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Coyote Management in San Francisco

Matthew Greer
mdgreer@dons.usfca.edu

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This Master's Project

Coyote Management in San Francisco

By

Matthew Greer

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Matthew Greer Date

Allison Luengen, Ph.D. Date

Table of Contents

- List of Figuresiii
- List of Tablesiii
- Abstractiv
- 1. Introduction 1
 - 1.1 Research Question 3
- 2. Methods 4
- 3. Urban Wildlife Management 4
 - 3.1 Why Urban Wildlife Management is Important 4
 - 3.1a How to Protect Urban Biodiversity Through Habitats 5
 - 3.1b Wildlife Management is a Component of Public Health 6
 - 3.2 Urbanization and Habitat Connectivity..... 6
 - 3.2a Urban Corridors 8
 - 3.2b Urban Greenspaces 9
 - 3.3 How Urban Wildlife Benefits Humans 10
 - 3.3a Co-benefits 11
 - 3.4 How Cities Affect Wildlife Behavior 11
 - 3.4a Cities as Habitats 12
 - 3.4b How Desirable Traits Help Urban Animals 13
- 4. Coyotes 15
 - 4.1 Coyote Biology and Life History 15
 - 4.2 Ecological Role 16
 - 4.3 Coyote Behavior in Urban Areas 18
 - 4.4 Interactions with Humans 21
 - 4.5 History of Coyotes 23
 - 4.6 History of Coyotes in San Francisco..... 24
- 5. Urban Coyote Management Plans..... 26
 - 5.1 Elements of a Good Urban Wildlife Management Plan..... 26
 - 5.2 Comparing Different Coyote Management Plans 27
 - 5.2a Chicago Coyote Management and Coexistence Plan 28
 - 5.2b Long Beach and Newport Beach Coyote Management Plans..... 29
 - 5.2c Davis Coyote Management Plan 30
 - 5.3 Common Features of Urban Coyote Management Plans 31
 - 5.3a Public Education and Outreach Programs 32

5.3b Humane Coyote Hazing Programs.....	33
5.3c Coyote Incident Response Plans	34
6. Recommendations for the San Francisco Coyote Management Plan	36
6.1 Coyote Management Challenges in San Francisco.....	37
6.2 Public Education Strategies	38
6.3 Coyote Tracking and Monitoring.....	41
6.4 Corridors and Greenspaces in San Francisco.....	43
7. Conclusion	43
Literature Cited.....	47

List of Figures

Figure 1. Shows an adult coyote standing on a hill in San Francisco.....	1
Figure 2. Adapted from Beben (2016). Different types of disruptive elements (forms of influence) on roadways as well as the types of animals most affected by those disruptive elements.....	8
Figure 3. Adapted from Beben (2016). Different types of urban corridors that can be constructed as crossings over a roadway.....	9
Figure 4. Adapted from Beben (2016). Locations in San Francisco where individual coyotes were spotted by residents/visitors at a particular time during a particular day.....	25

List of Tables

Table 1. Data compiled from Ellington and Gehrt (2019). Wildlife responses to urban environments can be either positive or negative.....	15
Table 2. Data compiled from Ellington and Gehrt (2019). Coyote responses to different levels of urbanization, showing differences in home range size, encamping time, travel time, and foraging time.....	20
Table 3. Adapted from Apfelbeck et al. (2020). Components of a well devised urban wildlife management plan including clear objectives and goals, a management team, community engagement, monitoring, and reevaluation over time.....	27
Table 4. Data compiled from Davis (2013). This rubric measures the effectiveness of the Davis coyote management plan by analyzing the number and severity of human-coyote conflicts that occur in the city each year.....	31
Table 5. Adapted from Davis (2013). Tiered list of human-coyote interactions including coyote observations, sightings, encounters, incidents, and attacks.....	35

Abstract

As cities in North America grow, coyotes have become progressively more important species in urban ecosystems. Moreover, as coyotes increasingly use these urban spaces, human-coyote conflicts have become more common, creating a need for new management strategies. This paper will explore how the city of San Francisco could create a new coyote management plan for its highly visible coyote population. San Francisco has had a persistent coyote population since the early 2000s (Todd, 2018). Currently, the coyote population is close to 100 individuals and is still growing (J. Young, Presidio Trust, pers. comm.). To explore this topic a literature review of research on urban wildlife and coyotes was done. Additionally, a comparative analysis was conducted on four existing urban coyote management plans includes ones from Chicago, Long Beach, Newport Beach, and the city of Davis. The comparative analysis revealed three key components that all successful coyote management plans must have. These key components include a public education program, a humane coyote hazing program, and a coyote incident response plan. In the case of San Francisco's management plan, the main component the city should focus on is public education on coyotes. Most of the human-coyote conflicts in the city are caused by the ignorance of city residents. This ignorance includes residents feeding the coyotes and letting their dogs off leash. By creating a new coyote management plan with a focus on public education, San Francisco can encourage better resident behavior which, in turn, reduces human-coyote conflicts and inspires coexistence.

1. Introduction

While coyotes, *Canis latrans*, have been a common sight in rural areas and forests for over a century, their appearance along busy city streets and crowded public parks has been surprising to many. “They lope down the streets at night in Los Angeles, skyscrapers glowing in the background, and trigger home security cameras in Houston. And in the Bay Area, one cocks an ear and lets a car pass near Telegraph Hill,” said journalist Kim Todd (2018) writing for the local conservation magazine Bay Nature. The article exemplifies an increasingly common experience among city residents: an encounter or sighting of an urban coyote (Fig. 1). Over the last twenty years coyotes have become an increasingly common feature of urban spaces in North America. In the city of San Francisco, for instance, coyotes have been visiting and living in the city since the early 2000s (Todd, 2018). While some city residents have responded to the arrival of the coyotes with delight, many other residents have repeatedly voiced their concerns over the coyotes and the potential threat they could pose (Wilson and Rose, 2019).



Figure 1. Photo from Taylor (2020). Shows an adult coyote standing on a hill in San Francisco.

While most urban residents have a vague idea of what a coyote is, the vast majority of residents do not know much about coyotes or their importance in local ecosystems (Wilson and Rose, 2019). This lack of knowledge combined with the increasing presence of coyotes in urban

spaces has contributed to a significant number of fears and misconceptions regarding coyotes (Wilson and Rose, 2019). For example, some residents in San Francisco mistakenly believe that coyotes are strictly nocturnal animals and that if a coyote is out during the day it must have rabies (J. Young, Presidio Trust, pers. comm.). Unfortunately, this belief represents a common sentiment among city residents when it comes to coyotes. To many people coyotes are still considered dangerous predators that should be kept out of cities at all costs. In reality, coyotes rarely attack people and are just as much a part of urban ecosystems as raccoons and pigeons are (Reilly et al., 2017).

While public fear and anxiety towards coyotes has continued to persist in many cities, there have been some encouraging signs that public perceptions of coyotes have begun to shift in a positive direction (Wilson and Rose, 2019). This shift has mostly occurred in the last ten years and has many possible explanations. One of the major explanations, however, has been that public perceptions of wildlife, including coyotes, have become more positive as urbanization has continued to increase (Wilson and Rose, 2019). Urbanization refers to the process in which an area of land becomes more urban and built up due to human construction activity (Apfelbeck et al., 2020). Urbanization is also a highly destructive process that damages or destroys natural habitats which, in turn, has negative effects on ecosystem functions and local biodiversity (Huber et al., 2011). Many city residents have become increasingly aware of the damage that urban development can cause to local ecosystems. With this increased awareness there has also been an increased appreciation for urban wildlife including urban coyotes (Wilson and Rose, 2019).

As urbanization has continued and appreciation for urban wildlife has increased, there has been a gradual shift in environmental conservation to focus on urban centers as a type of ecosystem (Pierce et al., 2020). In the past, urban wildlife management was primarily built around the removal of any and all unwanted animals from urban centers. While pest control is still a major component of urban wildlife management, modern wildlife managers are more interested in finding ways for city residents and urban wildlife to coexist. In order to achieve this goal, wildlife managers needed to create new urban wildlife management plans that would not only focus on public safety and pest control but also on the conservation of native species and the maintenance of biodiversity within a city (Apfelbeck et al., 2020). In the case of urban coyotes, many cities created specific management plans for them as well.

While coyote attacks in cities are still considered rare, the number and severity of human-coyote conflicts has been steadily rising as more coyotes visit and live in urban areas (Lawrence and Krausman, 2011). This is also true in San Francisco where coyote sightings and encounters have become an almost daily occurrence in many parts of the city. Moreover, while most San Francisco residents are against removing the coyotes there is still a lot of public concern over safety particularly when it comes to children and pets (Lewis, 2020). The city responded to these concerns by establishing coyote management teams that could help ensure public safety.

Since 2003, the San Francisco Animal Care and Control and the Presidio Trust have been managing the local coyote population. While these organizations have been largely successful at managing the coyotes, local experts believe that future management will require a more refined strategy (J. Young, Presidio Trust, pers. comm.). The reason local experts believe this is that the coyote population in San Francisco is still growing (Todd, 2018). Additionally, the city still does not have a formal coyote management plan or a written strategy for the future.

1.1 Research Question

As coyotes continue to become increasing more important predators in San Francisco, how can the city create a new coyote management plan that both reduces human-coyote conflicts and encourages coexistence? To help answer this question this paper examines research on urban wildlife, coyotes, and coyote management plans. The first section explores the difficulties of wildlife management and the specific challenges that urban centers create for local wildlife. Section two focuses on coyote physiology, their ecological roles, and their relationship with humans in urban centers. Section three compares the coyote management plans are four different cities. Finally, section four focuses on recommendation for San Francisco's new urban coyote management plan based on the research that was conducted for this paper.

2. Methods

In order to explore how the city of San Francisco could create a new urban coyote management plan, this paper examined both research articles and compared coyote management plans used in other cities. All of the research articles used in the paper came from Q1 and Q2 journals. Since both coyotes and urban wildlife are popular topics, a variety of journals were used. Additionally, some newspaper sources, dissertations, and city coyote management plans were utilized as well. Finally, an interview was conducted with Jonathan Young, the wildlife ecologist for the Presidio Trust in San Francisco.

Section one is a literature review that focuses on urban wildlife research in general. Section two is a literature review that focuses specifically on coyotes, their biology, and their history. Section three is a comparative analysis of four existing coyote management plans including plans from Chicago, Long Beach, Newport Beach, and Davis. Finally, Section four discusses recommendations for San Francisco's new coyote management plan.

3. Urban Wildlife Management

3.1 Why Urban Wildlife Management is Important

In the 20th and 21st centuries, humans have become the greatest influencers of environmental change on the Planet. Right now, more than half of humanity lives in cities. By 2050, the United Nations predicts more than 68% of humans will be living in urban centers (Pierce et al., 2020). Moreover, as these urban centers continue to expand and become more dense, more natural habitats both within and around cities will be degraded or lost. This is one of the primary reasons conservation efforts are often focused on protecting and restoring those remaining natural habitats. The expansion of urban centers, however, also highlights the need to create and maintain habitats within cities to protect native wildlife. In this way, urban centers have become increasingly important environments for maintaining local and regional biodiversity (Pierce et al., 2020).

One of the main challenges for urban conservation is creating and implementing an effective urban wildlife management plan. This challenge can be seen in a study by Pierce et al.

(2020) which compared the wildlife management plans of 39 cities around the World. In the study, researchers found that many of these cities did not have wildlife management plans that focused specifically on protecting biodiversity. A survey of experts from 25 countries suggested that the lack of focus on biodiversity was largely due to poor education on the topic. That is, many city governments did not know how important biodiversity was or possessed the technical knowledge needed to protect it (Pierce et al., 2020). For many of these cities, protecting biodiversity was a low priority compared to other development considerations like housing, transportation, and infrastructure (Miller et al., 2008). If these cities want to conserve local wildlife more effectively, they will need to treat biodiversity as a critical component of urban wildlife management.

3.1a How to Protect Urban Biodiversity Through Habitats

The main way a city can help safeguard local biodiversity is by protecting urban habitat patches. These habitat patches are important green spaces for both rare and common species. For a rare or endangered species, these habitat patches may serve as critical habitats that the species requires to survive (Apfelbeck et al., 2020). It is this reason that wildlife managers need to monitor local endangered species so that the critical habitats those species use can be identified and protected. In many cases, protecting these critical habitats will also be an important part of city planning. This will ensure that certain habitat patches are protected from future urban development (Apfelbeck et al., 2020).

Protecting the habitat patches that more common species utilize is important as well. All urban habitats are important for local wildlife and the more habitats that are protected the healthier urban ecosystems will be (Apfelbeck et al., 2020). Common urban animals like coyotes use a variety of different habitat patches throughout many urban centers. Since coyotes are important for maintaining local biodiversity, they should also be considered when coming up with conservation strategies. By considering the needs of both endangered and common species, urban wildlife managers can get a better idea about how many habitat patches need to be protected and which habitat patches are the most important (Apfelbeck et al., 2020).

3.1b Wildlife Management is a Component of Public Health

Urban wildlife management is also a critical component of both human and wildlife health and safety. As human populations in urban centers continue to increase, concerns over the spread of both known and novel diseases mount as well. In a 2006 study it was shown that urban development has a significant impact on the biologies of pathogens and their hosts and vectors (Bradley and Altizer, 2006). In some cases, the impact of urban development has reduced the number of pathogens in a city by limiting some of the sources of wildlife parasites that serve as vectors. In other cases, however, urban development has created conditions in which wildlife parasites like ticks can persist, allowing for pathogens to transmit from one host to another more easily (Bradley and Altizer, 2006). As the number of humans and animals living in and around cities continues to increase, the likelihood of new and more dangerous multi-host pathogens appearing will increase as well. In this way, urban wildlife management is not only important for preserving urban ecosystems but is also an important part of public health (Bradley and Altizer, 2006).

3.2 Urbanization and Habitat Connectivity

Urbanization negatively impacts ecosystems by destroying natural habitats as well as the connections between them (Huber et al., 2011). This loss of connectivity leads to habitat loss and fragmentation which is one of the major causes of species population decline and even extinction (Sih et al., 2010). Habitat loss and fragmentation negatively impacts wildlife by creating new resource distributions and environmental conditions. These changes can create new trophic cascades which can result in new species distributions and interactions. Some of these interactions include greater levels of predation and more interspecific and intraspecific species competition. This competition can lead to new species population dynamics which can then force some animals to leave their habitats or even go locally extinct (Sih et al., 2010). This is one of the main reasons that preserving urban habitat connections is so important (Huber et al., 2011).

Habitat connections are important for ecosystem health because they allow animals and nutrients to move freely from one habitat to another (Huber et al., 2011). These connections also help native species by providing pathways for gene flow between different populations. The

more gene flow there is, the more genetic diversity among populations which, in turn, helps population stability (Serieys et al., 2020). Habitat connections also make it easier for nutrients and minerals to cycle through ecosystems which contributes to ecosystem function and resilience (Huber et al., 2011).

In cities, habitat connectivity is hindered by urban development and human activity. This lack of connectivity is one of the main reasons many urban habitats tend to support less biodiversity and are less able to support ecosystem functions (Gregory et al., 2021). Urban centers, by their nature, disrupt the connections between habitats by creating barriers in the form of existing structures, construction sites, and other urban developments. The most common type of barriers are linear barriers like highways, roads, sidewalks, canals, or walls. Different types of linear barriers will create different challenges for different species of urban wildlife. In all cases, however, these linear barriers will affect wildlife movement patterns in urban areas (Gregory et al., 2021).

Aside from changing wildlife movement patterns, some linear barriers also create other types of disturbances to habitat connectivity. Sidewalks, for example, tend to have lots of pedestrian traffic during the day which can disrupt normal wildlife activity (Gregory et al., 2021). Roads and highways have many disruptive elements that can interrupt or prevent animals from crossing them. These disruptive elements include noise and sound pollution, chemical and heat emissions, and vehicular traffic (Beben, 2016). Additionally, some of these disruptive elements will affect some animals more than others (Fig. 2). Vehicular traffic, however, is by far the most disruptive element and also poses a direct danger to wildlife. Vehicle collisions are considered one of the leading causes of wildlife mortality in urban areas (Gregory et al., 2021).

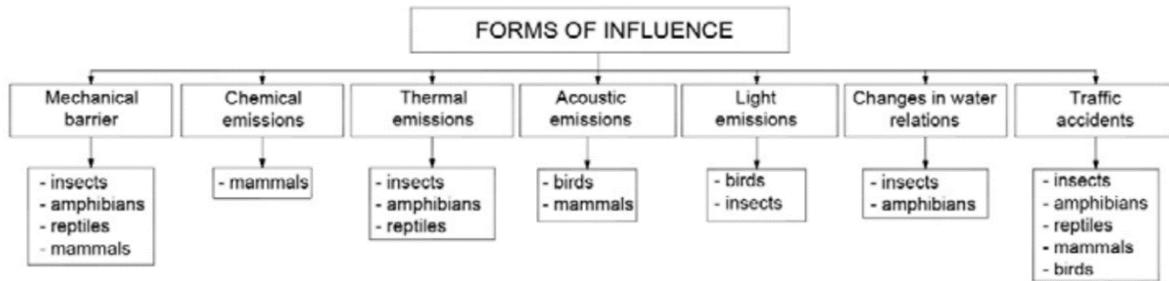


Figure 2. Adapted from Beben (2016). Different types of disruptive elements (forms of influence) on roadways as well as the types of animals most affected by those disruptive elements.

The large number of barriers and associated dangers that exist in urban areas highlights the need for urban wildlife managers to protect as many habitats and habitat connections as possible. To accomplish this, managers need to identify and protect any preexisting habitats and habitat connections within a city (Apfelback et al., 2020). More importantly, managers need to create new spaces that animals can use. These new spaces include greenspaces that serve as new habitats for animals and urban corridors which serve as new connections between existing urban habitats. The creation of new greenspaces and urban corridors can restore connectivity to urban ecosystems which, in turn, improves biodiversity (Huber et al., 2011).

3.2a Urban Corridors

The main way managers can restore connectivity to fragmented habitats is through the creation of urban corridors. Urban corridors are human-made pathways that connect urban habitat fragment together. These corridors can take many different forms, such as strips of vegetation between roads to culverts running underneath bridges (Gregory et al., 2021). The type of corridors used will often depend on the physical limitations of the urban environment (Beben, 2016). For example, depending on the type of roadway, a corridor can be constructed over it, across it, or underneath it (Fig. 3). In order to build the right kinds of urban corridors, managers will also need to understand the behaviors and physiologies of the local wildlife (Serieys et al., 2020). Once an urban corridor is built it can then be monitored over time to see how effective it is at restoring connectivity (Gray et al., 2020).

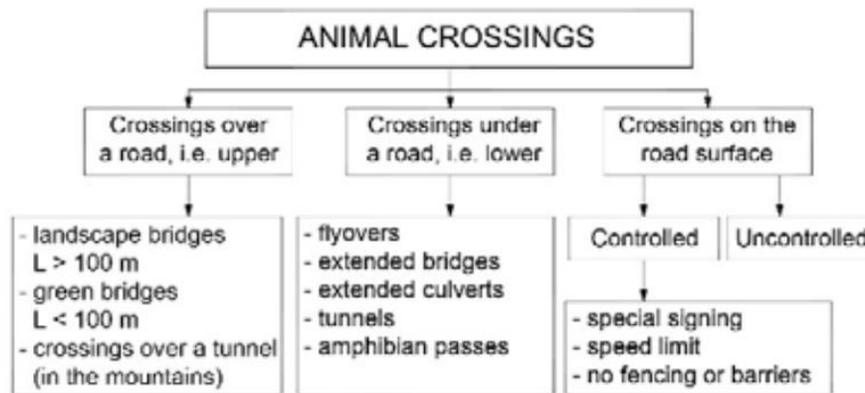


Figure 3. Adapted from Beben (2016). Different types of urban corridors that can be constructed as crossings over a roadway. Options include overpasses, underpasses, and roadway modifications that allow for safer transversal of the roadway itself.

Measuring the effectiveness of an urban corridor can often be difficult due to the challenges associated with monitoring wildlife movements over long periods of time. Regardless, most successful urban corridors will meet certain management objectives (Gregory et al., 2021). For instance, successful corridors will have very little or no human activity. These corridors will also create an effective buffer zone between urban habitats and areas with human activity. Finally, these corridors will provide safe crossings over linear barriers that wildlife can use (Gregory et al., 2021). The most effective urban corridors also will incorporate speed limits for vehicles, vegetation to reduce edge effects, and different types of crossings for various different types of species. Effective urban corridors will, over time, restore ecosystem functions and improve biodiversity in urban areas (Gregory et al., 2021).

3.2b Urban Greenspaces

Aside from restoring connections via corridors, urban wildlife management also requires the creation of new habitats or greenspaces. Greenspaces are patches of land within a city that are covered in vegetation. Some examples of greenspaces include both private and public gardens, backyards, vacant lots, and public parks (Apfelback et al., 2020). Greenspaces provide viable habitats for urban wildlife to use. The function of the greenspace will vary depending on its size and on the species that is using it. Some functions of greenspaces including serving as

temporary shelter from predators or weather events, serving as foraging or hunting grounds, or serving as sources of food and water (Apfelback et al., 2020). Greenspace can also help reinforce urban ecosystem services. For instance, greenspaces can help improve ecosystem and city health by reducing air pollution and ambient temperatures (Katti et al., 2012).

3.3 How Urban Wildlife Benefits Humans

Urban wildlife not only benefits urban ecosystems but also city residents. The reason for this is that cities with more wildlife tend to have more biodiversity which helps maintain ecosystem services. Ecosystem services are key components of a healthy ecosystem and are natural processes that benefit humans both directly and indirectly (Katti et al., 2012). While ecosystem services like water filtration and flood prevention are usually carried out by plant life, it is important to note that many other services are provided by local wildlife. For example, animals are important for maintaining ecosystem processes such as cycling nutrients, minerals, and other important resources that humans use (Sandifer et al., 2015). Some of these resources include raw materials, food products (the animals and plants that humans consume) and even water. Since urban areas have fewer healthy habitats than wilderness areas do, maintaining or increasing urban biodiversity can help restore ecosystem services and processes (Sandifer et al., 2015).

Beyond providing ecosystem services, local animals also help maintain ecosystem stability by occupying various ecological roles includes those of predators, herbivores, decomposers, and many others. The more complex the urban food web is the healthier and more stable the urban ecosystem will be. A more complete food web with more predators can also help keep pest species under control (Sandifer et al., 2015).

3.3a Co-benefits

Beyond protecting biodiversity and maintaining ecosystem services, urban wildlife also contributes to human health and wellbeing. Multiple human health and psychology studies have shown that humans benefit from seeing and being around wildlife (Sandifer et al., 2015). The physiological benefits to human health include reductions to physical stress and blood pressure as well as increases to healthy nerve activity and immunity system responses. The psychological benefits of wildlife to humans include reductions to anxiety and depression as well as increases to calmness, creativity, and perceived happiness (Sandifer et al., 2015). Additionally, humans also benefit from visiting the spaces that urban wildlife use such as public parks and other greenspace.

Urban wildlife can also benefit city residents by making those residents more aware of local conservation concerns. That is, seeing, hearing, and encountering wildlife makes people more aware of nature and its importance (Apfelbeck et al., 2020). This increased awareness of nature among city residents can create greater concern for habitat loss and native species loss as well as calls to action. In cities where residents are concerned about the plight of wildlife there will be more examples of environmental stewardship and more conservation efforts. This also includes a greater willingness among city residents to support new urban wildlife management plans (Apfelbeck et al., 2020).

3.4 How Cities Affect Wildlife Behavior

In order to create effective urban wildlife managements plans, wildlife managers need to understand animal behavior and how that behavior is affected by change. A compelling example of this occurred in early 2020, during the beginning of the COVID-19 pandemic, when many urban residents around the world noticed an influx of wildlife into urban spaces. While this increase in wildlife activity was not indicative of animals reclaiming cities, it did highlight how many animals would change their behavior when environmental conditions changed (Vardi et al., 2021). This also gave researchers an opportunity to study how different animals responded to reduced human activity in urban centers. Some animals, like mountain lions (*Puma concolor*), for instance, ventured further into dense urban areas than they would have normally. Other

animals, like moose (*Alces alces*), continued to avoid dense urban areas entirely (Vardi et al., 2021). Ultimately, these findings are yet another example of why urban wildlife management needs to include how different species and their behaviors are affected by urban environments.

3.4a Cities as Habitats

Cities are unique environments with many qualities that differ from those of natural habitats. Urban centers possess many features that create new selective pressures for animals that differ from those in the places many animals first evolved (Lowry et al., 2013). Some of these urban features tend to benefit wildlife. For example, urban areas tend to have more stable conditions, fewer large predators, and more year-round food and water sources than many natural areas do (Vardi et al., 2021). While all are these features are beneficial and appealing to wildlife, the year-round food and water sources are considered to be the main reason wildlife venture into cities in the first place (Laliberte and Ripple, 2004). Urban food sources include plant life from parks and gardens and anthropogenic food resources that are discarded by humans or found in trashcans and landfills. Water sources are also common in urban areas and include urban ponds and lakes, fountains, and from sprinkler systems (Lowry et al., 2013).

Urban areas also possess many features that create new challenges and pressures for wildlife. For example, the many structures and infrastructure elements in cities create lots of micro-climate zones which are areas with varied and extreme environmental conditions. These micro-climate zone create useable habitats for some species while introducing new challenges for others (Vardi et al., 2021). Some other challenging urban features include artificial lighting, linear barriers, and frequent human activity and disturbances. Urban environments also produce unique species population distributions which create novel interspecific and intraspecific species interactions and conflicts (Vardi et al., 2021). All of these features highlight both the complexity and importance of urban environments and how they affect animal behavior.

One important feature that sets urban environments apart from natural ones is that urban environments have significantly more human disturbances. Two major types of human disturbances are light and noise pollution (Lowry et al., 2013). Light pollution is caused by streetlights and other artificial light sources found in cities. These light sources can alter the

circadian rhythms of some animals which can result in disruptions to daily and seasonal routines (Russart and Nelson, 2018). Similar disruptions to animal behavior can also be caused by noise pollution. Noise pollution comes from many different sources in cities including from industry, construction, vehicular traffic, and human activity. Loud and frequent noises can impact bird mating calls and disrupt other routine behaviors (Lowry et al., 2013).

3.4b How Desirable Traits Help Urban Animals

The evolutionary history of an animal can help determine how well that animal can adjust to an urban setting (Vardi et al., 2021). That is, while all urban animals are affected by disturbances like light and noise pollution, some animals are more tolerant of these disturbances than others are. These more successful animals will possess traits that help them better adapt and thrive in urban environments (Lowry et al., 2013). Some of these traits include having more flexible diets and possessing greater levels of intelligence (Sih et al., 2010). One particularly desirable trait is behavioral flexibility, which is an animal's ability to modify its behavior in response to changing environmental conditions (Lowry et al., 2013). Some behaviors are more useful in urban environments than other are. For instance, vigilance and encamping behavior can help urban animal spot and avoid humans and other potential dangers (Ritzel and Gallo, 2020).

Another example of behavioral flexibility is that many animals living in urban areas exhibit different foraging and breeding behaviors than their rural counterparts. These differences in behavior are largely due to urban resource availability and the frequency of disturbances that occur in urban areas (Lowry et al., 2013). An example of this can be seen in urban European hedgehogs, *Erinaceus europaeus*, which forage later in the evening than their rural counterparts in order to avoid late night human activity. The greater resource availability in urban environments also affects the reproductive behaviors of many animals, particularly many species of birds (Lowry et al., 2013). For instance, Australian Silver gulls, *Larus novaehollandiae*, have longer breeding periods in urban areas than they do in rural ones. White-winged Coughs, *Corcorax melanorhamphos*, however, will have breeding periods that are identical to their rural counterparts but will start their breeding period a month earlier (Lowry et al., 2013). While these changes to reproductive behavior may seem significant, most of these changes do not impact the overall biological fitness of the species. That is, despite these behavioral differences, many urban animals exhibit similar levels of success as their rural counterparts do (Lowry et al., 2013).

Aside from behavioral flexibility, individual traits like temperament also affect how well an animal can adjust to urban environments. Temperament refers to an animal's personality and the behavioral responses associated with that personality (Lowry et al., 2013). A study conducted by Lowry et al. (2013) showed that North American song sparrows (*Melospiza melodia*) with bolder and less timid temperaments were generally more successful in urban areas. That is, song sparrows with bolder personalities were innately more tolerant of disturbances and exhibited less stress responses than the ones with more timid personalities. The song sparrows with bolder personalities also had a lower mortality rate and were more reproductively successful overall (Lowry et al., 2013). Similar results have been found for other types of urban animals that have bolder temperaments. In many of these cases, these bolder animals have greater survival rates and more reproductive success which allows their populations to persist more easily in urban centers (Lowry et al., 2013).

Many studies have shown that urbanization has varied effects on different species of wildlife including coyotes. Some species respond to urban development more positively while other species respond to urban development more negatively (Ritzel and Gallo, 2020). These positive or negative responses affect species' avoidance behavior, foraging habits, and home range sizes (Table 1.). Species that respond positively to urbanization, like rodents, will spend more time foraging and less time searching for food because food resources will be more widely available to them (Morzillo and Schwartz, 2011). This is part of the reason that some species experience greater population growth in urban areas than they do in natural ones (Ellington and Gehrt, 2019). In contrast, species that respond negatively to urbanization, like mountain lions, will spend more time hiding from humans and traveling greater distances to find prey (Suraci et al., 2020). For coyotes, both positive and negative responses to urbanization have been found. As coyotes become increasingly common in urban areas, the need to understand how these areas affect coyote behavior has become more important as well.

Table 1. Data compiled from Ellington and Gehrt (2019). Wildlife responses to urban environments can be either positive or negative. Three common responses among wildlife, including coyotes, to urbanization include: changes to territory size, encamping behavior, and time spent foraging vs traveling.

Response	Positive Responses	Negative Responses
Territory size	Smaller, less territory needed to fulfill energy requirements	Larger, more territory needed to fulfill energy requirements
Encamping behavior	Does not need to hide from humans often	Frequently must hide from humans
Time spent foraging vs traveling	Habitat patches with resources are closer together, individual does not need to travel far to meet energy needs	Habitat patches with resources are farther apart, individual needs to travel further to meet energy needs

4. Coyotes

4.1 Coyote Biology and Life History

The coyote, *Canis latrans*, is a species of canine found throughout North America from the east to west coasts. Coyotes can be found in a wide variety of habitats including open plains, forests, deserts, and even cities (Tigas et al., 2002). As generalists and omnivores, coyotes have a varied diet consisting of everything from fruits and vegetables to insects and other animals. That said, coyotes do have a preference for meat such as that of mid-sized and small mammals (Crooks and Soulé, 1999). Coyotes are also very opportunistic and have been known to eat carrion and scavenge for human food waste as well (Thompson et al., 2021).

Like other canine species, coyotes are social, but not to the same degree as species like wolves. For example, unlike wolves that hunt in packs, coyotes tend to either hunt by themselves or in pairs. Coyotes are also socially monogamous with mated pairs sticking together for many years (Carlson and Gese, 2008). Male coyotes have an average weight of 35 lbs while female coyotes are slightly smaller with an average weight of 25 lbs (Mastro, 2011). Male and female coyotes will form mated pairs during the breeding season in winter and early spring (Carlson and Gese, 2008).

Adult female coyotes have gestation periods that average from 60 to 63 days and typically give birth to pups in the spring between the months of March and May. Most coyote litters consist of 3 to 7 pups which mature by the end of their first year (Carlson and Gese, 2008). Mature coyote offspring usually help their parents defend their family territory from both transient coyotes and other predators. Eventually, these mature offspring leave the family group to establish their own territories elsewhere (Carlson and Gese, 2008). The lifespan of coyotes in the wild can reach 10 to 12 years though, on average it is usually closer to 3 to 4 years. This much shorter average lifespan is largely due to natural dangers like other apex predators, conflict with other coyotes, and hunting and trapping by humans (Mastro, 2011).

4.2 Ecological Role

Coyotes, like many other apex predators, help shape the ecosystems they inhabit. Moreover, as one of the few large predators found in cities, coyotes have a disproportionately large and positive effect on urban ecosystems (Fox, 2006). For instance, in a study in 1999 it was shown that coyotes can help maintain biodiversity and food web stability in urban habitats by controlling the numbers of mesopredators (Crooks and Soulé, 1999). Mesopredators are mid-trophic level predators that prey on small animals like rodents and many species of birds (Lawrence and Krausman, 2011). Common mesopredators found in the urban areas in California include native species such as striped skunks, raccoons, and grey foxes as well as exotic species like house cats (Crooks and Soulé, 1999).

The Crooks and Soulé study showed that in cities where coyotes were absent, mesopredator populations would rapidly increase which would then result in an increased mortality rate for local bird species. This is an example of the mesopredator release hypothesis which states that an ecosystem without predators like coyotes will have a larger mesopredator population which will then lead to a loss in overall biodiversity (Crooks and Soulé, 1999). In cities with more coyotes, however, mesopredator populations were lower resulting in larger native bird populations. Additionally, the cities with coyotes were found to have more biodiversity overall which contributed to a greater degree of urban ecosystem resilience (Katti et al., 2012).

While coyotes are good at keeping native mesopredators in check, it is arguably even more important that they keep exotic mesopredator populations under control. House cats, specifically, present a direct threat to native bird species and small mammals. Globally, house cats are responsible for killing about 3.7 billion birds and 10 billion small mammals per year (Kays et al., 2015). Fortunately, coyotes serve as effective deterrents. Both domesticated and feral cats tend to avoid coyote habitats and other areas with coyote activity. In the city of Raleigh, North Carolina, for instance, cats would completely avoid any coyote territory including territories that only had one coyote present (Kays et al., 2015). Beyond this, other studies have shown that the mere existence of a coyote in a habitat can deter cats and other mesopredators by making them more fearful and cautious (Suraci et al., 2016).

Aside from keeping both native and exotic mesopredators in check, coyotes also have other positive effect on urban ecosystems and ecosystem services. Many of these positive effects are indirect ones, meaning they are benefits that the coyotes indirectly provide through their effect on other animals. For example, coyote reduce mesopredator populations which, in turn, help urban seed dispersers (Kays and Dewan, 2004). Seed dispersers are mostly smaller animals like birds and rodents that help distribute plant seeds to new locations (Díaz et al., 2006). These seed dispersers are critically important in urban centers because there are fewer green spaces that plants can grow in and more obstacles that prevent seeds from distributing other ways. For this reason, cities with more small animals will tend to have more vegetation which will improve ecosystem and city health (Díaz et al., 2006). Additionally, on more rare occasions, coyotes have been known to be seed dispersers themselves depending on their diet (Roehm and Moran, 2013).

Another way coyotes help urban ecosystems is through pest control. Coyotes are opportunist hunters and will not only prey on mesopredators but also smaller animals including various species of rodents. While urban rodents are important seed dispersers, they also create many problems for the health of urban ecosystems and city residents (Díaz et al., 2006). For example, non-native rodent species like Norway rats (*Rattus norvegicus*) are known for causing property damage, consuming human food resources, and spreading diseases (Morzillo and Schwartz, 2011). Fortunately, urban coyotes can help reduce the damage caused by these rodents through both direct predation and intimidation. Rodents, like many other small mammals, are less likely to live or forage in areas where coyotes are present (Suraci et al., 2016).

4.3 Coyote Behavior in Urban Areas

Coyotes are highly social and form packs consisting of family groups. The most dominant coyotes in the family group are the parents followed by their adult offspring and pups. The coyote family group will defend its territory from nonresident coyotes, other predators like mountain lions, and other potential threats like humans (Carlson and Gese, 2008). The size and shape of the territory will vary depending on its proximity to other coyote territories, the availability of food resources, terrain characteristics, and the amount of human activity present (Ellington and Gehrt, 2019).

Since adult male and female coyotes have similar energy requirements, there is typically no difference between the sizes of their respective home ranges. Transient or nonresident coyotes tend to have large home ranges because they are often chased out of higher quality habitats by resident coyotes (Gehrt et al., 2009). This is true for nonresident coyotes both in natural and urban environments. In city environments, however, human activity and urban development will have a larger effect on coyote territory size and coyote behavior.

One of the main challenges that coyotes face in urban environments is habitat fragmentation. The more urban development there is, the more fragmented habitats become. The degree of habitat fragmentation affects food source availability which, in turn, affects coyote behavior and territory size. In a study conducted in Chicago by Ellington and Gehrt (2019) it was shown that the degree of habitat fragmentation resulted in both positive and negative responses from coyotes. For example, when comparing coyote home range sizes, researchers found that the coyotes that lived in suburban areas would have smaller home ranges than the coyotes that lived in natural areas (Table 2.). The home ranges in the suburban areas were 2.31 km² on average while the home ranges in natural areas were 3.24 km² on average (Ellington and Gehrt, 2019). The main reason that coyotes in suburban environments had smaller home ranges was that food sources, both wild prey and anthropogenic, were more readily available. Because food was closer by, the coyotes did not need to travel as far to meet their energy needs (Ellington and Gehrt, 2019).

While coyotes seemed to benefit from the greater food availability of suburban areas, the coyotes' responses to highly urbanized areas were more complex. Ellington and Gehrt (2019) found that coyotes living in dense urban zones had larger home ranges on average than the

coyotes living in either suburban or natural areas. The home ranges found in dense urban areas were 7.05 km² on average which is more than triple the average size of home ranges found in suburban areas (Ellington and Gehrt, 2019). This makes sense since dense urban areas are even more fragmented than suburban ones and have fewer high-quality habitat patches that coyotes can use (Thomas et al., 2021).

Despite dense urban areas being more fragmented and having fewer high quality habitats patches, coyotes still seemed to benefit from them (Ellington and Gehrt, 2019). Specifically, coyotes in these dense urban areas would spend more time foraging and less time traveling between habitat patches than coyotes in suburban or natural areas did (Table 2.). This can be seen by comparing the foraging to travel time ratios of suburban coyotes to those of urban coyotes (Ellington and Gehrt, 2019). Suburban coyotes had a foraging to travel time ratio of 0.81 while urban coyotes had a foraging to travel time ratio of 1.06 (Table 2.). The higher the foraging to travel time ratio is for a coyote, the more time spend foraging and the less time spend traveling for that coyote. This means that while the quality of the habitat patches in dense urban zones was lower, the habitat patches also tended to have more food resources in them. This also could explain why coyotes often live in highly urbanized areas despite the higher levels of fragmentation (Ellington and Gehrt, 2019).

In addition to greater levels of habitat fragmentation, highly urbanized zones also have more humans and human activity. Coyotes, despite their size, will avoid direct contact from humans whenever possible (Ellington and Gehrt, 2019). This means coyotes living in urban centers will feel more at risk and will spend more time doing avoidant behaviors like encamping (Table 2.).

The density of an urban center will also determine what percentage of the time coyotes will spend doing encamping behavior. For example, both natural and suburban areas have less human activity in them which will affect coyote avoidant behaviors in similar ways. This can be seen in the study by Ellington and Gehrt (2019) which showed that coyotes in natural areas would spend 57 percent of their time encamping while coyotes in suburban areas would spend 58 percent of their time encamping. Coyotes in dense urban areas, however, were exposed to significantly more human activity and would spend 62 percent of their time encamping (Table 2.). When coyotes are encamping, they are not actively hunting which diminishes the time

available for them to meet their energy needs. However, in dense urban areas this is less of a problem for coyotes because more anthropogenic food sources are available (Ellington and Gehrt, 2019).

Table 2. Data compiled from Ellington and Gehrt (2019). Coyote responses to different levels of urbanization, showing differences in home range size, encamping time, travel time, and foraging time. Also shows the differences in the foraging time to travel time ratios for both suburban and urban coyotes. N/A: the foraging time to travel time ratio for coyotes in natural habitats could not be determined.

Habitat type (amount of urbanization)	Home range size	Home range size (km ²)	Time spent encamping (perceived level of risk)	Percentage of time spend encamping	Time spent traveling between habitat patches	Time spent foraging in a single habitat patch	Foraging time to travel time ratio
Natural habitat	Medium	3.24	Small	57%	Large	Small	N/A
Suburban	Small	2.31	Medium	58%	Medium	Medium	0.81
Highly urbanized	Large	7.05	Large	62%	Small	Large	1.06

In addition to encamping, coyotes will also change their movement patterns during the course of a day to avoid as many humans as possible. During the daylight hours, coyotes will either encamp or stick to moving through habit patches with more dense foliage (Thompson et al., 2021). During the night, however, coyotes will be more active on roadways and around houses and buildings when human activity has decreased (Thompson et al., 2021). This type of behavior is particularly true for coyotes in suburban areas where there is less traffic overall.

Coyote activity in urban areas is also dependent on the time of year. In Ontario Canada coyotes had a higher presence in residential areas during breeding season (winter to spring) and during pup rearing season (spring to early fall). This was likely due to these residential areas having lots of anthropogenic food sources as well as plenty of space and cover that could be used to protect newborn pups (Thompson et al., 2021).

The artificial environment that urban centers create has also driven novel coyote behavior. That is, different urban features will serve different purposes for coyotes. Coyotes will use some areas for foraging, some for traveling, some for encamping, and some for den making (Thompson et al., 2021). While coyotes may utilize urban features in some of the same ways that other city dwelling wildlife do, there have also been some notable differences. For instance, coyotes will often use urban wildlife corridors as habitats instead of passages (Tigas et al., 2002). Conversely, coyotes will also use linear features like roads, sidewalks, and railways as pathways between suitable habits and food sources. Unfortunately, use of these features has led to an increase in coyote mortality in areas with heavy traffic, especially for pups and other younger, less experienced coyotes (Tigas et al., 2002).

While there is not much of a difference between the home range sizes for urban male or female coyotes, some differences have been observed during the breeding and pupping seasons. During the breeding season, single male coyotes have been observed to have larger home ranges than female coyotes do (Grubbs and Krausman, 2009). These larger home ranges are likely a result of male coyotes searching for mates. Male coyotes that have larger territories will have potentially greater access to female coyotes in the region (Grubbs and Krausman, 2009).

During pupping season, urban coyotes will utilize specific habitat types for den making. The den is the home base of a mated coyote pair's territory and the place they will raise their pups. Dens are typically established in areas with less human activity and plenty of cover (Grubbs and Krausman, 2009). In wilderness areas coyote pairs will usually create their den near natural shelter like fallen trees, large rocks, or thick bushes. While these shelter features also exist in some urban areas, coyote pairs have adapted to utilize any urban features that provide sufficient seclusion and safety. Urban coyote pairs have been known to establish dens in unusual locations such as culverts under roadways, abandoned houses, and empty lots (Grubbs and Krausman, 2009).

4.4 Interactions with Humans

As coyotes have become more common in urban areas, interactions between coyotes and humans have increased as well. This increase has led to more public concern over the potential

threat coyotes may pose. Although attacks on humans are rare, coyotes are still often perceived as a threat to city residents and their children (Thompson et al., 2021). While some human-coyote conflicts are simply a result of chance encounters, the majority of conflicts are related to habituation. Habituation is the process in which wild animals, like coyotes, become used to certain repeated stimuli and, eventually, stop responding to those stimuli (Thompson et al., 2021). In urban areas with abundant anthropogenic food waste, coyotes will often get used to human presence and will become less cautious towards them over time. When coyotes become less cautious about humans, the likelihood of human-coyote conflicts goes up. Encounters with coyotes are significantly higher in urban areas where food waste is plentiful and not properly stored or disposed of (Thompson et al., 2021).

The habituation of coyotes to humans is not only caused by the abundance of human food waste in urban centers but also due to bad human behavior. As coyotes have become more common in urban areas, there has also been an increase in public interest in coyotes. Unfortunately, this interest has led to a growing number of people who intentionally feed the coyotes (Thompson et al., 2021). Intentionally feeding coyotes is one of the leading causes of habituation and, by extension, human-coyote conflicts. More specifically, feeding coyotes increases the chances of coyotes approaching humans on purpose which leads to greater dangers for both humans and coyotes alike (Thompson et al., 2021).

Another major contributor to human-coyote conflicts are attacks on pet animals. In many cities, coyote attacks on pets are considered the most common type of conflict between coyotes and urban residents (Thompson et al., 2021). This concern over pet safety has led to multiple studies focusing on why coyotes may attack pet animals (Kays and Dewan, 2004). One of the main causes of attacks is simple predation. Coyotes are apex predators and they will prey on cats and small to medium sized dogs if there is an opportunity, or more easily accessible food sources are not available (Thompson et al., 2021). In addition to this, coyotes will attack and kill pets for defensive reasons. For example, coyotes may perceive pets as possible competitors for food resources or territory. Finally, during coyote pupping season, coyotes may also consider pets as potential threats to their young (Thompson et al., 2021).

4.5 History of Coyotes

Historically, coyotes have been found throughout North America in a wide variety of habitats. Coyotes, like wolves, have also been part of the human experience for a long time. While coyotes were never domesticated, they have been known to humans for over a millennium (Bateman and Fleming, 2011). Wherever human settlements existed, coyotes would usually establish territories nearby. This relationship would remain largely unchanged until the 20th century (Bateman and Fleming, 2011).

After the arrival of European settlers in America, and the urbanization that followed, many large North American mammals began to experience massive alterations to their habitats. For many of these mammals this meant habitat loss and reduced habitat quality. In one study it was shown that the vast majority of North American apex predators experienced range loss as a direct result of human population growth and urbanization (Laliberte and Ripple, 2004). For example, apex predators like black bears, grizzly bears, grey wolves, and mountain lions all lost over 20% of their historic ranges. The one major exception among larger predators was the coyote which experienced a 40% expansion to its historic range (Laliberte and Ripple, 2004). While there are many theories that try to explain this coyote range expansion; the most popular theory is that coyotes moved into territories that wolves had previously occupied (Ellington and Gehrt, 2019). Coyotes typically avoid wolf territories because wolves are larger and hunt in big packs. However, as European settlers moved across the continent, many wolf populations were either expelled or hunted, leaving an opportunity for coyotes to replace them (Laliberte and Ripple, 2004).

While coyote population growth in North America was fairly steady during the early 1900s, this changed as urban centers began to expand. In the last hundred years, coyote population growth around urban centers has increased. Additionally, coyotes have also been venturing into dense urban centers more frequently (Laliberte and Ripple, 2004). There are two main reasons why coyotes seem to gravitate towards these urban environments. The first reason is that many of these urban areas have expanded into and around areas where coyote habitats already existed (Laliberte and Ripple, 2004). The second, and more common reason is that urban centers offer an increase in resources that coyotes can take advantage of and utilize. For instance, urban centers provide year-round food and water sources. In addition to this, coyotes in urban

areas experience less competition from other apex predators making it easier for coyotes to hunt for prey and secure new territory (Laliberte and Ripple, 2004).

Beyond having plentiful sources of food and water, urban areas also seem to be safer for coyotes than some natural habitats are. Coyote population studies conducted in many cities in the United States have shown that urban coyote populations are, overall, stable (Laliberte and Ripple, 2004). Additionally, the survival rates of urban coyotes were usually found to be higher than the survival rates of rural coyotes (Laliberte and Ripple, 2004). This difference in survival rate is to be expected as rural coyotes must compete with other apex predators and are exposed to hunting pressures by humans. In contrast, most cities prohibit the hunting and trapping coyotes which is allow coyote populations to flourish (Ellington and Gehrt, 2019).

4.6 History of Coyotes in San Francisco

Like many other cities around the country, San Francisco has its own coyote history which, for the most part, was not that unusual. Coyotes are native to the Bay Area and have lived there for thousands of years including in the area that San Francisco occupies (Todd, 2018). In the mid 1900's, however, the coyote population in San Francisco was driven out by the State Government. During this period, many people considered the coyotes to be a menace and a state level hunting, trapping, and poisoning campaign was instigated (Todd, 2018). For a while after this event coyotes were a rare sight in the San Francisco area. This would change in the early 2000's when coyotes started to come back into the city in large numbers (Todd, 2018).

While the exact date of the coyotes' return to San Francisco is still debated, there is no question that coyotes were living in the Presidio by 2003 (Sacks et al., 2006). One of the first coyotes studied in The Presidio was a single adult male. When researchers trapped this male coyote and collected a blood sample, they found that the coyote shared genetic similarities to the coyote populations living north of the San Francisco in Marin County (Sacks et al., 2006). This revelation meant that one of the ways coyotes may have traveled into the city for colonization was over the Golden Gate Bridge. While it is possible this coyote was brought to the Presidio by humans on purpose, no compelling evidence of this has been found (Sacks et al., 2006). Regardless of the origin of their arrival in The Presidio, one certainty is that coyotes have

continued to persist in the city since that time. Most experts believe there are currently around 70 coyotes living in the San Francisco though the number could be as high as 100 (J. Young, Presidio Trust, pers. comm.).

Currently, San Francisco’s coyote population is considered stable though there are also some signs that it is increasing (Todd, 2018). The city utilizes two main methods for tracking the growth of its coyote population. The first method is through radio collars which managers attach to adult/subadult coyotes that are captured and then rereleased into the city (J. Young, Presidio Trust, pers. comm.). The radio collars help managers see the movement patters of individual coyotes. While radio collars provided detailed information on captured coyotes, the collars are not helpful for tracking younger coyotes, coyotes that have yet to be caught, or non-resident coyotes (J. Young, Presidio Trust, pers. comm.). The second method for tracking coyotes is through Project Coyote on the iNaturalist website. Project Coyote is a volunteer program that allows city residents and visitors to report the location of any coyote that is spotted in the city (Fig. 4). This method provides coyotes researchers and managers with lots of additional data but is not as accurate since city residents and visitors are usually not as experienced with identify coyotes correctly (J. Young, Presidio Trust, pers. comm.).

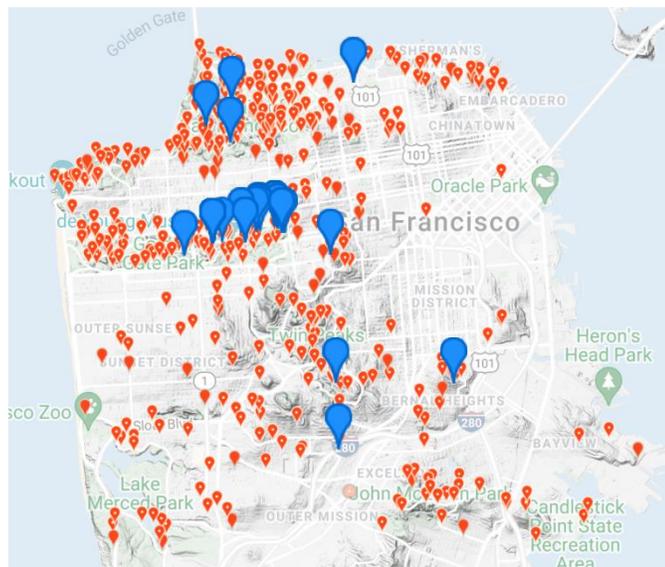


Figure 4. Adapted from Young, on iNaturalist website (2016). Locations in San Francisco where individual coyotes were spotted by residents/visitors at a particular time during a particular day. Locations where coyotes were spotted are marked with a red or blue flag.

5. Urban Coyote Management Plans

The prevalence of coyotes in many urban centers has created the need for more coyote focused wildlife management plans. Like any other effective wildlife management plan, these coyote focused plans are more successful when they adhere to the principles of good wildlife management policy (Apfelbeck et al., 2020). Many of these good wildlife management policies and strategies can be gleaned from exiting urban wildlife management literature.

5.1 Elements of a Good Urban Wildlife Management Plan

Urban wildlife management is about balancing the needs of both urban residents and wild animals. This requires the creation of management plans that are effective at protecting city residents, urban ecosystems, and the wildlife that lives in those ecosystems (Apfelbeck et al., 2020). To accomplish these objectives a wildlife management plan must meet certain requirements (Table 3). One requirement is that the management plan must be created with the input of an interdisciplinary team including ecologists who are knowledgeable about the animals involved. The involvement of local ecologists will ensure that the management plan considers the life histories and physiologies of the target species (Apfelbeck et al., 2020).

Good management plans will also need to consider the input of local stakeholders. Stakeholders include home and business owners, members of the city government, and anyone else that might be affected by any of the new policies or regulations proposed by the new management plan. Including stakeholders in the planning and the implementation of new wildlife management plans will reduce conflicts and ensure a greater degree of success (Apfelbeck et al., 2020). The urban wildlife management plan will also need to include monitoring strategies so further data can be collected. This monitoring can be conducted by professional researchers and/or by trained community members. Finally, managers need to reevaluate the management plan over time to see how effective it is and to see if any changes need to be made (Apfelbeck et al., 2020).

Table 3. Adapted from Apfelbeck et al. (2020). Components of a well devised urban wildlife management plan including clear objectives and goals, a management team, community engagement, monitoring, and reevaluation over time.

Elements of a Wildlife Management Plan	Description
Objectives and Goals	Management plan should have to goal of preserving local biodiversity and habitats, as well as protecting public safety
Management team	Management team should be interdisciplinary and should consist of ecologists that are knowledgeable about local wildlife and target species
Community engagement	Management plan should include input from local stakeholders and should also include community education
Monitoring	Management plan should include monitoring to measure changes over time. Monitoring can be done by both trained professionals and/or community members
Reevaluation, maintenance, adjustment	Effectiveness of management plan needs to be assets over time and should be adjustable so that it can be improved

5.2 Comparing Different Coyote Management Plans

While coyotes have been part of the human experience for a long time, coyote management in cities is still relatively new and has undergone quite a few changes. Early coyote management practices, for instance, mostly involved driving coyotes out of urban areas by any means necessary including through hunting, trapping, and poisoning (Bateman and Fleming, 2011). In modern times, however, these methods are no longer considered acceptable by most city residents (Lewis, 2020). As a result, many cities in the United States have created formal coyote management plans. While the specific details in many of these coyote management plans differ, the vast majority of plans have the same basic structure and objectives. The following sections will examine and compare the coyote management plans of several different cities.

5.2a Chicago Coyote Management and Coexistence Plan

Chicago, Illinois, like many other cities in the Country, did not have many coyotes until the late 20th century. Then in the 1990's, the coyote populations in and around the city of Chicago began to rapidly increase, creating a need for a comprehensive management strategy (Gehrt et al., 2009). Local experts estimate that the coyote population in the Chicago area is around 3700 individuals. Within the denser parts of the city of Chicago itself, however, the coyote population is much smaller and only numbers in the hundreds (CACC, 2020). Regardless, in order to manage such a large population of local coyotes, Chicago had to create a coyote management plan that was highly detailed and effective.

The organization responsible for managing the massive coyote population in the Chicago area is the Chicago Animal Care and Control (CACC). While the CACC may sometimes work with other Chicago based wildlife organizations, the CACC is largely responsible for any management decisions that involve coyotes. For example, the CACC is responsible for tracking local coyotes, investigating any and all human-coyote interactions, and taking necessary actions if any coyote poses a threat to public safety (CACC, 2020).

Despite having such a large coyote population, Chicago has not had many human-coyote conflicts that resulted in an actual attack on a human (CACC, 2020). While the rarity of coyote attacks is good news, the Chicago coyote management plan nonetheless includes details on what managers need to do should an attack occur. For instance, the CACC will identify and remove any problematic coyote from the city and then relocate it to a suitable natural habitat within the State (CACC, 2020). In more rare and extreme circumstances, the CACC will also lethally remove a coyote if necessary. If lethal removal of a coyote is required, the CACC will request a permit from the head biologist of the Illinois Department of Natural Resources. Most of the time, however, such extreme actions by the CACC are not necessary. The CACC's primary method for reducing human-coyote conflicts involves a variety of public programs and city mandates (CACC, 2020).

Some of the main ways the CACC has helped reduce human-coyote conflict is through the implementation of public programs. These public programs include a public education program that focuses on teaching residents about coyotes and a humane coyote hazing program which focuses on reducing coyote habituation (CACC, 2020). Aside from these programs, the

CACC's management plan also includes new city ordinances. These new city ordinances include an Anti-feeding Ordinance, which makes it illegal for a city resident to intentionally feed a coyote and a Leash Law which requires residents to always keep their dogs on a leash or in their control (CACC, 2020). Finally, the CACC also collects data on all human-coyote conflicts and interactions and then provides a report for the City Council Committee on Health and Environmental Protection. This report helps the CACC assess its current coyote management strategy as well as make adjustments, if necessary, to the overall coyote management plan (CACC, 2020).

5.2b Long Beach and Newport Beach Coyote Management Plans

Like in Illinois, in California there are many cities with local coyote populations that require management (Crooks and Soulé, 1999). This is particularly true for many of coastal cities in the Los Angeles area. Many of these cities also experience similar amounts of coyote activity and even share some of the same coyote populations (Crooks and Soulé, 1999). For this reason, many of these coastal cities utilize the same basic coyote management plan template. Both the cities of Long Beach and Newport Beach, for instance, use similar coyote management plans with similar strategies. There are, however, a few key differences between the Long Beach and Newport Beach management plans.

The main difference between the Long Beach and the Newport Beach coyote management plans is the organizations responsible for managing the coyotes. In the city of Long Beach, the local coyotes are managed by two organizations (ACS, 2015). The organizations are the Long Beach Department of Parks, Recreation, and Marine (LBPRM) and the Long Beach Animal Care Services (ACS). While both of these organizations are important components of wildlife management in Long Beach, the ACS is primarily responsible for managing the coyotes. The ACS's duties include tracking and monitoring local coyotes and responding to human-coyote interactions and conflicts (ACS, 2015).

While human-coyote conflicts in Long Beach are considered rare, the ACS uses several different strategies to foster human and coyote coexistence. Two of the main strategies the ACS use are similar to those used in Chicago, including a public education program and a humane

coyote hazing program (ACS, 2015). In the rare instances in which a coyote becomes a threat to public safety, the ACS can contact the California Department of Fish and Wildlife (CDFW). This is necessary because the ACS does not actually have the legal authority to relocate coyotes on its own. In California, coyotes are considered important native apex predators and removing or killing them is generally discouraged unless absolutely necessary (ACS, 2015). If the CDFW deems a particular coyote to be a threat to public safety, then it will take whatever actions are needed.

In the city of Newport Beach, the organization responsible for managing the local coyotes is the Newport Beach Animal Control, which is part of the local police department. The Newport Beach Animal Control uses the same methods for managing the coyotes that the ACS does (Newport Beach, 2015). Like ACS, Animal Control uses public education and humane coyote hazing programs to reduce human-coyote conflicts. Unlike, ACS, however, Animal Control does not have nearly as many staff members. Since Animal Control has less personnel available, they do not have the ability to track and monitor local coyote movements on their own. To solve this problem Animal Control trains local volunteers from the community to track coyotes and report any coyote sightings to the Animal Control office (Newport Beach, 2015). Unfortunately, it is unclear how effective this volunteer coyote monitoring program is because none of the collected data is mentioned in the management plan (Newport Beach, 2015). If any coyotes pose a risk to public safety Animal Control will contact the CDFW just as the ACS would.

5.2c Davis Coyote Management Plan

The coyote management plan used by the city of Davis is, for the most part, very similar to the coyote management plans used in other cities in California. Like with those other cities, a local organization is responsible for managing the coyotes and the CDFW is responsible for removing problematic coyotes if necessary. In Davis, the city itself manages the coyotes and implements both public education and humane coyote hazing programs to help decrease human-coyote conflicts (Davis, 2013).

A unique feature of Davis' coyote management plan is that it includes a section that details how the management strategy can be evaluated for its effectiveness over time (Davis,

2013). In this section, a rubric is provided, that scores the yearly number of human-coyote interactions and conflicts as well as the severity of those interactions and conflicts (Table 4). The data the rubric uses comes from both researchers and volunteers from the Davis community (Davis, 2013). This rubric helps managers measure how well the current coyote management strategy is working. The fewer human-coyote interactions and conflicts there are, the more successful the management strategy has been. If, however, the human-coyotes conflicts begin to increase, the management team can make adjustments to the management strategy. While this rubric does not explain how the number of acceptable coyote interactions was chosen, the rubric does provide a framework for reevaluating the management plan in future (Davis, 2013).

Table 4. Data compiled from Davis (2013). This rubric measures the effectiveness of the Davis coyote management plan by analyzing the number and severity of human-coyote conflicts that occur in the city each year.

Rubric for Success of Coyote Management Strategy
5 or less resident complaint calls about coyotes per year
10 or fewer coyote sightings in community per year
5 or fewer coyote encounters in community per year
5 or fewer coyote incidents in community per year
Zero coyote attacks in community per year

5.3 Common Features of Urban Coyote Management Plans

While the details among many city coyote management plans may vary, most management plans in the United States have similar goals and utilize similar methodologies. This is true for both the coyote management plans used in large cities as well as the ones used in small towns. A major limitation here is that none of the coyote management plans referenced in this paper included data on their effectiveness. Despite this limitation, all of these management plans included common features that are based on the elements of best urban wildlife management

practices (Table 3). This section will go over the main objectives of most coyote management plans as well as the methods that are commonly used and why those methods are important.

Most urban coyote management plans have the same overall objective. That objective is to manage urban coyotes in a way that reduces human-coyote conflicts and, simultaneously, encourages coexistence between humans and coyotes. To achieve this objective, most urban coyote management plans include public education and outreach programs, the creation and enforcement of new environmental policies, humane coyote hazing programs, and coyote incident response plans.

5.3a Public Education and Outreach Programs

Despite the rarity of coyote attacks in cities, coyotes are still often feared and misunderstood by the public. This fear and misunderstanding can lead to an increase in human-coyote conflicts which then leads to more negative outcomes (Wilson and Rose, 2019). For this reason, many coyote management plans include public education and outreach programs. These programs are usually run by either a coyote management organization or the city itself and are typically free of charge for city residents. Most of these programs also employ various education methods and mediums in order to reach as many city residents as possible (CACC, 2020). Some of these education methods and mediums include educational websites, flyers, informational signs in parks, local television programs, and even classes. The primary function of these education methods is to alleviate the public's concern over coyotes by providing them with accurate information about coyotes while also dispelling common myths and misconceptions (CACC, 2020).

One of the main ways education programs help reduce the public's fear of coyotes is by providing them with up-to-date information about the statuses of local coyotes (CACC, 2020). When city residents know more about the coyotes that live in the area, they are less likely to encroach on the coyotes' territories or harass the coyotes intentionally (Thompson et al., 2021). Public education programs also provide residents with information on how to reduce human-coyote conflicts (CACC, 2020). Most of this information focuses on changes that residents can make to their own behavior and routines. For example, it is suggested that residents not leave pet

food outside, dispose of trash properly, and use strong trash bins recommended by the city. Most importantly, residents are also instructed to keep control of their pets at all times and to not intentionally feed the coyotes. All of these recommendations help reduce the number human-coyote encounters which, in turn, reduces the number of conflicts and bad outcomes (CACC, 2020).

5.3b Humane Coyote Hazing Programs

Another important component of urban coyote management is the creation and implementation of coyote hazing programs. Coyote hazing programs are used to alter coyote behavior in a way that reduces and reverses habituation (CACC, 2020). Urban coyotes that are less habituated to humans will exhibit more natural coyote behaviors including more caution towards humans and more aversion to areas of dense human activity (CACC, 2020). Coyotes that exhibit more natural behavior will also be far less likely to come in conflict with city residents (Thompson et al., 2021). Coyote hazing programs are also very effective at reducing the amount of coyote activity in certain public spaces, which further reduces conflicts. Finally, coyote hazing programs provide city residents with an empowering tool that reduces their fear of coyotes while simultaneously fostering a greater appreciation for coyotes as important animals in urban ecosystems (CACC, 2020).

Coyote hazing programs work by training both researchers and city residents how to modify coyote behavior through the employment of disruptive actions. The way this works is when researchers or residents encounter a problematic coyote, they can use disruptive actions to scare that coyote away (CACC, 2020). This is strictly done for a coyote that has been identified as one involved in multiple encounters or incidents. Some of these disruptive actions include waving one's arms, making loud noises, and flashing bright lights at the coyote. In slightly more intense coyote encounters it is also recommended that residents either spray the coyote with water or throw a light object at the coyote such as a tennis ball, small rock, or stick (CACC, 2020). None of these distributive actions are meant to physically harm the coyote but to simply discourage the coyote from approaching humans in the future. Most coyote hazing programs also include a strict outline that details which disruptive actions are most appropriate and how much

hazing needs to be done. If a coyote continues to be an issue despite multiple hazing attempts, then removal of that coyote will be considered. (CACC, 2020).

5.3c Coyote Incident Response Plans

All city coyote management plans include a coyote incident response plan. While coyote attacks on humans are rare in most cities, public trust requires coyote management teams to have a plan in place in case any attacks do occur (CACC, 2020). These coyote incident response plans not only outline strategies for dealing with more serious human-coyote conflicts but also help alleviate some public concerns over local coyote populations. While the exact details of a coyote incident response plan may vary depending on the city or State, all coyote incident response plans include a detailed, tiered list of human-coyote interactions (Table 5.). The type of human-coyote interaction that occurs will determine if any actions need to be taken or not. Some human-coyote interaction will not require any responses at all while other, more serious, human-coyote interactions will require hazing protocols, removal, or even lethal removal of the coyote (CACC, 2020).

In a typical coyote incident response plan, all human-coyote interactions are put into different categories in order to help managers determine what if any actions need to be taken (Gehrt, 2015). These categories include coyote observations, coyote sightings, coyote encounters, coyote incidents, and coyote attacks (Table 5.). A coyote observation is when no actual coyote is seen but there is evidence of a coyote in the area (CACC, 2020). This evidence can include coyote scat, coyote footprints, or even coyote vocalizations. A coyote sighting, however, is when a coyote is actually spotted in area but does not come close to any humans. Both coyote observations and sightings are considered normal coyote behavior which means there is no risk to public safety and the management team does not need to take any serious actions. If coyote observations and sightings are frequent the management team can provide educational resources to ease any public concerns that arise (CACC, 2020).

A coyote encounter is when a direct meeting between a human and a coyote occurs but with no physical contact (CACC, 2020). Coyote encounters are considered to be more serious interactions between humans and coyotes than coyote observations and sightings are. When a

coyote encounter does occur, the management team will use hazing protocols (outlined in their coyote hazing program) to discourage that coyote from approaching a human again (CACC, 2020).

Table 5. Adapted from Davis (2013). Tiered list of human-coyote interactions including coyote observations, sightings, encounters, incidents, and attacks. Helps managers assess how they should respond to a particular human-coyote interaction. Seriousness of interaction and response is indicated by color with green being the least serious (only requires monitoring) and red being the most serious (hazing and/or removal or lethal removal required).

Type of Coyote Interaction	Coyote Behavior	Management Responses
Coyote observation	Coyote footprints/scat found, or coyote heard	Normal coyote behavior, dispense educational material
Coyote sighting	Coyote seen moving in an area	Normal coyote behavior, dispense educational material
Coyote sighting	Coyote seen resting in an area	Normal coyote behavior, dispense educational material. Monitor if necessary
Coyote encounter	Coyote approaches or follows a person	Educate residents on hazing methods, safety tips, and pet management.
Coyote encounter	Coyote approaches or follows a person with a pet	Educate residents on hazing methods, safety tips, and pet management.
Coyote encounter	Coyote enters a garden with a pet present but does not injure pet	Educate residents on hazing methods, safety tips, pet management, and what attracts coyotes to yards
Coyote encounter	Coyote enters a garden with both people and pets present but no injuries occur to any parties	Collect info on coyote involved and create a report. Educate residents on hazing methods, safety tips, hazing, pet management, and what attracts coyotes to yards.
Coyote incident	Coyote enters a garden and injures/kills a pet	Collect info on coyote involved, create a report, and establish a hazing team. Educate residents on safety tips, pet management, and what attracts coyotes to yards.
Coyote incident	Coyote injures a pet on a leash	Collect info on coyote involved, create a report. Educate residents on safety tips, hazing, pet management, and what attracts coyotes to yards.
Coyote incident	Coyote shows aggressive behavior towards a person but no physical contact or injury	Collect info on coyote involved, create a report. Educate residents on safety tips, hazing, pet management, and what attracts coyotes to yards.
Coyote Attack	Coyote attacks and injures a person	Identify and collect info on coyote involved, create a report. If a person is injured Animal Control will lethally remove the coyote or contact the appropriate organization. Educate residents on safety tips, hazing, pet management, and what attracts coyotes to yards.

A coyote incident is an even more serious human-coyote interaction than a coyote encounter is. The two main types of coyote incidents are ones that involve humans and ones that involve pets. Coyote incidents involving pets are more common and are defined as incidents in which a coyote injures or kills a pet animal (CACC, 2020). Coyote attacks on pets are also further categorized as attacks on attended (leashed) or unattended (not on a leash) pets (Table 5). Coyote incidents involving humans are relatively rare and are defined as human-coyote interactions that include aggressive coyote behavior (CACC, 2020). Aggressive behavior can include a coyote raising its back fur, baring its teeth, growling, or even lunging towards a person. For both coyote incidents involving people and pets, coyote managers will first identify the coyote and then utilize hazing protocols as well as pet management education to reduce the likelihood of future incidents. If a particular coyote continues to be involved in incidents despite hazing attempts, removal or lethal removal of the coyote may be required (CACC, 2020).

A coyote attack refers specifically to an attack on a human and is considered to be the most serious form of human-coyote interactions (CACC, 2020). Coyote attacks can either be categorized as provoked or unprovoked attacks (Table 5). A provoked coyote attack is defined as one in which a human intentionally creates a conflict with a coyote. Most provoked attacks are caused by a person trying to feed a coyote or approaching a coyote den with pups (CACC, 2020). An unprovoked coyote attack is defined as one in which a coyote attacks a person for an unknown reason. In both cases involving a provoked or unprovoked coyote attack the coyote management team will conduct a thorough investigation on the causes of the attack itself and will then take appropriate actions. For coyote attacks these actions usually require either relocating the problem coyote to a new location or lethally removing the coyote (CACC, 2020).

6. Recommendations for the San Francisco Coyote Management Plan

Since 2003, the city of San Francisco has been managing its local coyote population (Todd, 2018). The main two organizations responsible for this coyote management are the San Francisco Animal Care and Control and the Presidio Trust. Both organizations have wildlife experts on staff and have been managing the city's coyote population for over a decade (Todd, 2018). Despite this, San Francisco still does not have a formal urban coyote management plan. Moreover, while the local coyote population is stable, there are also signs that the number of

coyotes in the city are gradually increasing (Todd, 2018). The creation of a formal coyote management plan could be beneficial for both the city's coyote population and the city residents. A formal management plan could also provide a framework for the future that the city could use to further reduce human-coyote conflicts and promote a greater degree of coexistence.

The new coyote management plan for San Francisco should be based on the many existing coyote management plans that other cities in California use. Many of these existing management plans incorporate the many elements of good wildlife management practices (Table 3). Additionally, many of these existing coyote management plans possess three key features that are required for successful coyote management (Buteau et al., 2021). These three key features are a robust public education program, a humane coyote hazing program, and a coyote incident response plan. In order for San Francisco's coyote management plan to be effective, the plan will need to include these key features as well. Moreover, since most coyote management plans use the same methods for both coyote hazing programs and coyote incident response plans, San Francisco's new coyote hazing program and incident response plan can be identical to the ones used by other cities in California.

6.1 Coyote Management Challenges in San Francisco

In San Francisco, the main challenge for the coyote management team is public ignorance. In an interview with a local coyote expert, Jonathan Young, it was revealed that many of the coyote management problems in the city are caused by the poor actions of city residents and visitors. The most common problematic actions include people intentionally feeding the coyotes and people letting their dogs roam freely (J. Young, Presidio Trust, pers. comm.). Both of these actions have contributed to a greater degree of coyote habituation which has then led to an increase in human-coyote conflicts in the city. These conflicts not only can cause an increase in public safety concerns but also create more dangers for both the coyotes and the coyote management team (Thompson et al., 2021). Moreover, while introducing stricter city laws, such as leash laws for dog owners, have helped discourage some bad resident behavior, new laws are not enough on their own (J. Young, Presidio Trust, pers. comm.). The introduction of a new public education program could also help reduce the number and likelihood of human-coyote conflicts.

Public education on coyotes can not only reduce human-coyote conflicts in San Francisco but also can have a positive effect on coyote health and safety. For instance, the two leading causes of coyote mortality in the city are roadside accidents and accidental poisonings by rodenticides (J. Young, Presidio Trust, pers. comm.). Both of these causes of coyote mortality can be reduced with proper public education. For example, roadside accidents can be reduced by educating residents on why speeding is dangerous and why speed limits should be observed and followed at all times (Gregory et al., 2021). In the case of rodenticides, public education can also provide residents with alternative methods for dealing with rodents that do not cause harm to coyotes (Morzillo and Schwartz, 2011). Finally, public education can help alleviate public fear of coyotes which, in turn, can reduce the likelihood of coyotes being harmed (J. Young, Presidio Trust, pers. comm.).

For a public education program to be effective in San Francisco, coyote managers will need to consider multiple education methods in order to reach as many city residents as possible. These education methods will include both utilizing different education mediums (flyers, websites, signage) and education strategies. The following section will focus on why education strategies are important and how these strategies can be best used in San Francisco.

6.2 Public Education Strategies

For San Francisco's coyote education program to work, the program needs to be able to convince city residents that coyotes are important native species that need to be protected. Convincing enough residents that coyotes need to be conserved, however, is not an easy task. As with many other conservation education programs, the main challenge for the coyote education program is a lack of public engagement (Warner et al., 2021). This lack of public engagement has several different causes. One major cause is that while many residents understand the concept of environmental conservation, they do not necessarily know how important conservation efforts are or how they can help in those efforts. Another issue is that there are different levels of engagement in conservation education among different demographics of residents (Warner et al., 2021). Coyote managers need to consider these education engagement challenges when creating a new public education program.

Studies have shown that people who are already involved in one conservation program are more likely to involve themselves in additional conservation programs. Similarly, people that engaged in any sort of non-formal environmental education were found to be more likely to engage in other environmental education programs as well (Warner et al., 2021). What this means is that the coyote managers in San Francisco could increase public engagement in the coyote education program by networking with other environmental conservation and education groups. Since the Bay Area already has many environmental education organizations and groups, connected the coyote education program with other conservation programs should not be difficult (J. Young, Presidio Trust, pers. comm.). Additionally, the more residents involved in conservation education programs, the more effective both coyote management and other wildlife management programs will be.

Another way that the coyote management team could encourage residents to participate in the coyote education program is by connecting that program to a sense of personal well-being and satisfaction. A study on water conservation education showed that people are more likely to participate in conservation programs and education if they can connect those programs with a sense of happiness and community connection (Warner et al., 2021). The main explanation offered in the study for these positive feelings was that people that contribute to conservation efforts were more likely to feel like they were making a positive difference for both their community and their local ecosystem (Warner et al., 2021). Similar results have been seen from coyote education programs used in other cities. Residents that learned more about the local coyotes were more likely to treat the coyotes as part of the urban ecosystem. This feeling of interconnectedness, in turn, reduced human-coyote conflicts and encourages coexistences (Crooks and Soulé, 1999).

Another important component for the coyote management team to consider is San Francisco's community demographics. Community demographics include the ages, sexes, and education levels of city residents. Studies have shown that residents in different demographic groups hold different attitudes towards local coyotes (Vaske and Sponarski, 2021). Depending on the specific group of residents, some people will have more positive or more negative perceptions of the coyotes. These positive or negative perceptions can affect the likelihood of human-coyote interactions and conflicts (Vaske and Sponarski, 2021).

Studies showed that residents that were older, male, or only had a high school level of education were more likely to view coyotes negatively. In contrast, residents that were younger, female, or had a college level of education were more likely to view coyotes positively (Vaske and Sponarski, 2021). Additionally, studies also showed that the demographics of people that viewed coyotes more positively also tended to have more basic knowledge about the coyotes (Vaske and Sponarski, 2021). What this means is that coyote education programs can be effective provided they are able to reach the demographics of residents that are more ignorant of coyotes. When creating the coyote education program for San Francisco, coyote managers need target the specific demographics of residents that are the least likely to know about the coyotes. To reach these groups of residents, coyote managers need to utilize different education mediums and terminology. Different education mediums can include signs in public parks or even local news segments. Regardless of what education medium is used, they all should feature basic information and safety tips regarding the local coyotes. Conveying this information in a simple and clear way will increase the public knowledge of the coyotes and further reduce fears and misconceptions.

Coyote education programs can also reduce conflicts between different groups of city residents (Buteau et al., 2021). For example, in San Francisco's many parks and greenspaces there is a major conflict between dog owners, non-dog owners, and coyote managers when it comes to letting dogs off leash. Because free roaming dogs are one of the major causes of human-coyote conflicts in the city, finding ways to convince dog owners to control their dogs better is a high priority (J. Young, Presidio Trust, pers. comm.). The best way to convince dog owners to keep control of their dogs is through a coyote education program. For example, if dog owners learn that keeping control of their dogs in coyote territories is a way to keep their dogs safer, dog owners will be more willing to do so. This type of education can also be extended to cat owners who will want to keep their cats safe from coyotes as well (J. Young, Presidio Trust, pers. comm.). As long as pet owners understand why controlling their pets is so important there will be fewer conflicts between them and coyote managers which, in turn, will reduce human-coyote conflicts.

San Francisco's coyote education program can also help resolve conflicts between city residents and the coyote management team with regards to rules and regulations (J. Young,

Presidio Trust, pers. comm.). That is, city residents are more likely to follow the rules and regulations regarding coyotes if they understand why those rules and regulations exist (Buteau et al., 2021). For example, if residents understand that the regulations against feeding the coyotes and letting dogs roam freely help reduce both coyote attacks and harm to the coyotes, those residents are more likely to follow the regulations (Thompson et al., 2021). Educating the public about these regulations can also help reduce feeling of confusion and resentment within the community which, in turn, can lead to greater cooperation with the coyote management team. The more cooperation there is between coyote managers and city residents, the more effective the coyote management program will be.

6.3 Coyote Tracking and Monitoring

Aside from a public education program, San Francisco's new coyote management plan will also need a coyote tracking and monitoring strategy. Both San Francisco Animal Care and Control and the Presidio Trust use common coyote trapping and tracking methods that have been proven to be effective for coyote management (Todd, 2018). The first step in tracking a coyote is trapping that coyote using a leg-hold trap or something similar. Leg-hold traps are designed to not cause much harm to animals and are commonly used by both coyote researchers and coyote management teams across the Country (Ellington and Gehrt, 2019). Regardless of what type of trap is used, the trap and its use must be first approved by the State of California and San Francisco (Thompson et al., 2021).

Once the coyote is trapped it will be anesthetized using a common animal tranquilizer called Telazol (Ellington and Gehrt, 2019). While the coyote is under anesthesia the coyote management team can collect important physiological information including the coyote's sex, weight, and body size. The management team will also collect a blood sample and hair and whiskers samples which can be used to help determine the coyote's genetics. This genetic information can help managers figure out which coyotes in the city are related to one another and which coyotes might come from populations outside of the city (Thompson et al., 2021). The management team can also examine the wear patterns on the coyote's teeth in order to get a rough estimate of the coyote's age. Depending on the wear patterns on the teeth, the coyote will either be classified as an adult (greater than 2 years of age) or a subadult (between 0 and 2 years

of age). Finally, the coyote will be tagged and fitted with a radio collar which can be tracked using a GPS signal (Thompson et al., 2021). Once the anesthesia has worn off and the coyote has fully recovered, the management team will then release the coyote back at the site it was originally captured from (Ellington and Gehrt, 2019).

The main way that coyote managers track coyotes is through the use of radio collars. These collars help managers track a coyote's daily movements around San Francisco (Todd, 2018). Collecting data on these daily movements can help managers learn vital information about the local coyotes. This information includes the sizes of individual coyote territories, which parts of the city coyotes typically go to forage for food, and where coyote dens might be located (Ellington and Gehrt, 2019). Locating coyote dens during pupping season is particularly important to help prevent potential human-coyote conflicts. If a coyote den is found in a public park, signage will need to be put up in order to warn residents to keep their distance. In cases in which a coyote den is found close to a hiking trail, that trail may be temporarily closed off to dogs, which are largely responsible for human-coyote conflicts (Todd, 2018).

While radio collars are helpful for keeping track of the daily movements of the coyotes, the coyote management team will also use colored tags to help identify individual coyotes at close range. These colored tags are placed in both of the ears of a coyote after it is captured. Each coyote will get a pair of tags with a specific color and specific symbol marked on them. This will allow managers to identify a particular coyote quickly using binoculars (Todd, 2018).

The colored tags also provide the management team with another method for tracking the coyotes which is through the observations of citizen scientists (J. Young, Presidio Trust, pers. comm.). Since the colored tags are easy to see, most city residents can be taught to identify a coyote at a safe distance using binoculars or a camera and then report that coyote to the management team. The management team can then use the data residents send in to supplement the data they already have. A good example of this method is Project Coyote on the iNaturalist website (Fig. 2). Project Coyote is a program that was first set up by Jonathan Young in 2016. This program allows city residents to post where and when they saw a particular coyote at a particular location in the city (J. Young, Presidio Trust, pers. comm.).

The Project Coyote program has been proven to be valuable and should be integrated with San Francisco's new coyote management plan. The more data collected on local coyote

movement patterns, the more information the management team will have when making new management decisions. Additionally, Project Coyote fulfills a major element of best urban wildlife management practices by encouraging community engagement (Table 3). By allowing individual residents to participate in coyote management, those residents will feel more connected to the coyote management team and the local coyote population.

6.4 Corridors and Greenspaces in San Francisco

While San Francisco does not have many urban corridors, the city does have many greenspaces that coyotes use (J. Young, Presidio Trust, pers. comm.). The coyote management team should consider these greenspaces when implementing the new coyote management plan. Data collected from both the Presidio Trust and Project Coyote have shown that many of these greenspaces serve as habitats, foraging grounds, and den locations for local coyotes (J. Young, Presidio Trust, pers. comm.). Additionally, many of these greenspaces are also public parks that city residents spend their free time in. This means that these greenspaces could potentially contribute to human-coyote conflicts (J. Young, Presidio Trust, pers. comm.). For this reason, the coyote management team should also focus their attention on managing these greenspaces so that both local coyotes and city residents can use these areas safely. The management team can increase public safety and reduce conflicts by posting information signs about the coyotes in public parks and by educating city residents about the local coyotes.

7. Conclusion

Urbanization in the 20th and 21st Century has created a need for new environmental conservation strategies. As cities around the United States grow, many conservation groups have started to refocus their efforts on protecting urban wildlife and maintaining urban habitats (Pierce et al., 2020). Part of these conservation efforts include identifying and protecting critical habitat patches within cities as well as maintaining preexisting natural corridors (Huber et al., 2011). Due to the damage and destruction that urban development has caused to both habitats and habitat connections, wildlife managers have needed to create new greenspaces and corridors that wildlife can use (Gregory et al., 2021). By creating new habitats and habitats connections,

wildlife managers can help restore both biodiversity and ecosystem function to urban environments (Huber et al., 2011).

Studies have shown the urban areas with more wildlife biodiversity are more able to sustain the ecosystem functions and services that benefit city residents (Katti et al., 2012). Moreover, studies have also shown that higher levels of wildlife biodiversity have a positive effect on both human health and the public perception of conservation (Sandifer et al., 2015). The more wildlife city residents see, the more likely those residents are to support new urban conservation efforts. The support of city residents is invaluable to urban wildlife managers which can then use that support to create new management programs (Apfelbeck et al., 2020).

As the role of new wildlife management programs has expanded in cities, so has the need to understand how urban environments affect animal behavior (Lowry et al., 2013). Cities are unique environments with many features that affect different animals in different ways. Some animals prosper in urban centers while other animals do not (Vardi et al., 2021). Urban wildlife managers need to understand what adaptations allow certain animals to thrive in urban areas and how management programs can be best implemented to assist them. This is particularly true for coyotes which are a relatively novel species to many urban residents (Buteau et al., 2021).

Coyotes are one of the few large predators in America that have successfully adapted to living in urban environments (Tigas et al., 2002). The main reason coyotes have been so successful in cities is that they are highly intelligent, have diverse diets, and can live in a variety of environmental conditions with ease (Thompson et al., 2021). As apex predators, coyotes also help maintain food web stability and biodiversity in cities by preying on mesopredators (Crooks and Soulé, 1999). Studies have shown that cities with larger coyote populations have more small bird biodiversity which, in turn, helps with urban seed dispersal (Kays and Dewan, 2004). Beyond this, urban coyotes can also indirectly assist city residents by controlling invasive pest species like Norway Rats which can spread diseases that cause harm to public health (Morzillo and Schwartz, 2011).

As coyotes have become more common in urban centers, human-coyote conflicts have become more common as well (Thompson et al., 2021). The vast majority of these conflicts are a result of coyotes becoming more habituated to humans as a result of bad human behavior. In most cities this bad human behavior including people feeding the coyotes and people letting their

dogs roam freely without a leash (J. Young, Presidio Trust, pers. comm.). Both of these types of human behavior have contributed to not only the number of human-coyote conflicts but the severity of conflicts as well. The prevalence of human-coyote conflicts in many cities has also reinforced the need for new urban coyote management plans. This is particularly true in cities like San Francisco where coyotes are still considered a relatively new addition (Todd, 2018).

While San Francisco has only been dealing with coyotes since 2003, many other cities in California and other states have been managing coyotes since the 1990's (Todd, 2018). A good example of this is Chicago's coyote management plan which has been proven to highly effective at reducing human-coyote conflicts and encouraging coexistence (CACC, 2020). The same can be said for the coyote management plans used by the cities Long Beach, Newport Beach, and Davis. All three of these cities have used the same coyote management plans for many years without much need for alteration. The reason all these coyote management plans have been successful is that they all include key features such as public education programs, humane coyote hazing programs, and coyote incident response plans. These key features help coyote managers reduce the likelihood of human-coyote conflicts, respond to conflicts when they do arise, and foster coexistence between residents and local coyotes (CACC, 2020). In the city of San Francisco, where the coyote population is gradually increasing, the creation of a new coyote management plan that includes these key features would be beneficial (Todd, 2018).

While San Francisco's experience with coyotes is not completely unique, the city's coyote managers have identified some specific challenges that impact coyote management. The first challenge is that, despite the best efforts of coyote managers, there are still many residents in the city that try to feed the coyotes or allow their dogs off leash (J. Young, Presidio Trust, pers. comm.). The frequency of these types of actions have contributed to coyote habituation which has resulted in an increase in human-coyote conflicts in the city. Moreover, coyote managers have identified that the best way to discourage residents from these behaviors is by creating new public education programs (J. Young, Presidio Trust, pers. comm.). Unfortunately, creating new and effective education programs is a challenge as well.

In order for San Francisco's new urban coyote management plan to be effective it will need to have an education program that can reach the many different communities of people that live in the city. To reach San Francisco's many different demographics of residents, coyote

mangers will need to learn which communities have the most education about coyotes and which communities do not (Vaske and Sponarski, 2021). This information will help the coyote management team design a public education program that can cater to specific groups of residents. Specifically, the management team should focus on educating dog owners, residents that want to feed the coyotes, and residents that are particularly fearful of coyotes (J. Young, Presidio Trust, pers. comm.). By educating these three specific groups, the management team can not only greatly reduce human-coyote conflicts in the city but can also encourage more coexistence.

Aside from including a new public education program, the new coyote management plan for San Francisco should also include a coyote tracking and monitoring method. Fortunately, both the San Francisco Animal Care and Control and the Presidio Trust already have coyote trapping and tracking strategies (Todd, 2018). These existing coyote trapping and tracking strategies are highly effective and can be easily adapted into the new coyote management plan. The new coyote management plan should also include Project Coyote which is a citizen scientist coyote tracking program created by Jonathan Young. This program not only provides managers with more data they can use to track local coyote movement patterns, but also encourages city residents to participate in coyote conservation (J. Young, Presidio Trust, pers. comm.).

The goal of San Francisco's new coyote management plan is to not only reduce human-coyote conflicts in the city but to also create a more positive environment in which both city residents and local coyotes can coexist. Achieving this goal will require coyote managers and city residents to work together. This can be accomplished through public education, community outreach, and volunteer programs like Project Coyote. Through the combined efforts of both the coyote management team and city residents, San Francisco can become a safer and healthier environment for both humans and coyotes for the future. Additionally, if this new coyote management plan is successful it can be used a template for other urban wildlife management programs in the city. The coyote is only one of many native species that live in San Francisco. The successful implementation of the coyote management plan will provide local wildlife ecologists and environmentalists with new opportunities to introduce new wildlife conservation and management programs that will further benefits both San Francisco's local wildlife and city residents.

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