

# The return of an apex predator: the interplay between wolf establishment, human activity and an existing ecosystem in the Netherlands

## Abstract

After a strong reduction of their population in Central and Western Europe, the grey wolf is making a comeback, including in the Netherlands. Recolonization of wolves in Europe has led to high levels of livestock damage. Research shows that the presence of (large) wild ungulates can reduce the predation pressure on livestock, while prevention measures like fencing are considered effective prevention methods. One of the areas where wolves have settled in the Netherlands is the Northern area of Drents-Friese Wold, with successful reproduction in 2022. Livestock kills are particularly high in the northern provinces. The northern provinces don't have large wild ungulates like the red deer, wild boar and fallow deer, likely forcing wolves to prey more upon kill domestic animals. In the early stages of establishment of wolf packs, especially with cubs, easy kills of domestic animals are more likely, and the number usually drop when a pack has successfully settled itself. The use of prevention mechanisms like fencing and guarding dogs could also reduce the amount of livestock damage, although the effectiveness of these measures in the Netherlands is still poorly understood. The Drents-Friese Wold is potentially a suitable habitat for wolves, as the area is large enough for territorial wolves and it would be able to house large ungulates.

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# 1. Introduction

## 1.1 The decimation of European wolf populations

Historically, the grey wolf (*Canis lupus*) was widespread throughout the majority of Europe (Boitani & Mech, 2003). From Iceland to Great Britain, and from the Netherlands to Poland, wolves were found in every country of Western Europe. Initially, humans saw the wolf as an efficient predator and were even fearful of its capabilities. However, in the 18<sup>th</sup> and 19<sup>th</sup> century, the wolf was seen more and more as a threat to farming activities. The fear of the canine apex predator as a threat to humans was dwindling as well, because people started realizing wolf attacks on humans were rare. As a result, wolves were effectively decimated in Europe throughout the 18<sup>th</sup> and 19<sup>th</sup> century. Wolves in the Netherlands were likely already extinct in Friesland and the Western provinces since the 17<sup>th</sup> century (De Rijk, 1985). The remaining populations of wolves were consistently pushed back further south-east, with the populations Noord-Brabant, Limburg and Gelderland generally being considered extinct from the 19<sup>th</sup> century. Individuals wolves were still being killed in the Eifel at the end of the 19<sup>th</sup> century, and its close proximity to Limburg allows for the possibility that stragglers found their way in the Netherlands up until then. In 1869, the last confirmed Dutch specimen of the Grey wolf was found dead near the town of Schinveld, Limburg. Belgium followed in the years after this. After heavy prosecution, wolves had become extinct in the Northwestern part of Europe, and were limited to the far south and eastern parts of Europe.

## 1.2 The recolonization of the wolf in Europe

Over the course of the 20<sup>th</sup> century, the potential threat of wolves to society was gradually lost. This was in large part due to the simple fact that wolves and their attacks became almost non-existent, but it's also related to a change in how human society is built. These days, wolves only pose a threat to the livestock farming community, and our increased concern with the environment and biodiversity results in a perception of the wolf as a super predator that needs to be preserved and protected (Moriceau, 2014). Hence, in 1979, the wolf was officially designated as a protected species in Europe under the Bern Convention, increasing the conservation efforts on the wolf (WWF). Other factors aiding the resurgence of the wolf were increased political stability in Europe, higher levels of urbanization and financial support for protection of livestock. Gradually, the wolf reclaimed terrain in Europe, with populations growing especially in Poland and Germany (Reinhardt et al., 2015; Kaczensky et al., 2015). Wolves living in Germany, Western Poland and the Czech Republic are part of the 'Central European Lowlands' population, which is considered as the fastest growing population in Europe. In 2012, it was estimated that over 140 adult wolves were part of this population (Kaczensky et al., 2015). By 2018, the population had spread further west and the IUCN estimated a population of 1030 individuals (Boitani, 2018), whereas in 2021 individuals of this population were also found in Austria, Belgium, Denmark, Luxembourg and the Netherlands, with a total population estimated at 1850 individuals.

From the early 2010's onwards, individuals from packs living in the German provinces of Lower Saxony and Schleswig-Holstein would occasionally straddle the Dutch border, and in march of 2015 the first bits of evidence of wolf presence in the Netherlands were found (Lelieveld et al, 2016). On the 6<sup>th</sup> of march a resident near the town of Bargerveen in the Dutch province of Drenthe reported the sighting of a wolf. Less than a day later, DNA analysis of a sheep that had been killed confirmed that the wolf had been a culprit, confirming the return of the wolf in the Netherlands. On the 8<sup>th</sup> of March the wolf was sighted in the Drentsche Aa national park, and on the 11<sup>th</sup> of March it was confirmed the wolf had crossed the border back into Germany.

In the following years, more and more wolves from packs in Western Germany would wander into the Netherlands in search of suitable territory. That they were able to find this in the Netherlands was proven in 2018, when the first confirmed wolf territory was established in the national park 'De Hoge Veluwe', a large nature reserve with hills, forests and heath in the center of the Netherlands (Wolven in Nederland). Droppings and marking were found here repeatedly, showing territorial behavior (DBBW, 2023). A year later, the first cubs were born in this pack. In 2022, aside from the confirmed territories in the Veluwe, pairs of wolves were seen in areas south of Eindhoven, as well as the Drents-Friese Wold, a forested nature reserve in Friesland and Drenthe.

### 1.3 How suitable is the Dutch landscape for wolf establishment?

The recolonization of the wolf is a success story, as many large carnivores struggle to recover in human-dominated landscapes (Chapron et al., 2014; Kuijper et al., 2016). Many of the landscapes, which historically were part of the range of the wolf, have changed significantly. Extensive agriculture has largely been switched in favor of intensive agriculture, which results in an increase in both potential wild as well as domestic prey (Kuijper et al., 2019). While it is highly promising to see such success in a large carnivore in Europe, it inevitably leads to increased interactions between humans and wolves. Especially in Western Europe the human population density is high, and the chance of clashes between human and wolf activity is large. The reappearance of the wolf in the Netherlands sparked a lot of media attention, with a lot of focus on the potential threats for pet animals, as well as the safety of people walking in forested areas near the confirmed sighting. Debates would spark between nature conservationists and farmers, with the question whether it is realistic and feasible for the wolf the mutually exist along humans. The aim of this essay is to assess the ecological effects of wolves in landscapes that have been dominated by human activity, like the Netherlands. Part of this investigation will be research on how anthropogenic activity has shaped the habitat of the wolf. Finally, effects of the wolf on anthropogenic activity will be discussed, in particular regarding livestock animals. From this literature research, I will attempt to make a prediction on the suitability of the Dutch landscapes as a habitat for the wolf, as well as attempt to advice on how wolf and human can mutually live in the same location. The focus will be on two areas in the Netherlands where wolves have managed to establish themselves: De Hoge Veluwe (Figure 1) and Drents Friese Wold (hereafter: DFW) (Figure 2). In both areas, wolf packs have managed to establish territories and successfully have offspring (Van Heck, 2022;BIJ12), despite differences in habitats and prey availability.



Figure 1: A map of the Veluwe National park

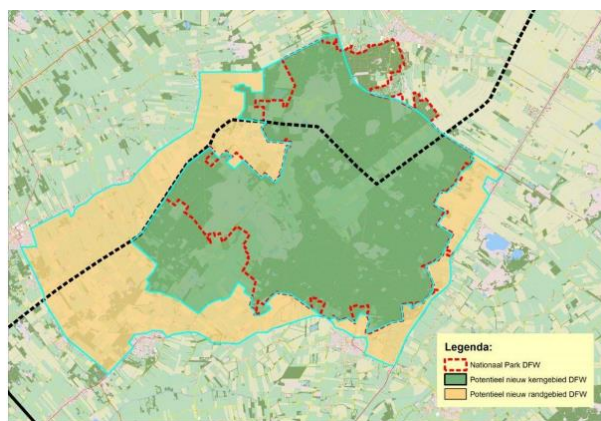


Figure 2: A map of the Drents Friese Wold (source: Spek & Schoon, 2016)

## 2. Wolves in anthropogenic-dominated landscapes: an overview of Europe

### 2.1 Wolves and their ecological interactions in human-dominated landscapes

The grey wolf is a highly social creature, living in packs usually between 6 and 10 individuals (Earle, 1987). Hunting also usually occurs in packs, with wolves capable of taking down prey of similar mass as the entire pack. The dietary preferences for the grey wolf highly differ across Europe. The Central European population in particular showed a balance between medium (23-130kg) and large (240-650kg) wild ungulates, whereas Scandinavian populations showed a preference for large ungulates (Newsome et al., 2016). The most commonly consumed medium-sized ungulates were roe deer (*Capreolus capreolus*), wild boar (*Sus scrofa*) and chamois (*Rupicapra rupicapra*), whereas large ungulates often consisted of red deer (*Cervus elaphus*) and moose (*Alces alces*). Size of prey appeared to mostly depend on the availability of such prey, not the pack size; pack size itself is dependent on prey availability (Boitani & Mech, 2003). The reintroduction of the wolf in the Netherlands could elicit a huge change in the food web, with the next largest predator being the red fox (*Vulpes vulpes*), which only very rarely appears to attack wild ungulates (Heptner & Naumov, 1988). Larger ungulates like the fallow deer (*Dama dama*) and red deer can now be preyed upon, and smaller ungulates like wild boar and roe deer are likely to be much more often preyed upon, like is the case in Germany (Ansorge et al., 2012). This suggests that the simple presence of wolves in areas where they previously did not occur, might induce behavioral changes in wild ungulates in the Netherlands. On top of this, it is possible that certain species which lacked a natural predator for a few decades, have lost the so-called antipredator behavior (Kuijper et al., 2016). There is a lot of research that has been done and is being done on anti-predator behavior. In a draft report on the changes in environmental use by red deer in the Veluwe, Mols et al used wild-cameras placed at various distances from known wolf denning sites, to assess the effect of wolf presence on the visitation rate of red deer. They found that red deer would visit the locations less likely, the closer the camera was to a wolf den (Mols et al., 2023). However, they did not find differences in the level of vigilance in red deer regardless of distance to wolf dens. This suggests that red deer alter the use of space in when wolves are present, but do not show alternative behavior when evidence of wolves is present. They speculate that this could be due to the fact that human activity around the Veluwe is high and predictable in time (daytime). This would force the wolves to be most commonly roaming in specific areas, during specific times, making their behavior more predictable for red deer. It's also worth noting that Mols also found that cameras closer to a human trail had significantly lower red deer visits compared to cameras further away, suggesting that both wolves and humans can affect use of space simultaneously.

But how is this for animals for smaller ungulates, which will likely serve as the main prey in areas where red deer are not present? In the central Italian Maremma Regional Park, fallow deer were found to alter their temporal activity according to wolf presence. Since wolves are nocturnal animals, fallow deer that were near wolf presence showed more of a shift to diurnal behavior (Esattore et al., 2022). Since wolves are nocturnal (Merrill & Mech, 2018), this indicates a change in behavior. Fallow deer vigilance was also higher according to higher wolf presence. This suggests the presence of wolves could impact fallow deer populations near the DFW. Anti-predator is also observed in the main deer that occurs in the DFW, the roe deer. In the Appenine mountains in Italy, roe deer mothers were found to select denser habitats during their lactation (Bongi et al, 2008). This was done to increase the success of the hiding that the fawns would do as they wait for their mother's milk. Other studies on the use of space by roe deer with predation risk from wolves were done in southern Sweden. Roe deer would have significantly reduced predation when in open areas and closer to human settlements and agricultural activity (Gervasi et al., 2013). Roe deer likely use the open area

and their maneuverability to quickly spot and flee from a potential predator (McCullough et al., 2000). Research on the response of roe deer to the odor of wolf urine however, suggests that there is no anti-predator response to olfactory cues of wolf presence (Elmeros et al., 2011), although there is evidence suggesting roe deer might avoid areas with unfamiliar scents regardless of its source (Sunde et al., 2022). A study on the diurnal activity of roe deer in proximity to both human and Eurasian Lynx (*Lynx lynx*) activity revealed that roe deer avoid areas of high predation by Eurasian Lynx only during the night, as the presence of the lynx was reduced during the day as a result of human disturbance (Bonnot et al., 2020). This again highlights the interaction between human activity and potential predators: the activity of humans could reduce the activity of predators during the day, resulting in a more diurnal shift for prey. However, since deer also adapt their habitat use both in time and space as a result of human disturbance (Bonnot et al., 2013), this could suggest a significant increase in stress and anti-predator behavior throughout the entire day. It remains to be seen whether prey in the DFW would show similar behavior, and how exactly they react to wolf presence. Often, the effects of wolf presence on ungulates might be hard to detect, as they often coincide with the effects of human presence (Kuijper et al., 2019; van Ginkel et al., 2019). It is also unclear whether the presence of humans will end up being beneficial for prey, or for predator. Wolves' fear of humans could induce a behavior response in prey that makes them live closer to areas of high human density to avoid predation pressure. However, this could also result in higher predation success for wolves as the prey density becomes highest near human activity, acting as a predation funnel.

The recolonization of the wolf in the Netherlands can also bring benefits to Dutch ecosystems. Wolves, like many other carnivores, generally prey on smaller, older and/or more vulnerable individuals, over individuals that are large and appear healthy (Mech & Peterson, 2003). This can have beneficial effects in the fitness of prey, as it allows the stronger individuals to survive, and the weaker individuals to succumb to predation pressure. This allows for the preservation of the strongest and fittest individuals of the herbivore populations. The population of red deer in the Veluwe has grown considerably in recent years, with a population of 3300 in 2021 (Linthorst, 2021). This is way beyond the proposed capacity of 1600 individuals, which was calculated based on the ability of vegetation to grow back to the same level after a year. Simply put, the population of red deer is consuming vegetation faster than it can regrow the next year. Because of this, seasonal culling of red deer had started since 2021 in July (VWV, 2023). The recolonization of the wolf could help keep the red deer population under control without the need for culling. The same goes for the wild boar, of which an increase in mortality as a result of wolves appears to lead to reduced need for culling (VWV, 2023). However, the 'power' of the wolf to naturally reduce prey density of course directly on the number of wolves. Kuijpers suggests that in many human-dominated landscapes, the density of wolves will never reach a level where it can impact prey populations in a significant way, due to hunting, poaching or simply the presence of human activity (Kuijper et al., 2016). More on the carrying capacity for wolves in the Dutch landscapes in section 4.3.

There is also evidence that wolves can reduce the occurrence of deer-vehicle collisions. Wolves use roads as a way to travel quicker and more efficiently, allowing a higher chance of killing their prey (Dickie et al., 2017). Research in Wisconsin in the United States suggested that wolves create a landscape of fear next to road systems, reducing the deer presence near roads and ultimately reducing the amount of deer-vehicle collisions (Raynor et al., 2021). The Netherlands has a high density of ecoducts which could already reduce collisions with wild animals (Wolbers, 2022), so it remains to be seen to what extent wolves impact this. There are however some signals that wolves may already lead to a decrease in vehicle-deer collisions. Since 2019, the number of fallow deer and red deer that died as a result of a collision has been decreasing around the Veluwe, which coincides

with the establishment of wolves in the Veluwe (VWV, 2023). However, the overall decline in the red deer population in the Veluwe as a result of culling also likely affects this rate.

## **2.2 Livestock damage in Europe**

The recolonization of the wolf near densely populated areas in Europe ultimately results in more frequent human-wolf interactions (Linnell & Cretois, 2018). One of the main concerns that is generally brought up with the recolonization of wolves, is the killing of livestock animals. Especially in Western Europe and in particular the Netherlands this is a concern, as a lot of farmers in highly urbanized areas have a lot of livestock in relatively small spaces (Schut et al., 2021) leading to higher predation rates of livestock compared to North American and Asian populations (Newsome et al., 2016). Hence, livestock kills as a result of wolves are quite high in many areas of Europe. For example, annually an average of ~36000 sheep were killed in Europe by wolves in a survey from 2012-2016 (Linnell & Cretois, 2018). There were large differences between countries however, and not just because of differing populations of both sheep and wolves. When expressing sheep kills as a ratio of the amount of wolves, especially Norway and Switzerland stand out. On average each wolf results in the killing of 30 sheep in these countries, whereas most countries report 1-14 kills per wolf. There is a good reason why livestock kills are high in countries like Switzerland and Norway. Here, many sheep and other livestock are able to freely graze the hills and forests, without fencing or the protection of guard dogs. Neighboring Sweden and Finland widely use fencing and guard dogs to protect their livestock, and it shows in the amount of kills by wolves. Losses of sheep here are between one-hundredth and one-thousandths of that of Norway.

The findings also suggest that sheep are the main livestock being killed by wolves. In almost all European countries, 70% of the compensation payment for livestock killed by wolves was for sheep. Other sources claim that other forms of livestock are consumed more often, however. According to Newsome et al (2016), the most commonly consumed domestic animals by wolves are the domestic pig, goat and horses. Cattle and sheep were consumed much less, although regional variations were found. It appears that the regional density of a certain type of livestock reflects in the likelihood of it falling prey to a wolf, although generally sheep appear to be killed the most. This could be because sheep tend to have the least defense mechanisms: cattle tend to shield their vulnerable individuals (Meriggi & Lovari, 1996), whereas both cattle and horses are heavier, stronger animals, more capable of defending against an attacking wolf.

## **2.3 Do wolves prefer wild or domestic prey?**

Not only do the livestock kills differ between European countries, the ratio between domestic and wild prey of wolves also differs across Europe. Southern European populations showed a much higher consumption of domestic animals compared to Central European and Scandinavian populations (Janeiro-Otero et al., 2020). This is partially due to the fact that ungulates are largely extinct in Southern Europe due to human activity. Research shows that the ratio between wild and domestic ungulates impacts the dietary choices of wolves (Janeiro-Otero et al., 2020). Over the last few decades, the diet of grey wolves in Europe has shifted more and more towards wild ungulates, and the dependency on domestic animals is decreasing (Newsome et al., 2016). This decrease in consumption of domestic animals was found to coincide with an increase in the availability of wild ungulates such as roe deer and red deer, suggesting that higher consumption of domestic animals likely occurs when wild ungulates are scarce. Research on the diet of wolves in Western and Central Poland showed similar results. Populations of wild ungulates such as roe deer, red deer were large, whereas the density of livestock was small. Almost 95% of all remains found in the wolf scats were of wild ungulates (Nowak et al., 2011). This further shows how the ratio of wild and domestic ungulates

shapes the diet of the wolf. Reintroducing former wild ungulates in an area of wolf presence, or allowing existing populations to grow and thrive, might reduce the predation pressure on domestic livestock. A similar phenomenon occurred in various regions in Italy during the last decades. The increase of wild ungulates would often result in a reduction in consumption of livestock by wolves (Meriggi et al., 2011).

According to Merrigi and Lovari, having a larger selection of wild prey species is more beneficial from the reduction of livestock predation, compared to a large number of individuals of a single species (Meriggi & Lovari, 1996). The reasons for this is likely the ability to shift between prey throughout the seasons, as well as giving a particular species less of an incentive to develop strong anti-predatory behavior. The prey choice of wolves also appears to depend on whether the wolf is part of a pack. In a study in northern Italy on the prey choice of wolves, dispersing wolves were found to feed on livestock animals significantly more than wolves belonging to a pack (Imbert et al., 2016). Dispersing individuals are often young and unexperienced, with lower hunting success compared to older counterparts. This results in a selection for livestock prey, which, as a result of domestication, are often less capable of defending themselves as well as wild prey (Meriggi et al., 1996).

## **2.4 Wolf attacks on humans**

Another major concern of people regarding wolves is the danger they may pose to humans or their pets. However, in practice, attacks on humans or their pets are incredibly rare. Wolves are generally cautious of afraid of humans and don't see them as prey (DBBW, 2023). From 2000 onwards, the majority of attacks on humans where cases of rabid wolves, often in Ukraine and Russia (Linnell et al., 2021). Many wolf attacks in Asia, North America and eastern Europe where rabies was not apparent, were either cases of people approaching cubs too closely, or a herder attempting to protect its sheep from a wolf attack. In recent years, there have been a few unprovoked attacks on people in Italy and Czech Republic, usually involving people walking their dogs (Linnell et al., 2021). This suggests wolves might indeed see (small) dogs as prey, and when offspring is around it might reduce the natural fear of humans. In July of 2023, a sheep herder in the Dutch province of Drenthe was attacked by a young, male wolf when it attempted to prey upon its sheep. This is the first documented case of a wolf attacking a human in the Netherlands. After this attack, the wolf was tracked and shot as it was deemed a hazard to public safety, although this resulted in some controversy among ecologists (RTV Drenthe, 2023). According to a renowned Dutch ecologist who specializes on wolf behavior, the attack was the result of the wolf feeling threatened after the farmer attempted to scare it away (van Maanen, 2023). The wolf likely got stuck in the fence around the livestock, and felt cornered as the farmer tried to fend it off, acting in self-defense.

## **3. Wolves in anthropogenic-dominated landscapes: focusing on Dutch landscapes**

### **3.1 Livestock damage in the Netherlands**

In section 2.2 and 2.3 attacks on livestock in Europe were discussed. However, how common are livestock kills in the densely populated and agriculturally intensively managed Netherlands? Data on the damage done to livestock in the Netherlands as a result of wolf attacks is publicly and easily accessible. When a domestic animal such as a sheep or horse is attacked, the owner of the attacked animal(s) can make a damage claim and ask to receive compensation for the damage caused. This can be done using the website of 'Bij12'. After the claim, an appraiser will visit the affected area and



decide upon the damage that has been inflicted, and decides on the amount of compensation that the affected might receive. A positive DNA match is needed to proof that a wolf was responsible. The site of 'Bij12' registers all these claims and compensation and keeps it in a large database (BIJ12, 2023). Hence, the database of Bij12 is a good indicator for wolf attack and each attacks gets sorted in a region. However, since likely not every wolf attack always results in compensation, this database is very likely an underrepresentation of the actual amount of attacks. On top of this, some keepers of domestic animals might make the decision to not report on the damage (for example if it is a sick animal or one that had escaped).

Since the database make the distinction between provinces, the spread of the wolf can be followed through this database as well. On top of this, the impact per province can be investigated. Data exists from 2015 onwards, and in the table below the confirmed kills by wolves per province are listed. Data was last updated on the 11<sup>th</sup> of August, 2023, and includes cases in which wolves are not (yet) confirmed but deemed very likely. Since sheep comprise almost all of the cases, they are the only ones included in this list. In order to highlight the progression in sheep killed by wolves, figure 3 shows how sheep kills over the years progressed, per province (BIJ12). Only provinces which showed clear temporal trends and had at least 50 sheep killed per year are shown in the figure.

Table 1: The total amount of sheep kills with the wolf as confirmed culprit.

Province	Sheep kills until 11 <sup>th</sup> of August 2023
Drenthe	797
Noord-Brabant	441
Friesland	352
Gelderland	271
Overijssel	211
Limburg	116
Groningen	42
Zeeland	19
Flevoland	10
Utrecht	3



Figure 3: Annual kills of sheep with wolf as confirmed culprit.

What’s striking about this data is the high amount of confirmed sheep kills in the Northern provinces of Friesland and Drenthe. On top of this, there is a sharp increase in sheep killed by wolves in 2022, for many of the provinces. This is in contrast with data from Newsome (2016), who suggests that the wolf’s dependency on domestic animals is decreasing. From data on the wolves from Germany, we know that individuals have been wandering into Dutch territory since 2015, likely killing domestic animals when coming across them. The provinces of Utrecht and especially Gelderland (which contains De Hoge Veluwe), have comparatively low confirmed wolf kills, despite this region having the highest presence of wolves in the Netherlands.

### 3.2 Describing regional differences in livestock damage

The areas of Utrecht and Gelderland are more urbanized and have higher populations and population densities compared to Drenthe and Friesland (CBS, 2023). As a result, the amount of land that is used for agriculture and potentially the herding of sheep, could be significantly higher in these provinces. In order to investigate this, data from Centraal Bureau Statistiek (CBS, or ‘Central Bureau of Statistics’ in English) on the amount of sheep per province was used. The total amount of land that was used for agricultural activities was also used, to get an idea of the density of sheep per province. Keep in mind that is amount of land used for agriculture includes the farmhouses as well as every plot of land that is owned by farmers, so the total amount of land used for agricultural purposes is likely overestimated. This results in the information shown in table 2 below.

Table 2: A comparison of the agricultural land use and sheep density between Dutch provinces

Province	Total area in km2	% used for agriculture (CBS, 2023)	Sheep (CBS, 2023)	Sheep/total km2	Sheep/agricultural km2
Friesland	3335.62	67.39	136869	41	61
Drenthe	2632.35	55,98	48428	18	33
Gelderland	4963.71	45,25	122448	25	55
Utrecht	1485.46	47,55	48030	32	68
Noord-Brabant	4905.46	48,06	132925	14	30

Table 2 shows that the sheep density is in fact highest in the provinces of Utrecht, with Friesland following closely behind. Drenthe actually has a relatively low density of sheep, seeing as even for its small size it has a small sheep herd. This suggests that just the density of sheep herds in the area likely does not dictate the likelihood of a wolf attack, at least not on its own. If this were the case we would have seen gigantic numbers of attacked sheep in Gelderland and Utrecht, especially considering the presence of wolves in the Veluwe National Park.

As mentioned before, the way of keeping the livestock could have a large impact on damage to livestock. In Europe, allowing livestock to freely graze in nature areas results in significant increases of wolf predation (Newsome et al., 2016). Fencing is generally considered a highly effective measure to reduce the impact of wolves on livestock; fencing was able to reduce 66-99% of damage to livestock in North America and Europe (Bruns et al., 2020). However, it is worth mentioning that the level of protection was higher in cattle compared to small stock such as sheep. The use of guard dogs was also effective, 42-79%, albeit not as effective as the use of fencing. It’s possible that farmers in the area of Veluwe have adapted better to the presence of wolves, by using defense measures to reduce the impact of wolf killing. This is not completely likely however, as the first confirmed wolf kills actually came from Drenthe (BIJ12, 2015), suggesting that farmers here would have enough time to prepare for the return of wolves. Information or data on differences in livestock management between northern provinces and other regions were not found. However, the data from Bij12 does suggest that the provinces of Friesland, Drenthe and Overijssel were the only provinces where a

significant number of attacks took place with livestock that was not protected by any means (at least as far as the data shows). This could either show that the amount of livestock damage in these three provinces could have been a lot higher, or it could suggest that fencing, which is also most commonly used as damage prevention, is not as effective in the Netherlands. Almost none of the attacks took place where there were guarding dogs. Again, it is uncertain what this exactly means in this case. It could either be because guarding dogs are not commonly used, or because they are very effective in the Netherlands.

Another reason for the large impact in the Northern provinces is the fact that wolf populations in the Veluwe have a large nature area full of wild ungulates such as red deer, fallow deer and wild boars (Liefting et al., 2012). According to Merrigi and Lovarri, a higher presence of wild ungulates would result in a reduced killing of domestic livestock (1996). The northern provinces do not have large ungulates, suggesting a higher likelihood of livestock falling prey to wolves.

Sheep kills in the Netherlands fluctuate heavily, and occasional periods of relatively few kills are often interchanged with days where sometimes dozens of sheep are found dead in one location (BIJ12). This is called 'surplus killing', and wolves are known to do this (Vucetich et al., 2012). Often this behavior is shown when carnivores come across a large amount of relatively defenseless prey, and it is suggested that it is done so the predator can consume the most nutritious parts of the animal (Muhly & Musiani, 2009). This could also suggest sheep in Drenthe is generally 'easier' prey compared to southern areas, perhaps owing to differences in the levels of protection between provinces. Also, since wandering or dispersing wolves are more likely to kill livestock compared to wolves that have settled (Natuurmonumenten; Imbertal., 2016), this could also explain the high kills in the North.

Another reason for the high livestock damage in Drenthe is the fact that the wolf pack in the area is growing in size. The pair of wolves had young for the first time in 2022 (BIJ12, 2023), and in 2023 the size of the pack was five individuals, of which three juveniles (BIJ12, 2023). However, this is of course also a process that also plays in other areas where the population is growing. Indeed, after the first cubs of wolves in De Hoge Veluwe were born in 2019 (Wolven in Nederland), the intensity of attacks in Gelderland grew most significantly in 2020, 2021 and 2022 (BIJ12). It could however explain that in 2022 the wolf attacks in Drenthe had tripled in the third quarter compared to the second quarter (BIJ12). This is however in contrast to This also suggests that if the wolf population keeps increasing near the DFW, the impact on farmers and their livestock will increase even further, putting more pressure on human activity and in reverse, on the wolves.

## **4: Drents-Friese Wold**

### **4.1 Establishment of wolves in DFW**

Interestingly, since 2022 farmers in Drenthe and Friesland have been noticing more and more roe deer carcasses, suggesting a potential shift from domestic to wild ungulates (Omrop Fryslân, 2022). This is in agreement with findings of Newsome in 2016, who found a decrease in the proportion of domestic prey in European wolf populations, and would also explain that properly established wolf packs switch to wild prey after some time (Natuurmonumenten). This could be an indication that the pack of wolves in Drenthe has successfully settled and is set to remain for a while. Still, the domestic kills in the province appear to be growing (BIJ12, figure 1). This brings up the question of suitability of the surrounding area for the wolf. Is the area too small to house a pack or multiple packs of wolves? Is there enough prey in the DFW for the wolves? And to what extent does human activity around the

area impact this carrying capacity, and tell us about the ability of wolf and man to live in or near the same area? In this section, these questions will be discussed.

## **4.2 Prey in the DFW**

Large ungulates like the red deer are normally completely absent in the area, with the fallow deer living in nearby areas such as Oranjewoud. This leaves the roe deer as the largest wild ungulate in the direct area (Website Drents-Friese Wold), likely becoming the main wild prey for the wolves. Occasionally red deer will wander into Drenthe, usually from the Veluwe or Germany, either as an escaped animal, illegal introduction or as a wild animal (Venema 2019). In the former two cases, the policy of the province of Drenthe dictates that the animal should be shot, to combat illegal introductions and to not have the emergence of populations of escaped animals (Province Drenthe, 2014). If a wild red deer emerges in an area, its fate is essentially decided based on the potential (agricultural) damage the individual will have. Since populations of red deer and wild boar are virtually non-existent as well as low availability of fallow deer, wolves might be more forced to prey more upon domestic ungulates. The reintroduction of larger ungulates in the area might mitigate the problem to some extent. As seen in the number of livestock kills in the Dutch provinces, the northern provinces appear to have larger livestock predation compared to Gelderland and Utrecht (BIJ12, table 1).

## **4.3 Size of DFW and connectivity with other areas**

Wolves usually have large territories, with sub-adult males requiring territories of size upwards of 200km<sup>2</sup> during autumn and winter (Jedrzej et al., 2007). In Europe, the average territory of a pack is 120km<sup>2</sup> (Potiek et al., 2012). The size of the territory also heavily depends on the availability of prey: when prey density is lower, wolves tend to establish larger territories (Boitani & Mech, 2003). The area of the DFW is approximately 60km<sup>2</sup> (Website Drents-Friese Wold), suggesting that the area might be small for the establishment of wolves. However, a pair of wolves had already successfully reproduced in the area, suggesting that the potentially limited size of the area does not limit wolf settlement. Since wolves tend to establish larger territories when prey is limited, this could suggest that the wolves have no problem finding significant prey. It's possible that this is facilitated by higher attacks on domestic animals. It also remains to be seen how the offspring disperse after growing up. Wolves disperse after one or two years and tend to disperse further when the pack is larger and when the habitat quality is lower (Potiek et al., 2012; Hayes & Harestad, 2000).

Another factor that needs to be considered is the ability of the wolf to freely move between different areas. And this could be the reason why wolves could successfully settle themselves in the relatively small area of DFW. The Netherlands is densely populated, urbanized and has an extensive infrastructure, with over 139.000 roads, which gives an average of 332 kilometers of road per km<sup>2</sup> (CIA, 2016). This of course leads to fragmented nature areas. The Netherlands however, has over 70 wildlife crossings spread throughout the country (Wolbers, 2022), which allows wildlife to freely cross larger highways and other roads. This can greatly 'expand' the potential territory available for wolves. In 2012, Wageningen University launched a study into investigating the suitability of the Netherlands for the settlement of wolf packs (Potiek et al., 2012). They conclude that prey and habitat are not an issue, due to large amount of variation in habitats that wolves inhabit around the world. According to the research, if wolves make use of the wildlife overpasses, the area of DFW would be part of a much larger potential territory that spans across the entirety of Drenthe, Overijssel, Flevoland and would include parts of Friesland, Gelderland and Utrecht, including the Hoge Veluwe. This suggests that the wolves that have settled in Drenthe could also have arrived from the packs at the Hoge Veluwe. The entire carrying capacity of the area would be around 300 individuals, with the availability of prey

being the limiting factor. What is interesting is that if prey was not an issue, the capacity would be limited at 482 individuals based on the area. Without the use of the overpasses, the area of DFW would be part of an area consisting of parts of Groningen and Drenthe, and would have a capacity of 20 individuals. This study not only highlights the importance of wildlife crossings, but also demonstrates the suitability of the Netherlands in terms of habitat and prey availability. The use of wildlife crossings by wolves in the Veluwe has been confirmed by wild cameras, part of preliminary research by Van Hall Larenstein (Bronkhorst, 2021), which is in line with other studies suggesting the use of wildlife crossings by wolves (Mysłajek et al., 2020). According to the research by Bronkhorst, ungulates would use wildlife crossings more often when wolves are in the vicinity, suggesting an increase in desire to move between locations. Perhaps this is already indicative of an increase in desire of large ungulates to move to northern provinces.

#### **4.4 Estimates on the (natural) carrying capacity of the DFW**

In 2014, estimates were made on the natural carrying capacity of the DFW for two larger ungulates: the red deer and the fallow deer. For red deer a capacity of about 2200 was estimated, whereas for the fallow deer estimates went up to 11500 individuals (Spek & Worm, 2014). These estimates were made based on the size of the DFW as well as food availability in the direct area. On top of this, since the DFW is not fenced, reintroduction of these species would likely result in the DFW becoming a population source, with individuals leaving the area. This estimate however disregards the enormous increases in roadkill as well as damage to agricultural land and therefore decreased support from the community, and created more as a way to visualize the potential of the DFW as a place where red deer and fallow deer could establish themselves. When considering the agricultural land around the DFW, Spek & Schoon estimated populations of 140-210 red deer, and (Spek & Schoon, 2016).

### **5. Discussion**

The DFW is likely a suitable area for establishment for wolves. Even without the use of wildlife crossings, sections of Drenthe, Groningen and Friesland would be able to house up to 20 individual wolves. Assuming wolves can use the crossings successfully, something that appears to be the case (Bronkhorst, 2021; Mysłajek et al., 2020), the DFW could be part of a much larger area connecting with the Veluwe as well, greatly boosting the ability of the wolf to disperse in the Netherlands and increasing its carrying capacity to over 480. This undoubtedly leads to more frequent human-wolf interactions, and potentially higher disregard for the wolf by local people. As expected in a small densely populated country with a lot of farming activity, livestock kills are high in the Netherlands, and on the rise (BIJ12). Especially in the provinces around the DFW, livestock kills were high, with Drenthe having almost 800 sheep killed by wolves in 8 years. This high number can be predominantly attributed to the ecology of wolves and their habitat, as well as potential management differences in the Netherlands.

#### **Ecology of wolves and their habitat**

The pack in the DFW had its first offspring in 2022, and the arrival of cubs causes the food requirements of a pack to rise significantly, and perhaps wolves try to find easier, defenseless prey. On top of this, Drenthe was the first location in the Netherlands where wolves were sighted and throughout the years many individual wolves were spotted, likely dispersing individuals. Dispersing individuals tend to be younger and attack prey that are less likely to have a developed anti-predator behavior (Imbert et al., 2016). On top of this, the pack of wolves in the DFW is growing, with the

arrival of two cubs in 2022 (Bij12). A growing pack needs a lot more food, and this is likely found in easier prey such as livestock animals.

However, what is potentially even more vital for both the conservation of the wolf as well as the safety of livestock, is the presence of large, wild ungulates. Research on the diet of wolf shows that large, wild ungulates tend to form the most significant part of the diet, if they are present in significant numbers. A reduction in wild ungulates can lead to increased livestock predation, whereas an increase in wild ungulates can lead to a decrease in livestock predation. The area of the DFW does not contain ungulates like the red deer or the wild boar, with the largest ungulates being small populations of fallow deer and roe deer. This lack of larger ungulates could explain the larger livestock kills in Drenthe and Friesland compared to the areas around the Veluwe, where large numbers of red deer and wild boar exist. If we want to preserve the wolf population in the DFW, as well as regulate the predation on livestock, the reintroduction of larger ungulates in the area is vital.

### **Livestock management in the northern Netherlands**

Another factor potentially contributing to the regional variations are differences in the way livestock is managed across the Netherlands. Fencing is an effective option to reduce livestock kills, and it is possible that the provinces of Drenthe and Friesland do not fence their livestock as effectively. Data from Bij12 suggests that only the northern provinces of Overijssel, Drenthe and Friesland have a significant number of attacks in agricultural land without prevention mechanisms. However, interpreting this is not easy. First off, the information of these farms could simply be lacking, or perhaps the farmer does not want to show or share this. Secondly, there is no information on the condition of the fences. Damaged fences with holes are much more likely to let wolves through (Reinhardt et al., 2012). Finally, it's difficult to draw a conclusion about the effectiveness of fencing, as the amount of livestock damage in other regions is still high despite the fencing. There is simply not enough information on this matter, and the only way to assess the potential effectiveness of fencing would be have a farm keep livestock without fencing for a certain amount of time, and then have livestock for a similar time with fencing. Finally, only very few cases had guarding or herding dogs as mechanisms to prevent damage. Once again, this could suggest either that dogs are highly effective, or that they are simply not used a lot. While research in other regions of Europe suggests fencing is highly effective (Bruns et al., 2020), and there is not a clear reason to assume it shouldn't be effective in the Netherlands, more research needs to be done on the potential differences in herding between provinces, before hard conclusions can be drawn.

### **Managing the interactions between wolves and humans**

The growing population of wolves and high density of human activity in the Netherlands calls for mechanisms/methods to reduce the chance of these encounters, and also reduce the impact of such encounters. Since wolves are protected under the so-called 'Wet Natuurbescherming' (Law of Nature Protection), the killing of a wolf is only considered legal if it is a threat to the public safety, usually the case when a wolf keeps approaching humans without cause (IPO, 2019). On top of this, the deliberate or indeliberate killing of wolves reduces the strength of the pack, likely resulting in a higher predation risk for easier prey like livestock (Imbert et al., 2016). Compensation for farmers is something that should remain in place, but a better methodology might be to give farmers in an area with known wolf presence a budget, that they can spend on protective measures against wolf attacks. This would reduce the need for compensation losses for farmers, especially in the long run, and might prove a worthwhile alternative to compensation payment.

Another measure that could be implemented more strongly would be wolf proof fencing, often with electrical currents and dug-in barriers. These barriers prevent wolves from burrowing under fences,

which they prefer over jumping over the fence (Bruns et al., 2020). Advisory is to have a height of at least 1.2 meters, and the fence should be electric. The electricity is likely to have a conditioning effect on the wolf, reducing the likelihood of it attempting to pass the fence. Fencing is considered a double edged sword, however (Kuijper et al., 2016). It can provide protection for livestock and even limit other human-wolf interactions, which could reduce the need for compensation payments and further limit the potential attacks. On top of this, it can also result in an increase in positive or at least neutral perception of the wolf, which can benefit the protection and conservation of the species. Finally, it reduces the need to cull a wolf if it poses a hazard to human safety.

A common protest against fencing is that it increases the level of fragmentation for wolves, a problem that is already highly present in small, densely populated areas such as the Netherlands. An extensive network of fences essentially separating human activity from wolf activity limits could lead to isolated populations, limiting gene flow and resulting in lower fitness. This again highlights the vital role of wildlife passages in the Netherlands, which could partially combat these issues.

Finally, another strategy to minimize human wolf interactions in a non-lethal manner would be to reduce the likelihood of wolves approaching human settlements or activity. This would be done by instilling fear into the predator. While the amount of attacks on humans does not seem to increase by much (Linnell et al., 2021), the chance of conflicts over livestock does increase. The upkeep of a strong sensation of fear of humans by wolves can reduce the frequency and severity of human-wolf interactions. Methods of attempting to reduce a wolf's likelihood to approach human settlements include the use of wolf collars, or the use of repellants (Kuijper et al., 2019). These measures can have the desired effects, but generally don't last long, as the wolf becomes habituated to these measures. In order to increase the fear of humans for wolves, a method needs to be found that could work in the long term. If a wolf is spotted attacking a livestock animal, approaching the animal on foot is not advised. Attempting to scare away the animal from a distance, or with the use of an enclosed vehicle like a tractor might be more effective and above all, safer for the farmer. In areas where wolf presence is known, like the Veluwe or DFW, dogs should always be leashed when walked in forested areas, to reduce the potential of an attack.

In conclusion, the argument could be made that the DFW is currently not a suitable location for the establishment of wolves, due to the lack of larger, wild ungulates and the vulnerability of the livestock around the area. However, this is something that could change if our policies change. The reintroduction of larger ungulates in the area, perhaps even initially even with a culling program to avoid an enormous population growth, could counteract the high number of livestock kills in Drenthe and other northern provinces. With the current strategy, livestock kills will remain high for a while, which will ultimately decrease support for the conservation and preservation of the wolf in the Netherlands. This is essentially a cycle that is unlikely to break by itself: something needs to change. Spek & Schoon showed that releasing a population of fallow and red deer and allowing the population to grow to a few hundred individuals could be done without added damage to agriculture and high deer-vehicle collisions. The successful reintroduction of wolves is desirable, as wolves provide beneficial ecosystem services such as keeping the herbivore populations healthier. It would also eventually reduce the need for management by people in the form of culling of herbivores, something that has just been introduced to red deer in the Veluwe. On top of this, the Netherlands could set a great example by showing how an apex predator that was once deemed dangerous and deadly, could thrive in densely populated country, dominated by human activity.

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