Impact of wolf reintroduction on bison and grizzly bear populations and trophic cascades in Yellowstone National Park

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Introduction

In the late 1800s and early 1900s, wolves (*Canis lupus*) were common inhabitants of Yellowstone National Park (Weaver, 1978). After the wolf population in Yellowstone experienced a sudden population growth in 1912, efforts were put into place in an attempt to remove the animals from the park (Weaver, 1978). These measures were enacted in order to protect undulate populations, ultimately resulting in complete removal of wolves from Yellowstone National Park by the 1940s (Weaver, 1978). After several decades, wolves were reintroduced into Yellowstone during the 1995 and 1996 season (Weaver, 1978). As a result, there have been numerous observed effects on the other species residing within the park, resonating throughout the trophic cascade. Specifically, the reintroduction of the wolf has had resounding impacts on the bison (*Bison bison*) and grizzly bear (*Ursus arctos*) populations found within the borders of the park. Wolf reintroduction has been shown to have positive impacts on food sources for both grizzly bears and bison. While this increase in food availability may improve the possibility of survival for both species, there are numerous other indirect factors that have been observed to influence the bison and grizzly bear populations. This combination of both direct and indirect factors leaves the question of whether or not the wolf reintroduction truly has positive impacts for species reestablishment and conservation in Yellowstone National Park.

Impact of wolf reintroduction on bison food supply

Wolf reintroduction has increased the availability of food for bison by reducing the amount of primary consumers that rely on the same food sources. Due to wolves consuming elk as their main source of food, the availability of a number of woody plants typically eaten by the elk has increased (Laundré, 2001). This cascade effect has allowed for the populations of aspen and cottonwood trees found throughout the park to grow in increased densities and with improved strength and stature (Smith et al., 2003). Bison are now able to cover a larger range of park territory for grazing as they have greater access to the food supply that had originally been a part of the elk diet (Painter & Ripple, 2012).

Effects of wolf reintroduction on grizzly bear food supply

A positive impact on the grizzly bear food sources has been observed as well due to wolf reintroduction. Since the reintroduction of the wolf populations, bears have gained more access to food in a number of ways. Similar to the bison population, grizzly bear populations have improved availability of plant and berry food sources (Ripple & Beschta, 2012). As previously stated, given that wolves primarily prey on elk, there has been a decrease in plant browsing animals (Ripple & Beschta, 2012). As a result of less browsing by elk, aspen trees have increased their average height, thus allowing for a greater diversity of berry-producing plants to be able to grow underneath the different heights of the aspen plants (Ripple & Beschta, 2012).

In addition to the increased availability of plant based food sources, grizzly bears have also gained greater access to animal-based food sources. Since the increase in wolf population in the park, the increase in predation has had tremendous benefits for bears and other carnivorous species in the park. The introduction of a predator such as the wolf increases the availability of carrion, or decaying flesh of previously consumed prey, accessible to carnivorous species throughout the park (Wilmers et al., 2003). This new availability of carrion throughout the entire year for carnivorous species, including the grizzly bear, has been especially beneficial during the winter months when food availability is typically low (Wilmers et al., 2003). Additionally, grizzly bears now take advantage of the predatory behavior of wolves by waiting for the wolves to finish hunting and then contesting the wolves for access to the carcasses of their kill (Smith et al., 2003). As a result of being the larger animal in these standoffs, bears usually win, giving them access to food without the work involved in actually tracking down and killing the prey themselves (Smith et al., 2003). In addition to the obvious benefit of being able to consume this food, the grizzly bear populations do not have to expend the energy to hunt, as they now have a species that virtually does the hunting for them (Smith et al., 2003).

Increase in grizzly bear and bison population size as a result of increased food supply

Having better availability of both plant and animal based food sources, the grizzly bear populations have grown since the reintroduction of the wolf (Barber-Meyer, 2008). The greater presence of both wolves and bears in the park has resulted in a higher prevalence of elk killings due to the activities of both groups (Barber-Meyer, 2008). This is especially true in the northern range of the park which has developed a very large bear population since the reintroduction of wolves (Barber-Meyer, 2008).

Bison population growth due to greater food availability

For the bison population, the reintroduction of the wolf has also been conducive to population growth. As previously stated, wolf reintroduction has decreased the elk population and allowed for a greater availability of food, making the habitat more suitable for a growing bison population (Ripple et al., 2010). While there could be potential concern regarding the possibility that wolves would begin preying on bison, the smaller size of the elk makes for an easier kill for the wolf (Ripple & Beschta, 2012). Thus, the wolf has a tendency to avoid using the bison as a food source, meaning that the bison population is unlikely to be negatively impacted by the hunting habits of the wolf populations (Ripple & Beschta, 2012). As a result of the combination of these factors, since the reintroduction of the wolf, the bison population in Yellowstone has been consistently growing about 15 percent each year, demonstrating the positive impact of wolf reintroduction on bison population size (White & Carrott, 2005).

Underlying consequences of limited capacity of bison migratory range

While the growth of the population may seem like a benefit, the resulting increase in density has actually caused some negative effects for the species. As a result of the increased population size, in order to maintain appropriate

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distribution of food, the bison have been forced to split into two distinct populations (Plumb et al., 2009). In addition to the population that continues to reside in the central portion, there is now a population that lives in the northern portion of the park (Plumb et al., 2009). Given the topography of Yellowstone, the central population has fairly easy access to the northern section of the park in comparison to the east or the south sections of the park (Fuller et al., 2006). This is likely because the southern and eastern areas of the park have a number of physical barriers including high ridges that would make migration to these parts difficult, as well as the lack of the appropriate vegetation necessary to support the bison population (Fuller et al., 2006). This fragmentation caused by the increased population density has resulted in these two groups having distinct genetic differences (Halbert et al., 2012). Through genetic analysis, it has been observed that these distinct populations are slowly beginning to develop alleles specific to each herd, indicating a loss of gene flow (Halbert et al., 2012). Eventually, if these populations continue to be separated, this could lead to enough genetic variation to cause barriers in reproduction between the two groups and potential inbreeding within each population (Halbert et al., 2012). Conservationists are concerned about the loss of genetic diversity especially in the Yellowstone bison (Halbert et al., 2012). The Yellowstone bison are known to be the most genetically diverse of all bison populations found across the country because of their isolation from local cattle populations, allowing them to maintain a genome free of genes typically found in cattle genomes (Halbert et al., 2012).

In an attempt to prevent complete genetic divergence between the two populations and reduce the risk of inbreeding, there has been an intentional movement of bison from the northern population back into the central population (Fuller et al., 2006). Regardless of these efforts, the northern population continues to remain consistent in numbers indicating that the central population is continuing to migrate to the northern population (Fuller et al., 2006). Looking at the stability of the numbers in the northern range even after intentional removal of individuals, it is highly unlikely that the northern population is being maintained simply by reproduction (Fuller et al., 2006). This implies that those from the central range do not have sufficient food supply in order to continue residing in the given area (Fuller et al., 2006). That being said, the northern and central areas of the park set constraints for the range of the bison (Fuller et al., 2006). This imposes a limit on the extent to which the bison population of Yellowstone can continue to grow because they are unable to expand their range to other areas of the park or to areas outside the park (Fuller et al., 2006). Given this information, it is clear that although the initial analysis of the growing population may be positive, ultimately, the growth of the bison population as a result of wolf reintroduction has actually had some negative secondary impacts on the bison population.

Larger bison populations cannot be supported by existing migratory range

Continuing with this concept, not only has the increased population caused problems in the domestic range of the bison, but it has also caused issues in terms of the bison's winter migratory area and their ability to survive. The bison's winter migratory range has been consistent for many years (Plumb et al., 2009). As a result of the increased populations, the usual migratory range is no longer sufficient in terms of size and the amount of food available to support the population during the winter months (Plumb et al., 2009). When the bison do migrate to their winter range, this sudden increase in foraging in the area during the winter months greatly decreases the plant growth in the area (Painter & Ripple, 2012). This limits the food available during the migratory period, but also decreases the quality and availability of the plants during the future winter seasons (Painter & Ripple, 2012). Furthermore, the small migration range available to the bison has a negative impact on the bison that are pregnant during winter months and any young calves that are born or must migrate with the herd during that time (Jones et al., 2010). The lack of food, as discussed above, is not sufficient to support the adult and young populations during the winter season (Jones et al., 2010). This puts strain on the new calves as they do not have proper access to food to support growth, but also puts a significant amount of strain on the pregnant bison which, occasionally, can lead to miscarriage (Jones et al., 2010). The winter survival of the bison is impacted negatively due to increased herd sizes as their usual range can no longer accommodate the increasing population size (Painter & Ripple, 2012).

In order to have an appropriate migratory range for the winter months, the bison need to expand the territory that they cover, but there are numerous obstacles preventing them from doing so (Plumb et al., 2009). One of the larger obstacles preventing them from increasing their range is the concern of local cattle ranchers. Bison have been known to carry the brucellosis infection since original transfer of the disease from cattle to bison in 1917 (White et al., 2011). Even though the disease was originally found in cattle, many local ranchers fear that if the bison populations are not controlled and maintained within a certain range, that the disease may begin to infect their cattle (White et al., 2011). With the increased population size and overcrowding in the original winter migratory range, the disease has been spreading more rapidly among the bison populations (White et al., 2011). The disease, itself, is harmful to the population as it can cause spontaneous abortion or the birth of non-viable offspring, and the close quarters under which the bison are living are not conducive to preventing infection (White et al., 2011). As conservationists from Yellowstone begin talks of attempting to allow the bison to increase their range beyond original limits, cattle ranchers have resisted efforts that would allow for bison to have a larger migratory range (White et al., 2011). The increased need for a larger bison range has caused the development of the Integrancy Bison Management Plan (IBMP), created by the federal government and the government of Montana (White et al., 2011). This plan aims to slowly and safely increase the range available to the bison during the winter months by testing and releasing only those bison that test negative for the brucellosis infection and vaccinate any brucellosis-negative bison (White et al., 2011). The release of non-infected bison into a wider range would be also used to determine the benefits of expanding the range and then herd the bison back into the park range during the spring season (White et al., 2011). Additionally, this movement of infection-free animals would allow for time to investigate the range at which bison and cattle can be safely kept apart without transmission of disease from one population to another while adapting to the growing populations since the reintroduction of wolves (White et al., 2011).

Larger grizzly bear populations require increased territory range

The increased bear population has also been seeking a larger range over which they can hunt and feed. Bears have faced limitations in their ability to establish such a range due to a larger amount of human activity in the areas surrounding the park. The grizzly bear populations in Yellowstone have been highly dependent on the presence of garbage dumps near and around the park (Knight & Eherhardt, 1985). These dumps provide a food source during the seasons when typically consumed vegetation is not available to the grizzly bears (Knight & Eherhardt, 1985). The progressive removal of these dumps has had negative effects on not only the population size itself, but the overall reproductive rates of the grizzly bear population (Knight & Eherhardt, 1985). Years after these dumps were removed, the grizzly bear population had lower overall survival rates than what was previously observed with the presence of the garbage dumps (Knight & Eherhardt, 1985). Additionally, since the removal of the garbage dumps, negative effects on the number of grizzly bear cubs have been observed. When compared to the years prior to garbage dump removal, the bear reproductive rate has decreased from 2.24 to 1.90, indicating that there is not enough nutrition available to the grizzly bears in order to maintain their previous reproductive rate (Knight & Eherhardt, 1985). Even with these reductions in food supply, it is believed that the termination of human caused removal of garbage dumps or some method of re-establishing of another supplemental food supply for the grizzly bears would allow for the population to be able to maintain its new, larger size (Knight & Eherhardt, 1985).

Several models have also been created to predict what effects human activity could have on the grizzly bears. In anticipation of future housing developments being constructed in the twenty counties surrounding Yellowstone, source/sink models have been created for both overall habitat degradation and potential impact of the housing itself. In these models, the source is a quality habitat capable of sustaining a population whereas the sink is a habitat incapable of doing so. Creating source/sink models helps conservationists understand which locations are important for population survival and which may be affected in a negative manner due to a given factor. The model looking at overall habitat degradation had originally predicted that severe habitat degradation would be required to have large scale impacts on the grizzly bear range and population (Doak, 1995). On the contrary, it was actually found that even very minor amounts of habitat degradation had large-scale impacts on grizzly bear habitat and population (Doak, 1995). The other problem with habitat degradation is that even with known amounts of habitat degradation, there is usually a large time lapse between the occurrence of the degradation itself and a noticeable decline in the population (Doak, 1995). This is especially troublesome in the case of an endangered species as the impact on the population may not be noticeable until the damage has already been done (Doak, 1995). One of the possible factors that could help in these situations is not simply monitoring the population of the endangered species, but rather monitoring other species that are related to the endangered one though trophic cascades (Doak, 1995). By monitoring the behavior and population sizes of these other species as a result of any occurring habitat degradation, any ripple effect that will affect the endangered species can be predicted before the significant decline in population (Doak, 1995).

The model analyzing the effect of housing developments near the park showed similar results to the overall degradation model. The establishment of even a few housing developments near the park area is predicted to create large sink areas for the grizzly bear populations (Schwartz et al., 2012). This sink can be attributed to a few different consequences of the housing development. One way in which the habitat would be disrupted is that the new residential areas actually cut the habitat that is useable by the grizzly bear into smaller fragments (Schwartz et al., 2012). Due to their small size, these fragments are no longer suitable to support grizzly bear populations (Schwartz et al., 2012). Additionally, the establishment of a manmade edge surrounding the grizzly bear habitat creates a distinct line between useable grizzly bear habitat and human used land (Schwartz et al., 2012). This eliminates any gradient from one type of land use into another and the abrupt end of the grizzly bear habitat can be detrimental to the ability of a population to be sustained that close to a human barrier (Schwartz et al., 2012). More so, this model was only taking the actual housing developments into account (Schwartz et al., 2012). The actual establishment of such construction projects would cause even more harm than that which was predicted, given that the model did not take into account the road development or additional infrastructural changes that would need to occur in order for the residential areas to be developed (Schwartz et al., 2012). Once these other factors would be taken into account, there is a possibility that the sink areas that would be created would be much larger and have even greater negative effects on grizzly bear population and survival than had been anticipated (Schwartz et al., 2012). Looking at these models, both have shown that the grizzly bear population would be extremely sensitive to any sort of human caused disruption.

Conclusion

Overall, the reintroduction of wolves into Yellowstone National Park has had a variety of direct and indirect effects on the bison and grizzly bear populations. The increased wolf population has been able to reduce the numbers of elk present in the park, allowing for an increased food supply for both the grizzly bear and the bison through the effects of the trophic cascade. While this has allowed for growth of both the grizzly bear and bison populations which, would appear to be beneficial for conservation, there are actually a number of other factors that do not allow for the benefit to be as impactful as would be desired. It has been shown that the growth of the populations has resulted in a very high density of individuals in both species, making it difficult for each species to continue living in its original territory. This, plus a number of human factors including habitat degradation and construction, has caused negative effects for both species. While the intentions of reintroducing the wolf back into Yellowstone National Park may have been good, there were several factors that were not taken into account, reducing the effectiveness of the measure.

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