

The Effects of Human Interaction on Coyote Evolution.

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Introduction

Coyotes originated in the plains, but with the extinction of red wolves in the wild and coyotes' master the ability to adapt to new environments. They have expanded beyond the Mississippi River through the east coast states. Since the 1950's coyotes have been moving into the southeast and by the 1990's coyotes were found throughout the state of Georgia, making themselves prevalent in metro-Atlanta (Mowry and Wilson, 2019). The eradication of red wolves aided in coyotes moving in the southeastern United States (Thurber & Peterson, 1991). Deforestation and habitat loss (i.e., urbanization) likely accelerated Coyote expansion. At the same time that all of this was happening, the human population and urbanization in Georgia was growing as well. This has caused humans and coyotes to encounter each other pretty regularly (Mowry and Wilson, 2019). Thus, the increase of human-coyote conflict began.

Southeastern coyotes are the larger of the species and there are ecological differences between eastern and western coyotes (Etheredge, 2013). Southeastern coyotes are mostly scavengers, meaning they are opportunistic foragers, although there have been many reports of predation on small animals such as pets or chickens (Etheredge, 2013). There have also been reports of higher levels of predation in areas with larger white-tailed deer populations. This has been suggested as a way to manage overpopulation of deer (Etheredge, 2013). All in all coyotes consume in a way that affects multiple layers of their ecosystem. Based on this, it is clear that coyotes have a major impact on their ecosystems and the other animals that also reside there including native species such as red foxes, gray foxes and bobcats (Etheredge, 2013). Coyote diets regulate rodent populations and aid in seed dispersal since they are opportunistic foragers. Coyotes have a way of shaping our communities and environment. One piece of information that is important to remember is that population densities of many species are affected by coyote presence and most rely on coyotes to improve the health of the ecosystem. So is this a good thing or a bad thing?

There is an on-going debate of whether or not coyotes should be considered native or non-native species in the southeastern states, because it is hard to agree on how they got here. Most people tend to believe that coyotes are not native to the area as it is stated in multiple papers, "coyotes are native to the western two-thirds of North America." However, some research may suggest that red wolves may be hybrids of coyotes and grey wolves. Regardless of their history, coyotes are in the southeast now and it is important to gain an understanding of

their impacts on our environment, whether it is positive or negative. History typically paraphrases itself so if we continue to treat coyotes the same way we treated red wolves in the area then the cycle of apex predators will continue. Humans must learn to coexist with coyotes in order to support a healthy ecosystem and thus a better environment created for all living in it.

For the city of Atlanta and the state of Georgia, there is an organization dedicated to educating, researching and understanding these intelligent mammals. The Atlanta Coyote Project (ACP), an organization that aims to provide credible information about coyotes, has an on-going citizen science project in which people can report their coyote sightings and encounters. This particular citizen science study began in 2014 and each year gains more participants (Atlanta Coyote Project, 2019). Coyotes that reside in urban settings help maintain species diversity through hunting, scavenging, or foraging which is important for ecosystem development (Humane Society). Through the extinction of red wolves in the wild and the creation of urban landscapes, humans have allowed coyotes to enter an evolutionary period where they are adapting to these environmental changes. This paper is going to discuss how these interactions affect coyote evolution.

Habitat and Landscape Changes

Humans have had an immense impact on our environments for some time now. From the quiet farm land to the hustling city-scapes, the land has changed drastically and with it, so has the wildlife that reside in it. Some species avoid urbanized areas altogether, while others may actually be able to thrive in these human-dominated areas. The changes humans have created in our landscapes creates a domino-effect for what happens with the wildlife that live there. Urban environments are special because parts of natural habitats are hidden within a human-dominated area. Over the last 30 years or so, coyotes have been learning to adapt to these ever changing landscapes. Studies have actually shown the multitude of habitats this species can live in, from forested mountain tops to rolling plains and even urban environments such as our backyards. Coyotes colonize cities and learn to consume the resources found in those areas. Urban areas have provided diet subsidies for coyotes in the form of gardens, trash, and pets (Larson et. al., 2020). Naturally, coyotes prey on the native rodents of urban environments, however those rodents are sensitive to habitat loss and fragmentation which readily occurs within a city. This causes coyotes to switch up their diet with more anthropogenic options such as waste or

unsupervised domestic animals. Although, some coyote prey populations can be as bountiful in cities as they are in nearby natural areas (Larson et. al., 2020).

Coyotes provide us with so much information about our ecosystems, because they are so adaptable. Coyotes have specific responses to changes in foliage, landscapes and environmental corridors. The responses are density dependent and change with season and behavior (Ellington, 2020). So, if there are any changes in those aspects of the environment, researchers can pinpoint the issue faster with the help of coyotes. Animals use the environment to obtain resources that meet their energetic demands such as reproduction, protection from predators, or environmental conditions (Ellington, 2020) It is suggested that coyotes utilize temporal avoidance. This means that coyotes pay attention to time when certain areas have high human activity and they will avoid the area when there is an increase in human presence (Ellington, 2020). With that, the layout of the land has a huge impact on the behavior of coyotes which can indicate to us that there is something wrong with our environment and we need to fix it. Some coyotes might prefer areas with high resource availability and avoid risky landscapes, such as cliffs or rivers (Ellington, 2020). How coyotes might perceive the costs and benefits of an environment can vary based on the space. For instance, cities may be considered risky landscapes but there is such a high availability of their necessary resources that coyotes tend to adapt to urban landscapes. Hence, why coyotes practice temporal avoidance. Though coyotes are actually omnivores, they do still have that carnivore instinct and thus do not rely only on the plants around them. This gives them a different relationship with their habitat than herbivores and allows them to utilize these different practices (Ellington, 2020). Coyotes typically change their behavior to minimize time traveling through challenging terrain. However, the “riskiness” of any terrain can differ based on the day or the season, but coyotes tend to make it work (Ellington, 2020). This brings us back to the notion that coyotes have adapted to city life and have learned to change with the evolving environments humans are creating.

The building of cities has accounted for so much habitat reduction and fragmentation. The intense cutback and fragmentation of natural habitat related to human development is problematic for larger carnivores such as wolves or mountain lions (Parsons, 2019). This has resulted in large carnivores avoiding human-populated areas altogether which allows coyotes to step into those areas without worry of being out-competed (Parsons, 2019). Furthermore, with the eradication of red wolves in the southeast, coyotes have since been able to essentially take

over the role as apex predators in the region. These eastern coyotes moving into the cities of the region have had an impact on urban foxes. A study comparing coyote residents in two eastern cities discovered both positive and negative interactions between coyotes and foxes (Parsons, 2019) These interactions are mostly reliant on green space availability, which suggests, “that fragmentation concentrates carnivores into remaining green space, leading to higher levels of spatial interaction between some species,” (Parsons, 2019). This study has made it apparent that urban development has a major role in coyote communities. Essentially, habitat fragmentation caused by city building is forcing coyotes and foxes to interact more than they normally would but interestingly with some positive occurrences (Parsons, 2019). To reiterate, large carnivores, such as wolves or mountain lions, usually avoid humans, and smaller carnivores, such as coyotes or foxes, have adapted to living in closer proximity to other carnivores on top of adapting to living close to humans. This is known as the “human shield effect”.

Coyote Management

As mentioned before, due to their intelligence and adaptability, in addition to extensive urbanization and the subsequent decline of larger predators, coyotes have successfully expanded their range across North America. It is important to keep in mind that coyotes have been interacting with and adapting to people for at least the last 100 years. (Humane Society). Beyond this, coyotes have learned to adjust to urbanization as there are many reasons coyotes are actually drawn to suburbs and cities, for instance: abundance of food, plenty of water, and access to shelter. Sounds pretty good for a coyote, however, human-coyote interaction has become a problem. While coyotes actually provide a lot of good for urban environments, such as pest control, humans are not so fond of them. Coyotes have been known to attack livestock, kill pets, and damage property.

The most costly of these conflicts seems to be attacking livestock. In fact, economically, the benefits of managing coyotes is determined by the value of protected livestock subtracted by the actual costs of the management practices (Brewster, 2019). For instance, if the value of the protected livestock, say 10 more cows were saved this year compared to last year, is \$5,000 but it cost us \$3,500 to put coyote deterrents into place, then the benefits of using those management practices is only \$1,500. Based on this, it is worth it to use these management practices, however, that may not always be the case. The National Agricultural Statistics Service (NASS) has stated

that the amount of cattle and calf losses due to coyotes has gone up greatly over the last 20 years (Brewster, 2019). Even though coyotes are time and time again considered the biggest cause of cattle deaths, this is not the case. Their damage is significantly less than the hundreds of other causes of death for cattle, such as respiratory issues, digestive problems, calving mishaps, weather-related disturbances, and the list goes on (Brewster, 2019). However, the most interesting is: Coyote behavior plays a major role in these situations as these attacks do not always seem to relieve hunger.

Pursuing and killing are not necessarily linked to eating, even in adult coyotes, killing is not always motivated by hunger (Lehner, 1976). When a coyote sees easy prey, searching and hunting become expendable and the coyote chooses to catch and kill. Coyotes are predators at birth, but their skills at identifying, capturing, killing and consuming prey are molded through experience. For instance, generally, the coyote is not born with an innate fear, but they are born with the ability to learn relations between certain stimuli and the associated consequences (Lehner, 1976). As new stimuli are encountered, the responses are modified and the effects of old stimuli are adjusted (Lehner, 1976). Based on this information, the focal point of recent predator inhibition has been the coyote's ability to learn. These attempts have been using aversive conditioning (Lehner, 1976). One such learned behavior forced on to coyotes by humans is their change from diurnal activity to nocturnal activity. This change in behavior has put sheep at greater risk of a coyote attack as they are more noticeable to a coyote at night (Lehner, 1976). It has been noted that coyotes use their vision first when detecting food rather than the assumed olfactory cues. It is important to keep in mind this relationship between coyote behavior and human interaction as coyotes do have an instinctive fear of humans that is learned from birth and typically avoid being in close proximity to humans. Almost everything a coyote has been able to do in the last 40 years, as far as changes in behavior, has been at the hand of humans.

Part of the reason coyotes have been able to encroach on urban landscapes, move into the southeast and evolve so much is because years ago red wolves were eradicated by humans. Red wolves, distant cousins to the gray wolves, were the coyotes primary competitor and thus the reason coyotes would not move into the southeast. Hunting by humans has had a major effect on our surroundings which can be a good thing or a bad thing. In the case of the red wolves, this was a bad thing, because they became extinct in the wild. However, this did give coyotes the opportunity to grow and prosper which inevitably created this never ending cycle of

human-coyote conflict. For a long time, wolves have been facing vulnerability at the hand of humans. In fact, wolves are often mistaken for coyotes and are illegally shot by hunters. In certain states and at certain times of the year, it is legal to kill coyotes in the United States, however these seasons put wolves and other animals at risk.

In the state of Georgia, coyotes are not legally protected, in fact, every year the Georgia Department of Natural Resources holds an event called the “Georgia Coyote Challenge”. Year round, Georgia residents are allowed to hunt and kill coyotes, but between the months of March and September when the challenge is on-going, the number of coyotes killed is much higher due to the competition (Atlanta Coyote Project). Now since red wolves have already been eradicated in Georgia, the concern of accidentally killing a wolf is not there, but that does not mean that willfully killing off coyotes comes without complications. Many people believe that lethal action is the only way to “deal” with coyotes, but what they do not know is how important coyotes actually are to the environment. In fact, coyotes are crucial for maintaining balance within the ecosystem by controlling rodent populations and aiding in seed dispersal (Atlanta Coyote Project). Recently, researchers have been working to determine which nonlethal-management practice works best for deterring coyotes.

One such study took a look at fladry, an effective nonlethal device that was created to protect livestock such as sheep and was originally developed to deter wolves (Young, 2019). Fladry is a deterrent that scares wolves and produces a flight response in them i.e. they run away. Young decided to test this repellent on coyotes. The study found that the fladry straight from manufacturing was not startling enough for coyotes. In fact, coyotes learned to desensitize themselves to it (Young, 2019). Different modifications were made and it was determined that the best course of action to deter coyotes would be to incorporate more than one repellent or deterrent along with fladry i.e. electrifying the fladry. Coyotes being such intelligent and adaptable animals require many layers of protection.

Hybridization

Much like the increase in urbanization in Georgia with the growth of coyote populations in the state, hybridization has also been increasing for coyotes. Researchers have observed an increase in contact between coyotes and wolves throughout the years (Bohling, 2016). Human activity can have a major impact on the amount of hybridization happening between these

species. Due to an increase in human development, red wolves, who were once found across the eastern United States, were disappearing from the wild. The last populations of red wolves were found along the coast in Louisiana and Texas (Heppenheimer et. al., 2020). During the 1970's, it was decided that the remaining red wolves would be captured for a breeding program and thus was born the Red Wolf Experimental Population Area or RWEPA, on a peninsula off the coast of North Carolina. The first known hybridization between coyotes and red wolves occurred in this area in 1993 (Bohling, 2016).

It was mentioned before that there is a debate on whether or not coyotes should be considered native to the southeastern United States because of how they entered the area. For instance, humans eradicated the red wolf who once resided in the eastern United States as an apex predator and biggest competitor to coyotes. So, when red wolves became extinct in the wild, coyotes moved in. This suggests that coyotes are not native to the east. However, some research has suggested that red wolves are actually the product of hybridization between coyotes and gray wolves (Bohling, 2016). Bohling's results affirmed that red wolves do exist as a distinct species in North Carolina meaning that based on the study, it is unlikely that red wolves themselves are a hybrid of coyotes and grey wolves. Red wolves are their own species (2016). Yet, after the "true" red wolves were captured in Louisiana and Texas for the breeding program, red wolf DNA continues to show up in these areas (Heppenheimer et. al., 2020). These individuals in Louisiana and Texas carry red wolf ghost alleles and provide an isolated region that ensures the prosperity of red wolf genetics (Heppenheimer et. al., 2020). This means that if some of the "true" red wolves from the RWEPA in North Carolina were to breed with the individuals isolated in those regions of Louisiana and Texas, the reintroduction of red wolves could be successful.

It is important to note that knowing this, it is recommended that the hunting of coyotes be regulated until more is known about the red wolf ghost alleles in Louisiana and Texas (Heppenheimer et. al., 2020). This will help ensure that those genetics are protected as it is more likely for wolves to be killed illegally during coyote hunting seasons. This diminishes the genetic variation of these species. As Bohling has demonstrated, the breeding of captive individuals can work to save the red wolf; however, hybridization may not be completely avoidable. Bohling stated, "creating policies, partnerships, and strategies that allow red wolves to maintain their genomic uniqueness through a combination of natural and management-assisted processes will

be critical to the viability of the species in the wild,” which is critical to the conservation of red wolves (Bohling, 2016).

Synthesis

Humans have been shaping the state of our ecosystem for quite a while now which impacts the wildlife that also live in that environment. Some species avoid urbanized areas altogether, while others may actually be able to thrive in these human-dominated areas. Coyotes are known for their ability to adapt to novel landscapes which can provide us with a lot of important information about our environment. Coyotes have particular responses to their surroundings whether that is changes in foliage or environmental corridors. So, if there are any changes in those aspects of the environment, researchers can pinpoint the issue faster with the help of coyotes. Urbanization has accounted for much of the habitat reduction and fragmentation found across the country. The intense cutback and fragmentation of natural habitat related to human development is problematic for larger carnivores such as wolves or mountain lions (Parsons, 2019). This has resulted in large carnivores avoiding human-populated areas altogether which allows coyotes to step into those areas without worry of being out-competed (Parsons, 2019).

As mentioned before, due to their intelligence and adaptability, in addition to extensive urbanization and the subsequent decline of larger predators, coyotes have successfully expanded their range across North America. Further, coyotes have made themselves comfortable in areas of high human presence which has created tension between humans and coyotes. The most costly of these conflicts seems to be attacking livestock. The benefits of managing coyotes is determined by the value of protected livestock subtracted by the actual costs of the management practices (Brewster, 2019). This helps to determine the worth of managing coyotes properly. For a coyote, pursuing and killing are not necessarily linked to eating, even in adult coyotes, killing is not always motivated by hunger (Lehner, 1976). When a coyote sees easy prey, searching and hunting become superfluous and the coyote chooses to catch and kill with no intention. Part of the reason coyotes have been able to encroach on urban landscapes, move into the southeast and evolve so much is because years ago red wolves were eradicated by humans. In the state of Georgia, coyotes are not legally protected. Though coyotes can be hunted year round, the Georgia Department of Natural Resources holds an event called the “Georgia Coyote

Challenge”. Between the months of March and September when the challenge is happening, the number of coyotes killed is much higher due to the competition which in turn can also increase the number of wolves killed. Wolves are a protected species in the United States, but coyotes have created an issue.

Coyotes have been adapting to people for at least the last 100 years. As urbanization and coyote populations increase in Georgia, hybridization has also been on the rise for coyotes and wolves. As mentioned, there is a debate about whether or not coyotes are considered native to the southeastern United States because of how they entered the area after the eradication of red wolves. However, some research has suggested that red wolves are actually the product of hybridization between coyotes and gray wolves (Bohling, 2016). After the “true” red wolves were captured in Louisiana and Texas for the breeding program, red wolf DNA continues to show up in these areas (Heppenheimer et. al., 2020). This means that if some of the “true” red wolves from the RWEPA bred with the individuals isolated in those regions of Louisiana and Texas, the reintroduction of red wolves could be successful. If the reintroduction of red wolves is successful then the health of our environments is improved.

Conclusion

It is our responsibility to understand the behavior of coyotes and learn to coexist with them as they are crucial animals within our ecosystems. Coyotes influence their landscapes and environments just as much as the environment affects them. This is why coyotes provide us with valuable information about the health of our environments. Management of coyotes is necessary in order to coexist with them but nonlethal actions are required to ensure the safety of our ecosystems. When humans eradicated red wolves, the balance in the ecosystem shifted. If humans continue on this shoot-to-kill strategy, the vicious cycle of apex predators continues. Hybridization of coyotes and wolves may stabilize the health of the environment. This is another reason to consider making it illegal to kill coyotes. They provide a valuable reservoir of red wolves genetics, increasing the chances of success when reintroducing red wolves to the wild.

Further research on the impacts coyotes may have on seed dispersal and rodent population regulation would be beneficial when understanding more about the species and their effect on the environment. Mowry provides a great example of a small sample of coyotes interacting with their ecosystem and discovered an increase in biodiversity surrounding the

coyotes' ranges (2019). This coincides with the need to learn to coexist with the species. Education about the history and evolution of coyotes is necessary in order to increase the understanding of coyote behavior. In order to coexist with coyotes, people need to know coyotes are important to the health of ecosystems. So, how does a coyote affect disease presence? Do coyotes have an impact on urban rodent populations? Can humans coexist with coyotes? If so, how?

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