Research on Great Crested Newt (Triturus cristatus) population

Capturing Great Crested Newts using funnel traps, comparison of captures to previous years and estimating population size (and range)

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Internship Report 2016-2017

Master in Biology: Biodiversity: Conservation and Restoration

grenspark De Zoom · Kalmthoutse Heide

Summary

Introduction

The *Triturus cristatus*/ Great Crested Newt is a newt species occurring in the largest part of Europe, from the south of France to Scandinavia and from the UK to the Balkan. It can be recognised by its orange/ yellow belly pattern that contains a unique pattern of black spots, the typical crest males grow during the mating season and the size: they are larger than other *Triturus*-species. Their upper side is usually grey or dark brown, with small white spots on it. The newts can be found in different types of forest, bush lands, meadows, even parks and gardens. During most of the year, they are terrestrial and can be found in refugees such as rotting deadwood. To reproduce, they migrate towards stagnant or semi-flowing waters such as ponds. This happens during spring.

Although its general conservation status is 'least concern', it is currently threatened in both Flanders and the Netherlands, amongst others. Population sizes in those areas are declining, causing reason for concern. The main threat for *Triturus cristatus* are changes in water quality, caused by for example industrial pollution, eutrophication or drainage of ponds. Another threat is habitat fragmentation. (IUCN). It is thus important to make sure the species doesn't go extinct in the following years. For this reason, monitoring Belgian and Dutch populations of the species is a must.

During this internship, the population of Great Crested Newts in Grenspark De Zoom- Kalmthoutse Heide (Netherlands - Belgium) was monitored and all studied ponds were assessed for their habitat quality for this species. This happened in the northern part of the park, situated at and near the boundary between the Netherlands and Belgium (see figure 1. Note that not all ponds in the encased area are monitored). The monitoring happened during the season the species is most active, which is from March until May. But, to monitor the larvae, a period at the end of June was chosen, to make sure the larvae were as active as possible. After this period, they migrate onto land and become more difficult to monitor.

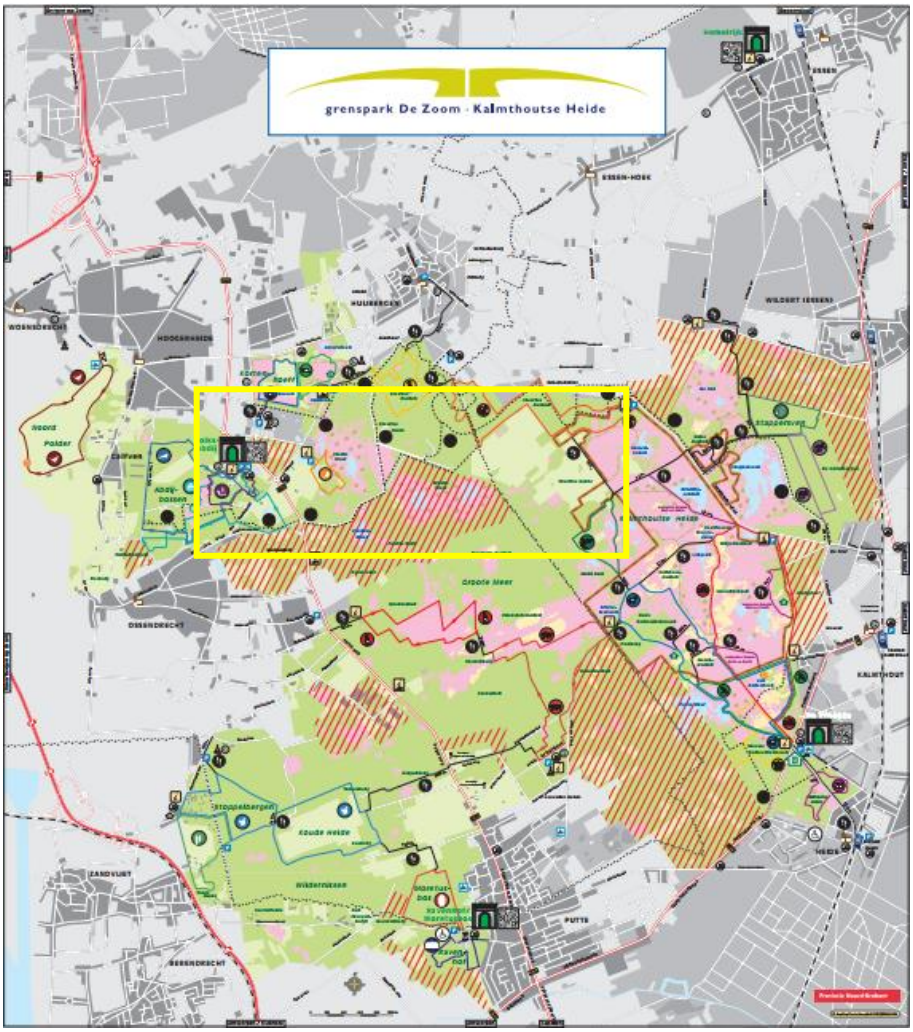


Figure 1. Map of Grenspark De Zoom- Kalmthoutse Heide. Encased is the monitoring area.

Activities

Monitoring of ponds and habitat assessment

A total of 16 ponds was selected to be monitored for Great Crested Newt. These ponds were the following (indicated on figure 2): Leemputten Noord and Zuid, Ranonkelven, Jagersrust, Werkschuur, Moerven, Bovenven, Moseven, Steertse Heide, Bomput Steertse Heide, Ruitvormige Wei, Kleine Meer, Groote Meer - Voormeer, Granaatven and Kwekerijven. 1 extra observed pond was named 'agricultural land', placed inside the circle shown on figure 2.

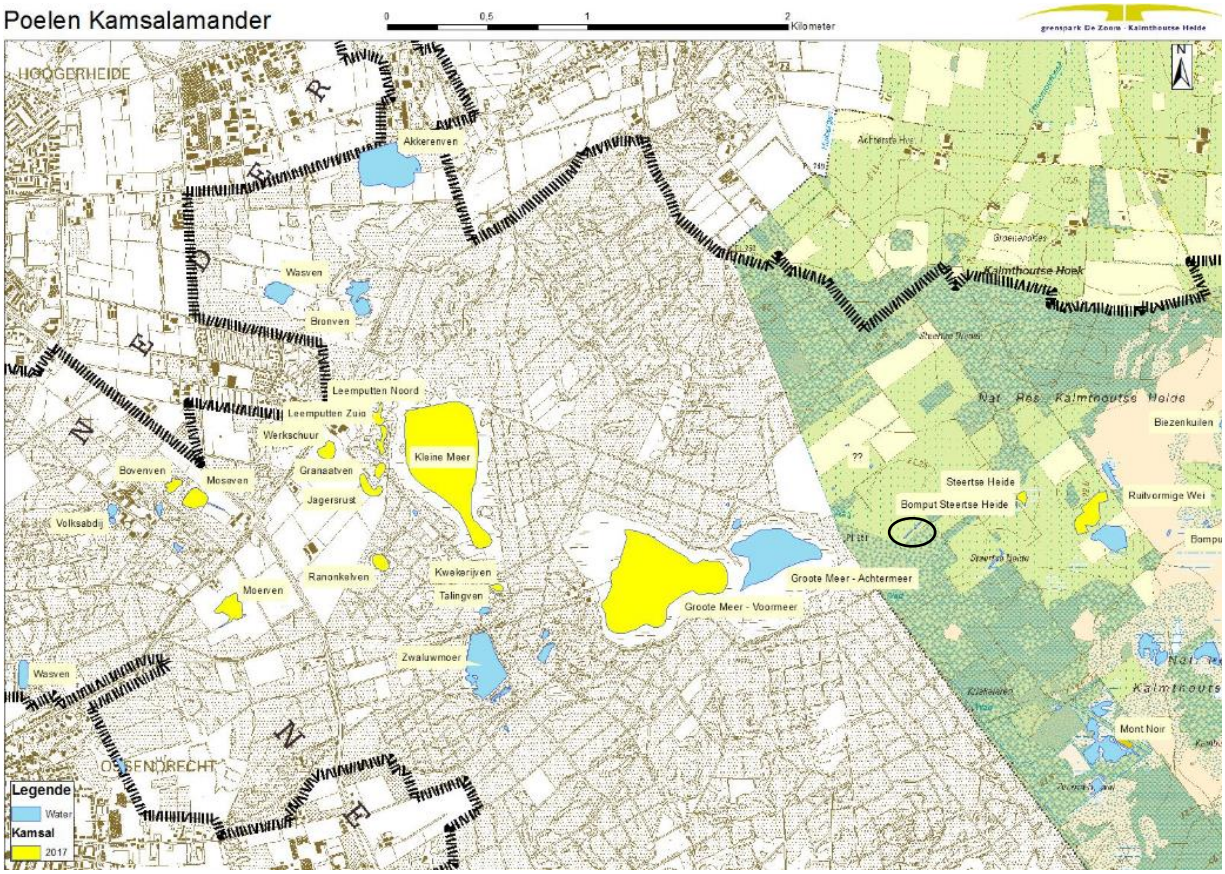


Figure 2, showing all ponds that were observed in yellow (and encircled) and their names.

2 first visits to Grenspark De Zoom- Kalmthoutse Heide were made on 10/03/2017 and 11/03/2017, to find all ponds and get a first look at how the landscape was built. Later, the field protocol and planning (both added in an extra document) were made. This was done using (for the protocol about the monitoring of the larvae and adult newts) the 'Monitoringsprotocol kamsalamander' (INBO) and the 'Offerte Monitoring kamsalamander Grenspark 2017' and (for the protocol about the habitat assessment) the 'ARG UK advice note 5: Great Crested Newt habitat suitability index' of the 'Amphibian and Reptile groups of the United Kingdom'.

Before starting placement of the traps in a pond, a habitat assessment of it was done. Hereby, the following information was noted down (according to the protocol):

- Surface. This was determined using google maps.
- Presence of fish.
- Water quality.
- pH. This was only measured during the very last visit to the ponds (at the same time the larvae were monitored), using a pen-type pH meter PH-02, since this is when the pH-meter became available.
- Amount of shadow.
- Maximum depth.
- Influence of waterfowl.
- Amount of pools in a range of 1 km. This was determined using a map of the area and a fitter.
- Macrophyte cover.

For each variable, a value of 0.01-1 was assigned, based on how suitable this variable was for Great Crested Newts.

After the habitat assessment, funnel traps were placed. This was done during the afternoon, before sunset. Funnel traps were always placed on the southern edge of the pond, as close to macrophytes as possible, since this is the place Great Crested Newts are most likely to be. After placement, a map of the location of all funnel traps in the pond was made. These could later be used to find the right coordinates of the traps, using google maps. The next day (and if it was possible, the day afterwards just as well), funnel traps were emptied. The traps were always emptied in the same way: First, all organisms inside were scooped up with a transparent plastic box. Then, they were all put in a bucket together, which was taken to shore to determine the species of everything inside. If any of the present amphibia was a Great Crested Newt, its gender was also noted down and pictures were made of its belly pattern. Afterwards, the Amphibia were released again, a small distance away from the traps to prevent them from immediately being trapped again.

Some deviations from the original plan still occurred. One deviation from the planning was made. On 03/04/2017, 1 extra funnel trap was acquired from Wilton De Dooij, the forester of the nature reserve. This extra funnel trap was used during the entire remainder of the internship. The exact coordinates of the funnel traps during each visit changes from visit to visit in some of the ponds. This is because sometimes, no Great Crested Newts could be found. If that happened, the placement of the funnel trap was changed during the next visit, as to find as many newts as possible. This approach was chosen due to the limited amount of funnel traps. It must also be noted that during the first monitoring period, a viewing point was being constructed at Bovenven, which might have disrupted any newts living there, even if the viewing point didn't come in immediate contact with the pond. The pond called 'agricultural field' had dried up by the second monitoring period. After thoroughly searching the surroundings for other suitable ponds and not finding any, it was decided that the last remaining funnel trap would be placed in the Steertse Heide, since this was the most recently successful sampling site in the vicinity.

Population size calculation

After comparing all currently captured Great Crested Newts with the ones from previous years using 'wild-ID', no matches were found. A more exact estimation of size is therefore impossible. A wider estimation was done, but it must be stated that the error on this is larger. The Jolly-Seber method is used to calculate population size. Therefore, the following formulas are used:

$$N_i = \frac{n_i * M_i}{m_i}$$

$$M_i = m_i + \frac{R_i * z_i}{r_i}$$

N is the total population size during sample i.
n is the number of animals caught in sample i.
M is the total amount of marked individuals in the population when sample i is taken.
m is the number of marked animals that are caught in sample i.
R is the number of animals released again during sample i.
z is the number of animals marked before, not caught in sample i, but caught again in a later sample.

r is the number of animals released during sample i and caught again in a later sample.

Using these formulas, population size of the Great Crested Newt is calculated for every visit made in a pond, based on the number of individuals found there during that visit. For the first and last visit, no population size estimation could be made, since not enough data were present (in the Jolly-Seber method, making these estimations is never possible). For every pond, the average population size of all visits was then calculated. This was all added to find a total population size. Since no recaptures have been made, m, z and r were always zero, causing some measurements to be impossible (due to divisions by zero). Thus, m, z and r were always made to have a value close to zero: 0.01. This number gave approximations closest to the population size found for Leemputten in the report made in 2015: 274. Results of this method can be seen in appendix table 1. An extra population size estimation has been included here: 'Average with visit 4'. This is because in most of the ponds where Great Crested Newts had been found, this was only during the first and/ or last visit, causing a population size estimation of 0 while newts where present. To prevent this, a population size estimation including the animals caught during the last visit was made, thus assuming no recaptures would have been present during a hypothetical fourth or fifth visit. Using these estimations of size, a second estimation of total population size could be made.

Monitoring of larvae

During the last two field days (22/06/2017 and 23/06/2017), larvae were monitored. First, a visit was made to visitor's centre 'De Vroente', to borrow a net to be able to sample amphibian larvae. Afterwards, the larvae of frogs and newts, and especially Great Crested Newts were monitored in all observed ponds.

Two of the ponds, being Kleine Meer and Ven Jagersrust, were dried up, thus no measurements were taken there. Ven Werkschuur had decreased to such a low waterlevel that no measurements could be taken there either: it was too low for the pH-meter to be fully under water and any larvae left would not have survived this waterlevel. The measurements were done according to the monitoring plan: along the most southern, sunny and vegetated shores, scoops with the net were done about every two meters. However, since a total of 30 scoops were done in every pond, to cover all potentially habitable areas, the distance between scoops could be larger. It was noted that only a very small amount of newt larvae could be found. This might have been due to the weather: measurements were done following a long dry period and temperatures during most of the measurements were well above 30°C.

Using a program called 'wild-ID', Great Crested Newts found during the previous years could be compared with the ones found this year. This works quite simple: the pictures taken of the newts during all years (cropped, so that only the belly pattern is visible) are inserted, and the program shows, for every newt, the 20 other newts that are most like it. In this way, manually comparing all taken pictures with each other is avoided.

Timetable

Table 1 provides a timetable of time spent on all activities. A total of around 171 hours were spent on this assignment.

Table 1. Timetable.

Date	Activity	Hours spent
17/02/2017	Meeting with Christoffel Bonte	0:40
08/03/2017	Creation Field Protocol and planning	06:00
10/03/2017	Site visit Grenspark De Zoom- Kalmthoutse Heide	03:00
11/03/2017	Site visit Grenspark De Zoom- Kalmthoutse Heide	03:00
22/03/2017	Adjusting planning	0:40
23/03/2017	Adjusting planning	0:20
24/03/2017	Adjusting planning	0:10
23/03/2017	Field work: placing funnel traps	03:45
24/03/2017	Field work: emptying funnel traps	02:45
25/03/2017	Field work: emptying funnel traps	02:15
29/03/2017	Creating internship report (text)	0:40
03/04/2017	Field work: placing funnel traps	05:00
04/04/2017	Field work: emptying funnel traps	03:55
05/04/2017	Field work: emptying funnel traps	02:40
06/04/2017	Creating internship report (text)	0:30
10/04/2017	Field work: placing funnel traps	06:00
11/04/2017	Field work: emptying funnel traps	04:00
12/04/2017	Field work: placing funnel traps	04:30
13/04/2017	Field work: emptying funnel traps	02:10
14/04/2017	Field work: placing funnel traps	01:50
15/04/2017	Field work: emptying funnel traps	02:10
17/04/2017	Creating internship report (text)	01:00
21/04/2017	Field work: placing funnel traps	03:00
22/04/2017	Field work: emptying funnel traps	03:00
28/04/2017	Field work: placing funnel traps	02:50
29/04/2017	Field work: emptying funnel traps	02:40
29/04/2017	Field work: placing funnel traps	02:10
30/04/2017	Field work: emptying funnel traps	02:30
03/05/2017	Field work: placing funnel traps	02:50
04/05/2017	Field work: emptying funnel traps	02:45
05/05/2017	Field work: placing funnel traps	02:20
06/05/2017	Field work: emptying funnel traps	03:10
10/05/2017	Field work: placing funnel traps	01:50
11/05/2017	Field work: emptying funnel traps	02:50
12/05/2017	Field work: placing funnel traps	02:50
13/05/2017	Field work: emptying funnel traps	03:00
17/05/2017	Field work: placing funnel traps	02:10
18/05/2017	Field work: emptying funnel traps	01:50
19/05/2017	Field work: emptying funnel traps	02:20
15/06/2017	Creating internship report (ordering photographs, habitat assessment, coordinates)	07:00

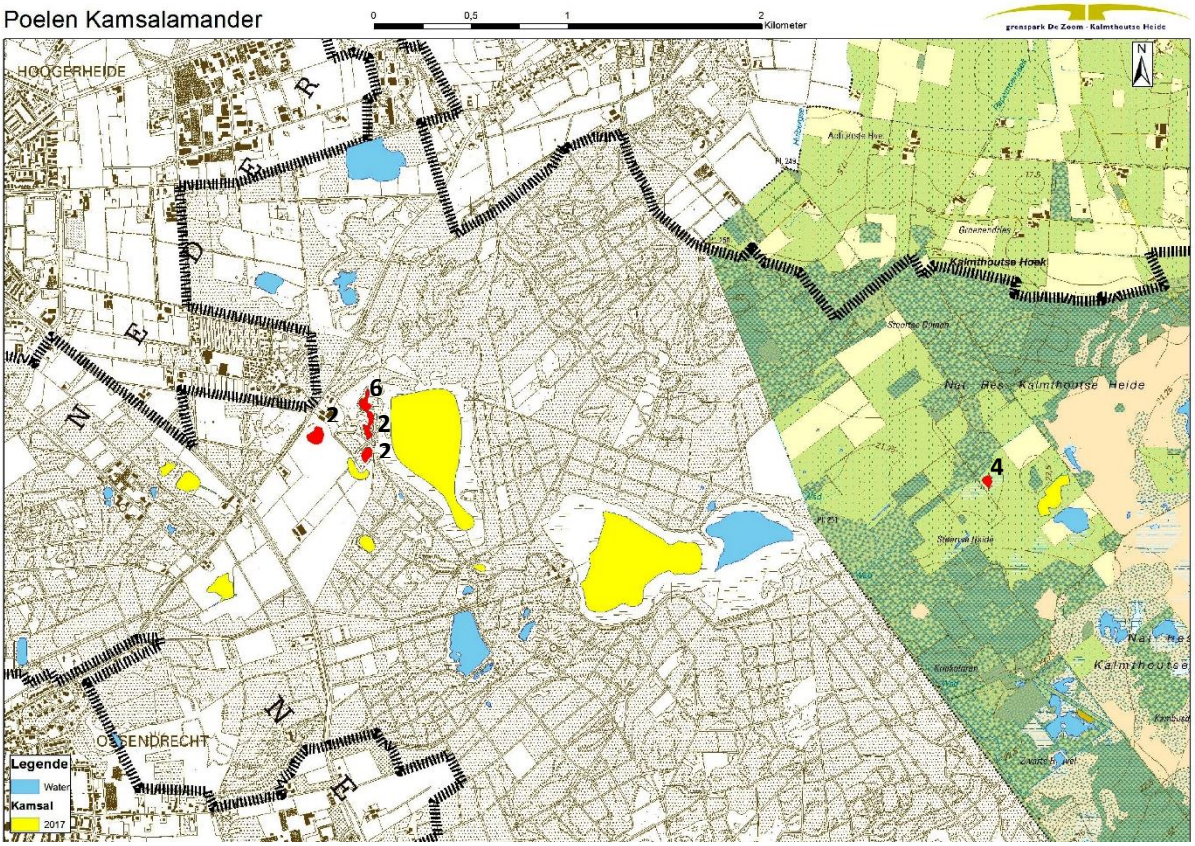
16/06/2017	Creating internship report (results, hours)	03:00
18/06/2017	Creating internship report (text)	0:30
22/06/2017	Field work: monitoring larvae	09:00
23/06/2017	Field work: Monitoring larvae	07:00
25/06/2017	Creating internship report (text and results larvae)	2:20
18/07/2017	Creating internship report (access and pictures scoops)	03:00
01/08/2017	Creating internship report (access)	01:00
02/08/2017	Creating internship report (introduction)	0:40
04/08/2017	Creating internship report (techniques, adjusting tables)	05:00
06/08/2017	Creating internship report (timetable, access file)	06:00
09/08/2017	Creating internship report (access file, creating pictures containing sites with great crested newts)	05:30
11/08/2017	Creating internship report (comparing great crested newts)	06:30
12/08/2017	Creating internship report (adding discussion, summary, adjusting methods).	04:15
15/08/2017	Creating internship report (habitat assessment,	14:00

Results

Range Great Crested Newts

A total of 16 Great Crested Newts were found, in the following ponds: Leemputten N and -Z, Granaatven, Ven Werkschuur and Steertse Heide Ondergelopen Weiland. This can be seen in figure 3, where in the ponds indicated in red, Great Crested Newts have been captured, while in the ones indicated in yellow, no GCN have been found. The numbers indicate the amount of GCN captured, per pond. As can be seen, most GCN have been found in Leemputten N (6 individuals) and in Steertse Heide (4 individuals). In all other ponds where Great Crested Newts have been captured, 2 individuals have been found.

Figure 3. Ponds where Great Crested Newt has been found are shown in red.



Other present amphibia

As for other present amphibia and leeches, table 2 shows which species have been found and where and how much of them has been found.

Table 2. Which amphibian species (other than Great Crested Newt) and leeches have been found, where and how many.

Pond	Species	Number
Leemputten N	Alpine Newt/ *Ichthyosaura alpestris*	7
	Marsh Frog/ *Pelophylax ridibundus*	9
	Medicinal Leech/ *Hirudo medicinalis*	1
Leemputten Z	Alpine Newt/ *Ichthyosaura alpestris*	1
	Brown Frog/ *Rana* sp.	1
	Marsh Frog/ *Pelophylax ridibundus*	2
	Green Frog/ *Pelophylax* sp.	2
	Medicinal Leech/ *Hirudo medicinalis*	33
Ranonkelven	Palmate Newt/ *Lissotriton helveticus*	1
	Marsh Frog/ *Pelophylax ridibundus*	3
Ven jagersrust	Brown Frog/ *Rana* sp.	1
	Marsh Frog/ *Pelophylax ridibundus*	5
	Edible Frog/ *Pelophylax* kl. *esculentus*	3
Groote Meer – West	Palmate Newt/ *Lissotriton helveticus*	1
	Marsh Frog/ *Pelophylax ridibundus*	1
	Pool Frog/ *Pelophylax lessonae*	1
Kwekerijven	Alpine Newt/ *Ichthyosaura alpestris*	1

Kleine Meer	Alpine Newt/ *Ichthyosaura alpestris*	1
	Marsh Frog/ *Pelophylax ridibundus*	1
Granaatven	Alpine Newt/ *Ichthyosaura alpestris*	3
	Palmate Newt/ *Lissotriton helveticus*	1
Ruitvormige Wei	Alpine Newt/ *Ichthyosaura alpestris*	1
	Smooth Newt/ *Lissotriton vulgaris*	1
Steertse Heide	Alpine Newt/ *Ichthyosaura alpestris*	20
	Palmate Newt/ *Lissotriton helveticus*	4
	Smooth Newt/ *Lissotriton vulgaris*	3
	Marsh Frog/ *Pelophylax ridibundus*	5
Bomput Steertse Heide	Palmate Newt/ *Lissotriton helveticus*	2
	Smooth Newt/ *Lissotriton vulgaris*	2
Agricultural Field	/	
Ven Werkschuur	Smooth Newt/ *Lissotriton vulgaris*	1
	Marsh Frog/ *Pelophylax ridibundus*	4
	Pool Frog/ *Pelophylax lessonae*	1
Moseven	Alpine Newt/ *Ichthyosaura alpestris*	1
	Marsh Frog/ *Pelophylax ridibundus*	2
	Green Frog/ *Pelophylax* sp.	1
	Medicinal Leech/ *Hirudo medicinalis*	6
Bovenven	/	
Moerven	Marsh Frog/ *Pelophylax ridibundus*	3

Population estimation

Table 4 gives a population size estimation of each pond, based on both of the methods explained before. Using these numbers, the total population size can be calculated as either 1405 (without final visit) or 1172 (including final visit). Comparing the number of animals in Leemputten with the amount found during the monitoring period of 2015 (274 versus 502/ 496), it can be seen that this number is larger, which is probably due to the lack of recaptures, which makes this estimation more inaccurate. Figures 4 and 5 show, according to both methods used, the total amount of newts in each pond, as calculated.

Table 4. Population size estimation of all ponds.

Pond	Population size (method 1)	Population size including last visit (method 2)
Leemputten N	502	335
Leemputten Z	0	134
Granaatven	0	51
Steertse Heide	603	452
Ven werkschuur	0	201

Figure 4. Total amount of newts per pond, method 1.

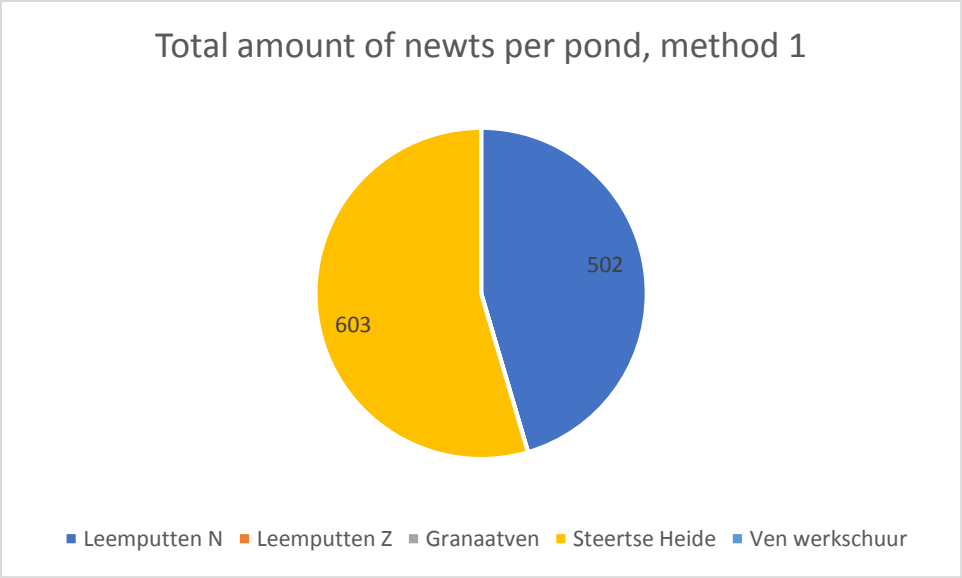
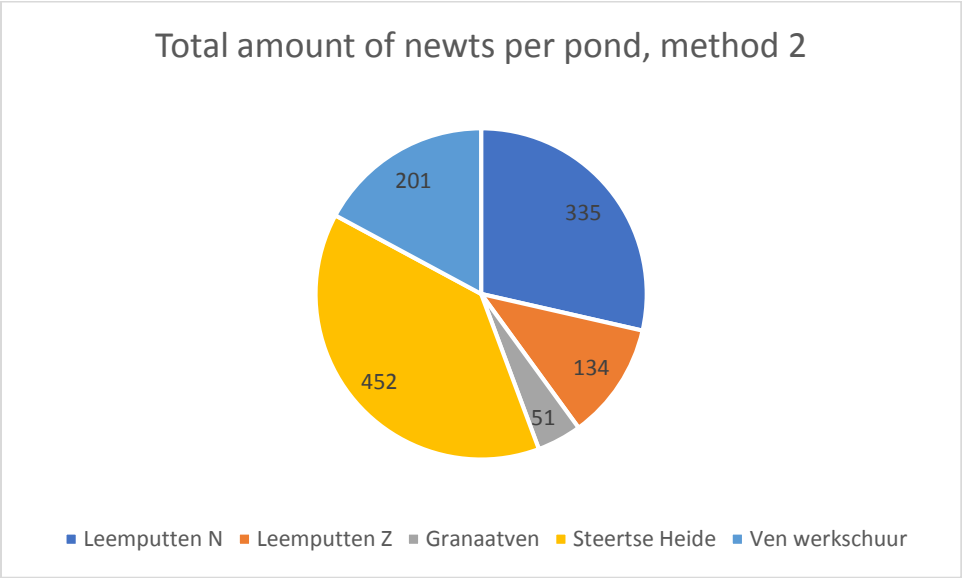


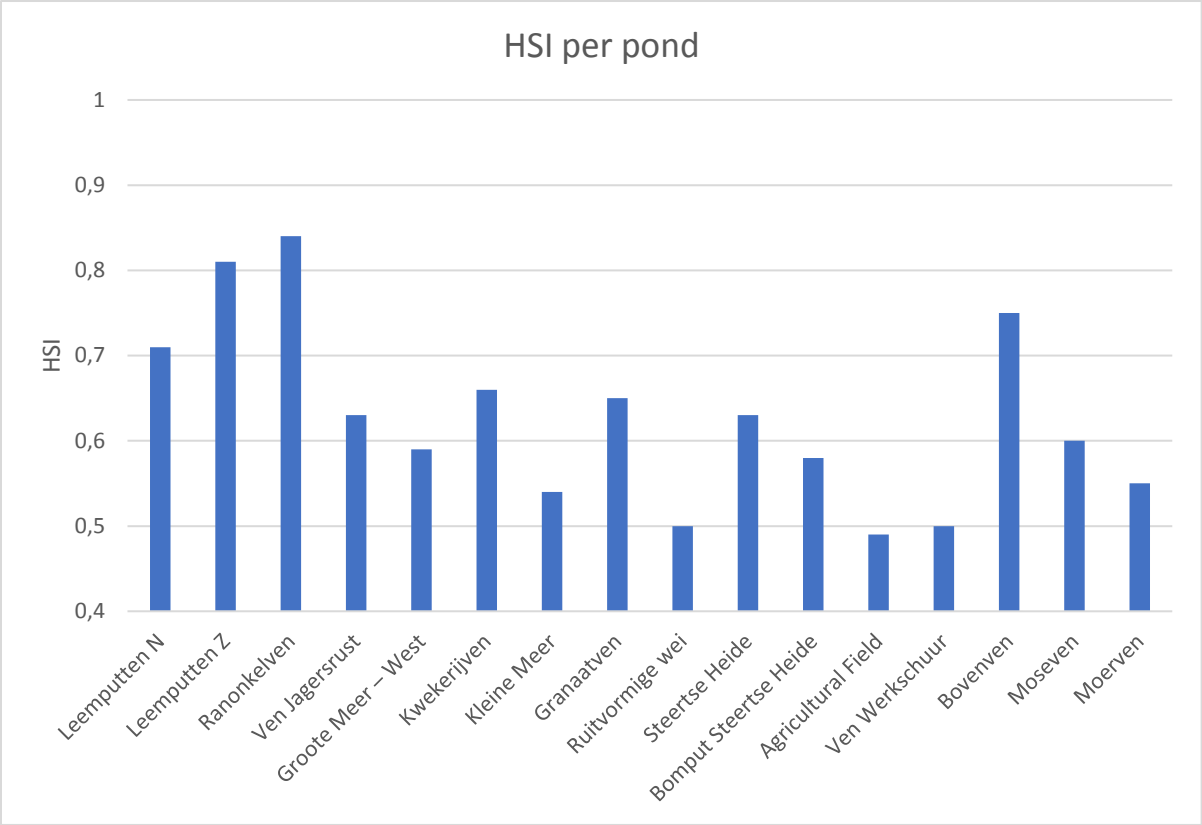
Figure 5. Total amount of newts per pond, method 2.



Habitat suitability index

The habitat suitability index for every pond can be seen in figure 6. Ranonkelven has the highest HSI (0.84), but no Great Crested Newts have been found here. Leemputten Z has the second highest measured HSI (0.81) and would thus also be one of the most suitable ponds for Great Crested Newts according to the method used. Most newts however could be found in Leemputten N and Steertse Heide, which have HSI's of 0.71 and 0.63, respectively.

Figure 6. Results Habitat assessments.



Monitoring Great Crested Newt larvae

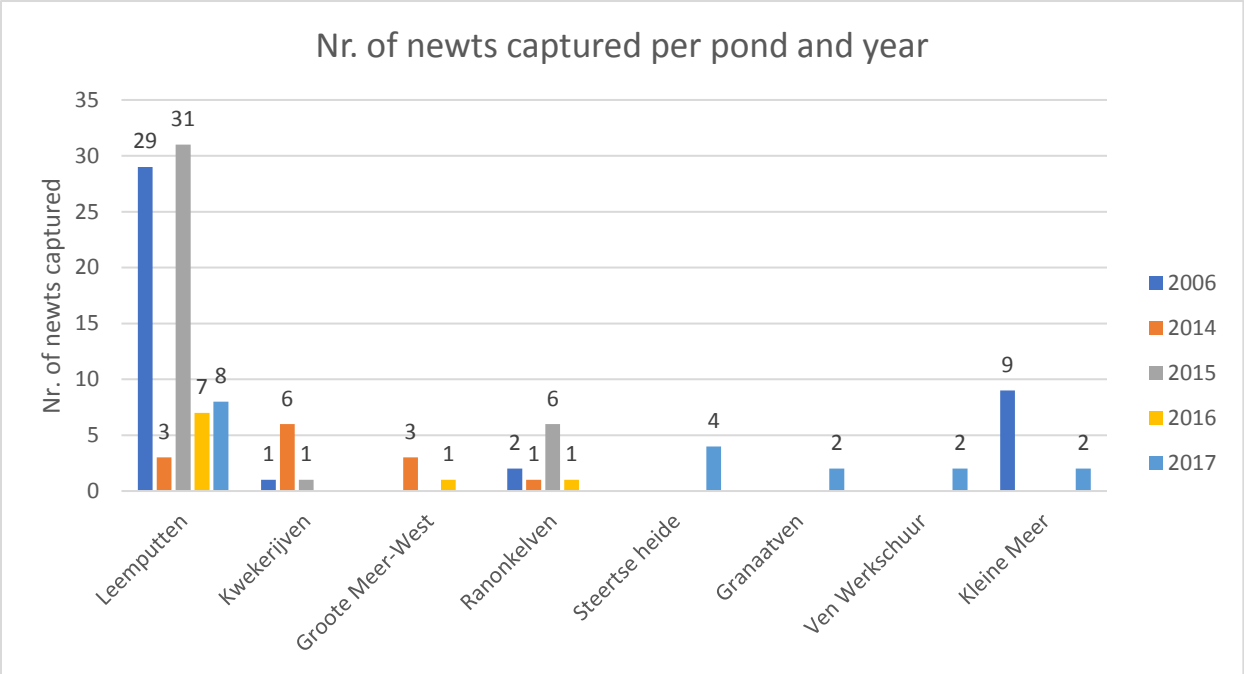
After monitoring Great Crested Newt larvae, only one was found, in Kwekerijven, a pond where no Great Crested Newts had been found previously during this monitoring period.

Discussion

Range Great Crested Newts

Since the larger number of Newts found in Leemputten N and Steertse Heide, it can be hypothesised their habitat is of higher quality for the newts. However, as will be discussed later, this was not the case. Figure 7 shows how much newts have been found in each pond, compared to previous years. This figure shows that during all years the population has been monitored, Great Crested Newts have been found in Leemputten. Especially in 2015, when a total of 28 has been found, which is the highest number of newts found in any pond. Also in Ranonkelven and Kwekerijven, Great Crested Newts are frequently being captured.

Figure 7.



Other present amphibia

Table 2 shows that at Leemputten Z, a large number of medicinal leeches has been captured, signifying that this pond probably contains a suitable habitat for this species. Leemputten N, which is connected to Leemputten Z, did also contain leeches, however, only one individual has been found in this site. Thus, both of these ponds must have a different habitat for this species. According to IUCN, the medicinal leech needs a habitat that contains enough hosts, such as frogs. Based on auditory observations, Leemputten Z seemed to have more frogs, however this is contradicted by the funnel trap captures. Medicinal leeches also need dense submerged and emergent vegetation. As noted down in the habitat assessment, Leemputten Z contained more of these types of vegetation than Leemputten N, since it contained more macrophytes in general. This might be the reason for the difference between the number of medicinal leeches in Leemputten N and Z.

From table 2 it can also be noted that Steertse Heide contained an unusually large amount of Alpine Newts compared to other ponds (20 individuals compared to an average of 2), meaning that this site might have one of the most suitable habitats for this species of all observed ponds. However, since no habitat assessments for species besides the Great Crested Newt has been executed during this internship, this can't be said with certainty.

Capture-recapture study

The most common explanation of the fact that no recaptures have been made is that the population of newts is so large that of all newts captured before, none could be caught again. Thus, it might be concluded that the population of newts residing at Grenspark De Zoom- Kalmthoutse Heide is very large.

Explanations besides the first one are possible. First of all, a low recapture rate is a general problem of capture-recapture studies, according to Griffiths et al. (2015).

A second possible reason for the lack of recaptures is presented in Griffiths et al. (2010). They state that after a mild winter (caused by climate change) newt survival (of both juveniles and adults) is low. In their research, some of the subpopulations of a larger metapopulation were in danger of extinction, since the mild winters caused an adult survival of less then 30%. This situation might also occur in Grenspark De Zoom- Kalmthoutse heide, especially considering the recent mild winters.

A final possibility is off course that no recaptures have been made because of bad luck. Looking at the low amount of newts captured during the previous year (five), catching any of those newts again is unlikely. The year before, a larger number of newts has been captured, but it is possible that merely by chance, none of these have been caught again. If this is indeed the problem, it can be solved by placing more funnel traps in all ponds (especially the ones where Great Crested Newts have been found during the previous years).

The lack of recaptures also means that no definite positive conclusions can be made about whether or not the Great Crested Newts migrate from one pond to another. Previous research has shown that most adult Great Crested Newts (99% of their study population) don't migrate between ponds. Juveniles however were found to emigrate more often. (Kupfer and Kneitz, 2000).

Habitat Suitability Index/ HSI

Previous years did capture a total of 4 newts in Ranonkelven, which is not a remarkably higher number then the number of newts captured in other ponds, but does signify that the species is able to survive in this pond and might even have been present during the internship, but couldn't be captured. Only two newts have been captured at Leemputten Z, a number again not remarkably higher than in other ponds. This could be due to the fact that only during the last visit, a funnel trap was placed on a site where Great Crested newts where found. If the trap had been placed in that site earlier, more newts might have been captured.

The HSI of Leemputten N and Steertse Heide, where most newts have been found, does not seem to be remarkably higher than the HSI of other ponds. In Leemputten N, the lower index was due to the fact that the pH was not perfect (An ideal pH is between 7 and 8, but here it was found to be 6.25, which is slightly too low), the amount of shadow was less then 30% (Great Crested Newts require more shadow), the pond was deeper than 1m (ideally the pond is entirely between 0.5 and 1m) and ca. 40% of the pond was covered in macrophytes (ideally this is between 70 and 80%). Steertse Heide received a non-ideal Suitability Index because of the surface (Ideally, newts require 600-700 m^2, but this pond was larger, with a surface of ca. 2 500 m^2), the water quality (some algae were present), the lack of shade and the signs of waterfowl (patches without vegetation occurred and lots of faeces could be found, however, rarely waterfowl could be spotted). Thus, although both of these ponds received a lower HSI, the largest number of Great Crested Newts could still be found inside them.

This might be because the protocol was not accurate enough. Although that should not be a problem, since it has been evaluated and is based on protocols that have been developed by professionals. (ARG UK, 2010, De Bruyn et al., 2015). Nevertheless, the habitat assessment made during the previous year showed different results, with Leemputten N having the best habitat quality, which would better explain the large numbers of newts found here. A decrease in habitat

quality of this pond between last year and this year is possible, however not very likely, since no major changes have been made.

Another reason for the inconsistency between the habitat assessment results and the occurrence of newts might have something to do with their shadow preference. Some sources state that Great Crested Newts prefer areas containing more shadow (De Bruyn et al., 2015, Briggs et al., 2009, Rannap et al., 2012, Rannap and Briggs, 2006), while others state the opposite (ARG UK Advice note 5, LIFE nature) since shade cools down the water, causing reproduction and development to slow down. Some sources (Rannap et al., 2012) state that only in the most northern latitudes, Great Crested Newts prefer non-shaded ponds, since there, temperatures are lower and reproductive season is shorter. Sunnier ponds will warm up faster and thus provide greater chances of eggs and larvae developing before temperatures start decreasing again in these regions. Since the studied ponds all occurred in lower latitudes, shaded ponds should be better for the newts according to this source. This theory was followed and shaded ponds were given a higher HSI, but that doesn't exclude the fact that other sources still state that Great Crested Newts occur in ponds containing less, and not more, shadow. Following that reasoning, results might be different.

A final reason for the discrepancy between habitat assessment data and numbers of newts found (specifically for Leemputten N and Steertse Heide) might have something to do with extinction debt: an environmental disturbance causing a change in habitat can eventually decrease population size and even cause extinction. (Hylander and Ehrlén, 2013.). This effect is delayed, which can have numerous reasons. Knowing the exact reason for this delay is important in understanding why the population declines and thus helps preserving the species. It is possible that in the past, both Leemputten N and Steertse Heide were ideal habitats for Great Crested Newts. Human interference or climate change (Haubrock and Altricher, 2016) might have changed the habitats of the ponds, causing a disturbance. Newt populations however haven't immediately reacted to this change, for a number of possible reasons, which is why a higher number then expected can still be found in these ponds. The larger number is thus a remnant of a time when habitat quality was better. Possible reasons for the delayed response are: 1) Habitat change causes larvae to have a decreased survival probability, thus although adult numbers remain the same, no new newts replace the old ones and only after these start dying, population size decreases. 2) Habitat change causes a lower fecundity, having the same effects as 1). 3) If newt populations in Grenspark De Zoom- Kalmthoutse Heide form a metapopulation (and even without recaptures, we can assume so, since all ponds are close enough to each other), it is possible connectivity between those metapopulations has decreased because of environmental disturbances, causing all of these populations to be more vulnerable to stochastic threats and thus to eventually decrease in size. Reason 3) would explain why no recaptures that show newts migrate between ponds have been made during the past few years. 1) and 2) might explain why more Great Crested Newts have been found in those two ponds than expected. (Semlitsch et al., 2017).

Monitoring Great Crested Newt larvae

The low number of newt larvae would mean newts had an extremely low reproductive success this year, not by far being able to sustain a healthy population. Previous years also found such a low number of newt larvae. This would indicate a decreasing trend in the population of Great Crested

Newts in Grenspark De Zoom- Kalmthoutse Heide. Since amphibian populations all over the world are decreasing in size, this comes as no surprise.

An often mentioned cause of this decline is a deadly fungus, *Batrachochytrium dendrobatidis/* amphibian chytridiomycosis, although sometimes other (closely related) Fungi species are named. (Daszak et al., 2003, Vredenburg et al., 2010, Martel et al., 2013, Hudson et al., 2016, Spitzen-van der Sluijs et al., 2016). This fungus however, does not occur in the park. Another reason that can be used for amphibian declines is the extinction debt mentioned earlier. This theory can, as stated before, give a possible explanation for the fact that 1) more individuals have been found in Leemputten N and Steertse Heide than expected based on the results of the habitat assessment and 2) no recaptures that show newts migrate between ponds have been made in the past few years. Plus, if an extinction debt is present, it is possible that because of changes in the environment, fecundity and/or larvae survival is lower, causing only a small number of newt larvae to be found. (Semlitsch et al., 2017).

Another possibility is related to temperature: a heatwave took place during the monitoring, with air temperatures rising above 30°C during the day (water temperatures will be about the same). According to Huey and Stevenson (1979), the performance of ectotherms, such as newts, depends on temperature: Low temperatures cause this performance to decrease, just as very high temperatures. No research has been done yet about the optimum temperature of Great Crested Newt larvae, but it is possible that temperatures above 30°C decrease their performance, causing the larvae to move towards cooler places, such as deeper in the pond. This means capturing them becomes more difficult.

Another explanation for the low number of larvae has to do with pH. Both of the ponds containing most of the newts have a low pH (Steertse Heide: 5.87 and Leemputten N: 6.25). As stated in the protocol, this pH is too low to be ideal for Great Crested Newts. These acidified waters can prevent reproduction from happening and thus this might explain why no larvae where found there. (Pierce, 1985, Griffithsand and de Wijer, 1994). Other ponds where Great Crested Newts have been found did not have a high pH, but also contained less newts, thus less chances of reproduction. Kwekerijven, the only pond where a Great Crested Newt larvae has been found, has a pH of 5.21. According to this theory, at such a pH, reproduction will be decreased. However, it is off course still possible that some larvae survive nevertheless. Ponds that did have an ideal pH were Leemputten Z, Ranonkelven, Groote Meer Voormeer and Granaatven. These ponds should thus have a higher larval survival, according to this theory. To gain more accurate knowledge about the pH of the ponds, more pH measurements should be taken, tracking the pH of the ponds through the season.

Conclusion

Leemputten N and Steertse Heide contained the highest numbers of newts during this monitoring year. The number of newts found during all monitoring years can be seen in figure 7. Here it is shown that over all years, Leemputten N contains the highest number of newts. Thus, it can be hypothesised the habitat here is the most appropriate for Great Crested Newts. However, the habitat assessment data show otherwise. They show that Leemputten Z and Ranonkelven have the highest Habitat Sustainability Index, while Leemputten N doesn't posses a remarkably higher HSI than other ponds.

This might have been because the protocol was not accurate enough. After all, the habitat assessment made in 2016 showed that Leemputten N has the highest HSI of them all, a result not obtained during this year.

After using the program 'wild-ID', it was shown that no recaptures had been made. Thus, there is no proof for migrations between ponds. Based on the amount of newts captured, and using the Jolly-Seber method (without and with the amount of newts captured during the last visit), it was calculated that the total population size of Great Crested Newts in Grenspark De Zoom- Kalmthoutse heide is either ca. 1405 or 1172. The estimated population sizes in each pond can be seen in table 4. This lack of recaptures is first of all a general problem of capture- recapture studies. Secondly, it might have been caused by bad luck, by chance not capturing any newts captured during the previous years.

Only one Great Crested Newt larvae has been found, in Kwekerijven. This means that the current GCN population is by far not reproducing enough to sustain itself. If it continues like this, it will go extinct. A possible reason for this is the low pH found in the ponds containing most of the Great Crested Newts. A low pH reduces reproduction, causing a lower amount of larvae and less larvae to survive.

One possible general theory to explain the lack of recaptures of newts that migrated between ponds, the discrepancy between habitat assessment results and number of newts found in ponds and the low number of larvae found revolves around the presence of an extinction debt. This can be caused by a lower connectivity between metapopulations, causing a lack of recaptures that show newts migrate between ponds. It can also be caused by a lower fecundity and/ or survival of larvae, which would explain the discrepancy and the low number of larvae. This lower fecundity can be caused by a low pH, which decreases reproduction.

Summary

During this internship, *Triturus cristatus/* Great Crested Newts (threatened in Belgium and the Netherlands) were monitored in the northern part of Grenspark De Zoom- Kalmthoutse Heide. This was done from 23/03/2017 until 19/05/2017, using funnel traps. A total of 16 Great Crested Newts were found, which is a reasonable number. Using the program 'wild-ID', it could be concluded none of the captured newts matched with any of the newts captured during the previous years, just like no matches were found between the newts captured this year. This increased the error on calculations of population size. After using the Jolly-Seber method, two total population sizes were calculated (one excluding and one including newt counts during the last visit). According to the first method population size was 1405, while according to the second method, this was 1172. Both of these estimations show a large population, however this is probably overestimated considering the lack of recaptures. The exact reason for this lack remains unknown, but there are some theories. It is certain that a lack of recaptures is a general problem in capture-recapture studies. Probably, the lack is due to bad luck, by chance not being able to capture the newts captured before. Placing more funnel traps in each pond could remove this problem. However, it also means that no conclusions about migration between ponds can be made. The habitat assessment data showed that the two ponds most suitable for Great Crested Newts are Ranonkelven and Leemputten Z. However, most newts have been found in Leemputten N and Steertse Heide, two ponds not having a remarkably higher HSI. This could be due to the protocol used to determine this HSI, since there were clear differences

between the HSI calculated this year and the one calculated during the previous year. During 22/06/2017 and 23/06/2017, the period Great Crested Newt larvae have hatched, but are still bound to water, they were monitored, using sweeping nets. These were swept along the shores that were deemed most suitable for Great Crested Newt larvae. Only one larvae could be found, at Kwekerijven. This is a very low number, which indicates the current population is not able to sustain itself and will go extinct in a certain time. Monitoring periods executed during the previous years also found an extremely low amount of larvae, thus this result came as no surprise.

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Appendix

Tables

Table 1. Results population size calculations.

Leemputten N				
captured marked	0	0	0	0
captured unmarked	2	3	1	0
captured total	2	3	1	0
M		3,01	1,01	0,01
N		903	101	0
Average	502			
Average with visit 4	334,6667			

Leemputten Z				
captured marked	0	0	0	0
captured unmarked	0	0	0	2
captured total	0	0	0	2
M		0,01	0,01	2,01
N		0	0	402
Average	0			
Average with visit 4	134			

Ven werkschuur			
captured marked	0	0	0
captured unmarked	0	0	2
captured total	0	0	2
M		0,01	2,01
N		0	402
Average	0		
Average with visit 3	201		

Granaatven			
captured marked	0	0	0
captured unmarked	1	0	1
captured total	1	0	1
M		0,01	1,01
N		0	101
Average	0		
Average with visit 3	50,5		

Steertse Heide			
captured marked	0	0	0
captured unmarked	1	3	0
captured total	1	3	0
M		3,01	0,01
N		903	0
Average	903		
Average with visit 3	451,5		