

Limitations of wolf populations in agricultural landscapes in Europe



Figure 1: Two wolves from Yellowstone Park (Goldenberg, 2011)

Abstract

When a species extends its range into an area where it was not present, it can have an effect on the entire ecosystem. The (re)introduction of a top predator such as the wolf in the agricultural landscapes of Europe can have positive influence on the species diversity. In this review, the needs of the wolf were studied in order to find out what the limiting factors could be and how big the influence of each of those factors is. In order to do this, possible influences were listed and the most important factors were investigated; these included humans, roads and habitat (divided into area, contiguous forest and prey availability). For each of these factors, the goal was to find how big the influence is on the different live stages of the wolf. Prey availability, roads and poaching were found to be limiting factors in the success of a wolf population; however, there was no research found on the impacts of area and forest contiguousness. Therefore it was not possible to define the factor that would be the most limiting in the agricultural landscapes of Europe.

1 Introduction

For a healthy and self-sustainable environment it is important that there are some specific factors present. One of these factors is the biodiversity of flora and fauna. A high biodiversity can be achieved by having a top predator, like a wolf, which can trigger trophic cascade effects (Figure 2) (Estes *et al.*, 2011). Top predators make sure that herbivore populations stay in balance with the environment, and that they disperse so that plants have the time to regenerate. Wolves coming back to agricultural landscapes such as The Netherlands might have positive effects on biodiversity and the environment. But to get a suitable environment for wolves, several factors need to be considered. Factors such as contiguousness of the forest and prey availability all have effect on the suitability of the environment for wolves.

In recent years, wolves have been dispersing throughout Western Europe (Trouwborst, 2010). This range expansion is concerning the people who live in possible settlement areas, as wolves populating nearby areas might cause problems. Because of this, there is a focus on what might be limiting factors to the wolves and what is needed to sustain a wolf population.

It is hypothesized that, in agricultural landscapes in Europe, wild prey availability will not be the limiting factor in sustaining a wolf population.

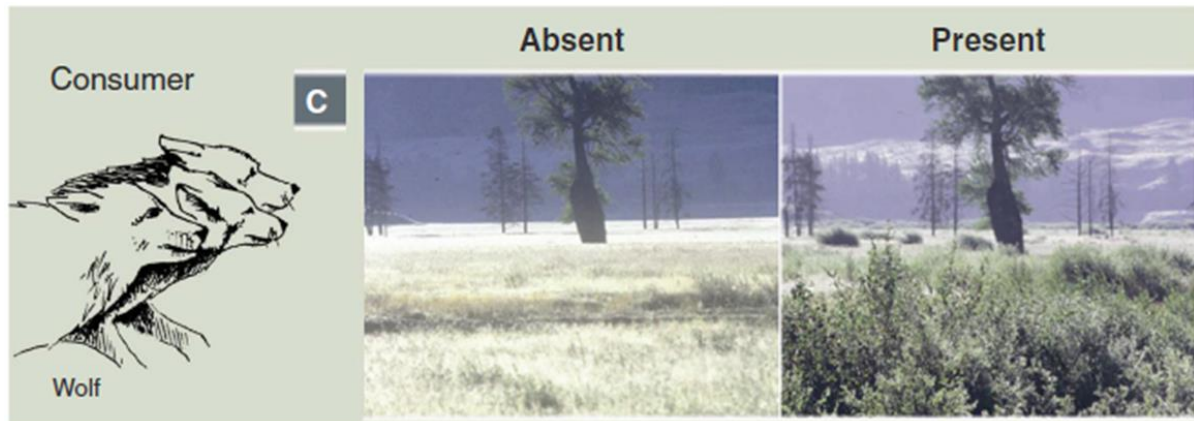


Figure 2. Riparian habitat near the confluence of Soda Butte Creek with the Lamar River (Yellowstone National Park) illustrating the stature of willow plants during suppression (left, 1997) from long-term elk browsing and their release from elk browsing (right, 2001) after wolf reintroductions that began in the winter of 1995-1996. (Estes *et al.*, 2011; Ripple and Beschta, 2003)

Methods

To investigate what is influencing the wolf's changes at a successful dispersal throughout Europe, factors that might be limiting were listed and the most important of those factors were investigated through literature search. The main criteria for the literature selection were peer-review and recentness.

Graphic Model

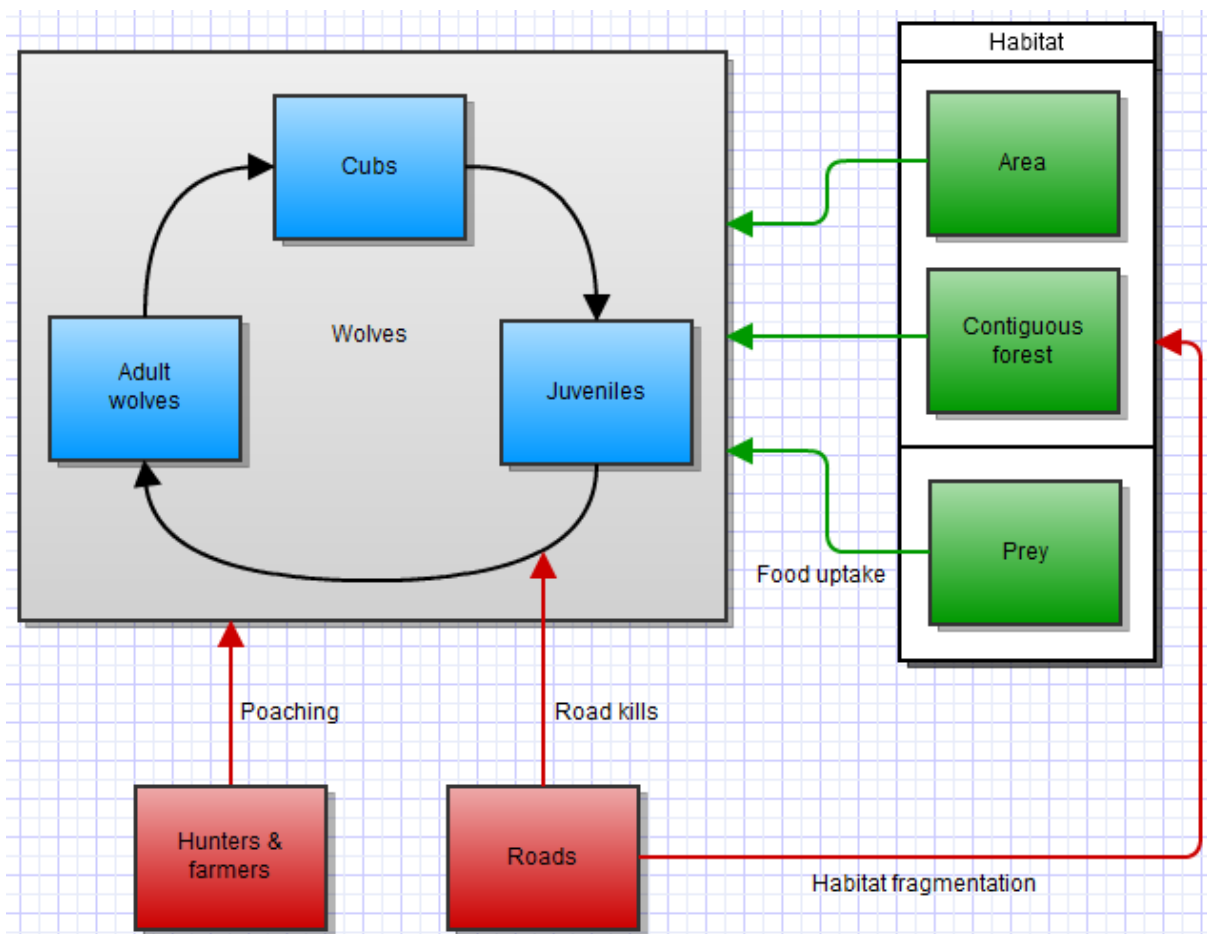


Figure 3. Graphical model of factors that influence wolf populations.

In this model, there are five main factors that influence wolf population's success, with different effects at different developmental stages of wolves.

Area is considered to be a combination of terrain type and different types of land cover and can have several influences on the wolves. An example of how the area can influence the wolves is by having effect on their hunting success. The surroundings and terrain determine if and how much a wolf can stalk and chase their prey.

The contiguousness of the forest plays a role in the distribution of wolves - it matters whether wolves have a certain area of contiguous forest or the same amount of forest divided over several locations. Having to move between different patches of forest might increase risks and effort.

Both the type and the amount of prey can influence the wolf prevalence. For example, when there are small or no numbers of wild ungulates in an certain area, wolf populations

cannot survive; prey availability would then be the limiting factor and thus causing habitat unsuitability for the wolves.

Roads influence all aspects of wolf habitat and threaten the dispersal of roaming individuals. By contributing to habitat fragmentation, roads reduce the sustainable habitat available to the wolf, both in terms of prey and contiguous forest patches. Non-territorial, free-roaming individuals are the most affected by collisions with vehicles.

Poaching of wolves poses a threat because of the low density and the slow population growth. Illegal killing of wolves by hunters and farmers has indirect effects on cubs, while the adults are affected directly.

2 Factors influencing wolf populations

Area

Grey wolves are found all around the world, but mostly in cold tundra or forests. Their habitat is formed by all the biotic and abiotic factors in the direct environment of the wolf. All these factors can have different influences on the wolf, where both the type and amount are important. Several variables that determine the suitability are: land cover type, road density, human population, landscape diversity, landscape dominance and prey availability. (Mladenoff *et al.*, 2003). Land cover type, or the lack of land cover, has a strong influence on hunting success of wolves, which is higher on flat ground than in an area with slopes (Kunkel and Pletscher, 2001).

Road density plays a role in the fragmentation of the landscape and wolves getting hit by cars is also an important cause of death. This will be explained later in more details. Human population and settlements have a comparable effect on fragmentation. Although no correlation could be found between the number of inhabitants in an area and the number of occurring wolves, it seems that areas with a higher human density are less likely to have a high number of present wolves (Eggermann, 2009). The number of settlements in an area is more important than the size of these settlements. A large number of small settlements could fragment an area more than a small number of larger settlements (Eggermann, 2009).

Contiguous Forest

Contiguous forest is considered to be uninterrupted forest. Forests can be fragmented by roads, big rivers, large number of settlements and agricultural land. The amount of contiguous forest has effect on the wolf because it can limit the space available to a wolf pack and might affect the amount of interaction between packs. Small roads (less than 700 cars per hour) seem to have no effect on the fragmentation of the landscape (Eggermann, 2009). In this study, these roads did not create isolated subpopulations and no genetic depression due to inbreeding could be detected.

Cubs are not directly influenced by the contiguousness of the forest, for they are taken care of in a den underground and will not change places. The fragmentation of the forest likely will play a role for the juveniles. When wolves mature, the males will disperse and leave the pack (Kojola *et al.*, 2006). When the area is limited by obstacles, such as roads, it will reduce their chances to find a new area. Adult wolves often have their own territory, therefore it only matters how much fragmentation there is within that area. Fragmentation and obstacles can limit their hunting area and can keep different packs separated which then can limit gene flow (Kojola *et al.*, 2006). When different packs cannot interact, inbreeding can occur due to the limited exchange of genetic material. Because fragmentation can influence parental wolves in several ways, indirectly it also influences the cubs. Due to fragmentation the parents might have trouble collecting enough food for themselves and their offspring and this can influence offspring survival.

Prey – Food Uptake

In Europe, wolves mainly predate on roe deer (*Capreolus capreolus*), red deer (*Cervus elaphus elaphus*) and wild boar (*Sus scrofa*). These ungulates can make up to 87.6 % of their food biomass, so when there are limited numbers of these prey in a certain area, it can limit the prevalence of wolves (Groot Bruinderink *et al.*, 2012; Nowak *et al.*, 2005; Nowak *et al.*, 2011). Logically, prey availability has effect on all stages of wolf development, from cub to adult. But there is a difference in how long a wolf can live without eating. Adult wolves have a feast-or-famine foraging pattern - when they catch a prey they eat almost the entire animal, and after that they can live without eating for days or they scavenge on carcasses (Stahler *et al.*, 2006). Cubs cannot do this and are therefore more dependent on regular food uptake.

The diet of wolves depends on the area they live in and on the wild herbivores that live in that area (Meriggi *et al.*, 2011). Wolves select on availability of wild ungulates and prefer to hunt on the weaker ungulates, like young, old or diseased individuals (Groot Bruinderink *et al.*, 2012).

This means the presence of wolves is dependent on the prevalence of wild ungulates. Wild boar, for instance, live in large groups which are easily found by wolves; they also do not have a specific breeding season - piglets are born all year round and the sub-adult wild boar roam around alone, being therefore easily predated (Meriggi *et al.*, 2011). Roe deer are relative small ungulates, what makes them easy to handle by small wolf packs (Meriggi *et al.*, 2011). They are present in large numbers all over Europe (on average 2.22 deer/km²), so the chance of encountering roe deer is high (Burbaite and Csányi, 2009).

Hunting rates of humans on those ungulates are, in most Western European countries, in balance with sustainable ungulate populations. In countries like Germany and Luxembourg, the population of roe deer increases even faster than the hunting bag (Burbaite and Csányi, 2009). In this respect, there can be opportunities for wolves to increase their populations.

Roads – Roadkill and Habitat Fragmentation

Roads have a multitude of direct and indirect effects in landscapes; the availability of resources changes and the population dynamics of animals and plants is affected (Coffin, 2007). Increasing road densities cause loss of habitat through the transformation of existing land covers (Angelsen and Kaimowitz, 1999) and reduce habitat quality by fragmentation and loss of connectivity (Theobald *et al.*, 1997; Carr *et al.*, 2002). Large carnivores are especially prone to road impacts, because of small population sizes and large home ranges with long daily movements and behavior that often clashes with human interests (Noss *et al.* 1996; Crooks 2002). When it comes to wolves, roads can act as a barrier to dispersal, impeding long-distance movements of populations (Thurber *et al.*, 1994). Wolf prey are also affected - some cervids avoid crossing roads after population establishment (e.g. Laurian *et al.*, 2008; Long *et al.*, 2010), but deer are often found in close proximity to roads (Long *et al.*, 2010). Increasing road densities decrease habitat contiguousness and may contribute to the reduction of white-tailed deer dispersal distances (Long *et al.*, 2010).

Wolf populations tend to survive where the density of roads is lower than 0,6 km/km² (Thiel, 1985); however, this density may be exceeded and the area still support wolves if it is

adjacent to extensive roadless areas (Mech, 1989). Studies in southern Europe found that human and road densities are, on average, significantly higher in marginal than in core areas of the wolf population (e.g. Bessa-Gomes and Petrucci-Fonseca 2003; Corsi *et al.*, 1999). In Poland, wolves were found to avoid main motorways, as well as areas with a high density of railway lines (Jedrzejewski *et al.*, 2004). Secondary roads were found to be less dangerous, and may even be used by predators to increase their mobility (Thurber *et al.*, 1994; Musiani *et al.*, 1998), as has been reported in wolves in North America by Thiel *et al.*, 1998.

Roads also affect wolf populations by causing direct mortality from vehicle collisions or poaching (Jedrzejewski *et al.*, 2004). Traffic is an important source of mortality: the proportion of recorded wolf deaths caused by vehicle collisions amounts to 52% in Italy (n=76) between 1991 and 2001 (Lovari *et al.* 2007) and 24.2% in Croatia (n=15) between 1996 and 2001 (Huber *et al.* 2002). In Spain, Colino-Rabanal *et al.* (2011) found that the best model to characterize wolf-vehicle collision locations included both traffic and human disturbance parameters; these collisions were more common in: 1) fenced highways - when a wolf enters a fenced highway, the fence increases the time the animal stays on the road and thus the probability of getting killed; and 2) agricultural areas - roaming individuals wander around areas influenced by humans due to high food availability, undergoing a higher mortality risk (Blanco and Cortés, 2002). In Italy, the age class up to 4 years old was found to be the most affected by roadkill, with a mortality peak in November and December, when non-territorial wolves start dispersing (Lovari *et al.*, 2007). The death of these non-territorial individuals may have limited consequences for population viability (Colino-Rabanal *et al.*, 2011).

Lelieveld (2012) modeled the ecological room for incoming wolves in The Netherlands, weighting the importance of road densities, and found room for at least 16 wolf populations to settle. The barrier effect can be reduced by the use of transverse structures (Clevenger and Waltho 2000), and several studies have confirmed improvements for large carnivores after the implementation of underpasses and overpasses (Rodriguez *et al.* 1996; Rodriguez *et al.* 1997; Grilo *et al.* 2008). Reducing roadkill numbers also requires the proper installation and maintenance of roadside fences (Colino-Rabanal *et al.*, 2011).

Hunters and Farmers – Poaching

The poaching of wolves possess a threat because of the low density and the slow population growth. In Sweden and Finland, research showed that 51% of the total population that was radio collared and/or accounted for had poaching as mortality cause; this resulted in a very slow growth of the population and risk of inbreeding depression and extinction in a short time frame (Liber, 2012). Poaching on wildlife is a widespread problem, but wolf populations in Europe are protected by the Bern convention. However, this does not mean they are not illegally killed by hunters and farmers. Poaching is probably the single most important mortality factor for the European wolf and some protected populations are estimated to lose 15-20% of their total numbers to poaching. For example in Italy, most wolves are killed accidentally, because they are victimized by traps that were meant for wild boars (Boitani, 2000). In Poland, illegal hunting on wolves is seen as the reason of the apparent decrease of wolf populations in the winter of 2001-2002 (Orkama, 2002; Gula, 2008).

To prevent poaching of wolves by farmers for economic reasons and to increase the social acceptance of wolves in Germany, the state and private organizations have made a conservation strategy - when livestock is killed by wolves, it is possible for the farmer to get a compensation, with the condition of having implemented safety measures against predators. The German authorities are hoping that this will ensure a safe habitat for wolves and lead to a better understanding of their nature by farmers, minimizing human-wolf conflicts (Thiel, 2012). Hunting a small part of a population can have an effect on its extinction risk, even if hunting pressure is moderate and hunting is only permitted above a defined threshold population size. In some European countries, it is sometimes legal and accepted to kill wolves when they are in high resource areas for humans (Nilsson, 2004).

The effects of poaching on the growth rate are explained by the way wolf packs breed. Usually only the alpha pair will breed - the alpha female chase other females away, while the alpha male will make sure the subordinate males do not breed. When packs are large and there is plenty of food available, sometimes the alpha pair will not succeed and more pups are born (Derix *et al.*, 1993).

When one of the alphas dies, its place will be filled by either a pack member or an outsider. The cubs are taken care of by their parents and the other pack members. Because usually only the dominant (alpha) pair will breed, it is difficult for populations to increase in size (Peterson, 2002). Pup survival is higher when one of the breeders is still alive and the pack consists of

more than 6 other members. If the alpha pair dies, there is the possibility that the pack will dissolve and find new territories themselves; what happens to the pups in these cases is not entirely clear (Brainerd, 2008).

3 Discussion and Conclusions

It was found that all five different factors can affect the sustainability of a wolf population.

Area influences wolves and affects a lot of different aspects of their lives. Although there are many articles that give examples on how the area has effect, no articles were found stating how big those effects are. Also, no research was found on the impact of interruptions in forest contiguousness and the magnitude of those impacts. Therefore, more research on this will be needed to be able to get a good conclusion on both of these topics.

The availability of wild prey in an area is very important in determining whether it can sustain a wolf population. Nevertheless, there are no specific articles available on this topic. There is a lot research done on which wild prey wolves hunt and in which amount, but these articles describe more the effects of wolves on prey, rather than effects of prey on wolves. So it can be recommended to do some research on how wild prey, or certain species of wild ungulates, can limit the presence of wolf populations and in which amount. For now, it seems that wolf populations can keep growing and dispersing further, because of large numbers of wild ungulates in most agricultural landscapes in Europe.

The influences of roads on the suitability of habitat can be examined as long as road density numbers are known throughout a region. As for the Netherlands, Lelieveld (2012) found room for wolf comeback, so comparative studies may be helpful in determining habitat suitable for wolf populations in agricultural landscapes throughout Europe. Nonetheless, the effects of roads can always be reduced by proper fencing and construction of ecological transverse structures.

Poaching poses a high risk for wolf populations in Europe, it is estimated that 15-20% of the mortality is caused by poaching. It is important to protect wolves against farmers and hunters through a conservation strategy that makes sure that livestock kills are prevented, but also compensated for. This way, not only humans and their resources are protected, but also the wolf populations.

Looking at all these different factors, it can be concluded that prey availability, road densities and poaching can all limit wolf populations to some extent. However, since there is no concrete data about the impact of area and contiguous forest and no studies comparing all different factors, it cannot be truly assessed which one would be the most limiting factor in an agricultural landscape.

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