

This document provides an overview of available documentation about the recent Muskrat research programme in the Netherlands. Further information can be obtained from: DMoerkens@uvw.nl or d.bos@altwym.nl

The papers or reports are all available either via [Researchgate](#), or via www.muskusrattenbestrijding.nl

A. Comparison of future scenario's of management

[Bos D, Gronouwe J \(2018\)](#) Toekomst van het muskusrattenbeheer in Nederland. De mogelijkheden onderzocht. Altenburg & Wymenga ecologisch onderzoek, Feanwâlden

In this study the possibilities are studied for complete removal of muskrat from the Netherlands. The study is in Dutch, but it has an appendix in English with an economic model. Three alternative strategies have been compared: a) The current strategy of year-round control at low densities b) No control, and c) Complete removal. The study provides information showing that complete removal is effective as a strategy and practically feasible as well. The direct costs are not prohibitive, and there are no significant negative effects (including indirect financial costs). In terms of water safety and costs, 'complete removal' is the best option compared to the other strategies. With this alternative, there are no risks for safety by burrowing muskrat anymore, no costs for repair of damage or economic damage to third parties. The control effort for the strategy 'complete removal' is clearly lower in the long term than under the year round scenario. Important benefits can also be identified in terms of animal welfare and effects on biodiversity. The risks that can occur with complete removal are manageable, and often smaller than under the current objective. The appendix presents a bio-economic model that was constructed to investigate under what assumptions eradication would be economically more optimal than year round control at any given equilibrium population density or no-control. This model and its result are presented in the appendix, in English.

Gronouwe J, Bos D (2018) Toekomst van het muskusrattenbeheer in Nederland. Deel B: Verschillende organisatiemogelijkheden. A&W-rapport 2482, DosPisos/Altenburg & Wymenga ecologisch onderzoek, Rheden/Feenwâlden

B. Synthesis of experience with Muskrat & Nutria control in the Netherlands, including an overview of relevant research results

[Bos D, Wymenga E, Ydenberg R, Loon E van \(2019\)](#) De muskusrat op zijn retour. De Levende Natuur 120:51–55 in Dutch

Muskrat ups and downs

*An extensive control programme for muskrat *Ondatra zibethicus* has been in effect for decades in The Netherlands, because muskrat burrowing can compromise the integrity of dykes and hence poses a public safety threat. To support evidence-based decision-making about muskrat control, field and modelling studies have been undertaken over the past decade. The number of muskrats trapped (as well as the amount of by-catch) has been declining since 2004. Experimental and statistical evidence supports the hypothesis that this can be attributed largely to trapping of sufficient intensity and quality. The field research enabled a basic premise of the control programme to be quantified, namely the relationship between muskrat numbers and damage inflicted. The results made it possible to compare alternative control strategies using criteria such as the number of animals killed over the medium term, the risk of damage to infrastructure, by-catch, and financial costs. The comparison reveals that short-term intense trapping to reduce or even eliminate muskrat numbers has many*

advantages in the medium and longer terms over alternative strategies. The current situation (low - moderate annual catch) is the result of a large investment in control over recent decades. We caution against reducing investment further, because the high reproductive potential of muskrats enables them to very quickly

[Moerkens D, Bos D \(2018\)](#) Intensive Bekämpfung von Bisam und Nutria in den Niederlanden. Erfahrungen auf Grundlage langjähriger Bekämpfung und Forschung. Natur NRW 4:17–21.

Die Bisampopulation in den Niederlanden ist durch Bekämpfung weitgehend unter Kontrolle. Nutrias wurden komplett aus dem Inland bis an die Landesgrenze zurückgedrängt. Der Grund für das intensive Bekämpfungsprogramm in den Niederlanden liegt primär in der Aufrechterhaltung des Hochwasserschutzes. Die wichtigsten Erkenntnisse eines Forschungsprogramms und die Organisation der Bekämpfung in den Niederlanden werden in diesem Artikel beschrieben. Der Schaden durch Grabaktivitäten an Ufern und Schutzanlagen ist größer, wenn mehr Bisame vorhanden sind. Der Schaden kann den Wasserschutz ernsthaft gefährden. Die Bekämpfung kann Auswirkung auf die Anzahl der Bisame haben, wenn genug Aufwand betrieben wird und die Organisation gut ist. In der niederländischen Situation halten sich die Kosten für die professionelle Bekämpfung auf nationaler Ebene die Waage mit dem Nutzen. Es gibt deutliche Hinweise, dass die Kosten der Bekämpfung letztendlich sinken, je kleiner die verbleibende Population wird. In German

[Bos D, van Loon EE \(2018\)](#) Beheer van de Muskusrat in Nederland. Synthese van een grootschalige veldproef en parallelle studies. Altenburg & Wymenga ecologisch onderzoek, Feanwâlden

This report is building upon a comprehensive interim report from 2016. The results of the research programme are summarised. They have been described in more detail in various publications referred to in the document. With this synthesis, we aim to provide an accessible representation of the main results and conclusions for the Dutch audience. In Dutch

C. Statistical population reconstruction

[van Loon EE, Ydenberg RC, Bos D \(2017\)](#) Statistical estimation of Musk rat abundance. Altenburg & Wymenga /Universiteit van Amsterdam, Veenwouden/Amsterdam. in English

This report contains the results of a study in which a dynamic population model has been developed to reconstruct the developments in the population of muskrats in the Netherlands. The report is in English, but is provided with a Dutch summary. The modelling resulted in independent and objective estimates on muskrat numbers per season at a high spatial resolution; insight in the degree to which local population levels are regulated by trapping; and an estimation of the relative importance of immigration and emigration. The general findings of the modelling exercise underpin one of the basic premises behind the muskrat control programme, that muskrat control leads to lower muskrat numbers. The model results are furthermore consistent with the idea that the required trapping effort to maintain a given population size declines with population density. In itself, the model can be an important tool in the planning of future muskrat control.

D. Study using historical data at provincial level on effectiveness of trapping

[van Loon EE, Bos D, van Hellenberg Hubar C, Ydenberg RC \(2017\)](#) A historical perspective on the effects of trapping and controlling the muskrat (*Ondatra zibethicus*) in the Netherlands. Pest Manag Sci 73:305–312. doi: 10.1002/ps.4270 in English

[Bos D, Moerkens D, Loon E Van \(2016\)](#) Muskusrattenbestrijding in Nederland een historische analyse. Dierplagen Inf 4:5–8 in Dutch

E. Field experiment. Large-scale management experiment and the results of an experiment with ‘no trapping’ in two large areas, for three years

[Bos, D., E. E. van Loon, E. Klop, and R. Ydenberg. 2020.](#) A Large-Scale Experiment to Evaluate Control of Invasive Muskrats. *Wildlife Society Bulletin* 44:314–322.

We report on a carefully designed and large management experiment to test hypotheses about the effectiveness of muskrat control by trapping. Muskrat populations can be controlled by trapping, but the spatial scale of implementation appeared to be much more important than anticipated.

[Bos D, Tuijl M, van Loon EE \(2018\)](#) Technische rapportage ‘objectbescherming en analyse van ontwikkelingen in de proefuurhokken’. Altenburg & Wymenga ecologisch onderzoek, Veenwouden, the Netherlands.

The main report is in Dutch, but it also has an appendix in English describing the results of an experiment with no trapping in two large areas, for three years:

[Bos, Daan, Rosemarie Kentie, Maurice LaHaye, and Ronald C. Ydenberg. 2019.](#) “Evidence for the Effectiveness of Controlling Muskrat (*Ondatra Zibethicus* L.) Populations by Trapping.” *European Journal of Wildlife Research* 65:45.

F. preliminary genetic study

de Groot A, Bos D (2018) Pilot genetische analyse van verspreidingspatronen bij muskusratten. Wageningen Environmental Research (WENR), Wageningen, The Netherlands. in Dutch

G. Study for the IUCN /EU on measures and costs of muskrat management

[Bos D \(2017\)](#) Information on measures and related costs in relation to species included on the Union list: *Ondatra zibethicus*. Technical note prepared by IUCN for the European Commission. in English

H. Study on trends in by-catch during Muskrat control

[Bos D, Hollander H, Klop E, Ydenberg RC \(2017\)](#) Bijvangst bij de muskusrattenbestrijding. Ontwikkeling tussen 2007 en 2016. *Zoogdier* 28:23–25 in Dutch with summary in English

For a good public debate on the pro's and contra's of muskrat control, it is useful to also weigh knowledge about the species and the numbers of by-catches. What factors affect the development of the number of by-catches? In this study we show that the number of by-catches from muskrat control in the Netherlands has fallen sharply in recent years. The number of by-catches depends mainly on the number of hours in the field (a proxy for the number of traps in the field). Apart from that there is a difference between control organizations, in interaction with the style of trapping. Our conclusion is that effective

muskrat control can be seen as a suitable investment, in order to achieve less by-catches in the long term.

I. Intermediate research reports with appendices in English

[Bos D, E. Klop, Hemert H van, et al \(2016\)](#) Beheer van Muskusratten in Nederland. Effectiviteit van bestrijding op grond van historie en een grootschalige veldproef. Deel 1 Samenvatting tussenrapportage. Altenburg & Wymenga ecologisch onderzoek, Veenwouden

This intermediate report describes the first results of a three year field experiment on the management of Muskrats in the Netherlands. Parallel to the experiment an analysis of historical data on catch and effort was done to put the field information into perspective. The report is in Dutch, it summarizes the first results and provides a synthesis. The report accompanies a separate back-ground report that has been written to document the results in a more detailed and scientific way. Some of these chapters are presented in English, for that reason. The experiment was performed by the Dutch water authorities, in cooperation with partners from Altenburg & Wymenga ecological research, Wageningen University and Research, The Dutch Mammal Society, and H&K Waterkeringen.

[Bos D, E. Klop, Hemert H van, et al \(2016\)](#) Beheer van Muskusratten in Nederland. Effectiviteit van bestrijding op grond van historie en een grootschalige veldproef. Deel 2. Achtergrond studies. Altenburg & Wymenga ecologisch onderzoek, Veenwouden

This intermediate report describes the first results of a three year field experiment on the management of Muskrats in the Netherlands. Parallel to the experiment an analysis of historical data on catch and effort was done to put the field information into perspective. The experiment was performed by the Dutch water authorities, in cooperation with partners from Altenburg & Wymenga ecological research, Wageningen University and Research, The Dutch Mammal Society, and H&K Waterkeringen. The report accompanies a separate summary report in Dutch in which the outcome of separate components of the study, are summarized and a synthesis in Dutch is given. This back-ground report provides the chapters that have been written to document the results in a more detailed and scientific way. Some of these chapters are presented in English, for that reason.

J. The period of Foot-and-Mouth Disease in 2001 revisited

[Bos D, Timmerman F, Ydenberg RC \(2016\)](#) Muskusrattenbestrijding tijdens de MKZ-crisis in 2001. Lutra 59:33–48. in Dutch with an English summary

Muskrat control during the outbreak of Foot-and-Mouth Disease in 2001. The muskrat populations in much of the low lying parts of northwestern Europe are subject to control programmes, in order to prevent damage by digging. Control is mainly implemented by trapping. As yet there is, however, no rigorous evidence that trapping actually affects the population size. In search for experimental evidence, we hypothesised that a temporary reduction in trapping effort during the outbreak of Foot-and-Mouth Disease (FMD) in the Netherlands in 2001 could be used for this purpose. The FMD epidemic hit the Netherlands when numbers of muskrat catches were rising in nine out of twelve provinces. During three months in spring, 16,000 field hours (15%) have been spent less than the five-year spring average until then. The reduction in effort was not absolute and also not homogeneously distributed in space. On average, there was a decline in effort and catches in agricultural areas, but an increase in urban areas. The variation and the range of the differences with the five-year average effort were not larger than in previous years. The outbreak of FMD, and the

associated reduction in effort, is confounded with an autonomous development in effort and catches. We therefore tested whether changes in catch rate in summer, autumn and spring, were related to differences in effort spent in spring. The developments in the polder area Krimpenerwaard have been summarised separately, because it was especially there that extreme numbers of muskrat had been caught in the years after FMD. The high levels of catches in the Krimpenerwaard in the period 1999-2006 cannot be attributed to limitations caused by the FMD epidemic. This is because the number of hours spent in the Krimpenerwaard was not significantly decreased during the FMD period as compared to the five-year average until then, and secondly because the catch rates had already sharply increased before the FMD crisis erupted. Our basic assumption, i.e. that the developments during and after the FMD period could be used to illustrate the effectiveness of the control programme in limiting muskrat populations, cannot be sustained. It is, however, justifiable to say that the FMD crisis may have strengthened existing negative developments. We conclude that the FMD period has limited value as a spontaneous experiment. The impact of the FMD crisis is small relative to other sources of variation and the increase in catches around the FMD must therefore primarily be seen as an autonomous development.

K. Theoretical studies as a motivation for the field experiments

[Bos, D. & Ydenberg, R. C. 2011.](#) Evaluation of alternative management strategies of muskrat *Ondatra zibethicus* population control using a population model. *Wildlife Biology* 17: 143-155. [In English](#)

*Muskrats *Ondatra zibethicus* are considered a pest species in the Netherlands, and a year-round control programme is in effect. Currently, the agency responsible for the management of muskrat populations in the Netherlands (the LCCM) is preparing for field studies to compare alternative strategies of control. In order to decide on the specific design of such field studies, a population dynamic model was built. The model compares the current management strategy with alternatives in which the effort is focused in space or in time. The model allows us to prioritise future research questions. The major gaps in knowledge at this moment are: 1) insight into the costs of harvesting at different harvest rates, and 2) the relationship between population density on the one hand and (financial damage or) safety risk on the other hand. We suggest continuing the current management, and to test our hypothesis that intensifying harvest will lead to lower numbers of animals killed in the medium term than more extensive harvest rates. The muskrat control programme offers excellent opportunities for applied biological studies of which the benefits are likely to outweigh the costs.*

[Bos, D., van Belle, J., van Wieren, S., Ydenberg, R. C., & Goedhart, P. W. 2010.](#) Naar objectieve schatting van aantallen Muskusratten in Nederland. *De Levende Natuur* 111: 94-99. [In Dutch](#)

We reconstructed local Muskrat population trajectories from annual (1987-2007) data on the numbers of harvested Muskkrats and catch effort, in a large sample using Sequential Population Analysis. Alternative strategies to the current year-round control programme were studied using a simulation model. This programme still has to be validated in field experiments. Based on the current insights we conclude that year-round intensive harvesting will be the most effective way to keep Muskrat populations low. This results in fewer animal deaths (and consequently less suffering) relative to harvesting at intermediate intensity. This situation has been reached in some parts of The Netherlands, but in others the harvest

proportion can be increased. It is worthwhile to consider whether the policy aim (in terms of population size and acceptable level of damage) should be equivalent across the entire country. If not, regionally differentiated control methods could be applied.

M. Management

[Bos D, Moerkens D \(2019\)](#) Nieuwe bestrijdingsstrategie muskusratten? Kijk op exoten Januari:14–15.

Uit onderzoek is aannemelijk geworden dat het terugdringen van de muskusrat (Ondatra zibethicus) tot de landsgrens tot de mogelijkheden behoort en dat dit vele voordelen biedt. Het gaat om een strategie waarbij het aantal muskusratten in Nederland tot nul wordt teruggebracht en herkolonisatie wordt voorkomen door instroom van muskusratten langs de grens weg te vangen. Deze bijdrage is bedoeld om daarover te informeren.

Bos D, Wetterskip Fryslan (2017) Folslein skjin. Altenburg&Wymenga, Wetterskip Fryslan, Leeuwarden/Veenwouden

Een werkgroep van de Friese muskusrattenbestrijding bestudeert de mogelijkheden om de Muskusrat volledig uit Fryslân te verwijderen. De redenen hiervoor, enkele achtergronden en de voorgestelde werkwijze worden in dit stuk beschreven om ze te kunnen bespreken met de collega's. De werkgroep stelt voor bij de bestrijding in Fryslân complete verwijdering na te streven. We noemen dit "Folslein skjin". Aanbevolen wordt om toe te werken naar één landelijke visie hierop en een gezamenlijke aanpak van de problematiek. Het idee van complete verwijdering van de muskusrat, moet worden uitgedragen en verdedigd in alle relevante gremia, tegelijk met de andere lessen die in Fryslân zijn geleerd over effectieve bestrijding.

N. Effect op biodiversiteit

[Bakker ES, Bos D \(2019\)](#) Invloed van Muskusratten op moerasontwikkeling en biodiversiteit. A&W-rapport 2540. Altenburg & Wymenga ecologisch onderzoek, Feanwâlden

Muskusratten zijn zogeheten 'ecosysteem engineers' die door hun graafwerk, huttenbouw en vraat de landschapsstructuur, soortensamenstelling en biodiversiteit van moerasgebieden danig kunnen beïnvloeden. Als invasieve exoot in Nederland en Europa wordt de muskusrat met name bestreden vanwege de schade die ze aanrichten met hun graverij. Het bestrijden van de muskusrat zou echter ook positieve effecten kunnen hebben op processen als verlanding, de ontwikkeling van waterriet en de bijbehorende biodiversiteit. Hier vatten we kennis samen over het effect van Muskusratten op habitats en soorten en inventariseren of bestrijding zou kunnen bijdragen aan natuurherstel in moerasgebieden.

O Effect on damage

[R.C. Ydenberg, E. Emiel van Loon, D. Bos & H. van Hemert \(2019\)](#) Damage to dykes and levees in the Netherlands is extensive and increases with muskrat (Ondatra zibethicus) density. Lutra 62 (1): 37-51

P. Financial analysis

[Zappeij-Ploeger, S., M. T. Pot, and D. Bos. 2020.](#) Cost-benefit analysis of invasive muskrat control in the Netherlands complete removal as financially rational strategy. *Water Governance* 1:36–41.

Student reports and papers

Over leeftijdsverdeling adv de molar index (Cameron et al. 2018)(Miller et al. 2018).
Publicatie in Zoogdier (Witzier et al. 2018)

Oostvaardersplassen (van de Venne 2015)

Schade (Akkermans 2014)(Koning 2018)(Akkermans and van Bendegem 2013)

Historie Caspara Hubar Hellenberg manuscript gepubliceerd als: (van Loon et al. 2017)

Zenderij (Visschers 2014) (Heeres and Struijf 2016) (Driessen 2014)

Sociaal en over volledige verwijdering (Dijkstra and Hermans 2017)

Levend vangen en CMR (Schrader 2015a, b; van den Akker 2016)

asmede bijdragen van

Maarten Tuijl , student ZV, JinRui Yang, Anne Rens Meijer, Bart Meijer

Akkermans M (2014) Muskrat digging capacity. STOWA, Amersfoort

Akkermans M, van Bendegem D (2013) Relatie tussen het bodemtype en schadegevallen door de muskratten. Onderzoek naar het bodemtype met betrekking tot "het aantal schadegevallen" en "de stabiliteit". Hogeschool van Hall Larenstein Dhr.

Cameron I, Kuip B, Wiersma E (2018) Leeftijdsverdeling van onbestreden muskratten (*Ondatra zibethicus*) uit Lelystad. Hogeschool Van Hall Larenstein, Leeuwarden

Dijkstra E, Hermans J (2017) Roadmap to a complete removal of the muskrat. Universiteit van Amsterdam

Driessen C (2014) Veldproef Muskratten Pilot zenderonderzoek Chris Driessen. Zoogdierverseniging, Nijmegen

Heeres RW, Struijf MS (2016) Muskratten bouwen in oevers. Afstudeerrapport van Hall. Waterschap Zuiderzeeland

Koning RR de (2018) Predicting muskrat (*Ondatra zibethicus*) digging damage in the Netherlands using Random Forest. Universiteit van Amsterdam

Miller C, Witzier P, Zobel M (2018) Leeftijdsfrequenties van een muskratten (*Ondatra zibethicus*) populatie uit Dinteloord in een onbestreden situatie. HAS Hogeschool, Den Bosch

Schrader TWD (2015a) Handleiding " Werken met Mark

Schrader TWD (2015b) Population size estimates of invasive species with limited data: the case of the muskrat (*Ondatra zibethicus*) in The Netherlands

van de Venne G (2015) Muskratten in de Oostvaardersplassen. Populatieomvang, verplaatsingen en graafactiviteiten. Hogeschool Inholland, Delft

van den Akker S (2016) DE VERSPREIDING EN BESTRIJDING VAN DE MUSKUSRAT IN

HET GRENSGEBIED VAN NEDERLAND EN DUITSLAND. WUR

van Loon EE, Bos D, van Hellenberg Hubar C, Ydenberg RC (2017) A historical perspective on the effects of trapping and controlling the muskrat (*Ondatra zibethicus*) in the Netherlands. *Pest Manag Sci* 73:305–312. doi: 10.1002/ps.4270

Visschers M (2014) Onderzoeksverslag. Zoogdiervereniging, Nijmegen

Witzier P, Miller C, Zobel M, Voeten M (2018) Leeftijdsschatting van muskusratten. *Zoogdier* 29:21–22