RISK ANALYSIS REPORT OF NON-NATIVE ORGANISMS IN BELGIUM

Risk analysis of the Raccoon dog

Nyctereutes procyonoides

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Risk analysis report of non-native organisms in Belgium

Risk analysis of the raccoon dog *Nyctereutes procyonoides* (Gray, 1834)

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Adopted in date of: 11th March 2013

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Produced by: Unité de Zoogéogaphie/Université de Liège & Cellule interdépartementale Espèces invasives (CiEi)/DEMNA/DGO3

Commissioned by: Service Public de Wallonie

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This report should be cited as : "Baiwy, E., Schockert, V. & Branquart, E. (2013) Risk analysis of the raccoon dog Nyctereutes procyonoides, Risk analysis report of non-native organisms in Belgium. Cellule interdépartementale sur les Espèces invasives (CiEi), DGO3, SPW / Editions, 37 pages".

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Acknowledgements

The author wishes to thank the reviewers who contributed to this risk analysis with valuable comments and additional references: René-Marie Lafontaine (IRSNB) and Koen Van Den Berge (INBO).

Etienne Branquart (Cellule Espèces Invasives, Service Public de Wallonie) 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. RBINS/KBIN was contracted by the Federal Public Service Health, Food chain safety and Environment to perform PRA's for a batch of species. ULg was contracted by Service Public de Wallonie to perform PRA's for a selection of species. INBO and DEMNA performed risk analysis for a number of species as in-kind contribution.

Steering committee members were:

Tim Adriaens	Research Institute for Nature and Forest (INBO)
Olivier Beck	Brussels Environment (BIM)
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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 could also be relevant for neighbouring areas with similar eco-climatic conditions (e.g. areas included within the Atlantic and the continental biogeographic regions in Europe).

The risk analysis tool that was used here 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 should it reflect stakeholder consensus. Although the document at hand is of public nature, it is important to realise that this risk assessments exercise is carried out by (an) independent expert(s)

[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).

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	Considering the current expansion rate of the raccoon dog in Germany, it is very likely that it will colonize and establish feral populations in Belgium in the coming decades. Its establishment may also be accelerated by escapes of captive animals.
Establishment capacity	The raccoon dog is likely to establish self-sustaining populations in the south-eastern part of the Belgian territory because appropriate climatic conditions, habitats and preys are encountered. Establishment in the Atlantic area is less likely because of the prevalence of more fragmented semi-natural habitats and of a moister climate.
Dispersion capacity	The raccoon dog can easily spread over long distances and has the capacity to colonize the Belgian territory in one decade only. It has a very high linear expansion rate, contained between 20 and 40 km per year.

EFFECT OF ESTABLISHMENT

Environmental impacts	Based on impacts observed in invaded areas in Europe, it is unlikely that the establishment of raccoon dog will have a strong negative impact on native prey populations in Belgium, except maybe on small isolated populations of amphibians. The outcome of competition with native carnivores is expected to be low to moderate as the raccoon dog has been shown to successfully coexist with them in many European areas. Another environmental consequence of raccoon dog establishment in Belgium could be the pathogen pollution, with the rapid spread and enhancement of some endemic diseases and parasites.

RISK MANAGEMENT

The prohibition of raccoon dog importation, trade and holding is not considered as an efficient measure for reducing the risk of entry to an acceptable level as the natural spread of the species is identified as the most probable pathway of entry in Belgium.

Because of its secretive behaviour, the raccoon dog is not easy to detect or observe at early stages of invasion and rapid eradication is difficult to be performed. Hunting is unlikely to prevent raccoon dog establishment. Where a reduction of population density is requested, satisfactory results may be achieved through costly coordinated actions based on several techniques, including trapping combined with the release of radio-collared sterilized raccoon dogs to be used as lures for the detection of other specimens. Small threatened areas might also be protected using fencing.

Résumé

PROBABILITE DE NATURALISATION ET DE DISSEMINATION DANS L'ENVIRONNEMENT

Introduction en Belgique	Si l'on tient compte du taux d'expansion actuel du chien viverrin en Allemagne, il est fort probable qu'il colonise la Belgique et y établisse des populations sauvages dans les prochaines décennies. Son établissement pourrait aussi être accéléré par l'évasion d'individus captifs.
Capacité de naturalisation	Il est probable que le chien viverrin puisse s'établir de manière durable dans le sud-est de la Belgique car les conditions climatiques ainsi que les habitats et les proies disponibles correspondent à ses exigences. Son établissement dans la région biogéographique Atlantique est moins probable en raison de la fragmentation des habitats semi-naturels et d'un climat plus humide.
Capacité de dissémination	Le chien viverrin se disperse facilement sur de longues distances et serait capable de coloniser le territoire belge en l'espace d'une décennie. Il affiche un taux d'expansion linéaire très élevé qui se situe entre 20 et 40 km par an.

EFFETS DE LA NATURALISATION

Impacts environnementaux	Sur base des impacts observés dans les zones déjà occupées en Europe, il est peu probable que l'établissement du chien viverrin puisse avoir un fort impact négatif sur les populations de proies indigènes, sauf peut-être sur de petites populations isolées d'amphibiens. La compétition avec les carnivores indigènes ne devrait avoir qu'un impact faible à modéré étant donné que le chien viverrin a montré qu'il pouvait coexister avec succès avec ceux-ci dans de nombreuses autres régions européennes. Une autre conséquence environnementale liée à l'établissement du chien viverrin en Belgique pourrait être la dispersion rapide et la prolifération d'agents pathogènes ou de parasites endémiques.

GESTION DU RISQUE

Etant donné que la dispersion naturelle du chien viverrin a été identifiée comme la voie d'introduction la plus probable en Belgique, l'interdiction de son importation et de son commerce et le renforcement de l'interdiction de sa détention ne sont pas considérés comme des mesures efficaces pour réduire le risque d'établissement à un niveau acceptable.

Ayant un mode de vie discret, le chien viverrin n'est pas facile à repérer ou à observer aux stades précoces d'invasion et son éradication rapide est dès lors difficile. Il est peu probable que la chasse prévienne l'établissement du chien viverrin. Là où la densité des populations doit être réduite, des résultats satisfaisants peuvent être obtenus par le biais d'actions coordonnées coûteuses et en ayant recours à des techniques variées incluant notamment la capture en combinaison avec le lâcher de spécimens stérilisés portant des colliers émetteurs en vue de les utiliser comme leurres pour le repérage d'autres spécimens. La protection de petites zones menacées pourrait aussi être obtenue à l'aide de l'installation de clôtures.

Samenvatting

WAARSCHIJNLIJKHEID VAN VESTIGING EN VERSPREIDING (BLOOTSTELLING)

Introductie in België	Gelet op de huidige expansiesnelheid van de wasbeerhond in Duitsland is de kans zeer groot dat de wasbeerhond de komende decennia België zal koloniseren en dat verwilderde populaties zich hier zullen vestigen. De vestiging van deze soort kan nog versneld worden door ontsnapping van dieren die in gevangenschap worden gehouden.
Vestigingsvermogen	Door de gunstige klimaatomstandigheden, de aanwezigheid van geschikt habitat en prooien in het zuidoosten van België is de kans vrij groot dat na introductie de wasbeerhond zijn populaties in dit gebied zal handhaven. Door de meer gefragmenteerde halfnatuurlijke habitats en het vochtiger klimaat is vestiging in de Atlantische regio minder waarschijnlijk.
Verspreidingsvermogen	De wasbeerhond kan zich gemakkelijk over grote afstanden verspreiden; slechts een decennium volstaat voor deze soort om het Belgische grondgebied te koloniseren. De soort onderscheidt zich door een zeer hoge lineaire expansiesnelheid die 20 tot 40 km per jaar bedraagt.

EFFECTEN VAN VESTIGING

Milieu-impact	Uitgaande van observaties elders in Europa waar de soort populaties heeft, is het weinig waarschijnlijk dat de vestiging van wasbeerhond sterk negatieve gevolgen zal hebben voor inheemse prooipopulaties in België. Een mogelijke uitzondering hierop vormen kleine, geïsoleerde amfibieënpopulaties. In heel wat Europese gebieden blijkt dat de wasbeerhond met andere carnivoren kan samenleven. De gevolgen van competitie met inheemse carnivoren zullen naar verwachting dan ook beperkt tot matig zijn. Een snelle verspreiding en bevordering van bepaalde ziekten, pathogenen en parasieten zou een bijkomend gevolg kunnen zijn van de vestiging van wasbeerhond in België.

RISICOBEHEER

Een verbod op de invoer, de verkoop en het houden van wasbeerhond vormt wellicht geen efficiënte maatregel om het risico van introductie tot een aanvaardbaar niveau terug te dringen, aangezien natuurlijke verspreiding uit populaties in de buurlanden (Duitsland) het meest waarschijnlijke introductiepad in België vormt.

Door zijn verborgen bestaan is het niet evident om wasbeerhonden in een vroeg stadium van de invasie te detecteren of waar te nemen. Een snelle uitroeiing is dan ook moeilijk. De jacht op wasbeerhond wordt al evenmin beschouwd als een efficiënt middel om vestiging te voorkomen. Het terugdringen van de populatiedensiteit vergt dure, gecoördineerde acties waarbij verschillende technieken gecombineerd worden, waaronder het uitzetten van vallen en het uitzetten van gesteriliseerde wasbeerhonden met een zender om de hals die kunnen worden gebruikt als lokmiddel om andere specimens te detecteren (“judasdieren”). Kleine, bedreigde gebieden zouden met aangepaste omheiningen kunnen beschermd worden.

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 damage 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 :	*Nyctereutes procyonoides* (Gray, 1834)
Synonyms:	*Canis procyonoides*
Common names :	Raccoon dog (GB), Wasbeerhond (NL), Marderhund (DE), Chien viverrin (FR).
Taxonomic position:	Chordata (Phylum) > Mammalia (Class) > Carnivora (Order) > Canidae (Family).

N. procyonoides is the only representative of its genus and is quite isolated in the *Canidae* family (Wang *et al.* 2004). Its taxonomic position is not clear, notably because it has the unusual characteristic of supernumerary chromosomes and shares homologous chromosomes with members of *Felidae* (Ward & Wurster-Hill 1990, Sheldon 1992). There are six recognized subspecies of *N. procyonoides*, but only *N. procyonoides ussuriensis* was introduced in the former Soviet Union and has spread to Europe (Nowak 1993, Kauhala & Saeki 2008, Kauhala 2012).

1.2 SHORT DESCRIPTION

The raccoon dog is a small fox-like canid measuring from 40 to 50 cm of height and 50 to 70 cm of length (Carr 2004, Léger & Ruette 2005). Its weight is around 4-6 kg in summer, but it can reach 10 kg in late autumn before hibernation (Kauhala 1993, Carr 2004, Léger & Ruette 2005, Rudert *et al.* 2011). There is no sexual dimorphism among this species (Rudert *et al.* 2011).

The legs are short and dark, the body is broad and its fur is long with grey-brownish colour. It has a short and bushy brown tail with a dark tip (Léger & Ruette 2005, Wittenberg 2005, Rudert *et al.* 2011). Due to similar size and black facial mask, it is often confused with the raccoon (*Procyon lotor*) and the European badger (*Meles meles*)* (Nowak 1993, Wittenberg 2005, Mulder 2011).

1.3 ORGANISM DISTRIBUTION

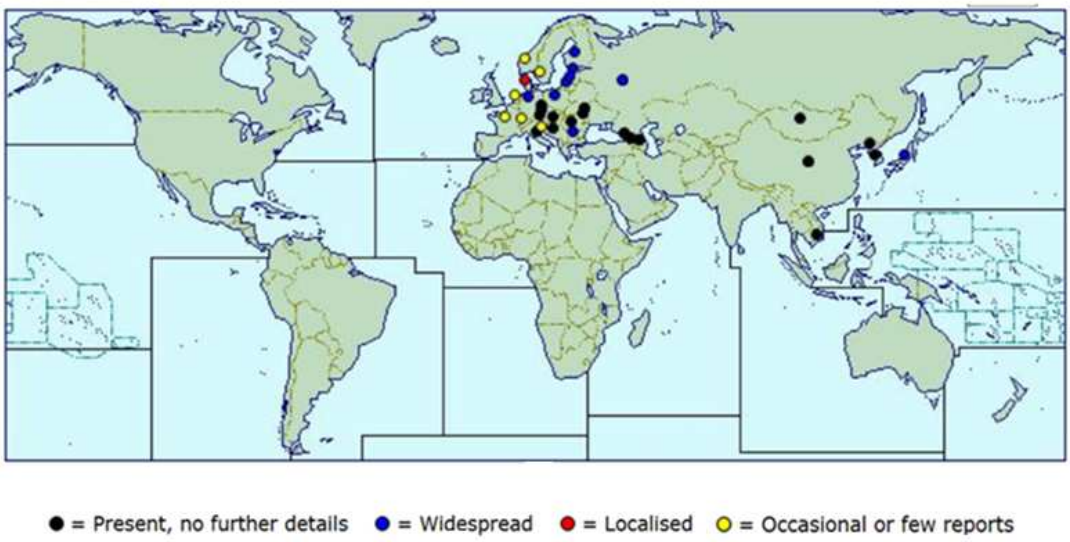
Native range

The native range of *N. procyonoides* is East Asia, including southeast Siberia, China, North Vietnam, Korea, Mongolia and Japan (Nowak 1984, Nasimovich & Isakov 1985, Carr 2004, Cirovic 2006, Kauhala & Saeki 2008).

Introduced range

Belgium:	The species is not established in Belgium, but casual observations have been recently reported (Libois, 2006)
Rest of Europe:	Established in the Baltic States, Belarus, Bulgaria, Czech Republic, Estonia, Finland, Germany, Hungary, Latvia, Lithuania, Moldava, Poland, north-western Russia, Romania, Slovakia, Ukraine, Yugoslavia (Serbia and Montenegro) (Ward & Wurster-Hill 1990, Sheldon 1992, Mitchell-Jones *et al.* 1999, Kauhala & Winter 2006, Kauhala & Saeki 2008, Kauhala & Kowalczyk 2011, Rudert *et al.* 2011).
Other continents:	Established in Armenia, Azerbaijan, Republic of Georgia, Kazakhstan and Yakushima island in Japan (Kauhala & Saeki 2008).

A



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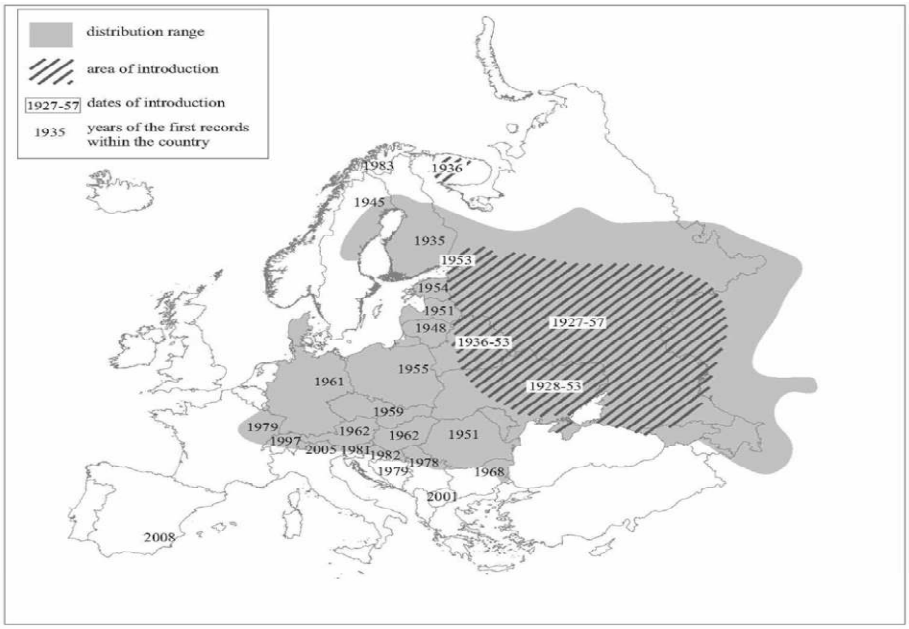

Figure 1- Distribution of the raccoon dog *Nyctereutes procyonoides*: (A) global distribution in its native and introduction ranges (CAB International 2012) and (B) areas of introduction and expansion in Europe, with indications of first observations in the different countries (after Kauhala & Kowalczyck 2011).

1.4 REASONS FOR PERFORMING RISK ANALYSIS

Up to now, there is no feral population of raccoon dog established in Belgium despite the fact that it is widely established in different parts of Europe and that some individuals are regularly observed in the Southern part of the country. As the species continues to spread rapidly westwards and southwards among Europe (Kauhala 1992), establishment is likely to occur in the future in Belgium as well. Detrimental impacts of the raccoon dog were reported to occur on the environment and public health in its invaded range; their potential occurrence should therefore be carefully assessed on the Belgian territory.

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 neighboring 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.

So far, isolated observations of raccoon dogs were made in Belgium but no evidence of reproduction has been found and the species is not considered as established in the country (Libois 2006, Van Den Berge & De Pauw 2003, Branquart *et al.* 2011). Since 1998, two specimens of raccoon dogs were collected as traffic casualties in Flanders (one in West Flanders and the other in Limburg) and a few other observations have recently been recorded; however, autopsy revealed no indication of reproduction in the wild (Van Den Berge 2008, Van Den Berge & Gouwy 2009). In Wallonia, raccoon dogs have been observed in different localities, especially in Ardenne (Libois 2006); 1 dead individual killed by road traffic has also been collected (Schockert *et al.* 2008). 1 adult and 3-4 pups have even been observed in 2010 near Smuid (Libin) (M. Thirion, pers. comm.).

2.1.2 Present status in neighbouring countries

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

Between 1929 and 1955, about 9,100 individuals of *N. p. ussuriensis* were introduced in the European and Asian U.S.S.R., firstly in breeding farms and later in several localities in the wild to enrich fauna with a new valuable fur animal (Lavrov 1971, Carr 2004, Wittenberg 2005, Kauhala & Kowalczyk 2011, Rudert *et al.* 2011). Its introduction was particularly successful, and the raccoon dog quickly started to extend to neighbouring countries (Nowak 1984, Nowak 1993, Mitchell-Jones *et al.* 1999, Kauhala & Saeki 2004, Wittenberg 2005, Rudert *et al.* 2011). In Poland, raccoon dog colonization started in 1950 and expanded rapidly; the species is nowadays more common than any other native medium-sized carnivores (Kowalczyk *et al.* 2009).

In Germany, the first raccoon dog was reported in 1961; the population rapidly increased since 1997, leading to a widespread distribution in the eastern part of the country (figure 2). Since 2005, about 30,000 individuals are shot yearly throughout the country (Nowak & Pielowski 1964, Ansorge & Stiebling 2001, Drygala *et al.* 2002 & 2008b, Anonymous 2010, Kauhala 2012).

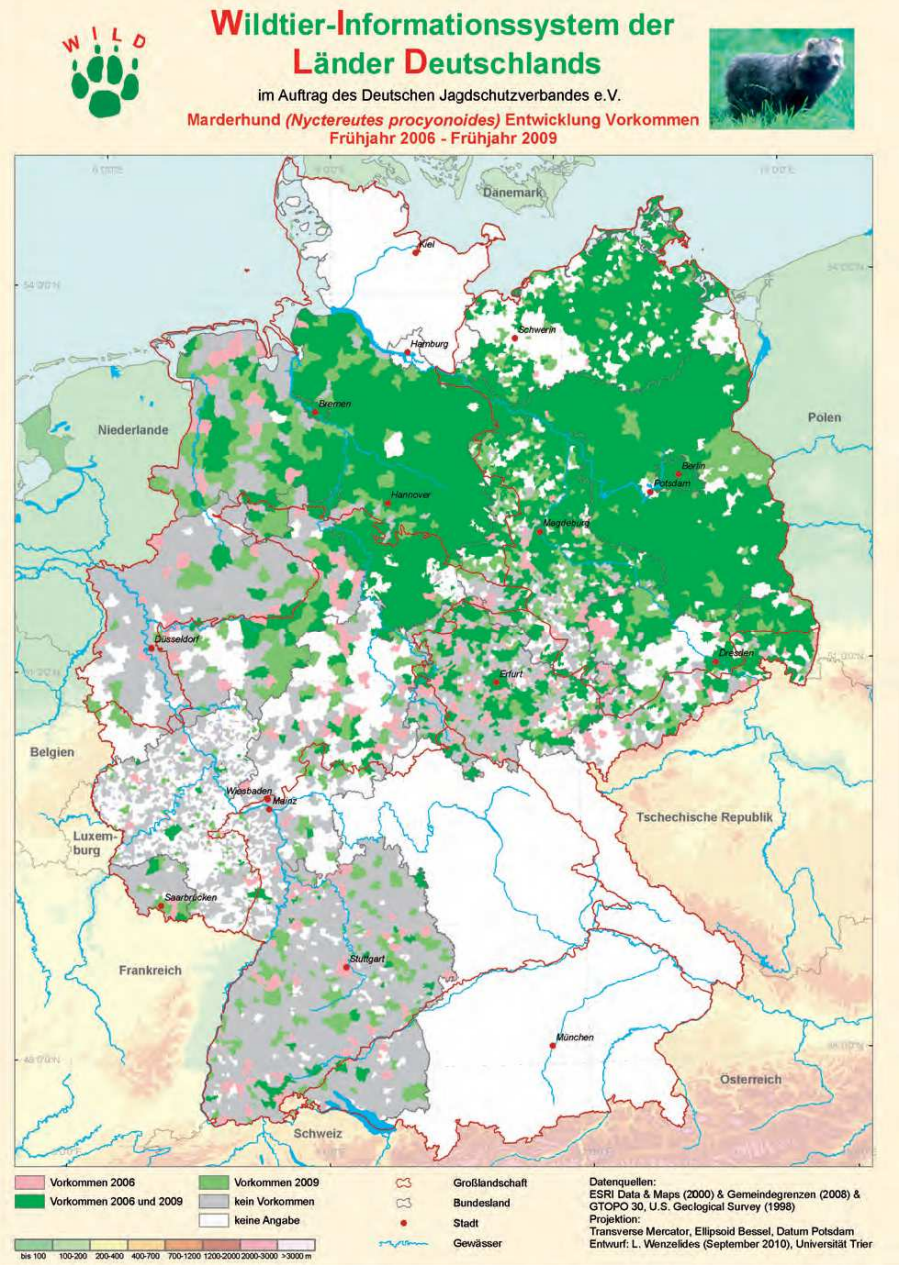

Figure 2 – Distribution of the raccoon dog at the municipality scale in Germany.
Dark green: observations in 2006 and 2009, pink: observations in 2006 only, light green: observations in 2009 only, grey: species not reported white: no data provided. Data: WILD project (Anonymous 2010).

Observations are also increasingly reported from France (especially the north-east area), Luxembourg and the Netherlands, but a firm evidence of the establishment of wild populations in these countries is still lacking (Schley *et al.* 2001, Leger & Ruette 2005, Wittenberg 2005, Hurel 2011, Kauhala 2012). Sporadic by steady observations are recorded from the Netherlands since 1990 (93 certain or probable records until January 2011). Most observations were made in the north eastern part of the country and were likely to result from a natural expansion of the German population (see figure 2). On the other hand, a few observations originated from the southern part of the country and were considered to be escapes because of a tame behavior and the lack of spatial continuity with the bulk of observations. There is an apparent lack of reproduction in the Netherlands as indicated by post-mortem research and absence of cub observations in the field (Mulder 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).

The raccoon dog may enter in Belgium following two main pathways: its range expansion from established populations in Central Europe, and escape or release from captivity. As the raccoon dog rapidly spreads westward, **a natural dispersion from Germany is very likely to cause species establishment in Belgium in the coming years** (Leger & Ruette 2005, Mulder 2011).

Accidental escapes from captivity (private detention by amateurs, zoo or fur farm) may also occur (Lavrov 1971, G.O.N. 2005, Mulder 2011). The species is likely to be hold in outdoor kennels as pets in Belgium as in neighbouring countries and may escape from them due to owner negligence, although detention by private owner is theoretically forbidden by the Belgian law on animal welfare (M.B. 03.12. 1986). This species is rather easy to retain because fences of only 1 meter high are sufficient to contain them, they eat more or less everything, they are not noisy and deposit their faeces in a single spot (called latrines) (Léger & Ruette 2005, Stier 2006, Mulder 2011). So far, there is no raccoon dog breeding farm in Belgium (Ann De Greef, GAIA director, *pers. comm.*), but establishment may not be excluded in the future. At last, intentional releases of raccoon dogs in the wild for hunting purposes is unlikely to happen in Belgium. This practice is strictly forbidden by regional hunting and nature conservation legislations.

ENTRY IN BELGIUM

Considering the current expansion rate of the raccoon dog in Germany, it is very likely that the raccoon dog will colonize and establish feral populations in Belgium in the coming decades. Its establishment may also be accelerated by escapes of captive animals.

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

Lifespan of raccoon dogs is 5-7.5 years in the wild and 11-14 years in captivity (Ward & Wurster-Hill 1990, Carr 2004, G.O.N. 2005). Raccoon dogs are monogamous and form mating pairs throughout the year (Kauhala *et al.* 1993a, Carr 2004, Rudert *et al.* 2011). They reach sexual maturity at 9-11 months (Ward & Wurster-Hill 1990, Sheldon 1992, Helle & Kauhala 1995, G.O.N. 2005, Kauhala & Winter 2006, Melis *et al.* 2007). The average of breeding females in the population is around 80% (Kauhala & Winter 2006, Kowalczyk *et al.* 2009). This species has a high reproductive capacity, even if there is only one litter per year. In Europe, females give birth to 1-16 (on average 6-9) pups, which is higher than in the species native range, and larger than expected for a medium-size carnivore species (Kauhala 1992, Helle & Kauhala 1995, Kauhala 1996b, Carr 2004, G.O.N. 2005, Kowalczyk *et al.* 2009, Mulder 2011). The mortality rate is high, in particular among juveniles; 70-90% of them die during their first year mainly because of hunting, traffic, domestic dogs and cub predation by foxes and badgers (Helle & Kauhala 1993, Drygala *et al.* 2010). The mortality rate is about 45% among middle-aged raccoon dogs (2-4 years), and only 1% of the individuals reaches 5 years of age (Kauhala & Kowalczyk 2011).

B/ Climatic requirements[2]

The raccoon dog is an invasive species showing a great plasticity to a wide range of climatic conditions. In its native range, the species occurs from subtropical regions (Japan, Vietnam, China) to harsh continental (subarctic) climates with cold winters (Mongolia, Siberia) (Kauhala 1996a, Kauhala & Kowalczyk 2011).

The raccoon dog prefers continental climate (with dry summer or even wet all the year), and warm temperate climate with dry summer and winter, but it tolerates also warm temperate or steppe climate (Melis *et al.* 2010, Kauhala 2012). It is well adapted to cold climate with severe winters as it may enter in lethargy with a metabolic rate decline of around 25% during harsh winters; hibernation occurs when temperature is below -10°C, snow depth >35 cm and day length <7 hr (Heptner & Naumov 1974, Singer *et al.* 2009, Kauhala & Kowalczyk 2011, Kauhala 2012). The current northern

[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.

limit of permanent distribution in Europe lies at the Arctic Circle (in Finland) where the mean temperature throughout the year is just above 0°C (Lavrov 1971, Helle & Kauhala 1991).

The species also has recently established in Atlantic and submediterranean European areas with milder winter conditions, like the north-eastern part of Germany. In the south, the species has managed to cross the Alps and is now present in northern Italy (P. Genovesi, INFS - Italian Wildlife Institute, Ozzano Emilia, Italy, pers. comm. 2005). No activity decline is observed in those areas characterized by mild winters (Kauhala *et al.* 2007, Mulder 2011). Frequent rainy events and hail or snow showers during spring may however affect the growth rate, the body condition and the survival rate of young raccoon dogs, which could potentially lead to lower population densities in Atlantic conditions. No population is established so far in the Atlantic region in Europe (Barbu 1972, Kauhala & Helle 1995, Melis *et al.* 2007 & 2010; Kowalczyk & Zalewski 2011, Kauhala 2012).

C/ Habitat preferences[3]

N. procyonoides has a wide range of habitat preferences and is found from sea level to high altitude areas (Carr 2004, Wittenberg 2005). Both in native and introduced ranges, it thrives in natural deciduous and mixed forests with sparse canopy, natural grasslands, damp meadows, riverbanks and wetlands. The presence of a **dense undergrowth** (thick under canopy, reedbeds, shrubs, etc.) is of primary importance and is much more important than the tree species community present because it provides both a shelter and a source of food. Scrubs and shrublands, cultivated and agricultural lands, managed forests, plantations and orchards, managed grasslands, gardens, urban and periurban areas (where it scavenges for food) are also tolerated (Ward & Wurster-Hill 1989, Ward & Wurster-Hill 1990, Sheldon 1992, Jędrzejewska & Jędrzejewski 1998, Drygala *et al.* 2008a, Drygala *et al.* 2008b, Drygala *et al.* 2008c, Ansorge *et al.* 2009, Kauhala 2012). It generally avoids open fields, and large coniferous forests or other dark woodlands with a thick canopy (Novikov 1962, Stroganov 1969, Yudin 1977, Nasimovich 1985, Mulder 2011).

Habitat preferences may change according to seasons and food availability. Areas along water, as lakes and river shores, are particularly used by the raccoon dog in early summer when they offer many frogs and other food items, whereas moist woodlands are preferred in late summer and autumn for their abundant berries. **As a result, the proximity of water and the availability of berries during the autumn largely determine the presence and the density of raccoon dogs at a landscape scale** (Kauhala 1996a, Melis *et al.* 2007, Kauhala & Saeki 2008).

According to EUNIS, raccoon dogs occupy the following habitat types in their invaded range: littoral zone of inland surface waterbodies (C3), mire, bog and fen habitats (D), grassland and tall forbs habitats (E), temperate shrub heathland (F4), woodland and forest habitats and other wooded land (G), regularly or recently cultivated agricultural, horticultural and domestic habitats (I), rural mosaics, consisting of woods, hedges, pastures and crops (X8).

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

In addition to the shelter and food availability, the raccoon dog habitat preference is also affected by den site accessibility (Kauhala 2012). Dens can be constituted by cavity under big rocks, in tree trunks or under outbuilding, or by badger and fox setts (Kauhala & Holmala 2006, Kowalczyk *et al.* 2008, Kowalczyk & Zalewski 2011). These burrows are used to give birth and raise pups, and for overwintering periods (Goszczyński 1999, Kauhala *et al.* 2007, Drygala *et al.* 2008a, Drygala *et al.* 2008b, Drygala *et al.* 2008c, Kowalczyk *et al.* 2008, Mulder 2011).

D/ Food habits[4]

N. procyonoides forages on the ground and on low vegetation, but it also fishes in lakes, rivers and streams; it can swim and dive underwater for food (Sheldon 1992). It has a poor vision but its sense of smell is well developed for hunting and foraging (Carr 2004). It is an opportunistic omnivorous carnivore, not fast but relentless, characterized as collector or gatherer (Ward & Wurster-Hill 1989, Ward & Wurster-Hill 1990, Wittenberg 2005, Sutor *et al.* 2010).

The raccoon dog forages on a wide range of food items, depending on their seasonal availability (Kauhala 1996a, Jędrzejewska & Jędrzejewski 1998, Wittenberg 2005). It is also known to forage on garbage during winter (Ikeda 1985, Ward & Wurster-Hill 1990, Sasaki & Kawabata 1994, Hirasawa *et al.* 2006). Its diet is made of insects, amphibians, mollusks, fishes, crabs, shrimps, sea urchins, snakes, lizards, birds (especially eggs and chicks), small mammals as rodents, carrion and plant parts such as stems, roots, leaves, bulbs, fruits, nuts, berries, and seeds (Kauhala & Auniola 2001, Carr 2004, G.O.N. 2005, Wittenberg 2005, Sutor *et al.* 2010). **Although its diet is highly variable, a common trait seems to be the specialization on carrion in late autumn-early winter, on amphibians in spring and summer, and on berries (especially *Vaccinium myrtillus, V. uliginosum* and *V. vitis-idaea*) in late summer** (Sidorovich *et al.* 2008, Sutor *et al.* 2010).

E/ Control agents

N. procyonoides may suffer from high mortality due to predation by different large predatory birds (eagle and eagle owl*) and mammal species (lynx, wolf, wolverine), especially in late autumn when its mobility is reduced by fat accumulation (Lavrov 1971, Ward & Wurster-Hill 1990, Sheldon 1992, Kauhala 1993, Saeki 1995, Kowalczyk *et al.* 2008, Kowalczyk *et al.* 2009, Kowalczyk & Zalewski 2011). As those natural enemies are absent or poorly represented in Belgium, they are likely to play a minor role on species establishment.

Competitors are also reported to possibly have a weak negative impact on population densities. In Japan, native raccoon dog abundance decreased after the invasion of raccoons (Ikeda *et al.* 2004). In Europe, raccoon dog pups are very occasionally vulnerable to predation and accessed by badgers* and foxes* which use the same burrows (Kowalczyk *et al.* 2009).

In their native and introduced ranges, raccoon dogs are important victims of rabies, sarcoptic mange, piroplasmosis and canine distemper virus. Several helminth species (*Trichinella spp.* and *Echinococcus spp.*) can also lead to population decline. Those parasites are however unlikely to hinder raccoon dog establishment as demonstrated by its high success of invasion in Central Europe

[4] For animal species only.

where those parasites are endemic (Ward & Wuster-Hill 1990, Nowak 1993, Shibata & Kawamichi 1999, Kauhala & Saeki 2008, Mulder 2011, Cha *et al.* 2012).

Humans are also reported as major threats for raccoon dogs by hunting, commercial trapping and fur farming or road collisions (often in autumn when juveniles disperse) (Ward & Wurster-Hill 1990, Sheldon 1992,Wittenberg 2005, Kowalczyk *et al.* 2009, Takeuchi *et al.* 2012). Moreover, *N. procyonoides* seems to be affected throughout its range by pollution such as organtins (OTs), lead, PCDDs, PCDFs and PCBs (Kauhala & Saeki 2008).

Although the factors described above may significantly impact the raccoon dog fitness, they may certainly not prevent the species to establish successfully after its arrival on the Belgian territory.

F/ Establishment capacity in Belgium

The raccoon dog is a successful invasive species and is currently dominant amongst the carnivore guild in several European countries (Jędrzejewska & Jędrzejewski 1998, Sidorovich *et al.* 2000, Kauhala *et al.* 2006, Kauhala & Kowalczyk 2011).

Its high success rate is due to its wide original distribution range, its high adaptability to environmental conditions and its high dispersal and reproductive potential (McNeely 2000, Kowalczyk & Zalewski 2011).

It is likely to be able to establish in Belgium because (i) the country climate matches that of regions where it has already successfully invaded large areas like the north-east of Germany, (ii) it is unlikely to be strongly affected by predators and diseases in Belgium, (iii) it has an opportunistic and omnivorous foraging behaviour and its preys are available in Belgium. The sporadic and steady observations that were performed during the recent years in Belgium probably match with the lag phase following species arrival as observed in other countries (Finland, eastern Germany and Czech Republic), which usually precedes a rapid exponential population increase (Helle & Kauhala 1991, Drygala *et al.* 2002, Mrštny *et al.* 2007).

G/ Endangered areas in Belgium

Almost all areas in Belgium are suitable for raccoon dogs, except extensive open agricultural landscapes and dense built up areas as found in the Brabant, the Flandrian and the Maritime districts. Other districts are considered as presenting optimal conditions for species establishment, including large amounts of semi-natural areas including wetlands and riverine forests and a good availability of den sites and food resources.

Establishment in the north-western part of the country is also likely to be hindered by moist winter and spring conditions that prevail under the Atlantic climate.

Establishment capacity in the Belgian geographic districts:

Districts in Belgium	Environmental conditions for species establishment[5]
Maritime	Suboptimal
Flandrian	Suboptimal
Brabant	Suboptimal
Kempen	(Sub-)optimal
Meuse	Optimal
Ardenne	Optimal
Lorraine	Optimal

ESTABLISHMENT CAPACITY AND ENDANGERED AREAS IN BELGIUM

The raccoon dog is likely to establish self-sustaining populations in the south-eastern part of the Belgian territory because appropriate climatic conditions, habitats and preys are encountered. Establishment in the Atlantic area is less likely because of the prevalence of more fragmented semi-natural habitats and of a moister climate.

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

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

Home range

The raccoon dog home range is about 10-50 ha in Japan and about 50-2,000 ha in Europe, according to the habitat type and the seasonal activity (Kauhala *et al.* 1993a, Jędrzejewska & Jędrzejewski 1998, Asikainen *et al.* 2004, Kauhala & Saeki 2004, Kauhala *et al.* 2006, Tae-Young & Park 2006, Drygala *et al.* 2008b). A mate pair shares the same home range, and home ranges of adjacent couples of raccoon dogs can overlap (this species is not territorial), except the core areas which are always exclusively used by the pair and avoided by neighbours (Kauhala *et al.* 1993a, Kauhala & Saeki 2004, Kauhala *et al.* 2006, Drygala *et al.* 2008a). The mean local pre-breeding population density is often between 0.5 and 1.0 adult per km^2 with sometimes, locally, a maximum of 2 adults per km^2 in the most varied landscapes (Kauhala *et al.* 2006, Drygala *et al.* 2008a, Sutor & Schwarz 2012).

Dispersal distances

Raccoon dog has an intrinsic tendency to wander over long distances, especially amongst juveniles searching for a new suitable home range (Kauhala & Helle 1994, Kauhala *et al.* 2006, Drygala *et al.* 2010), as far as 300 km in a year (Nasimovič & Isakov 1985) or 500 km within three years (Nowak 1973). In expanding populations, dispersal may be very intensive and is a combination of adult and juvenile movements. Spread is more limited in stable populations and results mainly from post-natal movements of juveniles at 4-5 months of age; in this case, dispersal distances rarely exceed 20 km from the natal home range (Nasimovič & Isakov 1985, Kauhala et al. 1993a, Kauhala & Helle 1994, Sutor 2008, Drygala *et al.* 2010). The very strong dispersal capacity of this species is confirmed by the weak population genetic structure of raccoon dogs across North and Central Europe (Pitra *et al.* 2010). Water systems and mosaic landscapes are used as migratory corridors by raccoon dogs, whereas crossing mountain ranges and villages/towns may represent some barriers to dispersion (Nowak 1973, Sackl 2001, Sutor 2008).

Expansion rates

As a result, *N. procyonoides* is able to extend its range very quickly, with an **average linear expansion rate of 20-40 km per year** from the introduction sites, usually following streams and wetlands (Lavrov 1971, Helle & Kauhala 1991, Drygala *et al.* 2000, Melis *et al.* 2007). Within 50 years (1935−1984), this Asiatic species colonized over 1.4 million square kilometers in Europe, and so, it doubled its world repartition range. Today, it continues to spread in Central, Southern and Western Europe (see figure 1B) (Nowak 1984, Kauhala & Saeki 2004, G.O.N. 2005, Leger & Ruette 2005). Under

continental climatic conditions, the species has the capacity to spread naturally all over one country in 10 years only, as demonstrated by its invasion histories in Germany, Lithuania and Poland (see figure 3) (Kauhala & Kowalczyk 2011).

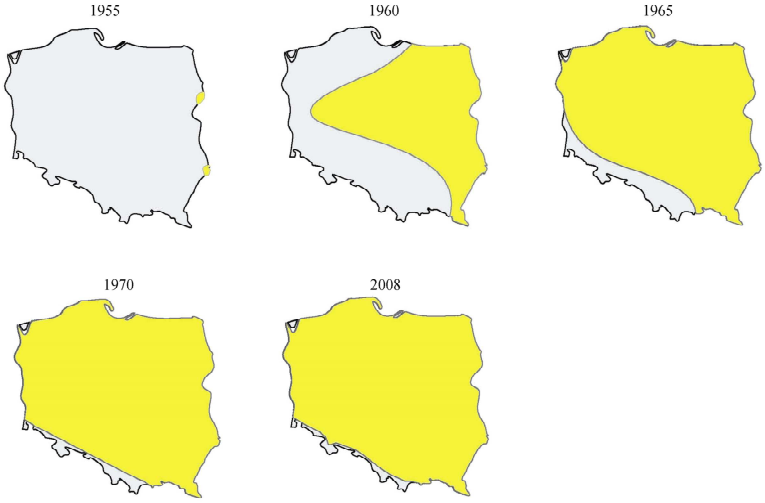

Figure 3 - Expanding of the frontier of raccoon dog distribution across Poland (after Kauhala & Kowalczyk 2011).

B/ Human assistance

The expansion rate of raccoon dog has been considerably enhanced in the past due to multiple intentional translocations of the species in Central Europe. Today, intentional release is unlikely to occur in Western Europe and accidental release is considered as a rare event because raccoon dog is not able to easily escape from captivity. Some isolated observations far away from the bulk of other observations may however indicate escapes (Léger & Ruette 2005, Mulder 2011).

DISPERSAL CAPACITY

The raccoon dog can easily spread over long distances and has the capacity to colonise the Belgian territory in one decade only. It has a very high linear expansion rate, usually contained between 20 and 40 km per year.

2.2 EFFECTS OF ESTABLISHMENT

Consider the potential of the non-native organism to cause direct and indirect environmental, economic and social damage 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.

The raccoon dog shares many of the life history traits linked to invasiveness and potential impacts on the environment and the economy in alien ranges, as identified amongst mammal species (large body, habitat generalist, wide diet breath and large litter size) by Kumschick *et al.* (2012).

The impacts described hereafter are evaluated on the basis of studies performed in areas where raccoon dogs are established and are present at high densities.

A/ Competition

The raccoon dog shares ecological aspects with several native and non-native medium-sized carnivores such as badger *Meles meles* *[6], red fox *Vulpes vulpes* *, polecat *Mustela putorius* *, pine marten *Martes martes**, wolf *Canis lupus*, European otter *Lutra lutra,* raccoon *Procyon lotor* and American mink *Neovison vison* (Jędrzejewska & Jędrzejewski 1998, Kauhala & Winter 2006, Zhang *et al.* 2009, Baltrunaite 2010, Mulder 2011). An interference competition and a resource competition can occur between these species (Pianka 1978).

Results found in the scientific literature about the potential outcomes of such interactions do not indicate a severe competition. **It is generally acknowledged that competition would not be severe enough to have a significant impact on the populations of native carnivore species**, even if those species often occupy the same habitats and search for similar prey species. No hard evidence is available to demonstrate that raccoon dog colonization might lead to a significant decrease of any of the species abovementioned; a raise in the global densities of carnivores is rather observed in invaded areas (Polis *et al.* 1989, Buskirk 1999, Sidorovich *et al.* 2000, Baltrunaite 2006, Melis *et al.* 2007, Drygala 2009, Holmala 2009, Kauhala & Kowalczyk 2011). Concerning the European badger*, it seems that it can easily coexist with the raccoon dog and use available resources with minimal competition for food, habitat and den use (Jędrzejewska & Jędrzejewski 1998, Kowalczyk *et al.* 2008). The cohabitation between both species is high in winter (90% of dens), but very low in summer (10% of dens), and it appears that raccoon dogs rarely give birth to cubs in occupied badger dens

[6] * Indicates native species occurring in Belgium.

(Kowalczyk *et al.* 2008). In very rare circumstances during cohabitation, badgers can kill raccoon dog pups, and inversely raccoon dogs sometimes kill badger cubs (Jędrzejewska & Jędrzejewski 1998, Kowalczyk *et al.* 2008). Similarly, competition between raccoon dog and red fox* is expected to be absent or weak, and the rise in raccoon dog population generally doesn't lead to red fox population decline in its introduction range (Kauhala *et al.* 1998, Sidorovich *et al.* 2000, Zoller 2006, Baltrunaite 2010).

However, in southern Finland, a predator removal study suggests a possible competition between red fox* and raccoon dog. When the hunting pressure is oriented towards one of them, the other one may benefit from it and increase in numbers (Kauhala *et al.* 1998, Kauhala 2004). In addition, another Finnish study has shown some character displacement in a population of red fox* due to the arrival of the raccoon dog: increase in tooth size and shift towards hypercarnivorous diet (Viranta & Kauhala 2011).

B/ Predation

The raccoon dog is an opportunist and generalist omnivorous carnivore, not fast but relentless, characterized as collector or gatherer, and which has a very diverse diet composition according to the season and the food availability in its environment (Lavrov 1971, Kauhala *et al.* 1998c, Melis *et al.* 2007, Sutor *et al.* 2010). **Concerns about its harmfulness on bird and amphibian populations were raised after its arrival in Central Europe.**

Hunters have suspected for a long time that raccoon dogs may destroy the nests of many game bird species. This assertion was however not based on hard facts. In addition, most studies dealing with the effects of predation are based on the analysis of scats or stomach content, where it is difficult to make the distinction between remains from actual predation or from scavenging. Today robust scientific studies clearly demonstrating damage caused to native birds are scarce or contradictory, even in insular environments (Melis *et al.* 2007, Sutor *et al.* 2010, Kauhala & Kowalczyk 2011). Most of authors agree the raccoon dog might represent a threat due to the increase of predation withdrawal but that **its impact on prey species is lower than this due to the activity of native predators as the red fox*; there is also a general agreement that the raccoon dog behaves rather as a scavenger or a gatherer than as an active predator** (Drygala et al. 2000, Melis et al. 2007, Sutor *et al.* 2010, Kauhala & Kowalczyk 2011, Mulder 2011).

According to most authors (84 data sets of diet studies from different parts of native and introduced ranges), the raccoon dog impact on the breeding success of bird populations is probably negligible. In a nest predation study in Latvia, the relative contribution of the predation activity of the raccoon dog was classified as very low (0,6%) in comparison with withdrawal attributed to other predators like marsh harrier* (53.7%), corvids* (14.7%) or American mink (9%) (Opermanis *et al.* 2001). Most predator removal studies don't show any strong evidence of the potential harmfulness of raccoon dogs to game bird populations, contrary to red fox and pine marten (Kauhala *et al.* 2000, Kauhala 2004, Kauhala & Kowalczyk 2011). However, one predator removal study in Finland indicated that raccoon dog might have a small effect on the breeding success of waterfowl (Väänänen *et al.* 2007). Passerines are the most frequent bird species eaten by raccoon dog, and are mainly consumed as

carcasses through scavenging behaviour (Novikov 1962, Barbu 1972, Drygala *et al.* 2000, Kauhala & Auniola 2001, Selva *et al.* 2003, Woloch & Rozenko 2007, Kauhala 2009, Sutor *et al.* 2010). However, it cannot be totally excluded that a raccoon dog may cause a significant impact on ground nesting birds and bird colonies in wetlands (greylag goose *Anser anser**, black-headed gull *Larus ridibundus**, purple heron *Ardea purpurea**, black tern *Chlidonias niger**, great bittern *Botaurus stellaris**), for which some people fear that damage could be considerable in a short time (Melis *et al.* 2007, Kauhala & Kowalczyk 2011, Mulder 2011). The main source of concern in those habitats is related to the high readiness of *N. procyonoides* to swim which may strongly supplement that the impact of the red fox (Mulder 2011).

Amphibians commonly occur in the diet of raccoon dogs in spring and summer. It is why **raccoon dog is suspected to be responsible for the local decline of small isolated amphibian and reptilian populations** (*Rana spp.**, *Bufo spp.**, *Bombina spp.*, *Triturus cristatus**, *Natrix natrix**, probably also turtles), especially on small islands and/or on endangered species, because of its diet preferences and the ease to catch frogs and tadpoles in wetland areas (Ivanova 1962, Lavrov 1971, Barbu 1972, Viro & Mikkola 1981, Kauhala *et al.* 1993b, Jędrzejewska & Jędrzejewski 1998, Kauhala *et al.* 1998a, Kauhala & Auniola 2001, Drygala 2009, Sutor *et al.* 2010). For example, frog populations have declined in some islands of the southwest coast of Finland after raccoon dog arrival in the 1970s (but frog populations have not declined on the outer islands where raccoon dogs are not found) (Kauhala 1996a). A study demonstrated that frogs, reptiles, shrews and carrion occurred frequently in the raccoon dog diet on the mainland, but are lacking or only occasional in the outer archipelago of Finland, suggesting that raccoon dog (and/or the American mink) already has(have) destroyed the local frog populations of some islands in the Finnish archipelago (Kauhala & Auniola 2001, Woloch & Rozenko 2007, Salo 2009, Kauhala 2012).

C/ Genetic effects and hybridization

There is no risk of genetic effects on native species, because *N. procyonoides* is rather an isolated species among the Canidae family, and hybridization with other dog species has not been proved, even in captivity (Mulder 2011).

D/ Pathogen pollution

The raccoon dog is not known to have imported East-Asian diseases or parasites that may spill over to European hosts. However, it has been reported to share the same diseases and parasites than European carnivores like the badger* or the red fox* and to provide a new potential reservoir for endemic parasites and pathogens (Weidema 2000, Melis *et al.* 2007, Mulder 2011) (see the list of pathogens referred in the control agent section).

N. procyonoides is a species which spreads rapidly (especially juveniles which can have long dispersal distances) and which sometimes interacts and coexists (home range overlaps) with other species as badgers and foxes. Raccoon dogs are also often killed by some carnivores (e.g. wolves and dogs, R. Kowalczyk, unpubl. data), which creates a risk of disease transmission to these carnivores. Thus, it can actively participate to disease transmission and might potentially bring new diseases or parasites

far from areas of endemism (Kauhala & Holmala 2006, Kauhala *et al.* 2006, Sutor 2008). Kauhala & Kowalczyk (2011) consider this fact as the most severe risk of the colonization of Europe by the raccoon dog.

The effect of spillback of endemic diseases and parasites to populations of native predators has been poorly described in the scientific literature. However, raccoon dogs have been shown to enhance the frequency of the sarcoptic mange in wild animals and so enhance their mortality, especially among foxes (Shibata & Kawamichi 1999, Stier 2006, Zoller 2006). The raccoon dog is also known to play a major role in the maintenance of the *Trichinella* spp. sylvatic cycle (reservoir function) and is assumed to have facilitated parasite expansion across Central Europe (Thies *et al.* 2001, Pannwitz *et al.* 2010). In Finland, an association between the density of *N. procyonoides* and the prevalence of *Trichinella* larvae amongst large European predators feeding on it has been demonstrated (Oksanen *et al.* 1998, Oivanen *et al.* 2002). It may also have played a role in the recent spread of the canine distemper virus in Eastern Germany (N. Stier, pers. comm.). However, **a strong decrease of native predator species leading to local species extinction due to parasite spillback from raccoon dog has never been documented to our knowledge**.

At last, the raccoon dog is becoming increasingly important as a significant secondary host for rabies, and adds complexity to the epidemiology and epizootiology of the virus in areas where it is still present in Europe; **it is nowadays the major rabies host in Northern Europe** (Botvinkin *et al.* 1981, Holmala & Kauhala 2006, Singer *et al.* 2009, Mulder 2011). Where raccoon dog density is high, it may outcompete the red fox because of apparent competition with the rabies virus (Singer *et al.* 2009).

The presence of the raccoon dog may strongly enhance the risk of rabies recurrence in virus-free countries in Europe because (i) it raises (about doubled in northern Europe) the combined density of susceptible animal to rabies which could become large enough to sustain a long-term rabies epizootic, where each vector species on its own was too low to sustain it, and (ii) it has also an impact on the number of interacting vector species (intra- and inter-specific transmissions); these consequences may considerably induce a shift in rabies limit to the north of Europe (Kauhala *et al.* 2006, Holmala 2009, Singer *et al.* 2009, Mulder 2011).

A colonization of Belgium by the raccoon dog will certainly not enhance the risk of rabies importation, because there are no chances that a raccoon dog coming from an infected area disperses around 1000 km to enter our country (Kauhala & Holmala 2006, Mulder 2011). But, if rabies is imported accidentally, **a cohabitation of red fox* with raccoon dog and raccoon will pose a problem because the overall density of coexistent vectors and potential reservoirs for the disease will be enhanced, which could facilitate the spread of this infectious pathogen** (Holmala 2009, Mulder 2011).

E/ Effects on ecosystem functions

The raccoon dog is not expected to have an important impact on ecosystems, for example by disrupting the food web, except in situations of very high densities or on small islands (Mulder 2011).

In these cases, one may not exclude that raccoon dogs might represent a significant additional predatory pressure for native preys and destabilize their population cycles (Wittenberg 2005).

ENVIRONMENTAL IMPACTS

Based on impacts observed in invaded areas in Europe, it is unlikely that the establishment of raccoon dog will have a strong negative impact on native prey populations in Belgium, except maybe on small isolated populations of amphibians. The outcome of competition with native carnivores is expected to be low to moderate as the raccoon dog has been shown to successfully coexist with them in many European areas. Another environmental consequence of raccoon dog establishment in Belgium could be the pathogen pollution, with the rapid spread and enhancement of some endemic diseases and parasites.

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).

Local agricultural damages are sometimes reported, especially in maize exploitations and in commercial crops of low hanging fruits (strawberries, blueberries, blackberries, etc.) but outcome is probably not significant (G.O.N. 2005, Mulder 2011, Rauel 2011). Raccoon dog do not climb easily, which implies that it doesn't predate on pets or poultry (Mulder 2011).

On the other hand, preventive and curative measures that have to be taken to prevent the expansion of diseases and parasites transmitted by raccoon dog can lead to considerable costs, especially for rabies control, but also emergence of *Trichinella* ssp. amongst pigs (Pannwitz *et al.* 2010). In case of reemergence of rabies in Western Europe, control measures will have to be scrutinized and reviewed, since the raccoon dog has been shown to be the main vector during the rabies epizootics in Finland in the late 1980s (Nyberg *et al.* 1990, Westerling 1991, Nyberg *et al.* 1992, Westerling *et al.* 2004, Holmala & Kauhala 2006, Singer *et al.* 2009, Kauhala & Kowalczyk 2011). This has significant implications for the rabies management decisions because the whole community of susceptible animals to rabies has to be taken into consideration in a multi-species model, and not only in one species model (Holmala 2009). Bait vaccinations against rabies are performed in northeastern Europe, as twice each year in Finland (Holmala & Kauhala 2006). The cost for testing and vaccination treatments estimated in 2012 in Finland is around 270,000 EUR, and this doesn't include the destruction, disinfection, salaries, equipments (European Commission 2012).

B/ Social impacts

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

The raccoon dog is a potential vector for several diseases to humans. It can be infected by *Trichinella spp* and *Echinococcus spp.,* including the small fox tapeworm *E. multilocularis* already present in Belgium. These two helminth species are very dangerous for humans, and probably represent the most important health risk conveyed by the raccoon dog (Näreaho *et al.* 2000, Jarvis *et al.* 2001, Thiess *et al.* 2001, Oivanen *et al.* 2002, Romig *et al.* 2006). A direct transmission of diseases and parasites (incl. rabies) by the raccoon dog to human is however unlikely because it is a shy animal that avoids the vicinity of people and infrastructure (Mulder 2011).

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.

There is no reliable data about the number of raccoon dogs imported, traded and kept in captivity in Belgium (zoos, private citizens, etc.). Detention by private owners is theoretically forbidden by the Belgian law on animal welfare (M.B. 03.12. 1986), which doesn't necessarily mean that there is no illegal holding in the country. Young or adult raccoon dogs may easily be purchased by Internet, which makes difficult to check the application of a regulation dealing with trade regulation (Mulder 2011). The very low number of road traffic victims observed in Belgium suggests that raccoon dog escapes from captivity may only occur very infrequently.

Today, there are no fur farms breeding raccoon dogs in Belgium. The most probable pathway for raccoon dog entry in the country is its natural spread from populations established in Germany.

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

As the natural spread of the species is the most probable pathway of entry in Belgium (Mulder 2011, Kauhala 2012), the prohibition of its importation, trade and holding is not considered as an efficient measure for reducing the risk of entry to an acceptable level.

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

In Belgium, raccoon dog holding and introduction into the wild are already strictly forbidden by existing legislations dealing with animal welfare and nature conservation, respectively.

As previously mentioned, this species is rather easy to keep confined without costly or complex infrastructure; fences of only 1 meter high are usually considered as sufficient to contain them. If kept in captivity, accidental escape will only occur due to owner negligence, which has however already been reported to occur in neighbouring countries (Stier 2006).

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)?

N. procyonoides is rather secretive in nature, because it mainly uses wet habitats covered with dense vegetation, it is nocturnal or crepuscular and spends the day in burrows or reeds (Wittenberg 2005, Kauhala & Kowalczyk 2011). As a consequence, **it is not easy to be detected at early stages of invasion** (Kauhala 2012). Detection is usually performed when populations are already flourishing, thanks to observations of tracks, typical latrines, and road traffic victims (Kauhala 2012).

A specific latrine survey using scat detection dogs may help to detect and provide accurate distribution data and densities of these animals (Smith *et al.* 2001, Tuyttens *et al.* 2001, Smith *et al.* 2003, Wilson *et al.* 2003, Smith *et al.* 2005, Browne *et al.* 2006, Delahay *et al.* 2007, Kauhala & Salonen 2012). This method can be combined with bait-marking and the use of an automatic camera trapping with infrared sensor and detection by trained dogs (Harrison 2006, Long *et al.* 2007, Kauhala & Salonen 2012). Detection may also be facilitated by setting-up a network to collect, identify and autopsy animals killed by road traffic (Van Den Berge & Gouwy 2009). Besides this, collecting data through public information websites (like www.observations.be) may help in the detection of such rare species thanks to a high number of observers.

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

The species is legally hunted all year round in several European countries (Estonia, Hungary, Latvia, Lithuania, Norway, Poland, Sweden, Germany) (Kauhala & Saeki 2008). However, hunting control is unlikely to stop raccoon dog expansion and has only minor impacts on spring densities (Mulder 2011). As for red fox*, hunting is considered as inefficient as *N. procyonoides* tends to increase its litter size to compensate population decrease due to culling (Helle & Kauhala 1995, Mulder 2011). It is assessed that the current hunting bag in eastern Germany (30,000 individuals per year) should be intensified two or three times to start reducing the breeding population (Stier 2006). Significant results may only be achieved at a local scale through intensive culling by professional hunters, after the period of dispersal (November-March) (Stier 2006, Väänänen *et al.* 2007, Mulder 2011).

In addition to culling, Nyborg traps (the most effective traps that are at present available to capture carnivores) may also be used to capture raccoon dogs and enhance population control at early stages of invasion. These traps use live bait, as tame doves for example, and can only be used from April to October to respect animal welfare. Radiotracking of individuals (Judas animals) or/and the use of hunting dogs are advised to identify den sites and control potential reproductive events (Melis *et al.* 2007, Dahl 2009, Steinar 2011). So far, the results obtained in Scandinavia with those techniques are very encouraging, but suggest that a strong cooperation is needed within and between countries to reach significant results, due to the high dispersion capacity of the raccoon dog (Dahl *et al.* 2010).

An autopsy of culled animals should be performed, firstly to check the infection by some parasites (*Echinococcus multilocularis*) and diseases (rabies), and secondly to obtain the age structure and other signs which indicate if the individuals are dispersing, colonizing, or if they are already established and ongoing reproduction (Melis *et al.* 2007).

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

As much as possible, killing traps should not be used to catch raccoon dogs as they may have some impact on non-target species like native carnivores. Since bait traps are usually used to attract raccoon dogs, it is imaginable that other animals would be tempted by this easy food, especially omnivorous species like the red fox* or the European badger* (Wittenberg 2005, Stier & Joisten 2006).

The eradication and control actions to remove raccoon dogs can also lead to a compensatory predation (numeric and functional response) from other predators, like foxes, and so may not induce the effects wanted on the breeding success of preys of interest (Kauhala 2004).

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

At the early stage of invasion, raccoon dogs are rarely shot because of their secretive behaviour (Wittenberg 2005). They are very cautious when leaving a burrow, making sure they feel safe during several minutes, so it is hard to shoot them (Wlodek & Krzywinski 1986). In all or most of the European countries, the raccoon dog has been hunted since the moment of its arrival, and in spite of a high number of animals shot, **no one of these countries has managed to stop their expansion** (Mulder 2011).

More successful results seem to be obtained making use of coordinated trapping campaigns combined with the use of Judas animals (see the best practices described above in (ii)). According estimation from studies in Sweden and in Norway, a permanent 'population' of about 100 radio-collared raccoon dogs should be sufficient to contain the invading population (Dahl 2009). The data available nowadays are however insufficient to provide a good evaluation of the success of the eradiation actions.

Raccoon dog is neither a protected species nor a game species in Belgium. In Wallonia and in Flanders, culling by hunters, private owners and foresters is allowed during the whole year, providing that a hunting permit is held (see e.g. the ministerial guideline n°2688 on the control of non-native animal species in Wallonia).

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

Local eradication or control measures can lead to a decrease of the impact of this predator on bird and amphibian populations (Kauhala 2012). To reach this goal, at least all new individuals produced yearly in excess of the annual mortality have to be removed annually to limit the population raise (Mulder 2011). However, controlling populations permanently is very costly and difficult on the long term, and substantially reduce the populations is really arduous (Kauhala 2004). In addition to culling and trapping, (electric) fencing can also be proposed locally as a solution to protect very sensitive wetlands and colonies of breeding birds (Stier 2006, Melis *et al.* 2007, Mulder 2011).

Besides this, the importance of an international coordination has to be stressed once more to prevent a rapid re-invasion of controlled areas by juveniles dispersing from neighboring sink populations (Kauhala 2012).

CONCLUSION OF THE RISK MANAGEMENT SECTION

The prohibition of raccoon dog importation, trade and holding is not considered as an efficient measure for reducing the risk of entry to an acceptable level as the natural spread of the species is identified as the most probable pathway of entry in Belgium.

Because of its secretive behaviour, the raccoon dog is not easy to detect or observe at early stages of invasion and rapid eradication is difficult to be performed. Hunting is unlikely to prevent raccoon dog establishment. Where a reduction of population density is requested, satisfactory results may be achieved through costly coordinated actions based on several techniques, including trapping combined with the release of radio-collared sterilized raccoon dogs to be used as lures for the detection of other specimens. Small threatened areas may also be protected using fencing.

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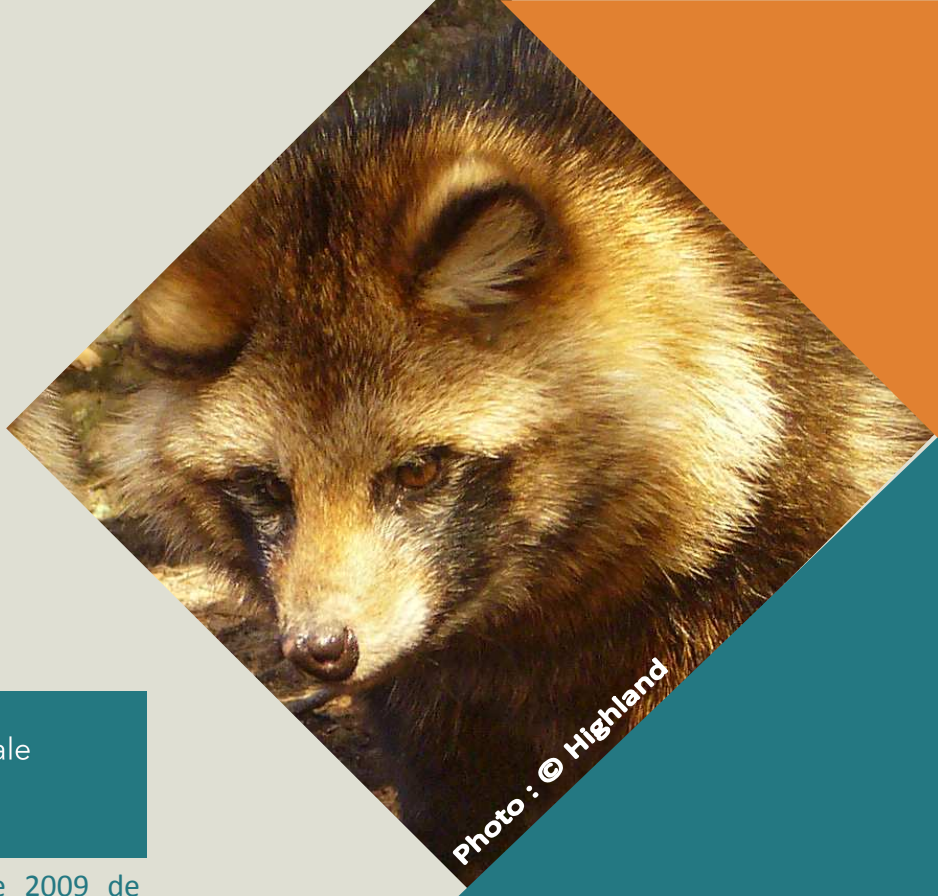

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La CiEi est chargée depuis novembre 2009 de coordonner les actions visant à limiter les dommages causés par les espèces invasives en Wallonie. Ses activités se fondent sur l'engagement du Gouvernement wallon à prévenir l'installation de nouvelles espèces invasives et de lutter contre celles dont la prolifération pose problème

http://biodiversite.wallonie.be/invasives
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DGO 3