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Grenspark De Zoom - Kalmthoutse Heide

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Monitoring the great crested newt *(Triturus cristatus)* at Grenspark De Zoom - Kalmthoutse Heide

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This report discusses the monitoring of great crested newts in Grenspark De Zoom - Kalmthoutse Heide.

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Reference front page pictures: Great crested newt female. Picture made by Jurriën Kooijman

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Abstract

The great crested newt *(Triturus cristatus)* is a amphibian species from the family *Salamandridae*, and is the largest newt species that inhabits West-European water bodies. Its habitat demands are relatively deep waters with abundant shore vegetation and the absence of fish. These requirements make it hard for the great crested newt to survive. For this reason, the great crested newt is included in Annexes II and IV of the Habitats Directive, which is the European law on the conservation of natural habitats, fauna and flora. In Grenspark De Zoom - Kalmthoutse Heide, which is an extensive cross-border park in Belgium and the Netherlands, a population of great crested newts is still present. In this research project, the suitable fens on the Dutch side of 'Grenspark de Zoom - Kalmthoutse heide' and the 'Steertse heide' on Flemish side of the park have been examined for the presence of the great crested newt and the evidence on a reproducing population. This resulted in an estimated population of 224 individuals, based on the Schnabel capture-recapture model. Also, at location 'Leemputten', reproduction is confirmed because of the presence of eggs and larvae. Some individuals were found in fens, close to the reproductive water body, though no eggs or larvae were present in those waters.

Because the great crested newt is sensitive to changes in its habitat, conservation measures are needed to avoid the decline of this species. Suitable wetlands need to stay in their original shape, with no industrial pollution or (accidentally) introduced fish species. However, we cannot always control natural succession. For now, water bodies must be able to contain water at all times for the development of the larvae. The newly formed fens at 'Jagersrust' have a high potential for becoming a new reproductive water for great crested newts. However, risks of pollution and the possibility that these water bodies won't hold their water year round, makes continued research necessary. Future research will monitor the population to ensure that the population is maintained. This includes following up of the measures that are needed to keep a sustainable population.

1.Introduction

1.1. Great crested newt (Triturus cristatus)

The great crested newt *(Triturus cristatus)* is a amphibian species from the family *Salamandridae*, and is the largest newt species that inhabits West-European water bodies (Karlsson, Betzholtz & Malmgren, 2007). The great crested newt is included in Annexes II and IV of the Habitats Directive, which is the European law on the conservation of natural habitats, fauna and flora. It states that conservation of protected species, included to the Habitats Directive, is needed when species are threatened to disappear in their natural range (Eur-lex, 2015). The great crested newt has declined very markedly during the latter part of the twentieth century. This is suggested to be the result of agricultural intensification. Due to deliberate filling and destruction of suitable ponds, the great crested newt is forced to find other ponds (Langton, Beckett & Foster, 2001).

The great crested newt is a species that inhabits relatively deep waters, with abundant shore vegetation (Oldham, 2000). The larvae develop slowly and thus, reproductive waters must contain water at all times. This is believed to be one of the reasons for the habitat choice of great crested newts (Oldham, 2000). Deep waters however, often contain fish that feed on the larvae. In Europe, introduced fish species have contributed greatly to amphibian reproductive failures (Orizaola & Braña, 2006) and as a result, the great crested newt is struggling to survive (RAVON, 2015). Because the great crested newt is sensitive to changes in its habitat, conservation measures are often needed to avoid the decline of this species. Suitable wetlands need to stay in their original shape, with no industrial pollution or; by accident introduced fish species. However, we cannot always control natural succession.

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Examination sites

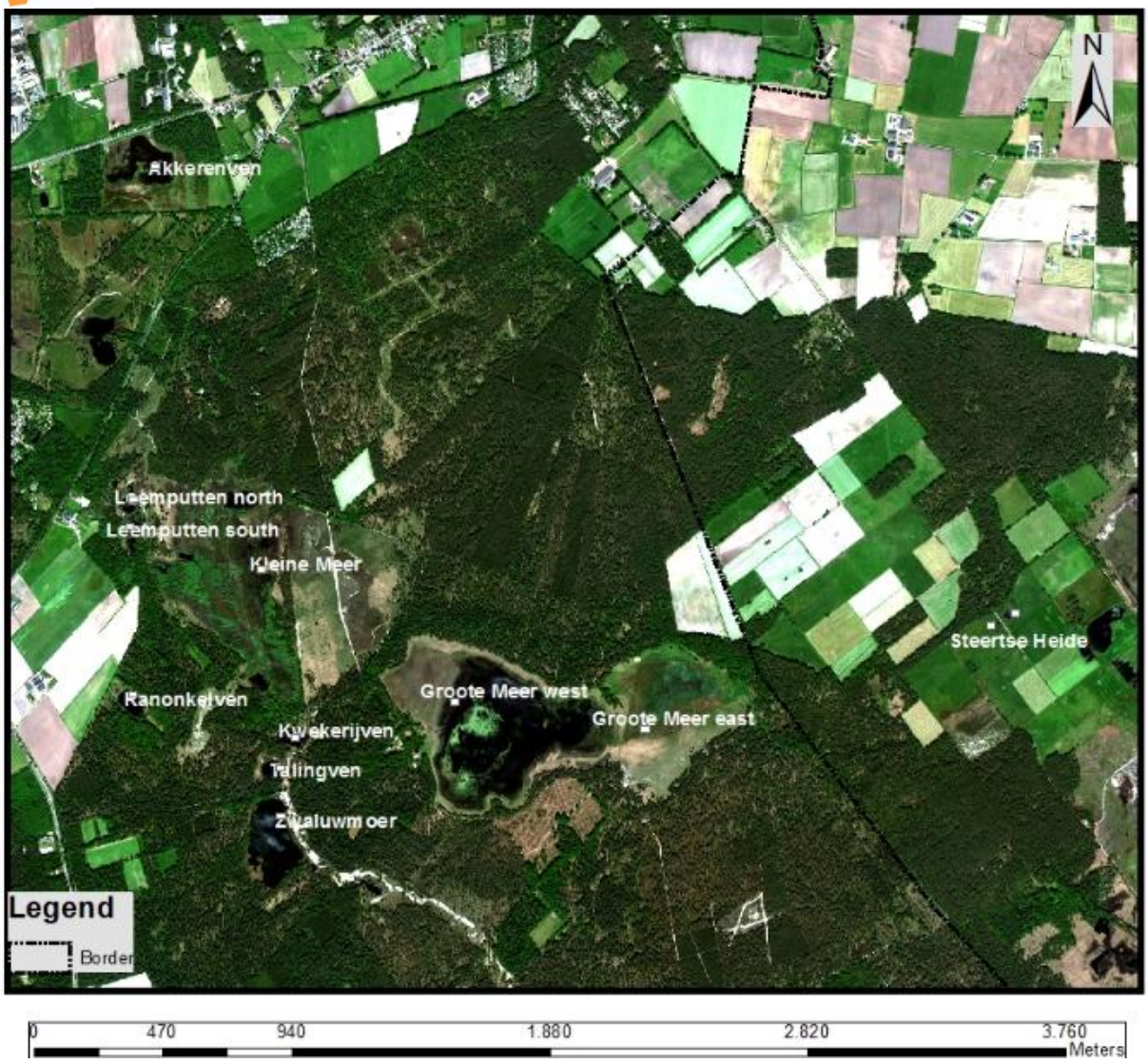

Figure 1.1 Examined fens for monitoring the great crested newt. Source: ARCGIS, maps from Grenspark de Zoom - Kalmthoutse heide

1.2.Organisation

The park is noted as NATURA 2000 area which means it's protected by European laws. The European Commission proposes policies and legislation that protect natural habitats, air, water and biodiversity (Natura-2000, 2015). The EHS (Ecological network) from the Netherlands and VEN (Flemish Ecological Netwerk) from Belgium, are the national “translations” of this European protection. The neighbouring of both protected areas across the border has resulted in the start of Grenspark De Zoom – Kalmthoutse Heide, of which the main goal is to work together, to connect this important area for improvements in biodiversity (Grenspark de Zoom, 2015). The park consists of areas which belong to nature management organisations and parts which belong to private owners. On the Dutch side, the park is managed by 'Natuurmonumenten', 'Staatsbosbeheer' and ‘Bosgroep Zuid Nederland’. In Belgium, the biggest part is managed by ANB (Agentschap Natuur en Bos) and a part in the northeast is managed by 'Natuurpunt'. Private owners allow research to be done on their land but only with a good collaboration, changes in favour of the park can be made.

A collaboration between all organisations, private owners, and governments from both the Netherlands and Belgium, is needed to manage it effectively. The special commission of consultation and advice from the Benelux makes an international cooperation possible (Grenspark de Zoom, 2015). This cooperation is the goal and was the incentive to start the Grenspark De Zoom – Kalmthoutse Heide. As umbrella-organisation, Grenspark DZ-KH brings the different organisations within the nature reserve together. The most important tasks are the monitoring research, supportive management, joint projects and consultation between organisation and partners. Also, promotion of the park and keeping the corporate identity, as well as finding subsidies, are among the tasks of Grenspark DZ-KH. By organising meetings with all associates, policies are made about management of the park. Which are then supervised by the managers from previous mentioned organisations (Ganzefles, 2014).

1.3. Monitoring Research

In this research project, the suitable fens on Dutch side of "Grenspark De Zoom - Kalmthoutse Heide" and the ‘Steertse Heide’ on the Flemish side of the park are examined for the presence of the great crested newt (Figure 1.1). Due to the amount of great crested newts caught in past years in the "Leemputten" (Teunen, 2006., Groffen, 2014.), it is expected to reproduce there. During the water-phase of the great crested newt, from March till the end of May, adult animals are caught using funnel traps. Later in the season, the fens in which great crested newts were found, are also examined for the presence of eggs and larvae.

The main reason for this research is to get a better view on the existing population of great crested newt, in "Grenspark De Zoom - Kalmthoutse Heide". Also, is the great crested newt reproducing successfully in the inhabited ponds? The great crested newt is known to be a difficult amphibian to capture and so, multiple types of funnel traps are used during this research. As a result, in future research, only the most effective type of funnel traps will get the preference. The individuals of great crested newts are documented by the pattern on their belly and so, a capture-recapture model is possible. The newts have not been marked, but the pattern on their belly is unique. This way a estimate can be made about the population size.

1.4.Description of fens

Leemputten

An area where two fens are found. The bigger, southern fen contained a thick sludge layer, some underwater vegetation and a covered shore. The shore mainly contained common reed (*Phragmites australis*) and cattail (*Typha spec).* The smaller, northern fen consisted out of a partial sludge layer and partial open shore. Some common reed and cattail is found here as well. Bog pondweed *(Potamogeton polygonifolius)* is a big part of the underwater vegetation. Both fens are situated along a predominantly coniferous and deciduous forest.

Figure 2.4; Southern fen, Leemputten

Figure 2.5; Northern fen, Leemputten

Ranonkelven

An average sized fen with a partial sludge layer. The shore is open and a characteristic type of plant that is found here, is the white water-crowfoot (*Ranunculus ololeucos*). A high density of underwater vegetation is present. This fen is located in a predominantly coniferous and deciduous forest and situated next to a open area that was previously used for agricultural purposes.

Figuur 2.5; Picture of Ranonkelven

Kwekerijven

An average sized, slightly acidic fen with a sloping shore. The shore is mainly covered with grasses and some parts contain common reed. Underwater vegetation is found near the shore but not in the deeper parts. The fen is situated inside a predominantly coniferous and deciduous forest.

Figure 2.6; Picture of Kwekerijven

Talingven

A small fen, located close to 'Kwekerijven' in a predominantly coniferous and deciduous forest. Here as well, the water is slightly acidic. The sloping shore is mainly covered with low growing plants. In this fen, a high density of underwater vegetation is present.

Figure 2.7; Picture of Talingven

Zwaluwmoer

A large lake-like, acidic fen that is divided in parts with a thick sludge layer. The shore is mainly covered with common rush *(Juncus effusus)* and purple moor grass (*Molinia caerulea)*, with some open spaces in between. There is hardly any underwater vegetation present. This fen is located inside a predominantly coniferous and deciduous forest.

Figure 2.8; Picture of Zwaluwmoer

Kleine meer

This quite large area consists of several small water accumulations which are surrounded by plains of purple moor grass. Unfortunately, most of this fen was dried out but the remaining pools contained many underwater vegetation and no sludge layer.

Figure 2.9; Picture of Kleine meer

Groote Meer

This lake-like fen contained a very low tide from the beginning of this research, compared to previous years (Kok, 2014., Groffen, 2014., Woensdrecht, 2015.). Wet winter periods ensure a high tide in this fen. The Groote Meer is well known for the plant community of the shore weed association *(Littorellion uniflorae)* (Grenspark, 2015). The water is relatively shallow. There is little peat formation and the soil consists mostly of bare sand (Groffen, 2014.).

Figure 2.10; Picture of Groote Meer

Akkerenven (Kortenhoeff)

The Akkerenven used to be a wet lowland in a landscape of dunes, forest and heath. In the course of time, many areas in the cultivated area were used as agricultural land or planted with forest. A part of 'Akkerenven' was put into use as agricultural grassland and another part was planted with poplars (Woensdrecht, 2015). Recently however, the historic pool has been restored.

Figure 2.11; Picture of Akkerenven (Photo: Scholte, 2015)

Steertse Heide

This area consists of open grasslands, flooded grasslands and tree rows. The examined water bodies include a bomb well and two flooded meadows. The area where the research has been done, was previously used for agricultural purposes. All water holding pools had clear shores and the soil consisted of grass, with the exception of the bomb well. The bomb well was relatively deep and contained many underwater vegetation.

Figure 2.12; Picture of Steertse heide

2.Methods

2.1.Monitoring plan

To find the great crested newts; pools in which this newt was previously found and pools surrounding this area, are included in this study. Figure 1.1 displays the examined fens. The great crested newt is known to inhabit the fens at location 'Groote Meer', 'Ranonkelven' and 'Leemputten'.

To capture the great crested newts, funnel traps will be placed, and checked the day after. The water bodies where great crested newts are found, are than checked for eggs (May) and later on, again for larvae (June-August). These inventories are needed to assure the successful reproduction of great crested newts in these water bodies. When looking for eggs, water vegetation is checked for folded leaves. Folded leaves are a characteristic that a female great crested newt might have laid her eggs on this leave (RAVON, 2015). Also leaves that have fallen from trees, might have been used for laying eggs, when these have sunk into the water (Karlsson, Betzholts & Malmgren, 2007).

2.2. Population size

To make a prediction about the population size of great crested newt in "Grenspark De Zoom - Kalmthoutse Heide", a capture-recapture model is used on the inhabited waters. The Schnabel method is used for a measurement of multiple examinations. The equation for this is:

$$M_t = \sum_{i=1}^{t-1} U_i$$

$$\hat{N}_s = \frac{\sum_{i=2}^{t} C_i M_i}{\sum_{i=2}^{t} R_i}$$

C_t = total number of individuals caught in sample t
R_t = number of individuals already marked when caught in sample t
U_t = number of individuals marked for the first time and released in sample t
M_t = number of marked individuals in the population just before the t^{th} sample is taken (Alcoy, 2013)

The newts have not been marked, but the pattern on their belly is unique. Every newt will be photographed upside down (figure 2.1) and then recorded in the program Wild-ID. This program compares all photographs and points out possible matches between individuals. This way it becomes a possibility to recognise previously caught newts.

Figure 2.1; Different belly patterns of great crested newts

2.3.Funnel traps

During the 9 weeks of monitoring, From the 23th of march until the 21st of may (Appendix I), depending on the water level and size of the water body, up to nine funnel traps are used per measurement. Three of the used funnel traps are floating traps with two funnel-openings. This way, the newts will stay inside the trap with the ability to surface for air. The remaining four funnel traps are a slightly older type and work with just one big opening (figure 2.2 & 2.3). For low water levels, the older types are the best choice. For deeper waters, the floating traps are ideal. When using the floating traps it is always needed to attach it to a nearby tree or bush so it won't float away.

Figure 2.2; Old type funnel-trap

Figure 2.3; Floating funnel trap

The floating funnel traps were, up till now, not used for the monitoring of amphibians in Grenspark DZ-KH before. For this reason, the 2 types of traps will be compared to each-other, based on the results. This is done to determine which trap is best to use in future research. To decide, the average caught amphibians per funnel trap are determined per type of funnel trap. An ANOVA test with repeated logistic regression will be carried out to see if the type of trap influences the presence of newt species, between these two types of traps. Because there is more than one observation, repeated logistic regression is needed since it's likely that two measurements of the same trap are more alike than two measurements of different traps.

The factors that are involved in this test are the type of funnel trap, four newt species and the interaction between the type of trap and the newt species (Figure 2.4). The test will determine if one trap is better than the other for catching a certain species of newt, and if the type of trap is of influence on the presence of newts in general. Some water bodies only contained enough water for the old type of funnel traps, these are not involved in this test and will be of no influence on the results.

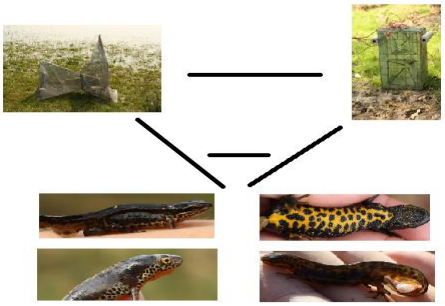

Figure 2.4; Visual image related to all subjects that are involved in this statistic analysis.

3. Results

3.1. Overview

Leemputten

All great crested newts are caught in the northern fen. This fen contained the most great crested newts, by far. 24 males were caught and 7 females.

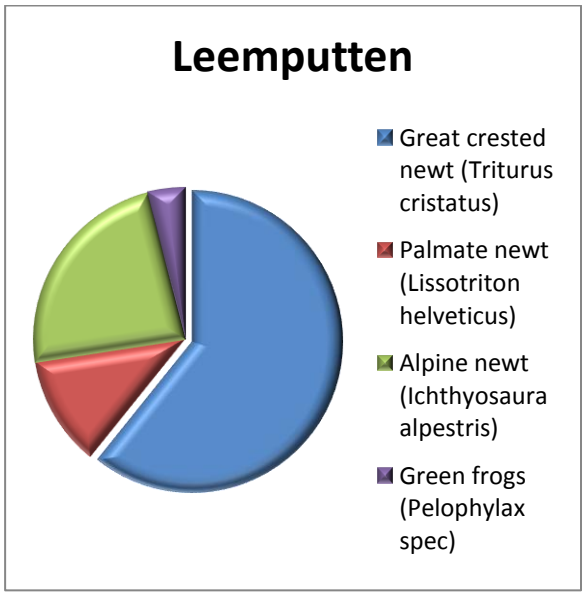

Table 3.1; Amphibians found at location 'Leemputten'

Leemputten	
Species	**Amount**
Great crested newt *(Triturus cristatus)*	31
Palmate newt *(Lissotriton helveticus)*	6
Alpine newt *(Ichthyosaura alpestris)*	12
Green frogs *(Pelophylax spec)*	2

Figure 3.1; Overview of all found amphibians at location 'Leemputten'

In this water body it seems clear that the great crested newt is the dominant newt species (figure 3.1). Smaller newt species like the palmate newt and smooth newt are remarkably low in amount, or even absent. The caught great crested newts differed in size, some measured only 9cm, while the largest great crested newt was a male with a size of 14,5cm. This shows that multiple generations are present. Eggs and larvae have been found and so these observations suggest that reproduction is successful.

The medicinal leech (*Hirudo medicinalis*) inhabits this fen, which is also a species that is protected, according to the habitats directive.

Ranonkelven

This fen contained a very abundant population of alpine newts. These are most found in a small ditch, next to the designated water body. Great crested newts have been found and individuals seemed to be of different age (difference in size of adult individuals), although no evidence of reproductive success was found.

The medicinal leech (*Hirudo medicinalis*) inhabits this fen as well.

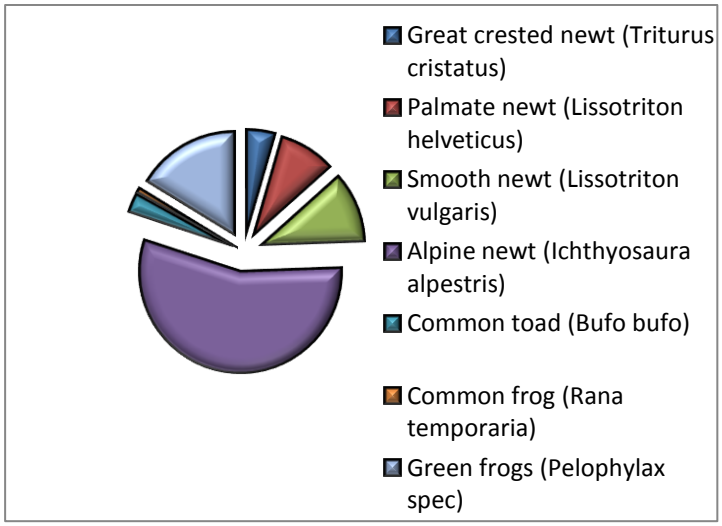

Figure 3.2; Overview of all found amphibians at 'Ranonkelven'

Table 3.2; Amphibians found at location 'Ranonkelven'

Ranonkelven	
Species	**Amount**
Great crested newt *(Triturus cristatus)*	6
Palmate newt *(Lissotriton helveticus)*	12
Smooth newt *(Lissotriton vulgaris)*	15
Alpine newt *(Ichthyosaura alpestris)*	75
Common toad *(Bufo bufo)*	4
Common frog *(Rana temporaria)*	1
Green frogs *(Pelophylax spec)*	22

Kwekerijven

This fen contained an abundant population of predaceous diving beetles. Even though, many amphibian species are found with, in particular, one male great crested newt.

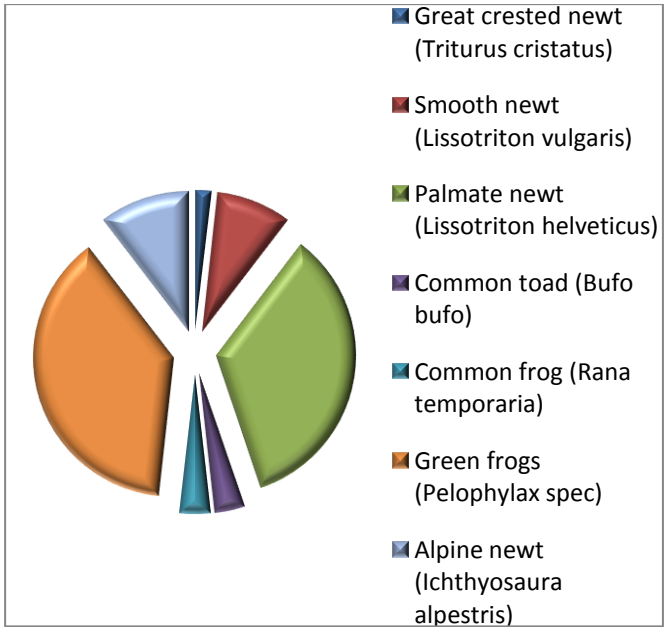

Table 3.3; Amphibians found at location 'Kwekerijven'

Kwekerijven	
Species	**Amount**
Great crested newt *(Triturus cristatus)*	1
Smooth newt *(Lissotriton vulgaris)*	5
Palmate newt *(Lissotriton helveticus)*	20
Common toad *(Bufo bufo)*	2
Common frog *(Rana temporaria)*	2
Green frogs *(Pelophylax spec)*	22
Alpine newt *(Ichthyosaura alpestris)*	6

Figure 3.3; Overview of all found amphibians at location 'Kwekerijven'

Kleine meer

This fen dried up after the first examination. The found results are therefore disappointing.

Table 3.4; Amphibians found at location 'Kleine meer'

Kleine meer	
Species	**Amount**
Common toad *(Bufo bufo)*	3
Alpine newt *(Ichthyosaura alpestris)*	1

Groote Meer

This lake-like fen contained a very low tide. During the research period it dried out completely. It was declared dry, at the end of May. With this drought, the rare shoreweed (*Littorella uniflora*) started to shape the area. Groote Meer did not contain many amphibians. Only during the first examinations, some amphibian species were found. None were found on the eastern side.

Table 3.5; Amphibians found at location 'Groote Meer'

Groote meer west	
Species	**Amount**
Common toad *(Bufo bufo)*	8
Smooth newt *(Lissotriton vulgaris)*	1

Talingven

This fen contained a very abundant population of predaceous diving beetles (chapter 6). Three species of amphibians were found.

Table 3.6; Amphibians found at location 'Talingven'

Talingven	
Species	**Amount**
Palmate newt *(Lissotriton helveticus)*	26
Green frogs *(Pelophylax spec)*	5
Alpine newt *(Ichthyosaura alpestris)*	7

Steertse Heide

This area has been used for agriculture purposes and has only recently been assigned as nature. A bomb well, surrounded by two flooded meadows, formed the water body that has been examined. Unfortunately, all but the bomb well dried out during this research project.

Table 3.7; Amphibians found at location 'Steertse Heide'

Steertse heide	
Species	**Amount**
Smooth newt *(Lissotriton vulgaris)*	32
Palmate newt *(Lissotriton helveticus)*	37
Alpine newt *(Ichthyosaura alpestris)*	23

The great crested newt has not been found, though it was expected to be present due to a earlier observation of one great crested newt, from another research. In this research, no great crested newts could be found. Unfortunately, the bomb well, just like the surrounding water bodies, dried out later in the season.

Akkerenven

A large fen with many bird-activity. Only a few fully grown amphibians are found and a lot of tadpoles were present. A pool frog (*Rana lessonae*) was found amongst the green frogs. A remarkable find was a three-spined stickleback (*Gasterosteus aculeatus)*, caught in a floating funnel trap on April 29th. Here as well, a great crested newt was found in a different research.

Table 3.8; Amphibians found at location 'Akkerenven'

Akkerenven	
Species	**Amount**
Green frogs *(Pelophylax spec)*	4
Smooth newt *(Lissotriton vulgaris)*	2

Zwaluwmoer

In multiple examinations, a high amount of predaceous diving beetles were found in this fen.

Table 3.9; Amphibians found at location 'Zwaluwmoer'

Zwaluwmoer	
Species	**Amount**
Alpine newt *(Ichthyosaura alpestris)*	8
Green frogs *(Pelophylax spec)*	11
Palmate newt *(Lissotriton helveticus)*	1

3.2.Water phase

According to all observations from caught newts during this research project, the water phase started in the second week of April and ended in the third week of May.

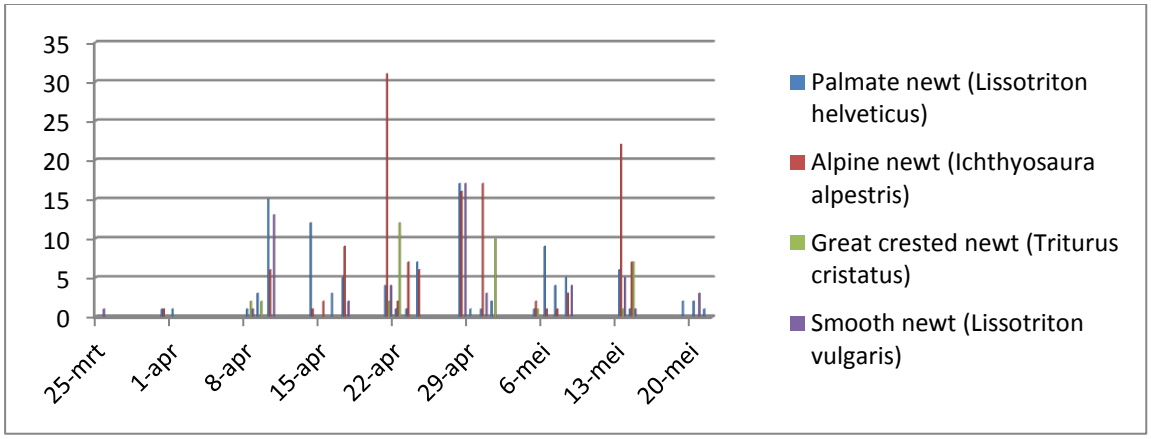

Figure 3.4; Water phase of all caught newt species, according to the results from this research project

3.3. Great crested newt range

The capture-recapture model, for the estimate of the population size of great crested newt, could only be carried out for results from the location 'Leemputten'. The newts for this model were checked in three measurements to get a clear view on the population size. On the first day of capturing, 12 newts were caught, the second day 10 and the third day 7. One newt was recaught between day 1 and day 3 (Figure 3.5 & Table 3.10).

The results from the Schnabel method are: $\frac{(10x12)+(7x22)}{1} = 274$

Table 3.10; Results used in the Schnabel method

Session *t*	#Captured Ct	#Marked recaptures Rt	#Marked before t
1	12	0	0
2	10	0	12
3	7	1	22

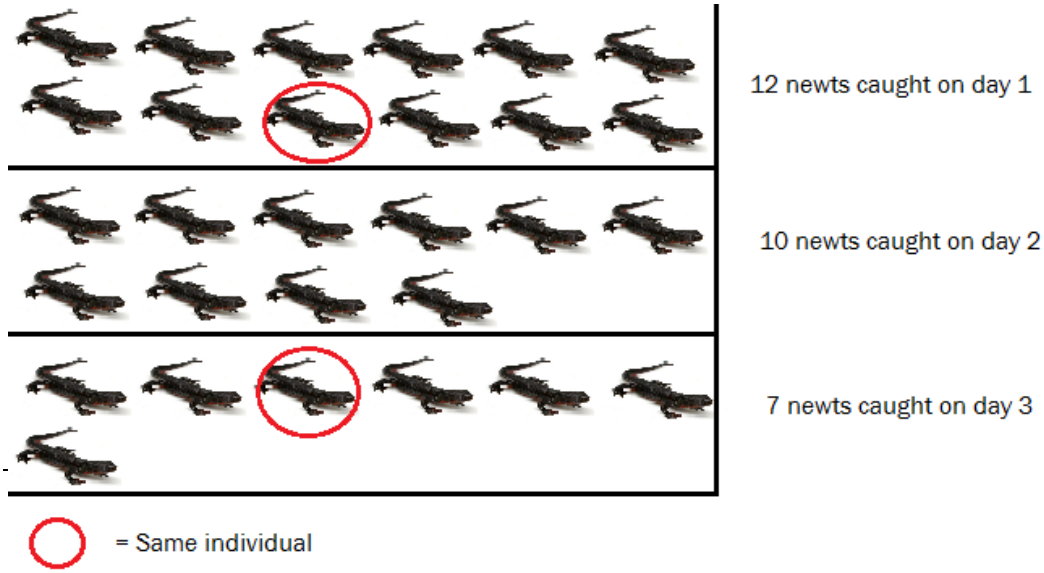

Figure 3.5; overview of the capture-recapture situation

Only one match was found with a male from day 1 and day 3. The outcome displays an estimated population size of 274. The Schnabel method, like other capture-recapture methods, could not be used to its full potential due to only one recaptured great crested newt.

All observations of great crested newts in 2015 are displayed in figure 3.6. No great crested newts have been found that moved from their first location, to another location. The observations of a great crested newt at 'Akkerenven' and 'Steertse Heide' came from different researchers.

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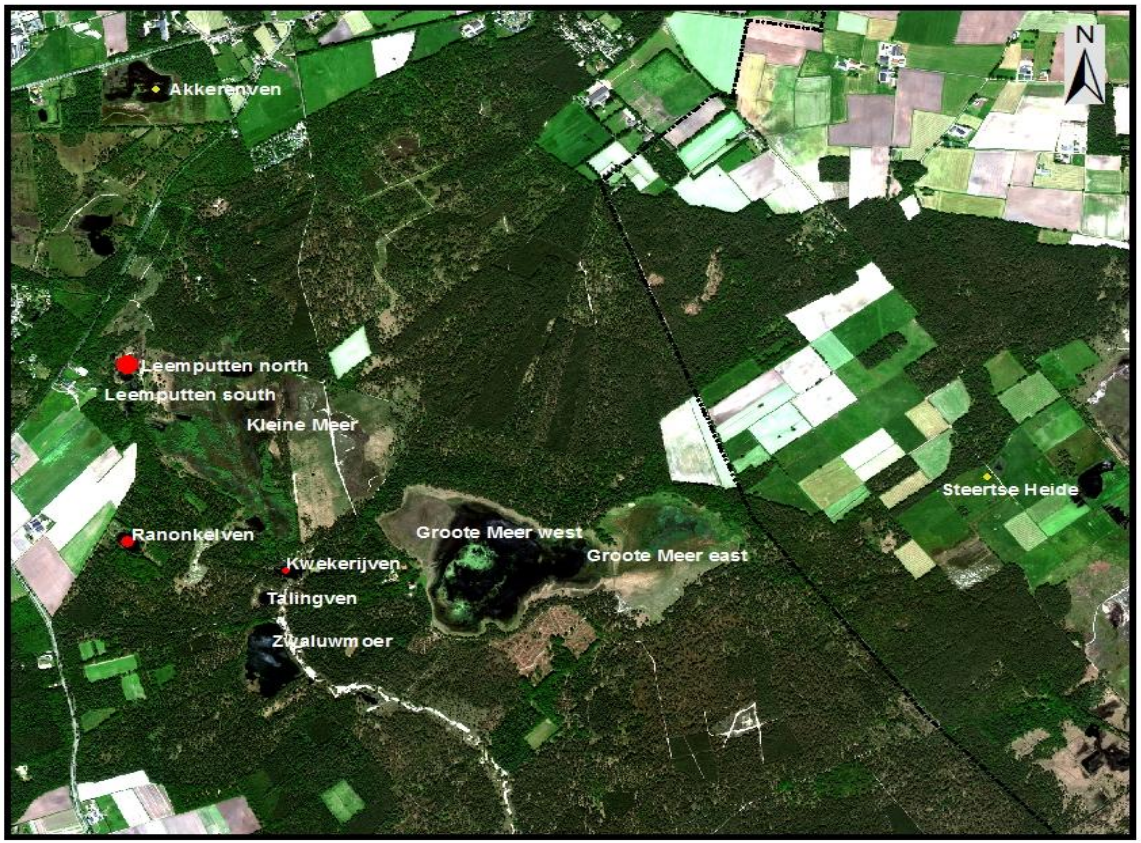
Great crested newt observations



Legend

- Found great crested newt
- Found great crested newt (observation from other)

0 470 940 1.880 2.820 3.760 Meters

Figure 3.6; Found great crested newts in Grenspark De Zoom, bigger dots resemble a higher abundancy (Source; ARCGIS, maps from Grenspark De Zoom)

3.4.Comparison of funnel traps

The comparison of both types of funnel traps was made to determine which trap was more effective for the monitoring project. In table 3.11 an overview is visible of all measurements that have been done. More old type funnel traps were available in this research and so, more measurements could be done with those. A statistic analysis however, evens this out to the floating funnel traps and will not influence the outcome. Locations where only one type of funnel trap could be used, have not been involved in this comparison.

Table 3.11; Overview of results from funnel traps

Funnel trap	Measurements	Empty traps	Succesfull traps	Contained amphibians	Total amount amphibians caught	From which newts
Floating	92	12	80	61	246	177
Old type	134	47	87	52	190	153

All involving factors, that could possibly influence the outcome, are tested on the presence of newt species, inside funnel traps. TYPE = the average chance of capturing a newt with one of the trap types. SPECIES = the chance this type of funnel trap captures a certain newt species (n=4). TYPE*SPECIES = the chance one type of funnel trap functioned better for capturing a certain newt species. Figure 3.7 shows that the only significance (0,011) was found on the TYPE of trap that is used. The mean difference is significant at the ,05 level (<0.05). One type of funnel trap has caught more newts in general, in comparison to the other funnel trap. Further tests are done to determine which type is better.

Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	95,820	1	,000
TYPE	6,400	1	,011
Species	7,788	3	,051
TYPE * Species	5,366	3	,147

Dependent Variable: Present
Model: (Intercept), TYPE, Species, TYPE * Species

Figure 3.7; Results of the ANOVA test with repeated logistic regression.

The two types of funnel traps are then compared and a significance of 0,019 (Sig. ,019) was found. Figure 3.8 displays that the floating traps are significantly better for capturing newts, in comparison to the older types of funnel traps. The results in Figure 3.8 also show that none of the two trap types are significantly better for catching a certain species of newt.

For example: The floating funnel trap is not better than the old type, when focussing on just catching the great crested newt, alpine newt, palmate newt or smooth newt. The floating funnel trap is however better for catching newts in general, compared to the old type of funnel trap.

Pairwise Comparisons

(I) TYPE	(J) TYPE	Mean Difference (I-J)	Std. Error	df	Sig.	95% Wald Confidence Interval for Difference	
						Lower	Upper
FL	OLD	,11[a]	,048	1	,019	,02	,21
OLD	FL	-,11[a]	,048	1	,019	-,21	-,02

Figure 3.8; Pairwise comparison of estimated marginal means, based on the original scale of dependent variable 'present'.

4. Discussion

4.1. Population

At the start of this research project, eight locations had been pointed out for examination (chapter 1.4). The great crested newt is most found at location 'Leemputten' (table 3.1). Together with the presence of a larva, caught in July, reproduction in this water body seems successful. At this location, natural enemies like medicinal leeches *(Hirudo medicinalis)*, predaceous diving beetles *(Dytiscidae)* and grey herons *(Ardea cinerea)* are common. These will influence the reproduction in a natural way. However, threads of pollution, and water bodies that dry out, are threatening the survival of larvae. The year 2015 contained more dried out water bodies than previous years (Diggelen & Laurijssens, 2014). No doubt, the dry year had its impact on amphibians. Many larvae of frogs and newts got separated from the main water into small puddles, which eventually dried out.

The southern fen at 'Leemputten', next to the reproductive water, has been tested without success. No great crested newts were found. Also, a thick sludge layer and no underwater vegetation made the water body unlikely to be suitable (Oldham, 2000). Since this fen is located directly next to the reproductive water, it's likely to be inhabited by the great crested newt. However, it needs to comply to the characteristics of the water habitat of the great crested newt, which are according to Oldham et al. (2000), Rannap & Briggs (2006), Van Delft et al. (2003) and Langton, Beckert & Foster (2001):

- Isolated and stagnant water
- Permanent hydrous
- moderately nutrient rich to nutrient rich
- Overall good water quality
- pH >5,5
- Shallow shore-zone
- Deep parts in the water body
- Up to 80% of the water surface consists of underwater and shoreline vegetation
- At least 400-750m^2 in size
- Partly shaded/open
- No fish
- Suitable water bodies in the vicinity (500m)
- Cluster of 4-6 pools present, optimal ≥ 4 per km^2
- Suitable land habitat (forest) within 80 meters of the designated water
- Buffer zone (brushwood and thickets) of at least five meters wide around the water

An important feature is the lack of another suitable water body. The surrounding water bodies have either fallen dry, or are not suitable for great crested newts. The great crested newt is known to demand multiple small fens, situated in groups close to one another, with no more than 500 metres separating them (Rannap, Lohmus & Linnamagi, 2012). Figure 4.1 displays the situation around the location 'Leemputten'. The water bodies; Ranonkelven, Kleine Meer, Groote Meer and Jagersrust have all dried out and are thus, not suitable for reproduction. Furthermore, a busy road possibly makes it hard for the great crested newts to reach the northern water body 'Bronven'. The southern fen at 'Leemputten' however, contains water and is in the direct vicinity.

grenspark De Zoom · Kalmthoutse Heide

Range great crested newt

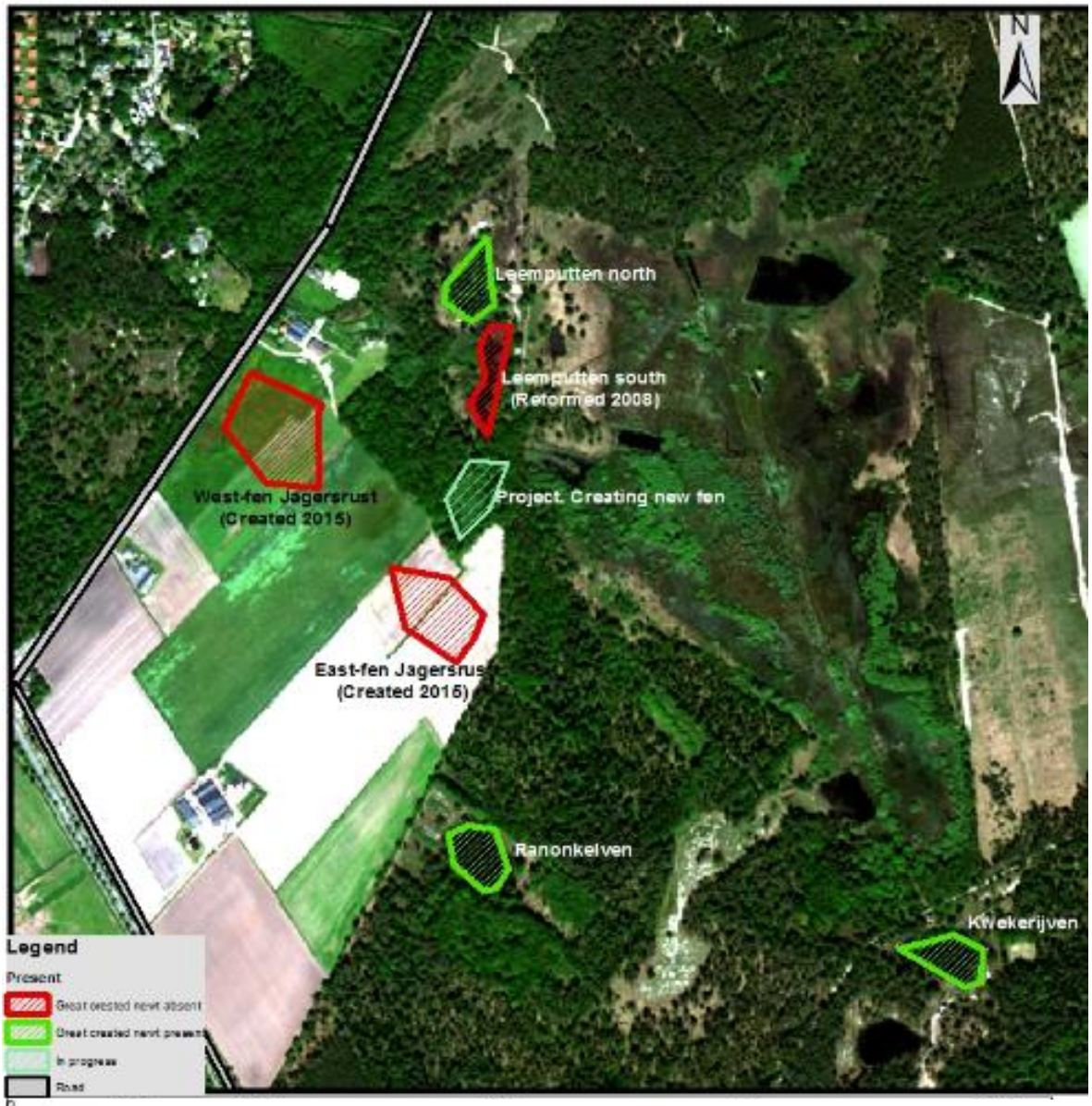


Figure 4.1; Overview of the situation around location 'Leemputten'

In a research from Kok, D (2014) the chemical values have been determined for both fens at location 'Leemputten'. The difference between the two fens can be seen in table 4.1.

Table 4.1; Chemical analysis from both fens at location 'Leemputten' (Kok, 2014)

Naam van ven	temp. °C	pH	O_2 mg/l	EC_{25} µS/m	NO_2^-N mg/l	NO_3^-N mg/l	NH_4^+N mg/l	$PO_4^{3-}P$ mg/l	SO_4^{2-} mg/l	HCO_3^- mg/l	Cl^- mg/l	Ca^{2+} mg/l	K^+ mg/l	Mg^{2+} mg/l	Na^+ mg/l	Fe(tot.) mg/l
Leemputten (R.)	7.3	6.55	9.1	12.11	< 0.003	< 0.05	0.09	0.02	12	12.8	20.9	5.3	4.6	2.1	12.0	0.13
Leemputten (L.)	7.5	7.09	7.6	31.81	< 0.003	0.10	0.03	0.04	29	97.9	31.4	26.0	17.0	7.3	18.0	0.05

Its immediately visible that Leemputten (L), which is the southern, larger fen, contained some remarkable chemical values. High amounts of bicarbonate (HCO^{3-}), sulphate ($SO4^{2-}$), chloride (Cl^-), calcium (Ca^{2+}) and potassium (K^+), clarify pollution. A high concentration of bicarbonate and sulphate will cause peat degradation, with phosphate formation as a result. Excessive amounts of phosphate cannot be absorbed by plants and can cause direct, or indirect eutrophication (Bouwman et al, 2011). The thick sludge layer is responsible for the lack of underwater vegetation as for most flora, a muddy sediment of <2cm is needed to sprout (Boedeltje, 2005). The relatively low amount of iron (Fe) slows phosphate formation down (Bouwman et al, 2011). The high concentration bicarbonate, buffers in the soil. It's also a strong pH buffer, mainly in the presence of calcium carbonate (CaCO3). However, since bicarbonate is quite mobile, and CO_2 diffusion is a slow process, the pH decrease in such soils after proton release by plants is small (Lucena, 2000). As a result of internal eutrofication, this fen might become more polluted every year. However, during the excavation of the fens, between 1-2 meters of the top layer has been removed which has definitely reduced the risk of eutrofication. It's advised to check the chemical values of this water body on a yearly basis, and act when excessive nutrient levels go up. Also, a decrease in the sediment layer might cause a positive growth of underwater vegetation, after excessive nutrient amounts have stabilized (Boedeltje, 2005). The great crested newt will not attempt to reproduce in this fen, in its current situation.

4.2. Creating a new reproductive fen

Creating a water-holding fen in the vicinity of the 'Leemputten' could improve the population. As seen in figure 4.1, Jagersrust contains two water bodies in the direct vicinity (<500m) of the northern fen. Those were created in the winter/spring of 2015 and have for now, dried out. However, they are pools with the potential of becoming a reproductive water, for the great crested newt. However, due to their agricultural history, these fens are sensitive for pollution (Abler et al, 2001). If these fens can contain water during the entire year, underwater vegetation sprouts, and shore vegetation shapes a suitable land habitat with high enough plants to cause a partially shaded water surface, it might become inhabited by the great crested newt over years. In order to achieve this; a winter- and summer observation of chemical values, in these fens are advised to be carried out. This way, a possible pollution can be dealt with quickly. Also, even in dry seasons, the water bodies should contain water at all times to give underwater vegetation a chance to sprout, grow and spread. The northern fen at Jagersrust might be less accessible than the southern fen. This is because its located on a bigger distance, from the forest. In a plan to protect the great crested newt, Spikmans, Janse & Zollinger (2007) advise to plant bush-forming, indigenous plants like hawthorn *(Crataegus spec.)*, filbert *(Corylus avellana)* and blackthorn *(Prunus spinosa)* to create a pathway for great crested newts, which will not quickly cross an open area.

Kleine Meer is also a great location for a reproductive water, for great crested newts. However, this water body dried out at the very beginning of spring. Forming a water retaining well in the vicinity of

'Leemputten', within 'Kleine Meer' might form another suitable habitat. However, it is unclear whether there is enough supply of groundwater to the marshes, and to what extent this is caused by groundwater extraction (for drinking water, industry and (former) agriculture).

4.3. Other water bodies

Akkerenven was involved later on in the study, due to a observation of a great crested newt from a different research. Because of this, less examinations have been done in comparison to the other locations. In this fen, one adult three-spined stickleback (*Gasterosteus aculeatus*) was found in a floating funnel trap at the first examination, end of April. Predatory fish species have a negative consuming and non-consuming effect on amphibians during their embryonic and larvae stage (Jarvis, 2010., Beebee, 1996). Not only do they feed on the larvae, it is suggested that certain fungi, carried by predatory fish, influence the percentage of hatchlings among amphibians (Jarvis, 2010). Together with many bird activity, 'Akkerenven' is unlikely to hide a reproducing population of great crested newts. A fully grown great crested newt from a different location, might have been found, looking for a partner.

Some water bodies like 'Kleine Meer' and part of 'Steertse Heide' have dried out and became impossible to test with funnel traps. Since great crested newts inhabit relatively deep waters (Oldham, 2000), dried out water bodies have not been further researched. Later in the season, 'Groote Meer', 'Steertse Heide and 'Ranonkelven' have fallen completely dry. 'Groote Meer' and 'Ranonkelven' are possible reproduction waters for great crested newts. Multiple great crested newts were found at Groote Meer in 2006 (Teunen, 2006). However, when fallen dry, before the larvae reach their adult stage, great crested newt larvae will not survive (RAVON, 2015). Though in 'Groote Meer' no great crested newts were found; in 'Ranonkelven', six were caught (table 3.1). An attempt to reproduce in this fen might have occurred, probably without success this year. Ranonkelven usually contains water during the entire season but as mentioned earlier, 2015 was a very dry year.
The medicinal leech is also a very rare species that is presented in the habitats directive, like the great crested newt. It requires warm-water ponds with a range of suitable hosts. Blood-meals from amphibians are crucial for the survival of their juveniles (Elliot & Kutschera, 2011). By protecting the amphibians, the medicinal leech profits as well.

Although the newts were caught at different locations and the information about the water phase (figure 3.4) therefore, is not very reliable, it's still possible to see a number of estimation points. According to the results from this project, the water phase started in the second week of April, and ended in the 3rd week of May, which is just a little later than expected according to RAVON (2015).

4.4. Comparison of funnel traps

Not only have the results from the statistic analyse (Chapter 3.4) shown that the floating funnel traps in general, catch more newts than the old type funnel traps. During the fieldwork it also became clear that they are much easier to handle and light in weight. The floating traps are an improvement, not just for the results, but also to make the fieldwork timesaving. They are easy to assemble and easier to carry (more at once). However, they can only be used in some deeper waters. The old type funnel traps are more effective in a low tide and thus, a combination of both funnel traps seems the best option. The great crested newt is a species of deeper waters (Oldham, 2000). It's highly recommended to keep using these floating traps in future monitoring research.

4.5. Schnabel method (capture-recapture)

The Schnabel method was conducted on three examinations at location 'Leemputten' (Figure 3.5). This method is used for capture-recapture models with more than two observations. However, in the end, all imported units are divided by the amount of recaptured animals. In this research, only one animal was recaught and thus, the method could not be used to its full potential. To get a clear view on the exact population size; a research needs to be done with more than five capture days. When executed at the start of the water phase, and thus closer follow up examinations, a more reliable estimation can be made. The capture-recapture model pointed out that an estimated population of 274 individuals is present at this location. Only one larva was found over a period of two hours, in a relatively small fen (±500m^2). This suggests that only a small amount of larvae will reach the adult stage. It's unclear if the estimated population size is a high or a low number. However, at location 'Leemputten', males and females were present and reproduction established. As long as young (1st or 2nd year) great crested newts are found and both males, and females are present in the same water body, they can sustain their population (Langton, Beckett & Foster, 2001).

5.Conclusion

A sustainable population of great crested newts is present in Grenspark De Zoom - Kalmthoutse Heide. Even though 274 individuals still seems a vulnerable population and needs to be protected. The greatest threat this population faces is the risk of water bodies falling dry. All water bodies, surrounding the location 'Leemputten' have fallen dry this season which make it impossible for the great crested newt to spread. Also, colonisations in these waters could have been harmful to the population due to failed reproductive attempts. The newly created fens at 'Jagersrust' will create new opportunities for reproductive success, for the great crested newts. Situated between 'Leemputten' en 'Ranonkelven', if all characteristics for the water habitat are met, colonisation can be achieved. However, with threads of pollution and falling dry; the fens at 'Jagersrust' must be studied thoroughly. This way measures can be conducted in time.

The floating funnel traps are significantly better for capturing newts than the older types of funnel traps. However, due to their design, a combination of both funnel traps works for water bodies with high- and low water levels.

5.1.Recommendations

Its important to keep monitoring this population of great crested newts and especially to focus on the identification of individuals, so it might be possible to get a view on their ability to spread to other water bodies. This way it might become clear just how important it is to create more water holding fens.

Its highly recommended to protect the reproductive water from visitors to the park. This can be done by placing a no admittance sign or by making it inaccessible for the public.

The water bodies at 'Jagersrust' should be studied continuously so that possible pollution can be dealt with quickly.

6. Distribution of diving beetles (Dytiscidae) in Grenspark De Zoom - Kalmthoutse Heide

Diving beetles are aquatic freshwater insects from the order *Coleoptera,* that come with around 350 species in the Netherlands and Belgium (Drost et al, 1992). *Dytiscidae* is the most diverse family in which both adults and larvae are aquatic (Ribera, Vogler & Balke, 2007). Among these species, all members are carnivorous diving beetles. Predaceous diving beetles like *Cybister lateralimarginalis* will feed on likely anything that is alive, and the proper size for them to handle. Herbivorous beetles like *Hydrophilus piceus,* feed mostly on plants and are slow swimmers (Drost et al, 1992., Ribera et al, 2007). Water beetles set high standards to their ecological niche (Calosi et al, 2009). The most important feature will be the absence of fish, as fish will feed on the larvae of diving beetles. Besides that, chemical parameters are directly related to the species that inhabit the water (Scheers, 2014). For example; *Dytiscus lapponicus* is abundant in relatively acidic waters (Drost et al, 1992). Even though they are bound to a life in an aquatic habitat, many species are strong flyers and able to disperse readily over land. This way, diving beetles are never abundant in polluted waters (Ribera et al, 2007).

Diving beetles are remarkably and often noticed, though the common species and whereabouts are in many wetlands unknown. From 2009 - 2014, the larger diving beetles from the families *Dytiscus* and *Cybister* have been documented for Grenspark the Zoom by Scheers & Lambeets, 2014. Now, in 2015, they will again be examined as a side-research from the monitoring of great crested newt *(Tristus cristatus).* In funnel traps, used for catching amphibians, diving beetles are exuberantly present. And so, their data is collected, without additional techniques.
Four species of predaceous diving beetles are found (Figure 6.1 - 6.4). These are *Dytiscus marginalis, Cybister lateralimarginalis,* ***Dytiscus lapponicus*** and *Dytiscus circumflexus.*

Figure 6.1; *Dytiscus marginalis*

Figure 6.2; *Cybister lateralimarginalis*

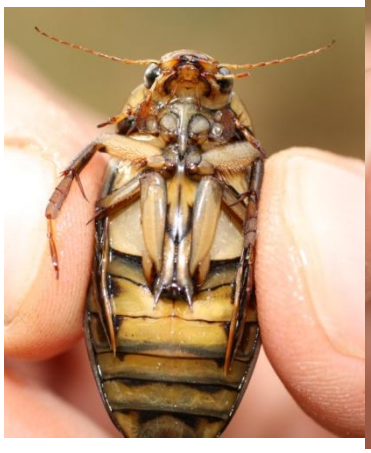


Figure 6.3; *Dytiscus lapponicus*

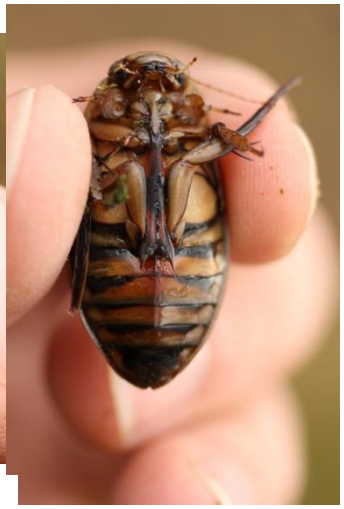


Figure 6.4; *Dytiscus circumflexus*

Next to these predaceous diving beetles, also the herbivorous *Hydrophilus piceus* was found at multiple fens (Table 6.1).

Table 6.1; Total caught diving beetles with funnel traps (* = rare species)

	D.marginalis	C. lateralimarginalis	D. lapponicus*	D. circumflexus	Hydrophilus piceus
Leemputten	13	52	X	1	4
Ranonkelven	34	86	X	X	3
Kwekerijven	19	101	31	X	3
Talingven	6	222	35	7	1
Zwaluwmoer	3	54	11	2	X
Akkerenven	1	3	X	1	X
Steertse Heide	1	1	X	1	1
Total	77	519	77	12	12

Table 6.1 also shows that *Cybister lateralimarginalis* is by far the most abundant species of yellow-banded predaceous diving beetles, mainly in 'Talingven'. In all probability, in this quite small fen, the same individuals have been caught in following examinations. Despite this, their numbers are still far greater than other species.

Dytiscus lapponicus is a rare species of predaceous diving beetles, especially in Belgium (Scheers & Lambeets, 2014). Also, the pools in the Netherlands where it was found, are newly discovered locations. *Dytiscus lapponicus* was found 77 times, which is a very positive amount for this rare species. The three locations where it's found, are all acidic fens which suggests that this beetle relates to a relatively high acidity.

The results show that *D. circumflexus* is actually more rare in Grenspark De Zoom. However, this species is marked as a common species and mainly inhabits small nutrient-rich fens (Drost et al, 1992). The nutrient poor and acidic waters in Grenspark De Zoom – Kalmthoutse Heide are, most likely, not the main habitat for this species. It's also possible that this smaller beetle is influenced by high competition from mainly *C. lateralimarginalis*.

These predaceous diving beetles are threatened by pollution of water bodies and the fragmentation of suitable waters. Many can fly and reach new water bodies easily. However, species like *Dytiscus lapponicus* can't fly and need water bodies that are permanently hydrous or water bodies that are in the near vicinity (Scheers & Lambeets, 2014). The examined fens do not contain fish and are for that reason very suitable to predaceous diving beetles. The situation at Grenspark De Zoom is very advantageous for these beetles. Mainly Zwaluwmoer, Talingven and Kwekerijven are acidic fens with the absence of fish, which contain water at all times. For now, without too many changes to the fens, populations of predaceous diving beetles should be sustainable.

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Appendix I planning

Every day the funnel traps were emptied, they were replaced in the next fen. Except for Fridays; funnel traps were brought to the storage location.

Table I1; Global view on the time format of fieldwork

Mon	Tue	Wed	Thu	Fri	Sat	Sun
Week 1 (23/3 - 27/3)						
Week 2 (30/3 - 5/4)						
Week 3 (6/4 - 12/4)						
Week 4 (13/4 - 19/4						
Week 5 (20/4 - 26/4)						
Week 6 (27/4 - 3/5)						
Week 7 (4/5 - 10/5)						
Week 8 (11/5 - 17/5)						
Week 9 (18/5 - 24/5)						

Legend	
	Placing funnel traps
	Emptying funnel traps
	Placing and emptying funnel traps