From meadows to marshland - response of small mammal populations

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Abstract: In January 2012, nature reserve De Onlanden, located in the northern part of the Netherlands, changed suddenly from a meadows and hayfield biotope on peat soil into a large-scale marshland biotope and water containment area. The effects of this sudden and major biotope change on the small mammal population in De Onlanden were studied. Monitoring was done by live-trapping of small mammals during the summer periods in the years before and after the biotope change. The small mammal populations changed completely as a result of the transition of relatively dry meadow biotopes with annual mowing and grazing into marshland biotopes with strong water-level fluctuations and uncontrolled vegetation development. Common vole (*Microtus arvalis*) almost completely disappeared from De Onlanden, even in the remaining grassland areas, probably as a result of high water levels in winter. Field vole (*Microtus agrestis*) numbers also declined, but the species could still be found at locations with dense vegetation and relatively low water levels. Shrew species increased their numbers in marshland biotopes. Common shrew (*Sorex araneus*) was present in high numbers before the biotope change, but was found in the marshlands in even higher numbers. Water shrew (*Neomys fodiens*) profited most of the biotope change. By the end of the study it occupied the whole study area. Locally, exceptionally high numbers were captured. Pygmy shrew (*Sorex minutus*) also started to appear at several locations by the end of the study. No evidence was found for food resource competition between the shrew species.

Keywords: De Onlanden, common vole, field vole, common shrew, water shrew, pygmy shrew, biotope change, monitoring, live-trapping, water management.

Introduction

In the Netherlands there is a growing need for capacity to store increasing amounts of surface water produced by heavy rainfall, as a result of climate change. One of the solutions for this storage problem is the transformation of rural grounds into water containment areas. This transformation often results in major biotope changes. Water levels are raised and the management regime of the area is changed. The effects of such biotope changes on nature in the area are predicted during the planning phase of the transformation project, and are sometimes monitored for certain critical species or communities after the transformation has been established. The effects can also be noticed, on a macroscopic level, by nature managers and visitors of the area. However, for many species living in the newly established water containment areas, the effects of the transformation on population size or distribution over the area are largely unknown or only poorly described.

In the northern part of the Netherlands, the nature reserve De Onlanden was also designated as a water containment area. Therefore, the largest part of the reserve has recently been transformed. From a farmland area, consisting of meadows and hayfields on peat soil with fixed surface water levels, it has turned into a marshland with much higher water levels and stronger fluctuations. The largest part of the area is now unattended, since high water levels make maintenance by mowing or grazing impossible. The resulting vegetation development in this part of De Onlanden contributed considerably to the large biotope change that has occurred.

The water shrew (*Neomys fodiens*) is adapted to wet biotopes and prefers clear, relatively deep water, like streams, large ditches, or ponds (Carter & Churchfield 2006). With its water repelling coat and fringes of stiff hairs on its back feet and tail to propel itself, it can dive up to 2.5 metres deep in search for food (like small invertebrates) in the water (Vogel et al. 1998). In the Netherlands the water shrew is a relatively rare species and is usually found in low densities during monitoring with live-traps in suitable biotopes (van Bemmel & Voesenek 1984, La Haye & Haan 1998, Bekker 2010, van der Linden & van der Weijden 2011). Before the transformation of De Onlanden, the occurrence of the water shrew was known here from a few locations through monitoring (R. Haselager, unpublished report; Bekker 2009), sightings (R. Blaauw and R. Oosterhuis, personal communication) and as prey in barn owl (*Tyto alba*) pellets (W. van Boekel, unpublished results).

The aim of this study was to monitor the changes occurring in the small mammal populations in De Onlanden as a result of the large and sudden biotope changes. It was predicted that the water shrew would clearly benefit from this change and that other species, such as common vole (*Microtus arvalis*) and common shrew (*Sorex araneus*), would be negatively affected. Since a comparable study had not been performed before, no prediction could be made about the speed of these changes.

Study area

De Onlanden is a nature reserve of about 3000 hectares, situated southwest of the city of Groningen in the northern part of the Netherlands (figure 1A). Two small rivers, Peizerdiep and Eelderdiep, run through the area from south to north. In the western part of the reserve lake Leekstermeer is situated. Until recently, most biotopes of the area consisted of extensively managed meadows and hayfields on peat soil, with fixed surface water levels, controlled by pumping stations. Management consisted of low density grazing by cattle or sheep. Mowing was done once a year, at the end of the summer period. Patches of marsh forest, dominated by black alder (*Alnus glutinosa*), grew in De Onlanden in places where in the past open water existed, like sites where peat soil had been excavated (figure 1B). These forest patches were not managed.

Between 2008 and 2012, the largest part of De Onlanden was transformed into marshland, serving as a water containment area designed to prevent flooding of inhabited areas in case of heavy rainfall. For this purpose a number of channels were dug out that connect the two small rivers to lake Leekstermeer (figure 1A). Also, much of the topsoil layer around these channels was removed to allow water to spread out over the whole area more easily. Dikes were built around De Onlanden in order to contain the water within the area. As a result of these changes, large parts of De Onlanden have turned into marshes or open water. Water level is no longer fixed, but is allowed to fluctuate depending on the amount of rainfall in the catchment area of the rivers. The higher water levels in the area serve nature conservation objectives too. In parts of De Onlanden to the south and directly east of lake Leekstermeer, water levels were raised in 2011. In the remaining area water levels were raised from the beginning of 2012.

Before 2012 the main biotope of De Onlanden consisted of the aforementioned grasslands on peat soil (figure 2A). Management by grazing and mowing resulted in low and relatively uniform vegetation, consisting mainly of grasses and herbs. At some places soft rush (*Juncus effusus*) dominated the veg-

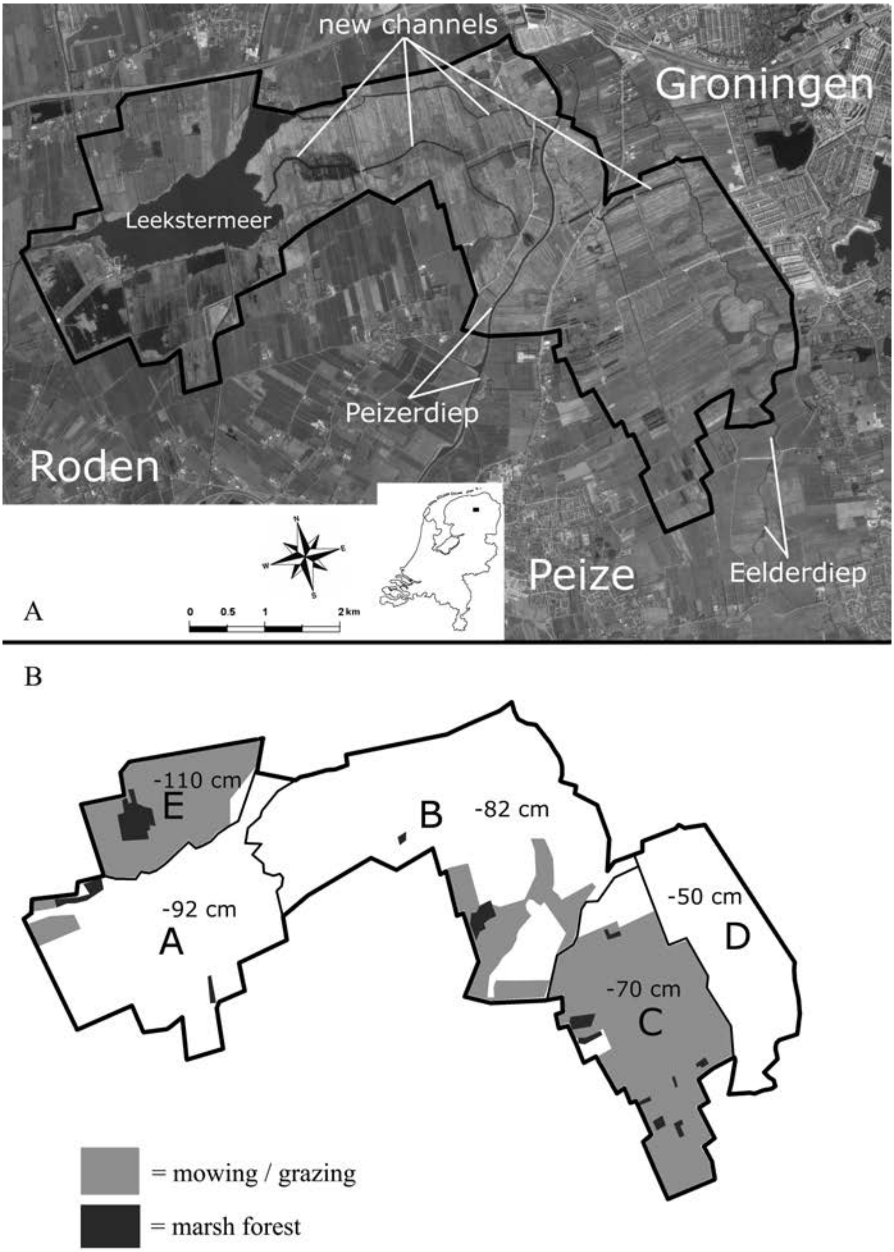

Figure 1. Location and area of De Onlanden in the northern part of the Netherlands. A. Aerial photo (with courtesy: Eurosense B.V.) of the situation in De Onlanden after the transformation into a water containment area, but before the water was let in. The newly dug channels are clearly visible. The black line marks the border of the study area. B. Parts of the study area with different surface water level regimes (in cm below standard sea level) after the biotope change (with courtesy: Waterschap Noorderzijlvest). Areas where mowing and/or grazing still occurred and the locations of the patches of marsh forest are also shown.

A

B

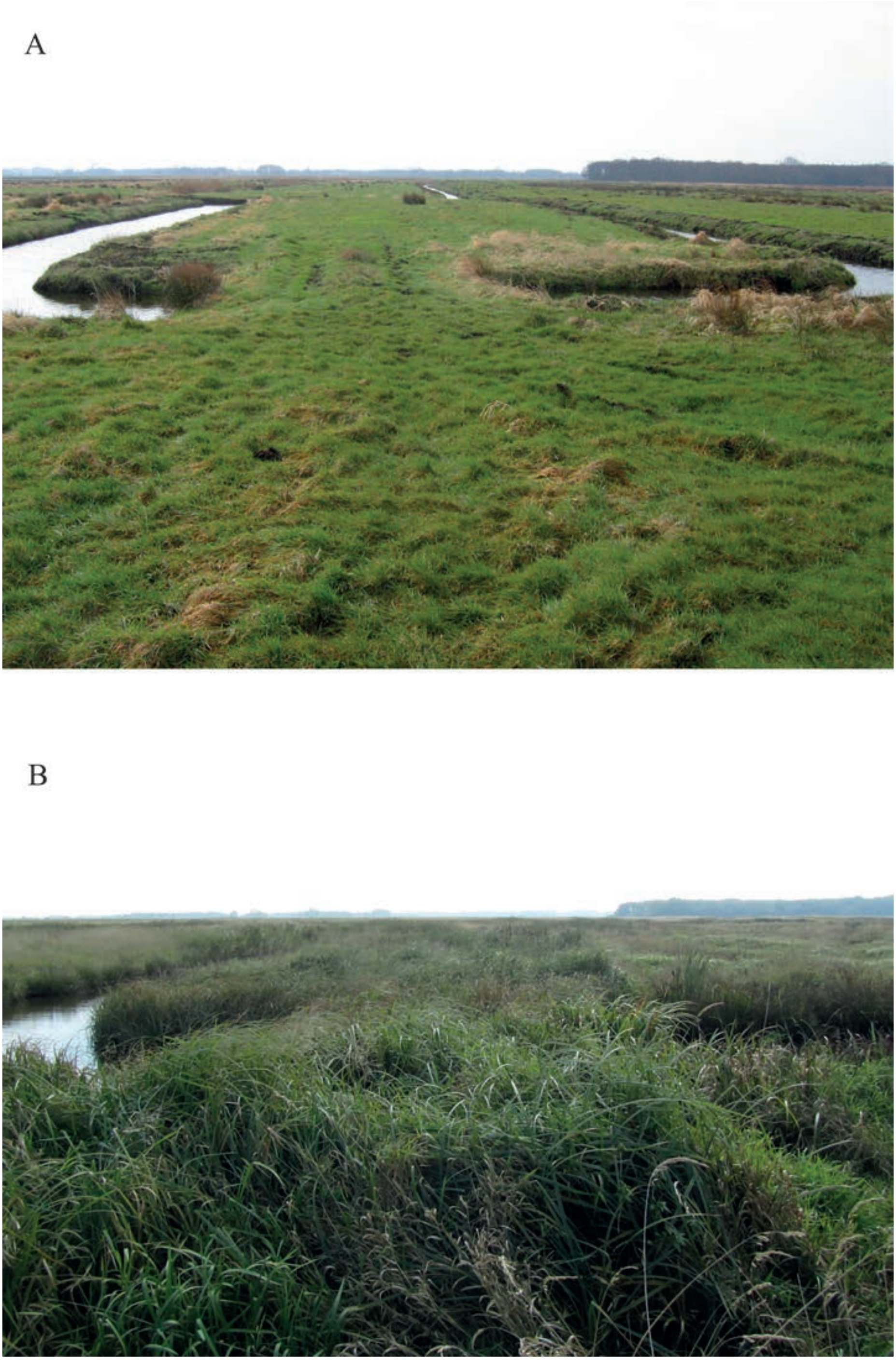

Figure 2. Example of the biotope change from meadow (A; photo taken in January 2009) to marshland (B; photo taken in September 2015) in De Onlanden as a result of the transformation to a water containment area. At this location (subarea B in figure 1B) the surface water level was raised by 30 cm in 2012. *Photos: Wim van Boekel.*

etation. Ditches and other water courses were cleared of excess vegetation yearly. Water level was kept constant at -110 cm NAP (i.e. 110 cm below standard sea level) in summer and -130 cm NAP in winter. Mean ground level was -80 cm NAP.

After the transition to water containment area and marshland a variety of biotopes were formed in De Onlanden, ranging from open water through marshlands with different mean water levels to grasslands with water levels just below ground level. Only the area to the north of lake Leekstermeer remained unchanged (subarea A in figure 1B). Minimum surface water levels were raised by 20 to 60 cm and varied in different parts of De Onlanden, due to several barrages in the watercourses (figure 1B). Water levels could fluctuate continuously, mostly in the range of ± 10 cm. In the winter months, water levels could rise by 20 to 50 cm over periods of weeks. In some parts of De Onlanden, management by mowing and grazing continued after the biotope change (figure 1B), but in the marshland areas this type of management was no longer possible. Here the vegetation was allowed to develop freely, with at most locations a much higher and more dense vegetation as a result (figure 2B). Reeds (*Phragmites australis*), sedges or soft rush dominated here. In marshlands with relatively low water levels, patches of grassland remained.

On 4 January 2012, De Onlanden was prematurely taken into use as a water containment area in order to prevent flooding of populated areas in the northern part of the Netherlands, caused by heavy rainfall in the preceding week. Within 48 hours the water level in De Onlanden was raised by 50-70 cm. The largest part of the area disappeared under water. After two days the water had started to run off and after a week, the water level had dropped to the new situation described above. The biotope change in De Onlanden was therefore not a slow transition, but occurred in a matter of days. Since then, water levels have been changing constantly, being relatively high in the winter period and low in summer.

Methods

The small mammal population was monitored yearly in the summer period (end of May until end of September), during the years 2009-2015. Each year 24 to 31 locations within the study area were sampled by live-trapping, except for 2009 when eight locations were sampled. Locations were chosen as to cover the whole study area in a two-year period. Locations were evenly distributed throughout the area within each trapping season. In trying to ensure that the monitoring included all small mammal species present, locations representing the variety of biotopes were chosen. For instance, after the biotope change traplines were placed in marshlands with different water levels, but also in the remaining meadows and hayfields and in the forest patches. Most locations were associated with ditches or larger channels in the area, in order to include the biotope of the water shrew, but traplines were also placed in the centre of fields or in marshes with water at ground level.

At each location a trapline was placed consisting of 20 Longworth live-traps in pairs at ten metre intervals. Traps were filled with hay, living mealworms (*Tenebrio molitor* larvae) and a piece of carrot. After two nights of prebaiting with secured trapdoors, three nights of trapping followed. Full details of the trapping method and procedure are described in van Boekel (2013). For each location a vegetation type description was made, and surface water level relative to ground level was noted.

Of all captured animals, except for water shrews, some hair on the back was clipped for recognition of recaptured animals. Water shrews were not clipped, since this might affect the water repellent properties of their coat. For recognition of previously captured water shrews their weight and the combina-

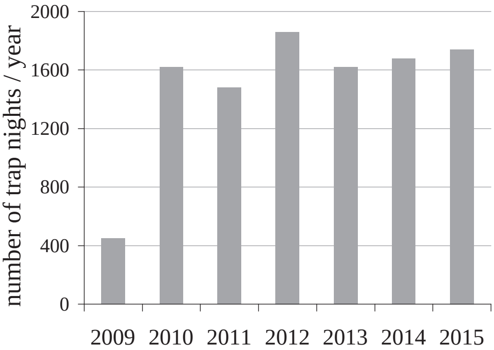

Figure 3. The total number of trap nights established during each year of the research period in De Onlanden.

tions of markings on their coat (i.e. white spots near eyes or on ear- and tailtips, black spots and stripes on belly or throat) were noted. In general, water shrews could well be recognised individually with this method, but at high densities (more than ten individuals caught in one trapline) recognition was not always certain. In cases of doubt, it was assumed that the animal had already been captured before in that trapline. At high densities of water shrews, the presented numbers are therefore minimum numbers of individuals.

Until now, there is no evidence that Millet's shrew (*Sorex coronatus*) lives in De Onlanden. In barn owl pellets from all locations in and around this area only skulls of common shrews were found (W. van Boekel, personal observations). It was therefore assumed that all captured animals of the *Sorex araneus/coronatus* group were common shrews.

Results

For the research period of 2009-2015 the number of trap nights per trapping season is given in figure 3. Some variation in trapping effort occurred between years, due to weather conditions and available time. In 2009 trapping could only be done at the end of the season, resulting in a much lower number of trap nights.

Over the study period the small mammal population showed a distinct change in the species composition (figure 4). The numbers of common voles and field voles (*Microtus agrestis*) that were caught in the traps were high in 2009 and 2011, when at some locations 20-25 individuals of common vole were trapped. From 2012 on, numbers of these voles were far lower. Compared with the period before the biotope change, common vole had disappeared almost completely from the study area (figure 5). Even in the biotopes that strongly resembled the former grasslands (mostly situated in subarea C in figure 1B), common voles could only be found in very low numbers. The total numbers of field voles caught in the last two years of the study period exceeded the numbers of common voles.

Numbers of the different shrew species increased during the study period (figure 4). This increase was most prominent for water shrew. The spatial distribution of captures of this species showed that water shrews colonised the complete area by the end of the study period (figure 6). By then, water shrews were found in high densities in the marshland biotopes. Largest number of animals (up to 15 individuals) was caught at locations with a half-open vegetation of *Juncus effusus* or reed sweet-grass (*Glyceria maxima*), with a water level at, or just above, mowing field, and with no open water at close range. At the end of the study period, water shrews were also found in low numbers along ditches in the yearly managed grassland biotopes. High numbers were also caught in some of the forest patches. In the large grove in area E up to ten individuals per trapline were caught.

Common shrews were caught in all biotopes within the study area, both before and after the biotope change. Numbers caught per location ranged from 1 to 27 individuals. The numbers of common shrew caught per 100 trap nights showed some increase over the study period, but also fluctuated between years.

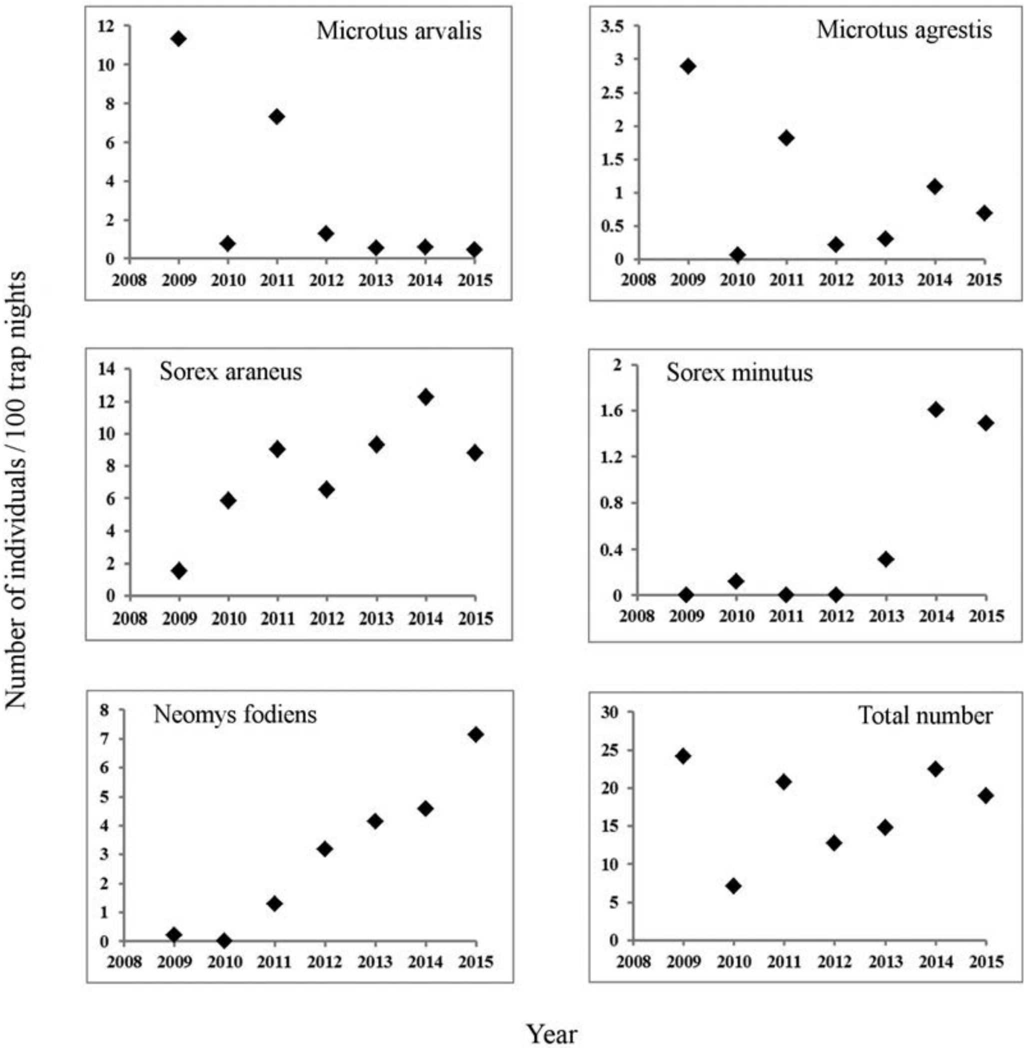

Figure 4. The numbers of individuals of common vole (*Microtus arvalis*), field vole (*Microtus agrestis*), common shrew (*Sorex araneus*), water shrew (*Neomys fodiens*) and pygmy shrew (*Sorex minutus*), and the total number of all small mammals captured per 100 trap nights, in each year of the research period in De Onlanden. Note the different scales of the y-axes.

Pygmy shrew (*Sorex minutus*) started to appear at several locations in the last two years of the study period. This species was found both in the forest patches and in marshland biotopes with dense vegetation.

Other small mammal species that were captured were bank vole (*Myodes glareolus*), wood mouse (*Apodemus sylvaticus*), harvest mouse (*Micromys minutus*), water vole (*Arvicola amphibius*) and white-toothed shrew (*Crocidura russula*). These species were captured only occasionally in very low numbers (water vole and white-toothed shrew) or locally in, sometimes, large numbers (bank vole and wood mouse in some of the forest patches). Nests of harvest mouse were found at some of the locations where the species was not captured with traps. At other locations

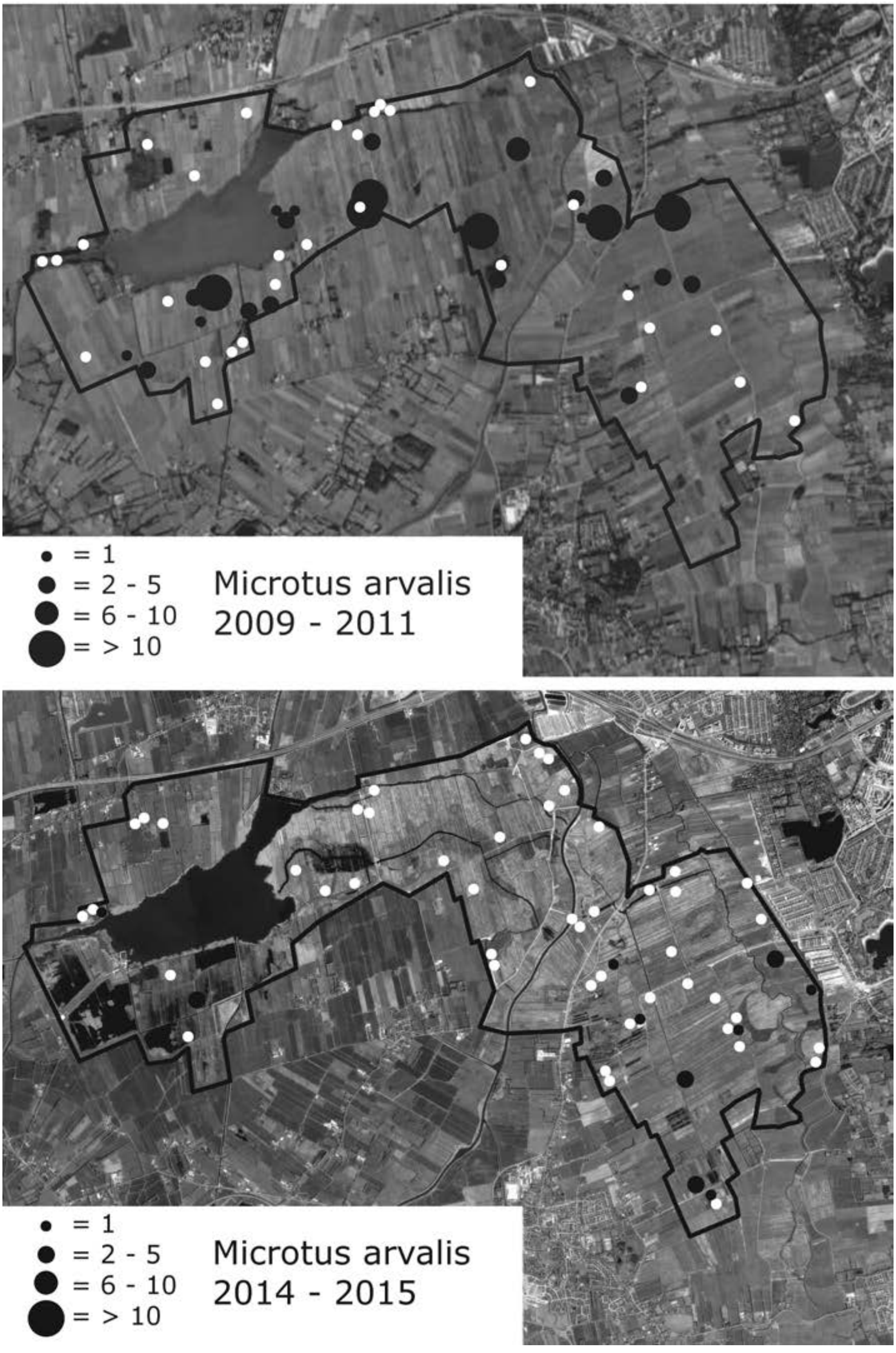

Figure 5. Distribution of trapping locations in De Onlanden and of common vole (*Microtus arvalis*) numbers captured at these locations in the years 2009-2011 (top) and 2014-2015 (bottom). White dots indicate that no common voles were captured at these locations. Note the differences in topography visible in the background aerial photos (sources: Google Earth, 2005 and Eurosense B.V., 2011).

relatively high numbers (up to twelve individuals) of harvest mouse were captured. In general, the annual numbers captured of these species were too low to show a trend during the research period.

The total number of small mammals captured per 100 trap nights fluctuated between years (figure 4). In the first years of the study the total number of captures was largely determined by voles. 2010 clearly was a year with relatively few captures, especially of voles. In the last years, the total number of captures was determined almost solely by shrews.

Discussion

As far as known to the author, this is the first time in the Netherlands that the response of small mammal populations to a large and sudden biotope change in an area of this scale has been followed over a period of years. The transition in De Onlanden of a grassland area into a marshland resulted in a rapid, major shift in small mammal species composition and relative densities. The dominant grassland species, the common vole, almost completely disappeared, even in the remaining grassland biotopes. Shrew species became dominant in the marshland biotopes, with common shrew and water shrew reaching almost equally high numbers. Both shrew species also dominated the small mammal population in the forest patches and in the remaining grassland biotopes. By the end of the study period the pygmy shrew had started to appear at several locations in the marshes. Bauer (1960) also found a dominance of shrews in the marshes surrounding the Neusiedler See in Austria. Shrews formed 62% of the total number of small mammals caught there. The common shrew was found to be most abundant, followed in numbers by the root vole (*Microtus oeconomus*), harvest mouse and water shrew.

The decline of the common vole population as a result of the biotope change in De Onlanden was larger than expected. Before 2012, the grassland biotope with its extensive management regime was found to inhabit large numbers of these voles in some years (figure 3 and Bekker 2009). Voles are known to have cycles of alternating good and poor years (van Wijngaarden 1957, Dekker & Bekker 2008). In De Onlanden, 2010 was a poor year, but in 2009 and 2011 high densities of common vole, with up to 25 individuals caught per trapline, were found at many locations in the area. In 2012, after the transition to marshland, the maximum number of common voles caught was eleven per trapline, while in the following years this number never exceeded four individuals. At many of the grassland locations common vole was not found at all. In the northern part of the Netherlands, 2014 was a year with extremely high common vole densities (c.f. Kleefstra et al. 2015, Wijnandts 2015), causing much damage to farmlands. In De Onlanden however, this common vole peak did not occur. Bauer (1960) suggested that the shortage of suitable food sources was the reason that voles and mice were almost absent from the marshes surrounding the Neusiedler See. In De Onlanden, food shortage does not explain the disappearance of the common vole, since at many locations suitable food, like grasses and herbs, could still be found. A possible explanation for the decline of the common vole population in the remaining grassland biotopes in De Onlanden may be the high surface and groundwater levels, especially in the winter period. Common voles usually live in burrows (Niethammer & Krapp 1982). From 2012 on, water levels in the remaining grassland areas in De Onlanden were mostly too high for burrowing. Shelter and nesting places for common voles were therefore scarce in the grasslands, which likely resulted in the decline of their numbers.

Like the common vole, field voles showed peak numbers in 2009 and 2011 too (figure 3), but at a smaller scale. Field vole numbers also declined after the transition. Compared to common vole, field vole is more adapted to wet biotopes with high, natural vegetation in which it often makes above-ground nests (Krapp & Niethammer 1982). After the biotope change, the highest numbers of field voles were found in the unmanaged areas of De Onlanden, where the vegetation offered more nesting opportunities. In the marshes of the Neusiedler See, root vole was found to be the most abundant vole species (Bauer 1960). This species does not live in De Onlanden, but it is found in other marshland areas in the Netherlands (La Haye & Haan 1998). It is likely that the root vole would be able to colonise the marshes in De Onlanden if it were able to migrate into it.

Even though it was assumed beforehand that water shrews would benefit from the biotope change in De Onlanden, the fast expansion of occupied area by the species and of the high numbers of individuals over the whole of the study area was not expected. At the time of writing, De Onlanden has become a major living area for water shrews in the Netherlands, with an unprecedented high population density. The number of individuals caught per 100 trap nights can be used as a relative measure for the density of the population. In other study areas in the Netherlands, with comparable marshland biotopes, like the Wieden/Weerribben (Haan 1999) and the Fochteloërveen (van der Linden & van der Weijden 2011), where the same trapping method was used, captures of water shrews were found to be 1.2-1.4 and 1.8 individuals per 100 trap nights, respectively. Numbers of 4.6 and 7.1 individuals per 100 trap nights, as found in De Onlanden during the last two years of this study, have not been mentioned in literature before. The almost linear increase of numbers caught, as shown in figure 4, suggests that the population of the water shrew in De Onlanden might even expand further over the next years. In the last year of the research period water shrews were found in biotopes that might be suboptimal for the species (Spitzenberger 1990), like grassland areas and some of the dikes, suggesting that locally the population in the optimal marshland biotope had reached its maximum density. At the same time, not all marshland territory in De Onlanden had yet been colonised by the species (figure 6), indicating that in some areas the population might still expand.

Harvest mice were only occasionally captured during the research period (at 10 out of 175 trapping locations). Usually, one to four individuals were captured, but at some locations larger numbers (with a maximum of twelve) were found. Monitoring of harvest mice with live-traps is known to be difficult, since this species lives in the top of high vegetation most of the time. In De Onlanden, this high vegetation developed in large areas of the unmanaged marshlands after the biotope change. Probably, the harvest mouse population increased in these areas, but the present study was unable to confirm this. Analyses of pellets of barn owls roosting at sites within De Onlanden showed a marked increase of the proportion of harvest mice in the yearly total of preys captured. Before 2012 harvest mice formed 2.5% (±1.36) of the prey of barn owls, increasing to 16.3% (±2.3) from 2012 onwards. Also, in the winter periods after 2012 the menu of specific barn owl individuals could exist for more than 50% of harvest mice (W. van Boekel, unpublished results). These findings indicate that the harvest mouse population has increased substantially in De Onlanden.

The three different shrew species captured in De Onlanden are often found living together in the same biotopes and are therefore potential competitors for the available food. Field and laboratory research has shown that each shrew species has its own range of food size and composition and that there is only partial overlap of food preferences between water-, common- and pygmy shrew (Churchfield 1991, Kirkland 1991, Rychlik & Jancewicz 2002, Churchfield & Rychlik 2006). Ellenbroek (1990) showed that territory size and feeding behaviour of pygmy shrews were not influenced by the presence or absence

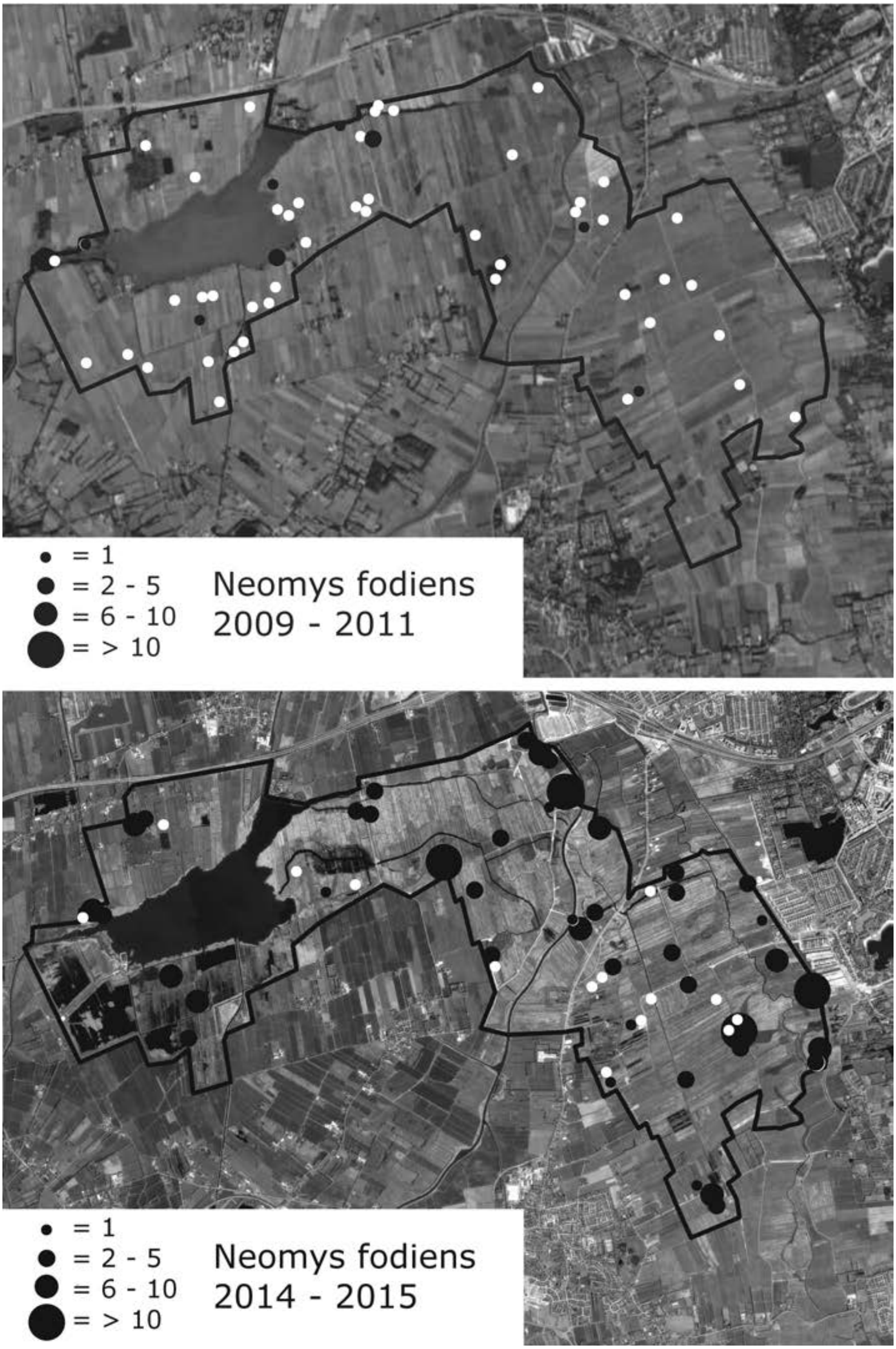

Figure 6. Distribution of trapping locations in De Onlanden and of water shrew (*Neomys fodiens*) numbers captured at these locations in the years 2009-2011 (top) and 2014-2015 (bottom). White dots indicate that no water shrews were captured at these locations. Note the differences in topography visible in the background aerial photos (sources: Google Earth, 2005 and Eurosense B.V., 2011).

of common shrews, both in laboratory situations as in field situations. He concluded that both species occupied a different niche, thereby avoiding interspecific competition. Ellenbroek (1990) suggested that intraspecific competition for the available food sources probably was more important for determining the number of individuals and territory size of each shrew species. Churchfield et al. (1997) studied seven species of shrews living together in different compositions and numbers in the Siberian taiga. They also concluded that each species occupied a specific niche and that the numbers of each species depended on the available food sources and vegetation structure, not on competition between species. During the last two years of the study in De Onlanden, large numbers of water shrew, common shrew and sometimes pygmy shrew were found living together in the same biotopes. For these locations no indications of competition could be found from the relations between their numbers. In general, with increasing total shrew numbers, all shrew species showed an increase in numbers (figure 7). Apparently, inter- or intraspecific food resource competition did not determine their numbers. The ability to find food under water is often seen as an important capacity for water shrew, enabling it to live together with common shrew (Churchfield 1984). In De Onlanden, even in biotopes without open water, where water shrew was not able to escape possible food competition with common shrew by finding food under water, both species were found living together in high densities. In these biotopes large amounts of water slaters (*Asellus* sp.) and freshwater shrimps (*Gammarus* sp.) could be found in the wet debris layer (W. van Boekel, personal observations). These Crustaceans are known to form a major part of the diet of water shrews in many biotopes (Carter & Churchfield 2006). Possibly, in De Onlanden these preys formed a major food source for both water shrews and common shrews at many marshland locations, enabling these species to live together in high densities. The populations of the shrew species, especially water shrew and pygmy shrew, in De Onlanden are probably still growing (figure 4). It will be interesting to study the future developments in these shrew populations.

Shrews are known as solitary living animals, which defend their food territory against individuals of the same species and often also against other shrew species. During the reproductive season (April-October) the females are most fierce in defending their territory. Only their young are tolerated until these are mature, while male shrews are only tolerated for mating. Males are mostly found wandering around in search of females (Saarikko 1989, Cantoni 1993, Krushinska et al. 1994). Because of this territorial behaviour of shrews, common shrews and water shrews are usually found in relatively low densities even in optimal habitats. Carter & Churchfield (2006) mention maximum densities of three to five individuals per hectare for water shrew in watercress beds (which is considered to be an optimal habitat for this species in the United Kingdom). Van der Linden & van der Weijden (2011), using live-traps, captured 1.8 water shrews and 5.6 common shrews per 100 trap nights in their study in the marshes of the Fochteloërveen in the Netherlands, which is also considered to be an optimal habitat for water shrew in the Netherlands (D.L. Bekker, personal communication). During the last year of the present study, the numbers of individuals caught per trapline of 90 metres length ranged from 0 to 27 for common shrew and 0 to 15 for water shrew. The, sometimes, extremely high shrew densities found at many locations in De Onlanden could indicate that here territories of shrews are comparatively small, due to an abundance of food resources (Ellenbroek 1990), or that the territorial system that is found in other biotopes is not present in De Onlanden. Further study on territorial behaviour of shrews in De Onlanden is needed to elude this phenomenon.

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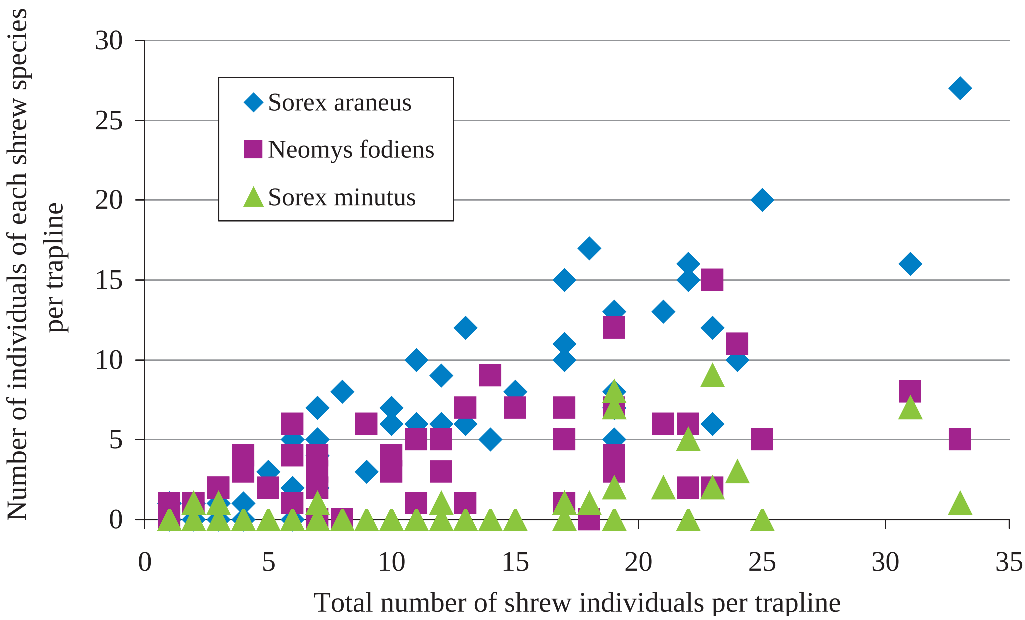

Figure 7. Relation between the total number of shrew individuals of all species, captured in traplines at different locations in De Onlanden in the years 2014 and 2015, and the numbers of individuals of common shrew (*Sorex araneus*), water shrew (*Neomys fodiens*) and pygmy shrew (*Sorex minutus*) captured in these respective traplines.

Onlanden will continue to develop in future, will depend on the developments in the marshland biotopes. In general it is expected that the vegetation in the marshes will become more dense, that the reed vegetation will spread over larger areas, and that locally new marsh forest will develop. These developments will be favourable for the shrew species, and possibly for the field vole and harvest mouse too, since these species all prefer dense vegetation. In the parts of De Onlanden that will remain under the management regime of grazing and mowing, nutrients will be removed from the soil. This will eventually result in less trophic biotopes, with possibly less available food for the shrews and other small mammals. Their numbers may decrease in these parts of De Onlanden. However, on peat soil it may take many years, if not decades, before a clear effect can be seen.

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Samenvatting

Van veenweide naar moeras in natuurgebied De Onlanden: effecten op muizenpopulaties

Natuurgebied De Onlanden, gelegen ten zuidwesten van de stad Groningen, veranderde begin 2012 van het ene moment op het andere van een veenweidegebied in een moerasgebied met waterbergingsfunctie. In de vier jaar voor deze overgang was het 3000 hectare grote gebied ingericht voor deze functie door de aanleg van dijken, het graven van verbindende slenken en het grootschalig plaggen van de toplaag. In deze studie is gekeken naar de effect dat de grote verandering van biotoop had op de samenstelling van de kleine zoogdierenpopulatie (muizen en spitsmuizen) in De Onlanden. De monitoring van deze populatie gebeurde in de periode van 2009 tot en met 2015 jaarlijks gedurende de zomerperiode met behulp van live-traps. Door de overgang van een veenweidebiotoop, met vaste waterstanden ver onder maaiveldniveau en jaarlijks beheer door maaien en begrazing, naar een grootschalige moerasbiotoop, met sterk wisselende waterstanden zonder vegetatiebeheer, veranderde de samenstelling van de muizenpopulatie volledig. De veldmuis verdween vrijwel geheel uit De Onlanden en werd zelfs in de resterende graslanden nauwelijks nog gevonden. Waarschijnlijk was het gebied vooral in de winter te nat geworden voor deze soort. Ook de aardmuis daalde in aantal, maar leek zich in de ruige, natte delen van De Onlanden wel te kunnen handhaven. De waterspitsmuis, die voor de herinrichting vrijwel ontbrak in De Onlanden, breidde zijn leefgebied sterk uit en nam in aantal toe tot plaatselijk zeer hoge dichtheden. De bosspitsmuis, die voor de herinrichting al in grote dichtheden in De Onlanden te vinden was, wist zich in de moerasbiotoop goed te handhaven en nam zelfs iets toe in aantal. De dwergspitsmuis profiteerde ook van de vernatting en verruiging van het gebied. Waarschijnlijk zullen de aantallen en de verspreiding van waterspitsmuis en dwergspitsmuis in De Onlanden in de toekomst nog groter worden.

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