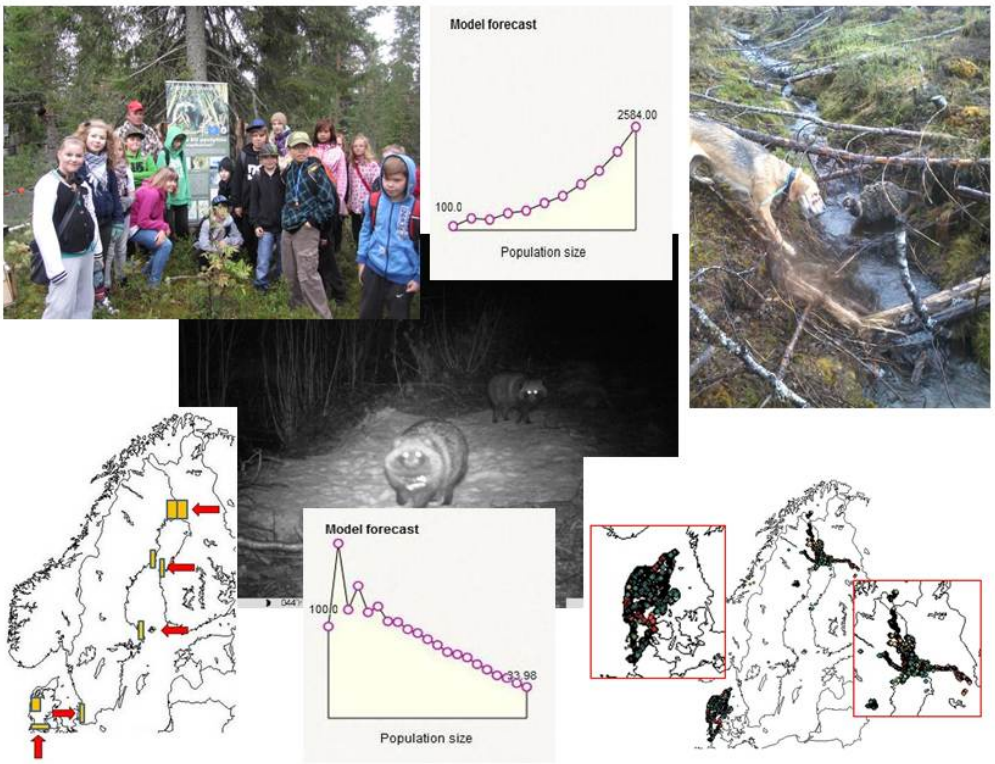
# Technical report, covering the results of the concrete conservation actions C1-C2, the public awareness and dissemination actions D1-D2, and the overall project operation and monitoring action E4, during the period 1 Sept 2010 – 30 Sept 2012

**Management of the invasive Raccoon Dog (*Nyctereutes procyonoides*) in the north-European countries (LIFE09 NAT/SE/ 000344)**



## Summary

Fighting invasive alien species is difficult and it takes time. Often it is impossible to eradicate the species if the population is connected to other populations and then the focus has to be on containment rather than on eradication, trying to stop the species from dispersing to other areas or to other countries. In our case with the raccoon dog in Scandinavia we have come a long way during just a few years.

We have set up Early Warning Systems (EWS) in all countries. The EWS has delivered many early warnings of invading raccoon dogs. We have set up citizen science systems in Sweden and Denmark where the public report observations of raccoon dog to the project. This has been very successful and most of our culled animals are today due to reports from the public. It is however often difficult to identify an animal, especially for a layman and even within the project it is impossible to be sure sometimes, so the citizen science system has to be used with some care and be managed professionally. When observations have been confirmed by the project, animals are (optimally) captured using traps or dogs, or culled. All captured individuals in Sweden and Denmark (both males and females) are sterilized to prevent reproduction, fitted with ear tags (to minimise the risk of shooting valuable project animals), GPS/SMS transmitters and then released. Due to the social nature of the raccoon dog (they are strictly monogamous and stay with its mate until someone die, then the survivor start searching for a new mate) the animal will search for and lead us to other raccoon dogs of the opposite sex in the area (i.e. Judas animals). Animals found by the Judas animals are either culled or incorporated in the Judas animal population.

From the project start, 1 Sept 2010, to 30 Sept 2012, 1908 observations of raccoon dog was reported to the project (only Denmark and Sweden). Out of these, 404 were confirmed as raccoon dog by the project (only Denmark and Sweden). 834 Animals were captured and/or killed (culled by project, hunters, traffic, found dead) (in Finland, Denmark and Sweden). Of the captured animals 131 individuals have been used as Judas animals. No raccoon dog has so far been confirmed outside the area where they were present before the project started.

Our population estimates and models show that the populations have not increased and that without our efforts the populations would have been much larger today than what it is at present. The models further show that the situation in 10 to 20 years' time would be very serious if we were to stop the management.

Project animals in Sweden are mainly captured as a result of observations coming in to the project. The experience of the personnel is constantly increasing and due to their knowledge alone many animals have also been captured. Judas animals are very efficient in all countries, especially in areas where animals are difficult to spot. The methods for capturing animals are constantly improved. Traps are efficient in all countries but traps adapted for raccoon dog capture would make this category even more efficient. Dogs are almost always involved in the captures, if nothing else to find the animals or as a backup if an animal escapes. In this project we have been able to demonstrate that our innovative methods are effective on raccoon dog, but also that at least some of them work on other species with similar behavior. In Denmark we got a raccoon (*Procyon lotor*) on one of our EWS cameras in southern Denmark. Within a few days we were also able to cull the newly invaded IAS.

Local hunters are invaluable for the project. In total there is almost 800 000 hunters in the project area and most of these are very interested in nature conservation. Few, if any, other groups in the society have the knowledge about hunting and about wild animals in general and about the areas where we work as the local hunters. They also spend a lot of time outdoors in

these areas which make them more likely to encounter raccoon dogs as well as other species. Especially in the areas where the project activities are the most intense, hunters are often more than willing to help out. Hunters help out with observations, trapping, guiding, capturing of animals in their areas, building of e.g. traps and artificial dens, dissemination of results, spreading the word about getting observations to the project and more. This co-operation, gaining both the project and the hunters by getting rid of raccoon dogs, is very valuable and could probably also be developed with success on a European level in the fight against IAS. Relying solely on local hunters however, is not possible since there is a need for a professional foundation in the system as described above.

It should be stressed that even though we have not been able to confirm any animal outside the present distribution area it is quite likely there will be found some single dispersers. As seen from our results, raccoon dogs can disperse very long distances and it is important that we follow up any observation also outside the distribution area.

Dissemination of project experiences and results, on the web page, in local communities, in relevant magazines, newspapers, radio and television as well as short courses for hunters and other nature organisations and education from kindergarten to university level are all very important parts of the project. All of these actions aims at a higher awareness and larger knowledge among the public about IAS in general and the raccoon dog in particular, and has led to more observations being reported, and a higher quality of the observations which will enable the project to put the efforts where most needed.

The project has in general been very appreciated by both the public and the authorities in the project countries. The project have put focus on the fight against IAS in the project countries and the fact that it is possible to meet the treat if we act fast and work together over the county borders.

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## Background

Invasion by non-native (alien) species has been recognized as one of the main threats to global biodiversity (Walker and Steffen 1997; Weidema 2000). Among introduced species, predators have had the largest effect on native fauna globally (Ebenhart 1988). Today, the impact of invasive alien species (IAS) is a major concern throughout the world and their management and control will continue to be a huge challenge for conservation biologists and managers during the coming decades (Allendorf and Lundquist 2003).

The raccoon dog (*Nyctereutes procyonoides*) is an invasive and alien opportunistic generalist carnivore native to eastern-Asia. Between 1929 and 1955 a total of 9 100 individuals were introduced to the wild as fur game in the European parts of former Soviet Union and it soon became widespread in central and northern Europe (Helle and Kauhala 1991). In the period from 1935 to 1984 the raccoon dog colonised 1.4 million km2 of Europe by secondary expansion (Nowak 1984). The raccoon dog is already established in Finland and is at the moment invading northern Sweden and Norway via Finland and possibly Russia, and Denmark via Germany. The raccoon dog has many features which make it a successful canid (Kauhala 1994). It is omnivorous and their food niche is much wider than those of most other carnivores, it has very high reproductive capacity, it sleeps through the winter where winters are harsh and is generally very adaptable to new environments even though it prefer wetlands (Kauhala & Saeki 2004, Kauhala 1994).

The raccoon dog can cause severe damage to native waterfowl in Europe (Kowalczyk 2006, refs in Kauhala 1996; Väänänen 2003) and may be a threat to amphibian populations (Kauhala 1996). The raccoon dog is also one of the main vectors of rabies in Europe and an important vector of several parasites dangerous to humans such as the fox tapeworm (Echinococcuss multilocularis) (Oivanen et al. 2002; Westerling 1991, Kauhala 2011). The raccoon dog is listed in Recommendation no. 77 of the Bern Convention (Convention on the Conservation of European Wildlife and Natural Habitats) among the invasive species that have proven to be a threat to biological diversity and should if possible be eradicated. In Recommendation No. 139 (2009) the Bern Convention Standing Committee recommends contracting parties to the Convention to monitor, control and eradicate the raccoon dog as effectively as possible.

In 2008 we initiated several national projects in Sweden, funded by the Swedish Environmental Protection Agency, the Directorate for Nature Management in Norway, and Swedish University of Agricultural Sciences (Environmental Monitoring and Assessment of Game Species) to develop and evaluate methods that could be used for finding and eradicating raccoon dogs and to prevent the raccoon dog from establishing in Sweden and thereby also Norway. The work was done in an adaptive approach, where management and research efforts ran simultaneously to support and continuously improve each other. Even though the results were encouraging, we soon realised that without including our neighboring countries from where the raccoon dog is currently invading Sweden and Norway (from Finland) or from where it will inevitable invade within a few years if nothing is done (from Denmark), our efforts will most likely be insufficient to stop the raccoon dog from establishing also in Sweden and Norway (Dahl et al. 2009). In 2009 we were approved a LIFE project for the period 2010-2013 to include Finland and Denmark in our efforts (Management of the invasive Raccoon Dog (Nyctereutes procyonoides) in the north-European countries, LIFE09 NAT/SE/ 000344). The LIFE project started in September 2010 and has a budget of 5.3 million Euro. The project works in line with the European strategy on invasive alien

species (http://www.cbd.int/doc/external/cop-09/bern-01-en.pdf), the dedicated legislative instrument on Invasive Alien Species which is due to be adopted in 2012 (http://ec.europa.eu/environment/nature/invasivealien/index_en.htm) as well as the RIO-convention (http://www.cbd.int), and is expected to contribute largely to the EU 2020 Biodiversity Strategy (http://ec.europa.eu/environment/nature/biodiversity/comm2006/2020.htm), as well as national goals for IAS, e.g. (http://www.naturvardsverket.se/sv/Start/Om-Naturvardsverket/Vara-publikationer/ISBN1/5900/978-91-620-5910-1/).

## Project objectives

-prevent damages on biodiversity.
-prevent the establishment of wild, free-living and viable population of raccoon dog in Sweden, Norway and Denmark.
-limit further increase and dispersal of the target species in Finland.
-use innovative methods to reduce and eradicate invasive species like Raccoon Dogs.
-use tagging with GPS/VHF transmitters for effective culling.
-use innovative methods to learn more about the social behaviour of invasive species.
-spread the results from the efforts in the project among hunters, local communities, ornithologists and international stakeholders of invasive species.
-improve the awareness among public to report presence of Raccoon Dogs

### Expected results

-Prevent further dispersal of raccoon dogs from Finland to other regions in Sweden and further to Norway.
-Stop the dispersal in Denmark and eradicate or at least reduce the population.
-The innovative methods for culling and management of the raccoon dog, developed and demonstrated in the project can be used in other countries and possibly also in the efforts to prevent dispersal from other invasive species.
-The structure and organisation of the cooperation between the countries will work as a showcase for other countries.
-Raccoon dog population will be quantified during the project time by capturing, tagging and re-capturing.
-The actions above will lead to unaffected areas in Sweden and Denmark and where a population is already established, have a positive influence on the species affected by raccoon dog which is proved by earlier studies in Finland.
-The information activities will improve awareness to report observations and indications of presence of raccoon dogs which will facilitate further elimination of the target species.
-A well visited International Conference at the end of the project where stakeholders get relevant information from the results in the project.

## Project organization

The project is coordinated by the Swedish Association for Hunting and Wildlife Management (SAHWM). The project is a cooperative effort between SAHWM and the associated beneficiaries Swedish University of Agricultural Sciences, the Danish Forest and Nature Agency and the Hunters´ Central Organization in Finland, together with the supporting organisations; the Swedish County Boards in the counties of Västerbotten, Norrbotten and Skåne, the Swedish National Veterinary Institute and the Swedish Institute for Infectious Disease Control in Sweden. The LIFE+ project is funded through LIFE+ and co-funded by

the Swedish Environmental Protection Agency and the Norwegian Directorate for Nature Management.

## Management methods

### Citizen science system

Raccoon dog observations by the public are followed up with IR/motion triggered game cameras directed at scent lures and by tracking by professional personnel to try to confirm or dismiss the observation. The citizen science system of the public reporting observations of raccoon dogs is one of our most important tools to find new raccoon dogs, especially in areas outside the core areas which the project personnel do not have time to cover at all times. Reporting is done to a 24h telephone hotline and the phone number is distributed on the project home page (www.mardhund.se) and in the press in connection to articles or information about the project in nature/hunting magazines and newspapers/radio/television. It is however often difficult to identify an animal, especially for a layman and even within the project it is impossible to be sure sometimes, so the citizen science system has to be used with some care and managed professionally. The project never confirms observations that we are not 100% sure about and that have not been thoroughly controlled by our professional managers, not even pictures. The risk with confirming observations that are not 100% safe is that we then would already have raccoon dog over all of Scandinavia, that is, animals that are believed to be raccoon dog but that in fact are something different. This in turn would be a serious threat against our work with trying to stop the raccoon dog since the authorities might then take the decision that the battle is a lost cause and stop the funding. We know by previous experience that most observations of likely raccoon dogs are in fact other species (figure 1).

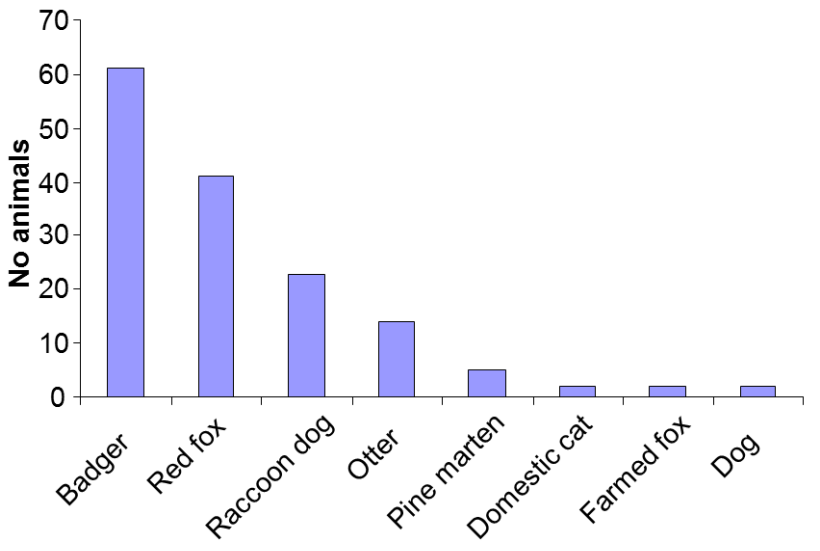


**Figure 1.** Distribution of species out of 150 public observations of “raccoon dogs” in Sweden after control by the project (data from the Swedish raccoon dog project 2008-2010).

It should be added that most observers in the cases in figure 1 are experienced hunters in the core area of the raccoon dog in Sweden, would it have been the public in general or outside the core area the confirmed observations of raccoon dog would have been much lower, very

fast approaching zero the further away from the core area you get. An undecided observation will therefore never be officially confirmed, it will however be followed up until being confirmed, dismissed or considered gone from the area. Figure 2a and 2b show an example of the difficulty of identifying the species from a picture sometimes. The first picture could have been a raccoon dog but since you do not see the face it is impossible to be sure and the picture cannot be confirmed. In picture b there is no doubt that it is a badger and the observation could be dismissed. Had it not been a second picture however the observation would have been unconfirmed. A sight observation from the car at night is of course even more difficult to be sure about, even if the observers almost always are 100% sure about what they have seen.


**Figure 2a**. Unidentifiable animal.


**Figure 2b**. Badger.

Photo: LIFE09 NAT/SE/ 000344 (2010-1013) project.

Our Citizen Science system is in practice in Sweden and Denmark. In Finland the raccoon dog is a very common animal and an official citizen science reporting system is not considered functional. It would be similar to the public in Europe reporting red fox, a lot of reports would come in, but most people would not bother since it is no big deal to spot a fox. In Finland the professional managers and engaged local hunters in the project area know better than anyone else where raccoon dogs are likely to be found, hunters report directly to the responsible manager. In all countries the local hunters are very important for the project success and are apart from reporting observations also helping out with finding and capturing animals. Professional managers in all countries are apart from following up citizen reports of course also constantly searching for raccoon dogs in their areas with the help from cameras, hunters, traps, tracks and dogs (figure 3).

**Figure 3**. Ebba (the dog) putting a raccoon dog at bay. Photo: LIFE09 NAT/SE/ 000344 (2010-1013) project.

## Capture and culling of raccoon dogs

When observations have been confirmed, animals are (optimally) captured using traps or dogs. All captured individuals in Sweden and Denmark (both males and females) are sterilized to prevent reproduction, fitted with ear tags (to minimise the risk of shooting valuable project animals), GPS/SMS transmitters and then released (figure 4). In Finland where raccoon dogs are plentiful the sterilization is not practiced.

**Figure 4**. Raccoon dog fitted with ear tags and GPS/SMS collar.
transmitter. Photo: LIFE09 NAT/SE/ 000344 (2010-1013) project.

Due to the social nature of the raccoon dog (they are strictly monogamous and stay with its mate until someone die, then the survivor start searching for a new mate) the animal will search for and lead us to other raccoon dogs of the opposite sex in the area (figure 5). When

the transmitter animal (Judas animals) stop dispersing it is an indication that it may have found a new mate and we go in and capture the mate (if there is one).

**Figure 5**. A GPS collared and sterilized female raccoon dog photographed by one of the project game cameras showing that she has found a new unmarked male. This was the third male this female delivered to the project. Photo: LIFE09 NAT/SE/ 000344 (2010-1013) project.

When a critical number of Judas animals have been built up all new unmarked individuals that are found is killed. The critical number depends on how many animals that can be effectively managed in an area, approximately 15-25 animals simultaneously (figure 6).

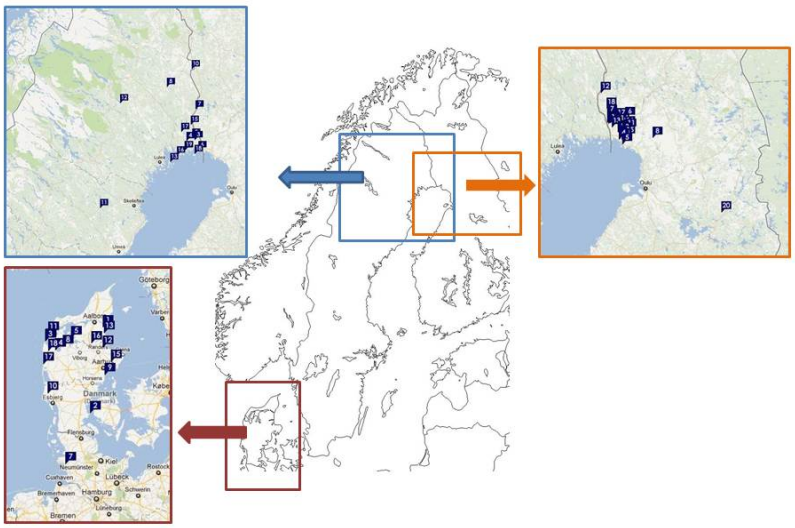

**Figure 6**. Active Judas animals in the project area in January 2012 (Data from the LIFE09 NAT/SE/ 000344 (2010-1013) project).

Hunting of raccoon dog is allowed all year around according to the project countries national legislations since it is an invasive species (an exception exists in Finland during the breeding period). Local hunters are however encouraged to capture the raccoon dog for the project if possible since single animals left behind will disperse and try to find a new mate, sometimes very long distances (figure 7).

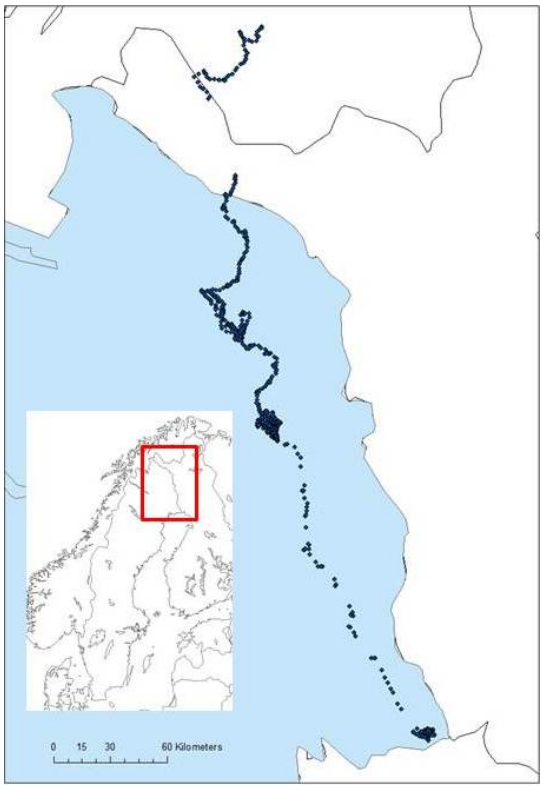


**Figure 7**. After losing its mate this raccoon dog dispersed 400 km in two months' time in search for a new mate. It was then shot in Kautokeino in northern Norway (the position furthest north) (data from the Swedish raccoon dog project 2008-2010).

Thus, general hunting may induce dispersal and hurry up the spread of the species. When a raccoon dog is killed during hunting, hunters are therefore also encouraged to immediately report the kill and hand in the carcass to the project to confirm the animal. If it is likely that there are more animals in that area, and especially if the killed raccoon dog was one of a pair, the project places cameras and if necessary a Judas animal in that area to find other animals.

## Early Warning System

In addition to the flexible actions (i.e. flexible IR/motion triggered cameras, Judas animals, tips, tracks and traps), permanent grid systems of cameras directed at scent lures, i.e. Early Warning Systems, have been set up adjacent to the boarders between Sweden-Finland, Sweden-Denmark and in Denmark against the boarder to Germany (figure 8). These EWS systems will, together with the Citizen science system and the Judas animals, reveal new immigration and monitor the development of the population as well as the effect of our actions.

## Monitoring of the population development and the effect of our actions

Some camera systems are larger and allows for a capture/re-sight estimate of the population to be done (and also a catch per unit effort index), while other smaller systems solely aims to get an early warning if new animals immigrate (figure 8).

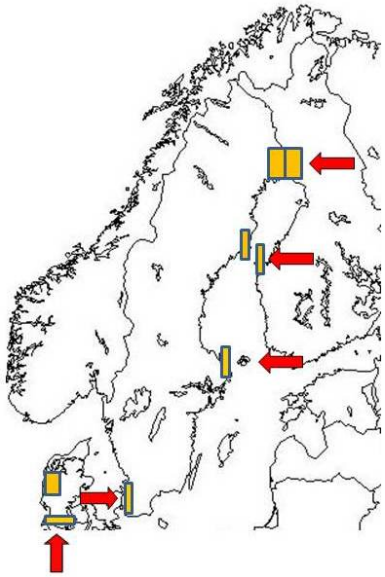

**Figure 8**. Layout of the early warning system of permanent game camera systems in the project area at the raccoon dogs potential invasion routes. Larger systems allows for population estimates through capture/re-sight techniques when enough raccoon dogs have been captured on picture.

The capture/re-sight estimate builds on capture-recapture theory (White & Burnham 1999). By knowing the proportion of marked animals out of all sightings, the number of total animals in the population (N) can be estimated according to $\mathbf{N = n_1 * n_2 / m_2}$.

- $n_1$=number of marked and released on the first occasion
- $n_2$=total number captured on the second occasion
- $m_2$=number of marked found on the second occasion

The estimates given below are the most likely estimates taken into account among other things difficulties of knowing if several pictures in the same place are of the same animal or not and difficulties to judge species from certain angles. Another assumption that we have had to handle with some care is the closed population assumption, since our transmitter animals are moving a lot more than expected. A very low sample size will further affect the quality of the calculations.

Moreover, we have created an Individual-Based Model to be able to predict the population development over time, with and without our management efforts (Chapron G, Unpublished). The model is very flexible and allows for incorporating new data and new parameters as time goes by, to constantly improve the accuracy of the model as we gain more knowledge.

In our model we have used the following input values:

Survival of pups: 40%

Survival of young: 40%
Survival of breeders: 60%
Survival of sterile individuals: 70%
Litter size: 10
Effort in culling: 25%
Effort in sterilization: 22%

Our input values are based on our results and experiences from the project so far and differ from previous estimates in established populations (see e.g. Helle & Kauhala 1993). Effort in culling and sterilization come from our proportion of culled animals out of all confirmed observations (adjusted for non-detected animals) and from our capture/re-sight data).

## Information, education and dissemination

Dissemination of project experiences and results, on the web page, in local communities, in relevant magazines, newspapers, radio and television as well as short courses for hunters and other nature organisations and education from kindergarten to university level are all very important parts of the project. All of these actions aims at a higher awareness and larger knowledge among the public about IAS in general and the raccoon dog in particular, and will lead to more observations being reported, and a higher quality of the observations which will enable the project to put the efforts where most needed. While actions directed towards e.g. local hunters will give a direct effect in the form of more animals culled, actions directed at small school children and university students will give an effect in the longer term since those persons are to take over nature management in our countries (figure 9). To analyse the media interest in the raccoon dog and the project in Sweden more specifically we have used the Meltwater software, which scan the internet for published articles including the word raccoon dog. The software only includes internet based hits such as newspapers, magazines, radio and television home pages (usually writing about the programs they sent). Some media cannot be reached with this software, such as paper newspapers when nothing is written on the web about it, thus the figures presented is an underestimate, but still give an interesting picture about the media interest and published articles about the raccoon dog and the project.

**Figure 9**. Lesson for school kids on raccoon dog management in Finland. Photo: LIFE09 NAT/SE/ 000344 (2010-2013) project.

Apart from the methods mentioned above, new methods are constantly being evaluated based on the experiences we gain, in the project and in associated projects, to further improve our efficiency. In Finland a new trap (soft catch paw hold trap) is currently being evaluated.

# Results

## Observations and culled animals

From the project start 1 Sept 2010, to 30 Sept 2012, 1455 observations of raccoon dog was reported to the project in Sweden. Out of these, 225 were confirmed as raccoon dog by the project, whereof 195 were captured and/or killed (culled by project, hunters, traffic, found dead). Fifty-five of the animals have been used as Judas animals.
In Denmark 453 observations of raccoon dog was reported to the project, whereof 179 has been confirmed. Of these 156 was captured and/or killed (culled by project, hunters, cars, found dead). Forty of the animals have been used as Judas animals.
In Finland 483 animals has been culled in the northern management area closest to the Swedish border (figure 10). Most of these have been killed by hunters involved in the project (with traps or dogs) and with the help from the Judas animals. Of these, 36 of the animals have been used as Judas animals.

**Table 1**. Raccoon dog capture/culling in Scandinavia 1 Sept 2010, to 30 Sept 2012

| Country | Reported observations | Confirmed animals | Captured/killed | Judas animals used |
|---|---|---|---|---|
| Sweden | 1455 | 225 | 195 | 55 |
| Denmark | 453 | 179 | 156 | 40 |
| Finland | N/A | N/A | 483 | 36 |
| Totalt | 1908 | 404 | 834 | 131 |

*Source:* LIFE09 NAT/SE/ 000344 (2010-2013 project)

No raccoon dog has so far been confirmed in south or mid-Sweden. There are no new confirmed raccoon dog observations further south than compared with the situation before the LIFE+ project started. Pairs or reproduction has only been confirmed in the area closest to the Finnish border (figure 10).

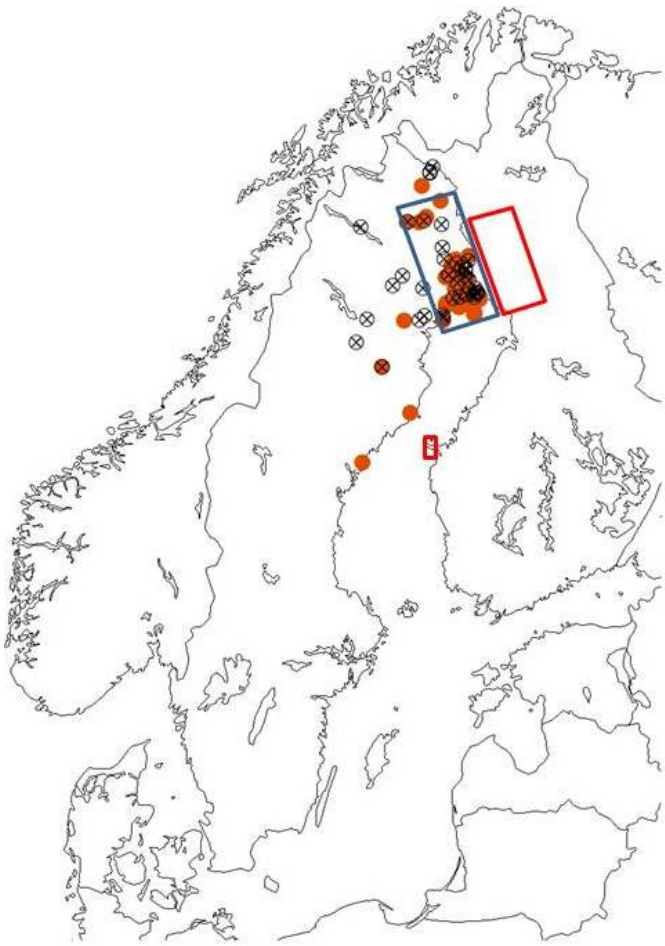

**Figure 10**. Confirmed raccoon dog observations in Sweden August 2008- August 2010 (before the start of the LIFE+ project = red filled circles) and during the LIFE+ project (September 2010-September 2012 = black open circles with cross, culled pups are included in the parents locations). Pairs or reproduction in Sweden has only been confirmed inside the blue box, close to the Finnish border. The red boxes represent the northern and southern Finnish management area close to the Swedish Border.

Project animals in Sweden were mainly captured as a result of observations coming in to the project. The experience of the personnel is constantly increasing and due to their knowledge alone many animals have also been captured. Judas animals are very efficient, especially in areas where animals are difficult to spot (figure 11).

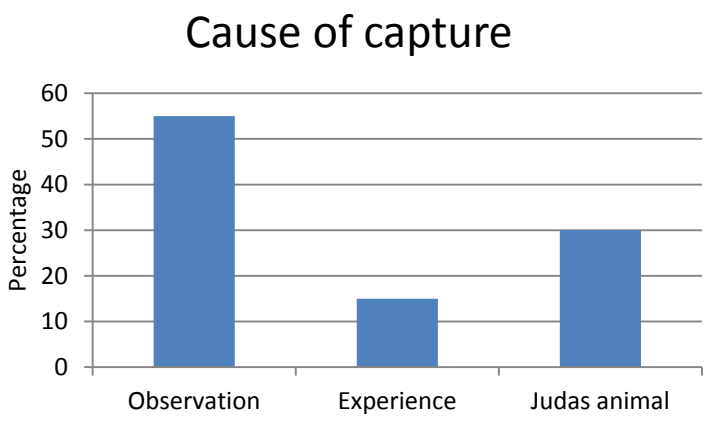


**Figure 11**. Causes of capture in the Swedish part of the project (Data from the LIFE09 NAT/SE/ 000344 (2010-1013) project).

The Judas animals are scanning the areas very efficiently, working for the project all day and all year around (figure 12).

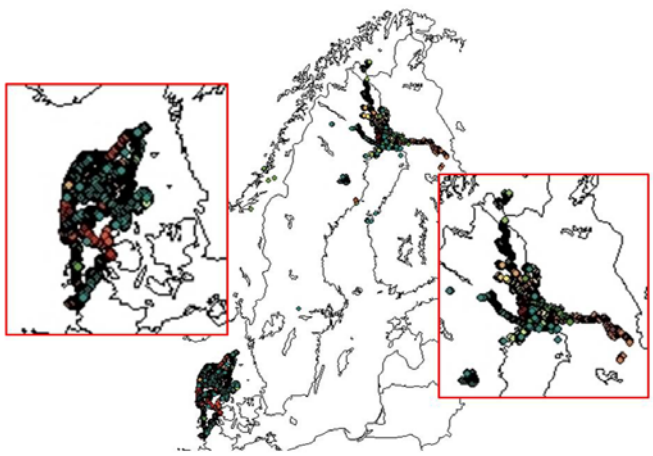

**Figure 12**. Approximately 100 000 positions from 91 Judas animals in northern Sweden, Finland and Denmark, scanning unexplored areas for new partners (Data from the LIFE09 NAT/SE/ 000344 (2010-1013) project).

The methods for capturing animals are constantly improved. Traps are efficient but traps adapted for raccoon dog capture would make this category even more efficient. Dogs are almost always involved in the captures, if nothing else to find the animals or as a backup if an animal escapes. Dogs are also used to find raccoon dogs in burrows, but once found raccoon dogs are dug up by hand (figure 13).

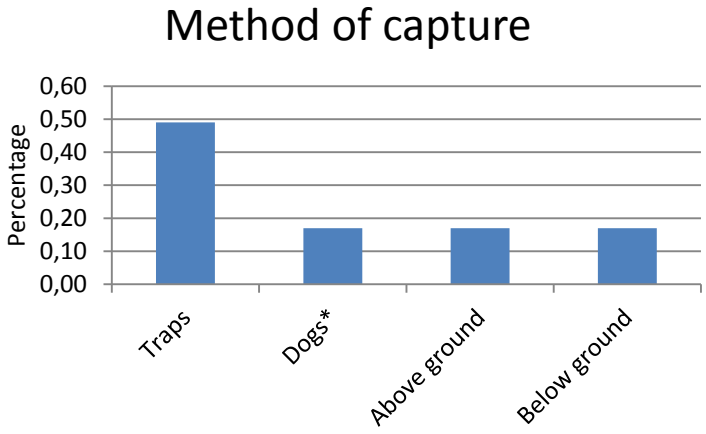


**Figure 13**. Methods of capture in Sweden after confirming raccoon dog occurrence. *Both of the categories above- and below ground (i.e. taken by hand) often also include dogs to find the animals (Data from the LIFE09 NAT/SE/ 000344 (2010-1013) project).

In Denmark no confirmed observations have so far been done on the islands, but only on the Danish main land (figure 14). This situation is the same as before the project started.


**Figure 14**. Confirmed observations in Denmark (Data from the LIFE09 NAT/SE/ 000344 (2010-1013) project).

## Population density

The population estimate indicated approximately 37 animals in the Swedish EWS in Haparanda in March 2011 (0.037/Km$^2$). The following 6-month estimates were similar or somewhat lower (in January 2012 the data was too poor to make an estimate) (Table 2). The March 2011 population in the Swedish EWS system was recalculated for the whole Swedish distribution area by using the assumption that density of confirmed observations is a reflection of population density in the area. Adult population for all of Sweden would with this assumption have amounted to about 130 animals in 2011. In total approximately 30 new animals has been detected by the EWS system during the period 1 Sept 2010 to 30 Sept 2012.

**Table 2.** Population estimates and density in the Swedish EWS system in Haparanda.

| Column1 | Pop estimate Sweden EWS | Density/km2 |
|---|---|---|

| | | |
|---|---|---|
| March 2011 | 37 | 0,037 |
| July 2011 | 22 | 0,022 |
| January 2012 | No Data | No Data |
| July 2012 | 29 | 0,029 |

In in the Finnish (Torneå) EWS system (which is about half the size of the Swedish) the population estimate was approximately 32 animals (0.06/Km$^2$) in July. The following 6-month estimates were similar (in March 2011 the data was too poor to make an estimate) (Table 3). In total approximately 24 new animals has been detected by the EWS system during the period 1 Sept 2010 to 30 Sept 2012.

**Table 3.** Population estimates and density in the Finnish EWS system in Torneå.

| Column1 | Pop estimate Finland EWS | Density/km2 |
|---|---|---|
| March 2011 | No Data | No Data |
| July 2011 | 32 | 0,064 |
| January 2012 | 49 | 0,098 |
| July 2012 | 19 | 0,038 |

In Denmark the data has been too poor to do any population estimate to date. There has been only a few raccoon dogs on picture in the Danish EWS system even though there has been captured/culled almost as many as in Sweden. One reason for this may be the smaller EWS systems used in Denmark.

## Population development

Unfortunately the population estimates are off to poor quality to tell, with any certainty, if the population is stable or changing. Another indication of the population development however, is the number of unique individuals captured in the camera system per time unit, i.e. a catch per unit effort index (CPUE). Both the Swedish and the Finnish CPUE show a decrease in photographed individuals per camera month (Figure 15 and 16).

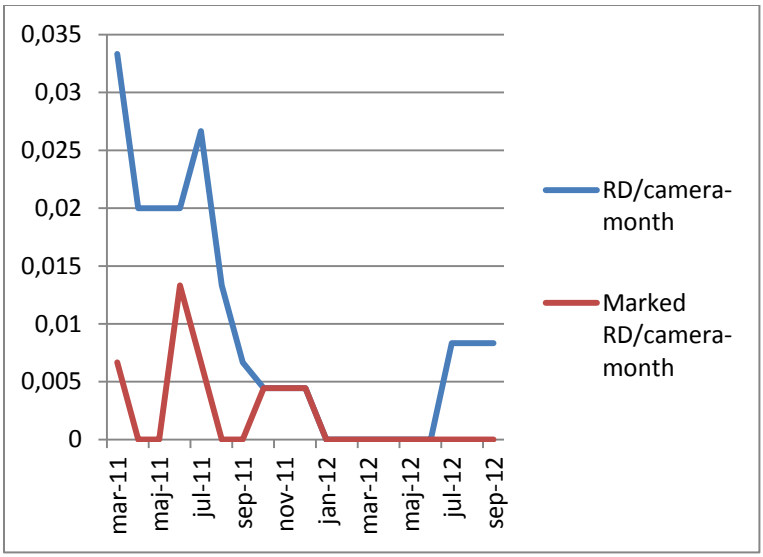


**Figure 15.** Catch per unit effort in the Swedish EWS system in Haparanda

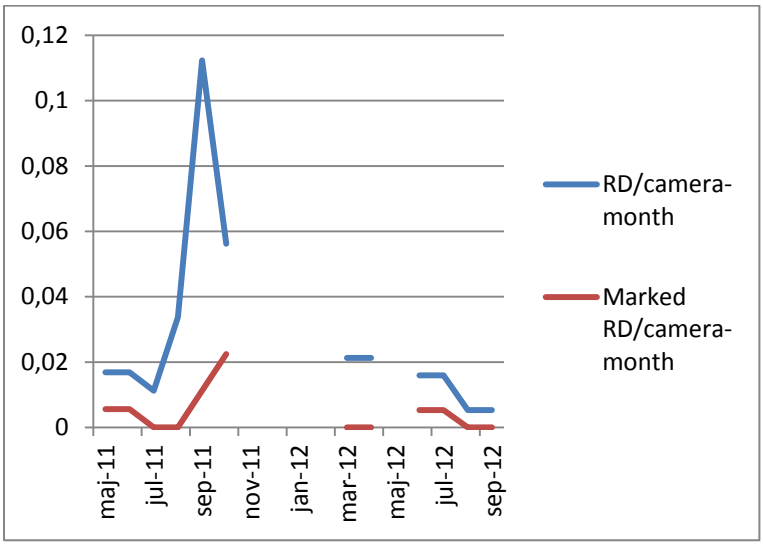


**Figure 16.** Catch per unit effort in the Finnish EWS system in Torneå

Population model

By using 100 individuals as initial population size (i.e. approximately the same size as in Sweden at the beginning of the project) and the parameter estimates estimated from the project data in Sweden (see method part) our population model suggest that the population will be kept at a constant size during the first five years (figure 17a). However, if no effort is done to limit the population there would be well over 650 individuals after five years according to the model (figure 17b).

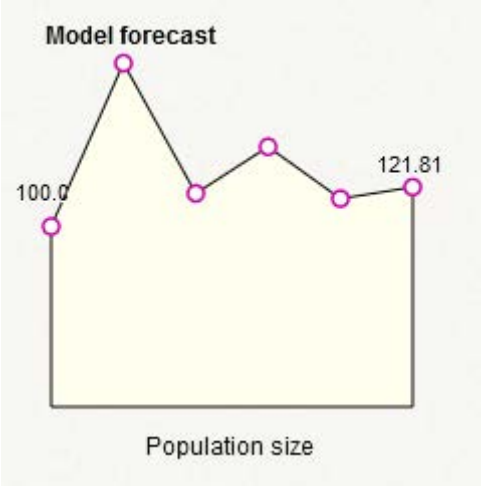


**Figure 17a**. Population development during five years including our efforts in culling and sterilisation.

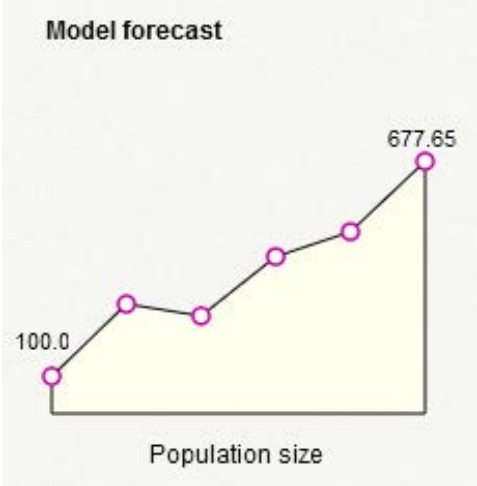


**Figure 17b**. Population development during five years without our efforts in culling and sterilisation.

Continuing the management at the same intensity, given that the input data reflects the reality reasonably well, would mean that the population decreases, and within 10-20 years only a few raccoon dogs remain (figure 18a). On the contrary, stopping the management would mean that we would have at least 2500 raccoon dogs in Sweden in ten years' time and over 10 000 in 15 years' time, i.e. the population would increase exponential as it has done in Finland and other countries invaded by the raccoon dog (Kauhala & Kowalczyk 2011) (figure 18b).

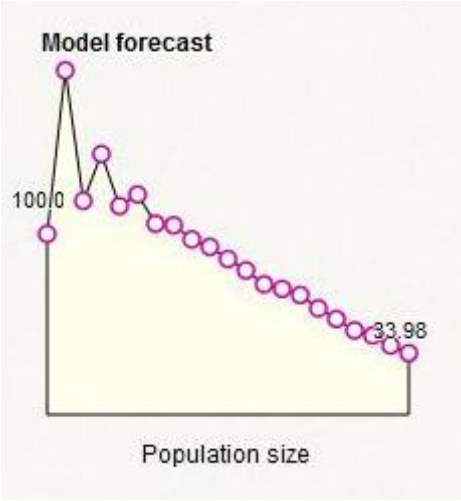


**Figure 18a**. Population development during 20 years including our efforts in culling and sterilisation.

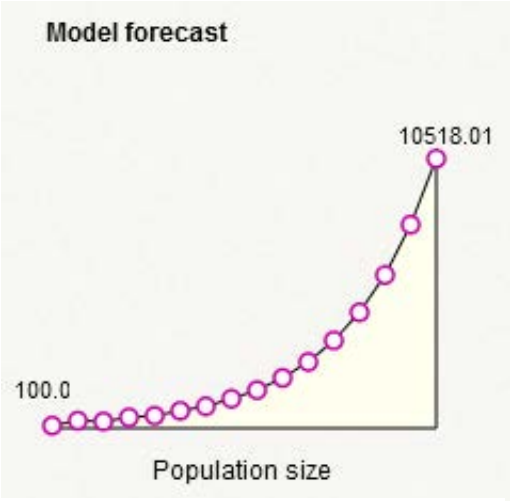


**Figure 18b**. Population development during 15 years without our efforts in culling and sterilisation.

## Dissemination of results, training and education

The project has disseminated its results with information activities, training sessions and education of hunters, students and the public in all countries (Table 4). All countries have

produced mobile notice boards and both a common and country wise home pages has been produced with 6047 hits since it started. Six public appearances have been made reaching several thousand persons, and about 200 university students have been educated about IAS and raccoon dog. Students have also produced two thesis.

**Table 4.** Dissemination activities of the project.

| | Mobile Notice Boards | Press releases | Articles in national press | Articles in local press | Special-ised press articles | Internet articles | Tv | Radio | Film | Exhibitions attended |
|---|---|---|---|---|---|---|---|---|---|---|
| Sweden | 10 | 2 | 4 | 5 | 4 | 13 | 6 | 5 | 1 | 4 |
| Finland | 10 | | | 2 | 3 | 7 | 2 | 2 | | 1 |
| Denmark | 10 | | | 5 | 1 | 4 | 2 | 2 | | 1 |
| TOTAL | 30 | 2 | 4 | 12 | 8 | 24 | 10 | 9 | 1 | 6 |
| Budgeted | 6 | 10 | 3 | 10 | 3 | 3 | 5 | 5 | 1 | 3 |

Media has shown great interest in the project (figure 19). The start of the first national Swedish project can be clearly seen in August 2008, before that very little attention was directed at the raccoon dog. The start of the LIFE+ project in September 2010 can also be seen as an increase in media interest. Since then approximately 32 articles per month has been about raccoon dog in the Swedish media.

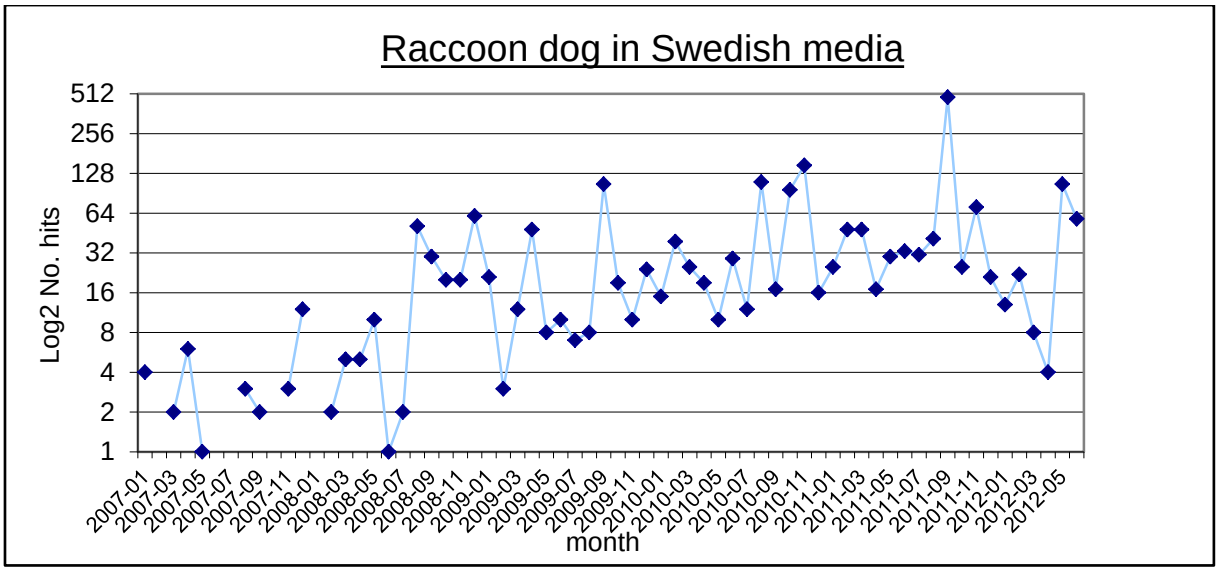


**Figure 19**. Raccoon dog media hits in Sweden per moths from 2007 – 2012. The first national raccoon dog project started in August 2008, the LIFE+ project started in September 2010. Peaks show larger press releases, articles or events. The analysis does not include paper newspapers, only internet based publications.

The large media interest, often following press releases, own articles or large events also affects the interest to report observations to the project (figure 20). It is therefore important to constantly inform the media about any project happenings.

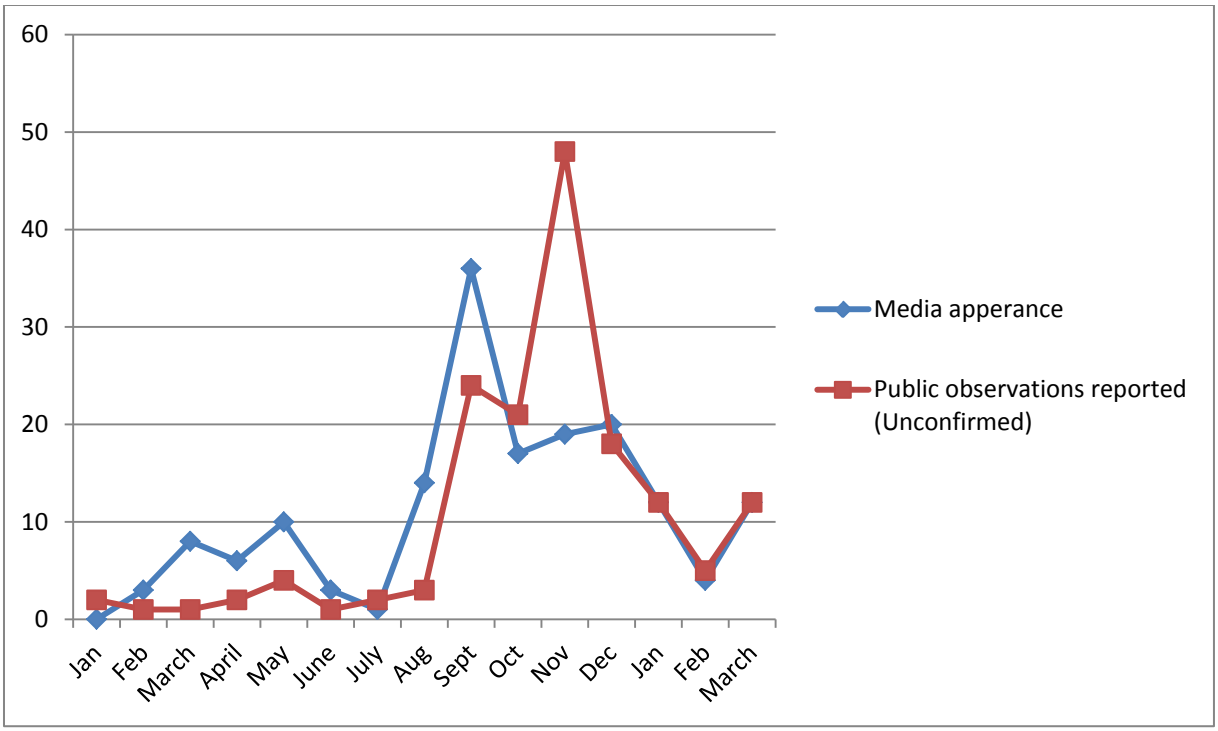


**Figure 20**. Example of how the public observations follow media attention of the raccoon dog. At all project media occasions the reporting system and contact information to the project is mentioned specifically.

In Finland over 1000 persons, both hunters and other public citizen's has been educated in raccoon dog management and IAS. Three appearances have been made in national television and over 10 appearances in local newspapers. Over ten presentations have been made directed to the public for example at national hunting fairs. The project has been cooperating with the rural wetland LIFE+ project (LIFE09 NAT/FI/000563) regarding trapping and information. The Finnish project also co-operates with the Finnish forest and park service and some private companies in the area that have built own traps for the project.

In Denmark the short courses have been divided into an intensive course for 15 hunters, a more extensive course for around 45 hunter and 4 information meetings for approximately 200 hunters and others interested in raccoon dog management.
There has been a great interest in the project which has led to several appearances in national and local television. Beside television, national and local newspapers, hunting magazines and other media have written numerous articles and in periods the LIFE+ project and raccoon dog management have been mentioned in articles every week.
The project has also been represented on a national hunting fair, where one of the staff members gave a short oral presentation.

## Discussion

Fighting invasive alien species is difficult and it takes time. Often it is impossible to eradicate the species if the population is connected to other populations and then the focus has to be on containment rather than on eradication, trying to stop the species from dispersing to other areas or to other countries. In our case with the raccoon dog in Scandinavia we have come a

long way during just a few years. A large part of this success is due to our common management of the species across the country borders.

We have together developed effective methods to manage the raccoon dog successfully. One of these methods are the Judas animals used to find other raccoon dogs. This tool is expected to become even more efficient as the population decreases further. The lower the population, the harder the animals will be to detect. It will be almost impossible to find animals by chance. The Judas animals however, will search the most likely areas and find any single disperser, thereby finding a proportionately higher proportion of all found animals. Traps have shown to be an efficient way to capture animals. However, we have also found that existing traps are not optimal and that many individuals do not get captured. This is not surprising considering that the traps we use are developed for other species such as red fox or badger. In the project we have started testing a new trap used for fur trapping in North America, the Soft-Catch Paw hold trap. The trap show very promising results so far, up to ten times more efficient compared with today's best practice. However, it will not be possible to demonstrate this trap on larger scale in the current project since there is no such time and budget left.

We have so far succeeded containing the raccoon dog in the areas of Sweden and Denmark where they were already present when the LIFE+ project started. In Denmark there are still no confirmed reports of raccoon dogs on the islands connecting Denmark to Sweden. This is the only dispersal route in to the rest of Scandinavia from the south, raccoon dogs cannot swim the distance needed to disperse from northern Denmark to Sweden. Two sterilized Judas animals are constantly kept on the island of Fyn to detect any dispersers at once. So far three animals have been captured in traps on Fyn and one has been killed by a car, all of these were sterilized project animals.

Our population estimates and models show that the populations have not increased and that without our efforts the populations would have been much larger today than what it is at present. The models further show that the situation in 10 to 20 years' time would be very serious if we were to stop the management. The model does, however, not take density dependent factors into account. The model with no management efforts (figure 18b) thus continues strait up until it gets unreasonable. Judging from the development of other populations the model is however very reasonable the first 15 years that the figure shows. In Finland the hunting bag increased from 818 individuals in 1970 to 172 000 in 2009 (Kauhala & Kowalczyk 2011). It should be noticed that our current estimates are somewhat rough and with large uncertainty due to the low number of pictures taken of raccoon dogs combined with the uncertainty to correctly judge number and species of animals. The population estimates is at best to be seen as an indication of the adult population (mainly adults are attracted by the scent lure). It is possible that a CPUE index alone would be both more practical and show the development of the population just as confident, possibly combined with a simple presence/absence index to follow the establishment/de-establishment over larger areas.

Our experiences regarding public observations and the difficulties to identify an animal should be a lesson for other projects working with IAS as well as the authorities working with IAS when forming their recommendations for management of IAS. To take any public observation as a fact without any professional confirmation will lead to a false picture of the reality. Most public observations are in our case not raccoon dog, and the raccoon dog is after all a rather big and distinct animal! Many of the observations have been cats or even martens or minks, showing that it is difficult for a layman without proper education to judge the animal. Having said this, we nevertheless want to stress the importance of public observations. Most observers are very objective and their observations have led to many confirmed animals. We rather get lots of observations where only a few are raccoon dog than no observations at all, but no observations can be confirmed without being checked by the

project first. In this case, getting the public informed and interested and getting in reports, media play an important role (disseminating our results) as can be seen by the media analysis. Also our education efforts play an important role in this case, especially when directed at the local hunters.
Local hunters are invaluable for the project. In total there is almost 800 000 hunters in the project area and most of these are very interested in nature conservation. Few, if any, other groups in the society have the knowledge about hunting and about animals in general and about the areas where we work as the local hunters. They also spend a lot of time outdoors in these areas which make them more likely to encounter raccoon dogs as well as other species. Especially in the areas where the project activities are the most intense, hunters are often more than willing to help out. Hunters help out with observations, trapping, guiding, capturing of animals in their areas, building of e.g. traps and artificial dens, dissemination of results, spreading the word about getting observations to the project and more. This co-operation, gaining both the project and the hunters by getting rid of raccoon dogs, is very valuable and could probably also be developed with success on a European level in the fight against IAS. Very moderate rewards for their help, such as information evenings and small gifts have paid off in the form of many captured or culled animals, probably in level with the total project budget if they were to be employed. Relying solely on local hunters however, is not possible since there is a need for a professional foundation in the system as described above.
The project has been very appreciated by both the public and the authorities in the project countries. The project have put focus on the fight against IAS in the project countries and the fact that it is possible to meet the treat if we act fast and work together over the county borders.

Finally it should also be stressed that even though we have not been able to confirm any animal outside the present distribution area it is quite likely there will be found some single dispersers. As seen from our results, raccoon dogs can disperse very long distances and it is important that we follow up any observation also outside the distribution area. For this sake we also have our monitoring systems to detect any new immigrants.

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