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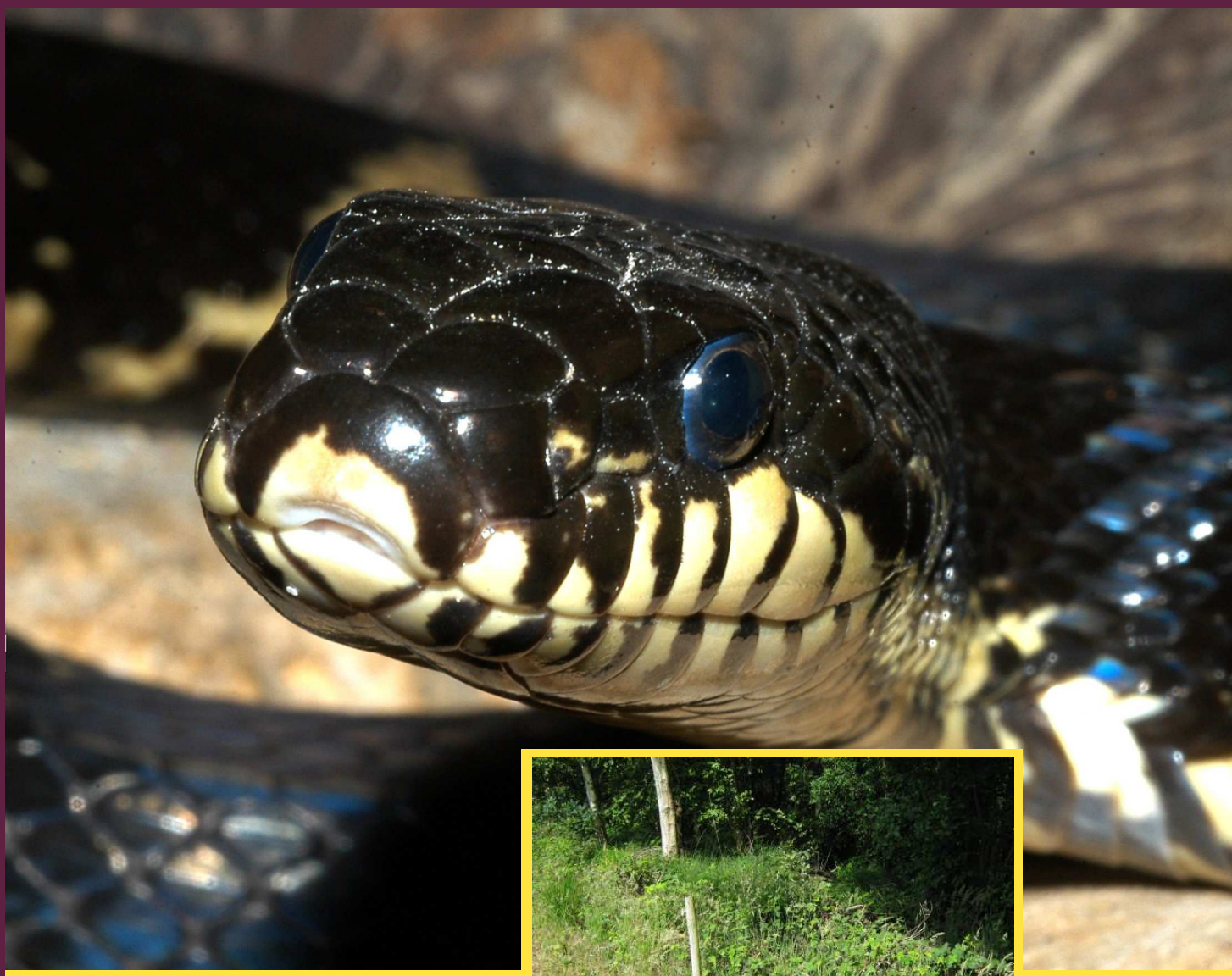
RISK ANALYSIS OF THE RUSSIAN RAT SNAKE (*ELAPHE SCHRENCKII*) IN THE NETHERLANDS



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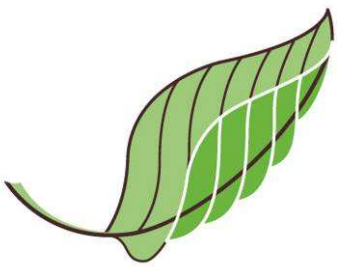
Commissioned by:
Invasive Alien Species Team
Netherlands Food and Consumer Product Safety Authority
Ministry of Economic Affairs, Agriculture and Innovation

RISK ANALYSIS OF THE RUSSIAN RAT SNAKE (*ELAPHE SCHRENCKII*) IN THE NETHERLANDS

S. van de Koppel MSc
drs. N. van Kessel
ir. B.H.J.M. Crombaghs
W. Getreuer
dr. H.J.R. Lenders



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NATUURBALANS – LIMES DIVERGENS BV
adviesbureau voor natuur & landschap

Universitair Bedrijven Centrum
Postbus 31070, 6503 CB Nijmegen

T (024) 352 88 01 / 352 88 02
F (024) 354 00 90

info@natuurbalans.nl
www.natuurbalans.nl

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Text and composition: S. van de Koppel MSc[1], drs. N. van Kessel [1], ir. B.H.J.M. Crombaghs[1], W. Getreuer[2],
dr. H.J.R. Lenders[3]

[1] Natuurbalans-Limes Divergens BV, Nijmegen, the Netherlands
[2] ReptielenZoo SERPO, Delft, the Netherlands
[3] Radboud University, Nijmegen, the Netherlands

Signed for publication: Managing Director, Natuurbalans-Limes Divergens BV, Nijmegen, the Netherlands
ir. B.H.J.M. Crombaghs

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SUMMARY

This report presents the risk analysis of Russian rat snake (*Elaphe schrenckii*) in the Netherlands. The study was initiated to provide insight into the potential effects of the occurrence of non-native populations of Russian rat snake in the Netherlands, their present distribution, introduction pathways, and the probability of establishment and spreading. The risk analysis consists of both risk assessment and risk management, and is based on data analyses, (inter)national literature, and field expertise. The risk analysis is justified by an expert team.

Russian rat snake is a constrictor species of the family Colubridae. The species naturally occurs in the Far East. Forests, forest edges, and diverse bushy and scrubby areas in hilly and mountainous areas provide the optimal habitat. Russian rat snake was introduced into the Netherlands near Eelde airport, municipality of Tynaarlo, around 1995. The species was able to survive, reproduce, and spread into the surrounding area.

Risk assessment
The probability of introduction of Russian rat snake into the Netherlands is moderate to high. Chances of introduction by deliberate or unintentional release from captivity are estimated to be significant. The species might be discovered in other parts of the Netherlands in the near future.

The probability of establishment of Russian rat snakes in the Netherlands is high, due to its climate tolerance, adaptability in habitat selection, and reproduction success. Nevertheless, if only a low number of specimens is introduced, establishment chances will be limited.

The probability of Russian rat snakes spreading in the Netherlands is high, as reproduction is likely and the species is opportunistic regarding habitat requirements. Although dispersal rate might be relatively low due to site fidelity, total dispersal distance can be fairly large after some years of presence, as Russian rat snakes are not limited by specific habitat requirements and might show density-dependent dispersal.

Concerning the species requirements in relation to climatic conditions and preferred habitats, most parts of the Netherlands are suitable for Russian rat snakes. It is expected that the species can find suitable habitat and a large food supply in nearly every area in the Netherlands, except in densely populated, urbanized areas.

Economic and social damage might occur to some extent, mainly by costs for risk management and due to social unrest. Ecological damage might be caused by predation and competition. Impact can be minimised by taking adequate action with regard to risk management.

Risk management
Prevention: public education is an important preventive measure against introduction of Russian rat snakes in the Netherlands. However public education programs have significant drawbacks, mainly the need of ongoing active maintenance and accompanying costs.

Eradication: capturing snakes by luring and trapping is considered the most efficient eradication measure. In order to successfully eradicate the species, devotion of ample resources during a sufficient long time span is essential. Regarding the situation at Eelde, without adequate eradication measures, it is expected that the species will disperse further and grow to a large population. Possible negative impacts could arise in the future.

Control: due to the fact that population control management is permanent, accompanied by high costs, control of Russian rat snake populations (minimise dispersal and impact) is not considered an option. Only if eradication is not possible, control of an established population can be used as an absolute last resort to prevent dispersal and impact.

1 INTRODUCTION

Russian rat snake (*Elaphe schrenckii*) is native to large parts of the Far East; Russia, China, Mongolia, and Korea (Szczerbak 2003; Terbish *et al.* 2006). In many other countries, including the Netherlands, the species is popular with terrarium keepers and greenhouse growers. By the latter it is kept as natural controller of mice and rats in the greenhouses (Van Uchelen 2010; RAVON 2011). However, the extent to which the species is kept in greenhouses is unknown, as other snake species might be preferred by greenhouse growers mainly due to lower costs, e.g., red rat snake (*Pantherophis guttatus*).

Free living specimens of the Russian rat snake were discovered around 1995 in the vicinity of Eelde airport, municipality of Tynaarlo, the Netherlands. Subsequent research revealed that several snakes were deliberately released in an ecological garden. The species was able to disperse into the surrounding area, causing unrest among residents of Eelde in 2006. Research concluded that approximately twenty specimens of several species, both native and non-native, occurred in the area. Native species in the area are smooth snake (*Coronella austriaca*), grass snake (*Natrix natrix*), and common European adder (*Vipera berus*). Discovered non-native snakes were mainly Russian rat snakes. Also some garter snakes (*Thamnophis* sp.) and one black rat snake (*Pantherophis obsoletus*, previously known as *Elaphe obsoleta*) were discovered, but did not survive or were captured (Getreuer 2006).

Since the Russian rat snakes of Eelde were not actively trapped and removed, the species still occurs in the area. Little is known about reproduction and dispersal of the snakes near Eelde, or any other introductions in the Netherlands. The presence of Russian rat snakes can display a negative impact on humans and native biodiversity, e.g., by competition, predation, or spread of diseases.

This study was initiated to provide insight into the potential effects of the occurrence of non-native populations of Russian rat snakes in the Netherlands, their present distribution, introduction pathways, and the probability of establishment and spreading. Although some field experience is gained with removing Russian rat snakes, there is relatively little known about what measures should be taken to prevent a sustainable establishment of (populations of) the species. Subsequently, this study deals with both risk assessment and risk management of Russian rat snakes in the Netherlands.

Project definition

The Invasive Alien Species Team of the Netherlands Food and Consumer Product Safety Authority (Ministry of Economic Affairs, Agriculture and Innovation) has commissioned Natuurbalans-Limes Divergens BV to perform a concise risk analysis of Russian rat snakes in the Netherlands. The risk analysis includes the following objectives:

- To develop a clear picture of the present distribution, probability of entry, establishment, and spreading of Russian rat snake in the Netherlands.

- To provide insight into the potential effects of Russian rat snake on native species and/or communities, economy (e.g., loss of profits or even economic

opportunities), and social aspects (e.g., recreational values and public health).

- To provide insight into measures that can be taken from the perspective of risk management with regard to prevention, eradication, and control.

Report structure

Chapter 2 deals with the methods of current risk analysis. Chapter 3 provides a concise general description of the species, which focuses on aspects that are of direct interest to the risk analysis. Chapter 4 presents the risk assessment, divided into probability of introduction, establishment, and spreading, vulnerable areas, and impact. Chapter 5 deals with the options for risk management (prevention, eradication, and control). Finally, the most important conclusions and recommendations are presented in chapter 6.

2 METHODS

2.1 COMPONENTS OF THE RISK ANALYSIS

Research on the following components was conducted in order to cover the complete risk analysis: risk assessment and risk management.

2.1.1 Risk assessment

Probability of introduction
The probability of introduction was determined by the possible introduction pathways of the species into the Netherlands, both present and future.

Probability of establishment
The probability of establishment was determined by the current dispersal range of the species and presence of potential habitat in the Netherlands related to (a)biotic requirements of the species.

Probability of spreading
The probability of spreading was determined with regard to the dispersal capacity of the species by natural means and by human action.

Vulnerable areas
Areas or habitats in the Netherlands that are at risk of invasion were selected and possible effects of the presence of Russian rat snakes within these areas were discussed.

Impact
Based on the results of the three probabilities mentioned above, the impact of the species was determined and the effects and risks were scientifically characterised, using the Invasive Species Environmental Impact Assessement (ISEIA) protocol. Subsequently, the (possible) ecological, economic, and social impacts as a result of the presence of the species were discussed.

2.1.2 Risk management

Based on the results of the risk assessment, measures were identified and proposed to counteract the introduction, establishment, and spreading of and damage caused by the species. The risk management dealt with measures for:

- *Prevention*
- *Eradication*
- *Control*

The (dis)advantages of each measure were investigated in terms of effectiveness, feasibility, and costs. Finally, a concise protocol was developed, which can be used to act adequately if the species occurs somewhere in the Netherlands in the future.

2.2 INVESTIGATION OF SOURCES

The risk analysis was based on existing data. Several databases and other sources of information were used. These are discussed in further detail below.

2.2.1 Literature

National (e.g., reports and species distribution atlases) and international literature (e.g., scientific articles via ISI web of knowledge, Google Scholar, Wiley Interscience, and Zoological Records) was investigated in order to get a clear view of existing knowledge regarding the subject. Additionally, several websites, e.g., Global Invasive Species Database and IUCN Red List, were used.

2.2.2 Distribution data

Data on the present distribution of Russian rat snake in the Netherlands was obtained using several databases. The extensive database of Natuurbalans-Limes Divergens BV on Dutch fauna was consulted, together with several general websites, e.g., www.waarneming.nl and www.telmee.nl. Also several organisations, e.g., reptile zoo SERPO and local herpetological societies and nature groups, were consulted.

2.3 EXPERT TEAM

The risk analysis was conducted in collaboration with an expert team in order to guarantee a sound scientific basis and justification. The expert team was formed by dr. H.J.R. (Rob) Lenders, assistant professor at the Department of Environmental Science of the Radboud University Nijmegen, W. (Walter) Getreuer, director of reptile zoo SERPO, and ir. B.H.J.M. (Ben) Crombaghs, managing director of Natuurbalans-Limes Divergens BV.

Dr. H.J.R. Lenders en ir. B.H.J.M. Crombaghs are authorities regarding research on reptiles and amphibians in the Netherlands. Mr. W. Getreuer delivered a major contribution to the risk analysis regarding knowledge about the present dispersal range of the species and determining possible vulnerable areas in the Netherlands. Furthermore, he has an extensive field experience in removing non-native reptile populations, including the Russian rat snakes near Eelde. Therefore, he provided an important input regarding possible measures in prevention, eradication, and control of Russian rat snake.

3 GENERAL SPECIES DESCRIPTION

This chapter presents a short species description of the Russian rat snake. Aspects that are of importance for the risk analysis are considered, mainly distribution, habitat, reproduction, and diet of the species. Table 1 presents an overview of several general characteristics of the species description.

Table 1. Characteristics of the Russian rat snake (*Elaphe schrenckii*).

Characteristic		**Source**
Length	Newborn: 21-47.5 cm Adult: average up to 170 cm (max. 250 cm)	Shannon 1956 Szczerbak 2003 Van Uchelen 2010
Range	Far East: Russia, Mongolia, China, Korea	Shannon 1956 Szczerbak 2003 Reptile Database
Habitat	Taiga forests, forest edges, bushy/ scrubby areas, nearby built-up areas	Szczerbak 2003
Food	Small mammals, nestling birds, eggs, amphibians	Szczerbak 2003
Active period	May/June - October/November	Szczerbak 2003 An *et al.* 2010
Reproductive age	9-10 years (within natural range)	Szczerbak 2003
Mean clutch size	7-15 eggs	Szczerbak 2003
IUCN Red List	n/a	-
First sighting in NL	Around 1996	Getreuer 2006
Last sighting in NL	September 2011	www.waarneming.nl

Species description
Russian rat snake is a constrictor snake of the family Colubridae (An *et al.* 2010; Reptile Database). The species is also known as Korean rat snake, Amur rat snake, and Siberian rat snake (Reptile Database). The snakes can grow very large, on average up to 170 cm and with a maximum of 250 cm (Shannon 1956; Szczerbak 2003; Van Uchelen 2010). Basic colour of Russian rat snakes is dark brown to black, with a narrow, light banding pattern (Van Uchelen 2010).

Natural distribution range and habitat
The natural distribution range of Russian rat snake is located in the Far East (figure 1). The species occurs in Russia (eastern Siberia and Primorskiy region), eastern Mongolia, northern and central China (provinces of Jehol, Hopei, and Shansi), and Korea (Szczerbak 2003; Reptile Database). Although the habitat of the Russian rat snake has not been extensively examined, some aspects of habitat preferences are documented. The main habitat is formed by (taiga) forests, forest edges, and bushy and scrubby areas. The species also occurs along rivers (Terbish *et al.* 2006) and in the vicinity of urban areas (Szczerbak 2003). Most of its natural habitat is located within mountainous areas (Terbish *et al.* 2006; Reptile Database), where the species lives at elevations up to 900 metres (Shannon 1956; Terbish *et al.* 2006).

Figure 1. Natural distribution range of Russian rat snake (source: www.toxinology.com).

Introductions outside the natural distribution range

Russian rat snake was introduced into the Netherlands halfway the nineties of the twentieth century. Four or five specimens were deliberately released in an ecological garden near Eelde airport. Research, conducted in 2006, revealed that approximately twenty snakes of several native and non-native species, including Russian rat snake, occurred in the area (Getreuer 2006). Russian rat snake was able to survive, reproduce, and spread. Sightings were recorded in four squared kilometre grids (Van Uchelen 2010).

Table 2 provides an overview of sightings of the species outside its natural distribution range. No introductions of the species in other countries than the Netherlands are known. At Eelde, the maximum number of Russian rat snakes sightings on one day is nine. The most recent sighting of the species dates from 10 September 2011. Besides the sightings at location Eelde, two other sightings of the species have been recorded in the Netherlands: (1) one specimen was found near highway A67 in the vicinity of Maasbree on 6 August 2010 (www.waarneming.nl), (2) also one specimen was discovered in the Bergse plaat, a newly build district within the city of Bergen op Zoom, on 24 March 2010 (www.regioactueel.nl). The latter was captured by the animal rescue team. It probably escaped from captivity. No other information about these two sightings is known. The species has not been found near Maasbree and Bergen op Zoom more recently and it is assumed that the species is not present anymore.

Table 2. Sightings of Russian rat snake in the Netherlands. Only the maximum number of specimens per life stage per day is shown. Sightings indicated with *: uncertainty about species.

Date	Number	Life stage	Location	Source
10 September 2011	1	Immature	Eelde	www.waarneming.nl
	3	Adult	Eelde	www.waarneming.nl
16 April 2011	9	Unknown	Eelde	www.waarneming.nl
	8	Adult	Eelde	www.waarneming.nl
	1	Immature	Eelde	www.waarneming.nl
6 August 2010	1	Unknown	A67 – Maasbree	www.waarneming.nl
24 March 2010	1	Unknown	Bergen op Zoom	www.regioactueel.nl
17 June 2009	5	Unknown	Eelde	www.waarneming.nl
14 May 2009	3	Unknown	Eelde	www.waarneming.nl
1 August 2006	2	Unknown	Eelde	Getreuer 2006
30 July 2006	1	Unknown	Eelde	Getreuer 2006 *
19 July 2006	1	Unknown	Eelde	Getreuer 2006 *
7 July 2006	1	Adult	Eelde	Getreuer 2006
6 July 2006	1	Unknown	Eelde	Getreuer 2006
May 2006	1	Unknown	Eelde	Getreuer 2006 *
March 2006	1	Unknown	Eelde	Getreuer 2006 *
Summer 2005	1	Juvenile	Eelde	Getreuer 2006
	1	Adult	Eelde	Getreuer 2006
2004	1	Adult	Eelde	Getreuer 2006 *

Reproduction

In their natural range Russian rat snakes are active from May/June to October/November (Szczerbak 2003; An *et al.* 2010). There, sexual maturity is reached after nine to ten years (Szczerbak 2003). As the reproductive age is climate dependant, it is possible that sexual maturity is reached at a younger age in the Netherlands, e.g., at three to five years. Reproduction takes place in the period May to July. Gravid females may aggregate in large groups of up to 300 individuals. Eggs are laid between late July and early August with a clutch size of seven to fifteen eggs. Newborns appear in September at a size of 210-475 mm. Russian rat snakes reach sexual maturity at the age of nine to ten years (Szczerbak 2003).

Diet

Russian rat snakes generally predate on small prey species. The main diet of the species consists of small mammals, nestling birds, birds' eggs, and amphibians (Szczerbak 2003).

Predators

The main predators of Russian rat snakes are birds of prey. Moreover, several mammal species, e.g., hedgehogs, foxes, and martens, are considered as predators of the species (Van Uchelen 2010).

4 RISK ASSESSMENT

The risk assessment examines the situation in which no measures for prevention, eradication, or control are taken. It focuses on the potential risks of the presence and invasiveness of Russian rat snake in the Netherlands. Therefore the probability of introduction, establishment, and spreading are discussed, resulting in an overview of vulnerable areas and an evaluation of the potential impact of the species.

4.1 PROBABILITY OF INTRODUCTION

Natural colonisation
Distribution of Russian rat snake by natural means from its natural range into the Netherlands is impossible. The western limit of its natural range is situated approximately 7.000 km from the Dutch border. Natural colonisation is therefore not considered to be a possible pathway.

Release from captivity
Introduction pathways caused by humans, both accidentally and deliberately, can result in introduction of Russian rat snakes into the Netherlands. Russian rat snakes that are kept as pet by snake keepers or as controller of mice and rats by greenhouse growers can escape from their captive environment. As greenhouses are relatively large in size, possible escape routes will not always be noticed in time. Furthermore, Russian rat snakes are excellent climbers (Van Uchelen 2010). This means that there is a serious risk that the species escapes from captivity. If snakes manage to escape, they will generally be found within a short distance from the source of introduction. Hence, snakes that are kept as pet will often be found in the direct vicinity of built-up areas. However, as greenhouses are often located in the countryside, the risk of accidental introduction from captivity into natural areas is estimated to be relatively high.

Moreover, deliberate releases of Russian rat snakes can also result in introduction into natural areas. Deliberate releases occur most likely on some distance from urban areas, as releasing non-native species is illegal. Since the species is popular with snake keepers and greenhouse growers, the probability of introduction by releases from captivity is estimated to be high.

Introduction through transport
Another possible introduction pathway is caused by transport. Animal and plant species are introduced through transport worldwide (Mack *et al.* 2000; Floerl & Inglis 2004; Wilson *et al.* 2009). Species travel from one place to the other for instance in luggage, cars, or cargo transport. No occurrences of introduction of Russian rat snakes by this pathway have been recorded. Russian rat snakes are large animals and therefore will be noticed relatively easy. Chances of introductions by this pathway are therefore considered to be very low.

In summary, introductions by releases from captivity, both accidentally as deliberately, is considered as most important pathway for introductions in the environment. Probability of introduction of Russian rat snake into the Netherlands by

this pathway is estimated to be moderate to high. It is expected that Russian rat snakes will be discovered in other areas of the Netherlands in the near future (Van Uchelen 2010).

4.2 PROBABILITY OF ESTABLISHMENT

Not all introductions result in the establishment of populations. The most important underlying factors are propagule pressure, habitat structure, climatic factors, and reproduction success.

Propagule pressure
No literature is available on the propagule pressure, i.e., the quality, quantity, and frequency of introduced organisms, of Russian rat snake. Nevertheless, it is obvious that more than one specimen or at least a gravid female is needed to establish a population of the species. In the unintentional cases, e.g., escapes from captivity or introduction by transport, it is most likely that only one snake will be introduced, thereby reducing the chances of establishment of a population. In cases where more specimens or a gravid female are introduced, a population might be able to establish.

Habitat structure and climatic factors
Under natural circumstances, Russian rat snakes occur in relatively cool climate zones of the Far East, where the species mainly lives in hilly or mountainous areas (Shannon 1956; Terbisch *et al.* 2006). Regarding climatic conditions in its natural distribution range, it is expected that the species has a high chance of survival in the Netherlands (Getreuer 2006), which is expressed in the establishment of a vital population near Eelde (Van Uchelen 2010).

Furthermore, it seems that the species is opportunistic in habitat selection. In its natural range, Russian rat snake is found in (taiga) forests, forest edges, scrubby/bushy areas, and in the vicinity of residences (Szczerbak 2003). In the area near Eelde the snakes mainly live in wooded banks, near forest edges, in all sorts of rough vegetation, and in gardens (Van Uchelen 2010). Hence, it appears that the species adapts easily to new habitats. Thereby increasing the chance of establishment in other areas in the Netherlands.

Reproduction success
Climatic factors are the most important possible inhibitor of reproduction of reptiles. As Russian rat snakes naturally occur in relatively cool climates of hilly and mountainous areas of the Far East (Shannon 1956; Terbisch *et al.* 2006), it is expected that the temperate climate does not form a limitation on reproduction success of the species in the Netherlands. This is confirmed by the fact that the species already reproduces yearly near Eelde (Van Uchelen 2010). However, due to the limited ecological research on the species, no scientific information about reproduction success and rate are available.

In summary, based on the ecology of the species, its habitat requirements, climate tolerance, and reproduction success, probability of establishment of populations of Russian rat snakes in the Netherlands is high. Nevertheless, a low number of introduced specimens can limit establishment chances.

4.3 Probability of spreading

If an alien species becomes established, the probability of spreading, determined by colonisation rate, is the third key aspect regarding the risk of the presence and the invasiveness of the species.

Colonisation rate

Russian rat snake is considered as a sedentary species (Getreuer 2006); it migrates relatively short distances (An *et al.* 2010). However, no ecological research has been performed to determine dispersal distances of Russian rat snakes. Based on expert judgment and research on other snake species, it is expected that dispersal of Russian rat snakes may range up to several kilometres. For example, research on grass snakes revealed dispersal distances of more than five kilometres (Völkl 1991). It is unknown whether density-dependent dispersal enables the species to disperse more rapidly over larger distances. Furthermore, colonisation rate of Russian rat snakes is not expected to be inhibited by specific habitat requirements. The species is adaptive regarding habitat selection. Therefore dispersal becomes more probable.

In summary, the probability of the species spreading from an area where it is introduced is high, as reproduction is likely to take place and the species is opportunistic regarding habitat selection. Although dispersal rate might be relatively low due to site fidelity, total dispersal distance can be fairly large after some years of presence, as Russian rat snakes are not limited by specific habitat requirements and might show density-dependent dispersal. Additional research is needed to determine reproduction and dispersal rates more precisely, which enables us to predict patterns of spreading accurately.

4.4 Vulnerable areas

In relation to Russian rat snake's requirements concerning climatic conditions and preferred habitats, a large part of the Netherlands is estimated to be suitable as habitat for Russian rat snake, except densely populated urban areas. The species is adaptive regarding habitat and food resources. The population near Eelde shows that all sorts of landscape structures are used (Van Uchelen 2010). Moreover, the diet of the species is very versatile: mice, rats, birds, eggs, etc. (Szczerbak 2003).

Considering the most important pathway of introduction, i.e., (un)intentional releases from captivity, several predictions can be made about vulnerable areas. Firstly, deliberate releases of Russian rat snakes are not bound to specific areas, but can take place in every part of the country. Often these take place on some distance from built-up areas (e.g., in rural areas) as releasing non-native animals is prohibited by Dutch law. Hence, direct colonisation of natural areas is possible by deliberate releases.

Regarding unintentional releases a few core areas can be appointed. The species can be kept by greenhouse growers, so areas which are important for food production in greenhouses are relatively vulnerable. These are mainly located in the Westland, around the cities of Aalsmeer and Venlo, and in the south-east of the province of Drenthe. Besides these core areas, every area with a greenhouse in which snakes are

kept, is vulnerable to introductions. As these are often located in the countryside, direct colonisation of natural areas is possible. Moreover, the species can be kept as pet in the whole country. Hence, all areas in the vicinity of built-up areas might get colonised by escaped Russian rat snakes. In that respect, the chance of colonisations directly in natural areas is relatively low. Nevertheless, natural areas are vulnerable to colonisation by snakes, as distances between natural areas and urban areas in the Netherlands are seldom large.

4.5 Impact

As concluded in the previous paragraphs, the risk of establishment and invasiveness of Russian rat snakes in the Netherlands is moderate to high. Ecological, economic, and social damage may occur. These aspects are discussed below. The ecological risks were also assessed using the Invasive Species Environmental Impact Assessement (ISEIA) protocol (appendix, Branquart 2009).

4.5.1 Ecological damage

Competition
Up to this moment no risks for native biodiversity caused by Russian rat snakes have been recorded. Most snake species are opportunists and therefore may compete for food and space with other species (Luiselli 2006). Preliminary results of sympatric populations of Russian rat snakes and grass snakes near Eelde suggest that the species can live, feed, and reproduce closely together in the same area. It seems that the species are not affected by the presence of each other (Van Uchelen 2010). However, this is based on some preliminary observations. Scientific research could provide more insight in possible competition between the species.

Competition for food is likely to occur with several native species, especially in areas where prey abundance is limited. Russian rat snakes feed mainly on small mammals, like mice and rats, nestling birds, eggs, and amphibians (Szczerbak 2003). Hence, competition could occur with a variety of other species, like birds of prey, native snakes, and foxes. However, impacts of competition have not been recorded.

Predation
Besides competition, ecological damage might be caused by predation. The effect of predation on populations of common species (e.g., mice and rats) is not expected to cause significant ecological damage. However, Russian rat snakes may also predate on several rare, endangered species (e.g., meadow birds), resulting in a more pronounced negative effect on prey populations. No consequences of predation by Russian rat snakes on prey populations have been recorded. Therefore it is highly speculative whether ecological damage by predation will occur, but if it occurs it could strongly affect populations of (rare) species.

Several native species might become important predators of Russian rat snakes, for example birds, e.g., buzzards and crows, hedgehogs, foxes, and martens (Gemeente Tynaarlo 2006; Van Uchelen 2010), thereby limiting population growth and decreasing possible ecologically damaging effects of predation by Russian rat snakes.

Hybridization
Hybridization is known as important ecological damaging factor with regard to other invasive species (Mack *et al.* 2000; Grosholz 2002). Russian rat snake is able to interbreed with Japanese rat snake (*Elaphe climacophora*) and produce fertile progeny (Reptile Database). Also hybridization with aesculapian snake (*Zamenis longissimus*) is reported, but the fertility of the offspring has not been proven (Treu 2008, according to Reptile Database). Both species are relatively closely related to Russian rat snakes and are not native to the Netherlands. No occurrences of hybridization with other (native) species are known. Moreover, native Dutch snake species are phylogenetically distant to Russian rat snakes. Thus, it is not expected that Russian rat snakes will hybridize with native snake species.

4.5.2 Social damage

Public health
Considering medical importance, Russian rat snakes are a source of human sparganosis, which is caused by the plerocercoid worm *Sparganium mansoni* (Kobayashi 1925, according to Weinstein 1954 and Cho *et al.* 1973; Honda 1938, according to Cho *et al.* 1973). The snakes can act as an intermediate host of this larval stage of the genus *Spirometra*, which is most common in East Asia (Weinstein 1954; Cho *et al.* 1973; Cho *et al.* 1975). Symptoms of human sparganosis mainly comprise the presence of a subcutaneous mass or swelling, inflammatory reaction, discomfort (e.g., itching), and (severe) pain. Moreover, there is a significant chance of complications by acute haemorrhage or abscess formation. Depending on the exact location of the tapeworm within the human body several peculiar manifestations can develop, like epigastric discomfort, urological symptoms (Weinstein *et al.* 1954; Cho *et al.* 1975), and nodules in internal organs, like lungs (Iwatani *et al.* 2006), brains, and spinal cord, accompanying e.g., headache, focal motor seizures, and weakness of limbs (Mineura & Mori 1980; Kudesia *et al.* 1998). In exceptional situations, infection with *S. mansoni* can lead to death, as a result of, inter alia, neurological symptoms, encephalitis, and severe bleeding (Cho *et al.* 1975). In the case of subcutaneous nodules or nodules in internal organs, surgical removal seems the best therapy. In all published cases this led to total elimination of the disease (Weinstein *et al.* 1954; Kudesia *et al.* 1998; Iwatani *et al.* 2006).

The main route of human sparganosis transmission by snakes is formed by eating raw snake meat, which is quite common in parts of Korea (Weinstein *et al.* 1954; Cho *et al.* 1973; Cho *et al.* 1975). It is believed that eating raw snakes provides a special nutritional value, a medicinal effect in combatting diseases, and potentiation of masculine activity (Weinstein 1954; Cho *et al.* 1975). Also, by some, snake is recognized as a delicacy (Weinstein 1954). Other possible infestation routes are drinking untreated water, eating raw meat of other infected intermediate hosts (birds, frogs, pigs, etc.), and contact of the flesh of an infected intermediate host with wounded skin or an abscess (Cho *et al.* 1975; Iwatani *et al.* 2006). As these practices are very uncommon, and most likely even absent, in the Netherlands, it can be expected that the chance of transmission of human sparganosis by Russian rat snakes in the Netherlands is (close to) nil. Nevertheless, Kudesia *et al.* (1998) conclude that this primary Asian disease will probably spread to other parts of the world through increased global transport, migration, and shifts in eating customs.

Besides human sparganosis, Russian rat snakes might be of public health importance due to Japanese encephalitis virus, an antigenically related zoonotic vector-born virus. It is wide-spread in a major part of east and southeast Asia (Rosen 1986; Solomon *et al.* 2000). It is spreading in large areas (Solomon *et al.* 2000; Erlanger *et al.* 2009), but declining in others, like Japan and South Korea, where control programs were launched (Erlanger *et al.* 2009). Only a minor fraction of persons that get infected with the virus develop medical manifestations of encephalitis. However, those manifestations are very severe and accompany a high death rate (approximately one third of patients), particularly if it occurs as an epidemic (Rosen 1986; Solomon *et al.* 2000; Erlanger *et al.* 2009). The virus can cause a form of encephalitis (inflammation of brain tissue) in humans, with a range of accompanying or preceding symptoms, like fever, diarrhoea, headache, vomiting, reduced level of consciousness, motor seizures, and hypertonia (Solomon *et al.* 2000). An annual worldwide amount of 50.000 cases of Japanese encephalitis, resulting in 15.000 deaths, is estimated (Solomon *et al.* 2000). People that survive have a high risk on neurologic sequelae (Rosen 1986; Solomon *et al.* 2000; Erlanger *et al.* 2009).

Mosquitos, mainly *Culex tritaeniorhynchus* which lives in northern Asia and parts of Africa (Erlanger *et al.* 2009), are probably the only vector of the Japanese encephalitis virus to humans (Rosen 1986). Vertebrates are considered as infection sources of mosquitos (e.g., birds, swines) or as hosts for the virus surviving the winter. Of the latter, cold-blooded animals might play a role in overwintering of Japanese encephalitis virus in the temperate zone. The reasoning behind this hypothesis is that cold-blooded animals suppress immune responses during hibernation and thereby viruses might survive winter within their bodies (Rosen 1986). Although only irregularly several clues were found, an experiment using three species of terrestrial snakes, including Russian rat snakes, demonstrated virus multiplication and traces of antibody formation in bodies of several snakes (Lee 1968). However, to date, there is still no hard evidence for the virus overwintering in cold-blooded animals. Moreover, Russian rat snakes that (may) occur in the Netherlands are most likely introduced from captivity and not from their natural range. Thereby, the chance that these animals are infected by Japanese encephalitis virus will be very low. Additionally, *C. tritaeniorhynchus* does not occur in the Netherlands. This species is considered to be the most important vector of the Japanese encephalitis virus, and possibly even the only vector of the virus to humans (Rosen 1986). Although it cannot be completely ruled out that another potential vector might occur in the Netherlands, chances of transmission of the virus to humans by Russian rat snakes in the Netherlands are very low.

In summary, Russian rat snakes might be of public health importance and can pose a threat to humans. There is a very small risk on spreading of diseases by the snakes. These diseases are rare and the chance of transmission to humans in the Netherlands is very low. Even though it is a relatively large constrictor, it is estimated that it will not even pose a threat to infants. It is considered a non-venomous, relatively harmless constrictor. However, incidents cannot be excluded.

Fear factor

Sightings of Russian rat snakes in the Netherlands might attract people to certain areas and thereby have a certain positive effect on recreational values. However, it is more likely that sightings of the species will cause a reaction of fear in the majority of the Dutch population. As a consequence, people tend to avoid the location, which in

turn poses a negative effect on the life of neighbouring people, and ultimately also on recreational values of the area. This will particularly be the case in areas that are frequently visited by people and/or areas near built-up areas.

4.5.3 Economic damage

Economic damage of Russian rat snakes is expected to be low to moderate. In a worst case scenario economic damage might be caused by:

- Costs for public health: treatment of snake bites, hospital treatments in the case of infections by *Sparganium mansoni*, and for acquiring vaccines against Japanese encephalitis virus. For the latter, large-scale immunization programs for humans have proven to be an effective measure in combating Japanese encephalitis (Solomon *et al.* 2000; Erlanger *et al.* 2009). As stated in the previous paragraph, disease transmission by Russian rat snakes is less likely, thereby decreasing costs for public health.

- Fear: damage to the recreational sector of the area in which Russian rat snakes are sighted can be significant, especially in nature areas that are frequently visited by people, or in areas near recreational facilities (e.g., sports centres, holiday parks, and swimming pools).

4.6 Case study: Russian rat snakes at Eelde

In this section, the three probabilities and possible impact are assessed relating to the Russian rat snakes at Eelde, after a short general background of this introduction is given.

Background
In 2006 unrest among residents of Eelde arose about the presence of snakes in their living environment. Reptile zoo SERPO from Delft, the Netherlands, conducted research and concluded that approximately twenty snakes of harmless species, including Russian rat snakes, occurred in the area. Subsequently, the problem was dealt with in a semi-passive way (Getreuer 2006).

Probability of introduction
Russian rat snakes were introduced into the Netherlands halfway the nineties of the twentieth century. Four or five specimens were deliberately released in an ecological garden near Eelde airport. It was (naively) thought that the snakes would not survive.

Probability of establishment
The species was able to survive and reproduce in the Netherlands, thereby establishing a small, but vital population near Eelde (Van Uchelen 2010). Reproduction takes place yearly and on several occasions juvenile snakes were sighted (table 2). However, uncertainty exists about the population size. The maximum number of individuals sighted on one day is nine (16 April 2011, table 2). Estimations of the population size range from approximately 20 (Getreuer 2006) to at least 100 individuals (Van Uchelen 2010). Hence, it is impossible to estimate the reproduction rate of the species in the Netherlands. But it is clear that the species,

due to its origin and adaptability, is able to establish a breeding population in the Netherlands.

Probability of spreading

Besides survival, reproduction, and thereby establishment, the species was also able to spread out of the introduction site into the surrounding area (Getreuer 2006; Van Uchelen 2010). According to Van Uchelen (2010) Russian rat snakes have been sighted in four squared kilometre grids. Until recently the species was only known west from airport Eelde, in the direct vicinity of the ecological garden where they were released. In 2009 the species has been spotted on the east side of Eelde airport, near the village of Yde (figure 2). As the species is already present since roughly 1995, it does not seem to spread fast. Indeed, according to An *et al.* (2010) the species migrates only short distances and is considered sedentary. However, as the population has settled only 2 km away from National Park Drentsche Aa, colonisation of this protected area in the long term is highly possible.

Impact

No occurrence of ecological damage (e.g., by predation or competition) caused by the Russian rat snakes near Eelde has been recorded. Special attention is focused on possible interactions between grass snakes and Russian rat snakes, as these species are sympatric near Eelde. It was predicted that interaction between these species could occur (Getreuer 2006), mainly due to comparable habitat and food requirements. However, Van Uchelen (2010) states that the population grass snakes near Eelde has established after the population Russian rat snakes settled. The species use similar habitats and are even found on the same hatch piles. Hence, it seems that both species can live in the same area without severe effects of competition for food or space. Also no occurrences of mutual predation are known (Van Uchelen 2010). Overall, it seems that the species are not affected by each other and can live, feed, and reproduce closely together in the same area. However, this is based on scarce and preliminary observations. Scientific research could provide more insight in possible competition between the species.

Besides ecological damage, the case of Eelde clearly demonstrates the effects of social damage. The presence of Russian rat snakes in the living environment of Eelde caused a lot of unrest among residents. The snakes frightened people due to their large sizes. Unfamiliarity with the species caused a lot of fear and anxiety in the neighbourhood (Getreuer 2006). However, it is suggested that in the meantime the residents have become accustomed to the snakes and the species is accepted by a large part of the community. Several residents are even helping the species by creating hatch piles (Van Uchelen 2010). As expected, the species are not of public health importance.

Finally, indirect economic damage occurred to a minor extent. Measures were taken as response to the sightings and the public was informed about the species. The economic damage was not significant and limited to the costs of these measures. Van Uchelen (2010) even states that the species became an appreciated controller of rodents, thereby having a positive effect.

Figure 2. Overview of the area in which a small population of Russian rat snakes lives in the Netherlands (map source: Google Earth). Red dot: location of ecological garden in which the snakes were set loose. Yellow circle: approximate area in which the snakes were mainly found until 2006 (based on Getreuer 2006). In 2009 also a sighting east of the airport, near Yde, was reported (Van Uchelen 2010). Overall, the species was found in four squared kilometre grids.

5 RISK MANAGEMENT

In this chapter measures are identified and proposed to counteract introduction, establishment, and spreading of and damage caused by Russian rat snakes in the Netherlands. The presented measures are based on the results of the risk assessment. Also a concise protocol is presented, which can be used to act adequately if the species is introduced anywhere in the Netherlands in the future.

5.1 PREVENTION

Possible measures to prevent introduction of Russian rat snakes in the Netherlands are discussed below. Policy, trade-related possibilities (e.g, import bans and legislation) are not described, as commissioned.

Releases from captivity are considered an important introduction pathway. Education is the only possible measure for prevention of both deliberate and accidental releases of Russian rat snakes. Public education campaigns, in which traders and retailers can play an important role, are essential to reach potential releasers. Information should be clearly directed at snake keepers and greenhouse growers, focussing on consequences and impacts of introductions, and appropriate measures to prevent snakes escaping from their captive environment. Moreover, it should be stated explicitly that releasing non-native animals is illegal.

Besides releases from captivity, chances of introduction of Russian rat snakes through transport are very low. The most likely preventive measure is increasing awareness amongst people who travel to areas within the species' natural range. Public education could help preventing Russian rat snakes ending up in luggage of travellers or cargo. Moreover, it will support people in making the right decision (i.e., alert an animal shelter or animal ambulance) if Russian rat snakes are discovered in luggage when arrived home. The species hitch-hiking in cargo transport could be prevented by thorough controls of the cargo before shipment.

A disadvantage of public education is the need of ongoing active maintenance and accompanying costs. This makes it hard to sustain an adequate campaign for a long time span, with effects rapidly fading. Moreover, whether education campaigns indeed prevent future introductions is highly uncertain. They can even have an opposite effect, encouraging people to release Russian rat snakes.

In summary, public education is the most important preventive measure against introduction of Russian rat snakes in the Netherlands. However, as public education programs have significant drawbacks (including high costs), it is disputable whether preventive measures should be taken at this moment.

5.2 ERADICATION

Since the probability of introduction, establishment, and spreading of Russian rat snakes in the Netherlands are estimated to be moderate to high, effective eradication

measures are needed to prevent further spread and possible impacts. These measures are designed to completely remove (a population of) the species.

Appropriate eradication measures should be undertaken as soon as possible to increase the chance of success of such measures. When an invasive species has become widespread, total eradication is often not feasible anymore. In order to successfully eradicate a species, rapid devotion of ample resources during a sufficient long time span is essential (Mack *et al.* 2000; Genovesi 2001). If introduced species are detected in an early stage and measures are taken accordingly, establishment is not likely (Genovesi 2001). However, if the species remains undetected for a longer period of time, the probability of establishment increases (Mack *et al.* 2000). Early species detection is expected in the Netherlands, as the sudden presence of Russian rat snakes is likely to be noticed in an early stage. The species is very conspicuous and does not resemble native Dutch snake species.

Capturing Russian rat snakes is a possible eradication measure. As previously discussed, Russian rat snakes are still limited to a relatively small area near Eelde and population size is expected to be fairly low. If appropriate eradication measures are undertaken as soon as possible, the chance of completely removing the population is high. Costs are involved, but the economic damage is relatively low. Eradication is even considered the most cost effective and ethical solution once an alien species is introduced (Genovesi 2001).

Capturing snakes is best performed by luring and trapping them by providing optimal habitat and climatic features. Therefore refuges are presented in the area, which attract snakes if used in large quantities in the right places. These may comprise carpet tiles, heat lamps, or other trapping systems. By monitoring these elements regularly it is likely all animals will be captured. Captured snakes can, for example, be housed in shelters and zoos, serving educational functions, or be euthanized. Monitoring involves costs. However, it is considered the most efficient eradication measure and once totally eradicated, no extra measures and accompanying costs are involved. Additionally, eradication will decrease social damage, as people know that actively measures are taken.

Regarding the situation at Eelde, it is expected that without taking appropriate eradication measures the species will disperse further and grow to a large population. Possible negative impacts could arise in the future. An eradication program is effective if developed following the *Guidelines for eradication of terrestrial vertebrates: a European contribution to the invasive alien species issue* (Genovesi 2001). Other non-native snake species that might still occur near Eelde (e.g., garter snake and black rat snake) can be eradicated simultaneously. Additional monitoring has to be conducted at the same time to determine the exact distribution range of Russian rat snake near Eelde. If future sightings are recorded in other areas or monitoring reveals the presence of the species, accurate eradication measures are again recommended.

5.3 Control

The third possible way of risk management is formed by measures to control an established population of the species. This means that further dispersal and impact of

the species is minimised. Due to the fact that population control management is permanent, accompanied by high costs, this possibility of risk management is not considered an option.

In some cases, control of an established population can be used as an absolute last resort in order to prevent dispersal and impact of Russian rat snakes. For example, a land owner might refuse providing access permission to his property, thereby preventing adequate eradication measures. In such case, control management of the population is the only possibility left. Specimens can be lured and trapped within the direct surroundings.

5.4 Protocol

This paragraph provides a concise overview of all necessary and/or possible steps for reacting adequately if the species occurs somewhere in the Netherlands in the future. Development of an extensive education program in this stage is considered premature and will not be discussed.

If the species occurs somewhere in the Netherlands, adequate action is necessary to prevent establishment and dispersal of the species. The following actions are considered essential (more detailed information on http://serpo.nl/verstekeling-slang.html).

The person who sights the snake should consider the following:

- Always assume that it is a dangerous snake, until the contrary is proven indisputably.
- Do not try to capture or frighten the snake.
- Keep a distance of at least 1 m to the snake. If you are closer, do not move and give the snake the possibility to crawl away.
- Try to follow the snake within a safe distance.
- Try to develop a clear description of the snake for a correct determination.

After these precautionary instructions have been taken into account, a sighting should be reported directly to the appropriate authorities among which the municipality in which the snake is sighted. Every sighting should be reported to reptile zoo SERPO (015-2122184) and to waarneming.nl / telmee.nl. By doing so, other (national) authorities are informed as well. Although Russian rat snake is a non-venomous species, a medical emergency might arise. In that case human health is of main priority and emergency services should be alarmed instantly.

Reptile zoo SERPO or another licensed authority will react on the sighting. They will verify the sighting and decide which actions should be taken in order to react adequately. If possible, the species will be captured and removed. If instant eradication is not possible, it should be decided, in consultation with the municipality, which subsequent steps are to be taken. Often these comprise informing the public, e.g., signs warning for snakes and briefings to local residents, informing other entities, e.g., general practitioners to be aware of victims of snake bites, and developing an action plan to eradicate the species.

6 CONCLUSIONS AND RECOMMENDATIONS

The existence of a population of Russian rat snakes outside its natural distribution range has been recorded only once worldwide. Several specimens were introduced into the Netherlands near Eelde airport, municipality of Tynaarlo, around 1995 (Getreuer 2006). The species was able to survive, reproduce, and disperse (Van Uchelen 2010). The current study was initiated to provide insight into the potential effects of the occurrence of non-native populations of Russian rat snake in the Netherlands, their present distribution, introduction pathways, and the probability of establishment and spreading. Besides risk assessment, the risk analysis deals with possible measures regarding risk management of the species.

6.1 RISK ASSESSMENT

The risk assessment defines probabilities of introduction, establishment, and spreading, and vulnerable areas, and describes potential impacts by ecological, social, and economic damage.

The probability of introduction of Russian rat snake into the Netherlands is moderate to high. Natural colonisation into the Netherlands from its natural distribution range is considered impossible, due to the large distance in between. Introduction pathways caused by humans, both accidentally and deliberately, can result in the presence of Russian rat snakes in the Netherlands. It is expected that the species will be discovered in other areas of the Netherlands in the near future (Van Uchelen 2010).

Based on the ecology of the species, its habitat requirements, and climate tolerance, the probability of establishment of populations of Russian rat snakes in the Netherlands is high. The species is adapted to relatively cool climates of the Far East (Shannon 1956; Terbisch *et al.* 2006), so it is expected that the species has a relatively high reproduction success and is able to survive in the Netherlands (Getreuer 2006). Moreover, it appears that the species adapts easily to new habitats, occurring in forests, wooded banks, all sorts of rough vegetation, gardens, and near forest edges (Van Uchelen 2010). Nevertheless, establishment chances can be limited due to a low number of introduced specimens.

The third key aspect regarding the risk of the presence and the invasiveness of the species, i.e., probability of spreading, is also estimated to be high. Russian rat snakes are opportunistic regarding habitat selection and therefore will easily disperse. Although dispersal may be limited to some extent due to site fidelity (Getreuer 2006; An *et al.* 2010), total dispersal distance can be relatively large after some years of presence. It is unknown whether density-dependent dispersal might enable the species to disperse more rapidly over larger distances. Additional research is needed to determine reproduction and dispersal rates more precisely, which enables us to predict patterns of spreading accurately.

Based on the probability of introduction, establishment, and spreading, the risks of the presence and the invasiveness of Russian rat snake in the Netherlands are relatively high. Ecological, social, and economic damage may occur. Ecological damage could be caused by competition and predation, posing a serious threat to

native species and ecosystems. However, due to the scarcity of research on the ecology, invasiveness, and possible impacts of the species, the impact by ecological damage is highly speculative, which is illustrated by Verbrugge *et al.* (2010) in general for recently established species: "If a species has only recently established the full extent of their impacts may not yet be known" (Verbrugge *et al.* 2010). Therefore, risk classification by the ISEIA protocol (Branquart 2009) was partly based on expert judgement and consultation of experts, as is required if data is scarce (Verbrugge *et al.* 2012). According to the ISEIA classification, Russian rat snakes in the Netherlands pose a moderate environmental risk. Social damage could occur as a reaction of fear among residents, thereby posing a negative influence on the lives of people and possibly on recreational values. Regarding public health importance, there is only a very small risk on spreading of diseases by Russian rat snakes (Kobayashi 1925, according to Weinstein 1954 and Cho *et al.* 1973; Honda 1938, according to Cho *et al.* 1973; Lee 1968; Rosen 1986), but these diseases are rare and the chance of transmission to humans in the Netherlands is nearly zero. Finally, economic damage is expected to be low to moderate. It might be caused by some costs for public health and damage to the recreational sector of an area due to fear.

6.2 Risk management

Risk management deals with measures to counteract introduction, establishment, and spreading of and damage caused by Russian rat snakes in the Netherlands. Recommendations for these measures are based on the risk assessment. Risk management is subdivided into measures for prevention, eradication, and control of the species. Public education is an important preventive measure against introduction of Russian rat snakes in the Netherlands. However, public education programs have several significant drawbacks, for example the need for ongoing active maintenance and accompanying high costs.

Eradication programs are designed to completely remove (a population of) the species. Capturing Russian rat snakes by luring and trapping is considered to be the most efficient eradication measure. Since the probability of introduction, establishment, and spreading of Russian rat snakes in the Netherlands are estimated to be moderate to high, eradication measures are suggested. Regarding the situation at Eelde, it is expected that without effective eradication measures the species will disperse further and grow to a large population. Possible negative impacts could arise in the future. In order to successfully eradicate the species, early detection and rapid devotion of ample resources during a sufficient long time span are essential (Mack *et al.* 2000; Genovesi 2001). The lack of scientific data and accompanying uncertainty of predictions must not be used as motivation to delay eradication (Genovesi 2001). An eradication program can be more effective if developed following the *Guidelines for eradication of terrestrial vertebrates: a European contribution to the invasive alien species issue* (Genovesi 2001). If future sightings are recorded in other areas or monitoring reveals the presence of the species, accurate eradication measures are most likely needed to prevent population build-up, spread and possible impacts.

Finally, control management of populations can be used to minimise dispersal and impact of Russian rat snakes. Due to the fact that control management is permanent, accompanied by high costs, this kind of management is not considered an option.

Only if eradication is not possible, control of an established population can be used as an absolute last resort in order to prevent dispersal and impact of Russian rat snakes.

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APPENDIX. ISEIA PROTOCOL

The Invasive Species Environmental Impact Assessement (ISEIA, Branquart 2009) protocol is used to scientifically assess the environmental risks (not impacts on human interests, e.g., public health or economic damage) of Russian rat snakes and to identify whether preventive and mitigation actions are of concern. In this appendix the results of the ISEIA for Russian rat snakes in the Netherlands are presented.

Risk categories

Using the ISEIA protocol, species are placed in one of the following risk categories.

- Category A (black list, score 11-12): species with a high environmental risk.
- Category B (watch list, score 9-10): species with a moderate environmental risk on the basis of current knowledge.
- Category C (low environmental risk, score 4-8): species that are not considered as a threat for native biodiversity and ecosystems.

Scoring system

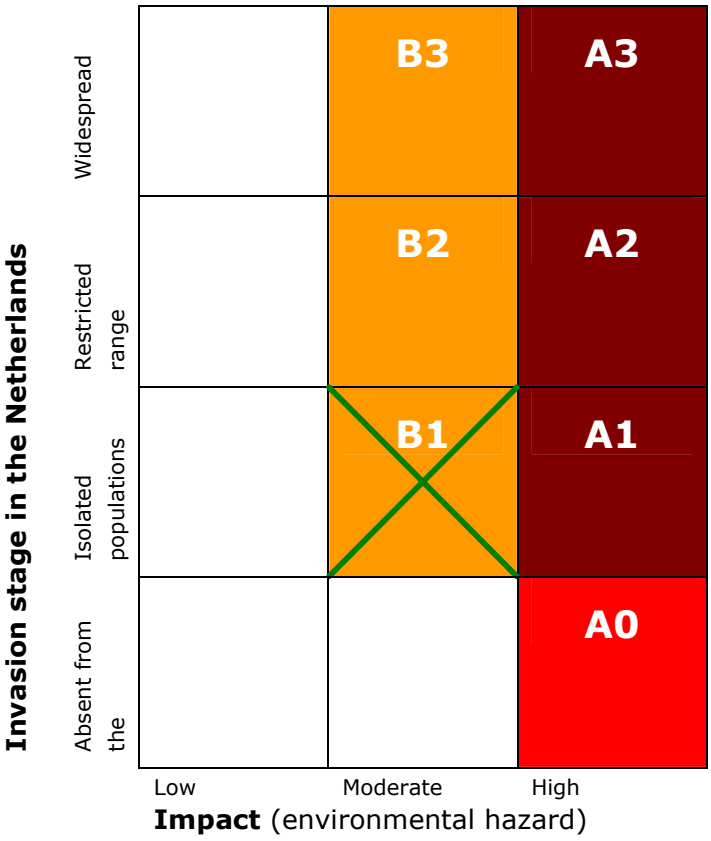
The scoring system used in the ISEIA depends on the availability of information.

- Low level of uncertainty (information documented in literature):
  - Score 1 = low
  - Score 2 = medium
  - Score 3 = high
- High level of uncertainty (information poorly documented):
  - Score 1 = unlikely
  - Score 2 = likely
- No information available:
  - No score = deficient data

Assessment Russian rat snake in the Netherlands

Section	Category	Score	Reasoning
Dispersion potential or invasiveness	Medium risk	2	Dispersal rate is fairly low, but reproduction is likely and total dispersal distance can be large after a few years of presence.
Colonisation of high conservation value habitats	High risk	3	Not limited to certain habitats and potential to outcompete other species.
Adverse impacts on native species	Likely	2	No data from invasion histories available. Expert judgement: competition and predation are likely; disease transmission is possible; hybridization is impossible.
Alteration of ecosystem functions	Likely	2	No data from invasion histories available. Expert judgement: disruption of food webs by predation is possible; other alterations are unlikely.
Global ISEIA score	**B**	**9**	

Conclusion: The global ISEIA score of Russian rat snakes in the Netherlands sums up to 9. This means that the environmental risk level is moderate, i.e., category B (watch list). Russian rat snake is considered a (potential) threat for native biodiversity and ecosystems. Considering the invasion stage in the Netherlands, the species is categorized as "species under naturalisation (isolated populations)" and placed on the watch list. The outcome of the total list system of the ISEIA protocol is presented in the figure underneath, indicated by the green cross (category B1).



Black list: A1 – A3
Alert list: A0
Watch list: B1 – B3