Using habitat preferences of the Eurasian Otter (Lutra lutra) to predict future potential habitat after reintroduction in the Netherlands.

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Content

Abstract

Reintroduction programs are often setup for conservation or recovery of an endangered species. Often target species are well-known to the public and represent a key species for a specific ecosystem. By enhancing public awareness and support they function as so-called “flagship species”. To make the reintroduction of flagship species a success, often efforts are made to improve habitat quality. By doing so, not only the target species , but also other wildlife that shares the same habitat could benefit. In 2002 the Eurasian otter (*Lutra Lutra*) was reintroduced in the Netherlands after it went extinct in 1989. 30 individuals were released into the national park Weeribben-Wieden with the intention to distribute and repopulate the Netherlands again. Since then the population has increased significantly to an estimated number of 360 individuals in the winter of 2018-2019. However, due to habitat fragmentation and dispersal between habitats, 97 individuals were recorded as killed by traffic in 2018. More information about distribution, bottlenecks and habitat preferences is needed to stimulate the construction of mitigating measures and conservation strategies. This study reports that otter habitat in the Netherlands typically consist of water bodies with dense vegetation along the banks and limited changes in water level. Beaver presence is preferred and human related disturbances are avoided. Based on this information we were able to predict future potential otter habitat with a habitat suitability model in the Geldersepoort. Overall, this study provided a better insight into otter habitat preferences in the Netherlands and by predicting future potential habitat it could stimulate the construction of mitigating measures and conservation strategies to increase habitat quality. This will contribute to a successful reintroduction of the otter in the Netherlands but will also make the Netherlands a better place for wildlife in general.

Keywords: Reintroduction, flagship species, Eurasian otter, habitat preferences, habitat suitability model

Introduction

Reintroduction programs are often setup for conservation or recovery of an endangered species (Griffith et al. 1989). Generally, this only benefits the endangered species. However, in some cases the reintroduced species contributes to several ecological processes and may affect the whole ecosystem (Ripple et al. 2004). When potential habitat is made suitable and accessible for the target species, multiple other species could also benefit from the reintroduction process. Often target species are well-known to the public and represent a key species for a specific ecosystem. By enhancing public awareness and support they function as so-called "flagship species" (Ingendahl et al. 2011).

A well-known flagship species in the Netherlands is the Eurasian otter (*Lutra lutra).* Before reintroduction in 2002, the last sign of the otter in the Netherlands dates back to 1989 (Koelewijn et al. 2010). Numbers of this semi aquatic mammal rapidly declined due to environmental pollution (e.g. Polychlorinated Biphenyls, PCB's) (Roos et al. 2001), an increase in roadkill due to habitat fragmentation (Hauer et al. 2002; Kruuk and Conroy 1991; Sommer et al. 2005) and incremental pressure from fisheries with fyke nets (as described in Koelewijn et al. 2010). "In 2002 a reintroduction programme was started, and between June 2002 and April 2008 a total of 30 individuals (10 males and 20 females) were released into a lowland peat marsh in the north of the Netherlands (Weeribben-Wieden)"(Koelewijn et al. 2010). Since then the population has increased significantly in size to an estimated number of 360 individuals in 2018 (Kuiters et al. 2019). However, due to habitat fragmentation and dispersal between habitats, 97 individuals were recorded as killed by traffic in 2018.

To increase the chances of a successful reintroduction of a flagship species IUCN stated that; "suitable habitat should meet the candidate species' total biotic and abiotic needs through space and time and for all life stages. In addition, habitat suitability should include assurance that the release of organisms, and their subsequent movements, are compatible with permitted land-uses in the affected areas" (IUCN, 2013). Although there are numerous studies about otter habitat preferences in different parts of the world (e.g. Ottino et al. 1995 (Italy) Ottino & Giller 2004 (Ireland); Madsen et al. 2001 (Denmark); Jo et al. 2017 (South-Korea)), results of these studies vary a lot. This indicates that otters might differ in habitat preferences in different parts of the world and highlights the importance of determining habitat preferences of the otter in the Netherlands.

There is not much known about habitat preferences of the otter in the Netherlands even though this is critical to predict future dispersal and habitat suitability of the otter. Habitat suitability models are often used to predict the ability of an area to support reintroduced populations (Gutt et al. 2017) and can be an important tool to support mitigating measures and conservation strategies (Guisan et al. 2013) (e.g. building Eco bridges and road underpasses, adjusting mowing policies and minimise disturbances in suitable habitat) to meet the needs of " the candidate species".

The goal of this study is to determine habitat preferences of the otter in the Netherlands, and use this data to make a prediction model for future potential otter habitat in an area where the otter did not get the chance to disperse to and settle yet in the time after the reintroduction. Because otters are known to be a shy species (Jefferies, 1987) we hypothesize that otters prefer water banks with dense cover for protection and rest. Human disturbance should most likely also be avoided, although this is hard due to habitat fragmentation in the Netherlands. Results of this study will not only contribute to a better understanding of the distribution and habitat preferences of otters in the Netherlands but can also stimulate further measures to make the reintroduction of this flagship species a success.

Methods

Study area

The entire study area had a total surface area of 1766 square km and ran from Weerribben-Wieden National Park to the Millingerwaard and was divided in two sub-areas: from the Weerribben-Wieden to Deventer “Area 1” and from Deventer to the Gelderse Poort “Area 2” (figure 1). Based on otter presence data of Kuiters et al. (figure 2), Area 1 was considered an area where otters are common and most likely have settled after reintroduction and that was suitable to do a habitat preference analysis. Area 2 was considered as an area where otters did not have the chance to settle in sufficient numbers yet. Some presences in Area 2 were noted in Kuiters et al. (2019) (figure 2), however the number of presences was too small to perform a reliable habitat preference analysis. Because of this it was a perfect opportunity to make predictions about habitat suitability in Area 2 based on the data of Area 1. Both study areas were divided in grid cells of 1 km^2 with the use of ArcGis Desktop 10.7.1 (ESRI)

Habitat factors

In total 235 individual grid cells were visited between March and June (139 in Area 1, 96 in Area 2). A total of 9 habitat factors were scored in both areas while otter presence was only scored in Area 1. Water banks were scanned for otter spraints (faeces) as a clear indication of otter presence. When otter spraints were not found in a visited grid cell it was noted as absent. Besides our own observations, confirmed observations of volunteers in the same period (March-June) from 2020 and 2019 (NDFF / Zoogdiervereniging), were used to decrease the chance of missing otter presence. In each visited grid cell, data on 9 variables were collected to represent habitat structure and composition (table 1). Habitat factors that were chosen for this study had either been significant factors in other otter habitat preference studies or have been proposed by local otter experts (see table 1). The number of habitat factors needed to stay small to keep enough statistical power with the small number of visited grid cells due to time and money limitations. Reed and tree cover on water banks was estimated in percentages and only the vegetation within the first 10 meters onshore were taken along into this estimation.

Table 1. List of habitat factors that could contribute to otter presence and have been chosen to score in each visited grid cell, their description, units and sources

Habitat factor	Variable description	Source
Tree coverage	Estimation of percentage tree cover on bankside	Madsen et al. (2001)
Reed coverage	Estimation of percentage reed cover on bankside	Instead of shrubs in Madsen et al. (2001)
Water depth	<1m – 1-2m - >2m	Madsen et al. (2001)
Houses	Presence/absence house within grid cell	Madsen et al. (2001)
Roads	Presence/Absence roads within grid cell	Jo et al. (2017)
Dog presence	Presence/ absence of dogs in grid cell	Local expert
Land use	Most common land use surrounding water bodies in grid cell	Ottino & Giller (2004)
Changes of water levels	<2m – >2m between highest and lowest water level	Local expert
Beaver presence	Presence/absence of beaver within 200m	Local expert

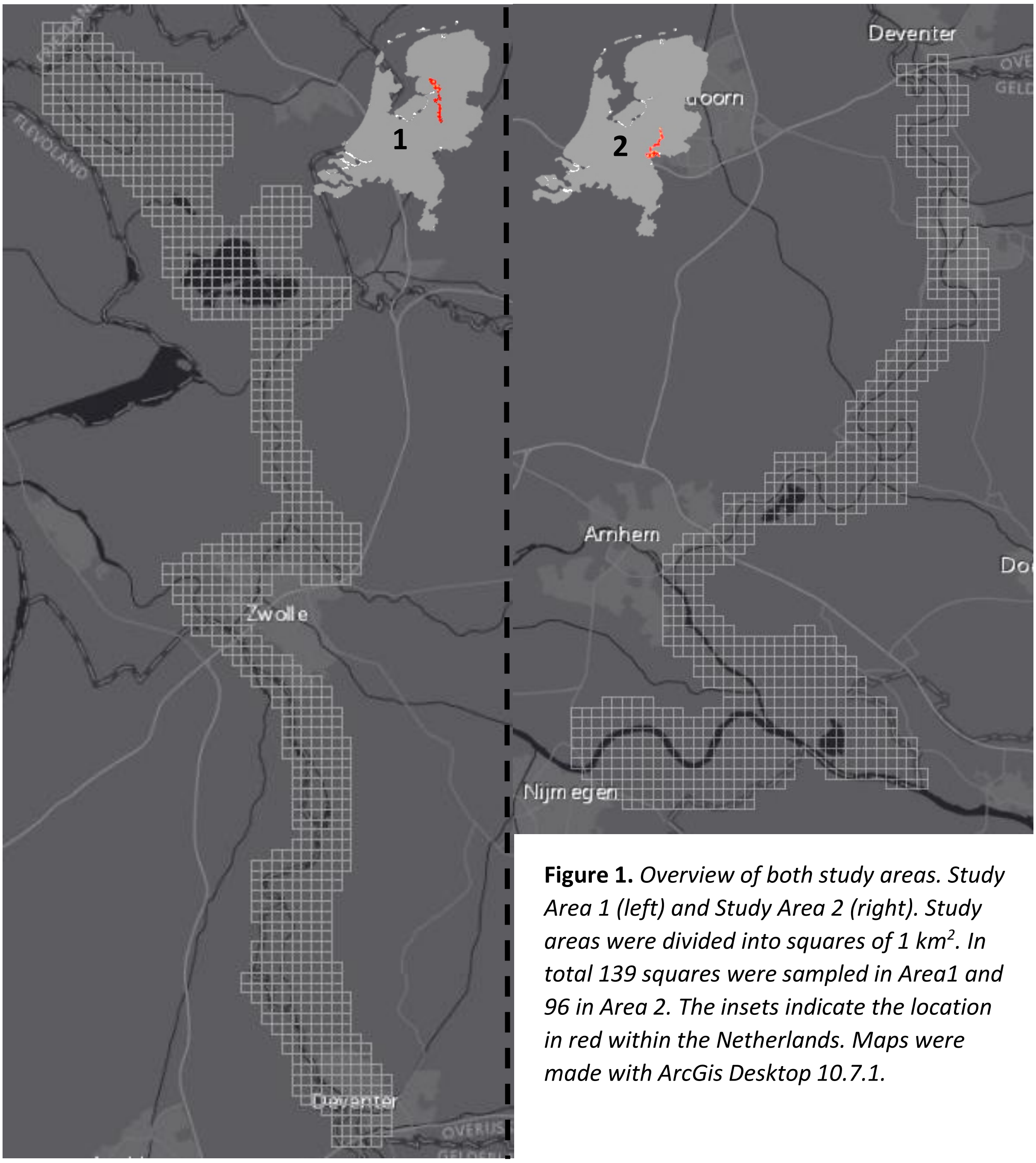

Figure 1. *Overview of both study areas. Study Area 1 (left) and Study Area 2 (right). Study areas were divided into squares of 1 km^2. In total 139 squares were sampled in Area1 and 96 in Area 2. The insets indicate the location in red within the Netherlands. Maps were made with ArcGis Desktop 10.7.1.*

Water depth was estimated as the average depth in the grid cell and therefore it was more convenient to estimate it in categories. In each grid cell human related disturbance was represented by the presence or absence of houses, roads and dogs. The most common form of land use, surrounding a waterbody in a grid cell, was determined using the most recent land use layer available on Arcgisonline (bodemgebruik 2015, Esri Nederland, CBS, Kadaster). Land uses in grid cells were categorized in: Residential, Agricultural, Forest, Wet natural terrain and Other. Changes in water levels were estimated and confirmed by local experts.

Standardisation between researchers

Because data was collected by two individual researchers, effort was taken to standardise the scoring process as much as possible. The first grid cells were visited together to make simple agreements so that both researchers made similar estimations at the end of that visit. This minimalized observer bias and contributed to a more reliable model.

Statistics

A factor analysis for mixed data (FAMD) was conducted to determine sites where otters were expected based on habitat factors, but where no indication of otter presence was found. The analysis and visualisation was performed using the *FactoMineR* and *factoextra* packages in R (R Studio, 2020). A stepwise multiple logistic regression was performed to determine the most contributing habitat factors in terms of otter presence. Habitat factors that were included in the final model were incorporated in the prediction model made with ArcGis Pro 2.4.0 (ESRI 2019).

Figure 2. *Distribution of the otter in the Netherlands in winter 2018/19 based on spraint locations and locations of death finds during the monitoring period (Kuiters et al. 2019).*

Results

FAMD

The first and second axes of the factor analysis for mixed data (FAMD) explained respectively 20.7 and 14.4% of the variance. Sites that were close together indicated that those sites have similar values of habitat factors. 95 % interval clusters around sites with otter presence and absence showed overlap (figure 3). Sites that were located within the overlap area and initially noted as “otter absence” were considered false negatives. In further analysis false negatives were noted as “otter presence” to improve the model. This resulted in a total of 89 sites with otter presence and 50 sites with otter absence (figure 4).

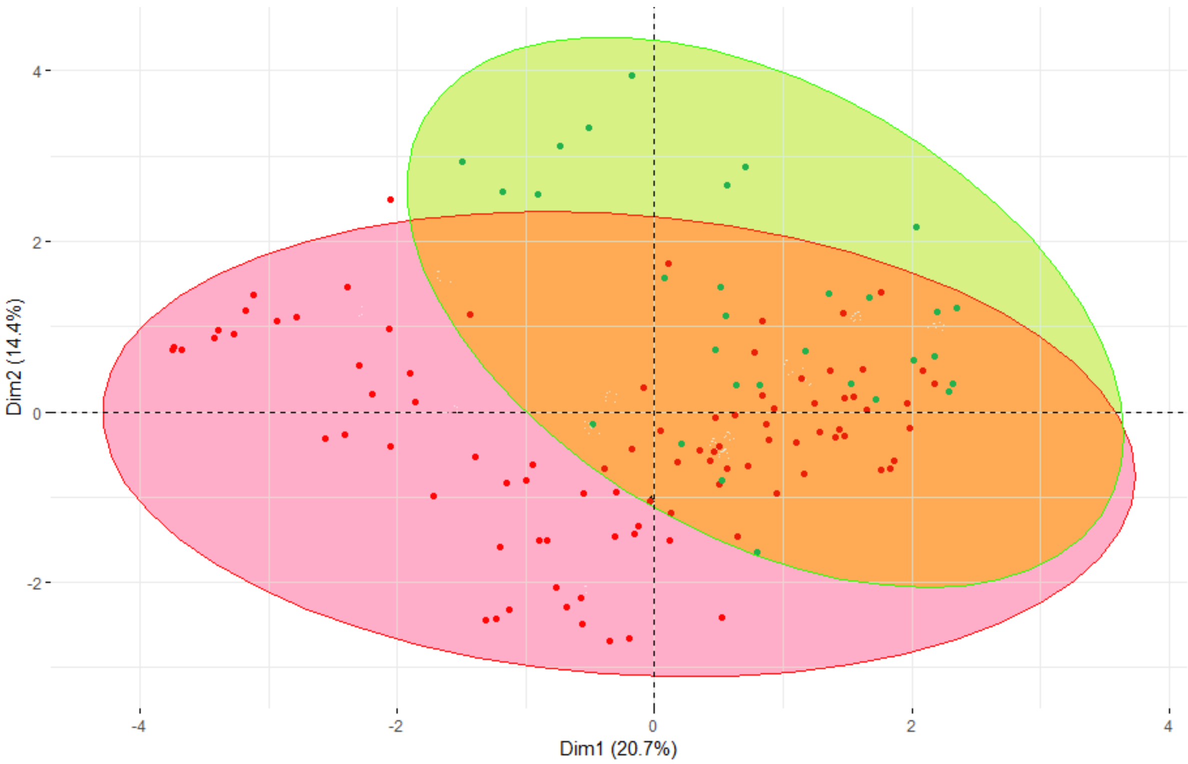

Figure 3. *Outcome of the factor analysis for mixed data (FAMD). The first and second axes explained respectively 20.7 and 14.4% of the variance. Green and red dots indicate otter presence and absence respectively. The orange area indicates the overlap between the presence and absence 95% confidence interval cluster and therefor possible false negatives. The closer sites (dots) are together the more similar they are in terms of habitat factors.*

Multiple logistic regression

All habitat factors were checked for collinearity and correlations with a correlation coefficient of 0.7 or above were excluded from further analysis. Dog-, House- and Road presence were co-correlated which resulted in the exclusion of house and road presence data. Dog presence was kept into the analysis because it had the lowest cumulative correlation coefficient of the three co-correlated factors.

Table 2. *Coefficients and p-values of habitat factors against otter presence included in the final model of the stepwise multiple logistic regression*

HABITAT FACTOR	SLOPE COEFFICIENT	P-VALUE
TREE COVER	13.27	< 0.001
REED COVER	7.48	< 0.001
WATER LEVEL CHANGE	-4.56	< 0.01
DOG PRESENCE	-1.72	0.064
BEAVER PRESENCE	2.21	0.111

A stepwise multiple logistic regression was conducted on the remaining seven habitat factors of 139 sites. The final model contained five habitat factors: Reed cover, Tree cover, Water level change, Dog presence and Beaver presence (table 2).

Reed and tree cover had a significant positive correlation with otter presence (P > 0.001). Water level change of more than two meters had a significant negative effect on otter presence (P <0.05). Although it was not significant, areas where dogs are allowed to enter are probably not favourable and were most likely avoided whereas areas where beavers are present were probably preferred. (Respectively P=0.064 and P =0.111)

Prediction model

Habitat factor coefficients of the final model were used as a proxy for the contribution of a single habitat factor in the prediction model. Tree cover, Reed cover and Beaver presence had positive slope coefficients and therefor a positive contribution to otter presence. Whereas Water level change and Dog presence had negative slope coefficients and therefor a negative contribution to otter presence. Slope coefficients were put into a "Weighted sum tool in ArcGis Pro 2.4.0 (ESRI 2019) which calculated a "Habitat suitability score" with the following formula:

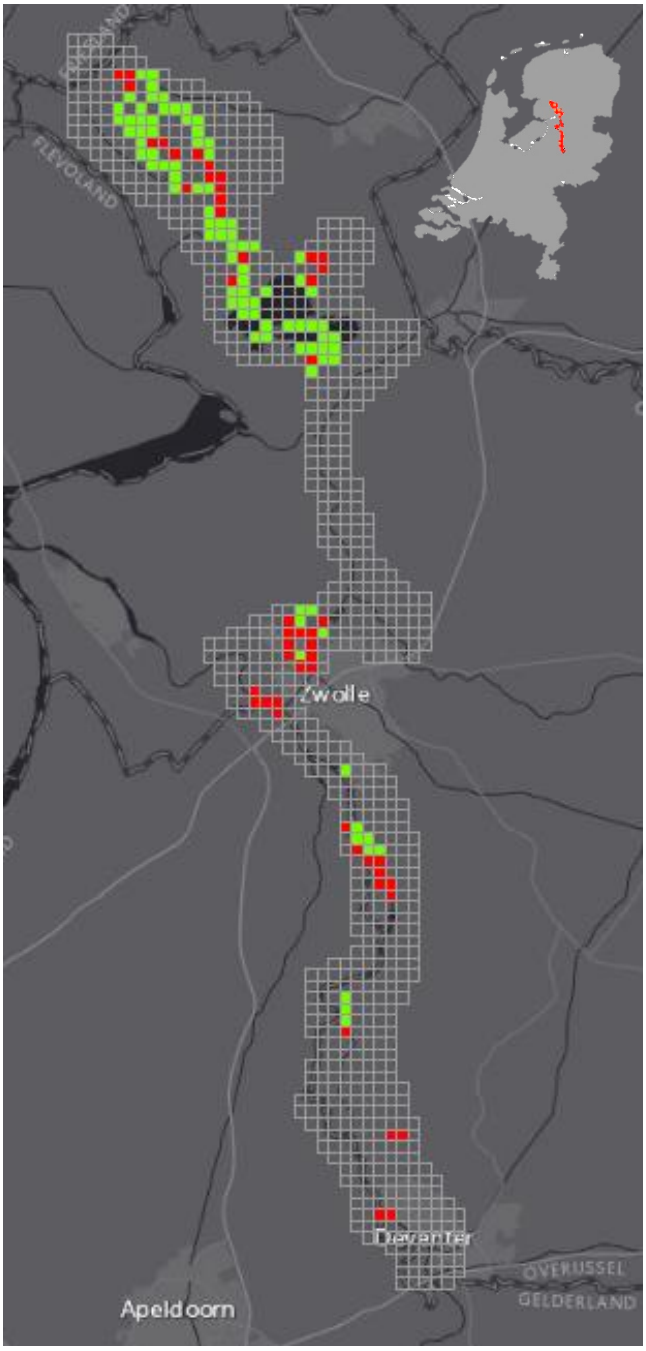

Figure 4. *Otter presence and absence in Area 1 after adjusting for potential false negatives. Green grid cells indicate otter presence, red grid cells indicate otter absence. The insets indicate the location in red within the Netherlands. Maps were made with ArcGis Desktop 10.7.1.*

$$Habitat\ suitability\ score = 13.27 * Tree\ cover + 7.48 * Reed\ cover + 2.21 * Beaver\ presence\ - 4.56\ Water\ level\ change - 1.72\ Dog\ presence$$

Habitat suitability scores varied between -627 to 1881 and were rescaled to 0 to 100. A score of 100 indicated suitable habitat and 0 unsuitable habitat. Plotted scores on a map help to visualise the data spatially (figure 5). Millingerwaard and lowaard (red circles in figure 5) scored low and were considered unsuitable otter habitat. Meertje, the Ooijpolder and the Rijnstrangen (green circles figure 5) scored high scores and were considered suitable otter habitat.

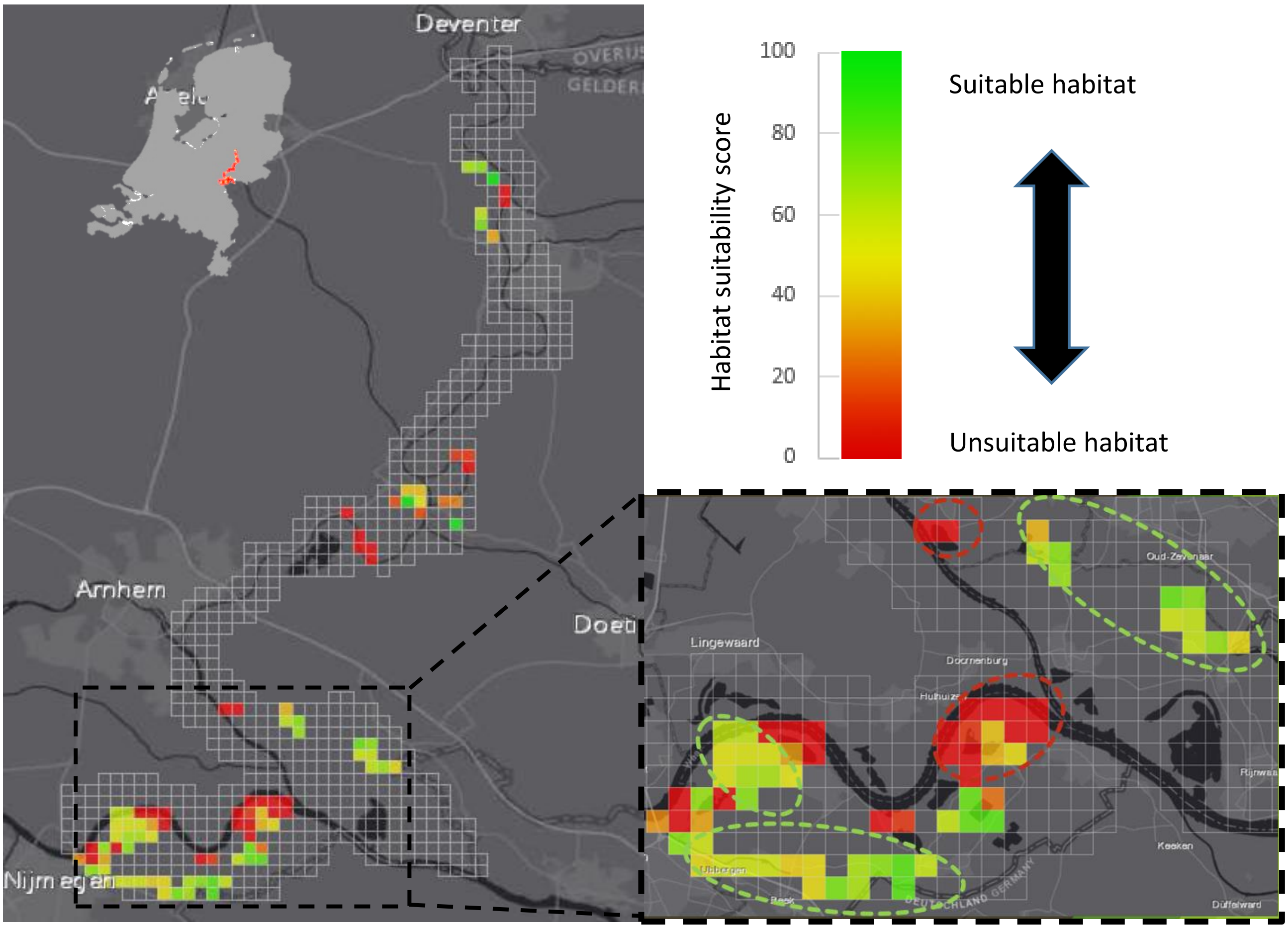

Figure 5. *Visualisation of the habitat suitability prediction model in Area 2. Habitat suitability is represented by colour, where red is unsuitable habitat and green is suitable habitat. The bottom right window zooms in on de Gelderse Poort where most data was collected. The red dotted circles represents unsuitable otter habitat (Milingerwaard and Lowaard) and the green dotted circles represents suitable otter habitat (Meertje, the Ooijpolder and the Rijnstrangen) . Maps are made with* ArcGIS Desktop 10.7.1 (ESRI)

Discussion

Habitat preferences

Results of this study suggest that otter habitat in the Netherlands typically consists of water bodies with dense vegetation along the banks. Because otters are considered a very shy species (Jefferies, 1987) and human population density is high in the Netherlands, dense vegetation seems needed to reduce the chance of human-otter interaction. The highest chance of human-otter interaction is in residential areas or with human infrastructure, which as expected seemed to be avoided. However, probably because roads and especially bridges are bottlenecks between two suitable habitat areas, these structures are used to demarcate otter territory by laying sprаints underneath them. Another benefit from this is that sprаints are more durable because they are less sensitive to being washed away by rain. Furthermore, the data reveals that waterbodies with less fluctuating water levels (<2m) were preferred. High water fluctuation is known to have a negative impact on water clarity (Anderson, 1987), which in turn decreases otter hunting success (Mason & Macdonald, 1986). Secondly when water levels decrease drastically, vegetation cover along the bankside decreases as well, as explained above makes a habitat less suitable for otters. Although it was not significant beaver presence seemed to be preferred, presumably because otters can use beaver burrows as resting sites and access to water in cold periods with ice (Thomas et al. 1999). The absence of the beaver in the Weeribben-Wieden probably caused the correlation to be weaker than expected but will become stronger when beavers will populate this area as well after their own reintroduction in the south of the Netherlands in 1988 (Nolet et al. 1996).

Data collection

As mentioned before, sometimes otters use bridges as spraint locations which is seen as "spraint location bias". The method of using spraints as an indicator of suitable habitat has therefore been discussed and criticized in Jefferies (1886), Kruuk et al. (1986), Conroy and French (1987), Kruuk and Conroy (1987) and Mason and Macdonalds (1987). The objection of these papers was that the location where the spraint was found was not considered to be representative of the entire otter habitat. To overcome spraint location bias, habitat factors were scored in an area of one square kilometre. In this way the spraint location was only a small area of the total area that was scored as suitable habitat.

Presence-absence data was used as logistic regression based on presence-absence data allows to do more accurate predictions of habitat suitability and relationships between variables than presence only data (Brotons et al. 2004). Besides our own observations, confirmed observations of volunteers in the same period (March-June) from 2019 and 2020 were used to limit the risk of missing spraints and false negatives. However, because this period is not the best period to find spraints there was still a chance that no signs of an otter were found even though the grid cell was located within an otter habitat what would result in a large number of false negatives. To find false negatives in the dataset a factor analysis of mixed data (FAMD) was used. Because the two clusters around sites with otter absence and presence did not completely match (figure 3), there was a good indication of the true negatives. Points in the overlapping area of the two clusters were considered false negatives. In this way we are convinced that the data set contained as few false negatives as possible but nevertheless also as few false positives as possible. Making the data set more reliable benefitted the logistic regression and therefore improved our prediction model significantly.

Model predictions

Predictions of the suitability model gave us insights for the future conservation of the otter but also an explanation of possible failures of the past. In 2014 a few otters have been observed in the Millingerwaard (figure 5). Because of the spontaneous establishment the Millingenwaard was considered to be suitable otter habitat and in 2018 two females were released to contribute to the stagnating genepool. However, the two females have moved out of the area, which could mean that the Millingerwaard may not be a very suitable area after all. Our model supports this hypothesis and values grid cells located in the Millingerwaard with a low score (0-38). The low score is mostly due to changes in water level of more than 2 meter and by low vegetation cover (especially reed) on the bankside by low water. In addition, it is allowed to walk with dogs through the whole area which also has a negative influence on otter presence. All these characteristics make the Millingerwaard a less suitable habitat than previously considered according to our model. This could start a discussion of choosing another, more suitable area for future releases which are indicated in our model as green areas. Green areas such as Meertje, the Ooijpolder and the Rijnstrangen indicate suitable habitat for otters and are also likely to be visited by otters in the future when numbers increase and otters will distribute more towards the south of the Netherlands.

Future research could use this model to predict potential suitable otter habitat in other parts of the Netherlands. To improve this model, more data in areas of our prediction model could be gathered and suitable habitats could be connected with a connectivity analysis. This information could show bottlenecks where otters have to cross roads or run into other obstacles which could decrease their survival chances. Further improvements could include a more detailed description of house and road presence, where presence could be divided into multiple categories (e.g. speed limit, number of lanes) or measured as a continues value (e.g. population density, surface area per grid cell, traffic noise) (Jo et al. 2017).

Overall, this study provided a better insight into otter habitat preferences in the Netherlands and by predicting future potential habitat it could stimulate measures to increase survival and make the reintroduction of the otter in the Netherlands an even greater success. Furthermore it showed that habitat suitability models can predict valuable information which can be used as a tool to stimulate nature management measures to improve habitat quality or nature conservation and meet the needs of a reintroduced species.

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