POPULATION DEVELOPMENT AND DISTRIBUTION OF WOLVES IN THE NETHERLANDS

A model-based study of how the recent settlement of wolves in the Netherlands can develop in terms of growth and distribution.
Including an analysis of how this Dutch (sub)population relates to wolf populations in neighbouring EU countries.

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Summary in English

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Introduction

In 2014, a first sighting of a wolf was reported in the Netherlands. This observation could not be validated with certainty. However, in the years that followed, wolves were observed more often, and it became certain that the wolf has recolonized the Netherlands.

After the first (non-validated) sighting of a wolf the number of individuals identified with DNA in the Netherlands increased from 1 to 10 animals between 2015 and 2018. The first reproduction was recorded in 2019, with at least 4 pups being born. For the years 2019 to 2021, reproduction remained within one pack. In 2022, 4 breeding packs were established.

Photo © Bob van den Brink

Almost 10 years after the first sighting, there are now (anno 2023) at least 7 breeding packs. More roaming wolves are being observed in an increasing number of places.

The most recent progress report from BIJ12 (May 2024) states that in the period between October 21, 2023, and February 15, 2024, a total of 51 different wolves in the Netherlands were identified with DNA.

An estimate of the total number of (adult) wolves occurring in the Netherlands remains difficult to make because roaming wolves (adult animals that have not yet occupied a territory or have not yet found a partner) are difficult to determine due to their roaming and hidden behaviour.

Since 2015, several studies and analyses have been carried out in the Netherlands. These were mainly based on data from Germany and other countries (including the USA). This was due to a lack of sufficiently reliable and long-term knowledge about the Dutch situation. Therefore, foreign data had to be used to make estimates about the behaviour and habitat use of the wolf in the Netherlands. See the bibliography at the end of this document.

After almost 10 years of wolf presence in the Netherlands, a picture is emerging that these wolves behave in a different way than previously had been predicted based on foreign data and knowledge. The high human density, the Dutch human-dominated landscape and land use appears to pose other and new challenges for the survival and further establishment of the wolf population.

The Research Assignment

The research is commissioned by the Association of 12 provincial Authorities (hereinafter: BIJ12). This organization is responsible for the monitoring the Dutch wolf population and registration livestock predation by wolves. Researchers Dr. Ir. Jasja Dekker, Bob van den Brink (M.Sc.), and Luuk Boerema (LLM, MA) have conducted an analysis to give an estimation what can be expected about future growth and distribution of the current wolf population in the Netherlands.

The goal of the project was to explore and model the following aspects:

1. The current and future trend of the wolf population in the Netherlands and the factors that may influence this.
2. The current and future trend of the distribution of the wolf in the Netherlands and the factors that may influence this.
3. The correlation between the current wolf (sub)population in the Netherlands and populations within other European member states.

The results are described in a report (in Dutch language) "Populatieontwikkeling en verspreiding van de wolf in Nederland 2024 [1]. This report contains partly complex explanations of methods and methodologies and requires from the reader a certain degree of knowledge about population modelling.

To reach a broader international audience, this English summary highlights the methodology and analysis results. The authors hope to produce a more extensive publication (in English) in the near future.

The relation between the Dutch wolf (sub)population and bordering European wolf populations

Within the countries which are part of the European Union, nine wolf populations can be distinguished. The status of the entire wolf population within Geographic Europe (excluding Russia) was estimated by the IUCN around 2018 at approximately 17,000 wolves, of which 13,000 to 14,000 wolves are believed to be within the EU member states. This publication also provides a summary description of the nine subpopulations within Europe. A recent document commissioned by the European Union (Blanco J.C. & Sundseth K. 2023 (see bibliography)) estimates that this number has increased to above 20,000 wolves and 23 Member States have now breeding packs. However, the above numbers must be treated with caution. The last inventory in 2023 shows considerable differences in the methods by which (numbers of) wolves are estimated or counted in different Member States.

[1] Dekker, J, Brink, D.B. van den, en Boerema, L., 2024. Populatieontwikkeling en verspreiding van de wolf in Nederland, een modelmatige studie hoe de binnen Nederland voorkomende wolvenpopulaties zich kan ontwikkelen, inclusief een ecologisch-juridische analyse hoe de Nederlandse populatie in relatie staat met de ons omringende landen. Jasja Dekker Dierecologie B.V, Arnhem.

The Dutch wolves and their connection with the Central European wolf population

The Central European wolf population (hereinafter: CE population) has developed from the Polish population and has a large distribution area. This includes Poland, Germany, the Czech Republic, Denmark, the Netherlands, Belgium and possibly parts of Austria. A possible (geographical) connection with the Baltic population is assumed. However, no significant genetic exchange appears to have taken place yet and both populations must still be regarded as separate populations.

There is sufficient genetic evidence to suggest that the wolves found in the Netherlands predominantly originate from the CE population (as mentioned above). Genetic analysis of material left by wolves (on prey or faeces) up to and including 2023 (source data: BIJ12) show that 3 out of 90 wolves in the Netherlands originate from the Italian French-Alpine population. Two of these animals were identified for the first time in 2020 and 1 animal for the first time in 2021. All the other identified animals originate from de above-mentioned CE population. To date, the interaction with the Italian French-Alpine population has been too limited to have an impact on the genetic uniqueness of the CE population. However, it can be expected that in the long term there will be more exchanges between the CE population and the growing Italian French-Alpine population.

Model study on future population trends of the wolf population within the Netherlands

To explore the current and future trend of the wolf population in the Netherlands, we used data from BIJ12 and the Dutch reporting point 'wolvenmeldpunt'. The data included both spontaneous observations as data collected using a fixed methodology. All observations are assessed for reliability, based on four scores, according to the SCALP-criteria: C1 (clear evidence), C2 (confirmed indications, e.g., observations), C3 (unconfirmed indications), and F (incorrect observation/fault). Only confirmed observations (C1 and C2) were used for this analysis. This includes visual observations, genotyped wolf faeces, and identified prey remains from passive monitoring, as well as monitoring and registration of livestock attacks.

Population trend of the wolf in the Netherlands

This part of the study focuses on a model-based assessment of the expected growth of the population within the Netherlands.

As a first step, the applicability of known existing population models was explored. Over the past 30 years a number of wolf population models have been drawn up and published. Fifteen models on population dynamics in a defined region or area could be found in the international literature. After assessing these models none of them appeared to be directly applicable to be used to get valuable answers on the current research goals.

Secondly, we analysed whether the collected data on behaviour, reproduction and distribution of wolves in the Netherlands since 2014 are sufficient to serve as a high-quality sample for a prediction of the future population trend. As it turned out this was not the case due to insufficient long series of necessary parameters available, such as litter size, migration, annual survival, dispersion and settlement probability. This was also the case in the models reviewed. Therefore, like the other models we reviewed, it was necessary to use data and knowledge from long term studies in Germany, other European countries in Europe and even North America where studies on population trends and behaviour have been conducted over a sufficient long period.

The mathematical model

For this reason, we developed a total new stage-structured population model, with density-dependent effects in the form of a maximum number of packs (territories). The model has been limited to predicting population development of wolves in the Netherlands, with migration to and from Belgium and Germany, but can be expanded to a larger area. It is implemented in the statistical programming language R.

For this model, a population of wolves is composed of five stages (Figure 1). A pack, consisting of pups, yearlings and wolves of 2 years and older, which can be subdominant or dominant. Only dominant wolves reproduce.

A fifth stage are the roaming adult wolves (no territory).

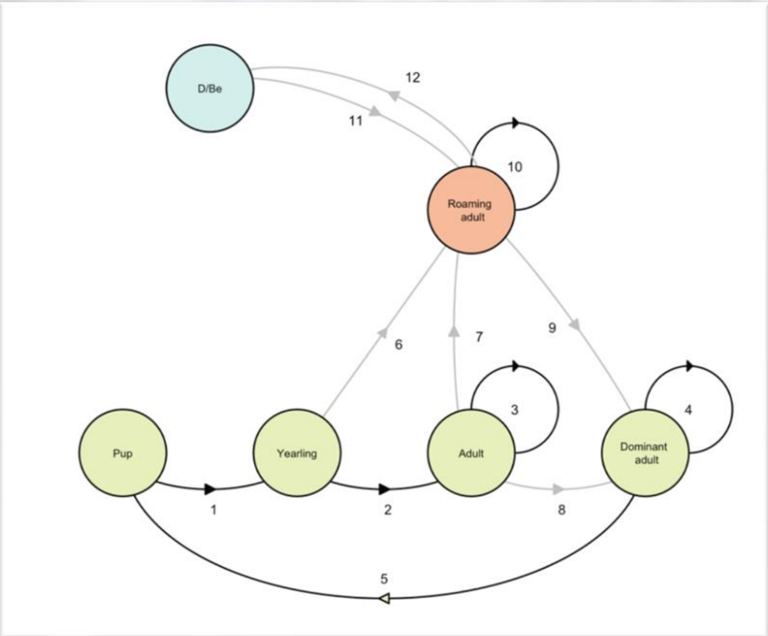

Figure 1. Structure of the population model of wolves in the Netherlands. Green = pack. Numbers at the transitions refer to the processes described in the overview at right.

Transitions between wolf populations' stages

1) Fraction of pups that survive to yearling.
2) Fraction of yearlings that survive the year and stay with the pack as an adult.
3) Fraction of adult subdominant wolves that survive the year and stay with the pack.
4) Fraction of dominant wolves that survive the year.
5) Birth-number of pups per female.
6) Fraction of yearlings that survive the year and disperse.
7) Fraction of subdominant adult that survive the year and disperse.
8) Fraction of subdominant wolves that survive the year and become dominant wolves.
9) Fraction of roaming wolves that survive the year and settle in a (new)territory.
10) Fraction of roaming wolves that survive the year and do not settle.
11) Immigrating wolves(to the Netherlands)/year.
12) Emigrating wolves (from the Netherlands)/year.

The model takes calculation steps of 1 year. Within that year, animals die, pups are born, and some wolves move from one stage to another. The share of pups that survive the year become yearlings, yearlings that survive and do not stay with the pack move to the stage 'dispersing wolves', etc. Dominant wolves remain dominant, but for this group the annual mortality is also calculated.

Used data and results

Where possible, parameters in the model for vital rates (e.g. survival rates and litter size) and stage changes (e.g. dispersal, settlement or migration) were derived from data from the Netherlands and Germany. Where these are not available parameter values were used from (most comparable) populations elsewhere.

The predictions of the model for the first 10 years of population trend were compared for validation with the data collected by BIJ12 on packs, population size and number of pups in the Netherlands in 2014-2023. In the model, the fraction subdominant or roaming wolves that establish a territory declines to 0 as the number of territories approaches a maximum value.

In the example calculations below, the predictions calculated by the model are shown next to the actual field data over the first 10 years (2014-2023).

Default model simulation.

<u>*10 years after first sighting*</u>

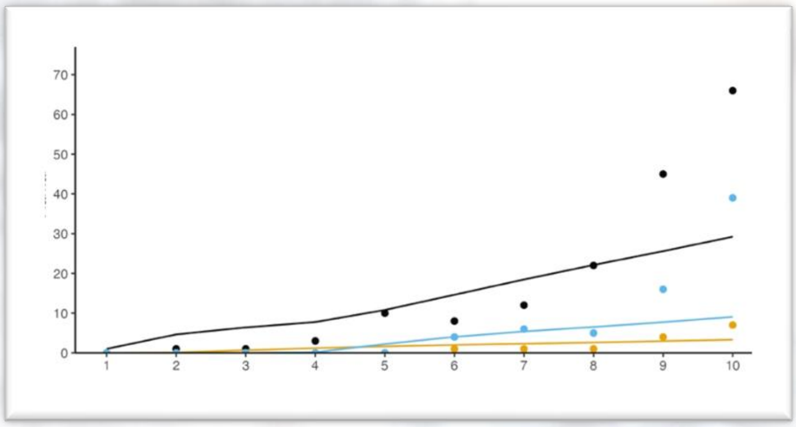

Figure 2. Projection of the Dutch wolf population from the model (lines) versus field data (dots): Black: population size/known number of individual wolves in the Netherlands: ; blue: number of pups; Orange: number of packs. Model-year 1 corresponds to 2014, model-year to 2015, etc.

<u>*30 years after first sighting*</u>

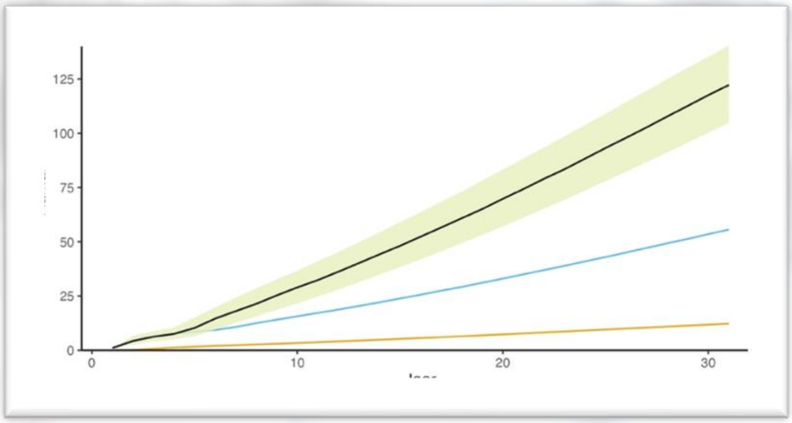

Figure 3. Projection of the Dutch wolf population according to the default model. Black with green: total population + standard deviation from Monte Carlo simulations; blue: number of adult wolves, orange: number of packs.

The default model simulation (figure 2) shows a slow increase in number over the simulated 30 years (figure 3). After 30 years, the model predicts a population of 122 wolves. The composition of the wolf population is predicted to be 43 pups, 24 yearlings, 10 subdominant and 24 dominant adults in 12 packs, plus 21 roaming adults.

The default simulation predicts a slower growth of the number of territories, pups and population size: the population in the Netherlands is growing faster in the first 10 years.

This means that the situation in the Netherlands is different than the model with these parameters (from field data and German or other European and North American studies on wolf vital rates) suggests.

To determine the most important driving factors for the Dutch situation, 13 variants of the model were parameterised and calculated with higher or lower parameter values. The calculated variant with an increased change on establishing a territory by roaming wolves shows (significant) changes in population development and territories. The results of this modelling variant are discussed below as an example.

Increased territory settlement by roaming wolves
The default model includes a 50% chance of establishment. This 'default' chance is derived from a North American study and is used in almost all population models for wolves. Using this default value appears not applicable to the Dutch situation. In the calculated variant where the establishment 'change' is sufficient higher than used in the default simulation the population reaches a stable size within 30 years. See figure 4 on the next page.

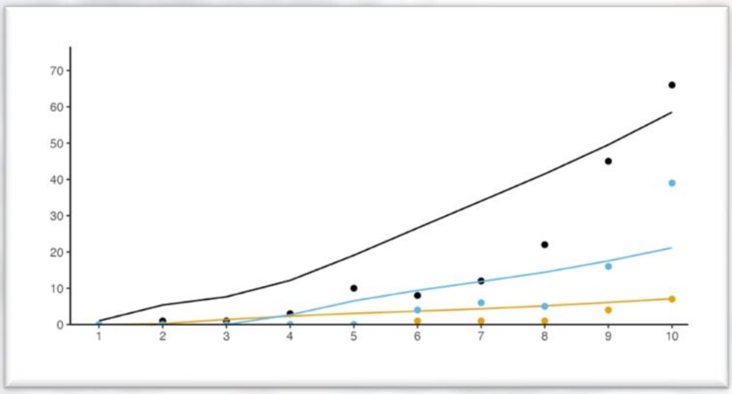

Figure 4. Trend of the wolf population in the Netherlands according to field data (dots) in comparison with the probability scenario of establishing a territory of 90% instead of 50% according to default-value (lines). Black: number of wolves, Blue: number of pups, and orange: number of packs. Model year 1 is equal to the field data of 2014 etc.

The simulation over the first 10 years fits well with the actual field data about numbers of wolves, packs and number of pups in the Netherlands over the past 10 years.

Summary of other results
As mentioned above, the model for this analysis was calculated with 13 different parameters and compared with known field data. The main conclusions that can be drawn from the population modelling are:

- In none of the simulated variants the Dutch (sub)population will go extinct. The main reason is a regular influx of animals from neighbouring countries.
- The maximum (ecological) carrying capacity will not be reached within 30 years in all variants, except in the above-described variant with a high chance of establishment.
- In all calculated variants, a wolf (sub)population develops that consists of established packs and roaming wolves. The packs consist of pups, yearlings and dominant and subdominant adults. The group of roaming wolves is formed by animals that immigrate to the Netherlands from abroad and animals that were born in the Netherlands and dispersed and have not settled. The model assumes that some roaming wolves will leave the Netherlands.

Suggestions for further improvement and use of the model
As wolves continue to occur in the Netherlands over a longer period, the amount of monitoring data on behaviour, settlement, reproduction and mortality will increase. With good quality data more specific knowledge of Dutch wolf ecology will be gained. This information can be used to improve and fine tune this model. As a result, the calculations from this model will provide increasingly reliable outcomes. This is scientifically valuable as wolves in the Netherlands must live in and adapt to a new type of predominantly human dominated landscape (habitat). Other ecological processes might play a role in (dispersal) behaviour than what we can interpret from earlier times or collected knowledge about wolf populations in less anthropogenic landscapes. The model can then also be used to calculate the effect of future changes in landscape and policies.

In addition, it is recommended to continue and, if possible, improve the data collection for several parameters. For example, data on litter size (how many pups are born per litter), the actual migration from and to the countries bordering the Netherlands, annual survival of individuals, and dispersal and settlement probabilities.

In addition, it is recommended to expand this model study to include Belgium and Germany to gain more insight into actual cross-border migrations, and through this how developments in the 3 countries may interact on the national populations and on the size of the (CE) population within its natural range extending over several EU member states.

Wolves in The Netherlands: Insight into current and future distribution through Occupancy Modelling

What can be said about the current and future development of the distribution of the wolf in the Netherlands?

The most common way to create species distribution images is to plot observations on a map. Usually in grid cells of 1x1 kilometre or 5x5 kilometres. However, the observation process, the process in which the presence of an animal species leads to a registered observation, is rarely perfect. This is the reason why such a map commonly is indicated as *naive occupancy*.

To be able to take these uncertain factors into account (not reporting, not enough evidence for validation, or not leaving traces), a specific statistical methodology has been developed: occupancy modelling. By statistically separating the probability of detection and the probability of occurrence (the probability a species is observed), this method converts the naive distribution picture into the 'likely' distribution picture: 'the probability of occurrence (occupancy)'.

First, we analysed the probability of occurrence and distribution over the years 2014-2023. Secondly, we analysed the probability of occurrence and detection and prediction of the distribution in 2023.

In most occupancy studies, the study area is clearly defined in advance: there is an area of interest where, as far as possible, an active inventory is made. This is not the case for this study. We decided to conduct the probability analysis not for the whole of the Netherlands, but to include only those 5x5 km grid cells where a wolf has been observed in the last 10 years, including the area with grid cells in between those observation cells. By choosing this area as a study area, the probability of encounter and occupancy is only calculated for 5x5 km grid cells where a wolf could have been present with some certainty.

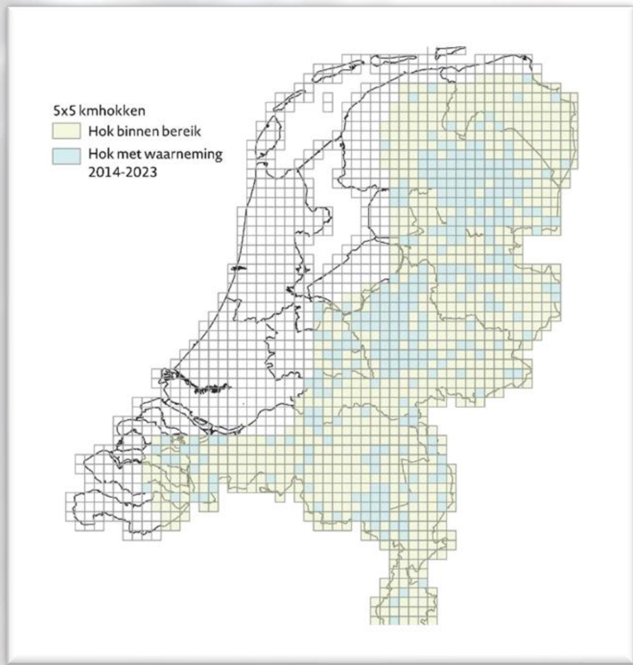

Figure 5. Naive occupancy in the period 2014-2023: 5x5 km grid-cells with observations of wolves (blue) and the occupancy study area (green).

In these analyses, based on the data collected on wolves occurring in the Netherlands, the effect of probability of occupancy and landscape characteristics on the distribution of wolves has been analysed for the first time. Using actual observations of wolves in the Netherlands is a valuable extension to normal distribution maps, because wolves can exhibit unexpected behaviour or ecological relationships in newly colonised landscapes and may remain undetected on certain locations.

The model suggests that slightly more 5x5 km grid cells are occupied than the number in which wolves have been observed. This concerns a few grid cells per year. In this way the distribution area, based on the current combination of collecting various observation sources (direct observations/camera traps, registration and validation of damage reports, systematic monitoring schemes) and other monitoring (droppings, prints), will be clearly demarcated.

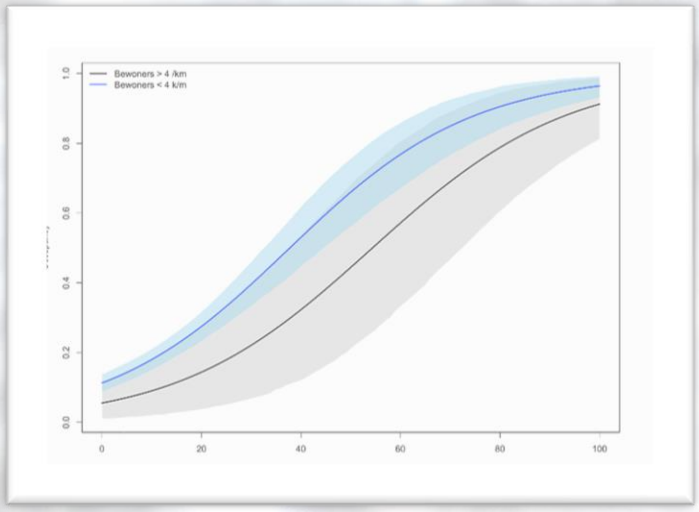

Figure 6. The relation between occupancy of wolves in 5x5 km grid cells and the surface of woodland, in high(grey) and low densities of human habitation (blue).

The effect on occurrence of (the data for) population density, presence of woodland and number of sheep in a 5x5 km grid cell resulted in some uncertain predictions. The reason is that the used data was insufficiently detailed. Some other influencing factors were not available in sufficient detail, such as the density of the road network, densities of deer species and other wild prey animals. It is also possible that wolves in the Netherlands do make (partly) other choices, like predation on livestock where natural prey is scarce.

Recommendations
The probability analysis as described is for now an initial exploration of the possibilities that such an analysis offers. The availability and degree of detail of data on densities of prey animals (sheep, deer species and wild boar) was a limitation for this study. The analyses had to be limited to relatively simple statistical modelling with a limited number of factors which can influence occurrence or detection. Several refinements for future use are possible, some of these are:

- Including more or better explanatory factors, compare models and use the best explanatory models for the project of current and potential dissemination.
- Better availability and use of descriptive data of these factors.
- Refining the model by including the effect of observation method (direct observations, genetic sampling of prey remains) on the probability of detection. This can be done with (multi-scale) multi-method occupancy analyses.
- Including a seasonal variance in the probability of detection. For example, wolves might be easier to spot during the summer period. There is also a higher chance to observe more animals around or after the moment when young wolves leave their pack and become roaming wolves. The effect of month or season on the chance of detection can be included with an 'occupancy with survey covariates' analysis.

Which factors can have impact on population growth and distribution in the Netherlands

Through a literature study, it was investigated which factors in the Dutch situation could have an important influence on the distribution and survival of wolf population in the Netherlands.

The first and main source is a 2015 publication by the Large Carnivore Initiative for Europe (LCIE), Boitani et al. (2015), see bibliography. This report describes the main threats to the nine European wolf populations. In 2022, another assessment was carried out (also by the LCIE) into the threats to wolf populations within Europe. This assessment identified 'road traffic', 'illegal killings' and 'disruption from tourism-related activities' as the most reported threat factors over the whole of Europe. But it also follows from this assessment that important influencing factors can differ per region or Member State. For densely populated countries, including parts of Germany, but certainly also the Low Countries (the Netherlands and Belgium), a different picture emerges. For the Netherlands certain factors can be distinguished. Direct threats for the current wolf population in the Netherlands are deaths from traffic accidents, illegal killing, the fragmentation, reduction or degradation of range or habitat, and disruptions due to certain recreational activities. Other 'pressure factors' for the Dutch situation are ddegradation of habitat quality, decrease in suitable habitat due to (nature) management measures and/or changes in land use, population management or culling of individual 'problem' wolves and restrictions of movement in rural areas due to fencing (including large-scale protection of livestock or other prey animals against wolf predation).

Anno 2024, hybridization does not seem to be a problem in the Netherlands. On a larger time scale however, this factor should be considered as a threat. This because wolf-dog hybridization can cause the introduction of non-adaptive genes into the wild wolf population and consequently influence the genetic identity, morphology and behaviour.

What can or should we do with collected data and information?

Determining the (favourable) Conservation Status

Based on the Habitats Directive, the Conservation Status of the wolf must be determined by formulating 'Favourable Reference Values' (hereinafter: FRVs). The information from this model study and the information from the habitat qualification study (Biersteker et al. 2024, see bibliography) can be useful in further developing and formulating these FRVs.

Cross-border coordination, monitoring and planning.

Determining and calculating the population size and determining the 'Favourable Conservation Status' (hereinafter: FCS) only within the borders of the Netherlands has little ecological and legal value. In both European and national case law on the assessment of the effect of an infringement on the protection of species, the line of case law is that the effect on the conservation status must be assessed 'from small to large': The effect on the conservation status must be assessed primarily at the local level, building up to the national level. For the CE wolf population, it is obvious to next assess the FCS on a broader (international) level, given the characteristics of the species and its extensive habitat and population range.

To gain insight into the actual size and distribution of the CE population and thus also to ensure an unambiguous determination of the (favourable) Conservation Status, it appears that coordination between the Member States Poland, Germany, Denmark, the Netherlands, Belgium and perhaps also the Czech Republic and Austria will have to improve. An unambiguous and mutually verifiable method of monitoring wolves within the distribution area of the Central European population will have to be implemented.

According to the European Commission, policy about and management of cross-border wolf populations must be coordinated with Member States in which the population in question occurs. But more than just coordination is needed. If derogations are wanted or needed, a cross-border protection and management plan will have to be in place for the (whole) population in question. Such a plan would address all relevant threats, conflicts, opportunities and needs related to the wolf. In this plan different factors and different challenges can be considered per region or per Member State. Such a plan would best ensure that a FCS for the wolf is achieved and maintained throughout its range, while providing, within the limits set by the Directive, the required flexibility in management. An appropriate and comprehensive wolf conservation and management plan can provide a good overall framework for the application of all necessary instruments measures and policies.

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