Analyses of environmental and social suitability of the Netherlands to wolves

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Faunis Srl



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Summary

The present report complies with three main questions: how many wolf packs the Netherlands could support, whether the Dutch wolf population is genetically healthy, and which management could be feasible and what "favourable conservation status" should mean in the Dutch context.

In a nutshell the central message is that wolves have successfully re-established themselves in the Netherlands and are now an integral part of the broader Central European wolf population. The Dutch wolf population is genetically healthy, continues to receive immigrants from neighbouring countries, and already meets the main criteria for a favourable conservation status (FCS). At the same time, the rapid expansion of wolves creates growing challenges for livestock farming, public acceptance, and management in a densely populated country. It is urgent a proactive management strategy focused on prevention, zoning, monitoring, and rapid intervention when problematic wolves emerge.

How many wolves could live in The Netherlands?

Using maps of land use, indexes of human presence and records of wild animals, we estimated that the Netherlands could theoretically accommodate about 94 breeding wolf packs, with a plausible range of 79 to 102. However, this is not a management target. Rather, it represents a theoretical maximum based on habitat characteristics alone and does not fully account (given by lack of data) for prey availability, livestock conflicts, human-wolf interactions, public acceptance, social and economic impacts. Importantly, wolves can establish themselves even in landscapes with limited natural prey by exploiting livestock and other human-related food resources; therefore, allowing population expansion without appropriate planning could increase ecological, economic and social conflicts.

Is the Dutch wolf population healthy?

Genetically, the Dutch population is in good condition. Most breeding pairs consist of unrelated wolves, with the contribution of individuals from Germany, Belgium, or even the Alpine region, bringing new genetic variation. No sign of inbreeding or loss of genetic diversity can be observed. The Dutch population is clearly not an isolated population but rather a subunit of the larger Central European wolf population, with continuous gene flow maintaining its long-term viability.

Conservation status

The current Dutch wolf population already meets the proposed criteria for Favourable Conservation Status, when assessed in the context of the wider Central European population. This conclusion is based on its effective population size, positive population trend, genetic diversity, habitat availability and continued connectivity with neighbouring countries. Consequently, the Netherlands does not need to pursue a predetermined numerical target for wolf packs, instead, conservation objectives should focus on maintaining a viable, genetically connected population occupying ecologically appropriate areas.

Human – wolf conflicts

The expansion of wolves has already generated substantial challenges for livestock farmers. In 2025, approximately: 3,300 heads of livestock were killed, totalling €1.4M compensation

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payments. An important contributor to the current situation is the insufficient implementation of preventive measures (94% of farms without prevention). Furthermore, livestock predation generates indirect costs, including additional labour, reduced productivity, administrative burdens and animal-welfare consequences. Moreover, between 2023 and 2025, five documented incidents involving wolves and people were reported, including cases in recreational areas with the worrying involvement of children.

The suggested management approach

The wolf management should vary across the country according to ecological suitability and conflict risk differentiating areas where wolves can survive from areas where their presence allows them to fulfil their natural ecological role: wolves contribute to ecosystem functioning primarily through predation on wild ungulates; where natural prey is insufficient, wolves may increasingly depend on livestock or other human-related food sources, increasing conflicts.

Key recommendations, to keep conservation goals and minimise conflicts, include:

- identifying areas where wolves can maintain their natural ecological role, by prioritising areas with abundant wild prey;
- preventing settlement in areas with insufficient natural resources and high conflict potential;
- expanding livestock protection measures;
- improving public awareness and education;
- increasing monitoring through GPS telemetry, genetics, and field surveillance;
- rapidly identifying and managing problem wolves.

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Premise

The return of the wolf (*Canis lupus*) to many European countries from which it had been historically extirpated has created new challenges for wildlife conservation and management, particularly in densely populated and highly anthropized landscapes. The recovery of wolf populations in Central Europe demonstrates the species' remarkable ecological plasticity and its ability to establish and persist in environments characterised by intensive human activities, fragmented habitats and a complex mosaic of natural, agricultural and urban areas. However, the capacity of wolves to establish territories in such landscapes does not necessarily imply that all areas are equally suitable for maintaining viable populations or for supporting the ecological functions that wolves perform in natural ecosystems. In particular, the availability of wild prey, the extent of human disturbance, the distribution of livestock and the frequency of interactions with people are important factors to consider when assessing the long-term sustainability of wolf populations and the potential for coexistence with human activities.

The Netherlands represents a particularly relevant case in this respect. Its high human population density, extensive road network, intensive livestock production and limited extent of natural habitats create a distinctive context in which to evaluate the ecological requirements of wolves alongside the potential for human–wolf coexistence. At the same time, the country's position within the Central European wolf population, together with the potential for dispersal and genetic exchange with neighbouring countries, means that the status of Dutch wolves cannot be assessed exclusively at the national level.

Since the first wolves returned in 2015, the Dutch wolf population has progressively expanded as part of the wider Central European population. Its development raises questions not only about the potential number and distribution of wolf packs that the Dutch territory could support, but also about the ecological conditions required to maintain the species' natural functional role, the genetic characteristics and viability of the population, and the implications of wolf expansion for livestock farming, human safety and wildlife management in the country.

In this context, the present report was prepared by Faunis Srl in response to a request from the Ministry of Agriculture, Fisheries, Food Security and Nature of the Netherlands. Its purpose was to provide a scientific assessment of the environmental, demographic, genetic and socioeconomic dimensions relevant to the long-term conservation and management of wolves in the country. The assessment was developed within the framework of the Habitats Directive (Directive 92/43/EEC), with particular reference to the concept of favourable conservation status (FCS) and the determination of favourable reference values (FRVs) for large carnivores, considering the methodological guidance developed for the European Commission.

The assessment is structured around four main objectives.

The **first chapter** aims to estimate the potential distribution of wolves and the number of packs that could establish territories in the Netherlands under the conditions represented by the available data. This involves modelling wolf occurrence using genetically confirmed records of wolf presence, together with information on land cover, human population density, infrastructure and indicators of human disturbance, as well as available data on wild ungulate occurrence. The resulting habitat suitability models are used to estimate the potential territorial capacity of the country. This estimate is intended to describe potential settlement

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opportunities rather than to define a target population size or a favourable reference population independently of ecological functionality and socioeconomic constraints.

The **second chapter** aims to assess the genetic characteristics and connectivity of the Dutch wolf population in relation to the wider Central European population Using genetic data from wolves sampled in the Netherlands between 2018 and 2025 and comparative data from neighbouring populations, the analysis intends to examine genetic variation, inbreeding, the origins of wolves detected in the country and the extent of gene flow between the Dutch population and neighbouring populations. Particular attention is paid to the contribution of dispersal and immigration to the maintenance of genetic diversity, as well as to the available evidence concerning possible hybridisation with domestic dogs.

The **third chapter** aims to suggest the more suitable livestock damage prevention policy in the Netherlands, considering the present efforts that are already relevant and represent a strong background for a further development. The suggested measures are expected to be well coordinated at the national scale and included in a national plan to give to this issue a solution that could be uniform and coordinated at the country level, rather than specific to single provinces.

The **fourth chapter** aims to interpret the results of the ecological and genetic analyses to provide a realistic and sustainable management allowing the conservation of wolves in the Netherlands in relation to the requirements for maintaining a favourable conservation status that should comply with the legal frameworks of the Habitats Directive, the guidelines to its application, and the interpretations of the Habitats Directive given by the European Court of Justice

This requires going beyond the maximum number of territories potentially supported by habitat suitability alone. The assessment therefore considers the ecological role of wolves as predators of wild ungulates, the availability and distribution of natural prey, the potential for livestock depredation, and the implications of wolf–human interactions for the long-term sustainability of conservation measures. The distinction between the potential capacity of the territory to accommodate wolf packs and the number of packs compatible with the maintenance of their ecological function and with the management of human–wolf conflicts represent a central element of the report.

The work integrates several complementary sources of information. However, the scope of the analyses is necessarily influenced by the availability, spatial resolution and completeness of the data provided. In particular, the absence of a georeferenced inventory of livestock farms and the lack of sufficiently detailed quantitative information on wild ungulate abundance limited the possibility of directly incorporating these variables into the habitat suitability models and of producing a comprehensive spatial assessment of livestock-conflict risk. These limitations are explicitly considered when interpreting the results and identifying priorities for future monitoring and management of the species.

Overall, the purpose of this report is not simply to establish how many wolves could potentially occupy the Netherlands, but to provide an integrated scientific basis for evaluating the conditions under which the country can contribute to the long-term conservation of the Central European wolf population. By combining habitat suitability modelling, population genetics, ecological considerations and an assessment of human–wolf interactions, the report seeks to

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support decisions that reconcile the conservation objectives of the Habitats Directive with the specific environmental and socioeconomic characteristics of the Netherlands, while recognising the uncertainties and information gaps that remain to be addressed.

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Chapter 1 - Species Distribution Modelling

1.1 – Disclaimer

The analyses of environmental and social suitability of the Netherlands to wolves were planned to be based on a number of variables that were formally requested, including:

- Wild ungulates distribution and abundance;
- Livestock distribution and density (with reference to different species).

In the former case the data available were related to the presence of different ungulate species from 2018 to present on a yearly basis but they didn't come from systematic monitoring and they were not actually quantitative so it was not possible to include the biomass of wild ungulates in the analyses as planned. Only in summer after May 2026 (when the data usable for the ecological model were made available to us through a formal transfer by various public bodies) we were able to find, by our initiative, data on ungulate distribution, numbers and culling figures that were used for the discussion but not for the model as this was already in advanced stage of elaboration.

As for the latter, in spite of many requests, data on livestock farms numbers, location and characteristics (species raised, number of heads, kind of management free ranging/stall) were unfortunately not available, so they were not included in the analyses and it was impossible to draw a map of risk for livestock breeding activities.

Moreover, the location of wolf packs was not given in coordinates but was blurred into a square of 5×5 km limiting the accuracy of the evaluation.

More in general, despite the considerable effort of the Offices of the Ministry of Agriculture, the data were made available quite late as they were provided in May 2026. However, not all the data provided were fully consistent with, or reflected, the information originally requested. Consequently, the analyses and the development of the model assessing the potential of the area and estimating the number of wolf packs that could potentially occupy the Dutch territory in the future had to be reconsidered and adapted based on the data that were actually available.

1.2 – Data modelling and results

To estimate the potential distribution of the wolf in the Netherlands, an empirical Species Distribution modelling (SDM) approach, on the original data of wolf distribution in the Country, was adopted. National yearly data, from 2018 to 2025, on genetically verified presence of the wolf were provided by the DG Nature and Fisheries of the Ministry of Agriculture, Fisheries, Food Security and Nature, on a regular square grid of 25 km^2 cells. This format, even if not selected on biological basis, was then set as the spatial resolution of the model (Figure 1.1).

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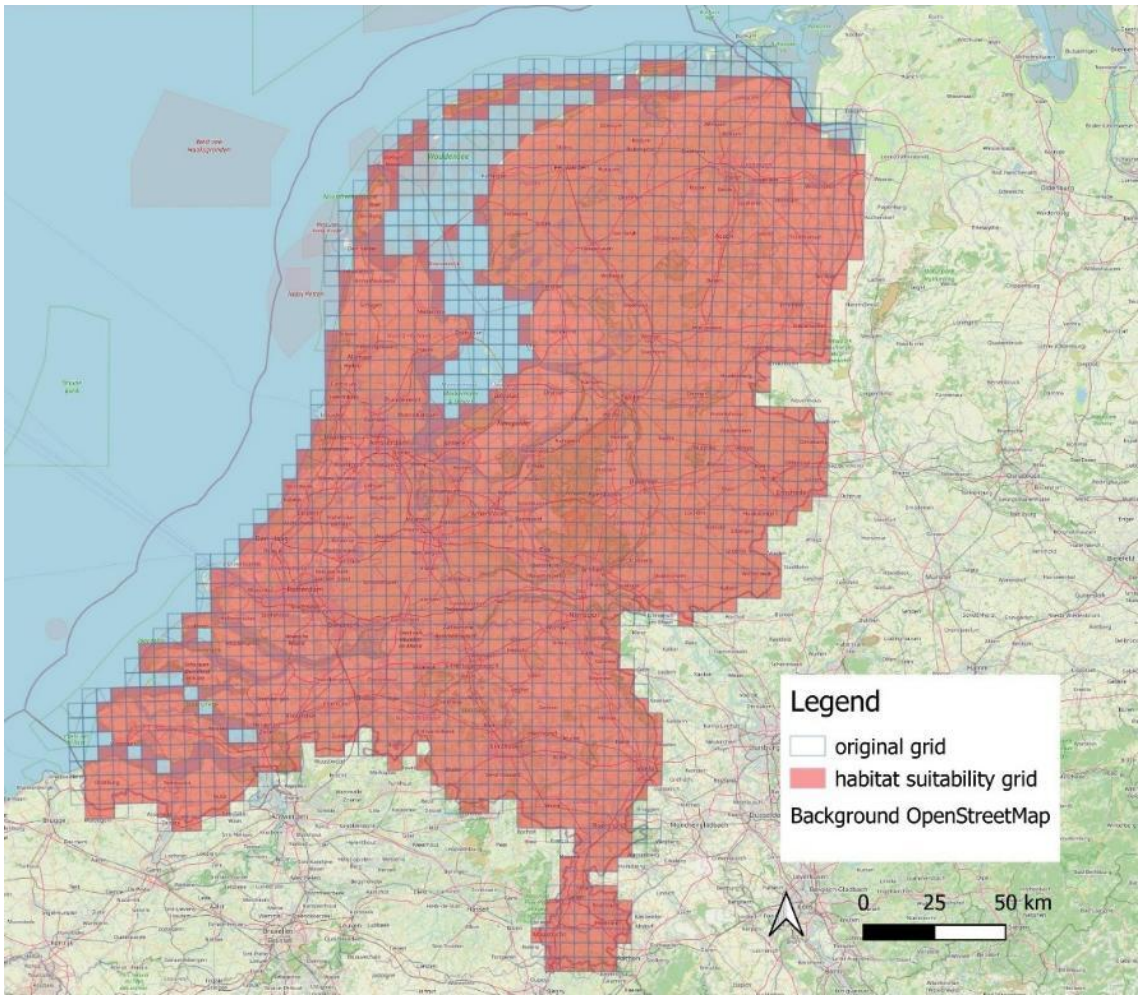

Figure 1.1 – The grid provided by the DG Nature and Fisheries of the Ministry of Agriculture, Fisheries, Food Security and Nature and the cells retained for the Habitat suitability models (25 km^2 cells).

The habitat of each cell was characterized by computing:

- the proportion of the 30 Corine Land Cover land use categories occurring in the Netherlands (CORINE Land Cover 2018 dataset - Copernicus Land Monitoring Service 2020) (Figure 1.2);

- the anthropic disturbance by considering 4 variables:

- length (km) of roads, railways and motorways per km^2, from PDOK dataset (https://www.pdok.nl/ - layer based on http://www.openstreetmap.org);
- length of "minor ways" (i.e. hippoways, bikeways, walkways) per km^2, from PDOK dataset (https://www.pdok.nl/ - layer based on www.openstreetmap.org);
- population density (n. inhabitants per km^2), from PDOK dataset (https://www.pdok.nl/introductie/-/article/cbs-bevolkingsspreiding-population-distribution-);
- average Human Footprint Index (HFI; https://storage.googleapis.com/hii-export/2020-01-01/hii_2020-01-01.tif; Sanderson et al. 2022);

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- the Ungulate presence, as estimated by a Confidence Index computed from the *Nationale Databank Flora en Fauna (NDFF) through the NDFF Uitvoerportaal* (Nationale Databank Flora en Fauna/NDFF - https://ndff.nl/citation/mwl/55623; Accessed 22-1-2026), considering all the recorded observations in years from 2018 to 2025 in each cell, weighted on the reference area of each observation; the index was set to zero where the reference area covered less than 10% of the grid cell.

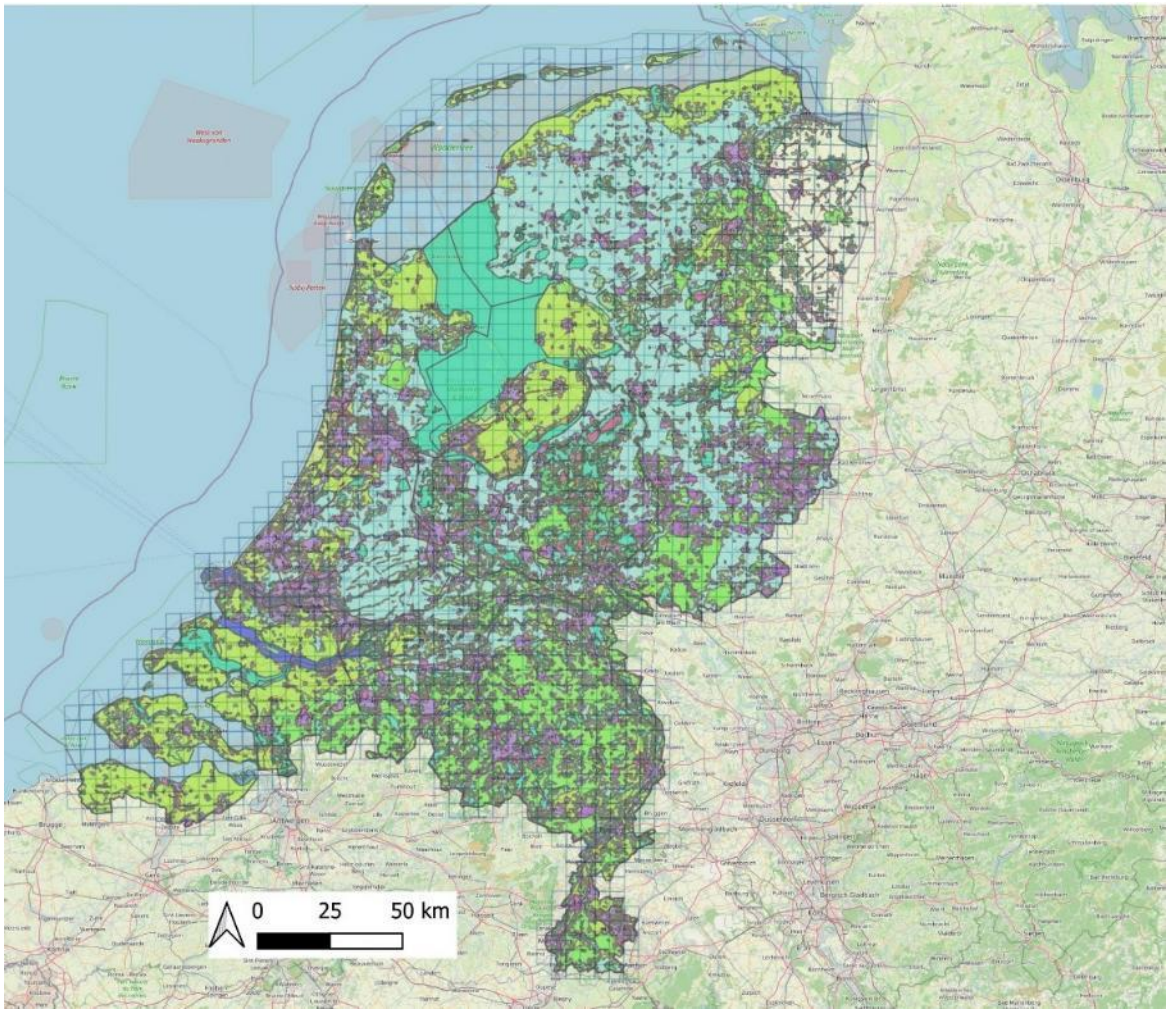

Figure 1.2 – Interpolation of the grid and the Land use by Corine Land Cover (CORINE Land Cover 2018 dataset - Copernicus Land Monitoring Service, 2020).

These 35 predictors were used to model wolf occurrence.

The original grid comprised 1,823 cells covering the Netherlands. It was reduced to 1,572 cells by excluding cells in which Dutch territory covered less than 10% of the cell area (228 cells), and cells dominated by wetlands or water bodies for which a representative mean HFI could not be estimated (23 cells; Figure 1.1).

All analyses were conducted in R version 4.6.1 (2026).

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Since the aim of the modelling was to improve estimates of the potential distribution of wolves rather than to draw inference on wolf ecology, predictor variables were processed to reduce potential statistical issues. In particular, spatial autocorrelation of the environmental predictors, the compositional nature of land-cover proportions (which necessarily sum to one) and zero inflation (i.e. the high frequency of zero values) could violate modelling assumptions and increase the risk of overfitting.

The procedure was aimed not to improve the knowledge on wolf biology, but to enhance the accuracy of the potential species' distribution estimates; to do so predictors were managed to minimize statistical issues. Particularly, the spatial autocorrelation of the environmental features, the composition of habitat types (that is the interdependency among proportions that have always to sum 1) and the zero inflation can undermine the assumptions of the statistical methods adopted in the analysis, leading to model errors and overfitting.

To reduce this risk, we:

- grouped some Corine Land Cover habitat categories of similar ecological value for the species (see Annex 1);
- replaced the zeros of the habitat variables by non-parametric multiplicative simple imputation, preserving the structure of the data (Martín-Fernandez et al. 2003), using the multRepl function in the *zCompositions* R package;
- applied a centred log-ratio transformation to the imputed compositional variables using the clr function in the compositions package, and log-transformed positive, right-skewed non-compositional predictors (van den Boogaart and Tolosana-Delgado 2008);
- standardised all predictors to z-scores;
- performed a standard Principal Component Analysis (PCA) using the *prcomp* function in the *"stats"* package, on the new set of variables to reduce multicollinearity and dimensionality while retaining most of the observed environmental variation (more than 85%, Table 1.1).

From the original set of 35 predictors (grouped to 17) the PCA yielded 11 principal components, which together explained approximately 87% of total variance (Table 1.1). Retaining 11 components was also consistent with Brun et al. (2020), who found that SDM performance may peak at intermediate levels of predictor complexity usually around 10-11 predictors.

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Table 1.1 – Contribution of the Principal Components to the overall variability of the habitat variables and inclusion in the final set of predictors.

Components	Standard deviation	Proportion of Variance	Cumulative Proportion	Inclusion in the pool of predictors (Y/N)
PC1	1.817	0.194	0.194	Y
PC2	1.561	0.143	0.338	Y
PC3	1.209	0.086	0.424	Y
PC4	1.205	0.085	0.509	Y
PC5	1.078	0.068	0.577	Y
PC6	1.010	0.060	0.637	Y
PC7	0.961	0.054	0.692	Y
PC8	0.930	0.051	0.743	Y
PC9	0.904	0.048	0.791	Y
PC10	0.850	0.043	0.833	Y
PC11	0.803	0.038	0.871	Y
PC12	0.777	0.035	0.907	N
PC13	0.734	0.032	0.938	N
PC14	0.708	0.029	0.968	N
PC15	0.580	0.020	0.988	N
PC16	0.457	0.012	1.000	N
PC17	0.000	0.000	1.000	N

Wolf occurrence in the Netherlands is highly dynamic because colonisation is ongoing, involving both newly established packs and dispersing individuals arriving from neighbouring countries. Therefore, separate SDMs were fitted for 2023, 2024 and 2025. Data from 2018 to 2022 were not modelled because the number of occupied cells was too small; in these years the largest annual number was 40 cells in 2022 (Table 1.2). For each of the three years, cells with genetically confirmed wolf presence were related to a set of background cells fitting 3 SDMs and then averaging the results (ensemble models).

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Table 1.2 – Frequency of presence cells per year and size of the background area (only for those years considered to build models).

Year	Presence (cells n)	Background (cells n)
2018	7	/
2019	10	/
2020	6	/
2021	22	/
2022	40	/
2023	60	503
2024	76	582
2025	78	646

The background area (that in this case was a pseudo-absence area, whose cells were available to the wolf but without signs of presence; Figure 1.3) was defined following the rationale by Stokland et al. (2011), who emphasised the importance of sampling design in pseudo-absence selection. We identified grid cells located between known wolf-occurrence areas in the Netherlands and the nearest known packs or breeding pairs in the German wolf population, based on the German national wolf-territory map (https://www.dbb-wolf.de/wolf-occurrence/confirmed-territories/map-of-territories). We additionally included cells with recorded livestock depredation events. The resulting fitted relationships between environmental predictors and wolf occurrence were projected across the Netherlands.

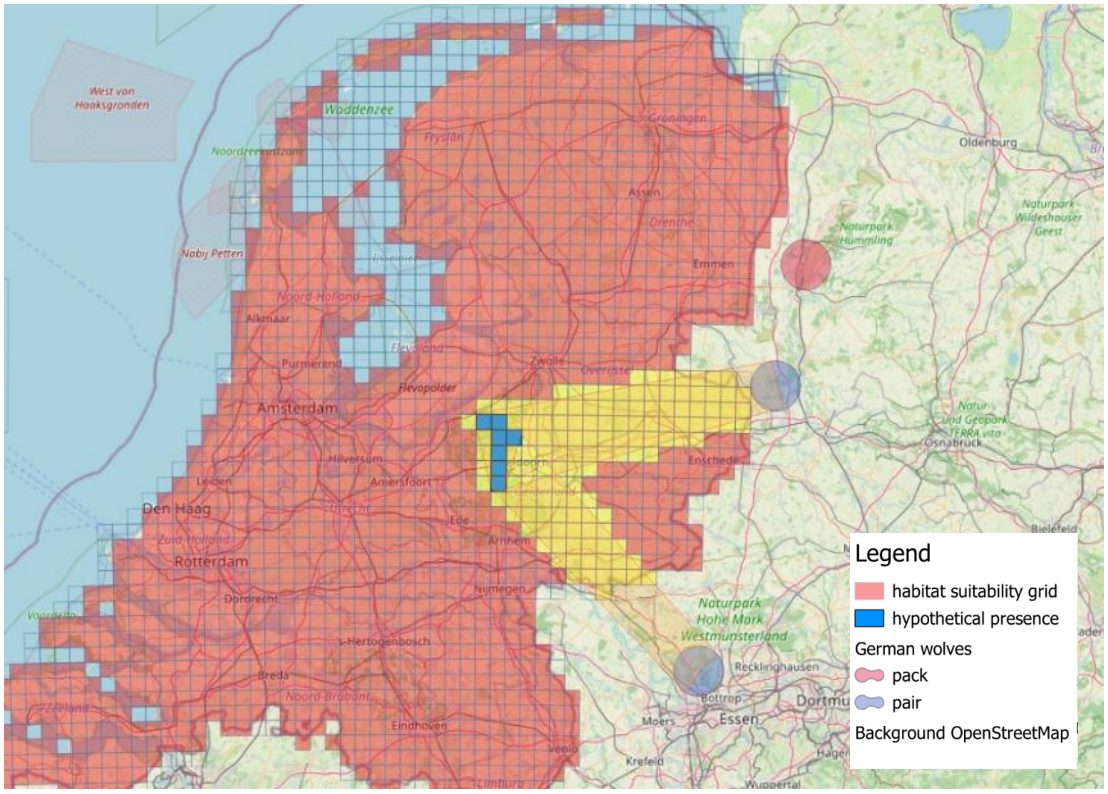

Figure 1.3 – Example of the delineation of the background area (yellow cells) based on a hypothetical wolf distribution in the Netherlands and mapped German packs or breeding pairs in the previous year.

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Habitat suitability was estimated using an ensemble-modelling approach implemented in the *biomod2* R package (Guéguen et al. 2026). biomod2 supports single-model fitting, ensemble modelling and projection for presence–absence and presence–pseudo-absence datasets.

For each year, the ensemble prediction was calculated as a weighted mean of models fitted using generalized linear models (GLMs), Random Forests (RFs), and Maximum Entropy modelling (MaxEnt). These algorithms were selected to combine modelling approaches with different assumptions and response structures given the data. To average the predictions the True Skill Statistic (TSS, Allouche 2006) was adopted as the weighting metric.

Model performance was evaluated using five-fold spatial block cross-validation, implemented with cv_spatial from the blockCV package (Valavi et al. 2019), with a block size of 5 km to equal the cells size and 100 repeats.

The three annual ensemble models showed variable predictive performance (Table 1.3). Their TSS values ranged from 0.460 to 0.595. TSS values around 0.5 are often interpreted as indicating good discrimination. Because absences were represented by pseudo-absence or background data, specificity (the proportion of correctly predicted absences) should be interpreted as relative measures of discrimination rather than as fully independent estimates of predictive accuracy.

Table 1.3 – Evaluation of the performance of the ensemble models for the three years.

Ensemble model Year	Sensitivity	Specificity	TSS
2023	0.983	0.612	0.595
2024	0.816	0.743	0.559
2025	0.897	0.563	0.460

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Figure 1.4 gives a visual representation of the results of the models by the Netherlands grid map with values between 1 and 1000, where 1000 stands for the highest level of suitability.

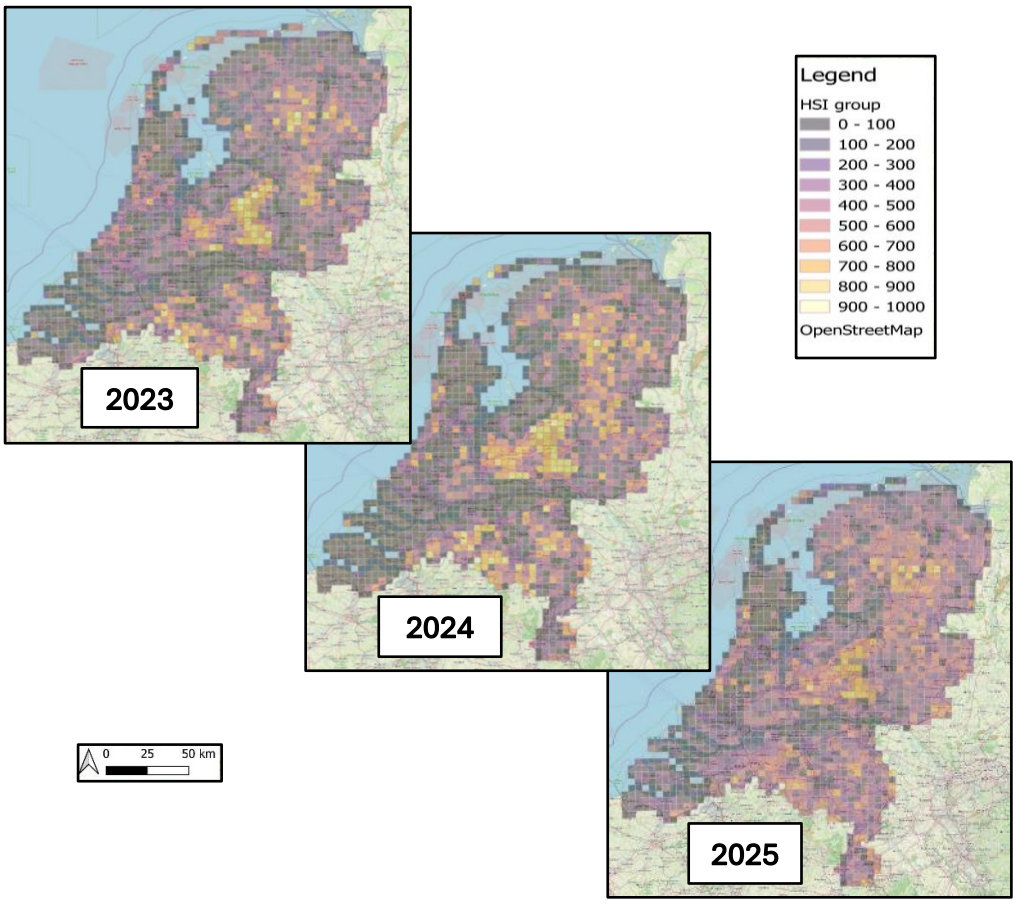

Figure 1.4 – Grid cells differentiated by the HSI (Habitat Suitability Index) as estimated via the SDMs of wolves in the Netherlands for the three years (2023-2025).

To estimate the potential number of wolf pack territories under saturation, we converted cell-level habitat suitability into an estimate of territorial contribution of the cell. We assumed that the mean HSI of occupied cells in each year corresponded to the mean territory size reported for the German wolf population by Planillo et al. (2024), approximately 234 km^2.

Considering the extreme plasticity of the spatial behaviour of the species (see for instance Cavazza et al. 2026), we allowed estimated territory size to vary as a function of relative HIS, rather than assuming a dichotomic potential presence of the wolf territory of fixed size.

Territory size was adjusted around the German mean territory size of 234 km^2 using the reported standard deviation of 129 km^2. Cells with higher HSI were assigned smaller territory sizes and therefore contributed more to the potential territorial capacity, whereas cells with lower HSI were assigned larger territory sizes and made smaller contributions. Namely we increased or reduced the average territory of *n* standard deviation for each related increase or reduction of *n* standard deviations of HSI. Each cell gave a contribution to a pack territory based on its suitability as below:

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$$p_i = w_i \frac{25}{234 \pm n_i 129}$$

Where:

p_i = proportion of the territory of a wolf pack provided by the i-th cell;

w_i = proportion of the i-th cell within Dutch national boundaries;

n_i = integer equal to the Standard deviations minus 1, needed to find the interval of values of HSI where the i-th cells fall (for the same cell it can change each year accordingly to the model estimates, it is positive for HSI below the mean value and negative otherwise).

A lower limit of 50 km^2 was imposed on estimated territory size (for very suitable cells), consistent with the lower end of territory sizes reported by Planillo et al. (2024), while cells with an HSI more than three standard deviations below the mean were assumed to make no contribution to territorial capacity.

For example, for a cell entirely located within the Netherlands ($w_i = 1$) and assigned a territory size of 234 km^2, the estimated territorial contribution was:

$$p_i = \frac{25}{234} = 0.107$$

Thus, approximately $1/0.107 = 9.36$ such cells would be required to represent one average pack territory.

The average HSIs values and their variability estimated for each year in the grid cells of occurrence of the wolf population in the same year, are shown in Table 1.4. The final pack estimation was then computed as explained above (Table 1.5) resulting in an average estimate of 93.8 packs at saturation (min-max: 79.0-102.4). A weighted (on models TSS) average returns a quite close estimation of 93.4 packs.

Table 1.4 – Annual average HSI and Standard Deviation in the grid cells of wolf occurrence.

Year	Presence cells	Mean HSI (SD)
2023	60	607.7 (201.01)
2024	76	642.6 (191.39)
2025	78	543.5 (160.27)

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Table 1.5 – Distribution of the grid cells among the suitability classes of the yearly SDMs and computation of the number of territories.

		Year	2023		2024		2025	
Suitability class of the i-th cell	**Territory size (km²)**	**Proportion of territory provided by the i-th cell (p_i)**	**A**	**B**	**A**	**B**	**A**	**B**
$x_i \leq \overline{HSI}$-3SD	-	0	0	0	467	0	183	0
$\overline{HSI}$-3SD <$x_i \leq \overline{HSI}$-2SD	492	0.051	812	36.0	487	23.2	460	20.5
$\overline{HSI}$-2SD <$x_i \leq \overline{HSI}$-1SD	363	0.069	410	26.3	277	17.8	434	27.9
$\overline{HSI}$-1SD <$x_i \leq \overline{HSI}$ +1SD	234	0.107	324	31.9	314	31.9	462	46.3
$\overline{HSI}$+1SD <$x_i \leq \overline{HSI}$ +2SD	105	0.238	26	5.7	27	6.1	32	7.2
$x > \overline{HSI} + 2SD$	50	0.5	0	0	0	0	1	0.5
		Totals	**1572**	**99.9**	**1572**	**79.0**	**1572**	**102.4**

A = Number of cells
B = Weighted n° of territories of the group

1.3 – Discussion about data modelling results

The values above on population size, should be interpreted as scenario-based estimates that depend on the selected HSI-to-territory-size conversion, the resolution of the grid, the use of German territory-size estimates, and the quality of occurrence and background data.

These analysis estimates a potential number of packs at saturation of the Dutch habitats considerably higher than previous studies (Biersteker et al. 2024, Lelieveld, 2012, Potiek et al. 2012), even if, as summarised by Jansman et al. (2021), the range of the estimations is quite wide (16-89 packs), partially overlapping the current predictions.

With respect to the most recent modelling study by Biersteker et al. (2024), visual comparison of predicted suitability maps did not suggest major differences in the broad spatial distribution of suitable areas. The difference between the estimate of 23–56 packs in that study and the 79.0–102.4 potential territories estimated here may therefore partly arise from the method used to convert habitat suitability into potential population size. In the present study, we tried to consider what recorded in Countries where the recovery of the species is steps forward than in the Netherlands and where the wolf exhibited substantial spatial and ecological flexibility (Cavazza et al. 2026). We then allowed the estimated territory size of a pack to vary continuously with habitat suitability, rather than fixing a territory size and treating cells as simply suitable or unsuitable. However, the way we relate suitability and territory size remains an assumption that should be tested against empirical data in the Netherlands as those data become available.

For a national view of the distribution of potential packs in each province, the predictions of the model are reported in Table 1.6.

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Table 1.6 – The approximated partition of the inferred wolf packs among the Dutch Provinces.

Provinces	Weigthed HSI	Proportion of packs	N° of packs	Area (ha)	Estimated pack density ($100km^{-2}$)
Drenthe	40764.9	0.10	10	268036.2	0.36
Flevoland	9630.4	0.02	2	147100.9	0.16
Fryslân	41957.0	0.11	10	353280.4	0.28
Gelderland	68754.3	0.17	16	511825.6	0.32
Groningen	20960.3	0.05	5	238510.1	0.21
Limburg	26436.2	0.07	6	221000.3	0.29
Noord-Brabant	67881.3	0.17	16	505363.6	0.32
Noord-Holland	18892.7	0.05	5	286536.8	0.16
Overijssel	45830.2	0.12	11	340863.9	0.32
Utrecht	23771.0	0.06	6	155385.7	0.37
Zeeland	7846.8	0.02	2	183965.2	0.10
Zuid-Holland	20171.1	0.05	5	296856.7	0.16
Total		1	94	3508725.2	

The accuracy of the estimates would improve if the following data were available for modelling:

- occurrence and spatial-behaviour data at a finer resolution than 25 km^2, obtained by monitoring individual wolves and resident packs, integrating genetic surveys, telemetry and camera trapping;
- detailed locations of livestock farms from a national georeferenced inventory, to quantify observation bias associated with depredation reports and to develop spatial risk maps for conflict prevention;
- ungulate abundance and distribution, because prey availability is expected to influence actual and potential wolf occurrence and territory use.

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1.4 – Final remarks and conclusions

The evaluation of the suitability of The Netherlands for the wolf can be summarised as follows:

- given the initial data on species distribution, habitat availability, anthropic disturbance and qualitative ungulate presence, the best estimate of the carrying capacity of The Netherlands for the wolf is of 94 packs on average (min. 79 – max. 102);
- the estimates provide a higher wolf populations size than previous studies, mostly because the present computation considers the ability of the species to vary its home range in relation to habitat quality;
- the models were built without considering socio-economic factors and namely livestock farms number and distribution, so generalising the current relationship between the wolf population and the environment, that is excluding management actions in relation to damages to livestock or to social concern;
- the best estimates provided by the models could be improved by implementing the analysis thanks to more detailed wolf distribution data and Ungulate presence and abundance. Moreover, the ongoing of the colonisation process can modify the scenario, calling for constant monitoring and frequent updates;
- livestock depredation risks, useful for management planning, could be estimated given the exact distribution of all the farms, the type of animal raised, and the number of heads raised.

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Chapter 2 - Genetic status of the Dutch wolf population

2.1 – Rationale and aims

This evaluation aims to assess the possible contribution of The Netherlands to the Central European Lowland wolf population, in the light of a favourable reference value at the population level. With specific reference to genetic aspects, this would imply the assessment of the genetic features of the Dutch population and its connections with the main subpopulations of Central Europe.

These analyses were made on the basis of data kindly made available in May 2026 by the University of Wageningen, deputed to the genetic monitoring, and additional ones referred to countries other than the Netherlands, that were retrieved online.

The general goal was subdivided into two operational aims:

1) To estimate the overall levels of genetic variation and inbreeding in the Dutch population and compare them with those of the Central European Lowland population;
2) To evaluate genetic connectivity with the surrounding populations, estimating the amount of gene flow.

Accordingly, this chapter will try to answer the following question: which level of genetic variation is expected in the Dutch wolf population in relation to the average genetic variability of the Central European population, also considering the possible gene flow mediated by dispersal from/to the neighbouring countries and by possible events of hybridization with the domestic dog?

2.2 – Origin of the Dutch wolf population

The Central European wolf population was originated in 2000 from dispersing Baltic wolves that settled along the Polish–German border (Jarausch et al. 2021) and grew rapidly to reach 219 packs, 48 pairs and 15 single individuals in 2024/25 only in Germany, dbb-wolf.de). From Germany, wolves have progressively colonized Denmark (2011, first reproduction in 2017, Sunde et al. 2021), the Netherlands (2015, first reproduction in 2019, Lelieveld et al. 2016), Belgium (2016, first reproduction in 2020, Den Berge 2018), Luxembourg (2017, no reproduction yet, Schley et al. 2021).

Genetically, the population encompassing Germany, Benelux and western-Poland, is considered a distinct conservation unit from the adjacent Carpathian, Alpine and Baltic populations (Szewczyk et al. 2021). Although breeding between relatives has been repeatedly documented, genetic diversity in German wolves is moderate compared to other European wolf populations, possibly maintained by long-range dispersal and occasional hybridization with domestic dogs (Jarausch et al. 2021). Wolf nuclei in Denmark, peripheral to the core population and living in highly fragmented and anthropized landscapes, seem to functionally represent sinks (Sunde et al. 2021). On the contrary, wolves in Benelux seem to be more viable. Wolves reappeared in 2015–2016 and, since then, many have dispersed to this region. Genetic data

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have suggested that immigration has taken place both from the Alpine and the Central European populations (Schley et al. 2021).

Although wolf-dog hybrids were found in the Central European population (e.g. Germany, Harmoinen et al. 2021), no evidence of canine introgression has so far been detected in Dutch wolves. However, only 9 dead individuals were submitted to a targeted genomic analysis (Stronen et al. 2024), whilst this information is not available for the samples analysed during the ordinary genetic monitoring in the Netherlands.

2.3 – Available data and data sources

In the Netherlands, since 2018 all genetic analyses of putative wolf samples are carried out at Wageningen Environmental Research (WENR). When a sample arrives at the laboratory, the species is first identified (wolf, dog or other species) using the control region of the mitochondrial DNA (CR-mtDNA). Different genetic variants exist within this region. Some variants occur in both wolves and dogs, while others are unique to wolves. The wolf haplotypes expected in the Netherlands are HW01, HW02, HW03 and HW22. HW01, HW02 and HW03 occur widely in North-Eastern and Central Europe, while HW22 is unique to the Alpine/Apennine wolf population. HW01 and HW22 occur exclusively in wolves; HW02 occurs also at low frequency (<2%) in dogs. About 95% of Central European wolves have HW01 (Jarausch et al. 2021).

The individual profiling, or genotyping, was based on a set of 13 autosomal microsatellite markers, plus a sex marker. The samples were collected and analysed on a quarterly basis and reported by BIJ12.

For the analyses of this report, raw genetic data (multilocus genotypes) were provided by BIJ12 under the agreement "Data Supply Agreement wolf and livestock depredation data Faunis SRL" signed in May 2026. Data provided refer to 237 individual genotypes (143 males, 94 female) derived from the genetic analysis of wolf samples collected between 2018 and 2025.

As a reference for a comparison of the estimated genetic diversity and inbreeding values, a dataset of 524 German individuals (period 2005-2015), genotyped at the same microsatellites and fully comparable with the Dutch ones, was downloaded from the Dryad repository (annex to Jarausch et al. 2021 - https://doi.org/10.5061/dryad.brv15dv90).

Unfortunately, no comparable domestic dog genotypes were available to perform a targeted analysis aimed at investigating possible signals of canine introgression into the wolf population due to wolf x dog hybridization.

2.4 – Results

Genetic variation and inbreeding

Variation at CR-mtDNA

Three mtDNA haplotypes were detected in Dutsch wolves, with the following frequencies: 82% HW01 (n=194), 16% HW02 (n=39) and 2% HW22 (n=4) (Figure 2.1).

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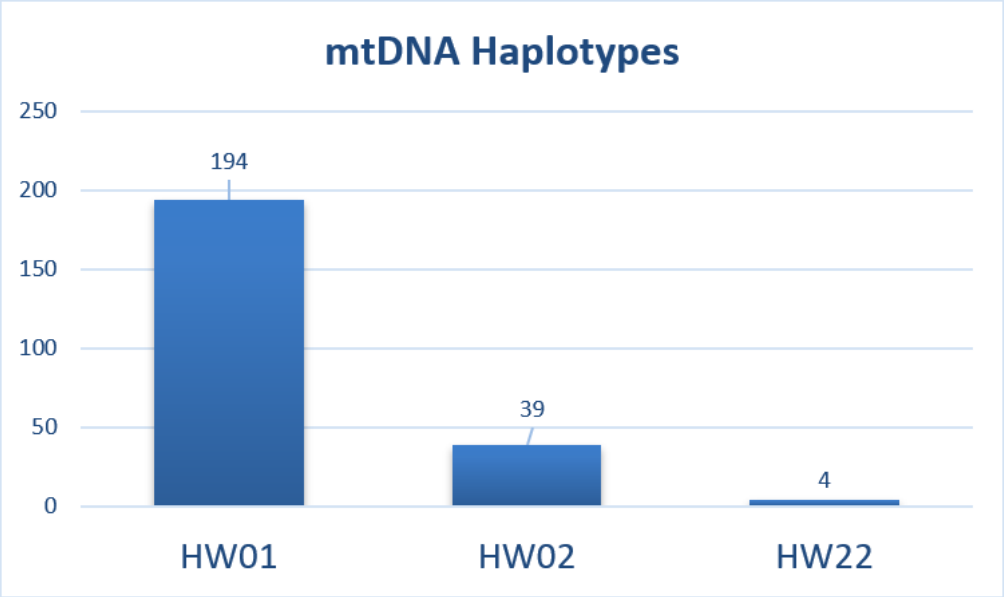

Figure 2.1 – Frequency of occurrence of the three mtDNA haplotypes in the Dutch wolf population.

These haplotype frequencies were close to those observed in the German population, namely: HW01 89-100%, HW02 5-11%, HW22 1% (Jarausch et al. 2021).

The large majority of HW01 and HW02 testifies the prevalent Eastern origin of the maternal component of the population (Figure 2.2).

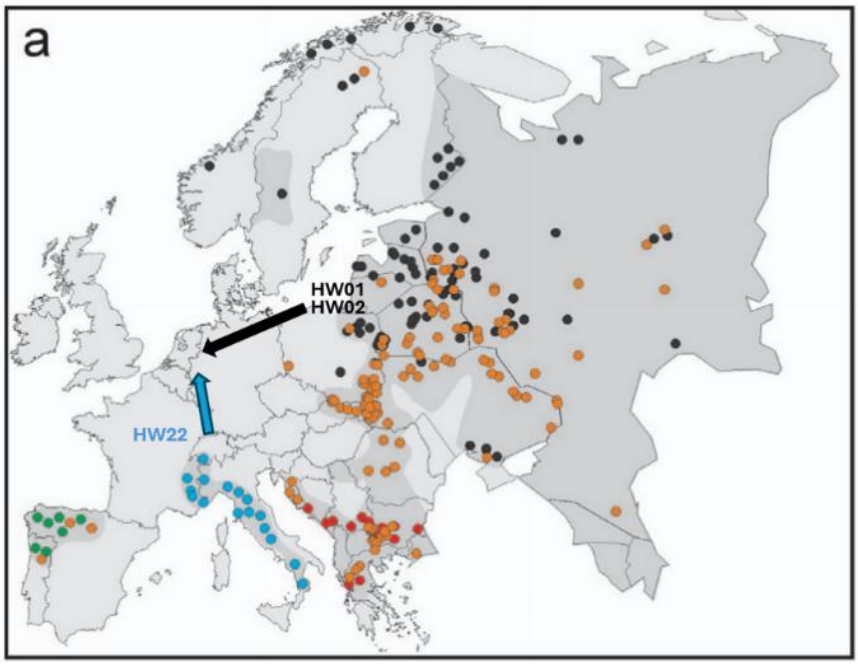

Figure 2.2 – Putative origin of the mtDNA haplotypes observed in the Netherlands (map from Pilot et al. 2010; dot colours refer to the geographic distribution of haplotypes). Haplotypes HW01 and HW02 are from North and East Europe, HW22 is from the Apennine/Alps population.

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The four individuals with HW22 were all males and three of them were relatives. Accordingly, it is possible to associate them to a minimum of 2 different long-range dispersal events from the Alpine region.

Variation at autosomal microsatellites

Three estimators were computed for the available Dutch genotypes:

- Heterozygosity
- Allelic richness
- Inbreeding

and were compared with values calculated for the reference German population (data from Jarausch et al. 2021).

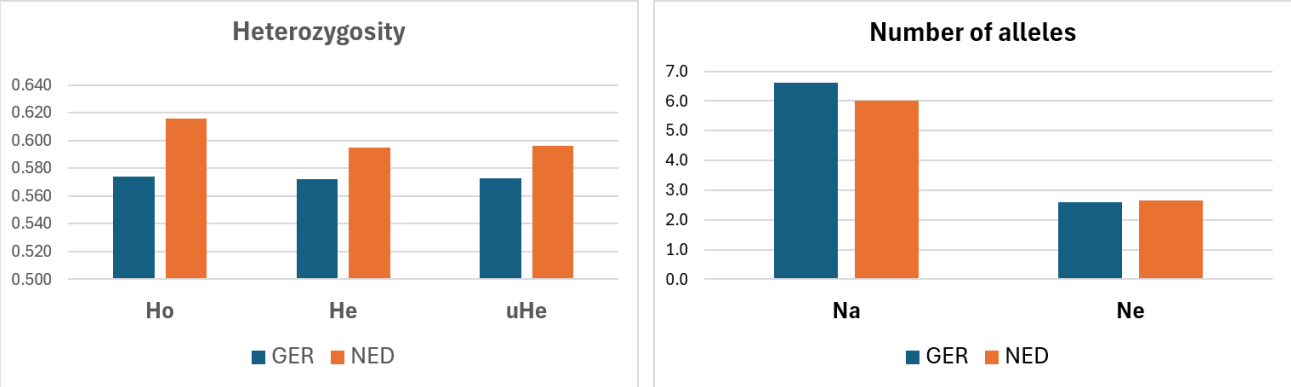

Figure 2.3 – Comparison of heterozygosity and allelic richness between Dutch (NED, n=237) and German (GER, n=524) wolves. Ho, observed heterozygosity, He, expected heterozygosity, uHe, unbiased expected heterozygosity, Na, mean number of alleles per locus, Ne, mean number of effective alleles per locus.

Values of heterozygosity were higher in the Dutch than in the German population. The higher number of alleles per locus (Na) was due to sample size, as the effective number (Ne, accounting for the sample size difference between countries) was very similar.

Given that, in presence of a founder effect, random genetic drift is expected to erode variation over time, these estimates were also calculated at three temporal scans for the Dutch population (2019, 2022 and 2024).

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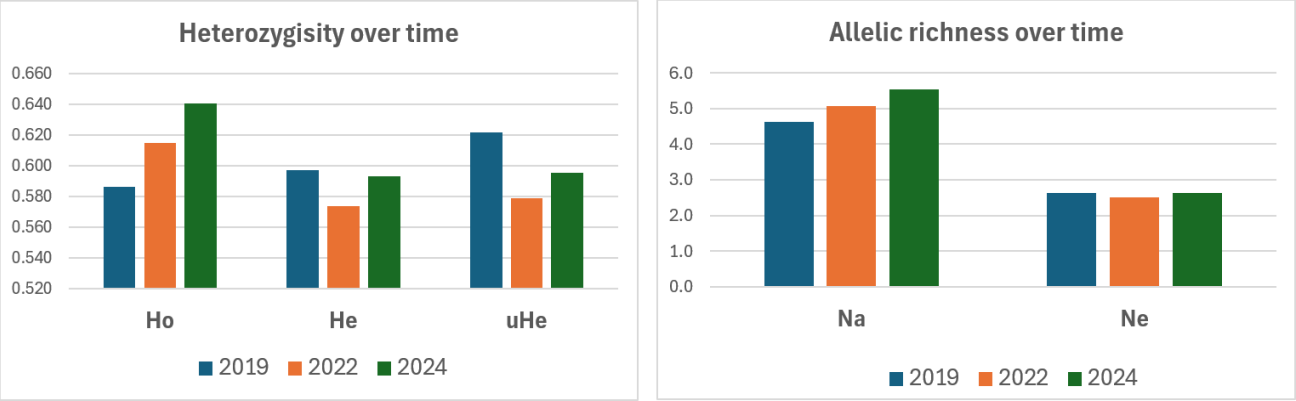

Figure 2.4 – Changes in heterozygosity and allelic richness over time in the Dutch wolf population. Ho - observed heterozygosity, He - expected heterozygosity, uHe - unbiased expected heterozygosity, Na - mean number of alleles per locus, Ne - mean number of effective alleles per locus.

No decline of genetic variation was detected over time. On the opposite the value of Ho (observed heterozygosity) increased from 2019 to 2024, suggesting a contribution of new variants by immigration (i.e. gene flow) from outside the country, as suggested by the increase of the overall number of alleles (Na). No temporal pattern was instead observed for He, unbiased He (uHe) and the effective number of alleles (Ne).

Inbreeding

A total of 17 wolf pairs, corresponding to a total of 32 different individuals (breeders), were genetically identified in the Dutch population; each pair reproduced from a minimum of one to a maximum of 7 times (GW998f-GW893m) since 2019. The number of mating pairs increased from one in 2019 to 13 in 2025.

The pack of origin was ascertained for all but 4 individuals. In most cases (n=11) the pair included at least one individual that had immigrated from a neighbouring country (Germany or Belgium). All pairs of known origin but one (94%) were constituted by individuals that had originated in different packs (i.e. unrelated, Table 2.1). Only pair GW2666f-GW1428m was represented by relatives (full-sibs, both offspring of the North Veluwe pair GW998f-GW893m). Until 2022 all formed pairs included at least one member dispersing from Germany. Only two individuals, out of 32, established a pair in their natal territory (two phylopatric females, Figure 2.5).

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Table 2.1 – Composition of the wolf pairs that reproduced in the Netherlands (2019-2025).

Pair composition	Nr.	%
Immigrant from abroad - Immigrant from abroad	3	17.6
Immigrant from abroad - Dispersing from other Dutch pack	6	35.3
Immigrant from abroad - Born in the area	0	0.0
Immigrant from abroad – Unknown origin	2	11.8
Dispersing from other Dutch pack - Dispersing from other Dutch pack	3	17.6
Dispersing from other Dutch pack - Born in the area	1	5.9
Dispersing from other Dutch pack – Unknown origin	1	5.9
Born in the area - Born in the area i	0	0.0
Born in the area – Unknown origin	1	5.9

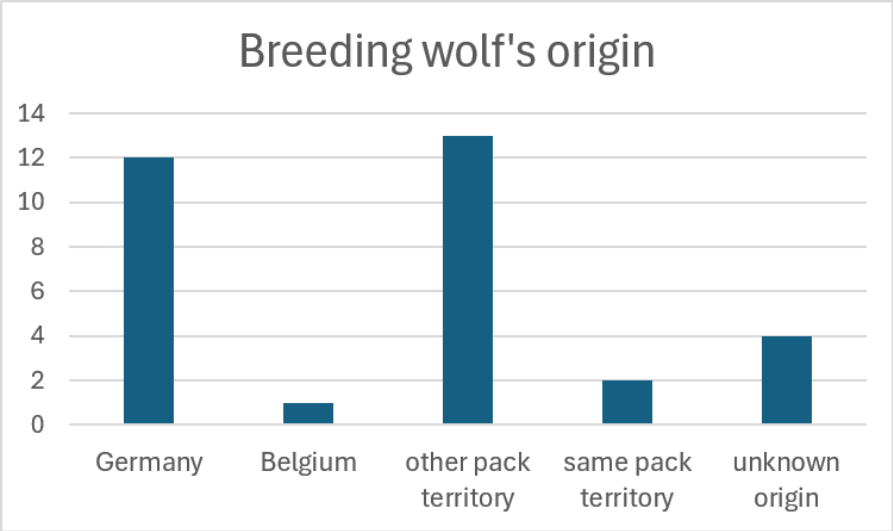

Figure 2.5 – Origin of the wolves breeding at least once in the Netherlands (2019-2025).

As a result of these pairing assortments, not only the pack breeders (F_{IS}= -0.087) but also the overall population appears as slightly outbred (F_{IS}= -0.030).

Genetic connectivity

In order to verify the overall genetic divergence between the wolf populations of the Netherlands (n=237) and Germany (n=524), a Principal Component Analysis (PCA) was run.

A full overlap of the two populations was obtained (Figure 2.6), confirming the reciprocal similarity that is suggestive of an extended ongoing gene flow, instead of a single founding event.

This pattern is consistent with the overall value of F_{ST} (0.011), meaning that around 1% of the overall variation is associated to genetic differences between the two populations.

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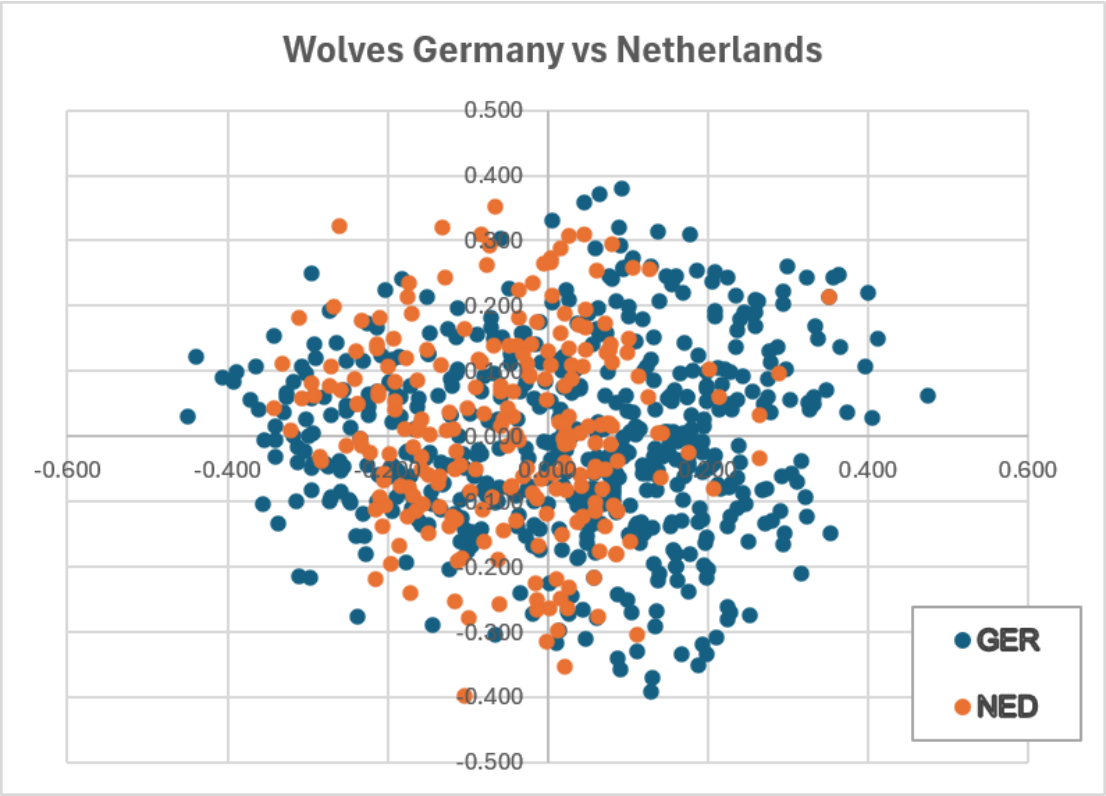

Figure 2.6 – PCA of wolf genotypes from the Netherlands (in orange) and from Germany (in blue).

The approach to assess the amount of genetic exchange between the Dutch population and the other surrounding wolf populations was twice:

- by directly considering the number of detected migrants into and out of the Dutch population (from genetic monitoring);
- by indirectly estimating levels of ongoing gene flow from a Bayesian cluster analysis on the merged dataset of Dutch and German wolves (n=761).

For a total of 195 (82.3%) genotyped wolves the origin was identifiable (Table 2.2). Most of them (56.1%) were born within an established Dutch pack, but one forth (26.2%) had immigrated from neighbouring countries (short-range dispersal) or from the Alpine population (long-range dispersal).

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Table 2.2 – Putative origin of the wolves detected in the Netherlands (2019-2025).

Birth / origin	No. of wolves	%	Interpretation
Netherlands	133	56.1%	Descendants of Dutch breeding packs
Germany	43	18.1%	Immigrants from German packs
Belgium	15	6.3%	Immigrants from Belgian packs
Alpine population	4	1.7%	Individuals assigned to the Alpine population
Unknown	42	17.7%	Parents not sampled or not identified by genetic monitoring
Total	**237**		

On the opposite, only for 8 wolves born in a Dutch pack it was possible to trace the destiny once they left the Netherlands. Six of them were detected later in Germany (mostly in Lower Saxony), one established in Belgium (Hechtel-Eksel) and one was sampled in Luxembourg.

Therefore, apparently, the inflow is much higher than the outflow. This is consistent with the maintenance of high level of genetic variation.

As a second exercise, Bayesian cluster analysis (in Structure) identified groups of individuals with similar genetic features. Using the simulation with K=8 (i.e. the number of inferred clusters) and counting individuals with a prevalent (>0.50) assignment to a specific cluster, three clusters were mostly assigned to Dutch wolves (III, VI and VIII in Table 2.3). In total, 187 out of 237 (79%) Dutch wolves and 487 out of 524 (93%) German wolves were attributed to one of the eight clusters, while the others had intermediate composition.

In particular, the breeding pack of Northern Veluwe is represented by a long-lasting pair (GW998f-GW893m) which produced a minimum of 33 detected offspring across 7 reproductive events (2019-2025). This genealogy appears to match clusters VI of the Bayesian analysis. It revealed 61 individuals with >0.50 assignment probability to this cluster, including almost all known offspring of the pair and 4 wolves sampled in Germany.

Table 2.3 – Partition of German (GER) and Dutch (NED) wolves among the 8 clusters inferred by Bayesian analysis (software Structure). Number in brackets indicate the mean assignment proportion to the cluster.

	INFERRED CLUSTER							
POPULATION	I	II	III	IV	V	VI	VII	**VIII**
GER	58 (0.81)	68 (0.82)	8 (0.87)	85 (0.80)	89 (0.80)	5 (0.67)	117 (0.88)	7 (0.67)
NED	19 (0.68)	7 (0.63)	32 (0.88)	6 (0.69)	3 (0.75)	56 (0.86)	7 (0.65)	57 (0.88)

A relatively high level of overlap was observed between clusters assigned to German and Dutch wolves, testifying, once again, a substantial level of gene flow.

In a similar analysis, 5 individuals were identified as long-range dispersers, nor attributable neither to the Dutch nor to the German population. Four of them were represented by the

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individuals carrying the mtDNA haplotype HW22, typical of the Italian/Alpine population, so are supposed to be immigrants from this geographic area. Unfortunately, no comparable reference genotype was available for the Alpine population to confirm their origin with autosomal markers.

2.4 – Final remarks and conclusions

The analysis of genetic data available for the wolf population in the Netherlands allowed to estimate the overall levels of genetic variation and inbreeding and the level of genetic connectivity with the surrounding populations.

Results of this assessment can be summarized as follows:

- Since its foundation the Dutch population has maintained a high genetic connectivity with the Central European population (here represented by the reference sample of German wolves).
- The overall level of genetic variation in the Dutch population is entirely comparable with that of the German one, both in terms of heterozygosity and allelic richness.
- Continuous and ongoing short- and long-distance dispersal events from larger populations (mostly Germany) and successful mating of the immigrants have prevented genetic drift and inbreeding in the Dutch population.
- On the opposite, a tendency to outbreeding has been observed, with almost all breeding pairs represented by unrelated individuals, although a growing number of breeding pairs has been formed by individuals born in the Netherlands.
- Allopatry seems to be the rule in breeding pairs, although a limited number of philopatric individuals was observed (all females).
- No evidence of a hypothetical founder effect at the first stages of recolonization was found.
- Gene flow within the Netherlands and between the Netherlands and neighbouring areas is substantial and, predictably, it would help to maintain a high effective population size.

Wrapping up, we can conclude that the Dutch population clearly constitutes a subunit, defined only by political borders, of the large and expanding Central European population.

The number of established wolves and wolf packs is growing, fuelled by a continuous migration from neighbouring countries. The viability of the population is assured by a high dispersal rate that favours a genetic shuffling in the population.

Assuming that hybridization with domestic dog is not an issue (as suggested by the limited information for the Netherlands and by the low rate observed in Germany), no obvious risks (genetic drift, loss of genetic variation, inbreeding) can be identified that could jeopardise the current vitality of the Dutch population.

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Chapter 3 - National strategy for mitigating wolf–livestock conflict in the Netherlands: Status, future scenarios and policy recommendations

3.1 – State of art

The natural return of the wolf (Canis lupus) to the Netherlands represents one of the most significant wildlife recolonization processes in Western Europe. After more than a century of absence, the first individuals were recorded in 2015, and permanent breeding territories were established from 2018 onwards. The population has subsequently expanded rapidly through both reproduction and dispersal from neighboring countries. According to the 2025 BIJ12 monitoring data, 131 different wolves were genetically identified during the year, with approximately 14 breeding packs currently established in the Netherlands. Around 70% of newly identified individuals originated from packs already established within the country, indicating that domestic reproduction has become the principal driver of population growth.

This development marks a transition from a conservation and monitoring challenge towards a long-term management challenge. Spatial modelling conducted by Faunis S.r.l. estimates that the Dutch territory could potentially be occupied by approximately 94 breeding packs, with a modelled range of approximately 79-102 packs. This figure should be interpreted as an estimate of a potential increase not linked to natural feeding resources. Nevertheless, it indicates that the current population can experience a substantial further expansion.

The geographical expansion of wolves has been accompanied by a growing number of livestock predation events. BIJ12 recorded 795 confirmed damage events in 2024, involving 1,848 animals killed, 568 injured and 262 missing. In 2025, approximately 3,300 livestock were killed, 97% of them were sheep and goats, while compensation payments reached approximately €1.4 million. Wageningen University analyses indicate that the economic impact extends considerably beyond the market value of livestock losses, particularly for farms repeatedly exposed to predation. Additional labor, surveillance, administrative procedures, productivity losses, management changes and animal-welfare impacts can represent a substantial proportion of the overall burden.

The distribution of conflict is highly uneven. Approximately 97% of affected holdings keep sheep and/or goats, while 94% of the farms included in the relevant report analysis had no preventive measures in place. A relatively small number of farms experience repeated depredation events, whereas many holdings experience either no attacks or isolated events. This concentration suggests that wolf–livestock conflict should be managed primarily as a spatial and farm-level risk-management problem rather than as a uniform national phenomenon.

European experience further indicates that an increase in wolf numbers does not necessarily produce a proportional increase in livestock losses (Singer et al. 2023). The trajectory of conflict depends strongly on the speed and quality with which preventive measures are

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adopted, the vulnerability of individual holdings, the effectiveness of technical assistance, and the ability of public authorities to intervene rapidly when wolves establish new territories (Bautista et al. 2023, Bautista et al. 2019, Berzi et al. 2019, Petridou et al. 2023, Oliveira et al. 2021).

The Dutch authorities have promptly taken positive steps in this direction, focusing on the implementation of policies aimed at preventing human–wolf conflicts and compensating for livestock losses.

This report recommends further advancing the transition from a predominantly reactive approach, based on interventions undertaken after damage has occurred, towards a preventive and predictive strategy capable of anticipating the species' range expansion, directing public investments towards areas at greatest risk, and progressively reducing conflicts between wolf conservation and livestock farming activities.

Compensation should remain an essential component of this system, but its primary purpose should be to ensure fairness and maintain confidence in the management framework rather than to constitute the principal instrument for addressing conflict.

3.2 – The proposed strategy

The proposed strategy is composed by **six interconnected principles:**

1. **Anticipatory prevention:** livestock holdings in newly colonized areas should receive rapid technical and financial support before repeated predation develops.
2. **Nationally consistent compensation:** compensation values, eligibility criteria and administrative standards should be harmonized while allowing territorial implementation and adaptation.
3. **Risk-based intervention:** public resources should be concentrated on holdings and areas where biological and farm-level vulnerability are highest.
4. **Permanent technical capacity:** specialized regional teams should provide damage investigation, prevention planning, farmer support and monitoring.
5. **Evidence-based innovation:** new technologies should be tested systematically under real farm conditions before being incorporated into the standard prevention toolkit.
6. **Adaptive wolf management:** prevention should remain the primary management instrument, complemented, where legally justified and scientifically supported, by targeted interventions against demonstrably problematic individuals or packs.

The objective should not be to eliminate all interactions between wolves and livestock, which is unrealistic in a country supporting a permanent wolf population. Rather, the objective

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should be to minimize preventable losses and associated economic and social costs while maintaining the conservation status of the species and the long-term viability of livestock farming.

3.3 – From compensation to risk reduction

Livestock depredation is currently one of the most visible consequences of wolf expansion. However, the number of confirmed attacks alone does not adequately describe the economic or social impact of the phenomenon. The relevant variables include the distribution of attacks, their recurrence, the type of livestock affected, the characteristics of the farm, the presence and quality of prevention, and the indirect costs generated by repeated incidents.

Sheep and goat holdings are particularly exposed, and the concentration of incidents among holdings without preventive measures demonstrates the importance of reducing farm-level vulnerability. Relevant factors include livestock species, flock size, grazing practices, farm organization, fencing, livestock guardian dogs, landscape characteristics and proximity to established wolf territories (Bautista et al. 2029).

Prevention should therefore remain the central component of public policy. Appropriate electric fencing, properly managed livestock guardian dogs, mobile protection systems, surveillance and adapted grazing practices can substantially reduce vulnerability when correctly designed, installed and maintained. Their effectiveness, however, depends on implementation quality and timing (Berzi et al. 2021).

A key concept should be the ***Newly Colonized Area***, defined as a territory in which a new wolf pack has stably established within the preceding twelve months. Such areas should automatically receive priority for prevention. Rather than waiting for repeated attacks, authorities should ensure the provision and continuity of a technical support service. technical inspections, temporary protection equipment, farmer training and financial support immediately after stable pack establishment.

This approach could be complemented by a national ***Preparation Time Index***, measuring the interval between confirmation of stable wolf presence and completion of the principal preventive measures at the most vulnerable livestock holdings. Reducing this interval should become a measurable objective of the management system.

Compensation should remain available for verified losses, particularly during the initial period following wolf establishment. However, in areas with established wolf presence, compensation could progressively become linked to compliance with minimum prevention standards, provided that the State guarantees reasonable access to appropriate technical and financial support. A transition period of at least twelve months following the official recognition of stable presence would allow farmers to adapt.

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The compensation system itself should be rapid, transparent and nationally consistent. Damage inspections should ideally occur within 24 hours and use a standardized protocol incorporating photographs, geolocation and, where feasible, genetic evidence. Where predation is highly probable, an advance payment could be made while the final assessment is completed. Compensation should reflect the updated value of animals and, where legally and administratively feasible, include relevant veterinary, disposal and documented indirect costs.

At the same time, technically compliant farmers should not automatically lose compensation when properly installed preventive systems are breached by wolves. The purpose of conditionality should be to encourage effective prevention, not to transfer all biological risk to farmers.

3.4 – A national prevention and technical support system

The current provincial distribution of responsibilities and funding mechanisms can create differences between provinces and between livestock holdings. A national framework should therefore establish equal subsidies and harmonized eligibility criteria, while leaving implementation to regional and local authorities.

A national coordination unit could remain responsible for defining:

- establishing technical standards for prevention;
- maintaining national risk maps;
- publishing reference costs and eligible equipment;
- coordinating training;
- monitoring performance;
- evaluating new technologies;
- maintaining national data standards;
- updating prevention requirements as evidence develops.

These functions, already in place except for the determination of shared criteria for subsidies, should be supported by specialized regional teams. Their responsibilities should include predation investigations, prevention audits, technical advice, temporary deployment of protective equipment, farmer training and coordination with wolf-monitoring programs.

The national system should also integrate wolf genetic profiles, pack locations, dispersal movements, livestock distribution, farm characteristics, previous predation events and prevention status. Such a database could support a dynamic risk map identifying areas requiring increased preparedness.

A national territorial classification could distinguish areas without stable wolf presence, areas affected by dispersing individuals, areas with established packs and recurrent-predation

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hotspots. The purpose of such classification would not be to create rigid administrative categories, but to allocate resources according to risk and to ensure that intervention intensity corresponds to actual vulnerability.

Farm-level indirect costs include additional labor, increased surveillance, searching for missing animals, changes in grazing systems, administrative procedures, productivity losses and impacts on animal welfare. For farms repeatedly affected, these costs can exceed the direct value of livestock losses.

Public costs include genetic monitoring, predation investigations, compensation administration, technical assistance, communication, research, training and legal procedures.

Social costs include declining trust in institutions, conflict among stakeholders, reduced acceptance of conservation policies and polarization of public debate.

This broader economic perspective changes the way prevention should be assessed. A preventive fence, livestock guardian dog program or automated surveillance system should not be considered simply as an additional public expenditure. It should be evaluated against the costs that could be avoided over the lifetime of the intervention (Treves et al. 2016).

A national ***Prevention Return on Investment (P-ROI)*** indicator could therefore compare the cost of prevention with reductions in compensation payments, administrative expenditure, farm-level losses and emergency interventions. The indicator should be reviewed annually and should also consider operational effectiveness, animal welfare and farmer acceptance.

A ten-year National Prevention Investment Plan could provide financial continuity and prioritize five areas: preventive infrastructure, technical assistance, technological innovation, training and applied research. Investment should be directed according to risk maps rather than distributed uniformly across the country.

3.5 – Innovation adapted to Dutch conditions

The Netherlands presents specific conditions that require prevention technologies to be adapted to a densely populated and highly anthropized landscape. Innovation should therefore complement, rather than replace, established measures such as fencing, livestock guardian dogs and appropriate livestock management.

Technologies should be evaluated through controlled field trials involving real farms and comparable control situations. Evaluations should measure not only the number of attacks prevented but also costs, labor requirements, reliability, animal welfare, human safety, maintenance requirements and potential wolf habituation. Negative results should be published alongside successful results to avoid the adoption of technologies based on anecdotal evidence.

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One promising area is the development of a national technical service for livestock guardian dogs. Such a program could support the selection, breeding, early socialization, training and deployment of dogs appropriate for Dutch conditions. Because grazing areas frequently overlap with roads, cycle paths and recreational areas, particular attention should be given to stable behavior and controlled socialization with people.

The service should assess the suitability of each dog–farm combination rather than simply distributing animals. Follow-up visits, veterinary care, farmer training, insurance and replacement arrangements should form part of the system. A national registry could record health, pedigree, behavior, effectiveness, incidents and final placement.

Different breeds and working lines—including the Pastore Silano, previously assessed by Faunis S.r.l. in Italian livestock-management contexts—could be evaluated alongside other candidates under Dutch field conditions. Selection should remain evidence-based and should not be based on breed reputation alone.

Intelligent surveillance could also provide useful support, particularly around livestock buildings and cattle farms. Thermal or conventional cameras combined with automated recognition could detect wolf presence and selectively activate alerts or deterrent systems. Such technologies should remain under human supervision and be assessed for recognition accuracy, false alarms, response time, data protection and long-term effectiveness.

Mobile systems, including electrified temporary fencing, turbofladry, motion-activated deterrents, odor-based biofences and livestock behavior sensors, may have value in newly colonized areas or temporary grazing systems. These should initially be regarded as complementary tools rather than universal alternatives to established prevention.

Technologies should progress from controlled pilot testing to conditional eligibility for public support and, only after independent evaluation, to inclusion in the standard prevention toolkit. A three- to five-year national research program involving universities, farmers, technical specialists, technology developers and agricultural organizations would provide the evidence base required for this transition.

3.6 – Adaptive management and targeted intervention

Active management of wolves should be incorporated into an adaptive framework rather than treated as an alternative to prevention. The applicable European and Dutch legal framework, conservation status requirements, animal-welfare provisions and proportionality principles must govern any intervention.

The available scientific evidence does not support treating population-level removal as a general solution to livestock conflict (Santiago Avyla et al. 2018, Wielgus & Peebles 2014, Van Eeden 2018). Instead, where legally authorized, intervention should focus on documented

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problematic behavior associated with identifiable individuals or packs and repeated damage (Meuret et al. 2021).

A robust evidentiary chain should establish the relationship between the animal or reproductive unit concerned and recurrent attacks, while also considering whether appropriate preventive measures were correctly implemented and whether less intrusive interventions remain available.

Targeted interventions may therefore be considered when repeated damage persists despite adequate prevention and other measures have proved insufficient. The removal of an entire pack should remain an ultimate solution and require strong evidence concerning the role of that pack, the inadequacy of individual-level intervention and the conservation implications.

Non-lethal conditioning and deterrence may also form part of the management toolkit where legally and technically appropriate. The use of rubber bullet or paintball are an example with some background in European context (Zanni et al. 2023). The objective is to maintain appropriate wariness of people and livestock facilities and reduce the likelihood of repeated use of domestic livestock as prey.

3.7 – Implementation and performance monitoring

The proposed strategy should be implemented through a coherent national framework rather than through isolated programs. Initial priorities should include national coordination, harmonized technical standards, an early-warning and risk-mapping system, common damage-assessment protocols and integrated genetic and livestock databases.

During the first 12–18 months, regional technical teams should be established, and newly colonized areas should receive structured support. In parallel, pilot programs should evaluate livestock guardian dogs, intelligent surveillance, biofencing and other innovative technologies.

Over the subsequent years, prevention requirements could progressively become part of compensation eligibility in areas with established wolf presence, provided that adequate financial and technical support is available. Preventive infrastructure should also be eligible for long-term maintenance funding rather than being treated solely as a one-off investment.

Policy effectiveness should be measured through indicators that capture both biological and administrative performance. Relevant indicators include:

- time between confirmation of stable wolf presence and first technical intervention;
- percentage of exposed holdings with an approved prevention plan;
- percentage of preventive infrastructure correctly maintained;
- time between a damage report, inspection and compensation payment;
- number of attacks and livestock losses relative to livestock exposure;

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- recurrence of attacks at individual holdings;
- proportion of incidents occurring despite verified preventive measures;
- additional labor and management costs for affected farms;
- public expenditure on prevention compared with compensation and emergency response;
- effectiveness and cost of individual preventive technologies;
- time needed to effectively detect and manage problem wolves.

A particular focus should be placed on recurrent damage and on the relatively small proportion of holdings that experience the greatest concentration of incidents. This would allow resources to be directed towards the situations where interventions are most likely to produce measurable reductions in conflict.

3.8 – Final remarks and conclusions

The return of the wolf has transformed the Dutch policy challenge from one of monitoring recolonization into one of managing an expanding large-carnivore population within a densely populated and highly productive landscape. Livestock predation is already generating significant economic and social costs.

The central policy opportunity lies in acting before these costs increase further. The Netherlands can use its strong genetic monitoring system, existing scientific expertise and institutional capacity to establish a predictive management framework in which risk is identified before repeated damage occurs.

Such a framework should combine nationally consistent compensation, anticipatory prevention, specialized technical assistance, integrated risk mapping, technological innovation and adaptive active management. Prevention should become progressively embedded in ordinary livestock management in areas where wolf presence is established, while newly colonized areas should receive immediate transitional support.

The success of the strategy should not be assessed primarily through the number of wolves present or removed, nor through the amount of compensation paid. The relevant measure is whether the system can reduce recurrent predation, limit economic and social costs, respond rapidly to emerging risks and maintain compliance with European conservation obligations.

The Netherlands therefore has an opportunity to establish a management model in which administrative and preventive capacity develops ahead of the biological expansion of the species. Such an approach would not seek to eliminate conflict, but to make coexistence increasingly predictable, economically manageable and compatible with both livestock production and the long-term conservation of the wolf.

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Chapter 4 - Analyses of the Dutch wolf's population characteristics in relation to the determination of a favourable conservation status and criteria to establish wolf zoning in the Netherlands

4.1 – Ecological carrying capacity and the maximum number of potential wolf packs

The actual figure of an average of 94 potential packs for the Netherlands given by our ecological model **is not to be considered a final goal for FRV** rather the maximum possible number of packs that can be achieved irrespectively from the amount of damage to livestock, the biomass of wild ungulates available (see disclaimer), the incidents with humans and finally from the maintenance of a natural role in the ecosystems. The results of this model are quite similar to those of Biersteker et al. 2024 with the main difference related to the evaluation of packs settlement opportunities that we have not limited fixing the minimum area required for a single pack to 234 (km^2 as adopted in the previous analysis. Based on our experience with other countries where pack territories were definitely smaller than this threshold (Cavazza et al. 2026), we have linked the degree of habitat suitability to territory size allowing smaller territories in areas where the scores of suitability were higher. The outcome was an obvious increment in the number of potential territories.

4.2 – Interpretation of the maximum number of potential packs

In our opinion the highest possible number of packs revealed by our model is to be considered a warning, as it is realistic in terms of settlement possibilities, but it does not consider the risks in terms of conflicts with human activities like livestock breeding and human welfare lacking data on ungulate density and livestock farms distribution and abundance. Moreover, it did not align with the main objective of the Habitat Directive (reported also in the document of Linnell and Boitani 2025) with respect to the conservation of wildlife species i.e. the proper conservation of their natural role with the consequent achievement of its ecosystem services. In the case of a large predator like the wolf, such services are represented by the ecological cascade triggered by its predation on natural preys (mainly wild ungulates in Europe), whose population dynamics and behaviour can be influenced and oriented by the wolf's action. It must be taken into account that the lack of a wide wild prey basis is not a limiting factor for the establishment of a wolf territory, that is possible almost everywhere thanks to the availability of many alternative anthropogenic resources (livestock, garbage, carcasses of different origin), that wolves are fully able to exploit, but a wide wild prey basis represents a prerequisite for the respect of the natural role of the wolf as a predator of wild species. The preservation of the functionality within the ecosystem is a fundamental value in the assessment of FCS and FRV as the Habitats Directive aim is to "... contribute towards ensuring biodiversity through the

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conservation of natural habitats and wild flora and fauna ….” (Article 2(1)) and the definition of Favourable Conservation Status mentions that species should be “…. a viable component of its natural habitats, …” (Article 1(i)). The role the species plays in the ecosystem of which it is a part falls within the concept of FCS and FRV, even though playing a key role naturally implies, first and foremost, being a viable entity. The fact that a species must remain a “component” of its habitat implies ecological functionality in addition to demographic viability. The language of the Directive thus suggests that ecological viability, which considers interactions among species and between a species and its habitat, is the more appropriate interpretation (see also Epstein 2016).

4.3 – Wild ungulate availability and wolf ecological function

With respect to the species’ ecological function, a primary characteristic of the area where wolves’ packs can establish is to have access to an adequate number of wild ungulates; the maps derived by available reports (see Annex 2) clearly illustrate the areas of the Netherlands where wolves can permanently settle preserving their natural role. We must recall that although wild ungulates constitute its main food source across much of the Northern Hemisphere, wolves are opportunistic predators whose feeding behaviour responds to local variation in resource availability, prey vulnerability and human influence (Meriggi and Lovari 1996, Mech and Boitani 2003, Newsome et al. 2016, Cerri et al. 2026). These conditions may determine not only if wolves consume more wild or domestic ungulates, but also whether they obtain their food through active predation, scavenging, or relying on anthropogenic resources (Ferretti et al. 2019, Mohammadi et al. 2019, Mysłajek et al. 2022, Barja et al. 2023), thereby altering their functional role within ecosystems. More specifically, the availability of livestock may provide alternative feeding opportunities, particularly when wild ungulates are scarce (Meriggi and Lovari 1996, Hovens and Tungalaktuja 2005, Mohammadi et al. 2019), that can be exploited with limited energetic costs. The ecological function expressed by wolves depends on the capacity of landscapes to sustain a feeding ecology centred on wild prey. Where this capacity is limited, greater reliance on livestock and scavenged resources, potentially including anthropogenic food subsidies, may increase the potential for conflict with human activities (see Annex 2).

More specifically a minimum biomass of at least 200/300 kg of wild ungulates/km^2 can be necessary (data derived by Italian contexts, e.g. Cavazza et al. 2026) to provide a supply sufficient to prevent the use of livestock or other human-derived products to become the main food source of wolves.

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4.4 – Livestock damage and implications for prey availability

As concerns the crucial aspect of wolf-human conflict, the present situation with livestock damage (Wolf Report 2025) calls for some careful considerations: the loss of 3300 heads of livestock most of which sheep (89.2% sheep following wolf report 2025, 97% following livestock damage report 2025) is an obvious outcome of the lack of prevention measures (on 1079 attacks only 81 took place where prevention methods were fully adopted and 45 where they were partially adopted – wolf report 2025). Accordingly, a relevant biomass of domestic ungulates might have been used by wolves in 2025, even though this amount could be more limited as not all the sheep killed by wolves are actually eaten by the attacking wolves. It happens regularly that in one attack several sheep are killed but only one or a few of them are taken for eating. Assuming that a fully effective protection of livestock can be assured (see wolf report 2025 and the specific section of this report), this amount of food will be removed from wolves' availability and has to be replaced by wild ungulates. The diet composition reported in the wolf report 2025 is clearly showing that, when present, wild ungulates can represent the staple of its diet: in the Veluwe wild boar (present in 62% of the excrements), roe deer (56%) and red deer (32%) are the main prey animals, on the contrary in the Drenthe, where almost only roe deer occur in the wild, wolves feed not only on deer (detected in 63% of the faeces) but also on cattle (43%), used for nature management, and on sheep (10%). This further highlights the need to carefully plan the desired wolf distribution in the Netherlands according to the availability of natural resources. The establishment of wolf packs should be prevented in areas where such resources are insufficient. This is important both to preserve the wolf's natural role within the ecosystem, rather than making the species dependent on anthropogenic resources, and to minimise potential conflicts with economic activities, particularly livestock farming, which is currently widespread in the Netherlands and accounts for 43% of the country's land use. It would also help reduce concerns related to human–wolf interactions, including predation on pets and the potential risk of encounters with people and aggressions. Considering the impact of wolf depredation, it is noteworthy that the share of predation on the total number of sheep in the Country (recorded from the web) is notably higher than in Southern Europe, as it represented more than 3% with respect to 0.7% of a Tuscan province at the beginning of the century (Gazzola et al. 2008) and the 0.5% in 2016 in the whole Tuscany (Gervasi et al. 2022). The same is true for the amount of payments as in 2025 it reached 1.4 million euros, with an estimated number of wolves of 131 that can be compared with the data of Tuscany region in 2016 with an estimated number of wolves over 500 (Merli et al. 2023) and a payment of about 645.400 euros (Gervasi et al. 2022). Obviously, a number of different factors do play a relevant role in these comparisons, but these results militate for a careful consideration of the impact of wolf's presence on livestock breeding activities.

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4.5 – Human–wolf interactions and human safety

The sensitive issue of wolf attacks to humans is also to be carefully considered defining a series of measures aimed at reducing the likelihood of such events occurring. At present the number of events is limited (5 events from 2023 to 2025; Annex 3) but it is quite high if related to the overall number of wolves in the country that peaked in 2025 with 131 individuals but it was lower than 100 in 2023. As a point of comparison, we can consider that in Italy, which has a population of several thousands of wolves (estimated about 3300 individuals in 2020,) in the same time interval there were 13 documented attacks (with 11 attacks caused by a single wolf). It is obvious that in the Netherlands this kind of events is definitely more frequent in relation to the number of wolves present: this is not surprising considering that the human population density is the highest in Europe, leading to more frequent contacts between the two species. These considerations further suggest planning wolves' presence carefully considering not only the availability of wild preys, but also the level of urbanisation of the different areas and acting quickly to avoid the settlement of individuals or pairs in peri-urban areas. The issue related to the massive use of recreational areas in the Netherlands, where millions of people use to go for excursions, is obviously open, also because these are the part of the country where wolves have more chance to settle or are already settled. Here a good communication and information system is crucial to have visitors prepared to manage an encounter with wolves. Finally an efficient and fast management of problem wolves is needed; the example of the wolf GW3237m who attacked a child in July 2025 in the Utrechtse Heuvelrug area and was removed in December 2025 calls for a different approach to similar events.

4.6 – FCS and FRV in the Dutch context

Trying to figure out a reasonable FCS and a FRV for wolves in the Netherlands, following the recommendations made by Linnell and Boitani (2025), that were used to formulate this section, we have to consider two factors: the size and environmental characteristics of the country and the genetic status of the wolf population at present. At the same time we will consider the 'Guidelines on concepts and definitions article 17 of Directive 92/43/EEC. Reporting period 2019-2024' starting from the consideration that the conservation status of a species in the Habitats Directive (Article 1(i)) will be taken as 'favourable'when:

-population dynamics data on the species concerned indicate that it is maintaining itself on along-term basis as a viable component of its **natural** habitats;
-the natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future;

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-there is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis.

EU Member States following Linnel and Boitani (2025) can be divided into three categories: the very small with less than 10.000 km^2 of semi-natural habitats (Luxembourg, Netherlands, Denmark, Belgium), medium sized from 10.000 km^2 to 50.000 km^2 (Slovenia, Estonia, Latvia, Lithuania, Slovakia, Croatia, Czechia, Austria, Portugal, Hungary and Bulgaria), and the large ones from 50.000 km^2 to 346.000 km^2 (Greece, Romania, Italy, Poland, Finland, Germany, Sweden, Spain, France). The Authors suggest that "it should be underlined that these figures are intended to be illustrative, ...and a more objective evaluation of cut-offs between size classes of country in needed.", however, as it is clear from the figures, the Netherlands is the European country with the highest human density and second lowest amount of seminatural habitats (being Luxembourg the first) in the European Union.

Different countries have radically different preconditions for conservation, which requires that ambition must be tailored to such preconditions. This implies that wolf FRVs should be viewed as achievable targets that member states can realistically reach. We must therefore aim to reach a FRV that can be maintained in the long run, having clear which management options are to be applied.

An example of consideration of local peculiarities for FRV concerns Sami reindeer herding in northern Fennoscandia, where the difficulties of preventing large carnivore depredation, and the paucity of wild alternative prey have led management authorities to adopt relatively low levels of recovery ambition for large carnivores, especially wolves, in an area that constitutes almost 40% of the country (Rasmus et al. 2020). A second example is represented by Sweden (more than 10 times larger than the Netherlands and with a human population smaller than the Netherlands), that set at 270-600 individuals, in different times, the minimum size of the wolf population to accomplish the FCV under the EU rules (Liberg et al. 2015; Miller 2023) even if in 2026 a further reduction was opposed by the court and stopped.

From these concepts descends that countries with "very small" (i.e. less than 10.000 km^2) areas of potential habitat can contribute to the permanent presence of reproductive units of large carnivores in a significant proportion of the country, but without setting quantitative goals, rather applying an adaptive approach leading to the reduction of conflicts (Figure 4.1-4.3).

We agree with Linnel and Boitani (2025) as they state that "Wolves have recolonised many of the very small and / or heavily human-dominated countries in western Europe (e.g. France, Germany, Denmark, the Benelux countries) to a degree that was probably not anticipated when the directive was drafted. This requires a reconsideration of the expected contributions from very small countries to collective conservation objectives and of the way conservation potential is conceptualised in landscapes with high human density and heavily human-modified landscapes."

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Moreover, as wolf population persistence or range expansion should not be assumed to entail an equivalent recovery of wolf-mediated ecosystem processes, which also depends on the ecological conditions enabling natural predator–prey interactions, we need to consider suitable only environments supporting abundant wild prey communities that are particularly important for conserving both wolves and their predatory role.

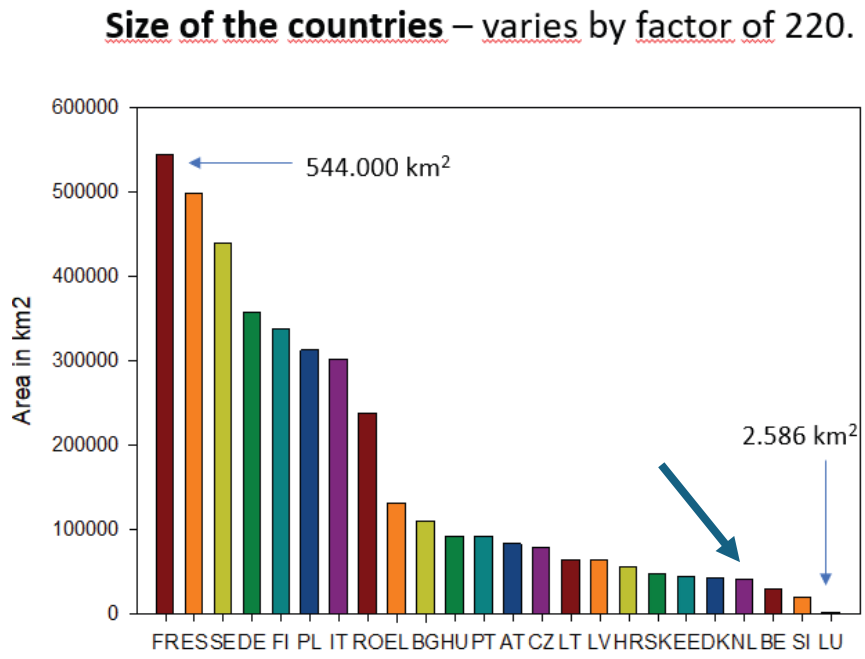

Figure 4.1 – Size of different European Countries (from Linnell and Boitani 2025).

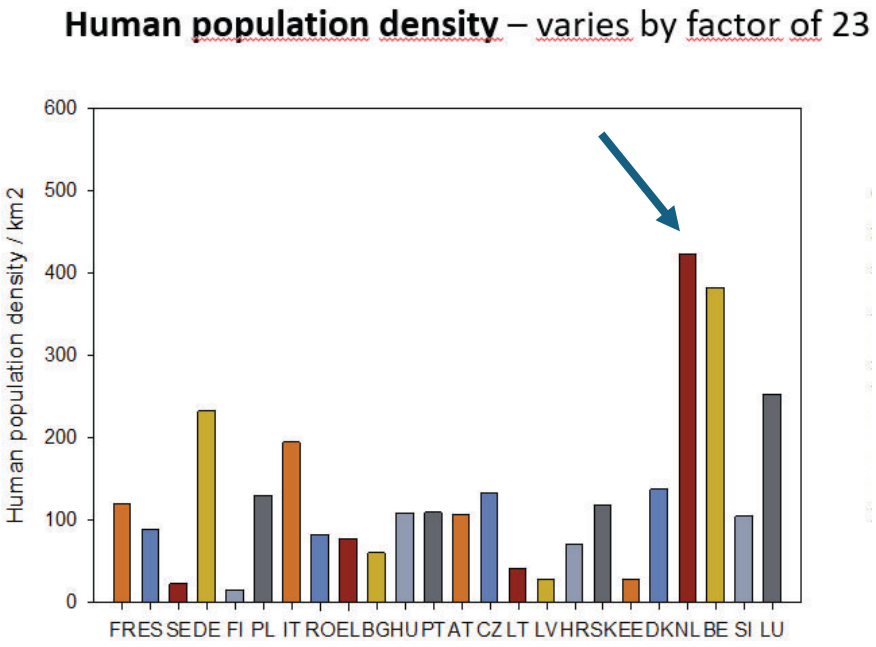

Figure 4.2 –Human population density of different European Countries (from Linnell and Boitani 2025).

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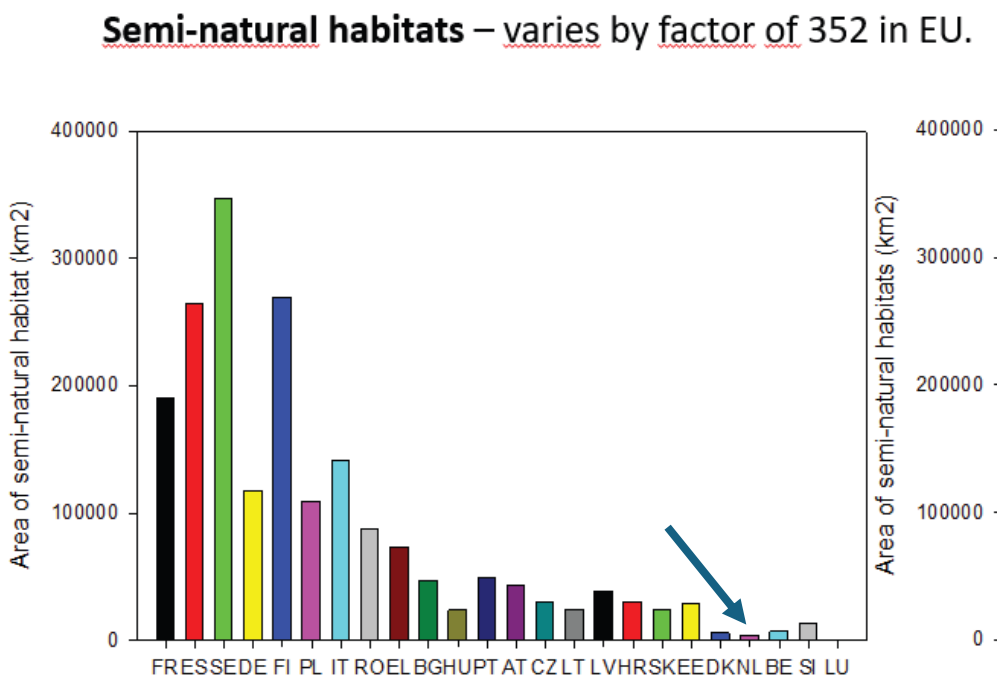

Figure 4.3 –Extension of semi-natural habitats in different European Countries (from Linnell and Boitani 2025).

Finally, it must be recalled that the Central European population is constituted by wolves living in Western Poland, Germany, Czeck Republic, Denmark, Belgium, Luxembourg, Austria and the Netherlands. As a consequence, given the vast areas available in countries other than the Netherlands, the contribution of the latter country to the Central European wolf population is not expected to be numerically significant but consistent with the small size and limited availability of natural areas.

This is consistent to what reported by the "Guidelines on the applications of article 17 of Habitats Directive" for species "...with inherently large home ranges (> 100 km^2 up to > 1 000 km^2); FRVs to be normally set for the whole population (or meta-population) or populations, which may imply cooperation between MS sharing the same population (meta-population)" so the Netherlands can only be called to contribute to limited extant to the whole Central European population.

In a general conservation perspective, the role that the Netherlands can play in the complex of the Central European population from the genetic point of view is relevant. Under this respect the results of the assessment done for this report (Chapter 2) are quite encouraging.

The Dutch population appears to be strongly connected with the German one, receiving immigrants that quite often have become pack breeders. Due to the high level of gene flow with the neighbouring populations and to a tendency for unrelated individuals to mate, Dutch

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wolves show high levels of genetic diversity and no evidence of inbreeding. Despite the impossibility to assess the occurrence of wolf-dog hybrids, there are objective arguments (i,e, no hybrid among a limited number of analysed carcasses, management of free-ranging dogs in the country, very low prevalence of hybrids in neighbouring countries) to do not consider anthropogenic hybridization a serious risk.

All these results confirm that the Dutch population can be considered viable from the genetic point of view, with no concerns with respect to a possible high inbreeding like in other European population (e.g. the Scandinavian one, see Lieberg et al. 2005) and with respect to the lack of genetic connectivity with the Central European population overall.

The following table (Table 4.1) represents a synthetic summary of conditions suggested by Linnell and Boitani (2025) to be verified in order to achieve FCS in a population and in a country.

Table 4.1 – Synthetic summary of conditions suggested by Linnell and Boitani (2025) to be verified to achieve FCS in a population (a) and in a country (b). Abbreviations: FRP - Favourable Reference Population, FRR - Favourable Reference Range, FCS – Favourable Conservation Status, pop – population, ms – Member State.

a)

		Parameter	YES/NO
FRP_{pop}			
	1	Does the sum of all member state contributions represents an **effective population size** greater than **500**?	**YES**
	2	Is the population **trend** positive or stable?	**YES**
FRP_{pop}			
	3	Is the FRR composed of a continuous and aligned area of **interconnected distribution**, or potential distribution?	**YES**
	4	Is the range stable or increasing?	**YES**
	5	Is there a **sufficient habitat** and without serious **internal barriers** to movement or **discontinuities** beyond average dispersal distance?	**YES**
	6	Is the **area large enough** to embrace the FRP_{pop} with realistic population densities?	**YES**
	7	Is the **prognosis for the habitat** quality and connectivity positive?	**YES**
	8	Are the **potential** connection corridors to **neighbouring populations** through which individuals can regularly disperse even if they are not resident?	**YES**
	9	Have all **genetically distinct units** or subspecies been included in the range?	**YES**
FCS_{pop}		If answer to all parameters (1-9) is yes - then FCS has potentially been achieved - if the answer to any parameter is no, then FCS_{pop} has not been achieved.	**YES**

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b)

	Parameter	YES/NO
FRP_{ms}		
1	Is your FRP greater than or equal to when you entered the European Union?	**YES**
2	Is your FRP large enough so that when summed with FRPs from other member states (and other contributing states) sharing a population it will allow an effective population size of at least 500?	**YES**
3	Does your population have a stable or positive trend?	**YES**
4	"Very small countries" – do you have the permanent presence of reproductive units of large carnivores in a significant proportion of the country?	**YES**
5	"Small to medium size countries" – is your population size greater than a demographic MVP or an effective population size greater than 50?	**-**
6	"Large countries" – is your FRP for each segment of a population that you co-host much greater (proportional to the available habitat) than an effective population size of 50?	**-**
7	Are reproducing units of the species present in the full range of Natura 2000 sites, biogeographic regions and relevant ecological conditions?	**YES** (no Natura 2000 sites designed for wolf in the Netherlands)
FRR_{ms}		
8	Is the FRR composed of a continuous and aligned area of interconnected distribution, or potential distribution?	**YES**
9	Is the range stable or increasing?	**YES**
10	Is there sufficient habitat and without serious internal barriers to movement or discontinuities beyond average dispersal distances?	**YES**
11	Is the area large enough to embrace the FRP_{POP} with realistic population densities?	**YES**
12	Is the prognosis for the habitat quality and connectivity positive?	**YES**, but if fencing of livestock farms will be extensive some problems will arise
13	Is the FRR aligned with neighbouring states to ensure sufficient connectivity to allow FCS_{POP} to be attained?	**YES**, the genetic data suggest this is the case
14	Does the FRR overlap all Natura 2000 sites designated for the species?	**YES**, as no Natura 2000 sites designated for wolf are present
15	Does the FRR overlap all biogeographic regions within the country that be considered natural range?	**YES**, as just one biogeographical region is present in the Netherlands
16	Does the FRR allow for the presence of the species in all ecological conditions, ecosystems and prey communities?	**YES**
17	Are all subspecies of distinct genetic populations included?	**YES**, just one subspecies represented in the Continental population
FCS_{ms}	If the answer to all parameters 1-3 and 7-17 and either parameter 4, 5 or 6 (depending on your situation) is yes – then	**YES**

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	FCS has potentially been achieved – if the answer to any of these parameter is no, then FCS_{MS} has not been achieved.

With regards to the evaluation of the effective population size (N_e, point 1 for FRP_{pop} and point 2 for FRP_{ms} in table 4.1), we relied on the outcome of Mergeay et al (2024). The authors estimated N_e for the German population, among others, by calculating the N_e/N_c ratio and N_c (as the number of adult wolves in the population). However, they also ended up proposing the overall number of wolf packs in the population as a proxy of N_e, usable for conservation policies. N_e/N_c ratio was estimated on average to 0.38 (0.44 for females and 0.34 for males). Applying this value to the counted number of adult wolves reported by the DBBW (Dokumentations- und Beratungsstelle des Bundes zum Thema Wolf) for the population in 2024/2025 (i.e. 544-606), a N_e value of around 207-230 is obtained only for Germany. On the other hand, considering the minimum number of wolf packs in the population (i.e. 219 packs in 2024/2025), a similar figure is obtained.
Other countries, however, contribute to the Central European population. The overall most updated contribution of the different countries can be summarized as reported in Table 4.2.

Table 4.2 – Overall, most updated contribution of the different countries to the Central European wolf population.

Country	Estimated nr. of wolf packs	Source	Notes
Germany	219 packs (+ 43 pairs)	DBBW (2025)	In 2024/25
Denmark	11 packs (+ 2 pairs)	SGAV (2026)	In 2026
Poland (western)	Around 280 packs	Kaczensky et al. (2024)	From total count in 2023 (increasing), assuming 6 individuals on average per pack
Czech Republic	40 packs	Vorel A. (pers. comm.)	In 2025. 34 packs in 2022/23 (Kaczensky et al. 2024)
Austria	3 packs (+ 2 pairs)	Österreichzentrum Bär, Wolf, Luchs (2026)	In 2026
Belgium	2 packs (+ 3 pairs)	INBO (2026)	In 2025/26
The Netherlands	10 packs (+ 4 pairs)	BIJ12 (2025)	In 2025
Total	**565 packs (+ 54 pairs)**		

Therefore, adopting the minimum number of packs as a proxy of Ne, as suggested by Mergeay et al. (2024), the Central European population already exceeds the effective population size limit of 500.

According to the abovementioned considerations, the present situation in the Netherlands is therefore already meeting all criteria to satisfy FCS.

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Considering the recent sentences of the European Court of Justice on wolf management it can be noted that the most cited cases are quite distant from the present situation of the Netherlands and are not consistent with the management perspectives given by this report like in the case of Court of Justice cases C-601/22, C-629/23 as they goes back to when the legal status of the species in the Habitats Directive was Strictly Protected (i.e. wolves could only be removed by derogation and on an individual basis). The downgrading of the legal status to Protected (Directive (EU) 2025/1237), implying a formal transfer of the wolf from Annex IV to Annex V of the Habitat Directive, some of the arguments in those judgments are no longer valid, since current legislation permits certain forms of management, provided they are compatible with maintaining a satisfactory conservation status. More specifically, in the case of Land Tyrol (C601/22) the point was a misuse of the FCS that was referred to the overall Central European population whether the Austrian national population was (and still is) in an unfavourable conservation status (in whole Austria there are only 5 reproducing packs even if is the richest European country in wild ungulates and has plenty of natural environments). Similarly, in the case of Estonia (C629/23) the issue raised was on regular hunting quotas provided by the Estonian government, another situation that was distant from the one discussed in the present document where we have not included any possibility and opportunity of a hunting exploitation of wolves in the Netherlands.

However, some key passages of the European Court's judgments that are closer to the present situation merits to be mentioned. Specifically, the judgment of the Court of Justice of the European Union in Case C-436/22 (Asociación para la Conservación y Estudio del Lobo Ibérico - ASCEL v Administración de la Comunidad de Castilla y León), delivered on 29 July 2024, that constitutes a landmark decision in the field of environmental law and wildlife protection referred to wolves living under the present flexible regime. The case concerned the legality of the hunting management plan of the region of Castile and León (Spain), which considered wolves located north of the Douro River as a huntable species (cinegetic exploitation). At the time, wolf populations north of the Douro fell under the more flexible protection regime of Annex V of the Habitats Directive. The main points were:

1. Prohibition of hunting in case of "unsatisfactory" state of conservation. The Court clarified that, even for species listed in Annex V (whose taking into the wild may be permitted), Member States have an absolute obligation to ensure the maintenance or restoration of the species at a favourable conservation status.
2. Prevalence of up-to-date scientific data. The Spanish Autonomous Community's plan was based on censuses dating back to the years 2012-2013. The CJEU ruled that: National authorities cannot approve hunting without having scientific, objective and rigorously up-to-date data on the real state of the population concerned. Moreover it was stated that constant monitoring (provided for in Article 11 of the Directive) is a legal prerequisite for any kind of planning or derogation.

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3. Application of the precautionary principle. The ruling explicitly extended the application of the precautionary principle also to species managed according to Annex V.

As it is obvious from the mentioned case the two main prerequisites needed to properly and legally manage a wolf population, even not necessarily under a hunting perspective like in the case of the Netherlands, are to maintain a FCS and to monitor the population on a yearly basis.

4.7 – Final remarks and conclusions

To summarise the following conclusion can be drawn on the conservation of wolves in the Netherlands and on the definition of an FCS:

- The figure of 94 packs on average predicted by our ecological model as a possible maximum number in the Netherlands is not a target to be achieved, but rather a serious warning: in absence of a proper plan to manage the wolf population considering its ecological role and levels of conflict with human activities and social acceptance, in the Netherlands wolves can expand into areas where the species could not rely on natural resources and could not play its natural role in the ecosystem. On the contrary in these areas, exploiting their ecological plasticity, wolves can rely exclusively on anthropogenic resources causing serious management problems.

- For this reason, a careful planning of the wolf distribution must be operated by zoning the country (Mech 2017), selecting areas where enough wild ungulates and natural environment can offer the wolves the possibility to be a viable component of its habitats and to maintain its ecological role.

- The present condition of wolves in the Netherlands already satisfies the criteria of FCS given its distribution and genetic characteristics. There is no need, given the small size of the country and its limited amount of natural environment, to determine precise figures for the pack numbers or the population size; on the contrary the management must drive the population to the occupancy of natural areas provided by rich populations of wild ungulates.

- Conflicts with wolves with respect to livestock breeding and human attacks are well over the average level observed in countries with far larger wolf populations. Therefore, the following measures are urgently needed:

    1) a clear policy in determining the limits accepted in the amount of damage that can be tolerated;

    2) an extensive implementation of livestock damage prevention methods;

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3) a proper information to the public on the behaviour to adopt in presence of the predator (especially in recreational areas);

4) a fast operational routine in the identification and removal of problem wolves.

- In spite of an already extensive effort in wolf monitoring, there is the need to enforce the careful monitoring of all the packs currently established in the Netherlands: extensive wolves captures and GPS telemetry (ideally with at least one individual per pack) are strongly recommended as this technique can allow proactive management of packs with precise indications on their spatial and feeding ecology. Moreover, new prevention techniques for livestock depredation, like the use of virtual fences and proximity sensors can be implemented in presence of GPS-monitored packs.

- Wolf management in the Netherlands should aim to the conservation of a number of established packs in suitable areas determined on the basis of the previous considerations, preserving the present connectivity with neighbouring nuclei and allowing long term survival of the breeding pairs, in order to ensure that the population remains as stable as possible.

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Annex 1 – Corine Land Cover classes

Grouping and reclassification of the Corine Land Cover Land Use categories (CORINE Land Cover 2018 dataset - Copernicus Land Monitoring Service, 2020).

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LEVEL 1	LEVEL 2	LEVEL 3	Groups
1. ARTIFICIAL SURFACES	1.1. Urban fabric	1.1.1. Continuous urban fabric 1.1.2. Discontinuous urban fabric	p2_urban
	1.2. Industrial, commercial and transport units	1.2.1. Industrial or commercial units 1.2.2. Road and rail networks and associated land 1.2.3. Port areas 1.2.4. Airports	p_112 p2_urban p2_urban p2_urban p2_urban
	1.3. Mine, dump and construction sites	1.3.1. Mineral extraction sites 1.3.2. Dump sites 1.3.3. Construction sites	p2_urban p2_urban p2_urban
	1.4. Artificial, non-agricultural vegetated areas	1.4.1. Green urban areas 1.4.2. Sport and leisure facilities	p_141 p2_urban
2. AGRICULTURAL AREAS	2.1. Arable land	2.1.1. Non-irrigated arable land 2.1.2. Permanently irrigated land 2.1.3. Rice fields	p_211 - -
	2.2. Permanent crops	2.2.1. Vineyards 2.2.2. Fruit trees and berry plantations 2.2.3. Olive groves	- p2_complcro -
	2.3. Pastures	2.3.1. Pastures	p2_pastures
	2.4. Heterogeneous agricultural areas	2.4.1. Annual crops associated with permanent crops 2.4.2. Complex cultivation patterns 2.4.3. Land principally occupied by agriculture, with significant areas of natural vegetation 2.4.4. Agro-forestry areas	- p2_complcro p_243 -
3. FOREST AND SEMI-NATURAL AREAS	3.1. Forests	3.1.1. Broad-leaved forest 3.1.2. Coniferous forest 3.1.3. Mixed forest	p_311 p_312 p_313
	3.2. Scrub and/or herbaceous associations	3.2.1. Natural grassland 3.2.2. Moors and heathland 3.2.3. Sclerophyllous vegetation 3.2.4. Transitional woodland-scrub	p2_shrub p2_shrub - p2_shrub
	3 .3. Open spaces with little or no vegetation	3.3.1. Beaches, dunes, sands 3.3.2. Bare rocks 3.3.3. Sparsely vegetated areas 3.3.4. Burnt areas 3.3.5. Glaciers and perpetual snow	p2_water - - - - p2_shrub
4. WETLANDS	4.1. Inland wetlands	4.1.1. Inland marshes 4.1.2. Peat bogs	p2_water p2_pastures
	4.2. Marine wetlands	4.2.1. Salt marshes 4.2.2. Salines 4.2.3. Intertidal flats	- p2_water p2_water
5. WATER BODIES	5.1. Inland waters	5.1.1. Water courses 5.1.2. Water bodies	p2_water -
	5.2. Marine waters	5.2.1. Coastal lagoons 5.2.2. Estuaries 5.2.3. Sea and ocean	p2_water p2_water -

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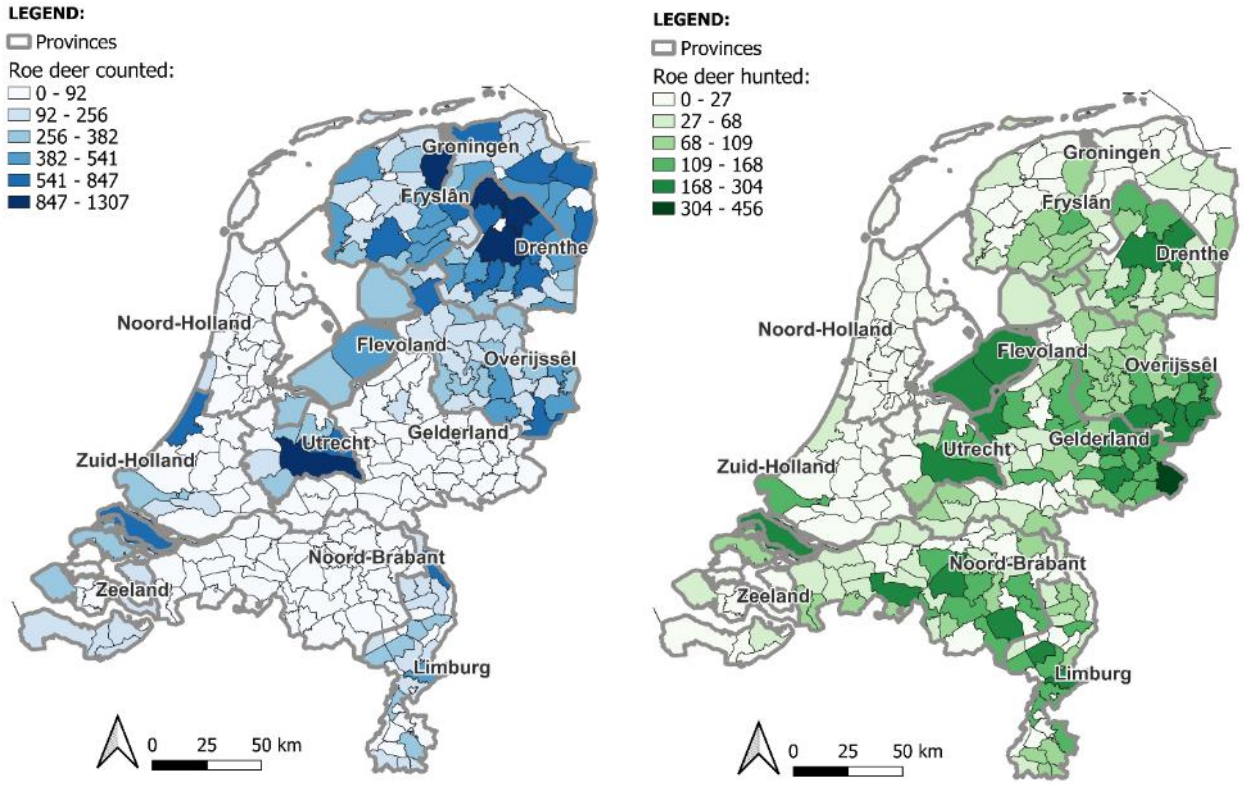
Annex 2

Evaluation of available wild ungulates, human population distribution, and impact on livestock.

Evaluation of available wild ungulates

With regard to the occurrence of wild ungulates, we conducted a review of the available data for the different management districts, with the aim of compiling information from the most recent years (2023–2025) on harvest levels and monitoring activities carried out for the management of the different species. The maps (Figure annex 2-A) below show the number of wild ungulates counted and harvested, disaggregated by species. These data, together with the distribution of domestic ungulates, provide an indication of prey availability and spatial distribution, thereby highlighting areas that may represent potential critical zones, i.e. areas where wild ungulates are less abundant and the predator may potentially shift its predation pressure towards domestic livestock. In general, in the Netherlands, wild ungulate populations show a heterogeneous spatial distribution, with higher densities generally associated with areas providing suitable habitat and sufficient food resources. Their abundance and distribution vary considerably among management areas and species, reflecting differences in habitat suitability, population management, and local environmental conditions.



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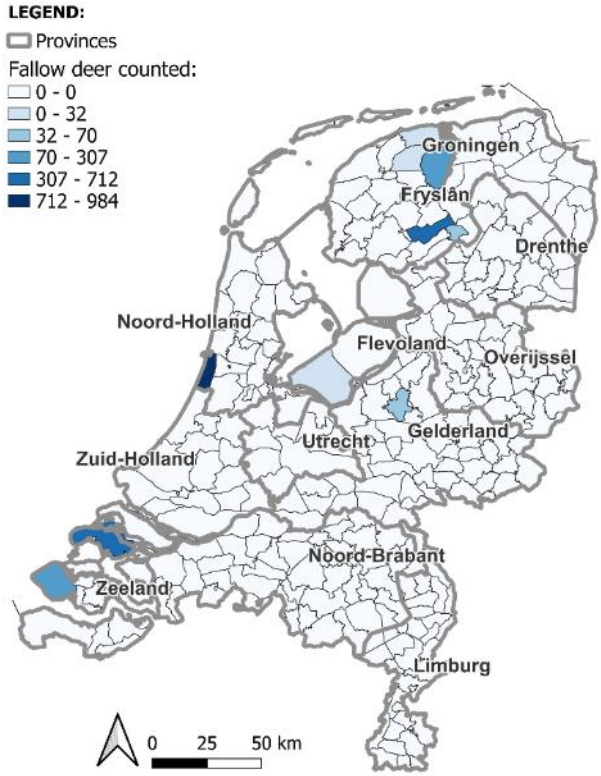



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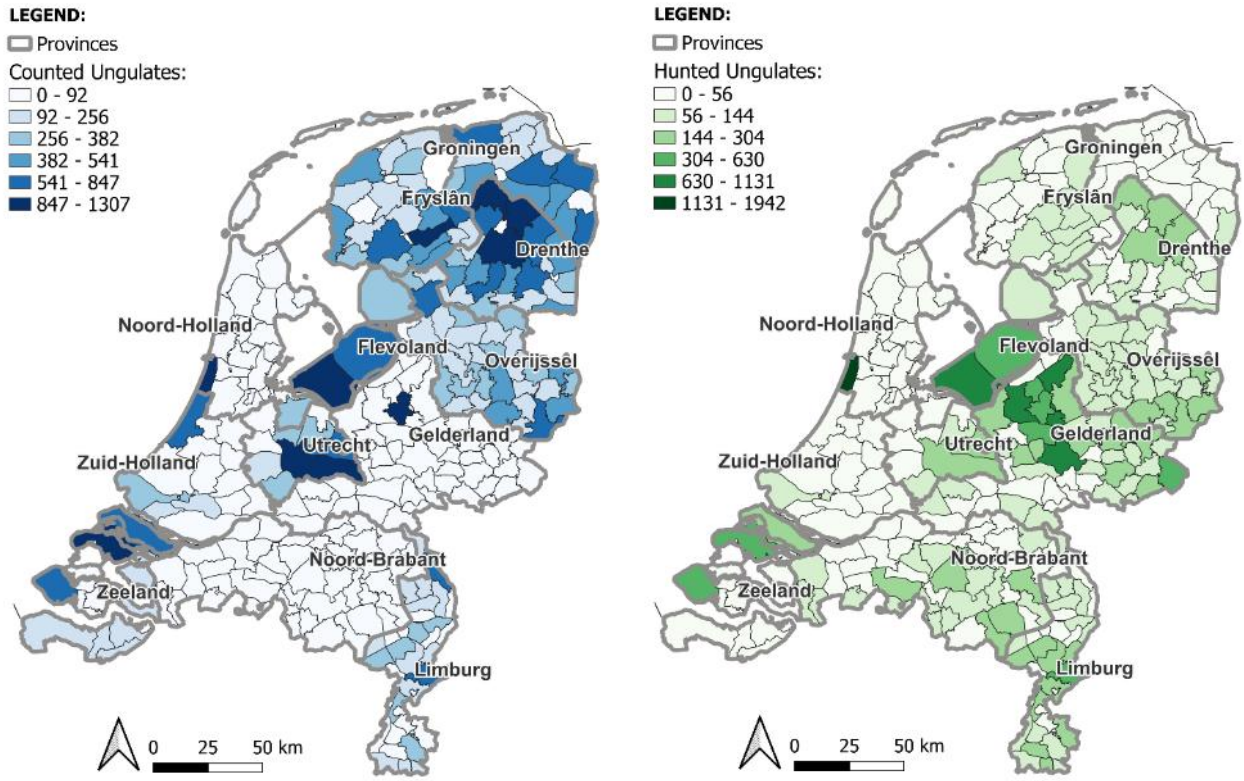

Figure annex 2-A – Annual counted (blue scale map) and hunted (green scale map) ungulates (red deer, roe deer, fallow deer, sika deer, wild boar, and total ungulates) for each hunting management unit. Data were compiled from publicly available reports: https://fbedrenthe.nl/jaarverslagen/; https://www.faunabeheereenheid.nl/flevoland/PUBLICATIES; https://fbefryslan.nl/jaarverslag-fbe-fryslan-2024/; https://fbefryslan.nl/faunabeheerplan-ree-fryslan-2025-2030/; https://fbefryslan.nl/omgevingsvergunning-damhert-gebied-oranjewoud-katlijk-2024-2029; https://www.faunabeheereenheid.nl/gelderland/PUBLICATIES; https://fbegroningen.nl/factsheet-ree/; https://www.faunabeheereenheid.nl/noordbrabant/PUBLICATIES; https://limburg.bestuurlijkeinformatie.nl/Document/View/61f20365-551c-4840-8398-8aa14e42252d; https://fbenoordholland.nl/fbe-bibliotheek/; https://fbeoverijssel.nl/factsheet-ree/; https://www.faunabeheereenheid.nl/utrecht/ACTUEEL/Nieuws/ArticleID/82238/JAARVERSLAG-2025-FBE-UTRECHT-ONLINE; https://www.faunabeheereenheid.nl/zeeland/PUBLICATIES; https://www.fbezh.nl/jaarverslagen/.

Human population distribution

The Netherlands is characterised by a high and relatively dense human population, with marked spatial variation in population density across the country. The highest concentrations of inhabitants occur in the urbanised western part of the country, particularly within the Randstad, whereas population density generally decreases towards the northern, eastern, and southern regions (Figure annex 2-B).

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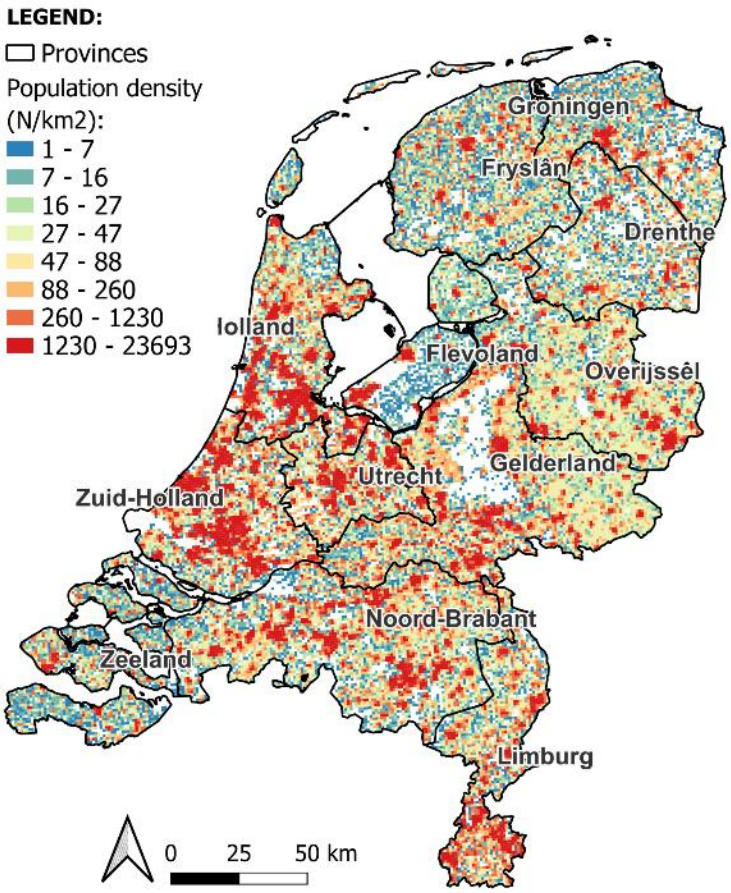

Figure annex 2-B – Population density (N/km^2).

Impact on livestock

One of the fundamental aspects to be considered in the management of a large carnivore is the potential impact of the species on the livestock-based economy. In this context, assessing the extent and spatial distribution of livestock depredation has become essential. The following maps and tables present the recorded depredation events for the period 2015–2025. In particular, Table annex 2-A showed the number of wolf predation events and Table annex 2-B the number of livestock animals affected by wolf predation (injured or killed), distributed across the various Dutch provinces from 2015 to 2025. The spatial distribution of predation events was reported in Figure annex 2-C.

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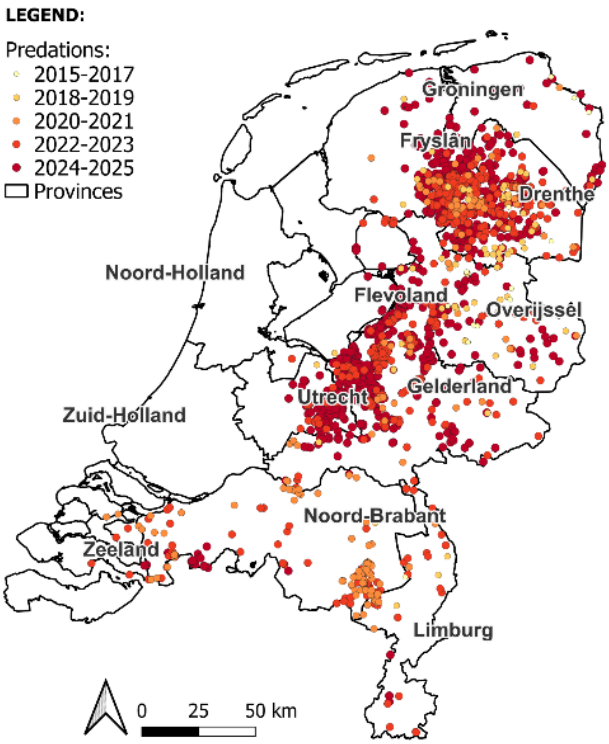

Figure annex 2-C – Nederland grid cells differentiated by the HSI as estimated via the SDMs of the three years (2023-2025).

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Table annex 2-A – Predations. Number of wolf predation events, distributed across the various Dutch provinces from 2015 to 2025.

	YEAR											
Provinces	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**Total**
Drenthe	2			14	11	17	25	99	112	125	187	592
Flevoland				1				2		3	8	14
Fryslân				6	3	2	9	35	108	114	149	426
Gelderland				2	2	13	12	40	112	404	521	1106
Groningen	2		1	3	1	1		4		2	28	42
Limburg				3		6	7	16	12	2	1	47
Noord-Brabant			1		2	50	44	45	22	16	9	189
Noord-Holland									1			1
Overijssel			7	14	5	3	5	32	16	41	71	194
Utrecht				1					14	56	105	176
Zeeland							2	4	2	7		15
Zuid-Holland												0
Total	4	0	9	44	24	92	104	277	399	770	1079	2802

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Table annex 2-B – Predations. Number of livestock animals affected by wolf predation (injured or killed), distributed across the various Dutch provinces from 2015 to 2025.

	YEAR											
Provinces	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**Total**
Drenthe	4			60	76	68	121	578	590	640	843	2980
Flevoland				2				12		13	22	49
Fryslân				20	7	13	22	198	512	636	949	2357
Gelderland				8	18	79	20	180	366	1424	1720	3815
Groningen	4		3	18	2	2		11		7	90	137
Limburg				15		24	13	67	33	9	1	162
Noord-Brabant			2		3	192	179	137	64	23	22	622
Noord-Holland									1			1
Overijssel			19	57	27	8	9	72	99	199	378	868
Utrecht				1					74	275	365	715
Zeeland							10	12	3	22		47
Zuid-Holland												0
Total	8	0	24	181	133	386	374	1267	1742	3248	4390	11753

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Moreover, the frequency of the predations' events with respect to suitable cells' (Table annex 2-C) or cells with ascertained presence (Table annex 2-D) was considered.

Table annex 2-C – Frequency of the predations' events with respect to suitable cells' distance (Maximum distance = 36,2 km).

Distance Class from the cell (km)	N° of events	%	Cumulative %
0 (within the cell)	282	26,1	26,1
0-0.5	105	9,7	35,9
0.5-1	107	9,9	45,8
1-2	181	16,8	62,6
2-5	289	26,8	89,3
5-10	75	7,0	96,3
10-20	29	2,7	99,0
> 20	11	1,0	100,0
Total	1079	100,0	

Table annex 2-D – Frequency of the predations' events with respect to ascertained presence cells' distance (Maximum distance = 86,9 km).

Distance Class from the cell (km)	N° of events	%	Cumulative %
0 (within the cell)	682	63,2	63,2
0-0.5	46	4,3	67,5
0.5-1	36	3,3	70,8
1-2	50	4,6	75,4
2-5	103	9,5	85,0
5-10	67	6,2	91,2
10-20	44	4,1	95,3
> 20	51	4,7	100,0
Total	1079	100,0	

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Annex 3 – Attacks to humans

https://nos.nl/artikel/2482129-wolf-valt-schapenboer-aan-bij-drents-dorp-dier-doodgeschoten

9 July 2023, 1:04 p.m.

Wolf attacks sheep farmer near village in Drenthe, animal shot dead

A sheep farmer was attacked by a wolf this morning in the village of Wapse in the Dutch province of Drenthe. Following consultations, the animal was shot dead by the police.

RTV Drenthe reports that at around 7 a.m. this morning, the farmer tried to chase the wolf away because it was attacking his sheep. When he approached the animal with a pitchfork and a shovel, it bit him on the arm.

The wolf was shot dead two hours later. The decision was made by Rikus Jager, mayor of the municipality of Westerveld, which includes Wapse.

https://nos.nl/artikel/2530880-dna-onderzoek-bevestigt-wolf-betrokken-bij-incident-met-kind

30 July 2024, 10:39 a.m.

DNA analysis confirms wolf was involved in incident with child

The province of Utrecht has confirmed that a child came into contact with a wolf in Leusden earlier this month. Wolf DNA was found on an item of clothing the child was wearing that day.

The incident occurred on 16 July at the Den Treek Estate. Children attending an out-of-school childcare programme were playing in the nature reserve that morning when a wolf approached a girl from behind and, according to the childcare staff supervising the group, bit her in the side.

The wolf reportedly released the girl immediately, but she was so startled that she fell and sustained minor injuries.

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https://nos.nl/artikel/2567547-rechter-wolf-die-hardloopster-beet-op-hoge-veluwe-mag-gedood-worden

16 May 2025, 7:02 p.m.

Court rules wolf that bit runner in Hoge Veluwe may be killed

The wolf that bit a runner in Hoge Veluwe National Park on 13 April may be shot and killed, the Gelderland District Court has ruled. After the provincial authorities previously issued a permit allowing the wolf to be shot, several animal rights organisations challenged the decision in court.

The court ruled that the province had made it "sufficiently plausible" which specific wolf in Hoge Veluwe National Park was causing problems and why "it is necessary to shoot this 'problem wolf' in the interests of public safety." According to the court, there are no alternative measures that could prevent the wolf from causing further problems in the future.

https://nos.nl/artikel/2569077-provincie-utrecht-wil-wolf-afschieten-na-bijtincident-op-landgoed-den-treek

28 May 2025, 5:16 p.m.

Province of Utrecht seeks to have wolf shot following biting incident at Den Treek Estate

The woman who was attacked by an animal last week at Den Treek Estate in the province of Utrecht has been confirmed to have been bitten by a wolf. The province now wants the animal to be shot because it poses a direct threat to people.

It is the same wolf that was involved in several incidents in the same area of the Utrechtse Heuvelrug last summer. The Utrecht Fauna Management Unit will apply for a permit to shoot the wolf. According to the province, it may take several weeks for the permit to be issued.

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https://nos.nl/artikel/2576956-opnieuw-bijtincident-wolf-gemeld-in-bossen-van-utrecht-kind-meegesleurd

30 July 2025, 4:45 p.m.

Another suspected wolf-biting incident reported in Utrecht woodlands: 'Child dragged away'

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A possible wolf-biting incident occurred in the woodlands of Utrecht this morning. The provincial authorities received a report of the incident and are investigating whether the injuries were indeed caused by a wolf.

According to the website of Den Treek Estate, the incident involved a child. The child was reportedly accompanied by several adults near the Pyramid of Austerlitz, a monument consisting of a grass-covered, pyramid-shaped mound of sand.

While playing, the child was reportedly attacked without warning and dragged away by the wolf. "Thanks to the swift action of the adults present, who struck the wolf with a stick, the wolf released the child in the woods and ran away," according to the account on the website.

The victim's condition is unknown. According to RTV Utrecht, the child was a six-year-old boy.

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