
Photo: Dog Chasing Wildlife (Vance 2015)

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Preface

This capstone project is expected to be published by United States Department of Agriculture Animal and Plant Health Inspection Service Wildlife Services (USDA APHIS WS) as part of a technical series guide available to the public through the website (https://www.aphis.usda.gov/aphis/ourfocus/wildlifedamage/sa_reports/ct_wildlife+damage+management+technical+series). USDA APHIS WS is responsible for mitigating human-wildlife conflict and requires current updated guidance on available methods and resources employed to decrease conflict with feral, free-ranging, and feral dogs. The target audience for this project is USDA APHIS Wildlife Services employees and other local or federal agencies concerned with damage caused by free-ranging dogs. The general public may access it as well as others interested in feral dog damage and how to reduce conflict such as biological technicians, wildlife biologists, conservation biologists, local communities, tribal communities. This will be a general guidance as each community and situation will be different and require input from the local community. The project follows similar guides in organization and subject matter, however some sections for the purpose of the capstone project will not be published in the final version such as “Recommendations and Future Research.”
## Contents

**Human-Wildlife Conflict** ........................................................................................................... 6

- **Human Dimensions** ...................................................................................................................... 7
- **Natural Resources** .......................................................................................................................... 10
- **Human Health and Safety** ............................................................................................................. 12
- **Agriculture and Livestock** .......................................................................................................... 14

**Damage Identification** .................................................................................................................. 15

**Management Methods** ................................................................................................................ 17

- **Animal Husbandry** ..................................................................................................................... 18
- **Exclusion** ..................................................................................................................................... 19
- **Fertility Control** ........................................................................................................................... 20
- **Frightening and Aversive Techniques** .......................................................................................... 21
- **Guard Animals** ............................................................................................................................ 21
- **Habitat Modification** .................................................................................................................... 22
- **Repellents** ..................................................................................................................................... 23
- **Shooting** ....................................................................................................................................... 24
- **Toxicants** ...................................................................................................................................... 25
- **Fumigants** .................................................................................................................................... 25
- **Trapping** ....................................................................................................................................... 25
- **Disposal** ....................................................................................................................................... 35

**Economics** .................................................................................................................................... 36

**Species Overview** .......................................................................................................................... 37

- **Identification** ................................................................................................................................ 37
- **Physical Description** ..................................................................................................................... 37
- **Range** .......................................................................................................................................... 38
- **Tracks** .......................................................................................................................................... 38
- **Sign** .............................................................................................................................................. 39
- **Voice and Sounds** .......................................................................................................................... 39
- **Reproduction** ................................................................................................................................. 40
- **Dens** ............................................................................................................................................ 41
- **Mortality** ........................................................................................................................................ 41
- **Population Status** .......................................................................................................................... 41
- **Habitat** .......................................................................................................................................... 42
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Behavior</td>
<td>42</td>
</tr>
<tr>
<td>Food Habits</td>
<td>42</td>
</tr>
<tr>
<td>Legal Status</td>
<td>43</td>
</tr>
<tr>
<td>Recommendations and Future Research</td>
<td>43</td>
</tr>
<tr>
<td>Glossary</td>
<td>45</td>
</tr>
<tr>
<td>Resources</td>
<td>46</td>
</tr>
<tr>
<td>Appendix</td>
<td>53</td>
</tr>
</tbody>
</table>
Human-Wildlife Conflict

Domestic dogs (*Canis familiaris*) are common companion animals in households across the United States. People’s close relationship with dogs has distributed dogs everywhere humans exist. Dogs have been used for companionship, health aids, hunting, drafting, guarding, law enforcement, and food. Many classifications have described the status of dogs and their relationship to humans. Dogs can be categorized as owned or unowned, which can be further classified as owned restricted, owned unrestricted, stray, and feral (Jensen 2007; Smith et al. 2019). These categories are not static, and dogs may change their status throughout their lifetime (Jensen 2007; Figure 1). Dogs may be abandoned for a variety of reasons such as when the human-dog bond deteriorates due to unwanted behavior or the high costs of pet ownership (Herwijnen et al. 2018), hunting dogs may become lost, dogs may get displaced after a natural disaster, or the death of an owner. Abandoned dogs can become strays and feral dogs, and the reverse may also occur as feral dogs may be captured and adopted, becoming owned. Free-ranging dogs can include owned unrestricted dogs, such as livestock protection dogs, or community village dogs.

Human-wildlife conflict arises when human interests and values compete with wildlife activity. As the human population increases and encroaches in once wild areas, the result may be increased conflicts (Ditchkoff et al. 2006). The adaptability of dogs to different environments and food sources supplemented by humans enabled dispersal of feral and free-ranging individuals in urban, rural, and natural areas (Reese 2015). Feral and free-ranging dogs can cause several sociological, ecological, and economic conflicts with humans and wildlife, including negatively impacting endangered or threatened species, competing with native species for resources, hybridizing with wild canids, spreading disease, injuring or attacking people, or
damaging livestock (Bergman et al. 2009 Jan 1; Young et al. 2011; Hughes and Macdonald 2013).

Figure 1. Adapted model of feralization process based on Jensen (2007).

**Human Dimensions**

The human-animal bond is defined as a “unique, dynamic and two-way (reciprocated) relationship between a person and an animal, one in which each member can influence the other’s psychological and physiological state” (Samet et al. 2022). Companion animals have been shown to decrease loneliness, improve social relationships, provide health benefits, and provide related assistance services (Morgan et al. 2020; Samet et al. 2022). Dogs have evolved alongside humans for over 15,000 years, and people’s relationship with them has evolved and
changed to meet their needs (Samet et al. 2022). Dogs have been used to fulfill roles in guarding, hunting, protection, herding, hauling resources, police or military services, disability services, disease detection, laboratory research subjects, locating cryptic species for conservation, entertainment, and companionship in Western societies (Selby and Rhoades 1981; Hasiwa et al. 2011 Apr 1; Hackner and Pleil 2017; Jervis et al. 2018; Jean-Marie et al. 2019). Dogs may be restricted to the owner’s home, but some may freely roam in rural or urban environments making determination of ownership status difficult to assess.

Free-ranging dogs tend to be concentrated in neighborhoods experiencing greater economic distress and building abandonment (Reese 2015). The city of Detroit is estimated to have 3,000 to 7,692 dogs roaming free (Reese 2015). These communities lack resources to manage the problem and are at greater risk of negative impacts on individuals, communities, and dog welfare (Reese 2015). Free-ranging and feral dogs may be prone to poorer health and welfare outcomes (Smith et al. 2019). Urban environments tend to have fewer roaming dogs; however, the relationships between rural communities and their dogs allow more roaming and feral dog presence (Reese and Vertalka 2021).

Native Americans have used dogs to fulfill similar roles to Western societies. Dogs were important in transporting goods, teepee components, children, and other resources before horses were mainly used for transportation services (Jervis et al. 2018). Dogs are common sights on some reservations and serve the community by providing guarding services, entertainment, and companionship (Jervis et al. 2018). The Navajo Nation reports around 3,000 dog attack and bites each year and estimates around four to five dogs per household on the reservation or as many as 445,000 dogs in total (Chacón, 2021). The Native American Humane Society was founded in 2014 to help manage the growing concerns of dog overpopulation, dog attacks, and dog abuse on
reservations (Jervis et al. 2018). Tribal animal control officers, animal shelters, and animal rescue organizations are combining efforts to combat stray and feral dogs in New Mexico’s Navajo Nation reservation (Figure 2). However, more resources are required due to the large numbers of dogs (Chacón, 2021). Educational programs and community engagement to raise awareness, increase understanding, implement social change, and ensure compliance with wildlife management methods and regulations are important in human-wildlife conflict resolution.

Figure 2. Stray dogs fighting in Navajo Nation (Chacón 2021)
Natural Resources

Dogs are considered non-native species and can negatively impact environmental systems (Lepe et al. 2017; Morin et al. 2018). However, contradictory evidence of impacts range from negligible (Gompper 2021) to positive to deleterious (Hughes and Macdonald 2013). The presence of canines can influence wildlife behavior by inducing antipredator behaviors of flight, freezing, avoidance, hiding, or other altered behavior (Kats and Dill 1998; Weston and Stankowich 2013). Bobcats (Felis rufus), mule deer (Odocoileus hemionus), squirrels (Sciurus spp.), rabbits (Sylvilagus spp.), and red foxes (Vulpes vulpes) displayed spacial and temporal displacement in protected wilderness areas compared to areas prohibiting dogs (Lenth et al. 2008). The scent of dog urine or feces has been shown to induce avoidance response behavior from several species, including bobcats, deer (Odocoileus spp.), rabbits, elk (Cervus elaphus canadensis), beavers (Aplodontia rufa and Castor canadensis), and other species (Kats and Dill 1998). The disturbance caused by the presence of dogs can decrease the suitable habitat used by native wildlife communities and negatively impact species richness (Yen et al. 2019).

Dogs can function as non-native predators and be responsible for chasing, harassing, or killing several wildlife species ranging from small rodents, amphibians, and reptiles to large ungulates (Bergman et al. 2009; Young et al. 2011; Hughes and Macdonald 2013; Gompper 2021). Dogs may also compete for food or territory with other wild carnivores (Vanak and Gompper 2009; Hughes and Macdonald 2013). Most predation studies involving dogs and wildlife focus on a single threatened or endangered species. An estimated 156 threatened vertebrate species are negatively impacted by dogs (Doherty et al. 2016). Dogs have been implicated in the extinction of wildlife populations, including the marine iguana (Amblyrhynchus cristatus), kiwi (Apteryx mantelli), Hawaiian rail (Zapornia sandwicensis), and at least 10 other
vertebrate species (Hughes and Macdonald 2013; Doherty et al. 2017). There have been reports of dogs serving as prey and major food source for wild carnivores, such as lions (*Panthera leo*) and leopards (*Panthera pardus*; Hughes and Macdonald 2013). However, this raises the potential for increased disease transmission from dogs to wildlife. Dogs can serve as reservoirs and vectors for disease transmission to wildlife (Vanak and Gompper 2009). Rabies, parvovirus, and canine distemper virus can be transmitted from dogs to native wildlife (Bergman et al. 2009). Canine distemper has been linked to the decline of the endangered black-footed ferrets (*Mustela nigripes*; Suzan and Ceballos 2005; Bergman et al. 2009). Gompper et al. (2013) reported 168 dog pathogens shared between dogs and wild mammals, including viruses, helminths, protozoa, bacteria, and fungi.

The close lineage between dogs, wolves, and coyotes enables dogs to hybridize with wild canid species (Leonard et al. 2013; Gompper 2021). The negative impacts of hybridization include introgression, the introduction of maladaptive genetic material, and potential loss of legal status for protected species (Leonard et al. 2013). Introgression, introducing dog genes into the genetic pool of wild canids, can lead to decreased fitness and reduce wild canid reproduction and survival (Lescureux and Linnell 2014). The endangered Ethiopian wolf (*Canis simensis*) with around 500 individuals remaining, has been shown to successfully reproduce with dogs and may threaten the “genetic integrity” of remaining individuals, which is a major concern for the survival of this species (Young et al. 2011; Gottelli et al. 2013; Leonard et al. 2013). Hybridization can alter genetic material in the gene pool altering the purity of the species, as seen with the transfer of the melanistic coat color allele from dogs to coyotes and wolves in North America and Italy (Caniglia et al. 2013; Leonard et al. 2013). The occurrence of hybridization between dogs and wild canids is relatively low, perhaps due to differences in
mating behavior and biology, but the frequency of hybridization can increase for small populations of wild canids, resulting in difficulty finding a mate (Leonard et al. 2013; Lescureux and Linnell 2014). Managing hybridization rates may not be effective as the incidence is low and removal efforts could increase factors that lead to further hybridization (Lescureux and Linnell 2014; Gompper 2021). The rates of hybridization could be managed by controlling feral and free-ranging dog populations.

**Human Health and Safety**

Dogs can serve as vectors for viruses, bacteria, parasites, and fungi through direct or indirect contact (Rahman et al. 2020). The risk of pathogen transmission to humans depends on several factors, including the agent of pathogenicity, transmission pathway, and susceptible host (Center for Disease Control, CDC 2021). Common zoonotic diseases from dogs include brucellosis (*Brucella canis*), campylobacteriosis (*Campylobacter spp.*), ehrlichiosis (*Ehrlichia, Neorickettsia, Anaplasma*), leptospirosis (*Leptospira spp.*), Lyme disease (*Borrelia burgdorferi*), plague (*Yersinia pestis*), Rocky Mountain spotted fever (*Rickettsia rickettsia*), salmonellosis (*Salmonella spp.*), tularemia (*Francisella tularensis*), influenza virus, rabies (Lyssavirus), giardiasis (*Giardia intestinalis*), hookworms (*Ancylostoma spp.*), and roundworms (*Toxocara spp.*; Rahman et al. 2020).

The most notorious and lethal disease attributed to dogs is rabies, which is responsible for 59,000 human deaths annually worldwide (Pieracci et al. 2019). The canine rabies virus was eradicated in the United States through mass vaccination efforts, control of free-ranging dog populations, and enforcement of legislation for responsible pet ownership (Bergman et al. 2009 Jan 1; Velasco-Villa et al. 2017; Rahman et al. 2020). Most cases of rabies in the US are caused by spillover events from bats, foxes, raccoons, and skunks (Pieracci et al. 2019). The CDC lists
over 100 countries and political units considered high risk for importing dog rabies into the US (CDC 2022). Approximately 1.06 million dogs are imported into the US annually, which increases the potential of importing infected dogs (Pieracci et al. 2019).

Aggressive or fearful dogs may attack people, resulting in disease transmission, infection, disfigurement, death, amputation, paralysis, post-traumatic stress, and other physiological or psychological issues (Reese and Vertalka 2021). The average number of emergency room visits per year for dog bites was 337,103 from 2005 to 2013 (Loder 2019).

Modern water treatment procedures can eliminate most water pathogens from contamination occurring from free-ranging dogs (Saba and Balwan 2021); however, many rural and tribal areas may not have access to treated water. Proper washing of fruits and vegetables can decrease the risks associated with pathogen transmission from crops irrigated with contaminated water (Saba and Balwan 2021).

According to the Federal Aviation Administration’s (FAA) National Wildlife Strike Database (FAA 2022), dogs have been involved in 53 aviation strikes, with seven reporting substantial damage, eight minor damage, and one aircraft destroyed since 1990. Dogs may access airfields through open access points, by digging under fences, or escaping pet transport carriers and pose a danger to aircraft and human safety.

The “One Health” concept encourages global collaborations with wildlife biologists, physicians, veterinarians, agriculturists, and others to prevent and control zoonotic diseases (Rahman et al. 2020). With the current knowledge gaps and disease reporting, potential emerging problematic zoonotic diseases are difficult to predict. Further research, reporting, monitoring,
and collaboration across multiple disciplines are needed to understand the extent, impact, control, and prevention of emerging or re-emerging zoonotic diseases.

**Agriculture and Livestock**

The impact of feral and free-ranging dogs on agriculture can include crop damage, killing or spreading disease to livestock and pets, and damage to equipment or structures. Direct losses can be valued based on current market prices, and producers can incur high economic losses. Indirect losses are more difficult to quantify and can include increased labor, reduced livestock reproductive success or weight gain, and potential loss of the genetic material of the killed livestock (Macon 2020). In 2015, dogs were identified as killing 4,700 adult cattle, accounting for 11.3% of total adult cattle deaths due to predators (USDA 2015). In addition, dogs were responsible for killing 15,740 calves, accounting for 6.6% of total calf deaths due to predators (USDA 2015). In 2019, dogs were responsible for 24,240 of adult sheep losses and 23,310 of lamb losses (USDA 2020; see Appendix II for table of data). Other livestock for which losses are reported due to feral dogs include llamas, ostriches, rheas, emus, white-tailed deer, fallow deer, axis deer, and blackbuck antelope (Bergman et al. 2009).

Minimal information is available on the role of dogs in spreading disease to livestock; however, several diseases are shared between dogs and livestock. The dog is the definitive host of the parasite *Neospora caninum*, which sheds oocysts in their fecal material (Bergman et al. 2009). *N. caninum* is responsible for abortions in cattle, which can become infected through contaminated food or water sources (Bergman et al. 2009). The role of dogs in transmitting *N. caninum* to cattle is not well studied.

Feral dogs have been reported to damage corn, fruit and nut trees, melons, berries, grapes, and sunflowers (Green and Gipson 1994; Bergman et al. 2009). Melons are usually bitten
open with the insides eaten (Green and Gipson 1994). Dogs damaging drip irrigation, resulting in crop damage, has also been reported (Bergman et al. 2009). Feral dogs may dig through garbage cans, chew equipment, eat unattended pet food, or damage abandoned structures.

**Damage Identification**

Properly identifying predators is essential in selecting and implementing effective mitigation methods to decrease damage and conflicts. Investigative techniques are often required to identify the responsible species as field observation of events is unlikely (Dolbeer et al., 1994). Bias toward identifying wolves as the predator can lead to underestimating the role of dogs (Plumer et al. 2018). Distinguishing between different predator species is not always straightforward and may require collecting on-site evidence (Bergman et al. 2010; Plumer et al. 2018). Evidence can include wound marks, canine puncture width (Table 1), scat, hair, tracks, sightings, trail camera pictures, and DNA analysis (Bergman et al. 2010; Hopken et al. 2016; Plumer et al. 2018).

Domestic free-ranging dogs attack the hindquarters, flanks, and head of livestock, inflicting wounds on the neck, shoulders, and ears (Dolbeer et al., 1994). Dogs rarely kill for food and do not generally consume their victims (Green and Gipson 1994), but may scavenge on carcasses. Signs of predation should be distinguished from marks left by scavenging. Evidence of an attack can include blood on the ground and tissue hemorrhaging on the hide and muscle tissue, whereas scavenging may not show these signs. Measurements of canine punctures measured from the tip of the canine cusps to the tip of the companion canine cusp between maxillary or mandibular tips can be used to distinguish between coyotes and dogs (Dolbeer et al., 1994; Table 1). Removal of the hide of the animal will reveal signs of hemorrhaging and puncture marks for easier measurements (Figure 3). DNA analysis using predator saliva has
successfully identified dogs in killing sheep and ground-nesting birds (Hopken et al. 2016; Plumer et al. 2018). A combination of field observations and laboratory analysis is more likely to accurately identify predator species.

Figure 3. (a) Puncture marks from canine scavenger with no hemorrhaging and (b) puncture marks from wolf attack with hemorrhaging (Environment and Parks 2018)
Table 1. Measurements of canine spread for wild canids to aid in identifying predator (Verzuh et al. 2018)

<table>
<thead>
<tr>
<th>Species</th>
<th>Weight range (kg)</th>
<th>Upper intercanine width</th>
<th>Lower intercanine width</th>
</tr>
</thead>
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<tr>
<td></td>
<td></td>
<td>( n )</td>
<td>Range</td>
</tr>
<tr>
<td>Gray fox (male)</td>
<td>3.0–7.0^1</td>
<td>18</td>
<td>14.2–19.5</td>
</tr>
<tr>
<td>Gray fox (female)</td>
<td></td>
<td>21</td>
<td>14.2–18.1</td>
</tr>
<tr>
<td>Bobcat (male)</td>
<td>4.1–17.6^1</td>
<td>12</td>
<td>20.2–25.3</td>
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<tr>
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<td>12</td>
<td>20.4–23.1</td>
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<td>7.0–20.0^2</td>
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<td>640</td>
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<td>23.0–41.0^2</td>
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<td>36.0–103.0^2</td>
<td>19</td>
<td>35.0–48.0</td>
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<tr>
<td>Mountain lion (female)</td>
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<td>8</td>
<td>32.0–39.0</td>
</tr>
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Management Methods

The ultimate goal of management is to reduce or eliminate damage caused by wildlife. No single method is as effective as employing multiple approaches, which may even amplify the success of reducing conflict (Moreira-Arce et al. 2018). Various tools and methods have historically been used to manage feral and free-ranging dog populations. Legislation, education, and sterilization promoted by the Humane Society of the United States, American Humane Association, and National Animal Control Association, have decreased the numbers of stray and unwanted pets in shelters (Rowan and Kartal 2018). Local regulations concerning licensing, breeding, vaccination, leashing, and sterilization should be enforced to encourage responsible pet
ownership (Rowan and Kartal 2018). Local fines for abandoning dogs or compensation for damage inflicted by unconfined dogs may decrease the number of stray and free-ranging dogs. Societal and community values are important considerations when selecting management methods, and the local community should be involved in implementing widespread management decisions. Management methods can include lethal and non-lethal tools to reduce feral dog damage. Non-lethal methods include fencing, guard dogs, fladry (strips of material tied along a rope fence at 50 cm intervals), protective steel collars, and other deterrents (Treves et al. 2016). Lethal methods can include snares and shooting; however, lethal snares may kill non-target animals, and this outcome should be considered when selecting predator control methods (Treves et al. 2016). Predation by dogs has not been well-studied and remains an area for further research. Methods to control predation of livestock by dogs include those implemented for coyotes and wolves (See Appendix I for a summary of management methods).

**Animal Husbandry**

Animal husbandry involves care and management in livestock production and can include multiple methods. Implementing techniques can often be labor-intensive and require proper record keeping, building housing or pens, timing of breeding seasons, culling, and proper sanitation (Shivik 2004). Animal protection items such as plastic or metal collars used to protect livestock throat area; however, the effectiveness is short-term as the predator can become habituated (Shivik 2004; Bergman et al. 2020). Bringing livestock into corrals in the evening or during birthing reduces losses from predators (Shivik 2004; Bergman et al. 2020). Increasing the livestock density in an enclosure may increase the risk of disease transmission and increase stress for the animals (Shivik 2004). Reducing or eliminating food sources by properly disposing of waste or carcasses can reduce the attractiveness of the area to nearby predators (Shivik 2004).
**Exclusion**

Physical barriers preventing predator access have been used effectively in reducing predator and human conflict for several years. Constructing and maintaining fencing can be a costly expenditure. Fencing can vary in complexity from simple net wire to electric fences. In 2015, the estimated proportions of fencing operations were 6.1% cattle operations, 54.8% sheep operations, and 44% goat operations (USDA APHIS 2015). Fencing installed to block access to other canids, such as coyotes and wolves, is also effective for dogs. The horizontal spacing of net fencing should be less than 6 inches (15 cm), and the vertical spacing should be less than 4 inches (10 cm; Green and Gipson 1994). The fence should be at least 6 feet in height (1.8 m) to prevent jumping (Green and Gipson 1994). Barbed wire or a buried wire apron along the base of the fence can prevent digging (Green and Gipson 1994). Electric fencing comprising up to 12 alternating ground and charged wires has proven effective in deterring dogs (Green and Gipson 1994; Figure 4). Regular maintenance of electric fencing is required to ensure it is functioning properly. Vegetation should be trimmed to reduce weeds or grass from touching the electric fence since it can decrease voltage and effectiveness of the fence. Bears and moose have been shown to destroy electric fencing (Green and Gipson 1994), and electric fencing may restrict the movement of other local wildlife (Robley 2011). Fencing of refuse sites may help reduce feral dogs’ access to human-subsidized food sources and reduce their population numbers.
Fertility Control

Surgical sterilization is the primary method to control dog populations and can provide lifelong reproductive control (Dugassa et al. 2020). Sterilization may decrease unwanted behavior such as the propensity for roaming or pet abandonment (Dugassa et al. 2020). Trap, neuter, and release (TNR) programs for dogs are not conducted as they are for cats due to societal concerns regarding the negative health and welfare outcomes of unconfined dogs (Lepczyk et al. 2010). Feral or stray dogs may be trapped and sterilized, and then placed with humane societies or animal welfare groups for adoption if possible. Dogs that have been
surgically sterilized often have longer lifespans and better health (Massei and Miller 2013). Large-scale surgical sterilization can be difficult due to limited staffing, funding, or other necessary resources (Dugassa et al. 2020). Various methods for non-surgical sterilization of canines can include injectable, implantable, and oral contraceptives, usually involving hormonal treatments (Dugassa et al. 2020). Non-surgical sterilization methods have been studied for several decades; however, these studies have not resulted in commercially available products for long-term canine sterilization in the United States (Rhodes 2016).

**Frightening and Aversive Techniques**

Several visual and auditory devices have been used to frighten coyotes from areas where they may be engaging in damaging behaviors, and these devices should be similarly effective with feral dogs. Most frightening devices are only temporarily effective, and animals’ reactions can vary depending on prior experiences. Varying the device positions, appearance, or combinations can decrease habituation and prolong their effectiveness (Shivik 2004). Frightening devices and equipment include animated scarecrows, fladry, lights and alarms, and propane cannons. Law enforcement personnel and neighbors should be notified when using noise-generating devices to prevent undue alarm.

**Guard Animals**

Guard dogs have been used for centuries and are a cost-effective measure to reduce predator conflicts (Shivik 2004), however their effectiveness has not been evaluated for deterring free-ranging dogs. Livestock protection dogs (LPDs) generally stay with or near livestock and respond aggressively to repel predators. LPDs appear more confident and efficient when using two or more within a flock when confronted by a predator (Gompper 2013). LPDs have been effective in reducing livestock loss caused by free-ranging dogs, wolves, coyotes, lynx,
wolverines, bears, leopards, cheetahs, lions, and jackals (Gompper 2013). LPDs should generally be raised with the species of livestock they are to protect (Gompper 2013). The most common breeds used as LPDs worldwide are Akbash, Anatolian shepherd, Great Pyrenees, Komondor, Maremma, and Kangal (Gompper 2013). Dogs used as LPDs within the Navajo Reservation do not belong to one breed and result from crossing several breeds (Gompper 2013). Breed selection, rearing, training, and other influencing factors affect the potential success of a dog in its desired role (Gompper 2013). Problems encountered with LPDs can include roaming and leaving the livestock unprotected, inappropriate aggression toward livestock or humans, and chasing or harassing nearby wildlife (Gompper 2013). Monitoring of LPDs and correcting unwanted behavior can decrease these conflicts.

**Habitat Modification**

Habitat modification involves altering the landscape to reduce availability or access to food, water, and shelter for feral or free-ranging dogs. Food should not be provided for stray or feral dogs, and owned pets should be fed indoors or inside enclosures where feral dogs are undesired. Trash should be secured with lids or placed in enclosed areas (Figure 6). Refuse sites should have fences to prevent animals from scavenging. Abandoned buildings, equipment, and structures that can provide shelter should be removed or access to them restricted.
Repellents

Repellents can include chemical substances, sonic and ultrasonic devices or electronic repellent. Chemical repellents for canids have shown mixed or inconclusive results (Lehner et al. 1976; Wolski et al. 1984). Chemicals may be useful for preventing feral dogs from establishing scent stations or relieving themselves but have shown little value in protecting livestock or poultry (Lehner et al. 1976; Green and Gipson 1994). Available commercial sprays to use on surfaces contain methyl nonyl ketone to prevent urination or defecation by dogs in yards, but may adversely affect other animals like sheep (Lehner et al. 1976; Green and Gipson 1994). A field study spraying methyl nonyl ketone on garbage bags reduced scavenging by dogs by 40 %, however exclusionary methods to prevent scavenging appear more practical (Wolski et al. 1984).
Other registered chemical repellents include anise oil, Bitrex, capsaicin, d-limonene, dried blood, essential oils, naphthalene, nicotine, Ropel, thiram, thymol, and tobacco dust (Green and Gipson 1994). Capsaicin and anise oil used in dispensers for personal safety may be effective in protecting humans from dog attacks (Green and Gipson 1994). Ultrasonic frequencies or electronic repellents are devices generating a sound of ultrasonic frequency not audible to humans but to birds, rodents, canines, and other animals (Tiwari and Alam 2016). Electronic repellents appear to repel dogs when devices are turned on (Atheeb et al. 2021), however habituation may occur over time (Mason 1998). Safety and efficacy of acoustic systems require more research to determine their effects on the variety of animals likely to be exposed to the frequencies.

**Shooting**

Firearm use requires skill and training to ensure humane and safe conditions for animals and humans. Local laws and state regulations regarding firearm use for lethal removal of feral and free-ranging dogs should be consulted. The selection of firearms, calibers, and bullets varies depending on conditions in the field. A properly placed shot renders the animal immediately unconscious. The use of non-toxic bullets is recommended to prevent exposure of scavengers to lead. Accuracy can be enhanced with accessories such as night vision, illuminated or fiber optic sights, tripods or shooting stands, adjustable trigger assemblies, and stocks. Establishing blinds near refuse sites or known travel corridors can aid the lethal removal of feral dogs. Aerial operations are efficient for locating and killing feral dogs (Green and Gipson 1994). Generally, the greater the conflict, the higher the public acceptance of lethal management techniques (Gompper 2013).
**Toxicants**

No toxicants are widely used for feral dog population control in the United States. M-44 ejector devices are triggered by the bite and pull of a coyote or feral dog which activates the capsule containing cyanide powder into the animal’s mouth. Sodium cyanide used in the M-44 ejector device is registered by the Environmental Protection Agency (EPA) for controlling coyotes, red foxes, gray foxes, and wild dogs. State agencies should be consulted before use, and some states prohibit their use in specific areas or against certain species. Toxic collars containing Compound 1080 (sodium monofluoroacetate) placed on domestic animals are only registered for use against coyotes; however, they may kill depredating dogs if they puncture the collar (Green and Gipson 1994). Livestock protection collars are registered by the EPA, and state and local agencies should be consulted before application.

**Fumigants**

No fumigants are registered for the control of feral dogs in the United States. Fumigants are highly toxic and can have negative health impacts to humans and animals.

**Trapping**

Trapping is regulated by state and local laws, and agencies should be consulted before setting any traps. The Association of Fish and Wildlife Agencies provides best management practice trapping guides as a tool for recommended practices, equipment, and techniques to ensure the welfare of trapped animals, however there is no report issued specifically for dogs (White et al. 2021). Trapper education and training program opportunities are offered through state agencies, private organizations, and online. Dogs are protected by animal cruelty laws at local and state levels. Refer to state and local laws for the recommendation on frequency of checking traps as they may vary, however it is generally recommended to check traps at least
every 24 hours. Remote monitoring, such as cellular transmitting cameras, may help ensure traps are checked frequently.

Live traps should not be set during harsh weather conditions. Live traps effectively capture feral dog pups and occasionally adult dogs (Green and Gipson 1994; Figure 7). Poorly set traps can frighten dogs away and result in avoidance or trap-shy behavior. Always ensure the trap is functioning properly before setting. Successful trapping requires preparation, identifying placement sites near dens or travel routes, and estimating the numbers of feral dogs to determine the scope of the problem. Non-target animals should be examined for injuries and may be released at capture site or presented to local animal control agencies. Injured non-target animals should be provided veterinary care or euthanized if injuries are untreatable.

Baits commonly used to trap dogs involve protein-based baits (e.g., carrion, rabbit, poultry) and wet or dry commercial dog food (Green and Gipson 1994). Scent-free gloves may commonly be used when handling and setting traps to avoid transferring human scent on or near the trap. Location and placement of the trap should be considered carefully and if possible, avoid areas with high human presence to limit potential tampering with the trap or stressing trapped animals. Preparation can include equipment and handling techniques used for non-target trapped animals. Trapped dogs should be checked for microchips to determine whether they have an owner. If a lactating female is captured then efforts to locate dependent young pups should be quickly implemented for humane handling and treatment. Trapping techniques for coyotes and other canine predators should be as effective with dogs, however some methods may not have been specifically evaluated for dogs. Trapping methods can include cage traps, net traps, foothold traps, cable snares, and other techniques for carnivore predator control.
Cage Traps

Cage traps are considered to be more successful in urban environments or on young pups in rural areas. Adult feral dogs in rural environments may be more wary of cage traps than dogs in urban areas where human-made structures are more prevalent. Cage traps may be less selective than other traps and capture other species such as skunks (*Mephitidae spp.*), opossums (*Didelphidae spp.*), racoons (*Procyon lotor*), bobcats (*Lynx rufus*), and other non-target animals. Cage traps are made from wire mesh and available from commercial suppliers in a variety of sizes. A dog sized cage can vary depending on size of targeted dogs, and range from medium (42 x 15 x 15 inches) to large (60 x 20 x 28 inches) sizes. Most cage traps have a door attached to a wire trigger or pan that activates closure when the animal is inside (Figure 7). Some cage traps have an additional door for placement of bait or easier removal of trapped animal. Traps should be set on level surfaces and preferably in the shade. Check traps frequently or with a remote monitoring device to ensure humane treatment of trapped animals. A trapped dog may be transferred inside the cage with a blanket or other covering placed over the cage to provide shade and decrease stress of the trapped animal. To remove a live trapped dog from the cage a catchpole may be carefully inserted and looped around the dog’s head and tightened when on the dog’s neck.
Figure 7. Navajo Nation animal control officer resetting cage trap after capturing young stray dog (Chacón 2021)

Net Traps

Net traps can consist of a soft netting or bag which surrounds and entangles the targeted animal. Netting should be made from high-tensile material to hold medium to large dogs and withstand cutting or tearing from biting or chewing of trapped dog. Net traps include a variety of devices such as a handheld metal pole with a net, drop net with trigger device, net gun, or other configurations. Nets may have rubber weights to add along the sides to assist in holding the animal in place. Handheld nets can be used in close proximity to trap a loose or fleeing dog
similar to a catchpole. Drop nets may be used more frequently in rural environments and can be effective against dogs reluctant to enter cage traps. Drop nets can be constructed in a variety of methods depending on the environment and additional cables, ropes, or wooden poles may be employed (Figure 8; Jedrzejewski and Kamler 2004). Net guns may be used at a distance of 35 feet to capture dogs and may be used from a moving vehicle (Figure 9; National Review 2013) or helicopter. Net guns are reusable, require gas cartridges to fire, and are commercially available. The effectiveness of these products has not been evaluated.

Figure 8. Components of a drop net configuration (Jedrzejewski and Kamler 2004)
Figure 9. Detroit Dog Rescue (DDR) volunteer shoots net gun at fleeing dog (National Review 2013)

**Foothold traps**

Foothold traps come in a variety of sizes and are available from trap manufacturers. Sizes and types can vary depending on the manufacturer as there are no commonly used standards. Components of a foothold trap typically consist of two jaws attached to a plate with a pan-trigger. Different types of spring mechanisms close the jaws around the animal’s foot when they step on the pan (Figure 10; White et al. 2021). Pan tension can be set for more or less weight to more selectively set for the targeted animal. Traps are anchored by the attached chain with multiple swiveling mechanisms to allow the trap to turn with the trapped animal to reduce chance of injury. The chain and swivel system are secured by anchors or stakes into the ground to hold the trapped dog. Drags may also be used if soil conditions do not allow a traditional anchor or stake. Drags consist of hooks that drag along the ground as the animal moves towards shelter and can get hooked on vegetation or other terrain features (White et al. 2021). Traps
should be maintained in good working condition and tested prior to setting. Treating traps with wax can keep them from oxidizing and prolong their use in the field (White et al. 2021). A foothold trap is typically set by digging a shallow hole in the ground wide and deep enough to fit the trap with a stake or two attached to a chain and driven below to anchor it in place (White et al. 2021). A piece of cloth or other covering is used to prevent soil from interfering with the pan trigger and the trap is lightly covered with soil and other litter in the area (White et al. 2021). The trap may be placed in a trail the dog travels and with or without bait to lure the animal to the trap. Check traps according to state and local laws.

Figure 10. Example of a coil-spring padded foothold trap (White et al. 2021)

**Cable Devices**

Cable snares can be placed in a dog’s movement path to capture it by the leg or neck. Neck cable devices can be used to trap a live animal or as a lethal removal tool depending on the type of trap. Setting snares is not legal in all states, and those allowed for use in states have regulations regarding their utilization. State and local laws should be consulted before setting.
Cable snares may be set at openings in fences or along narrow trails used by dogs; however, caution should be used as they may kill or injure pets or livestock. Cable traps are made of standard steel cable with a loop of cable used to encircle the animal’s body (Figure 11). There are a variety of different types, sizes, and lengths available. Components of non-powered cable devices can consist of relaxing lock, break-away hooks, swivels, stabilizers, and other mechanisms (White et al. 2021). Relaxing locks allow for the loop to draw smaller around the animal as it pulls, but stops when the animal stops pulling (White et al. 2021). Break-away devices allow the animal to break-free if it pulls with sufficient force (White et al. 2021).

Different configurations are used depending on the body part of the animal targeted (e.g., foot or neck; White et al. 2021). The neck snare is set to allow the cable loop to slip over the dog’s head and tighten as it passes through where it can stop if there is a locking mechanism to prevent killing the dog. The snare should be strong enough that pulling, twisting, or chewing on the cable does not free the animal unless it is a break-away snare. Powered cable devices use a spring to activate the snare over the animal’s foot when triggered by a pan in a similar method to foothold traps (White et al. 2021). The snare tightens as the animal pulls its foot away from the device. An anchor or similar attachment is used to hold the trap in place. The Collarumᵀᴹ is a powered cable device that triggers when bitten and pulled by a canine (Huot and Bergman 2007). The Collarumᵀᴹ trap targets canine species and is less likely than cage traps to result in non-target captures and has a capture efficiency of 87% (Huot and Bergman 2007). Check traps according to state and local laws.
Handling and Euthanasia

Animal handling and euthanasia techniques should aim to minimize pain and distress in dogs before death. Consult all state and local laws prior to engaging in handling and euthanasia efforts. Properly trained personnel should apply the best methods under varied and challenging circumstances. The primary influencing factor in selecting the best method for euthanasia is the amount of control over the animal. Intravenous injection of a barbituric acid derivative by a licensed, certified, or trained professional is the preferred method for euthanizing dogs (Leary
and American Veterinary Medical Association 2020). Proper handling and equipment (gloves, goggles, catchpoles, muzzles, etc.) prevent unnecessary injury to the handler and animal (Johnson et al. 2018). Those working with feral or domestic dogs may be given preventative rabies and tetanus vaccinations (Johnson et al. 2018). Contact with claws, teeth, saliva, blood, urine, or feces should be avoided to prevent injury and disease. A catchpole can be used to help transfer a dog from a cage or trap to be transported for spaying, neutering, vaccination, or euthanasia. The noose of the catchpole should loop around the dog’s neck and the chord tightened until it fits snugly and can be used to guide the dog in the desired direction (Figure 12; Johnson et al. 2018). The pole should not be yanked or pulled, and once the dog is secured, the chord can be loosened for release (Johnson et al. 2018). Dogs are responsive to both the emotional tone of voice and language of humans, and speaking in a calm, relaxed tone can be soothing for the dog and handler (Jensen 2007). Proximity to humans can be stressful for feral or free-ranging dogs and they may need to be euthanized from a distance (Leary and American Veterinary Medical Association 2020). Shooting with a firearm should be performed by trained and proficient personnel. The firearm should be aimed to allow the projectile to enter the brain for immediate loss of consciousness (Leary and American Veterinary Medical Association 2020). A gunshot to the heart or neck does not render the animals unconscious immediately but may be used when other methods are impossible (Leary and American Veterinary Medical Association 2020). Remote chemical immobilization may be needed if the animal is to be captured alive, and a trained individual may administer injectable anesthetic agents (Leary and American Veterinary Medical Association 2020). Anesthetized dogs may be euthanized similarly to domestic dogs. The American Veterinary Medical Association publishes guidelines for the euthanasia of animals, which are periodically updated (Leary and American Veterinary Medical Association 2020).
Death should be verified by cessation of vital signs before appropriate disposal.

Figure 12. Navajo Nation animal control officer using a catchpole on a stray dog (Chacón 2021)

**Disposal**

Local and state authorities should be contacted for current information on carcass disposal laws and regulations. Disposal methods include above-ground burial, composting, below-ground burial, incineration, and disposal in a licensed landfill (Vantassel and Klng 2018). Carcasses requiring testing for diseases, such as rabies, should be handled according to laboratory instructions (Vantassel and Klng 2018). Dogs euthanized with pharmaceuticals should be incinerated or deeply buried to prevent secondary poisoning of scavenging wildlife (Wells et
Secondary poisoning of migratory birds or endangered species can result in civil fines ($25,000), criminal prosecution with $500,000 fines, and incarceration for up to 2 years (Leary and American Veterinary Medical Association 2020). Properly disposing of animal carcasses prevents the spread of zoonotic diseases, contamination of groundwater, and potential poisoning of wildlife and reduces human-wildlife conflicts (Vantassel and Klng 2018).

**Economics**

Feral dog damage in the US is estimated to exceed $620 million annually (Bergman et al. 2009). Direct costs can be estimated through current market prices of livestock, medical treatment costs, animal control, and management costs. Indirect losses are more difficult to determine and may incur further economic losses (Macon 2020). Damage to livestock in Texas due to feral dogs is estimated to incur over $5 million in costs annually (Bergman et al. 2009). It is estimated that for every dollar spent on predation management by livestock producers, around $10.88 worth of livestock is saved (Bodenchuk et al. 2013). In 2015, cattle operations cost an average of $3,000 for non-lethal control methods and $300 for lethal methods (USDA APHIS, 2015). In 2015, goat operations cost an average of $1,085 for non-lethal predator control methods and $444 for lethal methods (USDA APHIS, 2015). Compensation programs to pay producers for the loss of livestock to certain predators have had mixed success in reducing human-wildlife conflict (Macon 2020).

Animal control in large cities in the US reported an average per capita expenditure of $3.80 for the 2007/2008 budget year (Rowan 2018). The Department of Labor estimates around 14,600 animal control employees and 30,000 shelter workers (Rowan 2018). Animal sheltering and rescue expenditures are estimated at $8 per capita (Rowan 2018). Total animal control expenditures are estimated at around $1 billion annually with another $ 1.5 billion spent by
private entities (Rowan 2018). In 2021 the city of Montgomery, West Virginia, reported a group of 15 feral dogs responsible for killing several pets in the neighborhood (Tierney 2021). The city spent $5,000 to purchase a tranquilizer gun and darts to capture the dogs and transfer them to the county animal shelter (Tierney 2021).

Medical treatment for animal attacks and prophylactic vaccines can be costly to people and communities. Estimated costs per year for dog bite visits to the emergency department are at least $400 million in the US (Loder 2019). Regarding preventing the spread of rabies canine rabies, importation response and health care costs are estimated at $213,833 per event, which occurs almost annually (Pieracci et al. 2019).

Species Overview

Identification

*Canis familiaris* evolved from Eurasian gray wolves, with a domestication date of around 15,000 to 20,000 YBP (Spady and Ostrander 2008; Gompper 2013). Domestic dogs are part of the canid family, along with wolves, coyotes, foxes, and jackals. Feral dogs can be difficult to distinguish from owned or free-ranging domestic dogs. Feral dogs can survive and reproduce without depending on humans.

Physical Description

The domestic dog’s morphological and behavioral diversity levels exceed those of any other land mammal (Spady and Ostrander 2008). The American Kennel Club (AKC) recognizes 157 distinct dog breeds in the US (Spady and Ostrander 2008). Feral dogs have as many variations as their domestic counterparts and are diverse in body size, coat color, head shape, leg
length, and various other aspects. After breeding in the wild for a few generations, they may resemble German shepherds or husky breeds (Green and Gipson 1994).

Range

Dogs are the most widespread of the wild canids and exist on every continent except Antarctica (Gompper 2013). Feral dogs probably occur in all 50 states and wherever people are likely to allow dogs to roam free or abandon unwanted pets. Home range sizes of feral dogs depend on the presence and availability of their food sources, denning areas, shelter, and other resources (Jensen 2007). Home range sizes are smaller in urban environments or near areas with higher human populations, whereas they may exceed 50 square miles in rural areas (Green and Gipson 1994; Jensen 2007). Home ranges are defended using scent marking, vocalizations, and aggressive behavior (Jensen 2007).

Tracks

Tracks left by feral dogs depend on the size and weight of the animals. Dog tracks can resemble coyote tracks; however, they are rounder and show more prominent nail marks (Green and Gipson 1994). The tracks left by a group of feral dogs generally have various sizes and shapes, which can further distinguish them from those of a pack of coyotes (Green and Gipson 1994). Dog tracks are generally wider and have a larger triangular heel pad than coyotes (Figure 13). The German shepherd has a forepaw width of 2.6 in (6.5 cm) and a hind paw width of 2.2 in (5.6 cm; Bennett 2012). Four claws are often visible in dog tracks, whereas coyote tracks usually only have the middle two claws present. Track impressions vary according to weight, substrate composition, and weather conditions.
Figure 13. Dog prints with larger forefoot on left and smaller hindfoot on right (Thomson and Rose 2006)

**Sign**

Urine marking by male feral or free-ranging dogs occurs near territorial boundaries, whereas females mark near their dens (Pal 2003). Male dogs mark strange or unfamiliar objects or equipment (Pal 2003). Urine contains information about sex and possible social status (Jensen 2007). Defecation is also used for marking, and feces are often deposited in elevated areas, such as near fences or trunks (Jensen 2007). The morphology of dog scat can vary depending on the diet and health of the individual. Dog scat is usually tubular with tapered ends, its size varying with that of the dog. A medium-sized dog scat can be 1 in wide and 3 in long. Scat can also range in hues from light brown to dark brown.

**Voice and Sounds**

The vocal sounds of canines can be categorized into infantile whining, howling, aggressive growling, submissive whining, and territorial defensive barking (Jensen 2007). Dogs emit an abundance of barks in different social contexts, which appear to be adapted from living
alongside humans (Jensen 2007). Barking can be categorized into play, greeting, loneliness, aggression, distress, exploration, and care-giving (Jensen 2007). Dogs bark in a wide range of frequencies, often repeated over a long duration (Jensen 2007). Dogs can have harmonic barks and may express different emotions that humans can distinguish within the emotional context of aggressive-sounding barking versus non-aggressive barking (Jensen 2007).

**Reproduction**

Domestic dogs mating and reproduction differ greatly from other wild canid species. The domestication process may have reduced the fitness of dogs to adapt and thrive in wild environments. Monogamy, polygyny, promiscuity, polyandry, opportunity, and rape have been observed in free-ranging and feral dogs (Pal 2011). Feral dogs suffer from high juvenile mortality rates and depend on human-subsidized food sources (Jensen 2007). Generally, domestic dogs can breed twice a year without influence from the time of year or season (Jensen 2007). Estrus periods range between 6.5 and 10 months, with around 50% of births occurring from February through March and the remaining scattered throughout the other months of the year (Jensen 2007). There is no evidence of group care of litters, and all females appear to raise their pups alone (Jensen 2007). Lack of communal or paternal support for pups may contribute to the high predation rate of the young (Jensen 2007). Litter sizes range from 3.6 to 5.5 pups/litter with low survival rates (Jensen 2007). Litter compositions tend to favor males; however, females are more likely to survive into adulthood (Jensen 2007). Feral groups may be unable to retain their group size based on reproduction alone, requiring them to actively recruit free-ranging or stray dogs.
Dens

Feral dogs prefer areas offering shelter and protection from human disturbance and the elements. Dens may be burrows dug in the ground, and feral dogs are often found using former fox or coyote dens (Green and Gipson 1994). Abandoned buildings, vehicles, or other abandoned structures are often used for denning. Females spend most of their time in the den, only leaving to access nearby food sources (Jensen 2007).

Mortality

The life expectancy of owned domestic dogs can vary based on body size, with smaller dogs generally living longer than larger dogs, with a median longevity of 12 years (O’Neill et al. 2013; Yordy et al. 2020). The mortality of most feral dogs is caused by human activity, including culling, disease, and car accidents, which can cause more than 80% of adult mortality in some instances (Jensen 2007). Litters of feral dogs have a mortality rate of around 75%, with pups culled by people (Jensen 2007). Free-ranging or unowned dogs can have poorer health and welfare than their domestic counterparts (Smith et al. 2019).

Population Status

The domestic dog population in the United States is estimated to be 22.4 dogs per 100 people (Kartal and Rowan 2018). The highest numbers of dogs per 100 humans are found in rural communities (Kartal and Rowan 2018). The total numbers of dog populations are difficult to assess as there are regional differences within rural and urban owned and un-owned dog populations. Differences may relate to societal norms, management and control methods, community resources, and the carrying capacity of dogs.
Habitat

Feral dogs are found in a diverse range of habitats, including urban abandoned buildings, reservations, forests, farmlands, airports, and military installations. Attractive locations offer shelter from human activity with nearby food sources. Suitable habitats often have low densities of other large carnivores, such as wolves (Jensen 2007). Feral dogs’ survivability is linked to local laws and regulations, and their existence is probably due to non-enforcement or lack of resources to implement policies.

Behavior

The members of feral dog groups are usually unrelated and lack the rules or hierarchical structure of other wild canids, as seen in wolf packs (Jensen 2007). Feral dog groups may range from two to six and may be determined by the availability of food sources (Jensen 2007). Sexually mature adults may recruit stray or free-ranging dogs during their breeding period, which will then be accepted by other group members (Jensen 2007). Aggression between individuals does not affect the social hierarchy of the group (Jensen 2007). Aggressive behavior toward humans is influenced by the individuals’ experience with humans and whether they were previously owned (Jensen 2007). Feral dogs are mainly active during nocturnal and crepuscular periods, similar to other canid species; however, they may adapt their activity to avoid humans (Jensen 2007).

Food Habits

Feral dogs are opportunistic and have a varied diet, including carrion, waterfowl, native fruits, green vegetation, small mammals, livestock, and refuse from garbage (Green and Gipson 1994). Various other factors influence their feeding habits, such as the availability of prey animals, human presence, garbage dumps, and group size (Jensen 2007). The limited number of
studies on feral dog food sources indicate a dependence on humans for food (Jensen 2007). One case study found that removing a garbage dump resulted in no feral dogs less than a year later (Jensen 2007). Some studies found that free-ranging dogs caused more livestock or wildlife predation than feral dogs (Jensen 2007; Young et al. 2011). Village or stray dogs may be directly fed by households in the community, although they may deny owning or feeding the dogs (Jensen 2007).

**Legal Status**

Dogs are considered property in the legal system and, as such, may be regulated to protect health and human safety; 50 CFR § 28.43 and 36 CFR § 2.15 allow the respectful disposal of dogs in national wildlife refuges or parks, forests, and public property observed by authorized officials in the act of killing, injuring, harassing, or molesting humans, wildlife, or livestock in the interest of public safety, protection of wildlife, livestock, or other resources (2020; 2021). Several state laws permit the prosecution of dog owners or killing of dogs that chase or harass wildlife (Young et al. 2011). Some state laws, such as Arkansas AR ST § 15-41-302, fire or fine state employees who try to enforce a repealed statute prohibiting dogs from running at large in wildlife areas (2017). State laws and local ordinances vary regarding dogs and wildlife and should be consulted to ensure compliance.

**Recommendations and Future Research**

The current dog population in the US is estimated from “gray literature,” and even less is known about feral or free-ranging dog numbers. Accurate population assessments of the dog population are needed to allow the scope of the problem to be understood and addressed. There is a lack of rigorous scientific studies and research regarding feral or free-ranging dogs and their
interactions with wildlife, human health, and livestock. The threat or impact dogs can pose to wildlife or livestock remains largely unknown. Before and after studies of feral and free-ranging management methods would help understand whether removal has any unintended negative consequences on surrounding wildlife. Research is needed to demonstrate the effectiveness of predator management methods to enable evidence-based decision-making by livestock owners or local and federal government agencies.
Glossary

Feral dog: an ownerless or homeless wild dog.

Free-ranging/free-ranging dog: a dog that is not under the owner’s direct control.

Hybrid dog: a canid that is the progeny of a domestic dog (Canis familiaris) and a wild canid (e.g., gray wolf, coyote) or its subsequent progeny.

Stray dog: an ownerless or homeless dog.

Key Words

dog, Canis familiaris, feral, free-ranging, free-ranging, hybrid, predation, management, damage, trapping, control, human-wildlife, conflict
Resources


Appendix

Appendix I: Damage Management Methods for Feral Dogs

<table>
<thead>
<tr>
<th>Type of Control</th>
<th>Available Management Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animal Husbandry</td>
<td>• Record keeping&lt;br&gt;• Timing of breeding season&lt;br&gt;• Livestock pens or housing&lt;br&gt;• Culling older or sick livestock</td>
</tr>
<tr>
<td>Exclusion</td>
<td>• Fencing&lt;br&gt;• Net wires&lt;br&gt;• Electric fences&lt;br&gt;• Barbed wire or buried apron fencing</td>
</tr>
<tr>
<td>Fertility Control</td>
<td>Surgical sterilization</td>
</tr>
<tr>
<td>Frightening Devices</td>
<td>Multisensory devices (e.g., scarecrows, fladry, lights, and alarms)</td>
</tr>
<tr>
<td>Guard Animals</td>
<td>Livestock protection dogs, donkeys, mules, llamas, ostriches, and goats</td>
</tr>
<tr>
<td>Habitat Modification</td>
<td>• Eliminate or restrict access to food, water, and shelter.&lt;br&gt;• Properly contain and seal garbage containers or enclosed areas&lt;br&gt;• Proper disposal of dead livestock</td>
</tr>
<tr>
<td>Repellents</td>
<td>• Methyl nonyl ketone prevents urination or defecation in yards by dogs&lt;br&gt;• Capsaicin and oil of anise in personal safety dispenser for attacking dogs</td>
</tr>
<tr>
<td>Shooting</td>
<td>Allowed with proper federal state, and local permits and regulations</td>
</tr>
<tr>
<td>Toxicants</td>
<td>No toxicants are widely used for dog control in the US</td>
</tr>
<tr>
<td>Fumigants</td>
<td>No fumigants are registered for dog control in the US</td>
</tr>
<tr>
<td>Trapping</td>
<td>Cage traps, net traps, foothold traps, and cable snares allowed with proper federal, state and local permits and regulations</td>
</tr>
</tbody>
</table>
Appendix II: Number of predator death losses for livestock and percentage of predator death loss by dogs (USDA, 2015 & 2019)

<table>
<thead>
<tr>
<th>Animal</th>
<th>Total Deaths</th>
<th>Percentage of predator death loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult cattle</td>
<td>4,700</td>
<td>11.3</td>
</tr>
<tr>
<td>Young calves</td>
<td>15,740</td>
<td>6.6</td>
</tr>
<tr>
<td>Adult sheep</td>
<td>24,240</td>
<td>33.9</td>
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<tr>
<td>Young lambs</td>
<td>23,310</td>
<td>15.0</td>
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