

# The raccoon dog: an exponential problem?

Management methods used in Europe  
to control the raccoon dog population  
(*Nyctereutes procyonoides*)



Lauren Florisson | Mieke de Kreij

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*This final thesis is made with the highest accuracy and completeness of the available information. The authors, supervisors nor the organization as a whole are liable for any direct or indirect loss arising from the use of this report.*

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Lauren Florisson & Mieke de Kreij

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## Summary

Invasive alien species can threaten biodiversity and can have negative effects on nature or other organisms. These alien species can have effects such as predation, compete with native fauna, alter habitats, effect genetic variability and can be sources of diseases and parasites. There are 44 invasive alien species in Europe, one of these is the raccoon dog (*Nyctereutes procyonoides*).

The raccoon dog was introduced in Russia and has been moving west ever since. Currently there are populations in: Finland, Poland, Germany and the Baltic countries. There are sightings in Norway, Denmark and Sweden. There is a high possibility that the raccoon dog will settle in the Netherlands.

Raccoon dogs pose a threat to breeding bird populations and amphibian populations and are vector species for diseases like rabies, the worms: trichinella spp and Echinococcus multilocularis (red fox tape worm) and a mite sarcoptes scabiei who cause mange. Therefore the Team Invasive Species (TIE) of the Dutch Ministry of Economic Affairs requested an overview of the management methods in Europe used to control the population of raccoon dogs.

The main research questions in this report are: which management methods are used to control the population in Europe? And when looking at public opinion, effect and cost efficiency which method would be most suitable to be applied in the Netherlands? To answer these research questions literature research, interview with experts and a population model was used.

The following management methods are used in Finland: specialized hunting dogs, culling, Judas animals, game cameras and specialized hunters. The public is aware of the raccoon dog and approves of the management methods. Finland, Sweden and Denmark are involved in a life project in which an overall budget of € 5 million was used for the management methods. The raccoon dog population in Finland is around 200,000 and the annual hunting bag is around 180,000.

Sweden applies the same methods as Finland. The population of raccoon dogs is around 8 animals and the public is aware of the raccoon dog and the management methods. Norway uses an early warning system, game cameras and hunting. The overall costs of the method is between € 80,000 and € 120,000. The public is not aware of the method and the presence of the raccoon dog.

Denmark uses the same methods as Finland except for live trapping and the annual costs of the methods are € 350,000. The population has been slowed down and prevented a fast population rise. The public is not aware of the presence and management method.

Germany uses hunting, however it is uncertain of what the effect of hunting is on the population. The public is not aware of the presence of the raccoon dog nor the hunting.

Austria and Switzerland do not have any management methods and have 10 to 20 raccoon dogs in the country.

There have been 174 sightings in the Netherlands, mostly in the Northern provinces. There is 41,000 km<sup>2</sup> of suitable habitat in the Netherlands. The carrying capacity in the Netherlands is 41.067 animals. They will have a possible impact on native predators, native prey species (amphibian populations and breeding bird populations) and are a vector for diseases.

The raccoon dog is protected by the Flora and Fauna law in the regulation of management and damage control. The provinces can give an exemption when there is a threat to the interest of public health and safety and to prevent damage to flora and fauna. Currently Friesland is the only province allowing the use of firearms to hunt raccoon dog.

If starting with a population 200 animals with sex ratio 50%, and 81% of the females are reproductive and have 3 daughters (6 pups) per brood then it would take 110 generations to reach the carrying capacity. One generation equals one year. If the females had 4 daughters (8 pups) per brood then it would take 26 generations to reach carrying capacity. If the females had 5 daughters (10 pups) then it would take 12.5 generations to reach the carrying capacity.

If management starts in year 20 and ends at year 80 with a hunting bag of 50 animals a year then the population will get eradicated. However if immigration of 10 animals a year is incorporated in the population then the population will rise to carrying capacity after the management stops. Hereby it does not matter if a hunting bag of 50 animals or a 100 animals is used.

The following discussion points arise:

- The population numbers were based on estimations and not on actual numbers and therefore no population trend could be made
- The actual effects of the raccoon dog on native predator and prey species is uncertain which makes it difficult to measure the actual impact the raccoon dog has on these
- It is important that there is a collaboration with other countries because it can affect the success of the management method
- The cost of the management methods are not properly recorded
- The research field of the raccoon dog is very small and not every aspect is researched, therefore this could influence the validity of the research

The management method that could be applied to the Netherlands is a combination of Judas animals, camera traps, public awareness and an early warning system.

The recommendations are:

- The management has to start as soon as possible
- Work closely together with Germany and Belgium
- Raise public awareness
- The current population has to be monitored and an early warning system has to be established to control migration

Furthermore more research needs to be done into: exact population numbers, the public opinion in the Netherlands, the effect of any future management method, the actual impact on the native predators and prey species, immigration numbers and origin of the raccoon dogs in the Netherlands and the actual cost of future management method.





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# 1. Introduction

An invasive alien species can be defined as an organism that migrates into a country from elsewhere with the aid of humans, either by transportation or by making use of the infrastructure. This organism successfully colonizes in the new habitat by reproducing and increasing the population size (Biodiversiteit, 2007). According to this definition there are 44 invasive alien mammal species in Europe (Genovesi *et al.*, 2009). Invasive alien species may threaten (local) biodiversity, and may have negative ecological effects through: predation, competition with native fauna, alternation of habitats, hybridization with native species, affecting genetic variability and can be sources of diseases and parasites (Hulme, 2007; Vilá *et al.*, 2010).

In order to prevent the harmful effects of invasive alien species on biodiversity, several policies can be applied. These policies were agreed upon in the Convention on Biological Diversity in 1992 and include. These policies include:

- Prevention of the arrival of the species
- Eradication of the populations if the populations are small
- Isolation and control management if the populations have grown too large

These control measurements depend on the expected harm and impact the invasive alien species will have on the biodiversity and human health and safety (CBD, 2014).

One of these invasive alien species is the raccoon dog (*Nyctereutes procyonoides*). The raccoon dog is a predator from the eastern regions of Asia and was introduced in Europe in the years 1929 -1955 in order to enlarge the number of fur producing species (Dahl *et al.*, 2013). Some animals escaped and some were intentionally introduced. The raccoon dogs occur in 21 European countries (Genovesi *et al.*, 2009) (figure 1).

The raccoon dog causes damage to the native fauna through predation and also competes with the native carnivores red fox (*Vulpes vulpes*) and Eurasian badger (*Meles meles*). It harbours parasites and zoonosis like: rabies, Echinococcus multilocularis and mange (Kauhala & Kowalczyk, 2011).

Within 25 years after the first sightings in Finland an exponential growth of the population of raccoon dogs was observed (Dahl *et al.*, 2014). Regular sightings of the raccoon dog in the Netherlands started from 2003 but the only province in the

Netherlands with an active management strategy to kill the species so far is Friesland, in which the use of firearms is allowed (Mulder, 2011).

The Dutch Team Invasive Species (TIE) of the Ministry of Economic Affairs collects information about invasive species and recommends measurements for prevention, control and management. A previous risk assessment estimates the possibility that the raccoon dog will be able to establish a population in the Netherlands (Mulder, 2011). In 2010 Finland, Sweden, Norway and Denmark worked together on a LIFE project to manage the raccoon dog population in northern Europe (MIRDINEC LIFE09 NAT/SE000344) (Dahl *et al.*, 2013).

The racoon dog population can grow very quickly within 12.5 years. Therefore it is important that management methods are in place to control the population before the population expands too quickly (Mulder, 2011). The TIE therefore requested to look into the current strategies of managing the population of raccoon dogs in European countries in order to gain information for a possible future management plan for the Netherlands.



**Figure 1**  
Occurrence of the raccoon dog in Austria, Belarus, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, Germany, Hungary, Latvia, Lithuania, Moldova, Netherlands, Belgium, Poland, Romania, Serbia, Slovakia, Sweden and the Ukraine (Genovesi & Scalera, 2008)

## **Aim**

The first aim of this research is to get insight in the strategies used to manage the raccoon dog population in Europe. The second aim is to get insight of potential management method and costs and give advice about potential future management for the Netherlands. This research will look at current strategies considering the following:

- The effect of the method on the population
- Implementation and communication of the method
- Costs of damage
- Costs of the method

## **Research limitations**

The researchers will not look at the public opinion regarding the raccoon dog and the management methods in the Netherlands. This is beyond the scope of this research due to time limitations and the size of the survey needed to be carried out to get a clear overview of the public opinion in the Netherlands.

## **Research questions**

In order to get an overview of the current management strategies to control the population in Europe, the following main research questions can be formulated:

- Which management methods are used to control the population in Europe?
- When looking at public opinions, effect and cost efficiency, which method would be most suitable to be applied in the Netherlands?

The research questions can be divided into four categories:

- The raccoon dog
- Management methods
- Public opinion
- The situation in the Netherlands

### **The raccoon dog**

1. What are the current population numbers of the raccoon dog in Europe?
2. What kind of damage does the raccoon dog cause?
3. What are the costs of damage caused by the raccoon dog?

### **Management methods**

1. Which management methods are used in Europe?
2. What is the effect of the management methods on the raccoon dog population?

3. How was the implementation and organization of the relevant management methods designed?
4. How was the communication regarding the management methods designed?
5. What are the overall costs of the management method?
6. What are the costs of the management methods in working hours per year?

## **Public opinion**

1. What was the general public opinion about the raccoon dog in the European countries?
2. What was the public opinion regarding the management method in the European countries?

## **The situation in the Netherlands**

1. Which method would be most applicable in the Netherlands?

## 2. Methods

In this chapter the methods, research population, data preparation, collection and analysis are described.

### 2.1 Research population

The research population consists of data of the following countries: Finland, Sweden, Norway, Denmark, Germany, Switzerland, Austria and the Netherlands.

### 2.2 Data preparation, collection and analysis

In this research literature study, interviews and a population model were used to obtain the results.

The first phase of the literature study was the determination of the information sources. Literature was found using databases; Scopus and Google Scholar. Papers were selected based on the following key words; raccoon dog, management/ eradication methods, pest / invasive species, culling, life trapping, Judas animals and *Nyctereutes procyonoides*.

For the interviews, experts were selected based on research papers, ministries and hunting associations from the countries named in the research population.

The experts (Table 1) were contacted through email and invited for an interview. After that the interviews were conducted through Skype, phone or email. A questionnaire was used to interview the experts (Appendix III).

In the preparations a protocol from van der Zee (2012) for analyzing interviews was used. The relevant information was extracted to an excel sheet and split up in fragments.

Each fragment was labelled and organized by expert name, country, and the subjects of: raccoon dog, public opinion, management methods and the Netherlands. After this a full text was written with the experts as a source.

**Table 1** Countries, names and organisations of experts interviewed

COUNTRY	EXPERTS	ORGANISATION
Finland	Mikko Alhainen	<i>Life project</i>
	Teemu Simenius	<i>Finnish Hunters' Association</i>
	Kaarina Kauhala	<i>Finnish Game and Fisheries Research Institute</i>
Sweden	Fredrik Dahl	<i>Swedish University of Agricultural Sciences, Department of Ecology &amp; Wildlife</i>
Norway	Claudia Melis	<i>Norwegian University of Science and Technology</i>
	Erik Lund	<i>Norwegian Environment Agency</i>
Denmark	Marie Louise Simmelgaard Platz	<i>Life project / The Danish Nature Agency</i>
Germany	Frank Drygala Norman Stier	<i>Researcher Dresden University of Technology</i>
Switzerland	Caroline Nienhuis	<i>Federal Office for the Environment FOEN, Wildlife and forest biodiversity Section</i>
Austria	Tanja Duscher	<i>Research Institute of Wildlife Ecology</i>
The Netherlands	Mirjam Maas	<i>RIVM</i>



### 3. Biology

The biological facts of the raccoon dog are presented in this chapter (Appendix I factsheet).



**Figure 2**  
Raccoon dog (Noah, 2014)

#### Taxonomy

The raccoon dog originates from eastern Asia. There are 7 subspecies. The subspecies *Nyctereutes procyonoides* was introduced to Europe by Russia to enrich the fauna with a valuable fur animal. About 9.100 individuals were introduced between 1929 and 1955 (Kauhala & Kowalczyk, 2011).

#### Physical characteristics

Raccoon dog is a small carnivore of about 70 cm long and has a height of about 50 cm. They can weigh up to 10 kg. The raccoon dog gets its name from the facial markings which include a white muzzle, a white face and black fur around the eyes. Its fur is long and it has short legs (Ward & Wurster-Hill, 1990).

#### Behaviour

Raccoon dogs are shy by nature. They prefer to forage together unless there are pups in the den. It is known to keep to its den in harsh climates. A harsh climate is defined as: the annual mean temperature being 0 degrees Celsius, a snow cover of 80 mm and a snow duration of 175 days (Carr, 2014; Kauhala & Holmala, 2006; Drygala *et al.*, 2008; Kobel *et al.*, 2014). Large fat reserves are accumulated before winter. Dens are mostly used during the winter time and pup rearing. When active they prefer to use covered areas (Kauhala *et al.*, 1998). Raccoon dogs are slow movers and when disturbed they prefer to hide or will swim to safety. When they are in danger they will often pretend to be dead or keep very still (Nowak, 1993).

#### Habitat

Raccoon dogs prefer a habitat with plenty of cover such as forests and areas with dense vegetation (thick underbrush, marshes and reed beds) and habitat that borders water such as wetlands, mir, bor and fen habitats (Carr, 2014; Kobel *et al.*, 2014). They do not prefer large coniferous forests and agricultural land, however they are often found in maize fields (Drygala *et al.*, 2008; Nowak, 1993). Shorelines are preferred in all types of habitat, mainly due to the cover and a possible escape route for danger (Kauhala, 1996).

#### Home range

The raccoon dog has an average home range of about 5 km<sup>2</sup> (Kauhala & Holmala, 2006). In the former Soviet Union the species expanded its distribution area with a rate of 40 km per year, while in southern and central Finland the annual rate of expansion is 20 km (Melis *et al.*, 2007).

#### Life history

Raccoon dogs have a maximum lifespan of about 7 to 8 years and reach sexual maturity around the age of 10 to 11 months (Mulder, 2012; Kauhala & Helle, 1993; Kauhala & Helle, 1995). Raccoon dogs are monogamous and form pairs in the autumn. Females are in heat after emerging from the den, whether between late January to early April (depending on the local climate). Gestation time is around 65 days. Pups are weaned after 50 days and stay in the den until they are 42 days old (Carr, 2014; Nowak, 1993). The average litter size is about 6 to 9 pups (Ansorge & Stiebling, 2001). Juvenile mortality is 69% in Germany, 82 % in Poland and 89 % in Finland and average adult mortality is 52 % (Kauhala & Helle, 1993; Kowalczyk *et al.*, 2009; Drygala *et al.*, 2010). On average 81 % of the females reproduces yearly (Kowalczyk *et al.*, 2009; Ansorge & Stiebling, 2001; Kauhala & Helle, 1995).

#### Diet

The habitat choice depends greatly on food availability. Raccoon dogs are opportunistic omnivores and their diet consists of: insects, amphibians, eggs, fish, reptiles, carrion and plants. The diet varies during the season. In the summer raccoon dogs will mostly eat small mammals, plants and amphibians and in the winter they will eat plants and carrion. Reptiles, fish and insects are eaten during all seasons (Carr, 2014; Kobel *et al.*, 2014; Ward & Wurster-Hill, 1990). There are reports of raccoon dogs picking up dropped fruit from trees, turning over cow dung for the insects and search the shorelines of (Baltic) seas

to catch fish and mollusks (Wlodek & Krzywinski, 1986).

Male raccoon dogs will feed the female and the pups during the time spend in the den (Drygala *et al.*, 2008).

### Distribution

The raccoon dog occurs in the following European countries: Austria, Belarus, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, Germany, Hungary, Latvia, Lithuania, Moldova, the Netherlands, Belgium, Poland, Romania, Serbia, Slovakia, Sweden and Ukraine (Genovesi & Scalera, 2008). The population estimations are based on sightings, hunting bags or road kills or a combination of these (graph1).

### Threats

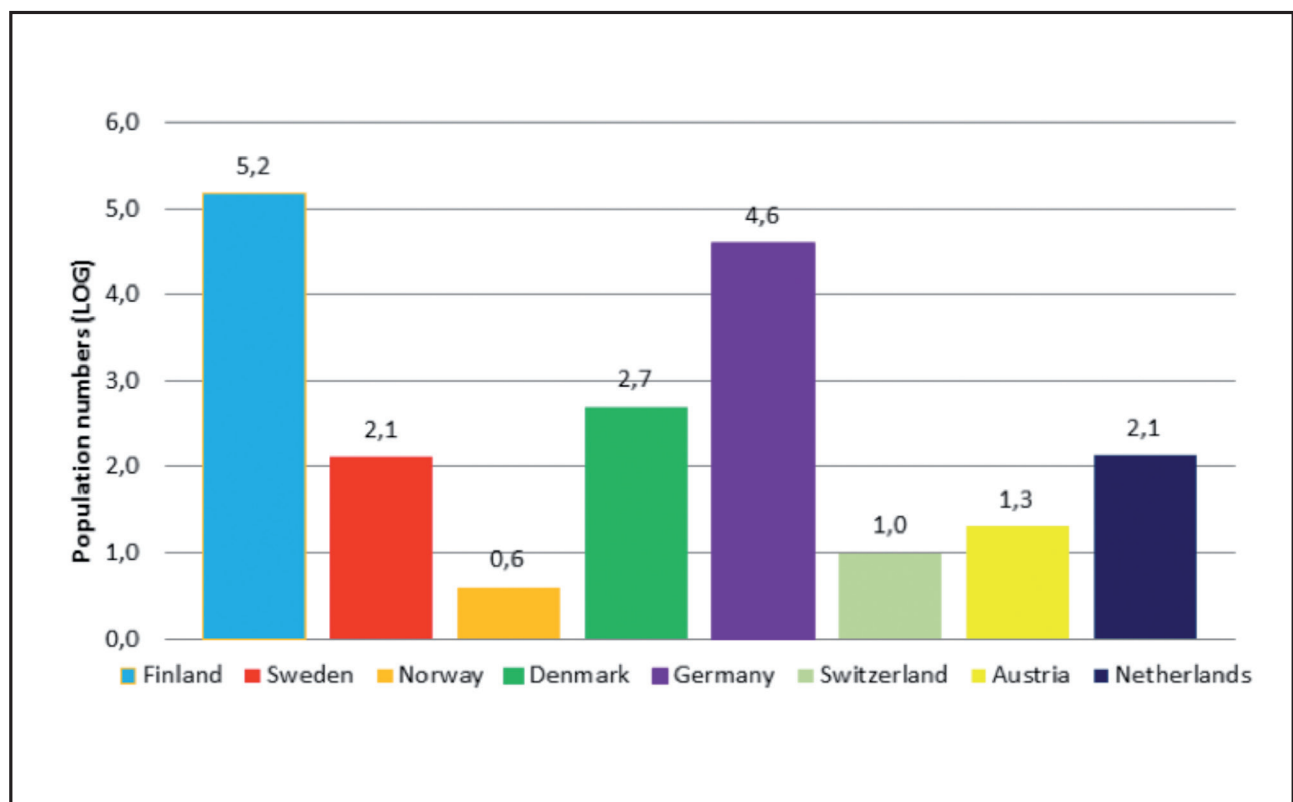
- Raccoon dogs pose a threat to ground breeding bird populations and amphibian populations.
- It can be a vector species and can carry diseases like: rabies, fox tape worm (*Echinoccus multilocularis*) and mange.
- Raccoon dogs can outcompete native predators such as red foxes and badgers by catching their prey and are preyed upon by lynx and wolves. There are no data found of it being responsible for killing life stock or damaging the crops (Carr, 2014; Kowalczyk, 2006; Kobel *et al.*, 2014).

### Ground breeding bird populations

It is uncertain how much effect the presence of the raccoon dog has on ground breeding bird populations. It is more likely that they catch sick or dead birds that have been left behind by hunters then actively catch birds. However the predation on ground breeding bird can cause a more rapid decline in the bird species because the predation pressure is higher than the reproductive rate (Dahl, F., Personal interview, 10 July 2014). The raccoon dog occupies an ecological niche next to the badger and the red fox, which also hunt ground breeding birds. The raccoon dog is an excellent swimmer and has been known to swim to islands or make use of wetlands which the badger and the red fox cannot use. Studies show that in wetlands, raccoon dogs are responsible for less than 1 % of the nest destruction and egg consumption (Obermanis *et al.*, 2001). However in 41% of their scat, egg shell remains were found suggesting that the birds are important for their diet (Kauhala, 2009).

### Amphibian population

Sutor *et al* (2010) found that the diet of raccoon dog living in wet areas consists of about 50 % amphibians and 11% fish and therefore it can be said that amphibians are important part of the diet (depending on the habitat) (Sutor *et al.*, 2010).



**Graph 1**

Raccoon dog population in European countries in LOG numbers

However it is uncertain how high the impact is of the raccoon dog on the amphibian population. About 10 to 15 % of the ingested diet comes from amphibian (Väänänen *et al.*, 2007). Mostly consumed are *Rana ssp*, *Bufo ssp*, *Bombina ssp* and *Triturus ssp*.

### **Diseases**

Raccoon dogs are vector species of diseases that can be harmful to other animals or humans. Diseases like rabies, worms (*Trichinella spp* and *Echinococcus multilocularis* (red fox tape worm)) and a mite (*Sarcoptes scabiei*) which causes mange. North and central Europe is rabies free.

Fox tape worm is a parasite that is harmful to humans, the parasite is very small and resides in the gut of the small carnivores (foxes and raccoon dogs). The eggs are excreted with the faeces and can contaminate vegetation. If this vegetation is eaten by an herbivore and then consumed by a carnivore then this is a closed cycle. However if the vegetation is consumed by a human then the eggs hatch into the larvae stage. This happens in the organs, (liver) and the incubation time can be 5 to 15 years. The eggs can also be ingested by drinking infectious water or even by eating contaminated meat such as large predator meat (bears and lynx) (Mulder, 2011, Maas, M., Personal interview, 23 July 2014). Bear meat is regularly eaten in Finland and needs to be prepared right and tested before consumption.

Raccoon dogs are vectors for canine distemper virus (CDV). This virus can be transmitted between canine species such as red fox and domestic dogs. At this moment there are no studies done into the presence of CDV in the European raccoon dog population but it cannot be ruled out that the disease is not present. In Denmark, Finland and Austria autopsy is performed on dead raccoon dogs to check for parasites or diseases (Simmelgaard Platz, L.M., Personal interview, 14 July 2014; Alhainen, M., Personal interview, 30 June 2014; Duscher, T., Personal interview, 3 July 2014).





## 4. Management methods Europe

This chapter describes the management methods per country. The methods used are: culling, hunting, Judas animals, public awareness system and early warning systems. An overview is given in table 2 and full text explanations are given below for each country.

### Culling

Culling is to reduce the population of (wild) animals by selective slaughtering or hunting of animals (Oxford, 2014). As a management option to control raccoon dog populations, culling or specifically hunting is used in a number of countries. The following European countries permit a year round culling of raccoon dogs: Poland, Hungary, Sweden, Norway, Latvia, Lithuania and Estonia. Seasonal hunting is allowed in Finland and Belarus. In Belarus hunting is allowed from the first of October until the end of February and Finland allows hunting on all animals except on females with pups in the months May, June and July. Denmark does not allow hunting until there is a negative impact on game animals. Germany has different rules for each of the different provinces (Kowalczyk, 2006; Kauhala & Saeki, 2008).

### Trapping

The use of a device to remotely catch the raccoon dog

### Specialized dogs

The use of specialized dogs who are trained to catch a raccoon dog

### Specialized hunters

The used of hunters who are specialized in culling raccoon dogs

### Hunting

Hunting is a sport that in many countries is considered as a hobby and for pleasure. The raccoon dogs that get killed by hunting are a by-catch for the hunters who do not go out and hunt specifically for these animals. Therefore it is considered as a different technique as culling were people kill the raccoon dog as described above. Hunting is a hobby preformed in the Netherlands, Germany, Finland, Sweden and Norway.

### Judas animals

Judas animals are raccoon dogs that are captured, sterilized and outfitted with GPS transmitters before being released to find their mates. When these animals find their mate, the mate is killed and the Judas animal is allowed to find another mate, which again is killed. This method is applied in Sweden, Denmark and Finland. Because of the sterilization the raccoon

dogs cannot breed even if they do find a new mate therefore preventing a rise in the population. Finland uses the Judas animal method without sterilizing their Judases (Dahl *et al.*, 2013).

### Early warning system

Norway and Sweden have an early warning system. This warning system consists of a number of camera traps with sent lure in three possible entry locations. Besides these camera traps a telephone line is used so people can call to report a possible sighting of a raccoon dog (Dahl *et al.*, 2013).

### Wildlife camera's

The use of general wildlife cameras who detect general wildlife

### Public awareness system

The public awareness systems consist of the communication of the raccoon dog presence to the public. This can be done by media such as TV, news sites or newspapers. This is to educate the public to recognize a raccoon dog and to communicate possible sightings to the experts either by a 'hotline' (a phone number) or by a website, Finland, Sweden and Denmark use a social media Facebook site to reach all types of people in the country. These sightings have to be verified by experts (Dahl *et al.*, 2013). In the Netherlands and Belgium such a website already exists (Waarneming.nl/be) where people can report animal sightings (Waarneming, 2014). The public responses are checked by using infrared trap cameras with sent lure (Meijer & Klop, 2014).

### LIFE project

The LIFE project (MIRDINEC LIFE09 NAT/SE000344) is a collaboration between Finland, Sweden, Norway and Denmark to manage the population of raccoon dogs in northern Europe. The project was established in 2010 and finished in 2013. The project had different goals such as:

- Prevent establishment of a wild, free and viable population in Sweden, Norway and Denmark
- Limit further increase and dispersal in Finland
- Use innovative methods to reduce and eradicate the raccoon dog
- Raise awareness in the general public
- Spread the results of the efforts in this project among hunters, local communicaties, ornithologists and international stakeholders (Dahl *et al.*, 2013)

The project was funded with a total budget of € 5,318,278. Out of this € 2,659,139 is funded by the European Commission LIFE+ fund and € 2,331,000 by the Swedish Protection Agency. Norway and Sweden funded the Finnish management during this project (Dahl *et al.*, 2013).

**Table 2** Overview of the methods, effect and costs of each country

<b>COUNTRY</b>	<b>METHOD</b>	<b>EFFECT ON POPULATION</b>	<b>COSTS</b>	<b>PUBLIC OPINION</b>
<b>Finland</b>	<ul style="list-style-type: none"> <li>• Specialized dogs</li> <li>• Culling</li> <li>• Judas animals</li> <li>• Game cameras</li> <li>• Specialized hunters</li> </ul>	85,000 individuals shot in 2000 and in year 2011 close to 180,000 raccoon dogs were shot.	Judas animals cost € 170.000 annually	Aware of the presence of the raccoon dog and they approve of the management methods.
<b>Sweden</b>	<ul style="list-style-type: none"> <li>• Specialized dogs</li> <li>• Culling</li> <li>• Judas animals</li> <li>• Game cameras</li> <li>• Specialized hunters</li> </ul>	Using culling combined with Judas animals and cameras as a method in Sweden resulted in a population decrease after about five 8-9 employed specialists	Judas animals cost € 170.000 annually	Aware of its presence and cooperate with hunters to report sightings
<b>Norway</b>	<ul style="list-style-type: none"> <li>• Early-warning system</li> <li>• Game cameras</li> <li>• Hunting</li> </ul>	No data available	Annual costs about € 80,000 - 120,000	Aware of its presence and eager to report sightings
<b>Denmark</b>	<ul style="list-style-type: none"> <li>• Specialized dogs</li> <li>• Culling</li> <li>• Judas animals</li> <li>• Early-warning system</li> <li>• Trapping</li> </ul>	Slowed down a further dispersal in Denmark and prevented a fast population increase	Annual costs about € 350,000	Not aware of presence and management method
<b>Germany</b>	<ul style="list-style-type: none"> <li>• Hunting</li> </ul>	Hunting does not reduce the population in the most regions	No data available	Not aware of the presence
<b>Switzerland</b>	<ul style="list-style-type: none"> <li>• Hunting</li> <li>• Wildlife camera's</li> </ul>	No data available	No data available	Not aware of presence and management method
<b>Austria</b>	<ul style="list-style-type: none"> <li>• Hunting</li> <li>• trapping</li> </ul>	No data available	No data available	Not aware of the presence and of the management method

## 4.1. Finland

### Population

The population in Finland is around 500,000 animals, this is during the summer months when the raccoon dogs have bred, in the winter this is around 200,000 animals. The highest density is found in the southern part of Finland (Simenius, T., Personal interview, 2 July 2014; Alhainen, M., Personal interview, 30 June 2014). In southern Finland the raccoon dog preys on breeding bird species that are protected by Nature 2000 legislation, causing a decline in these species (Alhainen, M., Personal interview, 30 June 2014).

### Management methods

The population is managed with the use of culling, Judas animals, life trapping, camera traps and hunting (Alhainen, M., Personal interview, 30 June 2014). The hunters performing the culling use specialized hunting dogs (terriers or dachshund). These dogs will chase the raccoon dog into a dead end and the hunter digs the raccoon dog out. Another way is to make the dog chase the raccoon dog towards the hunter from the den where the hunter shoots it when it comes out. Dogs are also used in night hunts, the dog barks or chases the raccoon dog (Simenius, T., Personal interview, 2 July 2014). In 1980 800 raccoon dogs were shot, in 2000 85,000 individuals were shot and in year 2011 close to 180,000 raccoon dogs were shot (Dahl *et al.*, 2014). Camera traps need to be checked regularly for sightings and dead batteries, this can be a disadvantage (Simenius, T., Personal interview, 2 July 2014). Judas animals are a very effective method for population control and eradication (in low population numbers). This method is only used in north Finland (Kauhala, K., Personal interview, 5 August 2014). The disadvantage is that it is expensive and the field worker has to be able to work in harsh conditions. Sterilization of Judas animals is not applied in Finland due to financial reasons (Alhainen, M., Personal interview, 30 June 2014).

Finland has two different management goals, in the south the goal is to keep the population numbers as low as possible. This is to give the birds in the Nature 2000 area a chance to reproduce. The population is controlled by culling and hunting and in the future Finland is looking to set up a LIFE project with the goal of eradication (Alhainen, M., Personal interview, 30 June 2014). In the north the current goal is to eradicate the raccoon dog and push it back south. In the north Judas animals, life trapping, cam trapping and culling are used (Alhainen, M., Personal interview, 30 June 2014). In a large scale study (5 years) done into the effects of medium sized predators on the impact of breeding success of prey species, Finland removed medium

sized predators from an area (Kauhala, 2004). However it is uncertain how successful this study was.

### Effect on the population

There were 85,000 individuals shot in 2000 and in 2011 this increased to 180,000 (Dahl *et al.*, 2014). However this does not seem to have an effect on the population.

### Costs

The hunters receive no compensation for their efforts: however some of the hunters sell the pelts (worth about € 20) (Simenius, T., Personal interview, 2 July 2014). The cost of rabies control is € 1,000,000 annually if management is stopped. In areas that require special protection (such as the Nature 2000 areas) the cost will be around € 3,30 per hectare (Dahl, F., Personal interview, 10 July 2014).

The exact costs of the methods for Finland cannot be answered. While in the north there are many voluntary hunters, there is also a specialized group of raccoon dog hunters. Finland has 380,000 registered hunters and 320,000 of these pay the hunting fees and their own materials. The cost of Judas animal used in Finland during the life project, were € 170,000 and the following was included: 15 Judas animals, 40 remote collars, 40 cam traps, materials needed for life traps and 1 field worker (Alhainen, M., Personal interview, 30 June 2014).

### Communication and implementation

According to the after-LIFE rapport Finland claims to be successful in the management because of the following achieved goals:

- Demonstrated a successful international management organization and cooperation to manage a highly mobile invasive alien species
- Slowed down the dispersal of raccoon dogs from Finland to Sweden and Norway and started reducing the population where it already exists in those countries, involved the local hunters in the management
- Informed and educated stakeholders and the public to increase the awareness of IAS and improve incoming reports to our citizen science systems
- Disseminated actions to managers and scientists in other countries at our international conference (Dahl *et al.*, 2014).

The communication is divided into north and south Finland and is mostly done through word of mouth, internet and magazines such as the hunting magazine (all hunters who pay the fees receive this magazine). The main goal was to reach the

hunters (Simenius, T., Personal interview, 2 July 2014). In the north schools were visited to raise awareness of the effect that the raccoon dog has on the wetlands. In the south raising awareness was not one of the main goals because the public is already aware of its presence (Alhainen, M., Personal interview, 30 June 2014). The raccoon dog is considered a harmful species in the legislation. It is protected under the Hunting Act and that means that females with young cannot be hunted during May, June and July (Simenius, T., Personal interview, 2 July 2014).

#### **Public opinion**

For Finnish people hunting is an important aspect of their culture. Most people are aware of the presence of the raccoon dogs, however in urban areas people do not regard the raccoon dog as such a threat. Outside of the urban areas it is seen as a pest species and is hunted actively (Alhainen, M., Personal interview, 30 June 2014).

### **4.2 Sweden**

#### **Population**

The population of the raccoon dog in Sweden counts around 130 animals. In Sweden the population of raccoon dogs is still relatively small and therefore it is uncertain whether the raccoon dog is responsible for the decline in breeding bird population (Dahl, F., Personal interview, 10 July 2014).

#### **Management methods**

Sweden uses specialized dogs in combination with Judas animals, game cameras, employed personnel and observations from the public (Dahl, F., Personal interview, 10 July 2014). For culling Sweden uses 8 to 9 employed specialists that devote 100% of their time to find and cull raccoon dogs (Dahl, F., Personal interview, 10 July 2014).

#### **Effect on the population**

Using culling combined with Judas animals and cameras as a method in Sweden resulted in a population decrease after about 5 years. It is expected that within the next 10-20 years only a few raccoon dogs will remain. Stopping the management method would result in at least 2,500 raccoon dogs in Sweden in 10 years and over 10,000 in 15 years (Dahl *et al.*, 2013). In 10 years Sweden hopes to only have sterilized Judas animals in their country. These will be used to find raccoon dogs that come from Finland (Dahl, F., Personal interview, 10 July 2014).

#### **Costs**

In Sweden culling combined with game camera's and Judas animals annually costs € 860,000, this includes salaries (Dahl, F., Personal interview, 10 July 2014).

#### **Communication and implementation**

The target audience in Sweden was the general public, the hunters and other nature conservationists. This was done in many different ways: the media, education at schools and universities, fairs and other public events (Dahl, F., Personal interview, 10 July 2014).

#### **Public opinion**

The people in Sweden are aware of the existence of the raccoon dog. In 2008 Sweden started with a media broadcast about the raccoon dog and their potential threats. In 2010 Finland, Sweden, Norway and Denmark worked together on a LIFE project to manage the population in northern Europe (MIRDINEC LIFE09 NAT/SE000344). One of the objects of this project was to make the public more aware of the threats. By educating the public, awareness was raised for this issue as well as for the management methods. The public cooperates with the hunters by calling in sightings of (dead) raccoon dogs (Dahl, F., Personal interview, 10 July 2014).

### **4.3 Norway**

#### **Population**

Norway has 4 confirmed sightings of raccoon dogs. There are no recordings of damage or the possible costs of damage (Lund, E., Personal interview, 21 August 2014).

#### **Management methods**

Norway has a management plan for the raccoon dog since 2007, this action plan was set up in close cooperation with Sweden. The decision on starting a management plan was based on the 6 killed individuals which were found at different locations in the north. The methods used are: continuous surveying with the use of an early warning system, camera traps and live trapping (Lund, E., Personal interview, 21 August 2014).

The Norges Jeger Og Fiskerforbund (NJFF) Hedmark in cooperation with the Statens Naturoppsyn (SNO) initiated a project around the raccoon and have created a contact group in each municipality in Hedmark, who quickly responds to the sightings of raccoon dogs (NJFF, 2013).

#### **Effect on the population**

The methods used are very effective because of the close coope-

ration between the Scandinavian countries. Currently there have been no sightings of raccoon dogs (Melis, C., Personal interview, 18 August 2014).

### **Costs**

The costs of the prevention methods are estimated to be between € 80.000 and € 120.000 a year (including salaries and equipment). The Norwegian State environment agency uses most of the money on following up on reported sightings. Currently no full time staff members are working on catching raccoon dogs (Lund, E., Personal interview, 21 August 2014).

### **Communication and implementation**

The organisation of implementation is a project of the Environment Agency. Mass media were used as communication tool (Lund, E., Personal interview, 21 August 2014).

### **Public opinion**

Norway worked together with Finland, Sweden and Denmark in 2010 on a life project to manage the raccoon dog population in northern Europe (MIRDINEC LIFE09 NAT/SE000344). In this project it was important to educate the public to raise awareness about the raccoon dog and the management methods. This was done by media broadcast on a Swedish news website. The most important reason was to motivate the public to report sightings of (dead) raccoon dogs (Dahl, F., Personal interview, 10 July 2014; Lund, E., Personal interview, 21 August 2014).

## **4.4 Denmark**

### **Population**

Denmark has an estimated population of about 500 raccoon dogs. These raccoon dogs are mostly present on the mainland (Jutland) and on the coastlines (Simmelgaard Platz, L.M., Personal interview, 14 July 2014).

### **Management methods**

Denmark created a management plan for the raccoon dog in 2009/2010 (adopted in 2010). The Danish Nature Agency found rapid response important and used targeted actions for implementation. The management methods used in Denmark are: Judas animals, early warning systems, culling, dog hunting and trapping. In order to be successful, experienced staffs is required. For these management methods there are about 3,500 hours a year used by the Danish Nature Agency. Hunting associations use at least 500 hours a year. It is unknown how many voluntary hours are put into management. In Denmark a small group of employees in the Nature Agency have worked intensively on trapping and hunting with dogs. The voluntary

hunters in the network are responsible for taking care of many observations by game-cameras and thereby taking part in maintenance of the early warning system (Simmelgaard Platz, M.L., Personal interview, 14 July 2014).

### **Effect on the population**

According to the after-LIFE rapport Denmark claims to be successful in their management because of the following achieved goals:

- Slowed down further dispersal in Denmark and prevented a fast population increase
- Demonstrated that innovative methods for culling and management of the raccoon dog also works on other species. Several raccoons (*Procyon lotor*) have been culled within the project in Denmark and Sweden (Dahl *et al.*, 2014).

### **Costs**

The annual costs for Denmark are about € 350,000 (Simmelgaard Platz, M.L., Personal interview, 14 July 2014). The Danish Nature Agency has approved funding until the end of 2015. After 2015 the project and the management plan will be evaluated before deciding about continuation (Dahl *et al.*, 2014).

### **Communication and implementation**

The communication about the project and the management methods in Denmark have consisted of many different elements. The main communication tools were homepages and specially printed flyers. When the management plan was adopted the Minister of the Environment presented the main objectives and methods in a daily prime time show on TV.

Another very important aspect of communication to hunters and landowners has been through the network of the voluntary hunters (Simmelgaard Platz, M.L., Personal interview, 14 July 2014). Denmark primarily intended to reach two main groups: hunters and the general public and the purpose was to raise awareness in both target groups. Denmark claims that the communication to these groups has been successful (Simmelgaard Platz, M.L., Personal interview, 14 July 2014).

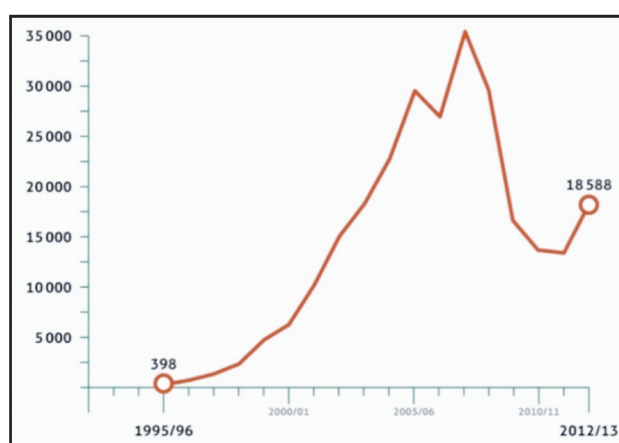
### **Public opinion**

People are aware that it is an invasive species and hunters are aware of the potential threat of the raccoon dog and know where to find it. The general public is aware of the special telephone number to report the sightings (Simmelgaard Platz, L.M., Personal interview, 14 July 2014).

## 4.5 Germany

### Population

The estimated population is around 50,000 animals. The raccoon dogs killed in 2013 were around 18,600 (graph 2). These raccoon dogs were killed by hunting or car accidents (Drygala, F., Personal interview, 8 July 2014). Since 1995 there has been an increase of 4,000 % of killed raccoon dogs with a peak in 2009 (35,000). There are no recordings of damage or the possible costs of damage (Drygala, F., Personal interview, 8 July 2014).



**Graph 2**

**The increase of the killed raccoon dogs in Germany between 1995 and 2013 (Jagdverband, 2014)**

### Management methods

Germany does not have a management plan for the raccoon dog. Nevertheless the raccoon dog is hunted in great numbers as hunter's by-catch (Drygala, F., Personal interview, 8 July 2014). The hunting started at the first sightings of the raccoon dogs in year 1995/1996 (Stier, N., Personal interview, 29 July 2014).

### Effect on the population

According to Stier (2014) hunting does not affect the population in most regions. The goal is to minimize the population because total eradication is not possible without working together with Poland (Drygala, F., Personal interview, 8 July 2014; Stier, N., Personal interview, 29 July 2014).

### Costs

The raccoon dog is considered to be by-catch and any costs are not reported.

### Communication and implementation

Since there is no official management plan there are no data available about communication and implementation.

### Public opinion

Germany has 350,000 registered hunters and most people are unaware of the raccoon dog. There may be some awareness in the north east because of a higher population density. The hunting bag is published yearly in a report of the German Hunting Association and accessible to the public (Drygala, F., Personal interview, 8 July 2014).

## 4.6 Switzerland

### Population

The estimated population of 20 raccoon dogs in Switzerland. In Switzerland there are no recordings of damage or the possible costs of damage (Nienhuis, C., Personal interview, 9 July 2014).

### Management methods

Switzerland has no management plan for the raccoon dog but it is hunted as by-catch. In 1986 the raccoon dog was added to the hunting legislation. Besides hunting Switzerland uses camera traps for general wildlife management. If a raccoon dog is spotted the hunters will search for this individual and kill it. If in the future the raccoon dog does establish a population Switzerland will promote hunters to shoot the animals (Nienhuis, C., Personal interview, 9 July 2014).

### Effect on the population

It is not known what the effects of hunting are on the population (Nienhuis, C., Personal interview, 9 July 2014).

### Costs

There are no compensation for hunters who kill the raccoon dog and there is no data about costs (Nienhuis, C., Personal interview, 9 July 2014).

### Communication and implementation

There are no data known about communication and implementation (Nienhuis, C., Personal interview, 9 July 2014).

### Public opinion

The public is not aware of the presence of the raccoon dogs in Switzerland. Since 1978, 8 dead raccoon dogs were recorded. The only people who are aware of the presence of the raccoon dog are the hunters and some researchers (Nienhuis, C., Personal interview, 9 July 2014).

## **4.7 Austria**

### ***Population***

The current population size in Austria is estimated to be around 20 raccoon dogs. However most of the provinces do not keep statistics on the population density of (new) carnivores. There are no recordings of damage or the possible costs of damage (Duscher, T., Personal interview, 23 July 2014).

### ***Management methods***

Austria does not use any management methods however the future goal is to eradicate the population should there a population establish itself. Currently it is allowed to hunt the raccoon dog in all parts of the country, however the hunting is not intensive enough to control the increasing population. The other management methods used is live trapping and shooting at wild boar feeding places (Duscher, T., Personal interview, 23 July 2014).

### ***Effect on the population***

It is currently not known what the effect of hunting is on the population (Duscher, T., Personal interview, 23 July 2014).

### ***Costs***

There are no data available for the costs because hunters have to pay for their own materials and do not record this (Duscher, T., Personal interview, 23 July 2014).

### ***Communication and implementation***

Austria is trying to educate hunters about the population increase in neighbouring countries and potential problems for their own country (Duscher, T., Personal interview, 23 July 2014).

### ***Public opinion***

The public is not aware of the presence of the raccoon dog. There are about 115,000 hunters who are aware of its presence (Duscher, T., Personal interview, 23 July 2014).







## 5. The Netherlands

In this chapter the current population and the possible management of the raccoon dog is presented.

### Current situation

There have been 174 sightings since 2003 in different provinces and most of these sightings were in the northern provinces Groningen, Drenthe and Friesland (**figure 3**) (Mulder, 2011). Mulder (2011) published a risk assessment in which until January 2011 a total of 139 sightings were recorded, however Waarneming (2014) claims to have recorded a total of 50 sightings from January 2005 until July 2014 (**graph 3**). These 50 sightings are not confirmed sightings, there was a peak in 2011 (Waarneming, 2014). Mulder (2011) stated that out of the 139 sightings, 62 sightings were confirmed and total of 17 sightings were considered raccoon dogs which escaped from captivity (Mulder, 2011).

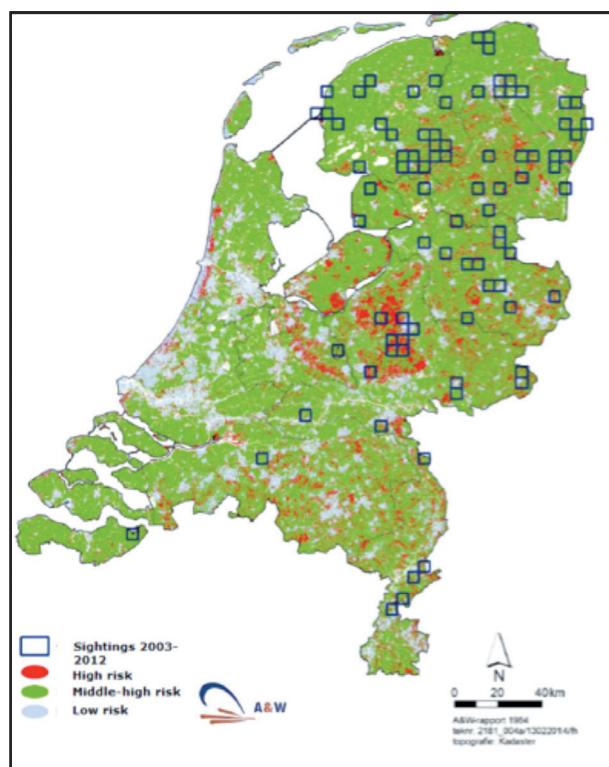
The Netherlands consists of a little more than 4 million hectares (CIA, 2014) and it is calculated that there is 41,067 of suitable habitat for the raccoon dog. **Figure 3** shows the areas which have the highest risk of a raccoon dog settling. Red areas indicate highly suitable habitat and high settlement risk, green areas middle to high suitable habitat and a middle to high settlement risk and grey areas are not suitable habitat and have a low risk of settlement (**figure 3**) (Meijer & Klop, 2014). The carrying capacity is 1,053 animals per 1,000 km<sup>2</sup> and when this is extrapolated then the carrying capacity for the Netherlands would be 41,067 individuals (Sutor *et al.*, 2010).

Mulder (2011) assessed the raccoon dog as being a category B species in the Invasive Species Environmental Impact Assessment Protocol (ISEIA): this means the animal has a 'moderate environmental risk' with the main risks being the high dispersion rate and the potential for colonization in the Netherlands (Mulder, 2011).

### Possible damage in the Netherlands

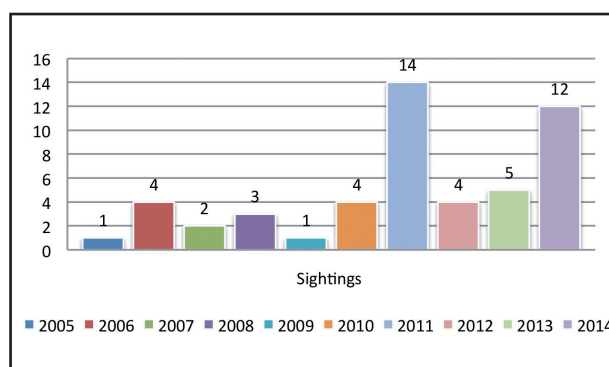
The raccoon dog might cause the following damage in the Netherlands: have an impact on native predators, impact on native prey species and be a vector species for diseases and parasites (Mulder, 2011).

The raccoon dog can interact with the badger, red fox and polecat (*Mustela putorius*) and it has been reported to exist next to the badger and red fox without completely out competing these species for their prey. However both the raccoon dog and



**Figure 3**

Map of the Netherlands in which the squares indicate sightings. The red area indicates high settlement risks, green indicates middle to high settlement risk and grey areas indicate low settlement risk (Meijer & Klop, 2014).



**Graph 3**

Raccoon dog sightings in the Netherlands from 2005 until 2014 (Waarneming, 2014)

the polecat are known to prey on amphibians and if the population of raccoon dogs rises then this may negatively impact the native predator species (Mulder, 2011).

The raccoon dog is an excellent swimmer and will prey on breeding bird populations and amphibian populations. The Netherlands consists of large wetlands areas (mostly Nature 2000 areas) in which breeding bird populations are present and protected. The ground breeding bird species most vulnerable with an increasing presence of the raccoon dog are:

- Purple heron (*Ardea purpurea*)
- Black tern (*Chlidonias niger*)
- Bittern (*Botaurus stellaris*)

Raccoon dogs may also have an impact on (isolated) amphibian population and will most likely feed on grass snakes (*Natrix natrix*). Raccoon dogs (as well as red foxes) are a vector for fox tape worm. With the increasing population and distribution of raccoon dogs the chances of infection increases. It is unknown which percentage of the population of raccoon dog is infected with fox tape worm (Mulder, 2011).

## 5.1 Current management in the Netherlands

The raccoon dog is mentioned in the Flora and Fauna law as 'marterhond' by article 67.4 appendix I of the Regulation of management and damage control. An exemption to hunt this species is only made when:

- It is in the interest of public health and safety
- In the interests of air safety
- Prevention of serious damage to crops, livestock, forests, fisheries and water commercial
- Prevention of damage to flora and fauna

This exemption can be given by each province and currently Friesland is the only province which allows the use of firearms to hunt (Economische Zaken, 2014; Mulder, 2014).

The National Institute for Public Health and the Environment (RIVM) is conducting a research into the diseases carried by Dutch raccoon dogs. The RIVM specially looks at the fox tape-worm. In 2008, the first case of infection with the fox tape-worm was found in the Netherlands, it is however uncertain if this was caused by the raccoon dog. The RIVM has put an advert in a Dutch the magazine named: 'Zoogdier Vereniging' (year number 25, Nr. 2) with the request to report found raccoon dogs for research via a phone number. There have not been any reporting's since the request (May 2014). In October 2014 the RIVM will publish this advert again in the magazine to raise more awareness for this subject. October is the time when farmers cut their maize and the RIVM thinks this could be the moment where farmers will find the raccoon dog in their fields (mowing victims). Previously found raccoon dogs were tested

negatively for any diseases (Maas, M., Personal interview, 23 July 2014).

## 5.2 Management vs no management

In this chapter the management methods that can be applied to the Netherlands will be compared to a no management situation, besides interviews and literature the program vortex was used to make predictions.

### Methods

Population models are created to give an insight in what effect management has on the Dutch population. The mortality rates and population numbers in this model are based on average mortality and population numbers found in literature. These numbers are only applicable in the population models. The population model was created using the software Vortex 10.0.7.3, the settings used in this population model are displayed in table 3. The carrying capacity for the raccoon dog is 1,053 for 1,000 km<sup>2</sup> (Sutor & Schwarz, 2012) and if this is extrapolate then carrying capacity for the Netherlands would be 40 times higher ( $1053 \times 40$ ) 41,120. As stated before only the urban areas are not suitable, and there are 880 km<sup>2</sup> of urban areas in the Netherlands (CBS, 2014) ( $88,000 \text{ ha}^2$   $4,000,000 - 88,000 = 3,912,000$   $\times 1,053 = 41,067$ ). In the Vortex a maximum carrying capacity of a 1,000 could be used and therefore all the numbers were divided by 40 to get a correct scale ( $41,067 / 40 = 1,026$ ). When divided by 40 the carrying capacity is 1,026 and therefore the rounded down number 1,000 was be used as carrying capacity and for the initial population size is 5 animals ( $200 / 40 = 5$ ). In all the vortex calculations 3 daughters will be used as example.

### No management

No management means that nothing is done to control the population and it is allowed to establish itself and grow at the natural rate.

In the population 81% of the females are reproductive (Kobel *et al.*, 2014). If the females in the population give birth to 3 daughters a year then the population would increases with 5% in one generation and this means that in the next 10 years the population will increase to 325 animals. However if the females give birth to 4 daughters then the population will increase with 23% in one generation and the population will increase in the next 10 year to 1.585 animals. If the females give birth to the maximum of 5 daughters then the population in will increase with 54% with one generation and the population will increase to 15.005 animals within 10 years (Appendix I: Factsheet, table 1: life table).

**Table 3** Used standard parameters in Vortex 10.0.7.3

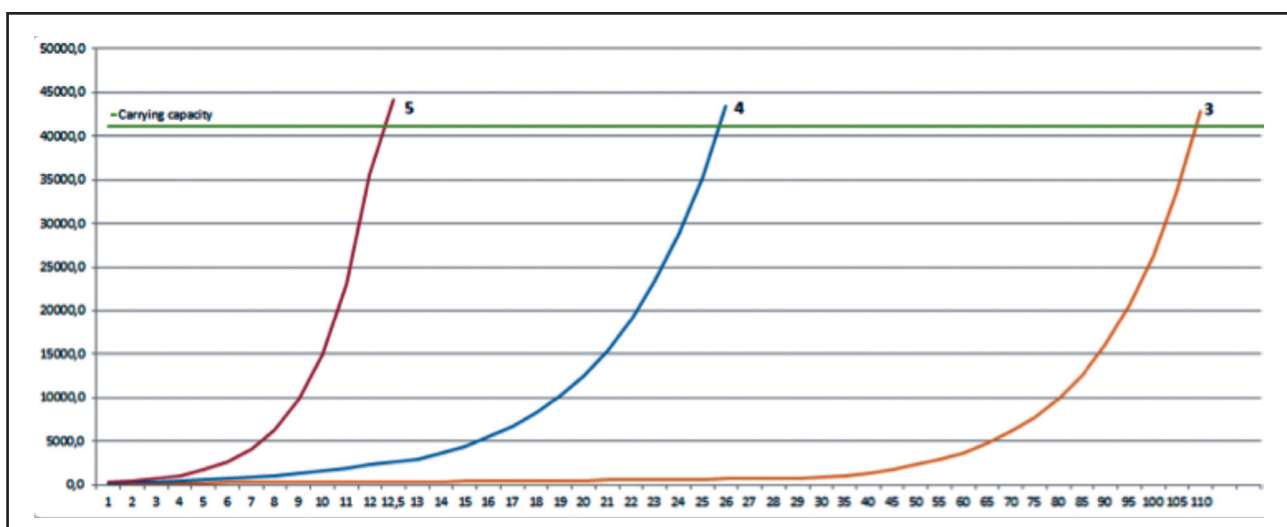
SETTINGS	NUMBERS	REFERENCES
Number of iterations	100	(Lacy & Pollak, 2014)
Number of years	100	(Lacy & Pollak, 2014)
Maximum life span	8	(Nowak, 1993)
Number of female offspring	3	(Kauhala & Saeki, 2004; Wlodek & Krzywinski, 1986)
Reproductive age	1	(Kobel et al, 2014)
% Adult breeding individual	81%	(Kobel et al, 2014)
Mortality rate Juvenile	45	(Kauhala & Helle, 1993; Kowalczyk et al, 2009)
Mortality rate Adult	40	(Kauhala & Helle, 1993; Kowalczyk et al, 2009)
Initial population size	NL 200 (model: 5)	
Carrying capacity for the Netherlands	NL 41,067 (model: 1,000)	

### Carrying capacity

Calculations from life tables (graph 4) show that if 81 % of the females are reproductive and:

- had 3 daughters (6 young) per brood, it would take 110 generations to reach the Dutch carrying capacity
- had 4 daughters (8 young) per brood, it would take 26 generations to reach the Dutch carrying capacity
- had 5 daughters (10 young) per brood, it would take 12,5 generations to reach the Dutch carrying capacity

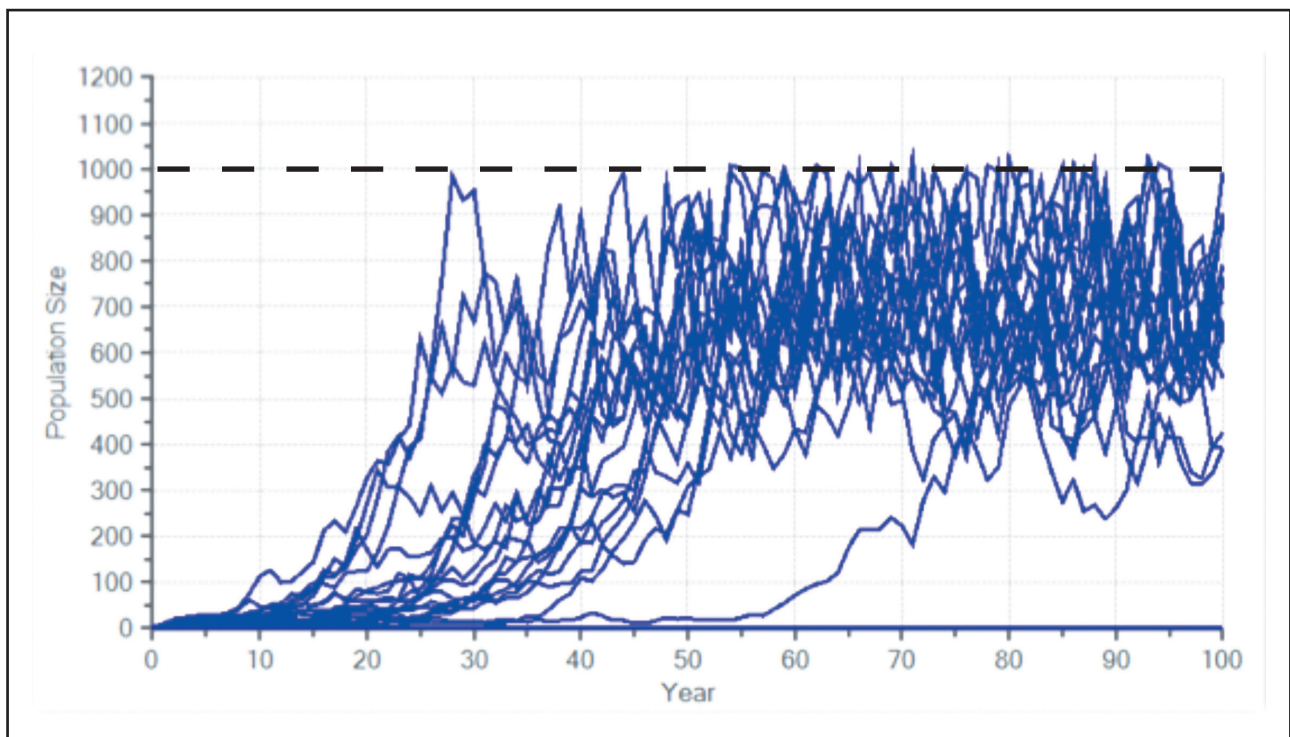
On average the generation time of the raccoon dog is 1 year and when compared with 6,8 and 10 pups in the litter the population will grow fastest with 10 pups. In the calculations with vortex the amount of 3 daughters will be used.

**Graph 4**

Expected population growth to carrying capacity over 100 year with different amount of daughters per brood per year with an initial population size 200 animals with sex ratio of 50%. X Axis shows the generation time in years, one generation equals one year. Y Axis displays the amount of animals with a carrying capacity at 41,067 animals.

## Population

Without any form of management the population size will grow to the carrying capacity. As soon as the population reaches carrying capacity, the percentage of females reproducing in the model will decline from 81% to 41% (graph 5).



**Graph 5**

Population prediction in the Netherlands without any form of management.  $N = 5$  with 3 daughters per brood per year. X Axis shows time in years, Y Axis displays the amount of animals with a carrying capacity at 1,000 animals. 1/40 Netherlands.

**Table 4** Potential risks of the raccoon dog in the Netherlands (Mulder, 2011)

ASPECT	SUB ASPECT	RISK
Dispersal Potential		High
Colonization of high value conservation habitat		High
Adverse impact on native species	Predation	Medium
	Competition	Low
	Disease	Low
	Genetic interaction	Low
Alteration of ecosystem services	Nutrient cycling	Low
	Physical alteration	Low
	Natural succession	Low
	Food web	Low

### Costs

The cost of no management is the cost of damage. Europe has been rabies free and this is largely due to the rabies vaccinations. The total annual cost in Finland to keep rabies under control is € 1,000,000. These costs are not the same for each country and can differ (Dahl, F., Personal interview, 10 July 2014). The annual cost per hectare of a protected habitat is € 3,30 (Dahl, F., Personal interview, 10 July 2014). It is likely that these costs will only continue to rise as the population increases.

### Threats (damages)

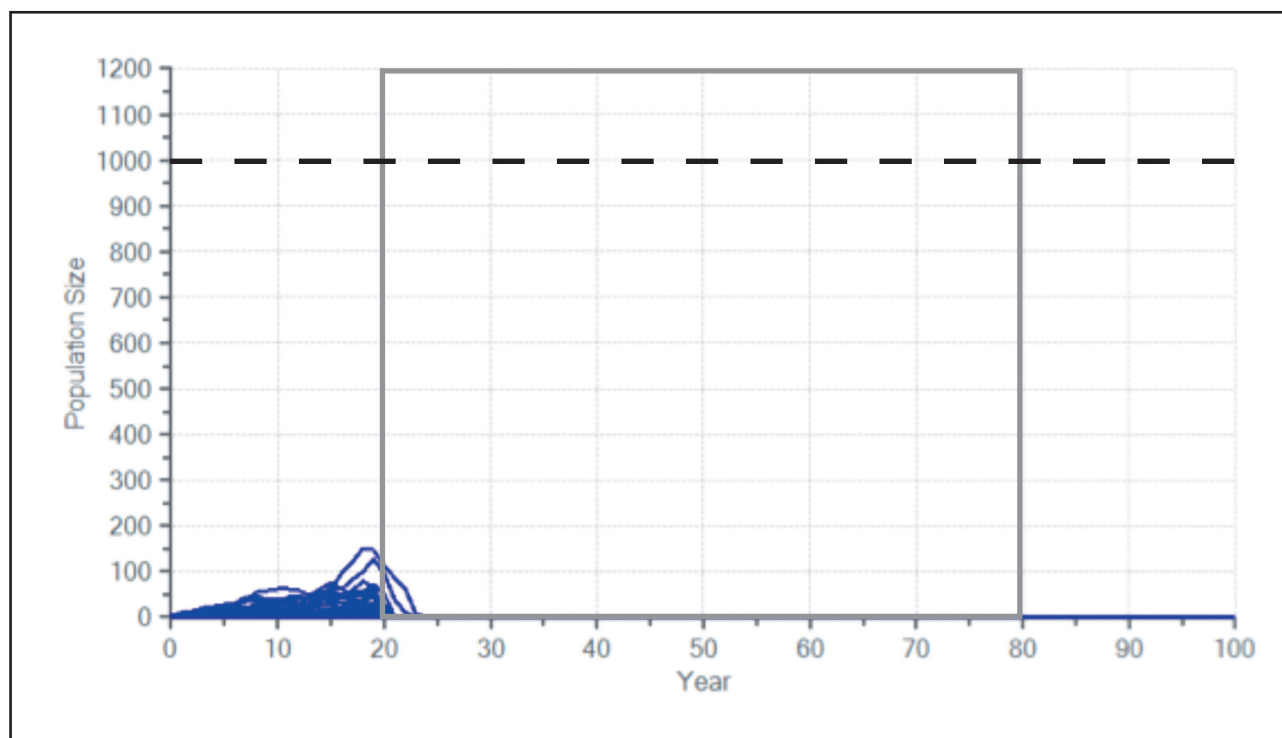
Without management the population raccoon dogs will rise quickly. With the rise of the population the possibility of damage will rise as well. Mulder (2011) performed a risk analysis on the raccoon dog and results are displayed in table 4.

### Management

In this part management is considered as any method used to control the population. It is shown that a population without management can rise to high numbers in the upcoming years, several methods are used for controlling raccoon dogs (Chapter 4) with the use of Vortex predictions can be made of how a population can respond to a form of management.

### Population

For the first population management method the program is set at a management starting from year 20 and ending in year 80 (graph 6). During this 60 years of management each year 50 individuals are harvested (25 females and 25 males). All the populations perish with this management and no population reaches the carrying capacity (graph 6).

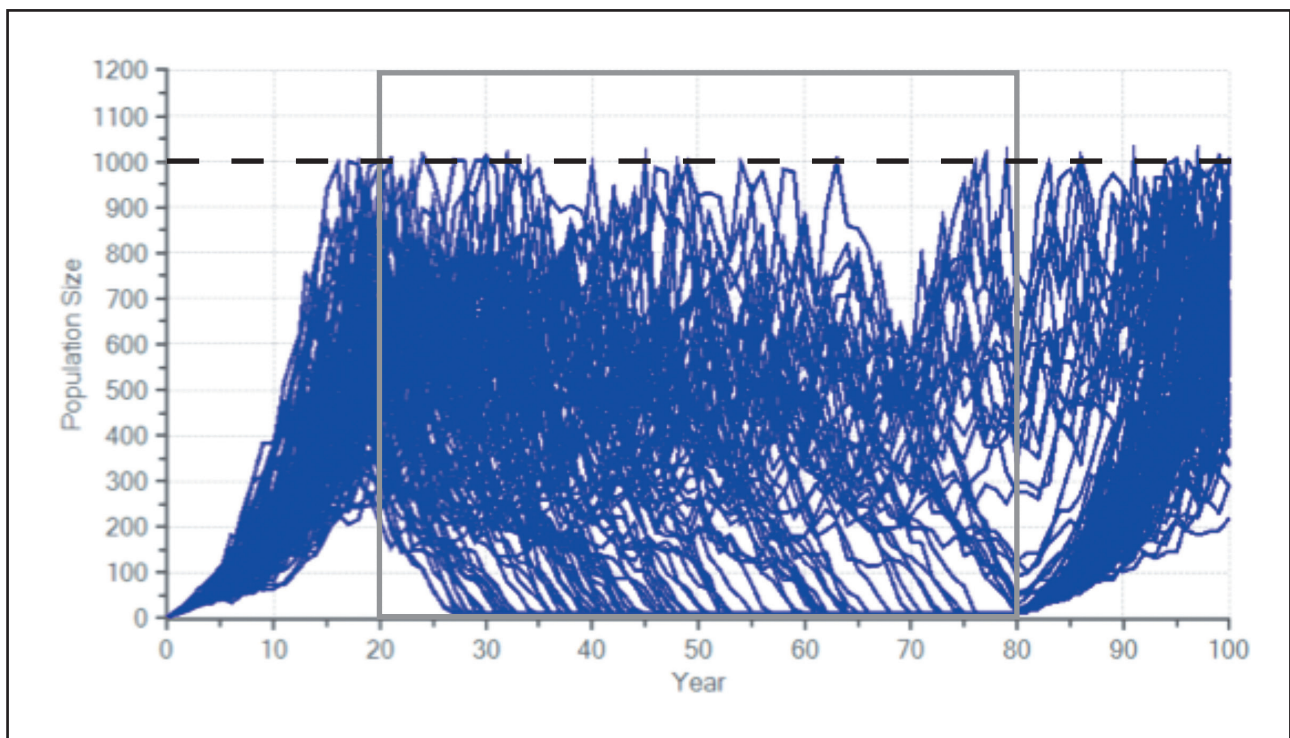


**Graph 6**

Population prediction in the Netherlands with management of 25 males and 25 females. Management starting in year 20 lasting until year 80.  $N = 5$  with 3 daughters per brood per year. X axis shows time in years, Y axis displays the amount of animals with a carrying capacity at 1000 animals. 1/40 Netherlands. Gray bar shows timeline of management.

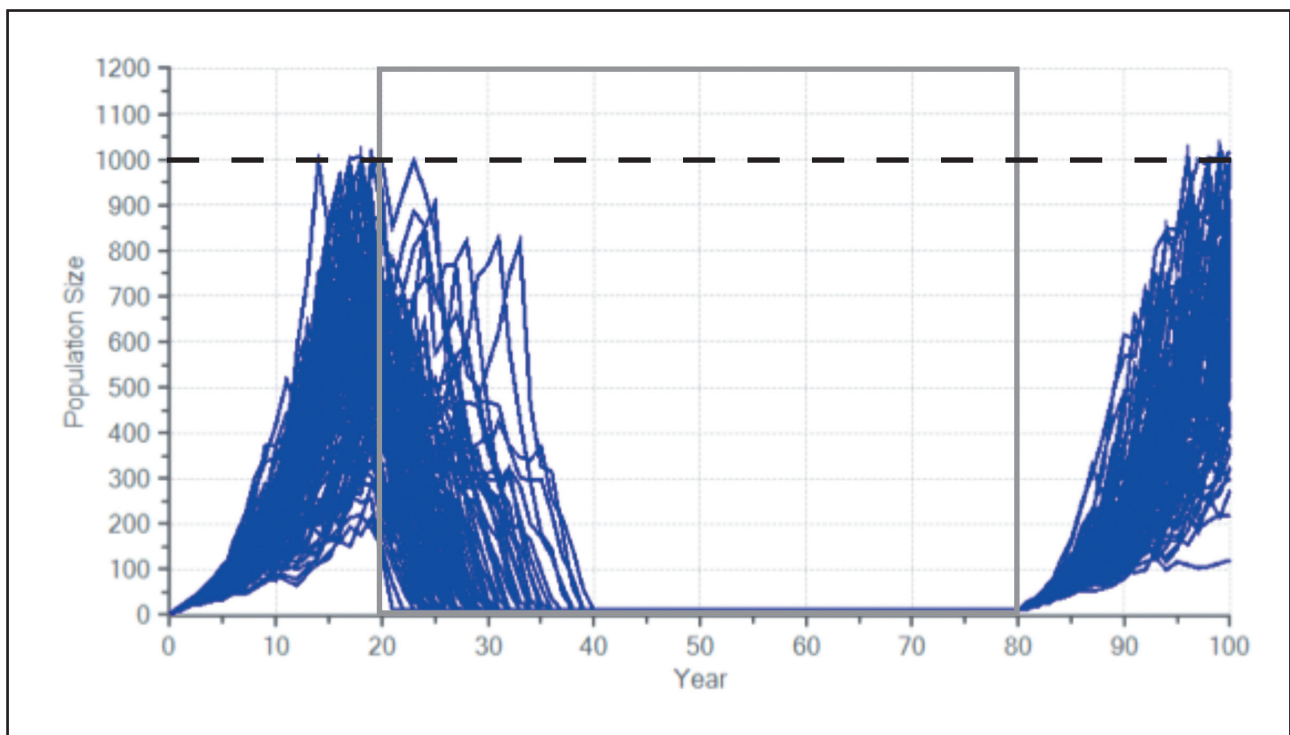
A very interesting input in population control is immigration. From other countries raccoon dogs are crossing the border to the Netherlands. If the population is managed with a hunting bag of 50 animals each year (25 males and 25 females), and the management starts at year 20 and ends at year 80 and there is an immigration of 10 animals a year (5 males and 5 females) then the population grows very quickly and reaches the carrying capacity. When management is stopped the population reaches the carrying capacity.





**Graph 7**

Population prediction in the Netherlands with management of 25 males and 25 females. Management starting in year 20 lasting until year 80.  $N = 5$  with 3 daughters per brood per year. Immigration starting in year 0 with 5 females and 5 males annually. X Axis shows time in years. Y Axis displays the amount of animals with a carrying capacity at 1,000 animals. 1/40.



**Graph 8**

Population prediction in the Netherlands with management of 50 males and 50 females. Management starting in year 20 lasting until year 80.  $N = 5$  with 3 daughters per brood per year. Immigration starting in year 0 with 5 females and 5 males annually. X Axis shows time in years. Y Axis displays the amount of animals with a carrying capacity at 1,000 animals. 1/40.

city again within 15-20 years (due to immigration) (graph 7). This management is not enough to eradicate the population.

To see whether a higher harvest has a different impact on a population a model was created in which 100 animals were harvested (graph 8). With the management started at year 20 and ending at year 80 (including the immigration of 10 animals) all populations perish within 20 years. When management stops the population grows back to carrying capacity. Previously the numbers used in the models were extrapolated by dividing them by 40. To now extrapolate this back to the real situation all the numbers have to be recalculated. In the population model a harvest of 50 animals was used (to relate this to the real situation this should be times 40) 50 animals in the model will be 2000 in the real situation ( $50 \times 40 = 2,000$ ). And with a harvest of 100 animals in the model 4,000 animals are need to be harvested in the real situation ( $100 \times 40 = 4,000$ ).

## Costs

The most important costs of the management methods are the salaries of the employees and the materials needed. These costs are detailed in the text below and table 5.

Annually it would cost € 860,000 to use 80 Judas animals combined with 40 wildlife cameras and 9 full time employees (Dahl, F., Personal interview, 10 July 2014). However it may not be necessary to use 80 Judas animals in the Netherlands because the population is smaller. If 15 Judas animals are selected with 120 wildlife traps, 40 wildlife cameras, 40 remote GPS tracking devices and 1 fulltime field work the annual costs are around € 170.000 (Alhainen, M., Personal interview, 30 June 2014).

A lot of man hours are used for hunting, culling, trapping and an early warning system. This will mean 3,500 hours per year from a nature agency and a minimum of 500 working hours from a hunting association. This annual costs of this will be around € 360,000, this does not include voluntary hunters (Simmelgaard Platz, M.L., Personal interview, 14 July 2014).

Due to the low population density the most effective method would be a combination of Judas animals and an early warning system with cameras( estimation based on numbers of other countries: € 170,000 + € 360,000 = € 530,000.

**Table 5** Cross table with overview of different methods and their efficiency depending on population density levels

	<b>CULLING</b>	<b>HUNTING</b>	<b>JUDAS ANIMALS</b>	<b>EARLY WARNING SYSTEM</b>
<b>High population density</b>	Effective	Not effective	Less effective, too many animals, effective in combination with hunting	Not effective
<b>Low population density</b>	Less effective, too much time spent in finding the animals	Less effective, too much time spent in finding the animals	Effective	Effective in combination with hunting or Judas animals
<b>Cost in Low population density</b>	High due to long searching time	High due to long searching time	High in preparation of the Judas animals	Costs are not dependent on population size
<b>Cost in High population density</b>	Low, animals are easily found	Low, animals are easily found	High in preparation of the Judas animals	Costs are not dependent on population size

### ***Management vs No management***

Differences between management and no management.

Without management:

- the population of raccoon dogs will rise
- the cost of no management can rise up to a total annual cost of € 1,000,000 for rabies control
- the threats (increase in diseases, decline of amphibians and breeding bird population and threats to native predators) will remain the same but the risk to these threats will increase.

With management:

- the population of raccoon dogs will (most likely) decrease
- costs of management are between € 170.000 and € 860.000 (depending on the management method)
- the threats (increase in diseases, decline of amphibians and breeding bird population and threats to native predators) will remain the same but the risk to these threats will decrease.



# Discussion

This chapter describes the discussion points that arose during the research. The discussion points will be divided into the following topics: the current situation in the Netherlands, the current situation in Europe, the future situation in the Netherlands and the method discussion.

## The current situation in the Netherlands

### *Population size*

There are a total of 174 sightings of raccoon dogs in the Netherlands, based on sightings and dead raccoon dogs. There are two main sources used: waarneming.nl and Jaap Mulder (2011). There is a difference in the number of sightings posted on Waarnemingen.nl and the number of sightings Jaap Mulder published. The sightings on the above mentioned website are not always checked on authenticity and therefore Jaap Mulder is considered a more reliable source.

### *Population trend*

The population size is based on estimation and therefore it is difficult to predict the population trend for the next years. In this research population models were used to predict a possible population development. Besides the current population numbers there is a constant immigration coming in from Germany or Belgium, immigration is not researched extensively and therefore exact numbers are not known. In the population models the immigration numbers were estimated to be 10 animals, however it is highly possible that these numbers differ from the actual situation. With these estimations the current population size is estimated to be 200 animals which is 0,48% of the carrying capacity (41,067).

### *Impact on native predators*

Drygala (2009) states that potential interaction between the raccoon dog, badger and the red fox, it is unlikely to severe in the European countries. Currently there is no research done in the interaction between the raccoon dog and the native predators in the Netherlands.

### *Impact on native prey species*

The raccoon dog does not show a significant impact on native prey species. Finland did a large scale study (5 year period) in which medium sized predators were removed to research the impact on the breeding success of prey species (Kauhala, 2004). It is unclear if the removal was not successful enough or the presence of other predators rose in the absence of the

raccoon dog (Mulder, 2011). In the Netherlands there are only estimations on the impact of the raccoon dog on the native prey species.

### *Carrier of diseases and parasites*

At this moment the RIVM is doing research on the impact of the raccoon dog in transmitting diseases in the Netherlands. This research is still ongoing at the time this report was written.

## The current situation in Europe

### *Population size*

All the population numbers are based on estimations, sightings, hunting bags and road kills or a combination of these. The population density and carrying capacity are very different for each European country and this makes it difficult to make a comparison between countries. Each country has different approach towards management and this is due to the population trend and the management goal (eradication, population control or preventing to establish a population). Currently there is no research done into actual population sizes. Besides population numbers, population trend is very important and this was not taken into account in this research.

### *Neighbouring countries*

The Scandinavian countries collaborated together on the LIFE project (MIRDINEC LIFE09 NAT/SE000344) to develop and test the effect of several management methods on a population (as goal eradicator or to prevent establishment). The experts noticed that a close collaboration with neighbouring countries can increase the effectiveness of the management methods. Some countries (Germany, Austria and Switzerland) do not have a management plan or method and do not communicate with one another.

### *Nature 2000*

If the raccoon dog does cause a decline in ground breeding birds, amphibians, reptiles and fish then this could have an effect on the compensation the European countries receive to protect Nature 2000 listed animals. Nature 2000 is a European network of protected areas in the territory of the Member States of the European Union. This network forms the cornerstone of the EU policy for the preservation and restoration of biodiversity. Nature 2000 is not only applied to protect areas (habitats), but also contributes to species protection. The Institute for Environmental Studies calculated the benefits of

Nature 2000 for the Netherlands. The IVM (2014) indicates in that the average income for all Nature 2000 areas is around € 4,000 per hectare per year. These benefits relate to:

- environmental regulation
- recreation and tourism
- improved environment
- supply of raw materials

The total size of Nature 2000 in the Netherlands is approximately 1.1 million hectares (The European Commission, 2014; De Regiegroep Natura 2000, 2014).

### Costs

The costs of the management methods are not described per management method but recorded (if recorded) for all methods. This makes it difficult to get a clear overview of the costs for one specific management method. The costs are calculated in a total amount instead of man-hours. Each management method consists of different aspects which influence the costs. Man-hours and materials are different for each method and are depended on which method is used, goal of management and population size. A smaller population could mean more man-hours if the goal is eradication and less man-hours if the goal is control. This makes it difficult to calculate the costs of

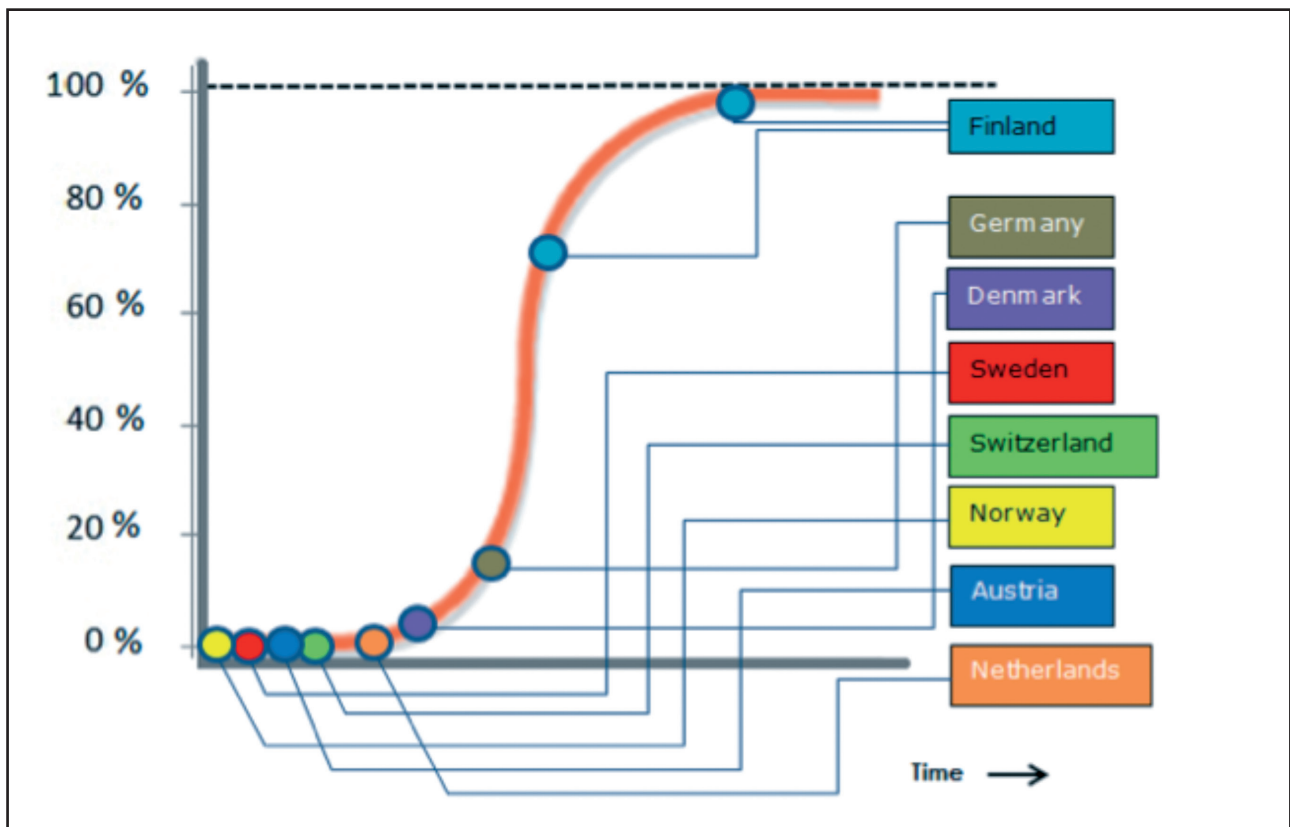
management for the Netherlands because it is unsure which method will be applied and how many man-hours and materials will be needed.

### Public opinion

The view on public opinion in this research is based on expert opinions. Due to time limitations a survey was not conducted in this research and this would have given a more accurate result. The experts stated that the general public accepted the management method or was not aware of it. If the people are not aware of the management method then the it is not able to give an opinion, it is very important to have public support to prevent criticism.

### Carrying capacity

For all the countries the carrying capacity is calculated (Table 7) and displayed in graph 9. To determine the position of each country in the S curve the carrying capacity was calculated in percentages using available habitat and divided by the amount of animals (1,053) that fit in 1000 km<sup>2</sup>. Finland is the only country in which carrying capacity is reached during summer and is on 70% during winter. The other countries are (except for Germany) far from the expected carrying capacity or even below 1 % of their carrying capacity.



**Graph 9**

Carrying capacity of raccoon dog for different countries. Total carrying capacity is 100 percent.

**Table 7** Carrying capacity for raccoon dog in 7 European countries

COUNTRY	CARRYING CAPACITY (based on land cover, average of 20% urban area's)	CURRENT POP NUMBERS		% OF THE CARRYING CAPACITY
Finland	284,041	500,000 200,000	summer winter	70%
Sweden	378,247	130		0.007%
Norway	271,993	4		0.001%
Denmark	35,641	500		1.4%
Germany	299,898	50,000		16%
Switzerland	34,672	15		0.04%
Austria	70,450	20		0.02%
Netherlands	41,067	200		0.48%

### The future situation for the Netherlands

#### Management

For future population management in the Netherlands there are two options:

- Start managing when the population is small, the costs per animal will be higher than with a larger population due to longer searching time. Total eradication is a reachable goal with this method. This strategy is applied in Sweden, Norway and Denmark.
- Not manage the population, let it increase and start management when it is at carrying capacity. The cost per animal will be lower since there is no active searching. When this method is applied the goal of eradication cannot be reached. The negative impacts will be higher. This strategy is applied in Finland and Germany.

#### Successful management of invasive alien species in the Netherlands

In the Netherlands there are several cases where a lot of money is spent on eradicating or controlling populations of pest species. One of these species is the coypu (*Myocastor coypus*): a large, herbivorous, semiaquatic rodent that originates from South America. Its destructive feeding and burrowing behaviour makes this invasive species a pest. The Dutch Water Authorities is in charge of the management of this species and claims to be

successful in the management. There are 16 fulltime employees working on managing the life traps. In the beginning there were around 4,000 catches and in 2013 this was 500. The current annual costs are € 900,000, at the beginning of management this was over a million (Moerkens, D., Personal interview, 9 September 2014). However coypu are still migrating in from Germany. Germany does not a management plan. In order to achieve the goal (total eradication) the immigration from Germany needs to be monitored. This can be achieved with clear communication with neighbourhood countries with preferable shared goals and interests of managing a population.

#### Expertise

The Netherlands is still in the starting phase of population development (graph 9). Other countries (Finland and Germany) have dealt with management of the population for a longer period. While the management may have various degrees of success, the Netherlands can learn from this and apply it. By looking (and collaborating) with countries that are in a similar situation (Sweden, Norway, Denmark, Austria and Switzerland) the Netherlands can develop a management method for its own situation.

#### Literature & interview validity

During this research a literature study was conducted and experts were interviewed. The experts were the authors of the research reports also used in the literature study. While the

information in the papers corresponded with the answers from the experts it is highly possible that information was biased or lacking. This could influence the validity of the research. The research field of the raccoon dog in Europe is a very small field. Often this field is worked on by the same researchers. While this means that the researchers working in this field are very knowledgeable, not everything concerning the raccoon dog has been researched yet. Diet studies, studies concerning the distribution and population studies are not researched enough or not intensely enough. The researchers are spread out too thin. This creates a lack of data which can be solved by having more researchers or by researching different aspects.

### Unanswered questions

At the start of this research several sub research questions were created to answer the main research question. During the research it was clear that some of the sub-questions could not be answered. This had several reasons: expert did not know the answer, lacking data or the information was never (properly) recorded. Therefore the following questions could not be answered fully:

- What kind of damage does the racoon dog cause?
- What are the costs of damage caused by the raccoon dog?
- How was the implementation and organization of the relevant management methods designed?
- What are the costs of the management methods in working hours per year?

### Vortex

The used program Vortex 10.0.7.3 did not function with the calculated carrying capacity for the situation in the Netherlands (41,067). In order to use vortex the carrying capacity and the population size (200) was divided by 40. Besides the carrying capacity the mortality rates of both juvenile and adult had to be changed from 80% to 45% for juvenile and 52% to 40 % for adult. These numbers are in the average range of mortality rates (69-89 % for juvenile and 52% for adult) but are different from the mortality rates used in the calculations of the life tables (see table 8 for exact differences). The results from Vortex need to be extrapolated to give insight in the situation of the Netherlands.

**Table 8** Difference in settings and outcomes of calculates used in the life tables and Vortex

DIFFERENCES	METHOD USED		
	<i>Life tables</i>		<i>Vortex 10.0.7.3</i>
Juvenile mortality	80%		45%
Adult mortality	52%		40%
Carrying capacity	41.067		1000
Carrying capacity reached at	3 Daughters	110 Year	25 - 100 year
	4 Daughters	26 Year	15 - 30 year
	5 Daughters	12,5 Year	8 - 25 year

# Recommendations

In this chapters the recommendations will be presented. There are two different recommendations: the recommendations for (future) management of the raccoon dog in the Netherlands and recommendations for future research.

The following recommendations can be given for managing the raccoon dog population in the Netherlands:

1. The management of this alien species has to start as soon as possible
2. The current population has to be monitored to keep record of the population development
3. A management plan has to be created
4. The best suitable method would be Judas animals in combination with trap camera's
5. An early warning system has to be implemented to control the immigration from Germany and Belgium
6. The hunters and general public need to be aware of the animal and should be educated
7. Media broadcast to request to report sightings of raccoon dogs



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# Appendix I

## Factsheet Raccoon dog

### Taxonomic status

Common name Raccoon dog

Scientific name *Nyctereutes procyonoides*

### Species description

#### Physical characteristics

Small omnivore

50 cm high and 70 cm long

Maximum weight 10 kg

Long hair and short legs

White muzzle and face, black around the eyes

Connection between inner toes

#### Behaviour

Shy animal

Prefers to stay hidden, nocturnal

Plays dead when in danger

Hypothermia

#### Habitat

Ranging from woodland to wetland habitat

Preferably densely covered

Favours close to water

Home range 5 km<sup>2</sup>

Breeding population density 0.5 / 1.0 Adults/km<sup>2</sup>

Distribution rate of 40km a year

#### Reproduction

Monogamous

Sexually active around 10 to 11 months

Mating between January and April

81 % of the females reproduce

Average litter size of 6 to 9 pups

Gestation is 65 days

Weaning after 50 days

#### Mortality

Juvenile 69 -89 %

Adult mortality 52 %

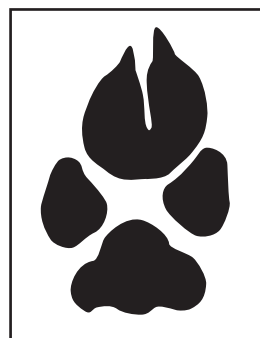
#### Diet

Omnivorous (Seeds, Nuts Fruit, Berries, Eggs, Reptiles, Amphibians, fish)



**Figure 1**

Raccoon dog ([adlayasanimals-wordpress.com](http://adlayasanimals-wordpress.com))



**Figure 2**

Front paw of the raccoon dog showing the inner connection between the front toes



**Figure 3**

Distribution of raccoon dogs in Europe, Plusses indicate a population growth of raccoon dogs and minus indicates a population decrease. Population numbers in LOG, Finland 5,17, Sweden 2,11, Norway 0,60, Denmark 2,69, Germany 4,60, Austria 1,30, Switzerland 1 and Netherlands 2,13

### Distribution

Origin South East Asia

Historical Russia (released in the years 1928-1958)

### Threats

- Breeding bird and amphibian populations
- Compete with native predators such as red fox (*Vulpes vulpes*) and badger (*Meles meles*)
- Carries diseases and parasites such as: rabies, fox tape worm (*Echinoccus multilocularis*) and mange

**Table 1** Life tables for 3 different amounts of daughters(3,4,5). For these life tables the Mortality rate of juveniles was 80% and the mortality for adults was 52%. 81% Of the initial 100 females is reproductive therefore the population growth is 5,23 and 54%.

Year	Lx	Survival	3 Daughters	4 Daughters	5 Daughters
0	100	20			
1	20	48	60	80	100
2	10	48	29	38	48
3	5	48	14	18	23
4	2	48	7	9	11
5	1	48	3	4	5
6	1	48	2	2	3
Population number after 1 generation			114	152	190
Population growth			5%	23%	54%

	JUVENILE	ADULT
Survival rate	20%	48%
Death rate	80%	52%

**Figure 4**

Mortality and death rates raccoon dog used in life tables and other calculations

## Appendix II

### Expert opinion

When the experts were asked what for advice they would give for the situation in the Netherlands, the responses were:

"In case of the Netherlands it is advised to start with trap camera's and also the Judas animals these Judas animals would work great because the current low population density. This method can be used with or without sterilisation of the Judas animal. If sterilisation is used the executive needs to have an article 12 permit. Furthermore it is important to look at the use of professional specialized hunters, this could be volunteers. The most important thing is to not let them establish a population and there has to be taken action while it is still possible."

(Alhainen, M., Personal interview, 30 June 2014) Finland

"It is very important to start as soon as possible, use every way you can. When there were a low number of raccoon dog the time was different and the fur was valuable. So in these days Finland didn't do anything to get rid of these animals. When the time and the minds changed it was already too late to eradicate the population. In 2011 number was 169800, and 2012 was 144500, 2013 was 157200 killed raccoon dogs. So recent years look that increasing is now ended or hunters resources are fully used."

(Simenius, T., Personal interview, 2 July 2014) Finland

"Since there are is not an established population yet it would be interesting to use Judas animals. There has to be research done to find out how they move and where the effort has to be put. Besides that the use of game cameras with MMS function combined with a scent lure in front will be very usefull when trying to find the raccoon dogs."

(Dahl, F., Personal interview, 10 July 2014) Sweden.

"Put up some camera's and monitor the situation, you could use the same methods used in Finland and Denmark but the best way to find an raccoon dog is with a raccoon dog."

(Lund, E., Personal interview, 21 August 2014) Norway.

"It is much easier to prevent a population from establishing then to eradicate one, so while there are only a few try to stop them." (Melis, C., Personal interview, 18 august 2014) Norway

"You have to be very focused to catch all the know individuals - use cameras to verify. If you know about current litters of pup

pies then use traps and bait, catch the adults with dogs and mark with GPS-collar and catch thereafter the other adult in the couple." (Simmelgaard Platz, M.L., Personal interview, 14 July 2014) Denmark

"Very intensive control between November (end of dispersal) and April (start of reproduction) is needed, each year, to reduce the spring population in a target area (which should not be too large) in order to achieve the desired results" (Stier, 2006) Germany.

"It is very hard to eradicate the raccoon dog. This is because a large stream of the raccoon dog will be coming from the east. The population in the east is very large so it cannot be eradicated without working together with Germany and Poland. For Germany it is already too late to eradicate the population of raccoon dog," (Drygala, F., Personal interview, 8 July 2014) Germany.

"For the Netherlands I would say to monitor the situation and to keep an eye out. The hunters need to be informed and they should be able to shoot the animals when seen. Maybe information leaflets. Also it is important to keep in touch with neighbouring countries," (Nienhuis, C., Personal interview, 9 July 2014) Switzerland.

"For now it is important to keep an eye on the animals and the population development."

(Maas, M., Personal interview, 23 July 2014) Netherlands

To prevent the raccoon dog from establishing itself in the Netherlands, if at all possible, should at least require an effort and professional organisation such as exists for controlling muskrats. Two management options remain:

- Intensive hunting on a local scale (a few km<sup>2</sup>) in places where problems (might) arise, during the months with no dispersal and no reproduction (December - March).
- Prevention of predation by blocking access for raccoon dogs, for instance by (electric) fencing of colonies of breeding birds or ponds with rare species of amphibians (Mulder, 2011).

## Appendix III

### Interview questions

#### *Public opinion*

- How do the people in your country look at the raccoon dog, do they know it is present?
- How does the public in your country respond to these method(s)?

#### *Population*

- Do you have any idea about current population numbers of the raccoon dog in your country?
- What is the damage caused by the raccoon dog in your country?
- What are the annual costs of damage done by the raccoon dog?
- We know that the raccoon dog can transmit diseases to humans. Has there been an increase in these diseases in your country due to the presence of the raccoon dog?

#### *Management methods*

- Does your country use any management methods to control the population of raccoon dog?
- When did you decide to apply a management method for the raccoon dog?
- What was this decision based on?
- What management methods are applied by your country?
- What is the long term goal for this methods, total eradication, and population control?
- What is the effect on the population after 1 year, 2 years, 5 years after using these methods?
- How many man hours are used for these methods?
- How was the communication regarding the management methods designed?
- With the communication regarding the management methods or the raccoon dog, who were you trying to reach and do you feel as though you were successful in reaching that group and making them more aware of the problems concerning the racoon dog?
- How was the implementation and organization of the relevant management methods designed?
- What are the annual cost of these methods?
- Which method do you think is the best and why?
- What are the advantages and disadvantages of these methods?

At this moment there have been a few sightings of successful breeding in the Netherlands and population numbers are currently low. We would like to know what management method Finland used when the raccoon dog had low population numbers.

- What would you recommend for the situation in the Netherlands?
- Do you have any additional information that might be important?