



Harmonia^{+PL} – procedure of 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

Dagny Krauze-Gryz

first name and family name

Wojciech Solarz

first name and family name

.....

acomment1.	Comments:	degree	affiliation	assessment date
		dr	Szkoła Główna Gospodarstwa Wiejskiego w Warszawie, Wydział Leśny	21-12-2017
		degree	affiliation	assessment date
		dr	Instytut Ochrony Przyrody PAN w Krakowie	21-12-2017
		degree	affiliation	assessment date
		Prof.	Institute of Nature Conservation Polish Academy of Sciences, Kraków	22.12.2017

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

Polish name

wiewiórka szara

Latin name

Sciurus carolinensis Gmelin, 1788

English name

Grey squirrel

acommm02.

Comments:

Polish name (synonym I)

Polish name (synonym II)

.....
Latin name (synonym I)

.....
Latin name (synonym II)

.....
English name (synonym I)

.....
English name (synonym II)

Eastern grey squirrel

Gray squirrel

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

x

aconf01.

Answer provided with a

low	medium	high
		x

level of confidence

acommm04.

Comments:

in „Comments” (questions acomm04-41) experts should provide **explanations for their answers and list sources of information**. In particular, Comments should explain the decision in cases when data is lacking, incomplete or uncertain, or if the available information is contradictory.

Source of the information should also be provided here, with author and year of publication; data sources should be divided into P – published results of scientific research; B - databases; N – unpublished data; I - other; A – author’s own data. Detailed information (including full bibliographic record) should be provided at the end of the questionnaire "Data sources". Guidance on data sources citation is available at the end of the *Harmonia*^{PL} – procedure of negative impact risk assessment for invasive alien species and potentially invasive alien species in Poland.

There is no evidence that the species is present in the wild in Poland. However, grey squirrels might be (although illegally now) bred, sold and kept as pets (Krauze and Gryz 2012 – P) and it cannot be excluded that some individuals were/will be released into the natural environment.

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

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

acommm05.

Comments:

The Grey squirrel is the species of a very wide range of impacts. It competes with the Red squirrel (also because it is a disease vector) leading to decrease of population (or extinction) of the native species. It is also a predator of bird nests, it competes with birds for breeding sites and food. Bark stripping affects whole forest ecosystems, resulting in financial loss when damaged trees die or the wood quality is decreased. It is also a garden pest and can damage human properties. Squirrels can bite when offered food. In most cases, the wounds will not be serious. However, in very rare cases squirrel can be a vector of rabies.

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

aconf02.

Answer provided with a

low	medium	high
		x

level of confidence

acommm06.

Comments:

The Grey squirrel does not occur in wild in the neighbouring countries. In Europe wild living populations can be found in Great Britain, Ireland and in Italy (Cassola 2016 - B, <https://www.cabi.org/isc/datasheet/49075> - B, European Alien Species Information Network EASIN, <https://easin.jrc.ec.europa.eu/Documentation/Baseline-B>).

Nevertheless, in the long perspective, the colonisation of Eurasia is ultimately only a matter of time (Bertolino et al. 2008 - P).

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

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

aconf03.

Answer provided with a

low	medium	high
		x

level of confidence

acomm07.

Comments:

No accidental introduction has ever been noted. Grey squirrels have always been released into the wild intentionally (UNEP-WCMC 2010 - I).

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

low

medium

high

x

aconf04.

Answer provided with a

low	medium	high
	x	

level of confidence

acomm08.

Comments:

Grey squirrels were (Krauze and Gryz 2012 - P) and probably are still now rarely bred in Poland. These days breeding of the species is significantly restricted by legal regulations. However, illegal trade/exchange of animals kept as pets cannot be excluded. Until now no case of the species release into wild has been registered. However, it must be kept in mind that in Italy pet animals released into wild are probably one of the main reasons for the spread of the species into new areas: ‘There is a strong suspicion that some of the recent nuclei in Lombardy (10 new reports in last 3 years), often found in parks, are the result of voluntary introductions to get rid of individuals of the Grey squirrels detained in captivity as pets’ (Martinoli et al. 2010 - 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

optimal for establishment of the *Species*

x

aconf05.

Answer provided with a

low	medium	high
		x

level of confidence

acomm09.

Comments:

According to data in the IUCN Red List (Cassola 2016 - B), the native range of the Grey squirrel covers east USA and adjacent south Canada. The range was enlarged to the west as a result of introductions (Teaford 1986 - I, Koprowski 1994 - I). Therefore, it can be assumed that climatic conditions in Poland will be optimal for the Grey squirrel. The model of climate suitability shows that the whole area of Poland offers climatic conditions that are sufficient for the species (Di Febbraro et al. 2013 - P).

Experiences in other countries show that a few individuals (below 10) can be enough to establish a viable population. Likelihood that the release of one pair of *Sciurus* species would establish a new population was higher than 50% (Bertolino 2009 - P).

In Ireland one introduction of 6 animals was successful and in Italy three out of four introductions of 4 to 6 individuals led to establishment of a viable population (review in Bertolino 2008 - P).

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

non-optimal

sub-optimal

optimal for establishment of the *Species*

x

aconf06.

Answer provided with a

low	medium	high
		x

level of confidence

acommm10.

Comments:

The Grey squirrel occurs most commonly in hardwood forests where their primary food is nuts and samaras of deciduous trees and shrubs (Moller 1983 - P). It is highly adaptable and commonly found in most types of woodlands as well as parks, gardens and urban environments (Lurz et al. 2001 - P).

In Polish forests, the share of other (mostly broadleaved) tree species has been systematically increasing. The foresters do not practice monocultures anymore, and they adjust the species composition of stands to that occurring naturally in a particular area. More and more broadleaved species are planted, including oaks, ashes, maples, sycamores, hornbeams (Polskie Lasy - I). It can be concluded, therefore, that vast areas of very suitable habitats are available in Poland.

A3 | Spread

Questions from this module assess the risk of the *Species* to overcome dispersal barriers and (new) environmental barriers within Poland. This leads 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 different from range expansions that stem from new introductions (covered by the *Introduction* module).

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

very low

low

medium

high

very high

x

aconf07.

Answer provided with a

low	medium	high
		x

level of confidence

acomm11.

Comments:

The sensivity of the Grey squirrel to fragmentation is relatively low as compared to other species from the genus), it is able to traverse most of habitats. It can disperse in mosaic landscape, using river valleys and woodlots (as well row of trees) (Stevenson et al. 2013 - P).

Data on the expansion from a single source (Type A)

The longest known distance of movement by the Grey squirrel is approx. 100 km. However, most juveniles as well as adults do not move further than 10-20 km (Sharp 1959 in Koprowski 1994 - I). Dispersal rate depends on the habitat, it is lower in discontinuous landscape and squirrel can use stepping-stone habitats, colonising more than 1 km between woodlands (Bertolino et al. 2014 - P).

Data on the population expansion (Type B)

Spread dispersal documented in the literature is various: less than 1 km per year (in Piedmont, Italy, Bertolino et al. 2014 - P), 1.94 km in Ireland (O'Teangana et al. 2000 - P), 7.66 in England (Okubo et al. 1989 - P). Dispersal rate is higher in big, continuous forest areas and natural river valleys (Bertolino et al. 2014 - P). For example, in the case of Piedmont population (Italy) dispersal rate was low in the first period (1948-1970) and the population range increased by 1.1 km²/year. Dispersal was hindered by vast agricultural areas, with scarce, fragmented forests. In the next period expansion rate increased to 10-20 km²/year when animals could move along riparian corridors. When population reached continuous broad-leaved forests, the expansion rate increased to 250 km²/year (Bertolino and Genovesi 2003 - P).

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

low

medium

high

x

aconf08.

Answer provided with a

low	medium	high
	x	

level of confidence

acomm12.

Comments:

Assuming that the Grey squirrel colonize Poland, translocations from existing populations to new places are possible (similarly as in Italy) (Martinoli et al. 2010 - P).

A4a | Impact on 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. 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 on the local scale: limited decline is considered as a (mere) drop in numbers; severe decline is considered as a (near) extinction. Similarly, limited ecosystem change is considered as transient and easily reversible; severe change is considered as persistent and hardly reversible.

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

inapplicable

low

medium

high

x

aconf09.

Answer provided with a

low x	medium	high
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level of confidence

acommm13.

Comments:

Predation

According to Mayle and Smith (ISSG 2005 - B), grey squirrels predate nests of a wide range of bird species both in North America and Europe. Species most at risk are those with open nests in the canopy, although birds nesting on the ground and in the understorey are also vulnerable. In the introduced European range of the Grey squirrel, different publications defined it as a bird predator for chicks and eggs (Moller 1983 - P, Hewson and Fuller 2003 - P, UNEP WCMC 2010 - I). During the last forty years, while the Grey squirrel abundance in the UK was increasing, woodland birds seem to have markedly declined (Hewson and Fuller 2003 - P) and some of them are now on red or amber list of 'Birds of Conservation Concern' in the UK. Now absent from a large part of the United Kingdom, the Red squirrel has also been considered as a bird predator before it became extinct in many areas but it occurred at lower densities than the Grey squirrel (Macdonald and Barrett 1993 - P, Newson et al. 2010 - P) and could therefore be historically associated to a lesser impact.

There are studies that suggest diverse influence of the Grey squirrel on birds (Newson et al. 2010 - P). Their study revealed that squirrel numbers were significantly higher in sites with the Hawfinch (*Coccothraustes coccothraustes*) and Lesser spotted woodpecker (*Dendrocopos minor*) declines, but the data were insufficient to detect any correlation. However, Amar et al. (2006 - I) mainly attributed these bird declines to the woodland structure changes (in wintering grounds especially).

According to Newson et al. (2010 - P), the common Blackbird (*Turdus merula*) and the Eurasian collared dove (*Streptopelia decaocto*) were, for instance, undergoing more nest failure at the egg stage when the Grey squirrel abundance was high, suggesting predation during that phase. Nevertheless, these bird species abundance did not decrease during the study period. In addition, the Eurasian jay (*Garrulus glandarius*) was presenting the highest decrease in growth rate as squirrel abundance increased, with an estimated decline of 1.7 % in growth rate for each Grey squirrel recorded (Newson et al. 2010 - P). Finally, Newson et al. (2010 - P) could not exclude that some bird species populations had been depressed in particular sites where grey squirrels were abundant, but they mainly explained these facts by the habitat quality variability.

Herbivory

Grey squirrels damage trees by bark-stripping (Kenward and Parish 1986 - P, Kenward et al. 1992 - P, Mayle et al. 2003 - I, Gurnell et al. 2008 - P). Damages at the tree base (up to 1 m height) are most common in oaks and many coniferous species, damages over 1 m height and below canopy are common in sycamore, beech, birch, larch, lodgepole pine. Damage may also allow fungal or microparasite invasion and most damaged trees die or get broken (Dagnall et al. 1998 after Bruemmer et al. 2000 - P). Up to 5% of damaged trees will die (Mayle et al. 2007 - I). Trees in the age class 10-40 years are damaged most often, mostly between May to July (review in: Bruemmer et al. 1999 - P). In Great Britain the percent of forests subject to the Grey squirrel damage increased from 31% in the years 1947-1949 to 51% in the years 1995-1998 (Mayle and Broome 2013 - P).

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

low
medium
high

x

aconf10.

Answer provided with a

low	medium	high
		x

level of confidence

acommm14.

Comments:

Introduced many times into some European countries, the Grey squirrel drove the native European Red squirrel to extinction in areas of overlap, mainly because of the competitive exclusion principle (Bertolino 2009 - P). The range of the Grey squirrel is still progressing in the British Isles, Ireland and Italy, causing a continuous displacement of the Red squirrel (Kenward and Holm 1993 - P, Rushton et al. 2000 - P, Bruemmer et al. 2000 - P, Lurz et al. 2001 - P, O'Teangana et al. 2001 - P, Bertolino and Genovesi 2003 - P, Genovesi and Bertolino 2006 - P, Bertolino et al. 2008 - P, Ross 2008 - B, UNEP-WPMC 2010 - I).

Since the Grey squirrel expanded its range in the UK in the 1930s, the species colonized a big part of England, Wales, and the Scottish lowlands (Gurnell and Pepper 1993 - P) and progressively replaced the European Red squirrel (Bruemmer et al. 2000 - P, Tompkins et al. 2002 - P, UNEP-WCMC 2010 - I). By the end of the 20th century, the Red squirrel became extinct in southern England, except in some islands such as the Isle of Wight (Bruemmer et al. 1999 - P). A few isolated populations could still be found in suboptimal habitats (coniferous forests), which are not preferred by the Grey squirrel. The Grey squirrel has been actively fought to prevent its establishment. However, the Red squirrel population decline is still relevant today despite ongoing control efforts made since the 1950s by the British government, especially in northern England (Kenward and Parish 1986 - P, Gurnell and Lurz 1997 - P, Lurz et al. 1998 - P, Bruemmer et al. 2000 - P, Mayle et al. 2007 - I, Signorile and Evans 2007 - P).

The Red squirrel replacement also occurred in Italy with the fast expansion of the Grey squirrel near Turin and Genoa in 1946 and 1966, range of Red squirrel decreased in the years 1970-1990 by 46% and in the years 1990-1996 by 55% (Gurnell and Pepper 1993 - P, Wauters et al. 1997 - P, 2001 - P, Bertolino and Genovesi 2003 - P). The same situation was reported in Ireland, where the Red squirrel still remains widespread and locally abundant, except in two counties (Meath and Westmeath, north of Dublin) where its population decrease was concomitant with its longest co-existence with the Grey squirrel (O'Teangana et al. 2001 - P, UNEP-WCMC 2010 - I).

Several characteristics of the Grey squirrel have contributed to the replacement of the native Red squirrel in many areas, preventing their co-existence in a same habitat. The mechanism of interspecific competitive exclusion is not fully understood (UNEP-WCMC 2010 - I) but shows an overlap of activity patterns, space use and food supply utilization between both species in almost every stage of life (Wauters et al. 2002 - P, Gurnell et al. 2004 - P, Bertolino 2008 - P). The Grey squirrel also digests acorns more efficiently than the Red squirrel does (Bertolino 2008 - P). Because of food competition there are different factors affecting the Red squirrel: decrease of body growth, reproductive success and recruitment rate (enhanced by the juvenile emigration). Another important factor of interspecific competition, known as pathogen-mediated competition (Gurnell et al. 2006 - P) is the better resistance of the alien squirrel to the squirrel poxvirus while this virus has, most of the time, a lethal effect on red squirrels (Kenward and Holm 1993 - P, Rushton et al. 2000 - P, Bruemmer et al. 2000 - P, O'Teangana et al. 2001 - P, Tompkins et al. 2002 - P, Gurnell et al. 2004 - P, Bertolino et al. 2008 - P).

The Grey squirrel could also potentially compete with woodland birds for nest sites and food (Hewson and Fuller 2003 - P) and with the Common dormouse (*Muscardinus avellanarius*) for food access (Hewson et al. 2004 - P, ISSG 2005 - B). Grey squirrels use tree holes and nest boxes and may deter tawny owls (*Strix aluco*) and other birds from using

them (Gurnell et al. 2016 - P).

Other studies show that the presence of the Grey squirrel at bird feeders can diminish bird species number which use them (Bonnington et al. 2014 - P), which should be especially considered in urban habitats (where correlation between food provisioning and bird abundance as well as with breeding parameters was noted).

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

no / very low

low

medium

high

very high

x

aconf11.

Answer provided with a

low	medium	high
		x

level of confidence

acomm15.

Comments:

There are no premises to suspect hybridization of the Grey squirrel and the Red one.

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

very low

low

medium

high

very high

x

aconf12.

Answer provided with a

low	medium	high
		x

level of confidence

acomm16.

Comments:

In Italy, a new nematode species *Strongyloides robustus* was found in grey squirrels (Romeo et al. 2014 - P, 2015 - P). Red squirrels acquired *S. robustus* via spillover from the alien congener, which suggests that the invaders' presence may also indirectly affect infection by local parasites through mechanisms diverse than spill-back and linked to the increased competitive pressure to which red squirrels are subjected. These results indicate that the impact of the Grey squirrel on red squirrels may have been underestimated and highlight the importance of investigating variation in macroparasite communities of native species threatened by alien competitors. Red squirrels co-inhabiting with the Grey squirrels are more likely to be infected by gastrointestinal helminths (Romeo et al. 2015 - P).

The Grey squirrel is the host to the squirrel poxvirus (SQPV). The incidence of disease in red squirrels was related to the time since grey squirrels arrived in the area. Analysis of rates of decline in the Red squirrel populations in other areas showed that declines are 17–25 times higher in regions where SQPV is present in the Grey squirrel populations than in those where it is not (Rushton et al. 2006 - P).

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

acommm17. Comments:
There is no data on the Grey squirrel affecting abiotic properties of the ecosystem.

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	high
	x	

 level of confidence

acommm18. Comments:
Bark stripping (Kenward i Parish 1986 - P, Kenward et al. 1992 - P, Mayle et al. 2003 - P, Gurnell et al. 2008 - P) leads to considerable damage to trees – breakage, deformation, increase of pathogen (fungal) infection.
Proportion of high forest vulnerable to squirrel damage (age class 10-40 years) in GB was from 31% in the years 1947-1949 to 51% in the years 1995-1998 (Mayle and Broome 2013 - P).
Up to 5% of damaged trees will die and many more will have degraded timber through stem deformation, rot and broken tops. Oak, poplar, Scots pine, Norway spruce are particularly vulnerable to stem breakage (Mayle et al. 2007 - I, Mayle and Broome 2013 - P). Mayle (2004 - P) suggested that the Grey squirrel bark stripping could cause a lack of recruitment of trees into the canopy and have particular effects in semi-natural beech forests causing a loss of associated fungi and invertebrates. Therefore, the structure and composition of these forests could be affected by feeding on seeds and plant bulbs preventing their regeneration (ISSG 2005 - B). On the other hand, the Grey squirrel may have a positive impact on the seed dispersal by its scatterhoarder behaviour and, thus, contribute to woodland regeneration (Linzey et al. 2008 - B). For example, Laborde and Thompson (2009 - P) have shown that the Grey squirrel was the most important disperser of hazelnuts into the grassland in Derbyshire (UK).

A4b | Impact on cultivated plants domain

Questions from this module qualify the consequences of the *Species* on 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 plants targets through **herbivory or parasitism** is:

inapplicable	<input type="checkbox"/>
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very low

low

medium

high

very high

x

aconf15.

Answer provided with a

low	medium	high
	x	

level of confidence

acommm19.

Comments:

The Grey squirrel is an important pest to forestry (Review in Lurz et al. 2001 - P). Grey squirrels cause damage to broadleaved and coniferous woodlands, the damage is estimated at between £6 and £10 million per annum in Great Britain, [https://www.forestry.gov.uk/pdf/the_Grey-squirrels-policy-and-action-plan.pdf/\\$FILE/the_Grey-squirrels-policy-and-action-plan.pdf](https://www.forestry.gov.uk/pdf/the_Grey-squirrels-policy-and-action-plan.pdf/$FILE/the_Grey-squirrels-policy-and-action-plan.pdf) - I, Maye and Broome 2013 - P). In Italy up to 5% of poplar plantations suffered from bark stripping by the Grey squirrel (Signorile and Evans 2007 - P).

Squirrels can also have important impacts on agricultural crops, mainly profitable cereals such as maize (Signorile and Evans 2007 - P) and in Italy, the risk of damages to hazel plantations is also of concern (Currado et al. in press, after Schockert et al. 2013). Grey squirrels are also pests in gardens and orchards where they eat bulbs, fruit, vegetables, seeds, buds and also damage bark (review in: Palmer et al. 2008 - P, Grey squirrels - I).

a20. The effect of the *Species* on cultivated plants targets through **competition** is:

inapplicable

very low

low

medium

high

very high

x

aconf16.

Answer provided with a

low	medium	high

level of confidence

acommm20.

Comments:

The species is not a plant.

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

inapplicable

no / very low

low

medium

high

very high

x

aconf17.

Answer provided with a

low	medium	high
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level of confidence

acomm21.

Comments:

The species is not a plant.

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

very low

low

medium

high

very high

x

aconf18.

Answer provided with a

low	medium	high
	x	

level of confidence

acomm22.

Comments:

Damage from grey squirrels acts as a disincentive to the planting and management of valuable broadleaved and coniferous trees. It serves to limit diversity of woodland planting thereby reducing potential resilience to pests, disease and climate change (Policy and Action - I).

As tree species damaged by squirrels are planted less often, it results in changes to fauna and flora (Mayle 2005 - P), connected to certain forest species and habitats.

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

very low

low

medium

high

very high

x

aconf19.

Answer provided with a

low	medium	high
		x

level of confidence

acomm23.

Comments:

There is no data that would suggest that the Grey squirrel can transmit pathogens to plants.

A4c | Impact on 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

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very low

low

medium

high

very high

x

aconf20.

Answer provided with a

low	medium	high x
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level of confidence

acomment24.

Comments:

There is lack of data that would suggest that predation of the Grey squirrel can affect domestic animals.

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

x

aconf21.

Answer provided with a

low	medium x	high
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level of confidence

acomment25.

Comments:

Grey squirrels can bite when attacked by a dog or a cat (e.g. Express 2009 - I). Assuming that the species is widespread in Poland, we can expect between 1 to 100 such cases per 100 000 domestic animals per year. Bitten animals will probably 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

x

aconf22.

Answer provided with a

low	medium x	high
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level of confidence

acomment26.

Comments:

The Grey squirrel can carry rabies (Fishbein et al. 1986 - P). This illness is lethal. Although squirrels are not often infected with rabies, direct contact between an ill animal and a dog or a cat cannot be excluded.

A4d | Impact on 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	<input checked="" type="checkbox"/>
very low	<input type="checkbox"/>
low	<input type="checkbox"/>
medium	<input type="checkbox"/>
high	<input type="checkbox"/>
very high	<input type="checkbox"/>

aconf23. Answer provided with a

low	medium	high
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 level of confidence

acommm27. 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	<input type="checkbox"/>
low	<input type="checkbox"/>
medium	<input checked="" type="checkbox"/>
high	<input type="checkbox"/>
very high	<input type="checkbox"/>

aconf24. Answer provided with a

low	medium	high
	x	

 level of confidence

acommm28. Comments:
Grey squirrels can bite even when fed by people (The Guardian 2016 - 1). Assuming that the species is widespread in Poland, we can expect between 1 to 100 such cases per 100 000 people per year. However, bites will not be serious and will not lead absence from work.

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

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

aconf25.

Answer provided with a

low	medium	high
	x	

level of confidence

acomm29.

Comments:

The Grey squirrel can carry rabies (Fishbein et al. 1986 - P, Wścieklizna - I). Assuming that the species is widespread in Poland, rabies transmission needs to be considered, especially that squirrel bites and the associated risks can be ignored by people. This may lead to delay in necessary medical procedures (such as vaccination).

When bitten by the Grey squirrel, people can get infected with tularemia, sporotrichosis, squirrels are also hosts to plague (Gurnell et al. 2016 - P). People can also acquire fungal infections from grey squirrels (Lewis et al. 1975 - P), especially in urban habitats when direct contact is probable.

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

x

aconf26.

Answer provided with a

low	medium	high
	x	

level of confidence

acomm30.

Comments:

Grey squirrels can nest within the roof spaces of buildings, gaining entry through poorly maintained structures or by chewing at soffits or other parts of the roof. This will give access to the building for birds (i.e. jackdaws and pigeons). They can also gnaw at residential electric wiring which can lead to the risk of electrocution from touching exposed wires and the risk of fire (review in Gurnell et al. 2016 – P). Damage done by grey squirrels in properties (damage to furniture, ornaments, cables) is estimated to be GBP 5,128,274; while the cost of removing squirrels in buildings and other properties is estimated in GBP 1,914,555 (total damage + control GBP 7,042,829) (Williams et al. 2010 – I). Damage to buildings and other infrastructures is estimated at GBP 5,128,000 (Williams et al. 2010 – I).

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

x

neutral
 moderately positive
 significantly positive

aconf27. Answer provided with a

low	medium	high
		x

 level of confidence

acommm31. Comments:
 Bark stripping has influenced woodland management practices in England, but not in Italy. This is probably related to different management practices in the two countries, with more natural forests in Italy (Kenward and Parish 1986 – P, Kenward et al. 1992 – P, Currado 1998 – P). This habitat change is likely to continue in the future in Britain, while in case of introductions of the Grey squirrel in other countries, woodland damage and alteration will depend on local management practices.

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

significantly negative
 moderately negative
 neutral
 moderately positive
 significantly positive

x

aconf28. Answer provided with a

low	medium	high
	x	

 level of confidence

acommm32. Comments:
 No influence on regulation and maintenance services is noted.

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

significantly negative
 moderately negative
 neutral
 moderately positive
 significantly positive

x

aconf29. Answer provided with a

low	medium	high
	x	

 level of confidence

acommm33. Comments:
 The Grey squirrel can be perceived as an attractive and desirable component of natural habitats. On the other hand, if it leads to decrease or even extinction of the population of the charismatic Red squirrel, it can be treated as unwanted pest and be perceived negatively.

of the Species

Below, each of the Harmonia+ modules is revisited under the premise of the future climate. The proposed time horizon is the mid-21st century. We suggest to take into account the reports of the Intergovernmental Panel on Climate Change. Specifically, the expected changes of 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

x

aconf30.

Answer provided with a

low	medium	high	level of confidence
	x		

acommm34.

Comments:

Climate changes will not affect the probability of species introduction to Poland.

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

decrease significantly

decrease moderately

not change

increase moderately

increase significantly

x

aconf31.

Answer provided with a

low	medium	high	level of confidence
	x		

acommm35.

Comments:

The species can establish in Poland even under the current climatic conditions. However, it can be assumed that with warmer and drier climate, this probability will be higher (Di Febbraro et al. 2013 – P), partly due to increased food base (higher productivity of oaks).

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

decrease significantly

decrease moderately

not change

increase moderately

x

increase significantly

aconf32.

Answer provided with a

low	medium	high
	x	

level of confidence

acommm36.

Comments:

The species can establish in Poland even under the current climatic conditions. However, it can be assumed that with warmer and drier climate, this probability will be higher (Di Febbraro et al. 2013 – P), partly due to increased food base (higher productivity of oaks). The present climate change may further benefit the species in colonising new areas (Di Febbraro et al. 2013 – P).

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

decrease significantly

x

decrease moderately

not change

increase moderately

increase significantly

aconf33.

Answer provided with a

low	medium	high
	x	

level of confidence

acommm37.

Comments:

As milder climate may lead to an increase in the population abundance and range (Di Febbraro et al. 2013 – P), it can be assumed that the scale of its negative impact on the environment will increase too.

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

decrease significantly

x

decrease moderately

not change

increase moderately

increase significantly

aconf34.

Answer provided with a

low	medium	high
	x	

level of confidence

acommm38.

Comments:

As milder climate may lead to an increase in the population abundance and range (Di Febbraro et al. 2013 – P), it can be assumed that the scale of its negative impact on plant cultivation will increase too.

a39. IMPACT ON 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

x

aconf35.

Answer provided with a

low	medium	high
	x	

level of confidence

acommm39.

Comments:

As milder climate may lead to an increase in the population abundance and range (Di Febbraro et al. 2013 – P), it can be assumed that the scale of its negative impact on animal production will increase too.

a40. IMPACT ON 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

x

aconf36.

Answer provided with a

low	medium	high
	x	

level of confidence

acommm40.

Comments:

As milder climate may lead to an increase in the population abundance and range (Di Febbraro et al. 2013 – P), it can be assumed that the scale of its negative impact on human will increase too.

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

x

aconf37.

Answer provided with a

low	medium	high
	x	

level of confidence

acommm41.

Comments:

As milder climate may lead to an increase in the population abundance and range (Di Febbraro et al. 2013 – P), it can be assumed that the scale of its negative impact on human will increase too.

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)	0.58	0.67
Cultivated plants impact (questions: a19-a23)	0.25	0.67
Domesticated animals impact (questions: a24-a26)	0.42	0.67
Human impact (questions: a27-a29)	0.75	0.50
Other impact (questions: a30)	0.50	0.50
Invasion (questions: a06-a12)	0.60	0.86
Impact (questions: a13-a30)	0.75	0.60
Overall risk score	0.45	
Category of invasiveness	moderately invasive alien species	

A6 | Comments

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

Below you can include your own comments on the assessment.

acommm42.

Comments:

The Grey squirrel is among the most invasive alien species in the world (http://www.issg.org/worst100_species.html). Its most apparent influence on the environment is competition with the Red squirrel and transmission of poxvirus which can lead to total extinction of the native squirrel.

Nevertheless, as a result of risk assessment for Poland, the Grey squirrel was included into the 'moderately invasive alien species' category. The maximum negative influence was shown for the 'Impact on human domain' module (questions: a27-a 29).

In the module 'Impact on environmental domain' (questions a13-a18), in two points that refer to competition (a14) and transmission of pathogens and parasites (a16), the Grey squirrel scored the maximum value. Nevertheless, the total value of environmental impact was significantly lower due to low scores of other questions this module.

It should be considered that, despite scoring low (0.17) in the 'Introduction' module (questions: a06-a08), the value of 'Establishment' (questions a09-a10) is maximum (1.0) and the value of 'Spread' (questions: a11-a12) – is significant (0.63). As shown by experiences from Great Britain and Italy, just a few individuals can be a source of a viable population. Its eradication is possible only in the early stage of expansion. However, at that early stage, usually no negative impacts on environment or economy are apparent and recognised, so any actions against alien species can be opposed by the society (and animal welfare organisations), who perceive squirrels as nice and harmless animals. Therefore, it is crucial that any individuals of grey squirrels which are found in Poland in the wild must be eradicated as quickly as possible, to prevent further spread.

It must be kept in mind that categories of invasiveness in this assessment were determined *a priori*, without knowledge of actual distribution of this parameter. Moreover, the maximum value scored by the Grey squirrel (0.75) is minimally lower (0.01) from the value allowing to categorise the species as 'very invasive'.

All these circumstances should be taken into consideration in the decision process on how to deal with alien species and how to prioritise them.

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