Risk analysis of the Amur sleeper *Perccottus glenii*

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Risk analysis report of non-native organisms in Belgium

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Etienne Branquart (Cellule Espèces Invasives, SPW) developed the risk analysis template that was used for this exercise.

The general process of drafting, reviewing and approval of the risk analysis for selected invasive alien species in Belgium was attended by a steering committee, chaired by the Federal Public Service Health, Food chain safety and Environment. Steering committee members were:

Tim Adriaens	Research Institute for Nature and Forest (INBO)
Olivier Beck	Brussels Environment (BIM)
Roseline Beudels-Jamar	Royal Belgian Institute of Natural Sciences (RBINS/KBIN)
Jean-Philippe Bizoux	Département de la Nature et des Forêts (DNF)
Etienne Branquart	Département de l'Etude du Milieu Naturel et Agricole (DEMNA)
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Maud Istasse (chair)	Federal Public Service Health, Food chain safety and Environment
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Sonia Vanderhoeven	Belgian Biodiversity Platform (BBPF)
Hans Van Gossum	Agency for Nature and Forest (ANB)
Hugo Verreycken	Research Institute for Nature and Forest (INBO)

Rationale and scope of the Belgian risk analysis scheme

The Convention on Biological Diversity (CBD) emphasises the need for a precautionary approach towards non-native species. It strongly promotes the use of robust and good quality risk assessment to help underpin this approach (COP 6 Decision VI/23). More specifically, when considering trade restrictions for reducing the risk of introduction and spread of a non-native organisms, full and comprehensive risk assessment is required to demonstrate that the proposed measures are adequate and efficient to reduce the risk and that they do not create any disguised barriers to trade. This should be seen in the context of WTO and free trade as a principle in the EU (Baker et al. 2008, Shine et al. 2010, Shrader et al. 2010).

This risk analysis has the specific aim of evaluating whether or not to install trade restrictions for a selection of absent or emerging invasive alien species that may threaten biodiversity in Belgium as a preventive risk management option. It is conducted at the scale of Belgium but results and conclusions are also relevant for neighbouring areas with similar eco-climatic conditions (e.g. areas included within the Atlantic and the continental biogeographic regions in Europe).

The adopted risk analysis tool follows a simplified scheme elaborated on the basis of the recommendations provided by the international standard for pest risk analysis for organisms of quarantine concern[1] produced by the secretariat of the International Plant Protection Convention (FAO 2004). This logical scheme adopted in the plant health domain separates the assessment of entry, establishment, spread and impacts. As proposed in the GB non-native species risk assessment scheme, this IPPC standard can be adapted to assess the risk of intentional introductions of non-native species regardless the taxon that may or not be considered as detrimental (Andersen 2004, Baker et al. 2005, Baker et al. 2008, Schrader et al. 2010).

The risk analysis follows a process defined by three stages : (1) the initiation process which involves identifying the organism and its introduction pathways that should be considered for risk analysis in relation to Belgium, (2) the risk assessment stage which includes the categorization of emerging non-native species to determine whether the criteria for a quarantine organism are satisfied and an evaluation of the probability of organism entry, establishment, spread, and of their potential environmental, economic and social consequences and (3) the risk management stage which involves identifying management options for reducing the risks identified at stage 2 to an acceptable level. These are evaluated for efficacy, feasibility and impact in order to select the most appropriate. The risk management section in the current risk analysis should however not been regarded as a full-option management plan, which would require an extra feasibility study including legal, technical and financial considerations. Such thorough study is out of the scope of the produced documents, in which the management is largely limited to identifying needed actions separate from trade restrictions and, where possible, to comment on cost-benefit information if easily available in the literature.

This risk analysis is an advisory document and should be used to help support Belgian decision making. It does not in itself determine government policy, nor does it have any legal status. Neither

[1] A weed or a pest organism not yet present in the area under assessment, or present but not widely distributed, that is likely to cause economic damages and is proposed for official regulation and control (FAO 2010).

should it reflect stakeholder consensus. It is important to realise that this risk assessments exercise is carried out by (an) independent expert(s) who produces knowledge-based risk assignments sensu Aven (2011). It was completed using a uniform template to ensure that the full range of issues recognised in international standards was addressed.

To address a number of common misconceptions about non-native species risk assessments, the following points should be noted (after Baker et al. 2008):

- Risk assessments are advisory and therefore part of the suite of information on which policy decisions are based;
- The risk assessment deals with potential negative (ecological, economic, social) impacts. It is not meant to consider positive impacts associated with the introduction or presence of a species, nor is the purpose of this assessment to perform a cost-benefit analysis in that respect. The latter elements though would be elements of consideration for any policy decision;
- Completed risk assessments are not final and absolute. New scientific evidence may prompt a re-evaluation of the risks and/or a change of policy.

Executive summary

PROBABILITY OF ESTABLISHMENT AND SPREAD (EXPOSURE)

Entry in Belgium	It is very likely that Amur sleeper will enter Belgian waters in the near future if it were to be used as an aquarium fish. Especially fish transports from fish farms in infested areas (where Amur sleeper can be present as a stowaway) to local fish farms here may serve as an important entry pathway. From aquaculture ponds it may spread via escapes or through fish stocking activities.
Establishment capacity	*Perccottus glenii* is not yet present in Belgium or neighbouring, interconnected river systems. However, all literature indicates a high probability of future establishment in most parts of Belgium (especially Flanders with its standing and slow streaming waters).
Dispersion capacity	Human aided dispersal (aquarium trade and aquaculture) has helped Amur sleeper to invade large parts of Eurasia. Natural spread was probably the main vector for downstream dispersal. Because of high propagule pressure from high density populations in standing waters in flood plains, the importance of this last vector must not be underestimated in the widespread distribution of *P. glenii*.

EFFECT OF ESTABLISHMENT

Environmental impacts	The environmental impacts of the presence of Amur sleeper in Belgium will be through competition for food and predation but also possibly through pathogen pollution and disruption of trophic interactions. Mainly native freshwater fish and amphibians will be affected but also (larvae of) large invertebrates will be heavily predated upon. Especially standing waters (oxbow lakes, ponds, etc.), where high densities of *P. glenii* can be expected, will be the ecosystems at risk.
Other impacts	In aquaculture facilities and in commercial fishing grounds, Amur sleeper may be a competitor for food and may thus reduce production of economically important fish species. Social impacts, however, have not been reported.

CONCLUSION FOR RISK ASSESSMENT

The Amur sleeper may easily reach Belgium as a stowaway of fish consignments and/or escapes or releases from aquaria. Once introduced, its establishment capacity is considered very high in standing or slow running waters. It represents a moderate to high risk for native biodiversity (e.g. amphibians). Recent records of this species in open waters in the Upper Danube basin close to the mouth of Main-Danube Canal may be a start of active migration of Amur sleeper or passive dispersal with ships into the canal towards rivers in Western Europe.

COCLUSION FOR RISK MANAGEMENT

Amur sleeper is not easy to detect or observe at early stages of invasion and rapid eradication is therefore difficult. Piscicides and ammonia may be useful in eradicating emerging Amur sleeper populations but only in (small) confined areas and at a big cost. A reduction of population density may be achieved by piscivorous fish species like pike and perch. Prohibition of the trade and use as aquarium fish or live bait of Amur sleeper can reduce the risk of species introduction in Belgium. Although it may be quite difficult to implement, import control of large trucks for fish transport and surveillance of fish stocking activities deserve to be done as stowaway specimens of Amur sleeper are regularly reported in fish consignments.

OTHER AREAS AT RISK IN EUROPE UNDER CURRENT AND FUTURE CLIMATES

Most of Europe is at risk since climatic suitability is high in most of central and western Europe. Only Iberia, the Alpine region and Northern Europe seem to have a lower climate match. However, taking into account the hardiness of Amur sleeper, it seems wise to regard the maximum potentially suitable habitat in Europe (figure 5) as an area at risk under current and future climates.

STAGE 1: INITIATION

Precise the identity of the invasive organism (scientific name, synonyms and common names in Dutch, English, French and German), its taxonomic position and a short morphological description. Present its distribution and pathways of quarantine concern that should be considered for risk analysis in Belgium. A short morphological description can be added if relevant. Specify also the reason(s) why a risk analysis is needed (the emergency of a new invasive organism in Belgium and neighboring areas, the reporting of higher damages caused by a non native organism in Belgium than in its area of origin, or request made to import a new non-native organism in the Belgium).

1.1 ORGANISM IDENTITY

Scientific name:	*Perccottus glenii* Dybowski, 1877
Synonyms:	*Perccottus glehni* (misspelled)*, Eleotris dybowskii, Eleotris pleskei*
Common names:	Amur sleeper, Chinese sleeper, rotan (EN), Goujon de l'Amour (FR), Amur- of Amoergrondel (NL), Chinesische Schläfergrundel, Amurgründling (DE)
Taxonomic position:	Chordata (Phylum) > Actinopterygii (Class) > Perciformes (Order) > Odontobutidae (Family).

1.2 SHORT DESCRIPTION

Figure 1: Amur sleeper *Perccottus glenii* (photograph: A. Reshetnikov, 2013).

Small fish species with a maximal total length of 25 cm and maximal weight of 250 g. Maximal reported age is 7 years. Distinguished from other European freshwater species by the following characters: 2 dorsal fins with the first with 6-8 simple rays, and the second with 2-3 simple and 8-12 branched rays; no spines on first dorsal fin; no barbels; pelvic fins not fused into a disc (*cfr* Gobiidae); no lateral line canals; males during spawning period, develop a hump on nape and become black with bright green spots on body and unpaired fins (Kottelat & Freyhof, 2007). For detailed description see Miller & Vasil'eva (2003).

1.3 ORGANISM DISTRIBUTION

Native range
The Amur sleeper is native to the Far East of Eurasia. This species inhabits oxbows, lakes, ponds and other similar water bodies in river basins of the east coast of the Pacific Ocean from North Korea in the South to Uda River basin (Russia) in the North. The main part of its native range is restricted to the Amur river basin (Reshetnikov 2010).

Introduced range

Belgium:	Not present
Rest of Europe:	(European part of) Russia, Latvia, Lithuania, Estonia, Byelorussia, Ukraine, Moldova Slovakia, Hungary (Reshetnikov, 2004, 2010) Poland (Terlecki & Palka, 1999; Nowak et al, 2008), Serbia (Simonović et al, 2006), Bulgaria (Jurajda et al, 2006), Croatia (Ćaleta et al., 2010), and Romania (Nalbant et al, 2004; Popa et al, 2006; Nastase & Navodaru, 2010; Covaciu-Marcov et al, 2011). Reported presence in the Po drainage (Italy) is not confirmed (Kottelat & Freyhof, 2007). Very recently, one record from Danube basin in Bavaria, Germany (Reshetnikov, 2013).
Other continents:	Kazakhstan & Mongolia (Asia) (Reshetnikov, 2010)

1.4 REASONS FOR PERFORMING RISK ANALYSIS

Currently the Amur sleeper is not present in Belgium nor in interconnected river basins of neighbouring countries. However the species is spreading westwards (upper parts of Danube in Germany) and Reshetnikov and Ficetola (2011) described two climatically suitable corridors that may connect already colonized areas in Eastern and Central Europe to Western Europe. Strong negative impacts on native biodiversity have been described for this species. As this fish is <u>often used as an aquarium fish</u> (and illegally released) and not yet present in Belgium, management actions must be undertaken to prevent its introduction and consequent spread.

STAGE 2: RISK ASSESSMENT

2.1 PROBABILITY OF ESTABLISHMENT AND SPREAD (EXPOSURE)

Evidence should be available to support the conclusion that the non-native organism could enter, become established in the wild and spread in Belgium and neighbouring areas. An analysis of each associated pathways from its origin to its establishment in Belgium is required. Organisms intentionally imported maybe maintained in a number of intended sites for an indeterminate period. In this specific case, the risk may arise because of the probability to spread and establish in unintended habitats nearby intended introduction sites.

2.1.1 Present status in Belgium

Specify if the species already occurs in Belgium and if it makes self-sustaining populations in the wild (establishment). Give detail about species abundance and distribution within Belgium when establishment is confirmed together with the size of area suitable for further spread within Belgium.

Amur sleeper was not yet recorded in Belgian waters (Verreycken et al, 2007, Retshenikov, 2013).

2.1.2 Present status in neighbouring countries

Mention here the status of the non-native organism in the neighbouring countries.

The Netherlands: not present, France: not present, Germany: 1 record in Danube in Bavaria (Retshenikov, 2013). It is to be noted that once the species reaches the Danube River, the Rhine-Main-Danube Canal offers no physical barrier to the spreading of this invasive species (into the Rhine and) to Western Europe (Müller et al., 2002).

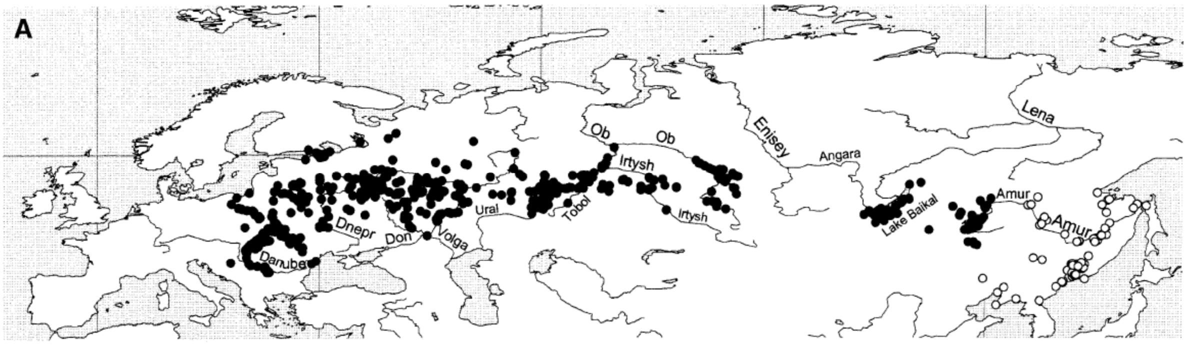

Figure 2: The range of the Amur sleeper, *Perccottus glenii*, in Eurasia. Open circles represent presence records within the native range. Black circles represent presence records within the invaded range (Reshetnikov & Ficetola, 2011).

2.1.3 Introduction in Belgium

Specify what are the potential international introduction pathways mediated by human, the frequency of introduction and the number of individuals that are likely to be released in Europe and in Belgium. Consider potential for natural colonisation from neighbouring areas where the species is established and compare with the risk of introduction by the human-mediated pathways. In case of plant or animal species kept in captivity, assess risk for organism escape to the wild (unintended habitats).

Amur sleeper was unintentionally introduced with <u>stocked fish</u> (e.g. Chinese carps) (Reshetnikov, 2010, Reshetnikov et al, 2011) but was also released by <u>aquarium hobbyists</u> e.g. in the 1950s into lakes near Moscow (upper Volga drainage) and this has led to very abundant populations throughout the upper and middle Volga (Kottelat & Freyhof, 2007). *P. glenii* actively spreads downstream, with source populations located in floodplain water bodies producing emigrants, especially during floods, whereas large rivers serve as important long-distance one-way (i.e. downstream) transmission corridors (Reshetnikov & Ficetola, 2011). Upstream expansion is very slow but as a result of local anthropogenic translocations, Amur sleeper can reach the heads of rivers and then spread downstream through new water basins (Reshetnikov, 2013). Its first occurrence in the River Tisza catchment suggests that it arrived, as with topmouth gudgeon, through the aquaculture trade as a contaminant (Copp et al, 2005a). The topmouth gudgeon *Pseudorasbora parva* was probably introduced in Belgium via the same vector (aquaculture) (Verreycken et al., 2007) and within twenty years nearly all river basins in Flanders were invaded by topmouth gudgeon. A similar invasion is to be expected for Amur sleeper should it be able to arrive with infested fish consignments in (aquaculture) ponds in (lowland) Belgium. Also release by aquarium hobbyists is very likeky to occur (Copp et al., 2005b) although yet there are no indications of sales of this fish species in Belgium. The risk of introduction of Amur sleeper in Belgium by human-mediated pathways (stowaway in fish transports and/or aquarium trade) is estimated more important than natural colonisation from neighbouring areas.

ENTRY IN BELGIUM
It is very likely that Amur sleeper will enter Belgian waters in the near future if it were to be used as an aquarium fish. Especially fish transports from fish farms in infested areas (where Amur sleeper can be present as a stowaway) to local fish farms here may serve as an important entry pathway. From aquaculture ponds it may spread via escapes or through fish stocking activities.

2.1.4 Establishment capacity and endangered area

Provide a short description of life-history and reproduction traits of the organism that should be compared with those of their closest native relatives (A). Specify which are the optimal and limiting climatic (B), habitat (C) and food (D) requirements for organism survival, growth and reproduction both in its native and introduced ranges. When present in Belgium, specify agents (predators, parasites, diseases, etc.) that are likely to control population development (E). For species absent from Belgium, identify the probability for future establishment (F) and the area most suitable for species establishment (endangered area) (G) depending if climatic, habitat and food conditions found in Belgium are considered as optimal, suboptimal or inadequate for the establishment of a reproductively viable population. The endangered area may be the whole country or part of it where ecological factors favour the establishment of the organism (consider the spatial distribution of preferred habitats). For non-native species already established, mention if they are well adapted to the eco-climatic conditions found in Belgium (F), where they easily form self-sustaining populations, and which areas in Belgium are still available for future colonisation (G).

A/ Life-cycle and reproduction

Eggs are laid on the lower surface of floating objects (boards, etc.) and plants and also on stones and other objects lying on the bottom (e.g. tins). At the time of incubation the clutch is protected by a male. The male fans the clutch with pectoral fins, therefore the eggs and embryos do not suffer defficiency of oxygen. However, Amur sleeper may eat its juveniles after hatching. Eggs are laid in even rows and are firmly fastened to the substratum by a thin filament. In the Vistula, at the beginning of the reproductive period (in April) the mean fecundity, was 7,766 eggs per female and ranged from 1,963 (at 48 mm standard length (SL)) to 23,479 (at 129 mm SL) (Gabrowska et al, 2010). One day larvae have a body length of 5.6 mm and height of 1.2 mm. From the first minutes of life the larvae swim freely and are spread among the vegetation. Larvae are weakly mobile (Bogutskaya & Naseka, 2002).

Spawning of Amur sleeper in the basin of the Amur River takes place at the end of May through June at a temperature of 15 – 20 °C at the age of 2^+ to 3^+ (i.e. on the third to fourth year) when body length is 5 - 6 cm. In aquarian conditions Amur sleeper can mature earlier at the second year of life (1^+) at the same sizes. In the European part of the acquired distribution range the majority of Amur sleepers mature at body length of 45 - 70 cm at the age of 2^+, but it occurs that specimens reach maturity in the second year (1^+)(Bogutskaya & Naseka, 2002).

Gabrowska et al. (2010) conclude that Amur sleeper invest in early reproduction but have a reduced growth rate in the invaded Vistula river.

B/ Climatic requirements[2]

Noteworthy is hardiness of Amur sleeper. It inhabits water bodies of different types and endures well low oxygen content and water chemical composition. Amur sleeper belongs to eurytherm fishes. It demonstrates normal vital activity within a very wide temperature range from 1 to 20 and even 37 °C. Its ability to freeze into ice and then to "melt" is well known (several authors *cfr* Bogutskaya & Naseka, 2002). Sometimes Amur sleeper winter in a different way, like *Carassius* species they are buried in silt (mud) and stay immobile for several months. They even can survive in drying water bodies. There is evidence that in the summer when the sun dries out some overgrown small water bodies to such an extent that hard silt crust is formed on their bottom, Amur sleeper are covered by mucus and in a dense capsule fall in dormancy (summer "hibernation"), like frogs (Bogutskaya & Naseka, 2002).

Reshetnikov & Ficetola (2011) calculated the bioclimatic suitability for the Amur sleeper *Perccottus glenii* in Eurasia following MAXENT models (a) calibrated using native records; (b) calibrated using invasive records; (c) calibrated using records from both native and invasive parts of the range (Figure 4) and Belgium is well within the high suitability zone. Also The Netherlands are climatically well suited (see figures 3 (Spikmans et al., 2010) and 4).

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[2] Organism's capacity to establish a self-sustaining population under Atlantic temperate conditions (Cfb Köppen-Geiger climate type) should be considered, with a focus on its potential to survive cold periods during the wintertime (e.g. plant hardiness) and to reproduce taking into account the limited amount of heat available during the summertime.

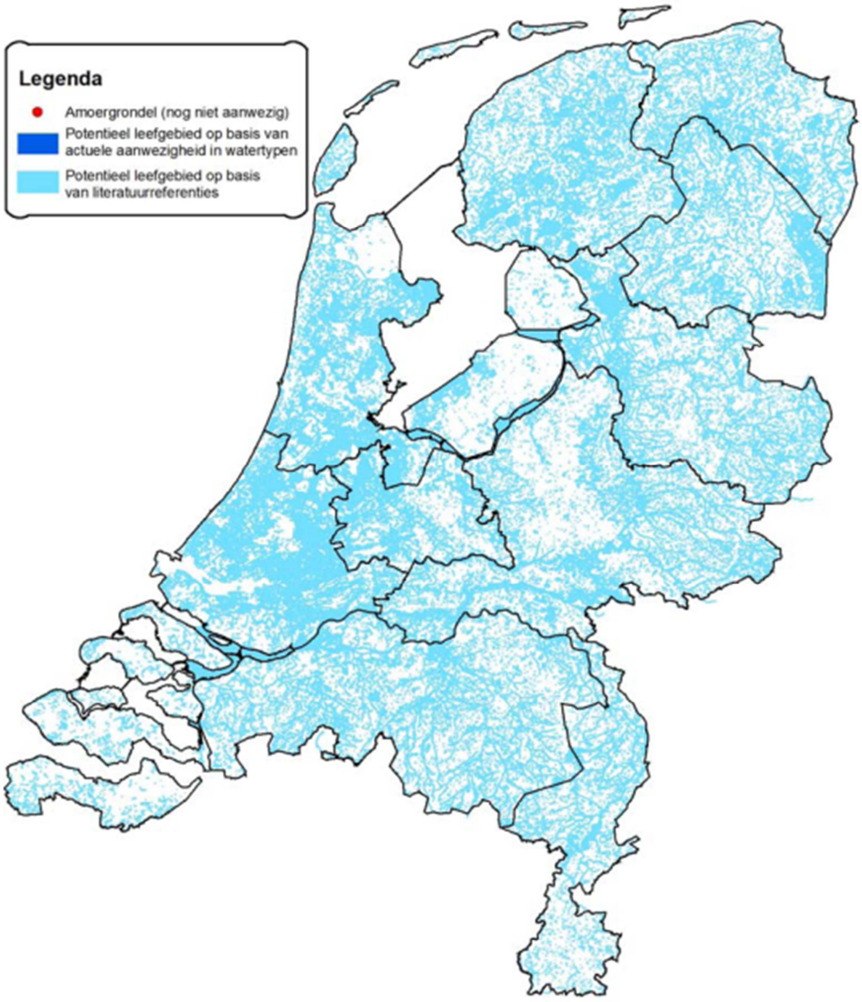

Figure 3: Potential habitat (light blue) for Amur sleper in The Netherlands based on literature (Spikmans et al, 2010).

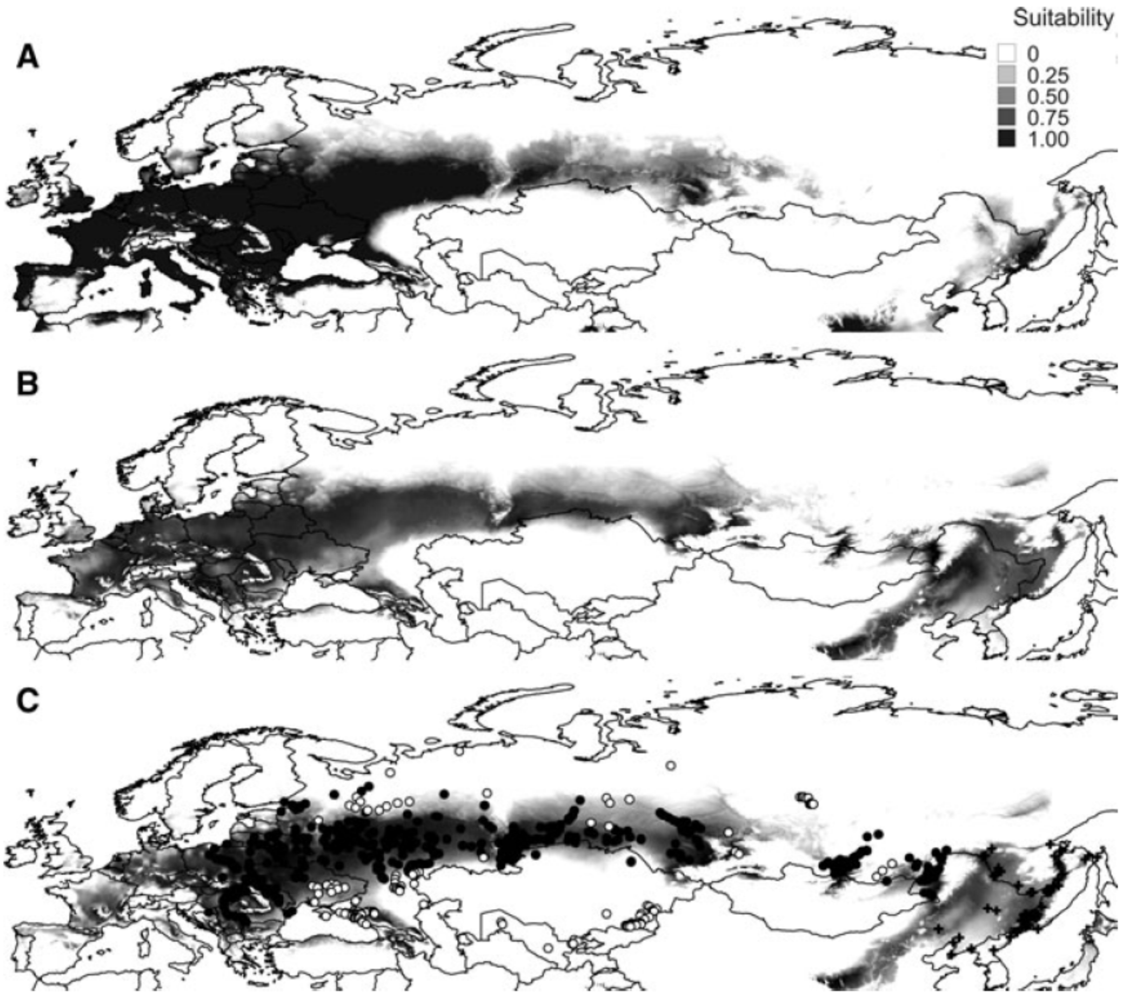

Figure 4: Bioclimatic suitability for the Amur sleeper *Perccottus glenii* in Eurasia following MAXENT models (a) calibrated using native records; (b) calibrated using invasive records; (c) calibrated using records from both native and invasive parts of the range. Darker colours indicate higher suitability. Data used for calibration: black crosses presence records within the native range; black circles presence within the invaded range; open circles are absence records outside the native range (Reshetnikov & Ficetola, 2011).

C/ Habitat preferences[3]

Amur sleeper occurs mostly in water bodies that either have a weak current or are stagnant with well developed higher water vegetation, in river flood plains with well developed vegetation, in the littoral zone of lakes, in swampy water bodies and even in swamps. It is particularly abundant in small water bodies with ground feeding, where in most cases Amur sleeper is the only representative of the ichthyofauna. Single specimens, usually after high water, occur also in rivers. Adult individuals prefer deeper areas and juveniles stay in overgrown shallow water areas (Bogutskaya & Naseka, 2002; Kottelat & Freyhof, 2007).

[3] Including host plant, soil conditions and other abiotic factors where appropriate.

D/ Food habits[4]

Amur sleeper consumes a wide spectrum of animal prey items from infusorians to vertebrates (Reshetnikov, 2003, 2013; Grabowska et al, 2009) however selectivity in its feeding has been reported (Manteifel and Reshetnikov 2002; Koščo et al. 2008; Reshetnikov 2008). The diet of Amur sleeper in the Włocławski Reservoir was diverse. A total of 50 food categories were identified, including such animal groups as crustaceans, insects, molluscs, annelids, araneids, fishes and amphibians. Amphipods and chironomid larvae composed the main forage base in all studied sites although their importance differed among sites (Grabowska et al, 2009).
Its diet includes fish eggs and small fishes. Fish eggs at later developmental stages are more vulnerable for predation by Amur sleeper because embryo's movements attract the attention of this predator (Reshetnikov 2008). The fish eggs may be one third of Amur sleeper stomach content mass during the spawning period of native fish (Bigun, 2012 *fide* Reshetnikov, 2013). Amur sleeper does not consume amphibian eggs (Reshetnikov, 2008) but this predator feeds selectively on amphibian larvae. Noxious tadpoles of the common toad *Bufo bufo* are comparatively well-protected against predation by this fish (Manteifel and Reshetnikov, 2002). Nevertheless, Amur sleeper readily consumes tadpoles of newts (*Lissotriton, Triturus*) and frogs (*Pelophylax, Rana*) as well as adult *Lissotriton*. In small water bodies this results in the entire elimination of all newt and frog larvae before their metamorphosis (Reshetnikov and Manteifel 1997; Reshetnikov 2003).

E/ Control agents

Many authors (*fide* Reshetnikov, 2013) emphasize that, in the natural distribution range as well as in new areas, Amur sleeper attains high abundance in small water bodies with poor ichthyofauna. In large water bodies with multicomponent ichthyofauna the density of Amur sleeper population is low. Probably in complex ecosystems, the increase of abundance of Amur sleeper is restricted by the pressure of predatory fish species (Reshetnikov, 2013). Large fish predators readily consume *P. glenii* (Bigun 2012 *fide* Reshetnikov, 2013) and may control its population density.

F/ Establishment capacity in Belgium

Establishment capacity of Amur sleeper in Belgium in probably high considering the highly adaptive characteristics of Amur sleeper and the bioclimatic suitability of the region.

G/ Endangered areas in Belgium

Probably most of the standing and flow streaming waters in Belgium are endangered areas. Most of the Netherlands was foud suited for Amur sleeper invasion (figure 3 - Spikmans et al., 2010) and also Belgium (especially Flanders) will not be immune to invasion by Amur sleeper (figure 4 - Reshetnikov & Ficetola, 2011). The higher parts of Belgium (e.g. the Ardenne) will be less vulnerable because of higher water velocities.

[4] For animal species only.

Establishment capacity in the Belgian geographic districts:

Districts in Belgium	**Environmental conditions for species establishment**[5]
Maritime	Optimal
Flandrian	Optimal
Brabant	Optimal
Kempen	Optimal
Meuse	Optimal
Ardenne	Suboptimal
Lorraine	Suboptimal

ESTABLISHMENT CAPACITY AND ENDANGERED AREAS IN BELGIUM
Perccottus glenii **is not yet present in Belgium or neighbouring, interconnected river systems. However, all literature indicates a high probability of future establishment in most parts of Belgium (especially Flanders with its standing and slow streaming waters).**

2.1.5 Dispersion capacity

Specify what is the rate of dispersal once the species is released or disperses into a new area. When available, data on mean expansion rate in introduced territories can be specified. For natural dispersion, provide information about frequency and range of long-distance movements (i.e. species capacity to colonise remote areas) and potential barriers for spread, both in native and in introduced areas, and specify if the species is considered as rather sedentary or mobile. For human-assisted dispersion, specify the likelihood and the frequency of intentional and accidental movements, considering especially the transport to areas from which the species may easily colonise unintended habitats with a high conservation value.

A/ Natural spread

Because of regulation of most rivers, there are less connected floodplains with standing waters where high densities of Amur sleeper can be reached in Belgium than in Central and Eastern Europe. These floodplains have proved to be an important impetus for expansion of *P. glenii*. As a consequence, spreading through natural distribution will probably be slower than in Eastern Europe. In Eastern Europe, Amur sleeper demonstrated a comparatively rapid expansion from riverheads to the lower sections of rivers and an absence or much slower expansion upstream in tributaries (Reshetnikov, 2013). Reports of the exact velocity of distribution of Amur sleeper along rivers (km/year) are probably not correct but analysis of spatio-temporal dynamics of records of Amur sleeper on large space and time scales may be regarded as a valuable tool for the investigation of the invasion speed of this species. Since 1912, this fish was introduced into more than 13 distant localities throughout Eurasia and from there, especially since the late 1960s, it colonised many large European river systems like the Dniester, Danube, Dnieper (Black Sea basin), and Vistula (Baltic Sea basin) (Reshetnikov, 2013). Distribution of this species within a river system can be well described through the metapopulation concept, with source populations located in floodplain water bodies producing emigrants, especially during floods, whereas large rivers serve as important long-distance one-way transmission corridors (Reshetnikov and Ficetola 2011). Although no data about natural spread of individual *P. glenii* are available, Jarić et al. (2012) report 10 different sightings in the Danube between 2003 and 2008 over a distance of 395 km and estimated the maximum range of

[5] For each district, choose one of the following options : optimal, suboptimal or inadequate.

Amur sleeper in that part of the Danube at that time at 670.93 km. Amur sleeper's high invasiveness, lack of geographical barriers and absence of reliable methods to prevent its spread will be reasons of further expansion in Europe (Reshetnikov and Ficetola, 2011).

B/ Human assistance

Amur sleeper was unintentionally introduced with stocked fish (e.g. Chinese carps) (Reshetnikov, 2010) but was also released by aquarium hobbyists e.g. in the 1950s into lakes near Moscow (upper Volga drainage) and this has led to very abundant populations throughout the upper and middle Volga (Koščo et al., 2003; Kottelat & Freyhof, 2007). At least 13 distant localities throughout Eurasia are known where this fish was introduced for aquarium trade and/or in aquaculture facilities (albeit sometimes unintentionally) (Reshetnikov, 2013). Human aided dispersal was responsible for long-distance spreading as was the case with *Pseudorasbora parva* (Copp et al, 2005a; Verreycken et al., 2007).

DISPERSAL CAPACITY

Human aided dispersal (aquarium trade and aquaculture) has helped Amur sleeper to invade large parts of Eurasia. Natural spread was probably the main vector for downstream dispersal. Because of high propagule pressure from high density populations in standing waters in flood plains, the importance of this last vector must not be underestimated in the widespread distribution of *P. glenii*.

2.2 EFFECTS OF ESTABLISHMENT

Consider the potential of the non-native organism to cause direct and indirect environmental, economic and social damages as a result of establishment. Information should be obtained from areas where the pest occurs naturally or has been introduced, preferably within Belgium and neighbouring areas or in other areas with similar eco-climatic conditions. Compare this information with the situation in the risk analysis area. Invasion histories concerning comparable organisms can usefully be considered. The magnitude of those effects should be also compared with those caused by their closest native relatives.

2.2.1 Environmental impacts

Specify if competition, predation (or herbivory), pathogen pollution and genetic effects is likely to cause a strong, widespread and persistent decline of the populations of native species and if those mechanisms are likely to affect common or threatened species. Document also the effects (intensity, frequency and persistency) the non-native species may have on habitat peculiarities and ecosystem functions, including physical modification of the habitat, change to nutrient cycling and availability, alteration of natural successions and disruption of trophic and mutualistic interactions. Specify what kind of ecosystems are especially at risk.

A/ Competition [HIGH]

Bogutskaya & Naseka (2002) report densities of Amur sleeper ranging from 41 to more than 4,000 per hectare in the Baikal system. Densities were highest in oxbow lakes without current and lowest in the river channels where the current was swift. Feeding relationships of Amur sleeper with local species of fish are relatively tense. Competition was clearly seen in water bodies of the delta of the Selenga River where the similarity of food items with ide *Leuciscus idus* is up to 90 % while also crucian carp *Carassius carassius* (81.2 %), roach *Rutilus rutilus* (67.3 %) and to a lesser extent dace

Leuciscus leuciscus (49.4 %) have high food similarity (Litvinov & O'Gorman, 1996; Bogutskaya & Naseka, 2002).

In water bodies with Amur sleeper, significantly lower diversity of some species of large macroinvertebrates such as leeches, water spiders, dragonfly and beetle larvae, and adult beetles is observed (Reshetnikov, 2003).

Theoretically Amur sleeper can compete for food with other fish species especially for larvae of Chironomidae (Litvinov & O'Gorman, 1996). Its diet includes fish eggs and small fishes. The fish eggs may be one third of Amur sleeper stomach content mass during the spawning period of native fish (Bigun, 2012 *fide* Reshetnikov, 2013). In shallow water bodies with high population densities of *P. glenii*, this fish can decrease relative abundance and even eliminate some native fish species: e.g., *Carassius carassius*, *Phoxinus phoxinus*, *Leucaspius delineatus* (Reshetnikov, 2003; Reshetnikov & Chibilev, 2009).

The metapopulation structure of amphibian species is altered because these amphibians cannot use the best permanent breeding ponds colonized by Amur sleeper (Reshetnikov & Manteifel, 1997). On the whole, species diversity of amphibians in small water bodies with Amur sleeper is considerably lower compared to Amur sleeper-free ones (Reshetnikov, 2003). The impact upon native species of newts is one of the most dramatic consequences of expansion of this fish in Europe (Reshetnikov, 2003).

B/ Predation/herbivory [HIGH]

Amur sleeper does not consume amphibian eggs but it feeds selectively on amphibian larvae (Reshetnikov, 2008). Noxious tadpoles of the common toad *Bufo bufo* are less predated upon by this fish (Manteifel & Reshetnikov, 2002 but it readily consumes tadpoles of newts (*Lissotriton*, *Triturus*) and frogs (*Pelophylax*, *Rana*) as well as adult *Lissotriton* (Reshetnikov & Manteifel, 1997; Reshetnikov, 2003). Litvinchuk and Borkin (2002) (*fide* Reshetnikov 2013) observed the disappearance of the newt *Triturus dobrogicus* from several water bodies in the Zakarpatie province (Ukraine) following the introduction of *P. glenii*.

Results of aquarium observations show selectivity of Amur sleeper to different foods at different length classes: specimens with a size of approximately 60 mm feed much more on large invertebrates (e.g. larvae of dragonflies) while larger individuals feed on fish (but retain a high degree of selectivity in relation to large invertebrates)(Bogutskaya & Naseka, 2002).

C/ Genetic effects and hybridization [UNLIKELY]

No native species of the genus *Perccottus* (and even from the family Odontobutidae) exist is Belgium (Kottelat & Freyhof, 2007) so the risk of hybridization and/or other genetic effects is extremely small.

D/ Pathogen pollution [LIKELY]

Within its invaded range, Amur sleeper transforms earlier established local parasite systems and demonstrates parasitological interactions with native fish species and some other animals (Sokolov et al, 2012; Reshetnikov et al, 2013). This fish species can harbour at least 67 parasite taxa within its native range and may be a host for almost 100 parasite taxa within its invaded range (Sokolov et al, 2013). Amur sleeper may play a significant role in the circulation of some European native parasites of fishes (Sokolov et al. 2012). This may influence other fish species involved to the same parasite system. Moreover the host-specific parasites *Nippotaenia mogurndae* and *Gyrodactylus perccotti* were brought to parts of the invaded range together with Amur sleeper (Košuthová et al, 2004; Mierzejewska et al, 2010, 2012; Ondračková et al, 2012). The cestode *N. mogurndae* has a complex life cycle and infects native copepod species. Up to 10 % of copepod *Mesocyclops leuckarti* individuals (one of the first intermediate hosts of *N. mogurndae*) may be infected by this cestode however the impact of this introduced parasite on populations of native crustaceans has not yet been assessed comprehensively (Reshetnikov, 2013).

In China, Amur sleeper can be a host for the trematode *Clonorchis sinensis* (family Opisthorchidae), causing a dangerous human parasite disease clonorchiasis (Reshetnikov, 2013). However, opistorchid trematodes, agents of western opisthorchiidosis (another dangerous human disease) were not found in Amur sleepers from floodplain water bodies of the Irtysh River in Siberia (region of well-known natural locus of this disease) (Sokolov et al. 2012). So, possibly *P. glenii* cannot be a host for these parasites. At the same time, this fish actively consumes gastropod mollusks and young-of-the-year cyprinid fish (intermediate hosts of the mentioned trematodes). Therefore theoretically, Amur sleeper may have a positive depressive impact (for humans) on natural loci of western opisthorchiidosis in water bodies through elimination of the above-mentioned intermediate hosts (Reshetnikov & Chibilev, 2009). European semi-aquatic snakes (e.g., *Natrix natrix* and *N. tessellata*) readily include Amur sleeper in their diet. In this case, the snakes may obtain the parasitic cestode *Ophiotaenia europaea* from this fish and these reptiles may be infected by this parasite with 100 % prevalence (Reshetnikov et al, 2013).

E/ Effects on ecosystem functions [HIGH]

Amur sleeper may be a source of food for many native fish, waterfowl and mammals within its invaded range: fishes European perch *Perca fluviatilis* and pike *Esox lucius* as well as birds grey heron *Ardea cinerea*, common gull *Larus canus*, black-headed gull *L. ridibundus*, herring gull *L. argentatus*, mallard *Anas platyrhynchos*, spot-billed duck *A. poecilorhyncha*, tufted duck *Aythya fuligula*, greater greenshank *Tringa nebularia*, common kingfisher *Alcedo atthis* and even mammals like American mink *Mustela vison*, another invader. In large well-developed delta systems Amur sleeper may be a significant component of the water bird diet. Distribution of this fish species may be the reason of an abrupt increase of the number of individuals and the number of colonies of gulls and herons in the delta of Selenga River, Russia. So, alteration of bird foraging habits and growth of populations (or winter aggregations) of some piscivorous bird species can be expected (Reshetnikov, 2013).

ENVIRONMENTAL IMPACTS

The environmental impacts of the presence of Amur sleeper in Belgium will be through competition for food and predation but also possibly through pathogen pollution and disruption of trophic interactions. Mainly native freshwater fish and amphibians will be affected but also (larvae of) large invertebrates will be heavily predated upon. Especially standing waters (oxbow lakes, ponds, etc.), where high densities of *P. glenii* can be expected, will be the ecosystems at risk.

2.2.2 Other impacts

A/ Economic impacts

Describe the expected or observed direct costs of the introduced species on sectorial activities (e.g. damages to crops, forests, livestock, aquaculture, tourism or infrastructures).

In aquaculture facilities, juveniles of Amur sleeper are competitors for food to many species of gobies, ruffe, perch, minnows, loaches; to common bitterling *Rhodeus amarus* and other fish species for chironomid larvae and crustaceans and among reared fishes to yearlings of carp *Cyprinus carpio*, crucian carp, Amur wild carp *Cyprinus carpio haematopterus* and Amur pike *Esox reichertii* (Bogutskaya & Naseka, 2002). Through competition for food, Amur sleeper was expected to reduce the populations of commercially important fish species Siberian roach and Siberian dace *Leuciscus baicalensis* in areas round Lake Baikal in the 1990s (Bogutskaya & Naseka, 2002). No confirmation of this assumption could be found in literature.

B/ Social impacts

Describe the expected or observed effects of the introduced species on human health and well-being, recreation activities and aesthetic values.

No social impacts were reported.

OTHER IMPACTS

In aquaculture facilities and in commercial fishing grounds, Amur sleeper may be a competitor for food and may thus reduce production of economically important fish species. Social impacts, however, have not been reported.

STAGE 3: RISK MANAGEMENT

The decision to be made in the risk management process will be based on the information collected during the two preceding stages, e.g. reason for initiating the process, estimation of probability of introduction and evaluation of potential consequences of introduction in Belgium. If the risk is found to be unacceptable, then possible preventive and control actions should be identified to mitigate the impact of the non-native organism and reduce the risk below an acceptable level. Specify the efficiency of potential measures for risk reduction.

3.1 RELATIVE IMPORTANCE OF PATHWAYS FOR INVASIVE SPECIES ENTRY IN BELGIUM

The relative importance of intentional and unintentional introduction pathways mediated by human activities should be compared with the natural spread of the organism. Make use e.g. of information used to answer to question 2.1.3.

The risk of introduction of Amur sleeper by human-mediated pathways (stowaway in fish transports and aquarium trade) is estimated more important than natural colonisation from neighbouring areas. Amur sleeper was unintentionally introduced with stocked fish and was also released by aquarium hobbyists in Eastern Europe and the European part of Russia. Today, many Western European aquaculturist buy fish in Eastern Europe and transport them to their own ponds. It is to be expected, since there are no border controls within the EU, that this will be the most important pathway for the introduction of Amur sleeper in Belgium as was the case in Poland (Copp et al, 2005a). The topmouth gudgeon *Pseudorasbora parva* was introduced in Belgium via the same vector (Verreycken et al., 2007) and within twenty years nearly all river basins in Flanders were invaded by topmouth gudgeon.

3.2 PREVENTIVE ACTIONS

Which preventive measures have been identified to reduce the risk of introduction of the organism? Do they reduce the risk to an acceptable level and are they considered as cost-effective? Specify if the proposed measures have undesirable social or environmental consequences. Consider especially (i) the restrictions on importation and trade and (ii) the use of specific holding conditions and effect of prohibition of organism introduction into the wild.

(i) Prohibition of organism importation, trade and holding

Fish transports should be regularly checked as stowaway specimens of Amur sleeper in fish consigments are probably the most important pathway for the introduction of this species. Import control of large trucks for fish transport, however, has proved to be very difficult. Also rigorous control actions are needed when fish stocking activities in public waters are executed.

Although no evidence of aquarium trade of Amur sleeper in Belgium could be found, it is advisable to prohibit trade of *P. glenii* for any goals (incl. ornamental and live bait functions) in addition to import restrictions. Disposal of aquarium fishes has more than once been proved to be an important vector for new introductions (a.o. Copp et al. 2005b).

(ii) Use of specific holding conditions and effect of prohibition of organism introduction into the wild

In accordance with Council Regulation no 708/2007, any introduction of Amur sleeper to an aquaculture facility is subjected to the issue of a permit by the receiving Member State, which may be only obtained when the risk of environmental impact is considered as negligible due to adequate holding conditions.

Belgian regional nature conservation and fishery acts strictly prohibit intentional release of most exotic fish species into the wild (incl. Amur sleeper) and their use as live bait for angling. In spite of those legal instruments, such practices cannot be completely prevented, e.g. because control actions in the field are time and resource consuming and demand a good knowledge of all fish species.

Also release and holding of infested fish consigments in earthen aquaculture facilities can create dense populations of Amur sleeper in these ponds which (1) are very difficult to get rid of (this species can withstand very harse environmental conditions) and (2) can be source populations for rivers and floodplains through escapes from these ponds.

3.3 CONTROL AND ERADICATION ACTIONS

Which management measures have been identified to reduce the risk of introduction of the organism? Do they reduce the risk to an acceptable level and are they considered as cost-effective? Specify if the proposed measures have undesirable social or environmental consequences. Consider especially the following questions.

(i) Can the species be easily detected at early stages of invasion (early detection)?

Detection of scarce, previously unknown, aquatic species is very difficult. This results in an unavoidable time difference (up to several years) between the actual introduction of a fish species into a water body and its recording (Reshetnikov, 2013). Even if an invasive fish species is known from interconnected river and canal systems, it may take years before a new species is recorded (e.g. round goby in The Netherlands since 2004 while first record in Belgium in 2010)(Verreycken et al, 2011).

(ii) Are they some best practices available for organism local eradication?

Eradication or control of *P. glenii* populations may be possible in smaller closed systems (like aquaculture ponds and oxbows) if action is taken soon after detection of the species. Amur sleeper, however, can withstand very harsh conditions like low oxygen contents and high alkaline concentrations, freezing in, drying out, etc. Therefore it will be difficult to eradicate all specimens. Experiments have shown that of all species of weed fishes Amur sleeper is the most resistant one to lime chloride (used to kill remaining life in aquaculture ponds) and ammonia water. Hundred procent death of Amur sleeper occurs when concentration of lime chloride is 0.3 g per 1 l of water at exposure of not less than 6 hours. In actual practice this may be done in only small pools. In processing catchment canals ammonia water works well. At water temperature of 7 - 8 °C and pH 9.0 100% death of Amur sleeper occurred in 1 hour 5 minutes after 1 ml of ammonia water was diluted in one pool (Bogutskaya & Naseka, 2002). *Perccottus glenii* is probably also susceptible to piscicides such as rotenone, but such toxicants do not discriminate between *P. glenii* and native species and thus are not ideal (Schreier *et al*., 2008).

(iii) Do eradication and control actions cause undesirable consequences on non-target species and on ecosystem services?

See *(ii)*

(iv) Could the species be effectively eradicated at early stage of invasion?

Probably yes, but it will be very difficult (see *ii*).

(v) If widely widespread, can the species be easily contained in a given area or limited under an acceptable population level?

Large fish predators readily consume Amur sleeper and may control its population density. Maintaining vigorous populations of perch *Perca fluviatilis* and pike *Esox Lucius* may well be an effective strategy for limiting the size of *P. glenii* populations (Bogutskaya & Naseka, 2002).

CONCLUSION OF THE RISK MANAGEMENT SECTION

Amur sleeper is not easy to detect or observe at early stages of invasion and rapid eradication is therefore difficult. Piscicides and ammonia may be useful in eradicating emerging Amur sleeper populations but only in (small) confined areas and at a big cost. A reduction of population density may be achieved by piscivorous fish species like pike and perch. Prohibition of the trade and use as aquarium fish or live bait of Amur sleeper can reduce the risk of species introduction in Belgium. Although it may be quite difficult to implement, import control of large trucks for fish transport and surveillance of fish stocking activities deserve to be done as stowaway specimens of Amur sleeper are regularly reported in fish consignments.

STAGE 4: IDENTIFICATION OF AREAS AT RISK IN EUROPE UNDER CURRENT AND FUTURE CLIMATES

The biogeographic regions in Europe suitable for the development of the Amur sleeper have been identified on the basis of the MAXENT model developed by Reshetnikov & Ficetola (2011), based on species records from both native and invasive ranges as presented in Figure 4. Climatic suitability is assessed as: (i) optimal for the Atlantic, Continental, Pannonian and Steppic regions, (ii) suboptimal for the Black sea, Boreal and Mediterreanean regions and (iii) inadequate for the Alpine and Arctic regions. Taking into account the hardiness of Amur sleeper (low oxygen content, high water chemical composition, very wide temperature range, surviving buried in mud) it is evident that this species can survive and even thrive in less suited climatic conditions now and in the future. Therefore, as a precautionary principle, it seems wise to regard the maximum potentially suitable habitat in Europe (figure 5) as an area at risk under current and future climates.

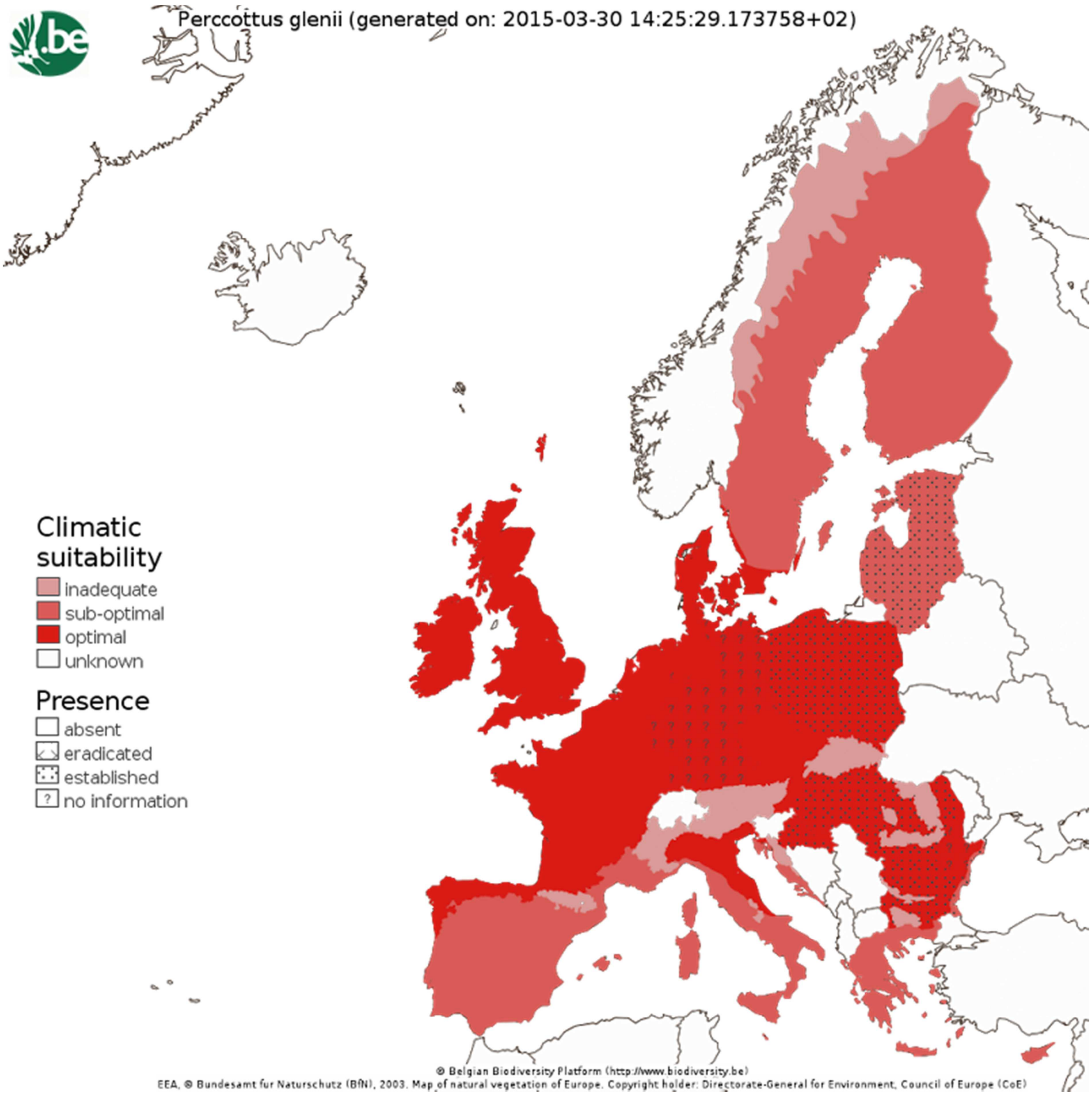

Figure 5: Identification of the biogeographic regions at risk for the establishment of *P. glenii* in Europe based on ecoclimatic preferences extrapolated from species distribution in its native and invasive ranges.

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