaver – *Castor fiber*, is present in the area. Currently, it is believed that the Canadian beaver does not occur in Poland.

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 species does not occur in Poland, so at present it has no impact. The wide spread of the species in our country is very unlikely, due to the lack of populations close to the site, terrain that prevents migration and the lack of closed farms and reasons for their establishment in the future. However, assuming that the species is widespread, it should be assumed that its impact will be significant for all domains, due to the proximity of biology and behavior with European beaver – *Castor fiber*, which shows this effect (Czech 2018 – A). The beaver modifies the ecosystems and the natural environment of the coastal areas by building dams and increasing the water level. It affects growing plants by changing hydrological conditions and actively chewing of crops. It also indirectly influences animal breeding, changing water conditions in pastures, collecting vegetation that can be used by farm animals, and destroying fences. Beavers are also often the initiator of relationships

with humans, affecting the infrastructure by digging dens, building dams, and increasing water levels and cutting trees. This type of activity of beavers may also have a negative effect, due to the occurrence of damages in the agriculture and forestry.
The threat of diseases in people or farm animals through beavers is mainly theoretical and not very real. The most dangerous disease that can be transmitted by the Canadian beaver is rabies. However, such cases have not been confirmed in literature .

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:

X	low
	medium
	high

aconf02. Answer provided with a

low	medium	high
		X

level of confidence

acomm06. Comments:
Stable wild living beaver populations in Europe, currently occur only in Finland and North-West Russia (Sjoberg and Ball 2011, Dewads et al. 2012, Parker et al. 2012 – P). Therefore, according to the adopted risk assessment procedure, it should be assumed that the threat that this species may appear in Poland in the future as a result of independent expansion is low.
The spreading of beavers is conditioned mainly by land hydrography, as well as by the abundance of the food base, so the pace of this process can vary. The most frequently migrated individuals are animals that reach sexual maturity, seeking new territory for establishment (Sjoberg and Ball 2011 – P).

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

X	low
	medium
	high

aconf03. Answer provided with a

low	medium	high
		X

level of confidence

acomm07. Comments:
Due to the lack of closed Canadian beaver farms in Europe and its specific behavior (Janiszewski and Misiukiewicz 2012 – P), introduction of this species into the natural environment of Poland as a result of unintentional human activities, for example, introduction along with the transported goods, is very unlikely. So far, there has not been a single case of introducing the Canadian beaver to the new area due to unintentional human activities (Czech 2010 – A).

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

X	low
	medium
	high

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

acomm08. Comments:
Catching and re-establishment of live beavers is difficult to implement due to technical reasons (appropriate equipment and trained people), as well as due to the behavioral aspects of the animals themselves (Janiszewski and Misiukiewicz 2012 – P). Therefore, the risk of introducing a Canadian beaver as a result of intentional human activities in Poland is very small. In addition, a number of legal conditions have been implemented in Poland prohibiting the intentional introduction of alien species and there is no public support for such activities, e.g. from the hunters.

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:
Considering the climatic conditions prevailing in the natural occurrence of the Canadian beaver and in the areas where the species was introduced artificially (Collen and Gibson 2001 – P), it can be concluded that the climatic conditions prevailing in Poland are optimal for the establishment of this species. Furthermore, this conclusion can also be drawn considering the intensive development of the native species population, i.e. the European beaver on the territory of Poland (Janiszewski and Misiukiewicz 2012 – P). There were no differences regarding ecological conditions, including climatic conditions, preferred by both the European beaver and the Canadian beaver (Halley and Rosell 2002, Sjoberg and Ball 2011 – 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:
Considering the climatic conditions prevailing in the natural occurrence of the Canadian beaver and in the areas where the species was introduced artificially (Gallant et al. 2004, Parker et al. 2012, Johnston 2017 – P) it can be concluded that the climatic conditions prevailing in Poland are optimal for the establishment of this species (Suzuki and McComb 1998, Janiszewski and Hanzal 2015 – P). There were no differences in the habitat conditions preferred by European beaver and Canadian beaver (Sjoberg and Ball 2011 – P).

A3 | Spread

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

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

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

	very low
	low
	medium
	high
X	very high

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

acomm11. Comments:

Dispersion from a single source (Data type: A)
Expansion of the Canadian beaver, just like the European one, is limited to watercourses and reservoirs (McNew and Woolf 2005, DeStefano et al 2006, McClintic et al 2014 – P). The rate of spread depends on the type of environment and catchment. In the case of favorable geomorphological conditions and a small number of uninhabited territories and random events (e.g. floods carrying particular individuals without their active resistance), the Canadian beaver can travel several dozen kilometers or further within a year (Czech 2018 – A). Research was carried out (Sjoberg and Ball 2011 – P) on the dispersion of the Canadian beaver population in northern Karelia, in the first years after the introduction in 1964. The environmental conditions of this region have been determined to be almost optimal. The pace of dispersion is estimated to be 4 km per year in a straight line and 8 km annually by waterways. Whereas in southern Karelia, also in the mid-twentieth century, the dispersion of the introduced Canadian beaver was determined at a similar level – 8 km per year. In western Karelia, where the beaver's feed resources were poor, the estimated pace of movement of individuals was higher – at 18 km per year in a straight line and 30 km annually through waterways.

Expansion of population (Data type: B)
Favorable geomorphological conditions and a network of watercourses will cause a large population expansion of over 10 km a year (Czech – A).

The factor limiting the possible dispersion of *Castor canadensis* may be competition with the native species, and to a lesser extent local predation by large predatory mammals (Rosell et al. 2005, Gable et al. 2016, Tadich et al. 2018 – P).

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

X	low
	medium
	high

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

acomm12. Comments:

The possible spread of the Canadian beaver in Poland with the participation of humans could take place primarily through targeted catching and re-establishment. This type of procedures used mainly in the 20th century on the native population of the European beaver are now becoming rarer in case of this species (Janiszewski and Misiukiewicz 2012 – P), and therefore the risk of spreading the introduced Canadian beaver is minimal.

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	high **X**	level of confidence

acomm13. Comments:

The Canadian beaver is a herbivore. Its potential presence will not affect native species through predation or parasitism.

The presence of this species will affect vegetation occurring in the coastal zone of watercourses and water reservoirs where they established (Gibson and Olden 2012, Parker et al. 2012 – P), as well as the presence of the European beaver (Czech 2018 – A).

Both species of beavers show similar food preferences in relation to trees and shrubs occurring in the coastal zone. In Karelia, where there are both species of beavers, it was found that both European and Canadian beavers preferred willows, birches and alders (Sjoberg and Ball 2011 – P). Cutting individual trees, or their clusters, locally increases soil exposure to sun in these places, which may affect changes in species composition of plants and animals.

Assuming that the Canadian beaver will be a widespread species in Poland, it may cause a small drop in the population size of native special care species or significant dicrease in the local population of other native species (for example, different species of sundews associated with protected areas). Therefore, the impact of this species as a result of herbivorousness will be, in the worst case, medium.

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 beaver, due to its higher fertility (Parker et al. 2012, Sjoberg and Ball 2011 – P), may locally displace native beaver species by occupying its territories and their effective defense. This may result in small decreases in the size of the European beaver population, which is a species under partial protection in Poland.

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

X	no / very low
	low
	medium
	high
	very high

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

acomm15. Comments:

Most literature states that the Canadian beaver does not interbreed with European beaver (Sjoberg and Ball 2011 – P), especially since the species have different numbers of chromosomes. Therefore, there are no indications that the Canadian beaver can interbreed with the native 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 **X**	level of confidence

acomm16. Comments:

Several types of pathogens or common parasites harmful to the native European beaver were found in the Canadian beaver (protozoa, viruses, bacteria, tapeworms, ticks, viruses and mites) (McKown et al. 1995, Fayer et al. 2006 – P, Najberek 2018 – N, Zavyalov 2014, Janiszewski and Hanzal 2015 – P). Pathogens or parasites that may possibly be transferred to native species include: cryptosporidia, giardia, streptococcus, yersinia and leptospira bacteria and parasites – *Stichotsis subtriquetrus, Castorstrongylus castoris, Travassosius ssp., Schizocarpus spp*.

The Canadian beaver can also carry rabies, a deadly disease from the OIE list.

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

	low
X	medium
	high

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

acomm17. Comments:

By flooding the areas as a result of building dams on watercourses, or digging burrows in waterfronts of watercourses and reservoirs, the Canadian beaver may disturb the abiotic factors of ecosystems (Anderson et al., 2009, Parker et al. 2012 – P). Not only their direct impact (e.g. cutting trees, building dams, lodges or digging burrows), but also effects of beaver activity – flooding meadows (or other habitats), slowing water flow, etc. should be taken into consideration. There are a number of habitats subject to protection that may be destroyed as a result of beaver activities (both European and Canadian).

In the worst case, the species causes hardly reversible changes regarding the processes occurring in the special care habitats.

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

	low
X	medium
	high

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

acomm18. Comments:

The role of the Canadian beaver in shaping the local composition of fauna and flora is widely described in literature (Rosel et al. 2005, Malison et al. 2014, Johnston 2017 – P). The Canadian beaver has been recognized as a keystone species, i.e. one whose impact on the structure and functioning of the ecosystem is disproportionately large in relation to their number or biomass.

By flooding vast areas (changing water relations), or cutting trees and shrubs (changing the composition of vegetation, changing the degree of soil irradiation), it may disturb / change the biotic factors of the ecosystem. These changes concern both flora and fauna. Beaver farming will entail an increase in the number and size of species associated with waters (mainly standing or free-flowing) and wetlands, at the expense of species preferring dry areas.

In the worst case scenario, *the species* causes hardly reversible changes in the processes occurring in special care habitats.

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
X	low
	medium
	high
	very high

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

acomm19. Comments:

The Canadian beaver will exert an analogous effect on the cultivation of plants by its herbivorousness in the same way as the European beaver. In the case of crops located near watercourses or reservoirs, local eating of crops or flooding may occur, but in the scale of the total crop area in Poland, the impact will be small (Johnston 2017 – P, Czech 2018 – A). The discussed impact will concern both agricultural and forest crops (Härkönen 1999, Janiszewski and Hanzal 2015 – P). In the case of forest crops, in addition to flooding the land and changes in water relations, the impact of the discussed species will also include cutting trees and shrubs in several to several dozen of kilometers of the coastal area.

In the worst case, the damage caused by the Canadian beaver will exceed 20% of crops. This conclusion can be based on data on damages caused by European beaver from damage estimation protocols

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 discussed species is an animal.

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

acomm20. Comments:

The discussed species is an animal.

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

	very low
X	low
	medium
	high
	very high

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

acomm22. Comments:

The Canadian beaver will have an analogous effect on crop cultivation by disturbing the integrity of crops just as the European beaver. In the case of crops located near watercourses or water reservoirs, local eating of crops or flooding may occur, but on the scale of the total area of crops in Poland, the impact will be small (Czech 2018 – A, Härkönen 1999, Pietrek and Fasola 2014 – P).

It can be assumed that the impact of the Canadian beaver will be no more than 1/3 of the crops being invaded, and in the worst case the yield of plants or single crop will be reduced from about 5% to about 20%.

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:

The discussed species is not a host or vector of pathogens and parasites harmful to plants (Czech 2018 – A).

A4c | Impact on the domesticated animals domain

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

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

X	inapplicable
	very low
	low
	medium
	high
	very high

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

acomm24. Comments:

The Canadian beaver is a herbivorous species, it 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:

X	very low
	low
	medium
	high
	very high

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

acomm25. Comments:

In literature there is no description of bites (predation) of farm animals by the Canadian beaver. There are also no reports that it would have any direct impact on farm or domestic animals in direct contact.

In addition, it is expected that the possibility of direct contact will amount to less than one case a year for 100 000 farm or domestic animals, and the possible effects of such contact will 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
X	very high

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

acomm26. Comments:

The Canadian beaver can be a carrier of rabies – a lethal disease from the OIE list – (Baer 1991, Fitzpatrick et al. 2014 – P.), therefore it cannot be ruled out that the virus spreads between Canadian beaver and individual animals in case of contact (e.g. with dogs) and their bites.

Among other parasites that may possibly be transferred from the European beaver to domestic animals there are: *Giardia ssp*., *Cryptosporidium ssp*., or *Yersinia pseudotuberculosis* **.** Potential pathogen infection may occur as a result of animal drinking water with pathogens, for example in the beaver spreading area. The symptoms of these diseases include: lack of appetite, apathy, diarrhea, wasting, etc. In the case of proper diagnosis and treatment, the diseases are curable (Dunlap and Thies 2002, Appelbee et al 2005 – 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:

X	inapplicable
	very low
	low
	medium
	high
	vert high

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

acomm27. Comments:

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
X	low
	medium
	high
	very high

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

acomm28. Comments:

It can be assumed that an attacked or injured Canadian beaver can bite a human. In the media (press, TV, Internet) there is some information about the bitings or attempts to bite people by beavers. Such cases result primarily from the defense of the animal against man.

There are reports of similar cases in relation to the beaver's native species, when the individuals caught, e.g. during the catch, bit people trying to free themselves.

It should be assumed, however, that the likelihood of such events will be low (less than one contact a year per 100,000 people), and their effect will be small (medical consultations will be rare, these events will not result in absence from work, permanent disabilities or high level stress).

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 Canadian beaver can be a carrier of rabies – a lethal disease from the OIE list – (Baer 1991, Fitzpatrck et al. 2014 – P), therefore it cannot be ruled out that the virus spreads between Canadian beaver and humans in contact (bites). However, in natural conditions, direct contact of this type is very rare.

Available literature does not mention other common pathogens and parasites that can be transmitted by a Canadian beaver to a human.

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
X	medium
	high
	very high

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

acomm30. Comments:

By flooding or partially flooding land and digging burrows in watercourses and water reservoirs Canadian beavers may have a negative impact on infrastructure (e.g. water flooding, landslides, etc.). The mentioned impact may result from the natural behavior of animals and the transformation of the inhabited area to their own living needs (Anderson et al. 2009, Hollander et al 2017, Parker et al 2012 – P).

The probability of occurrence of an event is estimated at above 1, but not more than 100 events per 100,000 objects per year, while the effect of these events will be partially reversible.

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
X	moderately negative
	neutral
	moderately positive
	significantly positive

aconf27.	Answer provided with a	low	medium	high **X**	level of confidence

acomm31. Comments:

The Canadian beaver will exert an analogous effect on the cultivation of plants by its herbivorous nature in the same way as the native beaver species. In the case of crops located near watercourses or reservoirs, local crops may be eaten (e.g. carrots, beets) or agricultural areas may be flooded, which will affect the quality of crops and harvests. However, on the scale of the total area of crops in Poland, the impact will be proportionally small (Gallant et al 2004, Czech 2010 – P).

Apart from the above, the negative impact of the Canadian beaver on agricultural economy may also indirectly be caused by the digging of the system of burrows in which farm animals (e.g. cows during grazing) or agricultural machinery may fall.

The discussed species may negatively affect the acquisition of wood raw material. Both by flooding the land, and consequently, the death of trees, and by direct tree falling, the Canadian beaver can cause losses in the forest economy. However, at the same time, in the forest areas located at a distance from the beaver springs, there are more and more secondary tree increments resulting from better soil humidity. The impact of the Canadian beaver on forest management and harvesting will therefore be both negative and positive (Janiszewski and Misiukiewicz 2012 – P).

Another negative impact of the Canadian beaver on supply services may result from the damaging of pond embankments, which may cause losses in the fishing industry.

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

	significantly negative
	moderately negative
	neutral
X	moderately positive
	significantly positive

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

acomm32. Comments:

A positive activity of Canadian beavers is analogous to that of European beavers and influences morphological and hydrological changes in watercourses and water reservoirs, and causes changes in physicochemical properties of water and sediments, as well as biological changes (Czech 2010 – P). Beavers have a positive influence on the process of small retention and improvement of soil moisture conditions. Beaver ponds can have a positive effect in the self-purification process (Gallant et al 2004 – P).

The negative impact of the Canadian beaver on regulatory services will result from clogging road culverts, as a result of building dams or digging dens, and thus from weakening

floodbanks, or strengthening road quays or railway tracks. Negative impact may also result from local flooding of roads.

In the case of native species, however, there were local cases like this on the territory of Poland (Janiszewski and Misiukiewicz 2012 – P).

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

	significantly negative
	moderately negative
	neutral
X	moderately positive
	significantly positive

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

acomm33. Comments:

In today's increasingly civilized world, the landscape value of beaver habitats is extremely valuable and difficult to assess. The appearance of a beaver pond, often with lodges, usually makes the area less attractive. This is especially interesting for people who have no contact with nature every day. The surroundings of the beaver pond and the pond itself can be used by children as a great biology lesson, a place for watching and photographing nature. Building educational paths in such places is easy, because on a relatively small area you can show many interesting natural phenomena (Czech 2010 – P).

Due to its unique engineering skills, the beaver is also a symbol of diligence and persistence. It also became a symbol / logo of many construction companies and stores, etc.

It is worth noting that the activity of Canadian beavers in agricultural areas may cause negative emotions for farm owners resulting from losses. However, the possibility of improving the damage assessment system and paying compensation should be considered.

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 moderately
	increase significantly

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

acomm34. Comments:

Due to the small impact of climate change on the Canadian beaver, it is not expected that they would be important for the species to overcome geographic barriers that would change the probability of its introduction into Poland (Czech 2018 – A).

There are no studies on the impact of climate change on the potential overcoming of geographical barriers and the appearance of the Canadian beaver in Poland. It can be assumed, however, that occurrence of droughts and drying of watercourses and reservoirs (seasonal or permanent) may hinder the migration of beavers to new, uninhabited areas.

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	high **X**	level of confidence

acomm35. Comments:

Due to the low impact of climate change on the Canadian beaver, it is not expected that such change would be important for the species to overcome barriers that previously prevented its survival and reproduction in Poland (Czech 2018 – A).

There are no studies on the impact of climate change on the potential establishment (survival and reproduction) of the Canadian beaver. It can be assumed, however, that occurrence of droughts and drying of watercourses and reservoirs (seasonal or permanent) may hinder migration of beavers and establishment of animals in new areas.

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:

Due to the low impact of climate change on the Canadian beaver, it will probably not be important for the species to overcome the barriers which until now prevented it from spreading in Poland (Czech 2018 – A).

There are no studies on the impact of climate change on the potential overcoming of barriers that have so far prevented the spread of the Canadian beaver in Poland.

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:

Due to the low impact of climate change on the Canadian beaver, no changes in the impact of this species on plants and animals as well as habitats and ecosystems in Poland are anticipated (Czech 2018 – A).

There are no studies on the impact of climate change on the potential overcoming of barriers that have so far prevented the spread of the Canadian beaver.

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:

Due to the low impact of climate change on the Canadian beaver, no change in the impact of this species on arable crops or plant production in Poland is anticipated (Czech 2018 – A). There is no research on the correlation between climate change and the influence of the Canadian beaver on arable crops or plant production. However, it can be assumed that in the case of prolonged droughts, agricultural areas located near the beaver backwaters will be characterized by a lower soil moisture content and, therefore, a higher yield compared to dry areas.

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:

Due to the low impact of climate change on the Canadian beaver, no change in the impact of this species on farm and domestic animals, as well as on animal production in Poland is anticipated (Czech 2018 – A).

There are no studies on the impact of climate change on the Canadian beaver's impact on farm and domestic animals, as well as on animal production.

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:

Due to the low impact of climate change on the Canadian beaver, no change in the impact of this species on farm and domestic animals, as well as on animal production in Poland is anticipated (Czech 2018 – A).

There is no literature data on the impact on climate change on this species. It can be supposed that prolonged droughts, leading to temporal or permanent drying of watercourses and

	water reservoirs, may cause that the role of beavers will be perceived as beneficial, as thanks to dam building the moisture level of adjacent soils will increase.

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: Due to the low impact of climate change on the Canadian beaver, no change in the impact of this species on other objects in Poland is anticipated (Czech 2018 – A).

Summary

Module	Score	Confidence
Introduction (questions: a06-a08)	0.00	1.00
Establishment (questions: a09-a10)	1.00	1.00
Spread (questions: a11-a12)	0.50	1.00
Environmental impact (questions: a13-a18)	0.50	1.00
Cultivated plants impact (questions: a19-a23)	0.17	1.00
Domesticated animals impact (questions: a24-a26)	0.50	1.00
Human impact (questions: a27-a29)	0.63	1.00
Other impact (questions: a30)	0.50	1.00
Invasion (questions: a06-a12)	0.50	1.00
Impact (questions: a13-a30)	0.63	1.00
Overall risk score	0.31	
Category of invasiveness	moderately 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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