



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

### QUESTIONNAIRE

#### A0 | Context

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

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

first name and family name

1. Dagny Krauze-Gryz
2. Jerzy Romanowski – external expert
3. Wojciech Solarz

acomment01.	Comments:	degree	affiliation	assessment date
		(1) dr	Faculty of Forestry, Warsaw University of Life Sciences - SGGW	22-01-2018
		(2) dr hab.	Faculty of Biology and Environmental Sciences, Cardinal Stefan Wyszyński University, Warsaw, Poland	31-01-2018
		(3) dr	Institute of Nature Conservation, Polish Academy of Sciences in Cracow	26-02-2018

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

nazwa polska: Wiewiórka czarna  
nazwa łacińska: ***Sciurus niger*** Linnaeus, 1758  
English name: Fox squirrel

acommm02.	Comments:		
	Polish name (synonym I)	–	Polish name (synonym II)
	Latin name (synonym I)	–	Latin name (synonym II)
	English name (synonym I)	Eastern Fox Squirrel	English name (synonym II)

**a03. Area under assessment:**

**Poland**

acommm03.	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
- alien, present in Poland in the environment, established

aconff01.	Answer provided with a	low	medium <b>X</b>	high	level of confidence
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acommm04.	Comments:
	According to the UNEP-WCMC report (2010 - P), fox squirrels used to be sold in many European countries. Poland was not covered by this survey. Currently, trade and breeding of this species is restricted (Regulation of the European Parliament and of the Council (EU) no. 1143/2014 of 22 October 2014 - I), but it is possible that individuals of this species are still traded/exchanged/reared.

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

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

acommm05.	Comments:
	<i>Sciurus niger</i> can potentially compete with the native squirrel <i>Sciurus vulgaris</i> , affect birds by eating their eggs and chicks, as well as compete for food at feeders. The species can also damage trees (bark stripping) and eat seeds, affecting both timber production and the regeneration of forests. <i>Sciurus niger</i> is a host to many parasites and pathogens, including those dangerous to wild native animals, humans and domesticated animals (e.g. SQFV, West Nile fever, rabies). It can damage cables and buildings.

## A1 | Introduction

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

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

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

aconf02.	Answer provided with a	low	medium	high <b>X</b>	level of confidence
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acommm06. Comments:  
*Sciurus niger* does not occur in countries neighbouring Poland or other European countries in natural environments (Linzey et al. 2016 – B, UNEP-WCMC 2010 – P). The probability of establishing a population of this species in Europe is very low, especially considering the existing restrictions on the breeding of invasive species. Therefore, there is no probability of its self-propelled expansion.

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

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

aconf03.	Answer provided with a	low	medium	high <b>X</b>	level of confidence
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acommm07. Comments:  
 Unintentional introduction of the species into new areas has not been reported. The species has increased its range of occurrence by natural expansion or as a result of intentional introductions (UNEP-WCMC 2010 – P).

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

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

aconf04.	Answer provided with a	low	medium <b>X</b>	high	level of confidence
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acommm08. Comments:  
 Bertolino (2009 – P) reported 42 introductions of the fox squirrel into different US states and two into Canada. Palmer et al. (2007 – P) reported 9 introductions into US states and one into Ontario (Canada). Most of the introductions (37 out of 44) resulted in the formation of a population increasing its size (Bertolino 2009 – P). Even the introduction of a small number (<20) of individuals may result in the formation of a population (Wood et al. 2007 – P). Probability that a released pair of individuals of *Sciurus* genus will establish a new, viable population is higher than 50% and rises with the number of released animals (Bertolino 2009 – P). Fox squirrels used to be sold and reared in Europe (UNEP-WCMC 2010 – P), possibly in Poland as well, as gray squirrels were (Krauze and Gryz 2012 – P). Currently, their breeding is significantly restricted. However, it is not impossible that individuals of this species are still illegally traded/exchanged. In the worst case scenario, we can expect more than 1, but no more than 10 cases of release/escape of the fox squirrel from captivity per decade.

## A2 | Establishment

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

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

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

aconf05.	Answer provided with a	low	medium	high <b>X</b>	level of confidence
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acomm09.	Comments: <i>Sciurus niger</i> occurs in most of the eastern areas of the United States, parts of Canada, and in Mexico (Linzey et al. 2016 – B). The species tolerates a wide range of temperatures (Koprowski and Doumas 2011 – I). It is assumed that the mean annual temperature should be between 8 and 23 degrees Celsius, the mean maximum temperature in the warmest month between 23 and 41 degrees, and the mean lowest temperature in the coldest month between -22 and 7 degrees. It should therefore be concluded that the climate of Poland, especially in the west and south of the country, is suitable for the fox squirrel. Introductions of fox squirrel to many US states and into Canada were successful (Palmer et al. 2007, Bertolino 2009 – P), including in areas with climatic conditions similar to those in Poland. Considering the above, the climate of Poland is optimal for the establishment of this species.
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**a10.** Poland provides **habitat** that is

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

aconf06.	Answer provided with a	low	medium	high <b>X</b>	level of confidence
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acomm10.	Comments: The species lives in many types of forests, riverside woodlands, mosaics of woodlands and agricultural areas, urban areas, and other areas transformed by human activity (Hoffmann et al. 1969, Burt and Grossenheider 1976, Allen 1982, King et al. 2010 – P). The species has the highest population density in deciduous and mixed forests formed by trees providing a rich food base (oak, hickory, pine) (Koprowski 1994 – P). In Poland, about 50% of the forest area is in forest habitats; mixed forests are grown instead of pine and spruce monocultures, the share of deciduous forests is increasing, the share of deciduous tree species is increasing, including oak, ash, maple and hornbeam (State Forests 2016 - I), which are species offering attractive energy-rich seeds. The fox squirrel is well adapted to altered ecosystems (e.g. agricultural) (Greene and McCleery 2017 – P). It also lives in transition zones between forests and open areas (prairies, King et al. 2010 – P), as well as in tree stands surrounded with arable fields (Allen 1982 – P). It shows great tolerance to anthropogenic transformations of the environment (Salsbury et al. 2004 – P), and is well adapted to urban areas (Mc Cleery et al. 2007, Salsbury 2008 – P). It can therefore be assumed that the availability of suitable habitats for the species in Poland is high. In addition, the fox squirrel may use food provided by humans (peanuts, dog food, leftovers in rubbish bins), which is especially important during periods of food shortage (Ortiz and Muchlinski 2015 – P).
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### A3 | Spread

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

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

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

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

aconf07.	Answer provided with a	low	medium	high <b>X</b>	level of confidence
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acomment11. Comments:  
Spread of populations (Data type B)  
The fox squirrel has the capacity to disperse successfully by natural means (King et al. 2010 – P). It is not sensitive to habitat fragmentation (Salsbury 2008 – P). It can travel across large open areas (Wright and Weber 1979 – P), and can disperse via ecological corridors along watercourses (Wright and Weber 1979, King et al. 2010 – P), engineering structures such as bridges (Wright and Weber 1979 – P), and cabling systems (King et al. 2010 – P). The fox squirrel spreads to the west of the US, using corridors along watercourses, colonizing urban areas and areas forested with deciduous trees (Geluso 2004 – P). The spread of this species has been estimated at 0.44-3.44 km/year in Los Angeles (King et al. 2010 – P), and 6.84 km/year (Clayton et al. 2015 – P). Recent reports reveal the spread of this species in Los Angeles at a rate of 1.5-3.0 km/year (Garcia and Muchlinski 2017 – P). The longest reported distance of natal dispersal was 64 km (King et al. 2010 – P).

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

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

aconf08.	Answer provided with a	low	medium <b>X</b>	high	level of confidence
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acomment12. Comments:  
Assuming that the fox squirrel becomes established in Poland, translocations to new sites will be possible. Squirrels are appealing animals that raise positive feelings in people, so humans can significantly contribute to the dispersal of these animals into new sites (Baiwy et al. 2015 – I). King (2010, after Clayton et al. 2015 – P) reported many cases of intentional dispersal of squirrels in Los Angeles; problematic individuals were captured and released in parks and on golf courses, which led to a significant increase in their range of occurrence. Similar conclusions were reached by Garcia and Muchlinski (2017 – P). Considering the current restrictions on breeding the fox squirrel, more than one case is expected, but no more than 10 such 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:

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

aconf09.	Answer provided with a	low	medium	high	level of confidence
			<b>X</b>		

acomment13. Comments:  
 Like other squirrels, (Newson et al. 2010 – P) *Sciurus niger* may have a negative impact on birds through predation. It is known that the diet of squirrels includes animal food (insects, eggs and chicks) (Koprowski 1994 – P). However, no detailed data on this subject are available in the literature (Baiwy et al. 2015 – I). Because squirrels feed on tree seeds, also contributing to their dispersal, they can, through herbivory, affect the age structure and species composition of forests (Baiwy et al. 2015 – I). For example, in pine forests of the south-eastern US, the fox squirrel can strongly affect seed production (>90%) by eating flowers and seeds (Koprowski 1994, Steele et al. 2001, Steele et al. 2005, Steele 2008 – P). Bark stripping is a common behaviour, especially during periods of food shortage. This was noted on elm, poplar and Ohio buckeye in different states of the US (Baiwy et al. 2015 – I). There are no exact estimates of the scale of bark stripping, but it seems that the impact of *Sciurus niger* is less significant than that of other squirrel species (Palmer et al. 2007, Bertolino 2009 – P). If *Sciurus niger* spreads across Poland, a slight decline in the population of birds can be expected (including passerine species of special concern), as well as a locally significant impact on woodstands (e.g. formed by beech, oak and other trees).

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

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

aconf10.	Answer provided with a	low	medium	high	level of confidence
		<b>X</b>			

acomment14. Comments:  
*Sciurus niger* has a negative impact on squirrel species native to North America (*Sciurus griseus*, *Tamiasciurus douglasii*, *S. alberti*) through competition for resources (Van der Merwe et al. 2005 – P, Koprowski and Doumas 2011, Baiwy et al. 2015 – I). Potential coexistence with other species of squirrels depends on the quality of the habitat (Van Der Merwe et al. 2005 – P). In some areas of California, *Sciurus niger* displaced native squirrel *Sciurus carolinensis* (Muchlinski et al. 2009 – P). The fox squirrel occupies a similar environmental niche as the grey squirrel. They have similar food preferences, and use similar shelters (Steel and Koprowski 2001 – I). On one hand, fox squirrels limit the access of grey squirrels to abundant food sources, but on the other hand grey squirrels can find alternative food (Baiwy et al. 2015 – I). Because in none of the areas fox squirrels coexist with red squirrels, it is difficult to assess their impact on this

species. However, it can be assumed that fox squirrels pose a threat to red squirrels (Baiwy et al. 2015 – I). If the fox squirrel spreads on a large scale, it may cause a locally significant decline in the population of the red squirrel. Fox squirrels may also compete with birds for food in feeders, which can be important especially in urban areas (Krause et al. 2010, Pennisi and Vantassel 2012 – I).

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

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

aconf11.	Answer provided with a	low	medium	high <b>X</b>	level of confidence
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acomment15. Comments:  
There are no data indicating the possibility of the fox squirrel interbreeding with other species of squirrels (Baiwy et al. 2015 – I).

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

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

aconf12.	Answer provided with a	low	medium	high <b>X</b>	level of confidence
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acomment16. Comments:  
Fox squirrels can transmit viral diseases (Pinger et al. 1975, Bewick et al. 2016 – P) and bacterial diseases, and are hosts to endo- and ectoparasites (Coyner et al. 1996, Foley et al. 2008, Goldberg et al. 2014 – P) (41 different pathogens and parasites have been identified) (Najberek 2018 – N)). The prevalence of West Nile fever (on the OIE list), and endo- and ectoparasites is high in the population of this species. In contrast, the prevalence of rabies (OIE list), cholera and equine encephalitis (OIE list) is low (Baiwy et al. 2015 – I). A case of rabies in the fox squirrel was reported from California (Cappucci et al. 1972 – P). The fox squirrel may also be an intermediate host for the nematode *Balisascaris procyonis* (Samuel et al. 2001 – P, Baiwy et al. 2015 – I), which in areas occupied by raccoons (its definitive host) may contribute to the spread of this dangerous parasite. According to Baiwy et al. (2015 – I) the fox squirrel can transmit 6 different viruses (with high frequency only for the Western Nile virus), 4 bacterial diseases (tularemia - OIE list, cholera, leptospirosis, Lyme disease), dermatophytosis (*Sporothrix schenckii*), 6 endoparasites (including *Balisascaris procyonis*, *Strongyloides robustus*, *Heligmodendrium hassalli*) and many ectoparasites. *Sciurus niger* is an important reservoir of Lyme disease (Roy et al. 2017 – P). The species was also found to carry SQFV (squirrel fibroma virus), a virus frequently infecting grey squirrels (may cause epizootics), similar to the one that causes the rapid displacement of the red squirrel by the grey squirrel in the United Kingdom (Wilcoxon et al. 2015 – P). *Strongyloides robustus* (an alien nematode species) found in the fox squirrel may pose a threat to the native red squirrel: the transmission of this parasite from the grey squirrel *Sciurus carolinensis* to the red squirrel has been reported (Romeo et al. 2014, 2015 – P). Because the fox squirrel and the red squirrel do not occur in the same areas, it is difficult to assess its potential impact through the transmission of pathogens or parasites. However, there is a lot of evidence that competition between these species may strongly depend on the prevalence and transmission of pathogens and parasites.

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

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

aconf13.	Answer provided with a	low	medium	high	level of confidence
			<b>X</b>		

acomment17. Comments:  
No data are available on the negative impact of the fox squirrel on abiotic properties of ecosystems.

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

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

aconf14.	Answer provided with a	low	medium	high	level of confidence
			<b>X</b>		

acomment18. Comments:  
Because squirrels feed on tree seeds, also contributing to their dispersal, they can, through herbivory, affect the age structure and species composition of forests (Baiwy et al. 2015 – I). Feeding on seeds can also affect the regeneration of forests (Blythe et al. 2015 – P). On the other hand, by burying seeds in open areas squirrels may promote natural succession (Stapanian and Smith 1986 – P). Bark stripping, a frequent behaviour during periods of food shortage, may reduce the resistance of forests and even cause their die back. If the species spreads on a wide scale in the natural environment, we can expect difficult to reverse changes (in the short term perspective) in the processes taking place in habitats that are not classified as habitats of special concern (forests, including managed forests).

## A4b | Impact on the cultivated plants domain

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

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

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

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

aconf15.	Answer provided with a	low	medium	high	level of confidence
			<b>X</b>		

acomment19. Comments:  
*Sciurus niger* eats many plant and animal foods, including seeds, nuts, tree bark, as well as crops: cereal grains, maize, soy, nuts and fruits (Baiwy et al. 2015 – I). Because squirrels feed on tree seeds, they can affect the age structure and species composition of forests (Koprowski 1994, Steele et al. 2001, Steele et al. 2005, Steele 2008 – P, Baiwy

et al. 2015 – I). Bark stripping may reduce the quality of timber and cause die back of trees. There are no exact estimates of the scale of bark-stripping, but it seems that the impact of the fox squirrel is less significant than that of other squirrel species (Palmer et al. 2007, Bertolino 2009 – P). There are reports of damage caused by foraging and bark stripping by this species in pine plantations and orchards (Jackson 1994 – P), cereal crops (Burt and Grossenheider 1976 – P), and home gardens (Koprowski 1994 – P). In California, where *Sciurus niger* was introduced, it is seen as a serious pest (the largest of the four species of squirrels living there) of crops in urban and suburban areas. It causes damage in home gardens, but also in commercial crops (Baldwin 2016, Salmon et al. 2006 – I). Squirrels eat seeds, fruits, strip bark, and dig out plant bulbs (Pierce 2012 – I). They feed on maize, nuts (pecans, walnuts), avocado, oranges and strawberries (Salmon et al. 2006 – I). Losses are usually estimated at a medium level (review in Baiwy et al. 2015 – I), but may be high on a local scale (Frey et al. 2013 – P). If *Sciurus niger* is widely spread in Poland, we can expect that it may impact 1/3 to 2/3 of cultivated plant targets (probability – medium), and in the worst case scenario the health of plants or the yield of a single crop will be reduced by more than 20% (effect – high).

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

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

aconf16. Answer provided with a 

low	medium	high
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 level of confidence

acomm20. Comments:  
*Sciurus niger* is not a plant species.

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

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

aconf17. Answer provided with a 

low	medium	high
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 level of confidence

acomm21. Comments:  
*Sciurus niger* is not a plant species.

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

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

aconf18. Answer provided with a 

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

acomm22.

Comments:

Through feeding on seeds and damaging trees it can cause changes in the species composition of crops, which may result in changes in the composition of flora and fauna. We can expect that it may impact less than 1/3 to of cultivated plant target (probability – low) , and in the worst case scenario the health of plants or the yield of a single crop will be reduced by about 5% to 20% (result – medium).

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

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

aconf19.

Answer provided with a

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

acomm23.

Comments:

Experimental studies demonstrated that *Sciurus niger* is a potential vector of fungal disease of oaks (*Ceratocystis fagacearum*), included in the A1 EPP0 list. Symptoms of the disease include discolouration of leaves, their wilting, defoliation, and eventually the death of the tree (Himelick and Curl 1955 – P). No data are available on disease transmission under natural conditions.

### A4c | Impact on the domesticated animals domain

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

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

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

aconf20.

Answer provided with a

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

acomm24.

Comments:

There are no reports on the effects of *Sciurus niger* on production animals or domestic animals through predation.

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

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

aconf21. Answer provided with a 

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

acomm25. Comments:  
A fox squirrel when attacked by a dog or cat may inflict painful bites. If this species spreads in Poland, we can expect the frequency of such incidents to range from 1 to 100 per 100,000 animals per year, and the effect will be small - bitten animals will recover quickly.

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

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

aconf22. Answer provided with a 

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

acomm26. Comments:  
*Sciurus niger* transmits rabies (Cappuccini et al. 1972, Leitheser 2013 – I). This disease is incurable, and its cases must be reported to the relevant authorities. Although squirrels are rare carriers of rabies, the risk of contact between an infected animal and a dog or cat cannot be ruled out. There are also two diseases that are transmitted by mosquitoes (WNV, West Nile virus and VEE, virus of equine encephalitis (Leitheser 2013 - I, Weaver et al. 1997 – P)), which are reported in squirrels and create a hazard to production and domestic animals: horses, rabbits, cats and dogs.

## A4d | Impact on the human domain

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

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

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

aconf23. Answer provided with a 

low	medium	high
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 level of confidence

acomm27. Comments:  
*Sciurus niger* is not a parasitic species.

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

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

aconf24. Answer provided with a 

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

acomm28. Comments:  
Fox squirrels may inflict painful bites to people visiting parks and trying to feed the animals (e.g. with peanuts). If this species spreads in Poland, we can expect the frequency of such incidents to range from 1 to 100 cases per 100,000 people per year (probability – medium). However, the bites will not cause absenteeism from work or permanent disabilities (effect – 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
- very high

aconf25. Answer provided with a 

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

acomm29. Comments:  
Fox squirrels can transmit viral diseases (Pinger et al. 1975, Bewick et al. 2016 – P) and bacterial diseases, and are hosts to endo- and ectoparasites (Coyner et al. 1996, Foley et al. 2008, Goldberg et al. 2014 – P) (41 different pathogens and parasites have been identified) (Najberek 2018 – N)). *Sciurus niger* transmits rabies (Cappuccini et al. 1972 – P), a disease deadly for humans. If the species spreads in Poland, there is a potential risk of rabies transmission. An additional hazard comes from the fact that squirrel bites may not be considered by injured persons as hazardous to health, which may delay necessary medical interventions (administration of serum). There are also two important diseases transmitted by mosquitoes (WNV, West Nile virus and VEE, virus of equine encephalitis, a potentially deadly disease). In addition, upon direct contact with the species, humans may contract dermatophytosis, especially in urban areas, where contacts of this species with humans may be frequent. *Sciurus niger* may also transmit tularaemia (Baiwy et al. 2015 – I, Bewick et al. 2016 – P). *Sciurus niger*, like other rodents, is a reservoir of Lyme disease (Roy et al. 2017 – P).

## A4e | Impact on other domains

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

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

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

aconf26. Answer provided with a 

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

acomm30. Comments:  
Like all species of arboreal squirrels, the fox squirrel can damage cables (when travelling along them and biting them), enter buildings, damage insulation, build nests in attics (Pierce 2012, Baldwin 2016 – I), and damage irrigation systems and car engines (Krause et al. 2010 – I). We can expect more than 1, but no more than 100 incidents like this per

100,000 structures per year (probability – medium), and the effects of such incidents should be reversible in part (result – result).

## A5a | Impact on ecosystem services

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

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

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

aconf27. Answer provided with a 

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

acommm31. Comments:  
The fox squirrel can affect the wood industry. By damaging the bark of trees it causes a decrease in the quality and quantity of produced timber. As a pest in horticulture, it can affect the production of fruits and nuts. By feeding on cereals (e.g. maize) it can have a negative effect on food production. In addition, by transmission of pathogens and parasites to livestock, it can affect animal production.

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

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

aconf28. Answer provided with a 

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

acommm32. Comments:  
Because the fox squirrel transmits pathogens and parasites, it affects biological regulation (regulation of zoonoses). In addition, it affects the pollination of flowers and dispersal of seeds, both in the positive (natural regeneration) and negative context (feeding on flowers and seeds).

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

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

aconf29. Answer provided with a 

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

acomm33.

Comments:

The fox squirrel may be perceived by some people as an appealing and desirable element of the natural environment. However, due to the fact that its presence may cause a decline in the number or total extinction of the red squirrel, and also cause damage to forests, gardens and buildings, its presence may also be assessed as significantly negative. Therefore, the overall effect of this species was assessed as neutral.

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

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

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

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

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

aconf30.

Answer provided with a

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

acomm34.

Comments:

The introduction of the species will be possible mainly due to intentional human actions, regardless of climate change. Climate change is unlikely to influence the capacity of the fox squirrel to overcome geographical barriers.

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

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

aconf31.

Answer provided with a

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

acomm35.

Comments:

The fox squirrel can become established in Poland even under the present climate. However, it seems that climate warming (milder winters, higher seed production of deciduous tree species) will increase the probability of establishment.

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

- decrease significantly
- decrease moderately

- not change
- increase moderately
- increase significantly

aconf32. Answer provided with a 

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

acomm36. Comments:  
The fox squirrel is able to spread in Poland even under the present climate. However, it seems that under a warmer climate the probability of spread will increase, among other reasons, due to the greater food base). Milder winters will promote the colonization of new areas by the fox squirrel. Milder winters may result in higher winter survivability and higher share of deciduous tree species (i.e. oaks) will result in higher food availability (i.e. acorns).

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

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

aconf33. Answer provided with a 

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

acomm37. Comments:  
Because the milder climate can contribute to an increase in the population size and range of this species, we can also expect a stronger negative impact of the fox squirrel on the natural environment.

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

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

aconf34. Answer provided with a 

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

acomm38. Comments:  
Because the milder climate can contribute to an increase in the population size and range of this species, we can also expect a stronger negative impact of the fox squirrel on cultivated plants.

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

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

aconf35. Answer provided with a 

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

acomm39.

Comments:

Because the milder climate can contribute to an increase in the population size and range of this species, we can also expect a stronger negative impact of the fox squirrel on domesticated animals.

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

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

aconf36.

Answer provided with a

low	medium <b>X</b>	high	level of confidence
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acomm40.

Comments:

Because the milder climate can contribute to an increase in the population size and range of this species, we can also expect a stronger negative impact of the fox squirrel on the human domain.

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

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

aconf37.

Answer provided with a

low	medium <b>X</b>	high	level of confidence
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acomm41.

Comments:

Because the milder climate can contribute to an increase in the population size and range of this species, we can also expect a stronger negative impact of the fox squirrel on other domains.

## Summary

Module	Score	Confidence
Introduction (questions: a06-a08)	0.17	0.83
Establishment (questions: a09-a10)	1.00	1.00
Spread (questions: a11-a12)	0.63	0.75
Environmental impact (questions: a13-a18)	0.50	0.58
Cultivated plants impact (questions: a19-a23)	0.58	0.33
Domesticated animals impact (questions: a24-a26)	0.42	0.67
Human impact (questions: a27-a29)	0.63	0.50
Other impact (questions: a30)	0.50	0.50
<b>Invasion (questions: a06-a12)</b>	<b>0.60</b>	<b>0.86</b>

Impact (questions: a13-a30)	0.63	0.52
Overall risk score	0.37	
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.

acom42. Comments:  
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