# Idaho Pronghorn Management Plan


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# EXECUTIVE SUMMARY

Pronghorn (*Antilocapra americana*) are found only in North America, preferring open rangelands, prairie, grasslands, and sagebrush steppe habitats. Rangewide, pronghorn may have exceeded 30 million individuals prior to European settlement but declined to around 30,000 in the early 1920s then rebounded to current estimates of approximately one million individuals. In Idaho, the statewide population estimate is reported at 13,000 pronghorn but populations are not currently monitored at a level to provide a precise estimate. Several factors may be impacting pronghorn populations including habitat change (e.g., fire, development), movement barriers (e.g., fences, roads), predation, changing climate, and combinations thereof.

The Idaho Department of Fish and Game (IDFG) was established to preserve, protect, perpetuate, and manage all of Idaho's fish and wildlife. As such, species management plans are written to set statewide management direction to help fulfill IDFG's mission. The intent of this plan is to provide guidance for IDFG and their partners to implement management actions that will aid in conservation and management of pronghorn populations and guide harvest season recommendations for the next 6 years. Statewide management directions and strategies are identified for all management challenges. Implementation of all strategies will be subject to available funding and personnel. IDFG will develop annual plans to describe in more detail planned activities to address management directions and strategies outlined in this document. Additional reference material and data available in the Supplemental Document.

Overarching objectives and priorities of this plan include:

- Improve the quality of pronghorn population monitoring data to better estimate population size and understand population trends.
- Collaborate with private landowners, land management agencies, and others to incorporate measures in land use and resource management plans that benefit pronghorn habitat.
- Increase knowledge of pronghorn survival, habitat use, genetics, and other factors affecting pronghorn populations, movements, and migrations.
- Maintain or increase pronghorn numbers statewide while considering depredation concerns and changing habitat conditions.
- Maximize harvest opportunity and provide a diversity of hunting experiences.

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# INTRODUCTION

## Purpose

The Idaho Department of Fish and Game (IDFG) was established to preserve, protect, perpetuate, and manage all of Idaho's fish and wildlife. As such, species management plans are written to set statewide management direction to help fulfill IDFG's mission. Overall guidance for this plan is provided by the Idaho Fish and Game 2015 Strategic Plan (IDFG 2015) and the annual Direction document (IDFG 2022a). Additional information is provided by the Idaho Action Plan (V4.0) for Implementing the Department of the Interior Secretarial Order 3362 (IDFG 2022b), the policy for avian and mammalian predation management (IDFG 2000), the draft Idaho State Wildlife Action Plan (SWAP, IDFG 2022c), and the previous pronghorn management plan (Crenshaw 1991). We also incorporated insights from current scientific literature, state and province pronghorn management plans (AZ, CO, MT, NV, NM, SD, UT, WY, provinces of AB, SK), and guidelines from the Western Association of Fish and Wildlife Agencies (WAFWA). This plan identifies statewide management directions and strategies for all management challenges (see Management Directions) that will be used to set annual work plan activities and establish funding priorities, subject to available funding and personnel. Additional reference material and data are available in the Supplemental Document.

## Ecology

Pronghorn (*Antilocapra americana*) are endemic to North America, historically occupying open sagebrush and grassland communities across the central and western half of the continent (O'Gara and Yoakum 2004). A majority of pronghorn habitat in Idaho centers around sagebrush steppe communities throughout the southern portions of the state, but pronghorn are often found in most, if not all, of southern Idaho's open landscapes including mountain valley and alpine grasslands. Due to changes in these habitats and other stressors, pronghorn are proposed as a species of greatest conservation need (SGCN) in the current 2022 draft of the Idaho SWAP (IDFG 2022c).

Rangewide, pronghorn may have exceeded 30 million individuals prior to European settlement, followed by a precipitous decline to around 30,000 in the early 1920s (O'Gara and Yoakum 2004) and a conservation-driven rebound to current estimates of approximately one million individuals (Schroeder 2018). In Idaho, statewide population are not currently monitored at a level to provide a precise statewide estimate. However, estimates from past WAFWA pronghorn workshops report a statewide population of around 13,000 animals in recent years (Schroeder 2018).

Pronghorn males, females, and young of the year are known as bucks, does, and fawns, respectively. Bucks are characterized by a black cheek patch and

horns. Does can also have horns, although they tend to remain much smaller than those of bucks. Horns are made up of a bony core and an outer sheath that is shed every year (Davis et al. 2011). Pronghorn bucks typically attain maximum horn size by age 3 (O'Gara and Yoakum 2004, Monteith et al. 2013), which is earlier than other ungulates. Pronghorn in Idaho generally breed from mid-September to early October, with bucks defending harems or a territory (Deblinger and Alldredge 1989). Gestation is around 250 days with most fawns being born from late May to early June (Pojar and Miller 1984). Pronghorn does generally give birth to twins, but singles and triplets do occur to a far lesser degree (O'Gara and Yoakum 2004).

Pronghorn are the smallest big game ungulate in North America, yet have evolved the largest respiratory capacity (scaled to body size) to support increased oxygen uptake and endurance (O'Gara and Yoakum 2004). Their smaller size provides some advantages when it comes to speed; however, it also comes with disadvantages including a smaller digestive system which limits the quantity of food pronghorn are physically capable of ingesting. Thus, pronghorn require forage higher in carbohydrates, fats, protein, and digestible energy such as forbs and younger grasses. This need for high-quality forage can lead to reduced survival during harsh winter weather as they cannot eat enough lower quality forage to limit body fat loss (Hofman 1989).

Habitat

Pronghorn habitat in Idaho includes a variety of open vegetation types including sagebrush steppe, mountain valley grasslands, alpine grasslands, and agricultural fields. Typically, use across these landscapes varies by season with many pronghorn herds migrating from low elevation, drier winter ranges, to high elevation, wetter summer ranges. Winter movements are often driven by factors such as snow depth, while spring and summer migrations are primarily a product of pronghorn seeking forage that is higher in carbohydrates, fats, protein, and digestible energy. Pronghorn shift their diet from these more nutritious grasses and forbs during the growing season to shrubs during winter. Agricultural crops (e.g., alfalfa, winter wheat) may supplement or subsidize some populations during different times of the year, particularly where native habitat is degraded or unavailable (e.g., Camas Prairie, Panting et al. 2021).

As with most ungulates, population viability is influenced by adult female and fawn survival, both of which are often variable and linked to habitat condition and other factors (O'Gara and Yoakum 2004). Habitat structure (i.e., canopy cover and height) plays a significant role as fawns use a hiding strategy for the first 3 weeks of life and require horizontal obstruction (e.g., areas with taller herbaceous vegetation or slight depressions in the ground) to avoid predators (Barrett 1981, Alldredge et al. 1991). Shrub canopy also likely provides some

additional protection from golden eagles, a significant predator of pronghorn fawns in some systems (Bodie 1979, Panting et al. 2021).

Although several modeling approaches have been used to improve understanding of pronghorn habitat use and distribution (e.g., Leu et al. 2011 Jakes et al. 2020, Zeller et al. 2021), none provide potential distribution for pronghorn in Idaho using the most current observation data. To aid in development of this management plan, we developed a model of pronghorn annual distribution using a subset of current location data and several environmental variables likely to influence distribution. Modeled potential habitat included 37% (30,792 $mi^2$ [79,750 $km^2$]) of Idaho; however, few pronghorn may regularly occur in some areas despite the presence of modeled suitable habitat due to local variation in habitat quality or other site-specific factors (e.g., invasive plants, fire, fences, competition, vegetation structure).

### Summer & Winter Range Distributions

Long-distance migrations between summer and winter ranges make it difficult to manage populations based on Game Management Units (GMUs). Recent research on Idaho pronghorn indicates management planning will likely be most effective if focused on subpopulations (Gese et al. *in review*). Thus, in this plan, pronghorn herds and the area they inhabit are divided into summer range distributions (SRD) and winter range distributions (WRD) that approximate subpopulations (Figure 1, extent = 35,596 $mi^2$ [92,192 $km^2$]). These biologically meaningful units are based on current knowledge of habitat, seasonal ranges, migration patterns, and connectivity among herds. Some SRDs and WRDs are relatively well-defined with location data from pronghorn fitted with Global Positioning System (GPS) collars, while others are delineated by best biological opinion because data on migrations and seasonal ranges are not available.

Movements among SRDs and WRDs are not completely understood with little to no migration in some areas and extensive dispersal in others. The extent of some WRDs may also vary with winter severity and snow depth as pronghorn concentrate near food sources or in areas with the least amount of snow. Additional information on population structure, connectivity, and interactions among all SRDs and WRDs will help refine these boundaries and benefit management. Population status and objective, harvest, current management considerations, and detailed maps for each SRD, WRD, or SRD/WRD combination (for herds with little to no migration) are provided in the Supplemental Document.

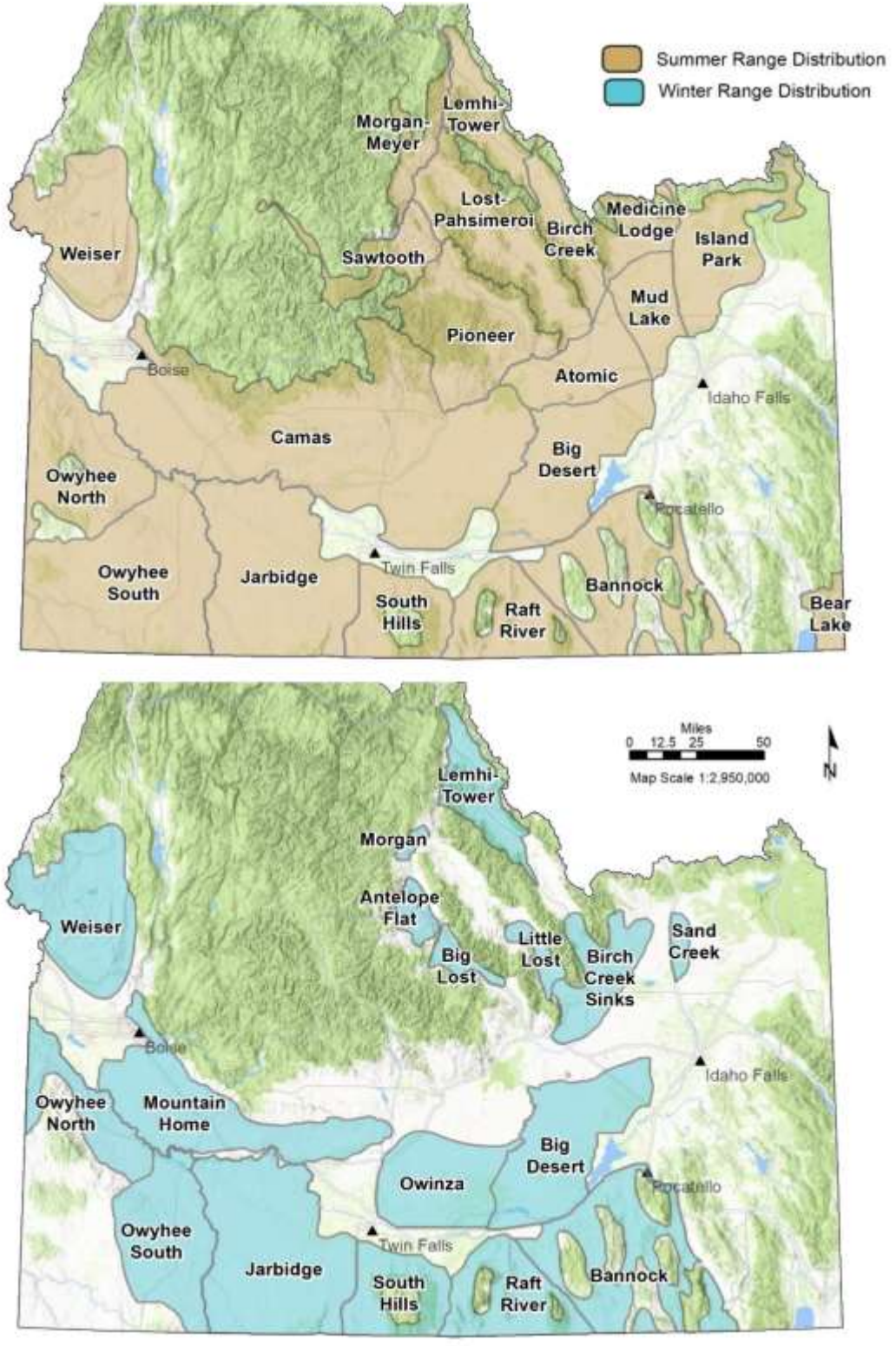


Figure 1. Pronghorn summer (top) and winter (bottom) range distributions in Idaho.

## Movement & Migration

Many ungulates migrate seasonally (i.e., use distinct areas for winter and summer) across large areas of the western US to avoid severe winter conditions and access key resources, such as forage (Kauffman et al. 2020, 2021, 2022). As forage quality and quantity shift across the landscape with temperature and precipitation changes, migration behavior shifts as well, typically resulting in animals moving to higher elevations in the spring and summer to obtain higher quality forage and lower elevations in autumn and early winter to avoid deep snow. It is believed that migratory behavior allows populations to exist at higher numbers relative to species with less mobile life histories. In theory, this occurs because migrating ungulates can exploit more nutritious vegetation resources over longer periods of time by "surfing the green wave" of younger plants throughout the growing season (Aikens et al. 2020). Extended access to high-quality forage typically results in improved body condition, leading to increased survival and reproductive output of migratory individuals (Barnowe-Meyer et al. 2017, Aikens et al. 2020, Jones et al. 2020, Kauffman et al. 2021). For example, seasonally migratory pronghorn have an increased survivorship relative to resident individuals (7% on average, Jones et al. 2020).

Recent research has shown that the composition and position of vegetation on the landscape often dictates the length and duration of seasonal migration for ungulate species (Aikens et al. 2020). In general, spring migration for Idaho pronghorn occurs from mid-March to late April and autumn migration from early October to early December (Kauffman et al. 2022). However, pronghorn tend to show variability in timing of migration and some flexibility in migration distances depending on environmental conditions (Hoskinson and Tester 1980, Barnowe-Meyer et al. 2017, Collins 2016, Jakes et al. 2018). Further, short-distance daily movements are common (Dalton 2009, Jones et al. 2017, Reinking et al. 2019) and individual pronghorn in Idaho are known to move >20 mi (32 km) during winter to find snow-free areas (Bergen et al. 2022).

Along migration routes, animals may spend extended time foraging or resting in specific areas known as stopovers (Sawyer and Kauffman 2011). Not all herds, nor even individuals within the same herd, use the same routes or the same stopovers. Knowledge of migratory routes for ungulates appears to be learned behavior, making restoration of lost migrations extremely difficult and taking 30–80 years for reintroduced populations to develop migratory behaviors in a new landscape (Jesmer et al. 2018). Thus, conservation of the diverse migratory behaviors of animals in an area may be as important as conservation of the migration route itself (Kauffman et al. 2021) and may promote more stable populations in some ungulates (Lowrey et al. 2020). Furthermore, identifying locations of stopovers is equally important for guiding future land management decisions as these areas can be extremely important

for migrating individuals. Methodology for accurately mapping stopover locations for pronghorn needs to be developed (Bergen et al. 2022).

The Idaho Action Plan (IDFG 2022b) provides a framework for habitat and technical assistance on big game migrations in the state. The plan identifies priority areas and corresponding management efforts across jurisdictions and is intended to be updated on an annual or biennial basis. It also establishes opportunities for partnership with Idaho Transportation Department (ITD) and others. The current version identifies 5 priority areas for managing pronghorn, mule deer (*Odocoileus hemionus*), and elk (*Cervus canadensis*) winter range and migration habitat in Idaho and highlights ongoing and new priority management needs. Pronghorn SRDs and WRDs that overlap these priority areas include Atomic, Bear Lake, Birch Creek, Camas, Island Park, Medicine Lodge, and Mud Lake SRDs, Birch Creek Sinks, Mountain Home, and Sand Creek WRDs, and Big Desert and Lemhi-Tower SRD/WRDs.

*General Migration Strategies of Idaho Pronghorn*

In Idaho, pronghorn appear to follow 3 general migration strategies: (1) relatively nonmigratory residents or short-distance migrants with partially to completely overlapping summer and winter ranges, (2) animals from multiple isolated winter ranges converging on a single summer range, or (3) animals from a single winter range dispersing to multiple isolated summer ranges. Current GPS data suggest examples of each strategy include Owyhee North and Big Desert SRD/WRDs (strategy 1), Mountain Home and Owinza WRDs with Camas SRD (strategy 2), and multiple SRDs with Birch Creek Sinks WRD (strategy 3) (Figure 2).

While some individuals occupy the same range year-round, others travel extensive distances (>209 km, >130 mi) during migrations (Kauffman et al. 2022). Switching tactics (e.g., resident to migrant) or seasonal range locations have also been documented in adjacent states (White et al. 2007, Barnowe-Meyer et al. 2013, Jakes et al. 2018). Although IDFG has been acquiring pronghorn location data with GPS collars since 2004, data are still limited in many areas and other seasonal migration tactics and strategies of pronghorn may exist. Complementary to population-level analyses, long-term data on individuals are needed to evaluate the fidelity of seasonal migration tactics and why individual animals may migrate some years but forgo movements in others. Continued development and refinement of range and migration routes will be instrumental in prioritizing areas for conservation and management, designing appropriate hunt structures, and implementing habitat improvement projects, as well as improving IDFG's ability to provide technical services to land management agencies.

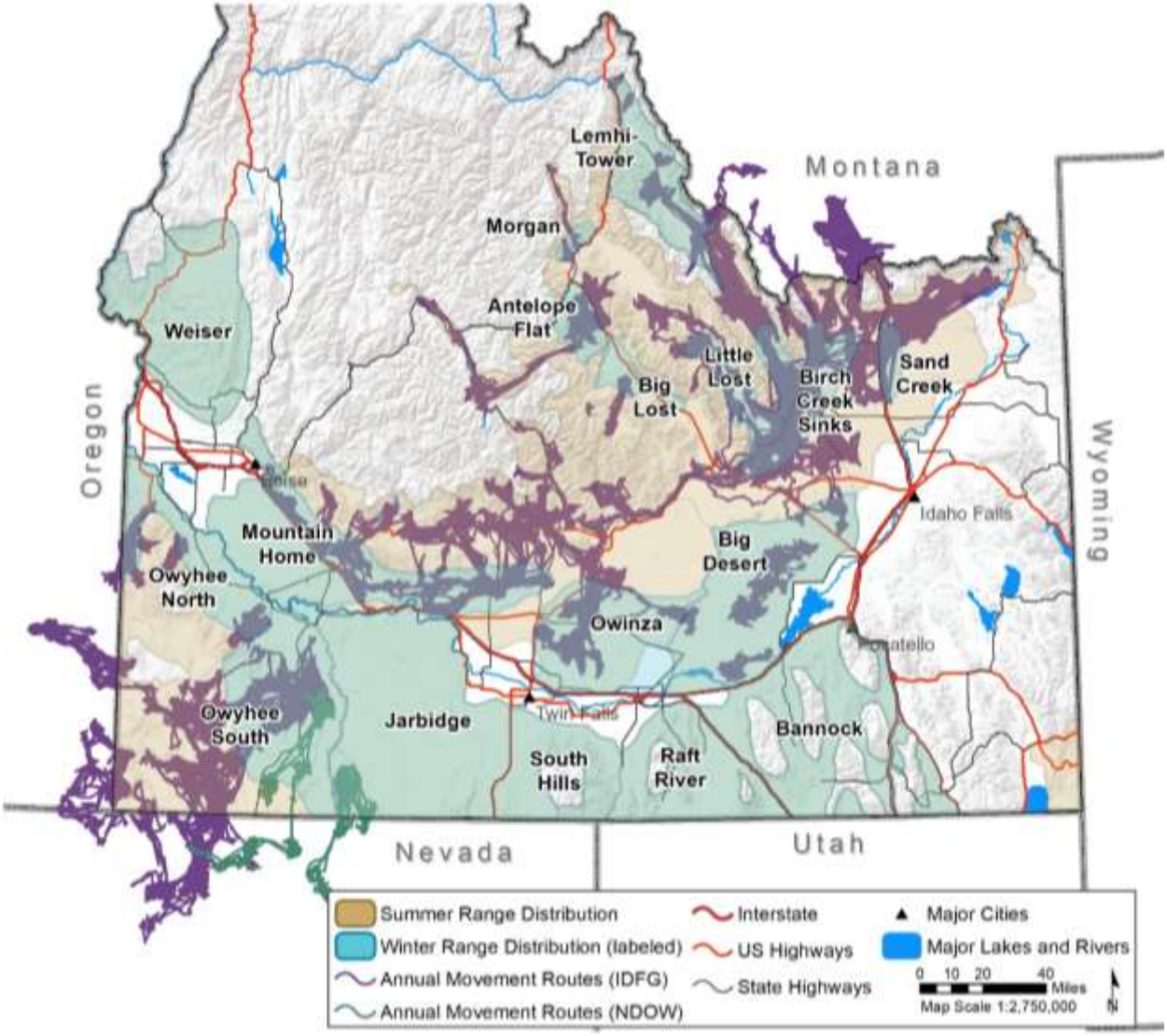


Figure 2. Biologist-identified summer and winter (labeled) range distributions of pronghorn overlaid with annual movement routes of GPS-collared animals ($n$ = 283) in Idaho, 2004–2022. Data provided by Nevada Department of Wildlife (NDOW) ($n$ = 5) identified separately. Additional movement routes have not yet been mapped.

## Harvest Management

Wildlife managers incorporate many factors to determine harvest strategies for pronghorn such as habitat conditions, hunter preferences, population size and trajectory, herd composition, population vital metrics, depredations, and harvest statistics. These factors, as well as the availability of these data, can vary substantially from year to year and among different geographic areas. Because data on pronghorn populations are limited, managers have relied largely on harvest metrics and hunter preferences to set harvest seasons.

Season timing, length, and weapon types are factors that influence harvest rates and pronghorn behavior. Input from hunters has indicated a preference for adjustments to the timing and length of pronghorn seasons so they do not interfere with the opportunity to participate in hunts for other big game species. Consequently, the opening of pronghorn seasons has occurred prior to openings of deer and elk hunts, meaning most hunting opportunity occurs during the pronghorn breeding season (mid-September to early October). Pronghorn seasons have been consistent across Idaho for many decades. However, where populations are in decline, occur at low-density, or are widely dispersed, managers may need greater flexibility in season length, timing, or weapon type to meet management objectives or to provide a diversity of hunting experiences.

*Hunting Opportunity & Odds of Drawing*

There are no general season opportunities for pronghorn in Idaho with all tags being allocated through a controlled hunt draw system. Idaho offers a variety of hunt types with different weapon choices to meet varied biological needs and social parameters (Table 1). Doe- or fawn-only hunts are offered to provide additional opportunity in areas where populations are increasing, to maintain or reduce population growth, or to address depredation complaints. Doe harvest rates vary based on herd status (above or below objective), potential for depredations to stored or standing crops, and reproductive rates (e.g., fawn ratios). Either-sex hunts are offered because some female pronghorn have horns and bucks shed their horn sheaths in late October to November, making identification difficult. Harvest reports indicate bucks are primarily targeted on either-sex hunts (93% on 2021 any-weapon hunts).

Archery hunting participation and harvest nearly tripled in Idaho between 2002 and 2020, while numbers of all other hunters increased only slightly (Figure 3). Because reliable population data on pronghorn are lacking in many areas, impacts of this increased harvest are unknown. Concerns with the increased archery participation to date have largely been social, such as potential hunter crowding in certain areas and increased hunter competition for water holes. In addition, an increasing number of applicants for a consistent number of any-weapon, either-sex tags have resulted in decreasing draw odds (Figure 4). Steps to address this issue have included changing archery from a general season to controlled hunts (2009), converting unlimited controlled hunts to first-choice only applications (2021), and adopting a rule in which hunters who drew an either-sex pronghorn tag became ineligible to apply for any limited pronghorn tag during the first application period of the following year (2021).

Table 1. Pronghorn hunting opportunity, including various hunt types and metrics, during the 2022 hunting season in Idaho.

| Hunt Type | Total Tags Available | Number of Hunts | 2022 Avg. Drawing Odds | Total Harvest | Avg. Success Rate |
|---|---|---|---|---|---|
| Any-weapon (Either-sex) | 1,095 | 24 | 4.0% | 807 | 76% |
| Archery-only (Either-sex) | 3,195 | 17 | N/A* | 490 | 20% |
| Muzzleloader-only (Either-sex) | 230 | 5 | 28.6% | 105 | 52% |
| Short-Range-Weapon-only (Either-sex) | 45 | 2 | 15.3% | 20 | 52% |
| Doe- or Fawn-only Tags (any-weapon) | 150 | 3 | 21.9% | 82 | 61% |
| Youth-only (various sex and weapon types) | 95 | 5 | 19.3% | 53 | 63% |
| Landowner Permission (extra Doe- or Fawn-only) | 75 | 2 | N/A* | 39 | 69% |
| TOTAL | 4,810 | 56 | | 1,596 | 40% |

*Average drawing odds for archery-only and Landowner permission hunts not calculated because unlimited controlled hunts are included in this summary. For archery-only hunts with limited tags, 2022 average drawing odds equaled 58% for 410 tags.

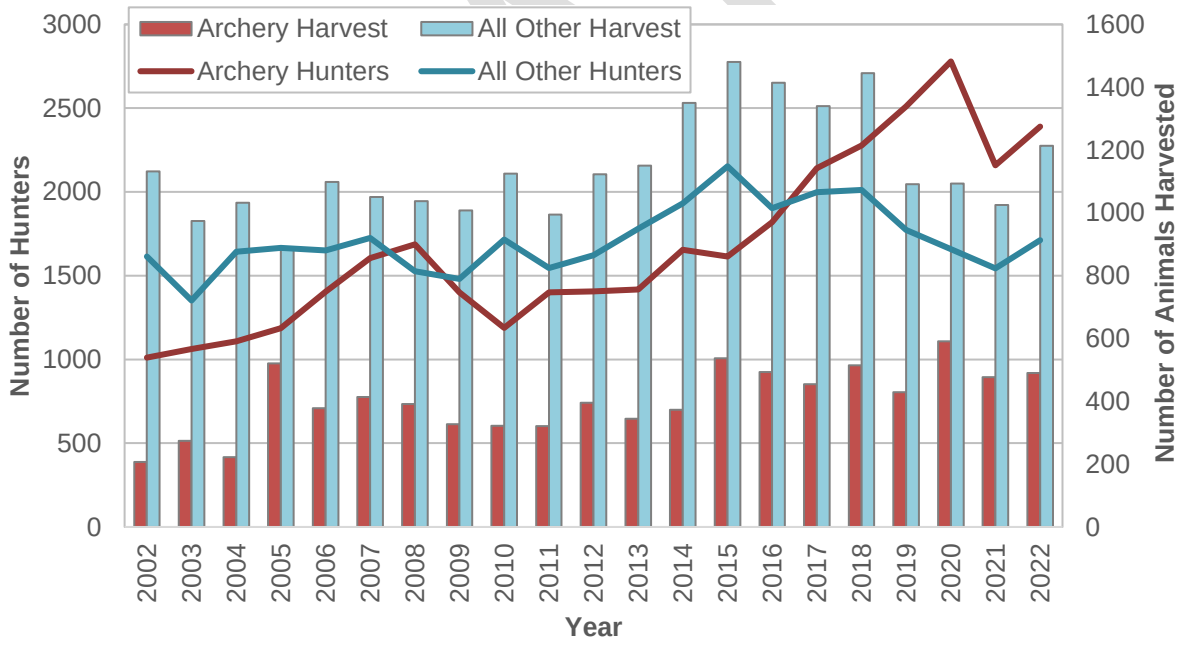


Figure 3. Total number of pronghorn hunters and harvest by weapon type (archery versus all other) in Idaho, 2002–2022. Archery-only pronghorn opportunity switched from a general season across the state to unlimited controlled opportunity in 2009.

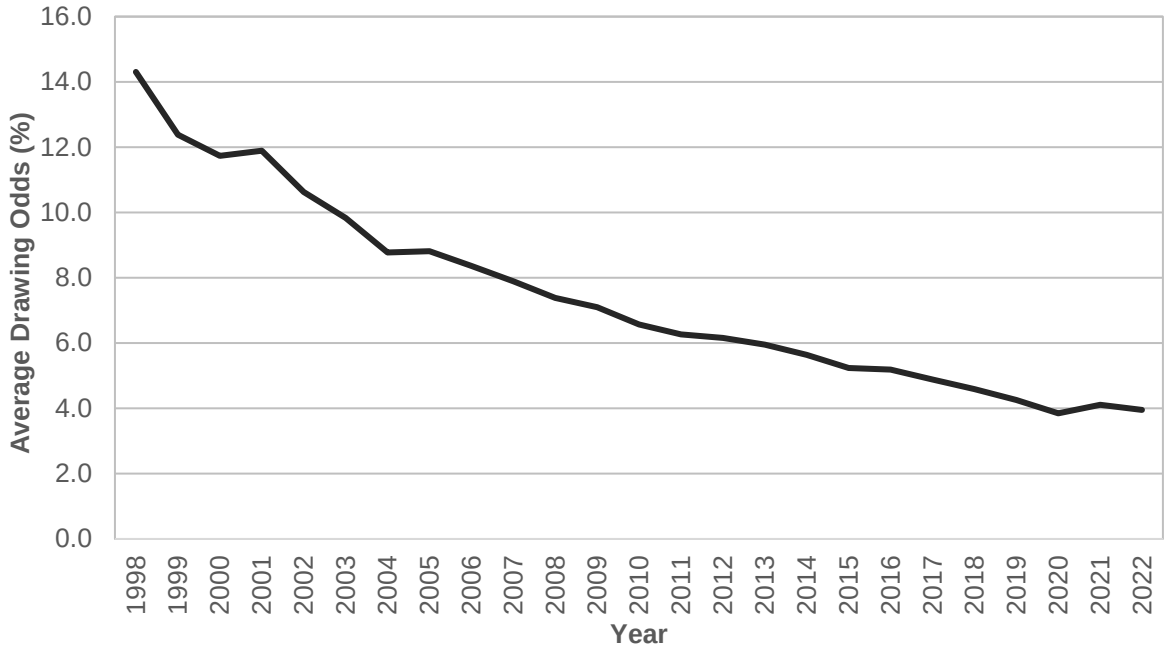


Figure 4. Average drawing odds for any-weapon, either-sex pronghorn tags in Idaho, 1998–2022.

*Seasonal Exposure to Hunting Pressure*

Seasonally migratory pronghorn covering long-distances may experience increased exposure to multiple hunting pressures throughout the migration period. Likewise, the effects of harvest management may be dispersed with implications beyond the original targeted management action. For example, GPS location data indicate some animals summering in the Little Wood River basin at the base of the Pioneer Mountains migrate to winter range near Birch Creek from early October through late November. If these animals continue to follow similar paths between summer range (Pioneer SRD) and winter range (Birch Creek Sinks WRD) during similar time periods, an individual animal may be subject to nearly continuous hunting exposure from 15 August to 30 November, over 100 days in 9 different controlled hunt areas based on 2021 and 2022 seasons (Figure 5, Animal A). In comparison, an animal with resident or short-distance migration behavior would only be exposed to the hunt structure of that area. For example, a short-distance migrant from Copper Basin to the Big Lost River would only be exposed 15 August to 15 September (Archery-only, Controlled Hunt Area [CHA] 49-1) and 25 September to 24 October (Any-weapon, CHA 49), a total of 64 days (Figure 5, Animal B).

Given the broad extent of annual pronghorn migration routes and range of migration strategies in Idaho, differences in control hunt exposure are to be expected. Not only are pronghorn exposed to different harvest strategies in 4 IDFG regions, but also 4 other states (Montana, Oregon, Nevada, and Utah). Further coordination among IDFG regions and neighboring states on the

timing and placement of control hunts is warranted to achieve desired results and meet management objectives.

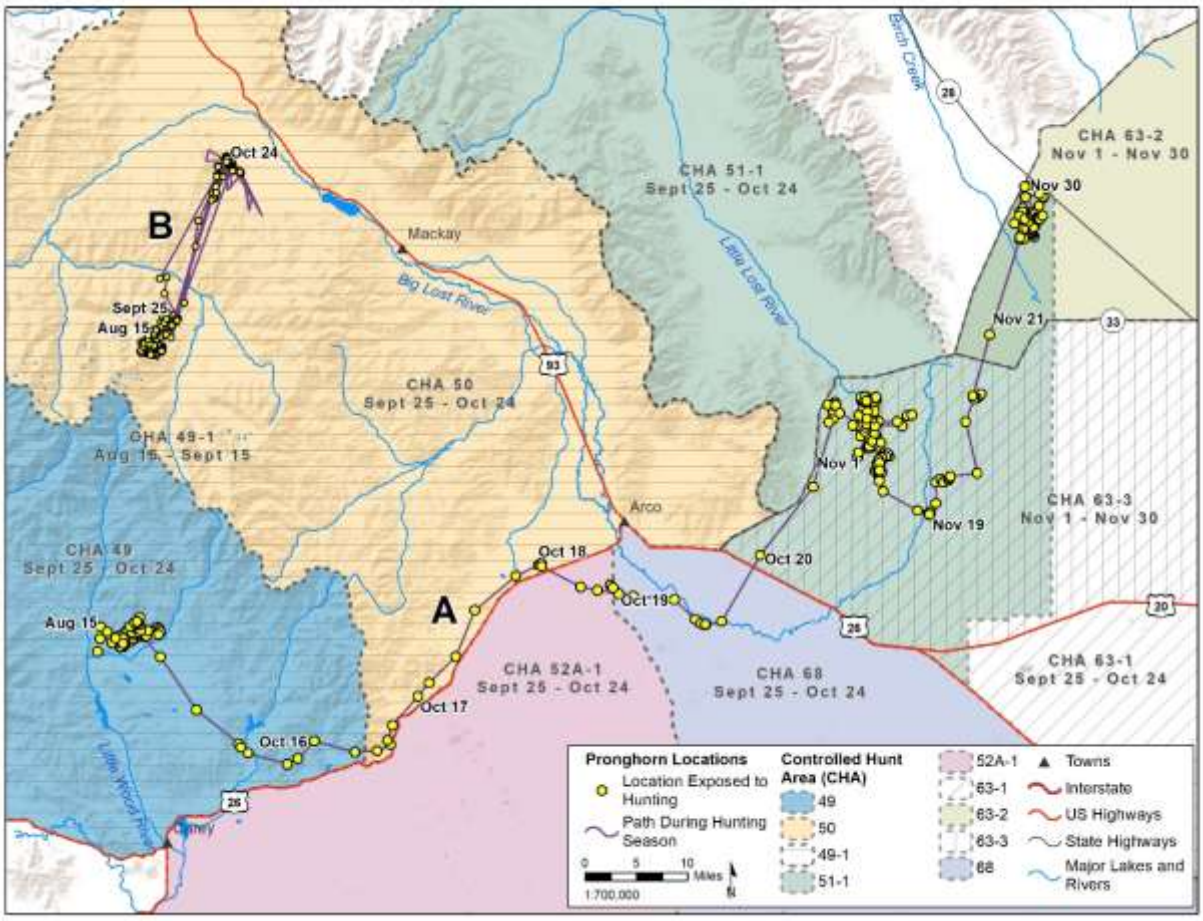


Figure 5. Examples of potential hunting exposure for pronghorn (A) summering in the Little Wood River basin and wintering near Birch Creek, and (B) a short-distant migrant from Copper Basin to the Big Lost River valley. Only hunts during which example animals would be exposed are displayed and labeled.

### *Hunter Opinion Survey*

In 2021, IDFG and the University of Idaho conducted a pronghorn hunter opinion survey to help inform future management and hunting opportunity for pronghorn. Results from the survey broadly indicate that pronghorn hunters are generally satisfied with their overall pronghorn hunting experience (67% satisfied or very satisfied), harvest success, number of pronghorn observed, and amount of pronghorn habitat, but are dissatisfied with tag drawing odds. Participants indicated a lower perception of crowding while hunting pronghorn compared to other big game hunters; however, 65% of archery hunters perceived crowding to have increased since 2015 compared to 46% of rifle hunters.

# MANAGEMENT CHALLENGES

## Population Monitoring

A variety of methodologies exist to survey and inventory pronghorn, each with different strengths and limitations. Pronghorn populations in Idaho generally occur at lower densities with sporadic distribution on the landscape as compared to places like Montana and Wyoming. They can display nomadic behavior in winter and some populations inhabit higher elevation and rugged terrain in the summer. These factors in combination with the highly migratory and mobile nature of pronghorn degrade the reliability of aerial survey methods traditionally used for most of Idaho's other big game species. Currently, no standard statewide monitoring protocol or survey design exists for pronghorn. Instead, monitoring methods are tailored to fit data needs, staff availability, funding, and survey area conditions. These data are then combined with hunter numbers, hunter success, and depredation concerns when allocating tag numbers and structuring hunting seasons. Strategies aimed at improving pronghorn population estimates are a priority for this plan in the next 6 years.

Surveys may be designed to (1) estimate population abundance (e.g., sightability surveys), (2) provide an index to population status (e.g., trend surveys), or (3) determine age and sex ratios (e.g., composition surveys). In addition to surveys, harvest statistics and survival monitoring are important metrics for developing comprehensive population monitoring programs. Often, a combination of these methods is used to gather reliable data given funding constraints and logistical hurdles. Furthermore, one methodology will not work in all situations or locations across Idaho. Commonly used techniques for addressing overarching population monitoring goals for pronghorn follow.

### *Population Abundance*

Numerous states and provinces across pronghorn range are currently using line-transect distance sampling to generate population estimates. This method has been tried in Idaho on several occasions, but low pronghorn densities and steep topography in narrow mountain valleys on some summer ranges reduce the utility of this method to accurately monitor all pronghorn herds in the state. While a few formal aerial surveys have been attempted, most pronghorn information collected from aircraft has been incidental to deer, elk, or bighorn sheep (*Ovis canadensis*) surveys.

### *Herd Composition*

IDFG has conducted ground surveys for total counts, herd age, and sex composition ratios in several pronghorn populations. Surveys during August (i.e., preseason) are ideal to collect fawn:doe ratios because the fawns are past their hiding stage, are easily distinguishable from adults, and groups are still

relatively small and dispersed. Additionally, herds are not likely to have migrated out of an area (O'Gara and Youkum 2004, Yoakum et al. 2014). However, lone bucks and small bachelor groups can be easily missed. The desired preseason buck:doe ratio depends on management objectives, but Salwasser (1980) and Hailey (1979) reported a buck:doe ratio of 25:100 is desirable to allow for maximum recruitment into a population while a ratio of 50:100 is desirable when trying to achieve maximum trophy buck production (i.e., a relatively large number of ≥ 3-year-old bucks, Yoakum et al. 2014). Salwasser (1980) noted that a postseason buck:doe ratio of 20:100 is biologically safe to achieve complete breeding of reproductive females.

*Harvest Monitoring*

An important component of pronghorn management in Idaho is harvest-based monitoring. Harvest data are collected through mandatory harvest reports and telephone surveys; however, increased reporting rates would improve harvest-based estimates. Harvest per unit effort (i.e., hunter days) is considered most sensitive to changes in animal abundance (Keegan et al. 2011) because it is assumed that as animal numbers decline, hunters will have to spend more days afield to be successful.

*Emerging Monitoring Methods*

With technological and statistical advancements, additional methods for monitoring populations are emerging as potentially practical and reliable options. Trail cameras have been used successfully to collect population demographics for a variety of species (Moeller et al. 2018, Pfeffer et al. 2018, Palencia et al. 2021, Taylor et al. 2021). This technology may be useful for producing a valid pronghorn population or herd composition estimate. Infrared (IR) technology is also becoming increasingly popular for animal surveys (e.g., Schoenecker et al. 2018). However, this technology remains expensive, and requires specific environmental conditions (i.e., early mornings with cold temperatures) that limit its usefulness. Non-invasive genetic sampling, such as fecal DNA, may also be an option to obtain cost-effective estimates on small, clustered pronghorn populations (Woodruff et al. 2016, Pfeiler et al. 2020).

*Future Monitoring Needs*

Idaho needs an accurate and cost-effective way to monitor pronghorn populations across the state to more precisely determine population trends, maximize hunting opportunity (i.e., better allocate permits and harvest), and evaluate adaptive management strategies. For example, archery harvest has tripled in the last 20 years, but this increase in harvest has not led to decreases in tag numbers or season lengths (other than for some hunter crowding issues during archery-only season). Given limited population survey information, the degree to which this exponential increase in harvest is affecting pronghorn populations is unknown.

The need for better population estimates will likely become more acute as wildfires, human infrastructure and development, and climate change continue to alter pronghorn habitat. However, pronghorn management needs vary among regions and populations. For some populations, monitoring using harvest metrics may be sufficient for estimating trend (Keegan et al. 2011). Other populations need reliable counts or consistent trend data to monitor herd health. Currently, there is no budget allocated for monitoring pronghorn populations statewide.

### Habitat Loss & Fragmentation

Any loss or fragmentation of native grassland and sagebrush habitat can negatively affect pronghorn to some degree. In Idaho, increasingly significant stressors to pronghorn habitat include residential and agricultural development, infrastructure (roads, railroads, and fences), outdoor recreation, mining and energy development, wildfire, encroachment of invasive plants, and climate change. These stressors can also constrain or "bottleneck" pronghorn seasonal migrations (Seidler et al. 2015; Kauffman et al. 2020, 2021, 2022).

#### *Residential & Agricultural Development*

Idaho is currently one of the fastest growing states in the US, increasing over 17% between 2010 and 2020 with an annual projected growth rate of 1.1% (IDOL 2021). As Idaho's human population grows so does urban and suburban expansion. While just over half (54%) of pronghorn habitat in Idaho is on public land, which generally precludes urban and agricultural development, many private lands within pronghorn SRD and WRDs are experiencing the effects of human population growth. Between 2007 and 2021, all SRDs and WRDs experienced at least some conversion of native grassland and sagebrush habitats to cropland and several experienced >5% conversion (USDA 2021). This trend can negatively affect pronghorn through the direct loss and fragmentation of habitat, changes to or loss of migration routes, and increases in other stressors such as invasive plants, wildfire ignitions, and human disturbance. While cropland conversion can benefit pronghorn in some instances by providing additional forage resources (Torbit et al. 1993, Hoffman et al. 2010, Christie et al. 2015), extensive pronghorn use of cropland may result in depredation conflicts and reduced landowner tolerance. In addition, much of Idaho's pronghorn habitat is grazed by domestic livestock. While well-managed moderate livestock grazing may help mitigate effects of the fire-cheatgrass cycle in some instances (Davies et al. 2011), improper livestock management can result in loss of native plant species, degradation of soil and water quality, reduced water availability, and increased invasive plant species, depending on local factors such as precipitation, soils, and plant communities (Chambers et al. 2017, Monroe et al. 2021).

*Roads, Railroads, & Fences*

Infrastructure (e.g., roads, railroads, fences) associated with development cover extensive areas of southern Idaho (Monroe et al. 2021). These linear manmade features can hinder pronghorn seasonal and daily movements and can significantly affect pronghorn directly through injury or death, or indirectly through prolonged or curtailed migration routes and increased rates of movement, potentially diminishing survival and production by increasing the energy needed to navigate them (Seidler et al. 2015, Jones et al. 2020, Jakes 2021, Robb et al. 2022, Xu et al. 2023). Road density can be negatively associated with pronghorn abundance (Christie et al. 2015), survival (Eacker et al. 2023), and increasing traffic volumes may lead to increased pronghorn-vehicle collisions (Gavin and Komers 2006, Robb et al. 2022). Both roads and railways in Idaho have also been associated with several pronghorn mass mortality events, predominantly in winter when they provide shelter or relatively snow-free areas during extreme weather (see the Supplemental Document).

The distribution of barbed and woven wire fencing across southern Idaho may exclude pronghorn from certain areas and markedly alter daily movements and seasonal migration routes. Woven wire and low bottom strands are known to prevent pronghorn movements and may increase energy expenditures leading to increased mortality during severe winters (Jones et al. 2020) (see the Supplemental Document for wildlife-friendly fence specifications). While fences built along multilane highways reduce wildlife-vehicle collisions, they also prevent pronghorn crossings and can disrupt migrations, potentially negating the increased survivorship of migrant individuals by limiting access to preferred habitat and increasing cost of migration (Jones et al. 2020, Van Moorter et al. 2020, Jones et al. 2022). For example, I-15 likely impedes traditional east-west pronghorn migration between winter and summer ranges (IDFG 2022b). Despite what could be 40 years of separated seasonal migration routes, both herds still use areas directly opposite one another with no movement of GPS-collared pronghorn across I-15 (Figure 6).

Mitigating the effects of infrastructure on pronghorn will continue to be a primary objective for managing this species. Construction of wildlife overpass structures can decrease wildlife-vehicle collisions and mitigate the effects of fencing that impede migrations. Successful overpass structures used by pronghorn during seasonal migrations have been designed and constructed at numerous locations in adjacent states (e.g., Trappers Point Wildlife Crossing on US Highway 191, Wyoming) for federal and state highway systems and decreased wildlife-vehicle collision by 80% or more (Ament et al. 2021). However, overpasses are costly to construct and not always a viable option. Other wildlife crossing structures, such as underpasses or bridges, are typically

avoided by pronghorn, presumably because underpasses impair their vision and constrain movements (Sawyer et al. 2016).

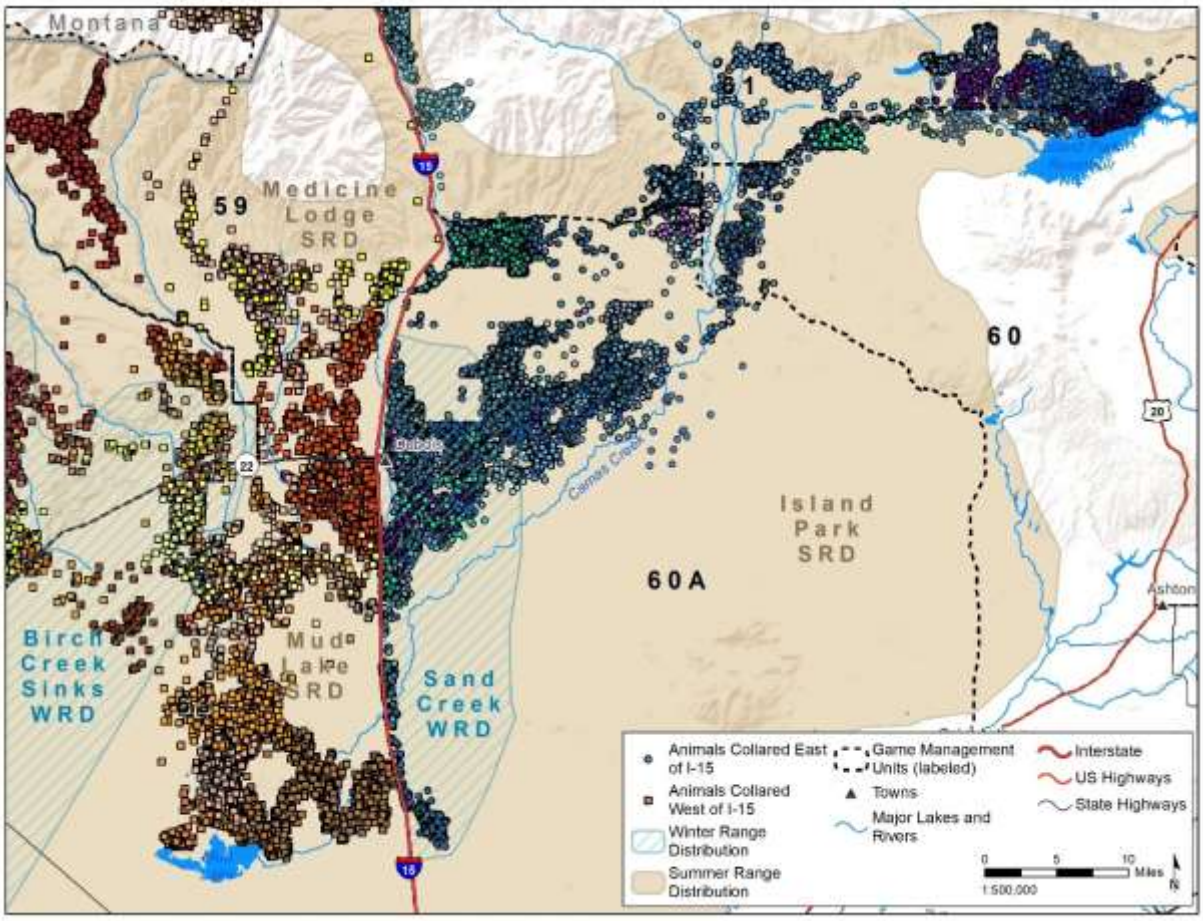


Figure 6. Separation of known seasonal migration routes for pronghorn due to I-15 and associated fencing. Cool colors (circles) represent individual animals collared east of I-15 ($n$ = 32) and warm colors (squares) represent individual animals collared west of I-15 ($n$ = 23), 2011–2022.

### *Outdoor Recreation*

Over 90% of Idahoans participate in one or more forms of outdoor recreation, including hiking, biking, motor boating, rafting, snow and water skiing, snowmobiling, and off-highway vehicle (OHV) use (IDPR 2022). Pronghorn herds in Idaho are exposed to different amounts of outdoor recreation and areas once considered remote and difficult to access are now more accessible. Potential effects of various outdoor recreation, based on pronghorn studies and known impacts to other ungulates, include but are not limited to stress-related population declines, increased daily movements, displacement into poorer habitat, increased vulnerability to harvest and predation, spread of

invasive plants, and loss of fat reserves (Taylor and Knight 2003, Wisdom et al. 2004, Gavin and Komers 2006, Switalski 2018).

*Mining & Energy Development*

Development associated with mining, oil and natural gas extraction, and renewable energy (i.e., solar, wind, geothermal) has increased across much of the pronghorn range in the western US (Allred et al. 2015, Jones et al. 2015). This demand has led to tremendous investments in energy infrastructure in Idaho, including transmission lines associated with the increased development (OEMR 2022).

While the long-term cumulative impacts of mining and energy development on sagebrush-associated and -obligate wildlife populations, including pronghorn, are not fully understood (see Aldridge et al. 2021 for review), research has shown that energy development and associated infrastructure can result in loss and degradation of habitat, avoidance of infrastructure, changes in migratory behavior, and at least partial abandonment of traditional ranges (Sawyer et al. 2019, Jakes et al. 2020, Smith et al. 2020, Lambert et al. 2022, Sawyer et al. 2022). The significance of population level-effects on pronghorn herds will likely depend on the location, extent, and context of development. For example, in south-central Wyoming, wind energy infrastructure did not affect winter survival of female pronghorn (Taylor et al. 2016) but did lead to avoidance and abandonment of traditional winter ranges (Smith et al. 2020, Milligan et al. 2023). Similarly, Beckmann et al. (2016) failed to detect differences in adult female pronghorn condition and survival between developed and undeveloped areas in western Wyoming but did document changes in movement behavior. While broad-scale developments are often the focus of concern, even small-scale developments may have significant effects if located within important migration or stopover habitat (Sawyer et al. 2022). In addition, cumulative effects may occur with associated infrastructure development including increased human presence, invasive plant species, and wildfire ignitions.

*Wildfire & Invasive Plants*

Historical fire regimes in southern Idaho sagebrush ecosystems are thought to have been highly variable depending on local conditions (see Crist et al. 2021 for review). The spread of invasive annual grasses, climate change, and increased prevalence of human-caused fires have contributed to increases in total area burned, fire size, severity, frequency, and lengthened fire seasons across nearly all sagebrush communities in the Snake River Plain, particularly in the lower elevations (Crist et al. 2021). In contrast, fire now occurs less frequently than it likely did historically in higher elevation mountain big sagebrush (*Artemisia tridentata vaseyana*) communities, leading to expansion

of juniper (*Juniper* spp.) and pinyon pine (*Pinus monophyla*) in some areas (Bukowski and Baker 2013).

Larger and more frequent fires typically result in a loss of sagebrush and increased extent and abundance of invasive annual grasses. Large areas of sagebrush communities in the Snake River Plain are particularly vulnerable to such conversions, mainly in hotter, drier, lower elevation sites (Chambers et al. 2014, 2017). From 1970–2021, 31% of pronghorn SRDs and 38% of WRDs burned at least once, 13% of SRDs and 18% of WRDs burned 2 or more times, and some areas burned as many as 10 times based on mapped perimeters of large >1,000-acre wildfires (Weber 2021, Figure 7) (see the Supplemental Document for extent of wildfires in SRDs and WRDs). Once converted, the value of these sagebrush landscapes as pronghorn habitat is significantly reduced. Postfire restoration and recovery are logistically difficult, expensive, and success is extremely variable due to limited precipitation, site differences, prefire composition, and other factors (Crist et al. 2021). In addition, sagebrush recovery to preburn condition is exceptionally slow (several decades to more than 100 years; Nelson et al. 2014, Shinneman and McIlroy 2016) and, once converted to invasive annual grass, risk of reburning is high, further perpetuating the grass-fire cycle. Even so, treatments to inhibit recolonization by invasive annual grasses and noxious weeds, and replanting with beneficial native and possibly nonnative grasses, forbs, and shrubs may improve pronghorn habitat. Forbs are especially critical in maintaining high-quality pronghorn habitat (Bleke 2022).

Although numerous invasive plants affect areas of pronghorn habitat in Idaho (see Boyd et al. 2021 for review), cheatgrass (*Bromus tectorum*) and medusahead (*Taeniatherum caput-medusae*) have the greatest impact, particularly in more arid Basin big sagebrush (*A. t. tridentata*) and Wyoming big sagebrush (*A. t. wyomingensis*) communities (Miller et al. 2011, Chambers et al. 2014) (see the Supplemental Document for extent of invasive annual plants in SRDs and WRDs). These species can drastically alter grassland and sagebrush communities by displacing native plants, increasing wildfire occurrence, and fragmenting and degrading habitat. The reduced forage availability and lower quality nutrition may ultimately affect pronghorn reproduction and survival, although early growth stages of cheatgrass can be a preferred forage when seasonally available (McInnis and Vavra 1987). Continued changes in climate (e.g., warmer temperatures, drought, rising carbon dioxide) are likely to benefit cheatgrass, medusahead, and other invasive plants (Miller et al. 2011, Bradley et al. 2016).

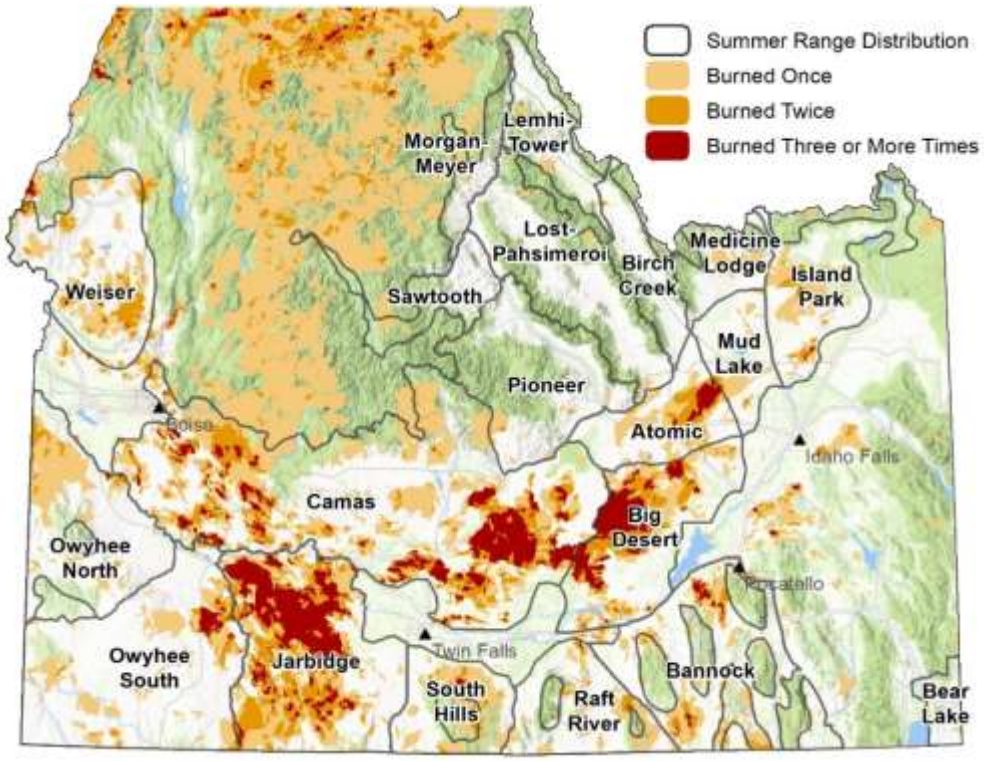


Figure 7. Frequency of large (>1,000-acre) wildfires, 1970–2021, in pronghorn summer range distributions in Idaho. Data from the Historic Fires Database, version 3.0 (Weber 2021).

## Climate Change & Severe Weather

Long-term empirical evidence indicating effects of ongoing and projected climate change on pronghorn is generally lacking. However, changes in weather can both directly (e.g., through physiological limitations and reduced energy reserves) and indirectly (e.g., through forage quality and quantity) affect pronghorn abundance, behavior, reproduction, survival, distribution, and migration (Hoskinson and Tester 1980, Brown et al. 2006, Byers et al. 2006, Dalton 2009, Barnowe-Meyer et al. 2010, Hoffman et al. 2010, Christie et al. 2015, Gedir et al. 2015, Collins 2016, Jones et al. 2020, Kauffman et al. 2021, Malpeli 2022). While increased precipitation generally benefits pronghorn populations due to increased forage quantity and quality, severe winter weather (cold temperatures, heavy snowfall) is often associated with population declines. Snow depths exceeding 11 in (30 cm) inhibit pronghorn movement (O'Gara and Yoakum 2004) and greater snow depth, density, and hardness can influence use of traditional winter range (Bruns 1977, Barrett 1982). For example, animals near Craters of the Moon National Monument and Preserve have become trapped on summer range when early snowstorms have occurred along the migration route (John Abel, National Park Service [NPS], personal communication). Similarly, extreme storm events can be associated with pronghorn movements to areas outside traditional ranges. For example, in January 2017, approximately 300 pronghorn crossed the ice on

American Falls Reservoir into GMU 68A. That same winter, approximately 50 pronghorn became stranded on the ice on Lake Walcott as deep snow pushed them farther south than normal. Ice conditions in 2017 also allowed pronghorn to cross the Snake River from Oregon into the town of Payette.

In Idaho, mean annual temperature has increased 1.8 °F (1 °C) since 1895 with summer and winter temperatures increasing more than other seasons, extreme events (e.g., heat waves, false springs) becoming more common, and growing season lengthening (Abatzoglou et al. 2021). Trends in precipitation are more variable but suggest statewide decreases in summer and autumn precipitation and increases in spring and winter precipitation with decreases in the proportion of precipitation falling as snow, particularly at low to middle elevations (Abatzoglou et al. 2021). Following current trends, future projections indicate progressively hotter, drier summers and warmer, wetter winters with greater overall variability (e.g., record cold temperatures even as record highs become increasingly frequent) (Rupp et al. 2017). Warming is generally expected to be greatest in the Snake River Plain, and during the summer months. Total annual precipitation is projected to increase slightly (5–10%) although substantial variability in annual and seasonal precipitation is projected with some areas experiencing abnormally wet years or seasons, and others abnormally dry (Abatzoglou et al. 2021). Consecutive years of snow drought, earlier peak snowpack, and an upward elevational shift in snow levels are projected (Catalano et al. 2019, Marshall et al. 2019) (see the Supplemental Document for climate projections in individual SRDs and WRDs).

The ability of pronghorn to adapt to ongoing and projected changes is uncertain and, given the multitude of contributing factors, herds in different areas of the state are likely to respond differently to changing conditions. In some cases, changing conditions may be a benefit to pronghorn; in others, they will be a detriment. Mild winters with reduced snow may increase overwinter survival by increasing access to quality winter forage or improving dispersal ability. Because precipitation is a primary factor in plant productivity in arid grassland and shrubland systems (Deguines et al. 2017), increases in spring precipitation, earlier spring green-up, and longer growing seasons may benefit herd productivity due to greater availability of high-quality forage. Yet these trends (less snowfall, earlier spring green-up) may result in altered migration timing, duration, distance, destination, or even switching from migratory to resident (Hoskinson and Tester 1980, Dalton 2009, Collins 2016, Malpeli 2022). Warm spring and summer temperatures coupled with decreased precipitation may result in decreased survival or recruitment due to reduced forage (Brown et al. 2006, Gedir et al. 2015), decreased water availability and quality (Jacques et al. 2015, Mattson and Holton 2022), or increased incidence of disease or parasites (e.g., Aleuy and Kutz 2020, Buttke et al. 2021, Rivera et al. 2021). In arid landscapes or during drought years,

access to surface water may be especially important for pronghorn, depending on location, season, and forage quality (O'Gara and Yoakum 2004, Mattson and Holton 2022). Given projected increases in summer drought conditions, access to water may become more of an issue for some herds. These changes likely compound other stressors to pronghorn, such as invasive plants, wildfire, disease, and interspecific interactions. A better understanding of the complex relationship between temperature, precipitation, and pronghorn population dynamics at local levels, including direct and indirect effects as well as individual- and population-level responses in Idaho SRDs and WRDs is needed to fully understand and appropriately manage herds under changing climatic and severe weather conditions.

### Depredation

Pronghorn damage to agricultural crops is a concern for both landowners and IDFG. Depredations may occur when populations are high, environmental conditions cause animals to seek high-quality forage or water during drought or heavy snows, or when traditional seasonal ranges are impacted by development or disturbance. Idaho Code 36-1108 outlines statutory requirements for producers and IDFG to control damage by pronghorn, elk, deer, and moose (*Alces alces*), and requirements to be eligible for damage compensation.

Drought conditions during the summers of 1987 and 1988 and a string of severe winters in the 1980s resulted in extensive big game depredations. One of the areas with the heaviest influx of animals was in and around Mud Lake in eastern Idaho. Pronghorn were one of the primary contributors to the depredation problem in this area (Rimbey et al. 1991). The depredation program for Idaho was developed by legislative action (§36-1108, §36-1110) as a direct result of the damage reported by landowners (Idaho Session Law 1990, Rimbey et al. 1991). Currently, depredation impacts attributed to pronghorn have been minimal. In the last decade, only 1 or 2 claims have been filed per year for pronghorn damage. These claims account for <5% of total wildlife claims filed each year and the majority were <$3,000.

IDFG uses hunters as a tool to proactively address depredation concerns by managing pronghorn population size. When responding to complaints, wildlife managers initially use nonlethal techniques such as hazing, scare devices, and fencing to discourage pronghorn use of private land. When nonlethal options are ineffective IDFG will then consider lethal techniques such as depredation hunts, landowner permission hunts, and kill permits. When these techniques fail to satisfactorily solve the problem, landowners may be eligible to file a claim, as outlined in Idaho Code 36-115, 36-1108 and 36-1110.

## Predation

Predation of pronghorn is highly correlated with the age of the pronghorn with neonatal fawns (<3 weeks of age) the most vulnerable (Linnell et al. 1995). A recent two-year study in Idaho found that, depending on year and study site, pronghorn neonate mortality ranged from 38–72% ($n$ = 217), of which 34–81% was attributed to coyotes (*Canis latrans)* and a lesser amount to bobcats (*Lynx rufus*), golden eagles (*Aquila chrysaetos*), and black bears (*Ursus americanus*) (Panting et al. 2021). Fawn survival rates increased with the presence of alternative prey species (e.g., rabbits), but were not impacted by predator densities (Panting et al. 2021). Adult pronghorn are well adapted to detect and escape predators and have a higher survival rate than neonates. However, adverse weather, deep snow, and habitat conditions can affect the likelihood of predation on both adults and fawns (Firchow 1986, Barnowe-Meyer et al. 2010).

Predator control is a complex and controversial subject. Predation can impact population size but is likely working in concert with other limiting factors. When pronghorn populations are below management objectives, many factors need to be assessed including habitat loss, previous environmental conditions, harvest levels, competition with other species, and limitations to daily and seasonal movements. It is likely that habitat restoration, mitigating impediments to movements, and mild weather conditions will increase long-term pronghorn populations more than a short-term predator control effort. In some unique situations (e.g., small, isolated populations), short-term management of predators may be an important tool for IDFG to aid in pronghorn management.

In 2000, the Idaho Fish and Game Commission adopted a "Policy for Avian and Mammalian Predation Management" to guide IDFG's implementation of predator management activities (IDFG 2000). The policy directs IDFG to develop a predation management plan if there is evidence predation is a significant factor preventing prey populations from meeting IDFG management objectives. If predation is determined to be a contributing factor to pronghorn population decline, the managing region will develop a predation management plan using the best available scientific information to guide their management actions. The predation management plan is intended to address predator and prey population objectives, contributing factors, proposed management actions, monitoring, and public outreach and education. Predation management plans require Director approval prior to implementation and will be reviewed and evaluated annually.

## Competition

When multiple species depend on the same limited resources, such as forage or water, interspecific competition can occur if one species is better at

exploiting the resource or interferes with the other species' ability to use the resource, and as a result, the species population performance is lower than it would be otherwise (McInnis and Vavra 1987). Differences in physiology and forage preferences typically result in some partitioning of resources among pronghorn, other ungulates, and domestic livestock (Hofmann 1989); however, competition for either forage or access to water may occur in some seasons or in areas compromised by wildfire, invasive plants, or extended drought.

Because pronghorn forage mostly on forbs and shrubs, there is usually little opportunity for interspecific competition between pronghorn and other ungulates (e.g., mule deer, elk) (Hofmann 1989, O'Gara and Yoakum 2004). However, competition may occur in areas of high mule deer or elk densities or limited forb or shrub availability, due to increased pressure on preferred browse species (Mackie 1976). Increased competition may also occur in areas of limited water availability (e.g., the Big Desert). Similarly, pronghorn dietary overlap with cattle (*Bos taurus*) and horses (*Equus caballus*) is usually low (Johnson 1979, McInnis and Vavra 1987, Yoakum et al. 2014). However, when conditions require pronghorn to switch to diets higher in perennial grasses (e.g., drought, lack of forbs and shrubs), dietary overlap and potential competition are much greater (McInnis and Vavra 1987). In these situations, increased cattle density may result in reduced doe condition and fawn production (Hoffman et al. 2010). Dietary overlap with domestic sheep (*Ovis aries*) is greater, particularly with preferred forage species such as common winterfat (*Krascheninnikovia lanata)* and black sagebrush (*Artemisia nova*) (Johnson 1979, Clary and Beale 1983, O'Gara and Yoakum 2004), and may result in reduced pronghorn density when key forage plants are limited during winter (Clary and Beale 1983).

Competition with feral horses for access to limited water sources may directly affect pronghorn populations (Gooch et al. 2017, Hall et al. 2018). Behaviorally dominate over native ungulates, feral horses may outcompete pronghorn for access to water. Co-occurrence at water sources results in increased avoidance (Hall et al. 2018), increased vigilance (Gooch et al. 2017), and decreased foraging and drinking (Gooch et al. 2017) by pronghorn. The resulting increase in energy costs could ultimately affect pronghorn survival and production (Gooch et al. 2017, Hall et al. 2018, Hennig et al. 2021). In Idaho, feral horses are known to occur in Owyhee North and South SRD/WRDs, Pioneer SRD, Weiser SRD/WRD, Sawtooth SRD, and Antelope Flat WRD.

### Health Assessment

Disease in wildlife is concerning from a conservation, economic, and public health perspective. The extent to which disease limits wildlife populations is of concern to wildlife managers, particularly when disease could compound the effects of habitat loss and fragmentation, predation, and climate change. Like

any other species, pronghorn are susceptible to diseases and parasites (Stauber et al. 1980, Samuel 2001) which may affect populations or be transmitted to other wildlife and domestic livestock. In general, pronghorn populations in Idaho appear to be relatively healthy. However, active disease monitoring has not been conducted regularly, and documentation has been sporadic and mostly opportunistic.

The disease with the most potential to impact pronghorn populations in Idaho is hemorrhagic disease, which is caused by 2 closely related viruses: epizootic hemorrhagic disease (EHD) and bluetongue (BT). Approximately 3,200 pronghorn died of BT in eastern Wyoming during 1976, and 300 died in 1984 (Thorne et al. 1988). Both viruses are transmitted by biting flies (*Culicoides* spp.) and could become more prevalent in Idaho as climate change results in conditions allowing these insects to persist longer (Pfannenstiel et al. 2015, Rivera et al. 2021). Thought to be limited by cold weather, biting flies (and thus the diseases) were historically restricted between 35 degrees south and 40 degrees north latitude. In recent decades, extensions northward (up to 50 degrees north latitude) in North America and Europe have been attributed to warmer climate patterns (Purse et al. 2005, Rivera et al. 2021) and projections suggest additional expansion in coming decades (Zuliani et al. 2015).

Other pathogens detected in pronghorn in Idaho include bovine virus diarrhea, infectious bovine rhinotracheitis, bovine adenovirus, *Anaplasma marginale*, parainfluenza virus, bovine rhinovirus, bovine respiratory syncytial virus, and *Pasteurella multocida septica* (Murray 1951, Stauber et al. 1980). None of these have been detected at high rates in Idaho and while some are detected in surveillance screening, pronghorn rarely present with disease. Wyoming has documented *Mycoplasma bovis*, which is usually found in cattle, as the primary cause of approximately 160 pronghorn deaths during 2019 and 2020 (Johnson et al. 2022). Neither brucellosis nor chronic wasting disease has been detected in wild pronghorn populations.

Although disease does not appear to be a limiting factor in most pronghorn populations, disease surveillance for detecting both known and emerging diseases may be an important component of pronghorn management in the future. Changes in climate patterns have led to more favorable conditions for several diseases and parasites known to affect pronghorn (Samuel et al. 2001), although the magnitude of effects are complex and variable, often depending on many factors (see Rose et al. 2014, Aleuy and Kutz 2020, Buttke et al. 2021, Rivera et al. 2021, for review). Emergence of new pathogens or parasites common in pronghorn populations in other states may pose a risk (Samuel et al. 2001, Weaver 2013). Conversely, extreme weather conditions (e.g., exceeding critical temperature thresholds, extended drought, or flooding) may reduce survival and pathogen transmission of many macro-parasites in local

areas (Aleuy and Kutz 2020). The combination of various stressors (e.g., habitat fragmentation, spread of invasive plants, climate change), along with disease, has the potential to present challenges important to the long-term management and conservation of pronghorn in Idaho.

### Genetics

Wildlife managers are challenged to identify biologically meaningful population units, measure population size and connectivity, and evaluate the capacity of populations to endure and adapt to environmental change. Genetics and genomics can provide baseline information about population structure, genetic diversity, and connectivity, which may help to inform management strategies (Hohenlohe et al. 2021). Loss of genetic diversity may suggest population declines or fragmentation and can reduce a population's ability to survive and reproduce as well as resiliency to changing environmental conditions or disease (Hohenlohe et al. 2021). Genetic markers can also provide an indication of gene flow among populations which may help inform management needs such as delineation of populations and hunt area boundaries, planning translocations, and predicting potential pathogen transmission.

Current management questions that genetic structure analysis could assist in answering include:

- Have current pronghorn populations been isolated from historically larger metapopulations? Has there been a loss of genetic diversity as a result?
- Have translocations influenced genetic structure of pronghorn herds in Idaho?
- Does genetic structure of the population confirm how we currently delineate pronghorn herds in Idaho?
- Do resident and seasonally migrating populations differ genetically?

This information could help inform future translocations (e.g., suitable source herds), as well as measure the effectiveness of current management strategies focused on promoting connectivity across pronghorn range in Idaho (e.g., barrier removals or mitigation). Increasing sampling of hunter harvests, roadkills, and captured pronghorn would improve baseline genetic data for Idaho pronghorn herds.

### Translocations

Wildlife translocations have been broadly implemented for many species to augment, establish, or restore populations to a particular geographic area. Often, these past translocations provide important wildlife-related recreation opportunities for the public that likely would not otherwise be available today. Within pronghorn historical range, translocations have been celebrated as

contributing significantly to the dramatic recovery of this iconic species. Between 1920 and 1997, more than 30,000 pronghorn were translocated across 17 states (O'Gara and Yoakum 2004).

In Idaho, efforts to trap and transplant pronghorn began in the early 1940s (Beck 1942) with the first successful transplant occurring in 1946 (Davis 1946, Twin Falls Times News 1946). Between 1946 and 2004, IDFG moved several hundred pronghorn with the intent to extend the species' range, improve production where suitable habitat existed, or reduce depredations on forage crops. Results of translocations appear to have varied in success, but most lacked detailed post-translocation monitoring to thoroughly assess effectiveness. In fact, consistent detailed records are generally lacking for capture and release sites, sex and age composition of animals, or sometimes even the total numbers of animals translocated (see the Supplemental Document for translocation history).

Successful translocations lead to the establishment of self-sustaining populations, or to increasing the size, growth rate, genetic diversity, or occupied range of existing populations. While translocations have been an important tool in restoring pronghorn rangewide, they are expensive, pose risks to animals and humans, and are not always successful. In addition, they may require extensive coordination among many stakeholders such as land management agencies, private landowners, sportsmen groups, and others. Current guidelines intended to improve pronghorn translocation success include conducting a feasibility study, preparation phase, release or introduction phase, and a follow-up phase (Yoakum et al. 2014). Part of the process requires sufficient coordination among stakeholders, as well as an assessment of potential conflicts with current land uses such as agriculture, development, and roadways.

Prior to initiation of any translocation effort, IDFG will follow current procedures and guidelines (i.e., Yoakum et al. 2014) to ensure feasibility studies, preparation, release, and follow-up plans are achieved. IDFG will develop specific translocation management plans for each individual translocation. Pronghorn translocations in Idaho will meet one or more of the following objectives:

- expand pronghorn range to suitable but currently unoccupied habitat,
- augment existing populations that are below objectives, or
- increase genetic diversity in small or isolated populations.

Although IDFG does not currently have any proposed pronghorn translocations, some areas in the state might be suitable for translocation efforts in the future. For example, areas thought to have once been occupied by pronghorn but no longer possess a viable population or areas where

pronghorn populations are in decline but appear to have adequate habitat to support greater numbers, may be considered for translocations. Populations at or exceeding objectives may be considered as suitable source populations for translocations efforts.

# MANAGEMENT DIRECTIONS

This plan provides management directions and strategies (Table 2) that will be used to set annual work plan activities and establish priorities, subject to available funding and personnel.

Overarching objectives and priorities of this current plan include:

- Improve the quality of pronghorn population monitoring data to better estimate population size and understand population trends.
- Collaborate with private landowners, land management agencies, and others to incorporate measures in land use and resource management plans that benefit pronghorn habitat (e.g., fire rehabilitation, wildlife-friendly fencing).
- Increase knowledge of pronghorn survival, habitat use, genetics, and other factors affecting pronghorn populations, movements, and migrations.
- Maintain or increase pronghorn numbers statewide while considering depredation concerns and changing habitat conditions.
- Maximize harvest opportunity and provide a diversity of hunting experiences.

Table 2. Statewide pronghorn management direction and strategies by topic area.

| Topic | Management Direction | Strategy |
|---|---|---|
| Movement & Migration | Collaborate with federal and state agencies, American Indian tribes, counties, nonprofit organizations, private landowners, and others to incorporate important pronghorn migration habitat and routes in management decisions. | Collaborate with federal and state agencies, landowners, and other stakeholders to reconnect seasonal ranges where migration routes have been interrupted (e.g., crossing structures, wildlife-friendly fencing, and conservation easements as appropriate). |
| | | Implement the Idaho Action Plan (IDFG 2022b). |
| | | Collaborate with partners to reduce negative effects of fencing on pronghorn, especially along known migration routes, by considering fence placement, using wildlife-friendly fencing specifications, and removing unnecessary fences. |
| | | Collaborate with ITD to continue to collect wildlife-vehicle collision data and identify areas of concern. |
| | | Participate as requested by ITD in design, engineering, and public input processes for planned highway wildlife crossing structures and funnel fencing. |
| | | Develop and implement strategies and cooperative agreements (e.g., conservation easements, land exchanges, and Land and Water Conservation Fund) to protect and enhance key migration routes and other important habitat use areas. |
| | Use data from GPS-collared pronghorn to develop information | Identify data gaps and prioritize pronghorn populations for GPS-collaring efforts to develop migration and range maps. |

| Topic | Management Direction | Strategy |
|---|---|---|
| | regarding important migration routes, seasonal ranges, and stopover locations. | Identify areas of elevated pronghorn mortality associated with movement barriers and work with appropriate agencies and others to facilitate pronghorn movement in these areas. |
| | | Develop methodology for accurately mapping stopover locations for pronghorn. |
| | | Coordinate with adjacent states to better understand interstate pronghorn migrations and habitat use. |
| Harvest Management | Maximize hunting opportunity while providing a diversity of hunting experiences, including doe/fawn and mature buck hunts where appropriate. | Develop guidelines for harvest opportunity using hunter success rates and hunter days, in addition to population indices (e.g., ratios, survival rates, population or trend estimates, etc.), depredation concerns, habitat conditions, winter severity and other metrics. |
| | | Provide buck-only hunting option in areas where harvesting pronghorn does may decrease populations and objectives are to maintain or increase numbers. |
| | | Use population metrics (e.g., adult survival, fawn ratios) to determine level of female harvest needed to meet management objectives. |
| | | Evaluate methods for improving drawing odds, especially for any-weapon opportunities. |
| | | Assess whether new archery rules are having the desired effect to reduce hunter crowding. |
| | Use information from the 2021 hunter opinion survey to inform pronghorn management. | Analyze the 2021 hunter opinion survey by GMU and by weapon type to better assess localized differences among pronghorn hunters. |
| | | Evaluate perceptions and attitudes of crowding following changes to the 2021 and 2022 archery-only seasons through random surveys. |
| | | Conduct a follow-up hunter opinion survey prior to the next management plan. |
| | | Evaluate methods to reduce hunter congestion such as stratified hunts, spatial separation, and restrictive weapon types. Evaluate effectiveness of changes through hunter surveys. |
| Population Monitoring | Improve the quality of pronghorn population data to better evaluate population trend and viability. | Develop valid method(s) and a survey monitoring plan that provides for periodic assessments of population status, trend, and distribution, evaluates frequency of surveys needed, and develops pilot projects to test emerging methods. |
| | | Identify opportunities to engage in research focused on survival, recruitment, and other factors limiting populations. |
| | | Review results of tooth collection studies conducted in Idaho. Evaluate if collecting teeth or photos of dentition from harvested pronghorn could currently be useful to manage pronghorn population age structure, composition, status, or trends. |
| | | Continue to use GPS-collared pronghorn or alternative technologies (e.g., remote cameras) to help delineate distribution, identify movement patterns, and develop and refine suitable habitat models. |

| Topic | Management Direction | Strategy |
|---|---|---|
| | | Collect and compile incidental pronghorn locations during deer and elk surveys to improve understanding of pronghorn distribution and abundance. |
| | | Conduct cause-specific mortality studies in SRDs and WRDs with suspected population declines. |
| | | Continue to compile historical records (e.g., aerial surveys), including digitizing hardcopy documents, and archiving all records in a centralized location. |
| Habitat Loss & Fragmentation | Engage with land management agencies and other stakeholders to improve the quality and quantity of pronghorn habitat throughout Idaho. | Work with appropriate agencies to ensure important pronghorn migration habitat, routes, and stopovers are considered in management decisions. |
| | | Coordinate with land management agencies, American Indian tribes, and others to promote practices that benefit pronghorn habitat, such as invasive plant control and other habitat management practices to maintain important seasonal habitats, especially those that improve pronghorn ability to withstand a range of environmental conditions. |
| | | Coordinate with land management agencies on postfire rehabilitation, promote the establishment of beneficial grasses, forbs, and shrubs (native and potentially nonnative), and limit the establishment of invasive plants. |
| | | Work with land management agencies, private landowners, and others to evaluate water availability, identify where and when access to water might be limiting, and assess feasibility of maintaining, improving, or developing other water sources (e.g., stock tanks or springs and riparian areas). |
| | | Actively engage public and private partners to identify, prioritize, and participate in invasive annual grass treatments (e.g., NRCS cheatgrass challenge grant program) that promote the resilience of native bunchgrass and shrub steppe plant communities across the landscape. |
| | | Identify important areas for pronghorn conservation and management (e.g., key migratory routes and summer or winter range concentrations critical to local populations), and work with land management agencies to develop and implement strategies and cooperative agreements (e.g., conservation easements, land exchanges) to protect and enhance these areas. |
| | | Participate with federal and state agencies, private landowners, and other stakeholders in cooperative habitat restoration and enhancement projects as opportunities occur and are appropriate, including postfire restoration, native vegetation restoration, conifer encroachment, invasive weed control, diversification of crested wheatgrass monocultures, and wildlife-friendly fencing. |
| | | Participate with partners (e.g., agencies, private landowners, NGOs) as opportunities occur and are appropriate in cooperative conservation |

| Topic | Management Direction | Strategy |
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| | | easements and Farm Bill habitat conservation programs for pronghorn winter range and migration habitat. |
| | Use data from GPS-collared pronghorn to better identify changes in seasonal habitat use. | Improve habitat suitability models to help evaluate long-term viability of pronghorn populations. Consider agricultural land use and potential migration routes in this evaluation. |
| | | Assess potential for modeling fawning habitat using recent GPS location data. |
| | Provide technical assistance to local and federal agencies, industries, and others in response to challenges or stressors with the potential to affect pronghorn. | Collaborate with others to gather new or augment existing data (e.g., GPS collar locations) to better understand effects of energy development, land use change (e.g., housing development, cropland conversion), or land management decisions on pronghorn populations. |
| | | Assist industry, resource managers, regulatory authorities, and other stakeholders with planning and implementing approaches to avoid, minimize, or offset adverse effects of energy development on pronghorn populations. |
| | | Provide technical assistance to land managers to develop plans for road management and OHV use (e.g., implement strategic road closures, evaluate impacts of disturbance, promote monitoring, enforcement, and signage to curtail new user-created routes). |
| | | Continue to educate the public on the impacts of outdoor recreation on wintering wildlife and evaluate opportunities to expand outreach efforts. |
| | Work with land management agencies, private landowners, American Indian tribes, and other interested parties to maintain preferred forage species on the landscape for pronghorn. | Where pronghorn habitat is used by domestic livestock or feral horses, work with land management agencies and private landowners to maintain access to preferred forage species and water resources. |
| | | Work with federal and state partners to incorporate a mixture of forbs, legumes, and other species that benefit pronghorn and other wildlife species into range rehabilitation and postfire seed mixtures. |
| | | Evaluate effects of limited forage or water availability on pronghorn in areas where habitat use overlaps with other wild ungulates. |
| Climate Change & Severe Weather | Improve understanding of existing and potential effects of changing climates, specifically changes in growing seasons and snow conditions, on pronghorn recruitment, survival, distribution, and migratory behavior. | Identify and support collaborative research, standardization of methods, and opportunities focused on identifying and understanding changes in climatic conditions that could affect pronghorn populations either positively or negatively. |
| | | Work with researchers to develop climate projections at biologically meaningful scales for projecting future conditions and habitat trends in pronghorn SRD and WRDs. |
| | | Engage partners in collaborative efforts to address challenges to pronghorn populations that may be compounded by effects of climate change. |
| Depredation | Implement proactive measures to reduce and minimize | Coordinate with land management agencies, American Indian tribes, private landowners, and others to improve pronghorn habitat (e.g., forage |

| Topic | Management Direction | Strategy |
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| | pronghorn depredations. | and water availability), especially adjacent to private land with chronic depredation issues. |
| | | Evaluate nonlethal measures and other novel methods to determine effectiveness at reducing depredations. |
| | | Work with land management agencies, private landowners, and others to evaluate if water availability, or access to water, is contributing to depredation issues. |
| | | Use harvest to manage depredation issues when and where appropriate. |
| | | Review current literature for forage consumption and Animal Unit Months (AUM) estimates for pronghorn and determine if more appropriate values are available than are currently being used. |
| Predation | Characterize the extent and evaluate the effect of predation on pronghorn productivity. | Evaluate cause-specific mortality and assess the role of predation in pronghorn productivity, recruitment, seasonal movements, habitat use, and survival. |
| | | Implement the Predation Management Policy when evidence indicates predation is a major cause of pronghorn populations failing to meet management objectives. |
| Health Assessment | Improve understanding of existing and potential effects of disease on pronghorn populations. | Investigate opportunities for disease monitoring and surveillance (e.g., radio-collared, roadkill, harvested animals). |
| | | Develop a baseline dataset for disease types and prevalence in pronghorn in Idaho. |
| Genetics | Increase knowledge of pronghorn population genetics and genomics in Idaho herds as funding allows. | Increase opportunistic genetic sampling (e.g., roadkill, hunter harvest, captured animals). |
| | | Measure and evaluate genetic diversity of pronghorn herds. |
| | | Use genetic structure analysis to evaluate how we currently delineate pronghorn herds and connectivity among them. |
| | | Evaluate how past translocations may have influenced genetic structure in pronghorn herds. |
| | | Consider genetic ancestry and genetic diversity when conducting translocations. |
| Translocations | Develop a protocol to provide direction on when, where, and how to translocate pronghorn to maximize likelihood of translocation success. | Evaluate translocations to create new herds or augment small herds with the goal of creating additional hunting and viewing opportunities. |
| | | Assess potential for conflicts on private lands in areas near translocations. |
| | | Use habitat models developed to predict pronghorn distributions to evaluate potential translocation areas. |
| | | Evaluate genetic information from source and destination populations. |
| | | Evaluate individual population health histories of source, destination, and adjacent (if any) populations to reduce or eliminate potential transfer of pathogens from one location to another. |
| | | Develop and implement short- and long-term, post-release, monitoring protocols to determine the success of the translocation including an |

| Topic | Management Direction | Strategy |
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| | | assessment of population persistence and productivity. |
| | | Work with other state management agencies and review current literature to refine capture and handling protocols as new knowledge, methods, and techniques become available. |

# LITERATURE CITED

Abatzoglou JT, Marshall AM, Harley GL. 2021. Observed and Projected Changes in Idaho's Climate. Idaho Climate-Economy Impacts Assessment. James A. and Louise McClure Center for Public Policy Research. Boise (ID): University of Idaho.

Aikens EO, Mysterud A, Merkle JA, Cagnacci F, Rivrud IM, Hebblewhite M, Hurley MA, Peters W, Bergen S, De Groeve J, et al. 2020. Wave-like patterns of plant phenology determine ungulate movement tactics, Current Biology 30 (17): 3444–3449.

Aleuy OA, Kutz S. 2020. Adaptations, life-history traits and ecological mechanisms of parasites to survive extremes and environmental unpredictability in the face of climate change. International Journal for Parasitology: Parasites and Wildlife 12:308–317.

Aldridge C, Chalfoun A, Deibert PA, Espinosa SP, Holloran MJ, Withroder A. 2021. Mining and Energy. In Remington TE, Deibert PA, Hanser SE, Davis DM, Robb LA, Welty JL, editors. Sagebrush Conservation Strategy—Challenges to Sagebrush Conservation. US Geological Survey Open-File Report 2020–1125. p. 163–178.

Alldredge AW, Deblinger RD, Peterson J. 1991. Birth and fawn bed site selection by pronghorns in a sagebrush-steppe community. Journal of Wildlife Management 55:222–227.

Allred BW, Smith WK, Twidwell D, Haggerty JH, Running SW, Naugle DE, Fuhlendorf SD. 2015. Ecosystem services lost to oil and gas in North America. Science 348:401–402.

Ament R, Jacobson S, Callahan R, Brocki M. 2021. Highway crossing structures for wildlife: Opportunities for improving driver and animal safety. Albany (CA): US Department of Agriculture, Forest Service, Pacific Southwest Research Station. General Technical Report PSW-GTR-271.

Barnowe-Meyer KK, White PJ, Davis TL, Smith DW, Crabtree RL, Byers JA. 2010. Influences of wolves and high-elevation dispersion on reproductive success of pronghorn (*Antilcapra americana*). Journal of Mammalogy 91(3):712–721.

Barnowe-Meyer KK, White PJ, Waits LP, Byers JA. 2013. Social and genetic structure associated with migration in pronghorn. Biological Conservation 168:108–115.

Barnowe-Meyer KK, White PJ, David TL, Treanor JJ, Byers JA. 2017. Seasonal foraging strategies of migrant and non-migrant pronghorn in Yellowstone National Park. Northwestern Naturalist 98(2):82–90.

Barrett MW. 1981. Environmental characteristics and functional significance of pronghorn fawn bedding sites in Alberta. Journal of Wildlife Management 45:120–131.

Barrett MW. 1982. Distribution, behavior, and mortality of pronghorns during a severe winter in Alberta. Journal of Wildlife Management 46(4):991–1002.

Beck JO. 1942. Nineteenth Biennial Report of the Fish and Game Department of the State of Idaho (1941–1942). Boise (ID): Idaho Department of Fish and Game.

Beckmann JP, Olson SH, Seidler RG, Berger J. 2016. Sub-lethal effects of energy development on a migratory mammal—the enigma of North American pronghorn. Global Ecology and Conservation 6:36–47.

Bergen S, Berg J, Hurley MA, Roberts S. 2022. Deciphering Idaho's pronghorn antelope seasonal movements; modifying migration mapping methods for migration route estimation, seasonal range analysis and conservation. In 29th Biennial Pronghorn Workshop; August 22-25; Deadwood (SD).

Bleke C. 2022. Evaluation of noninvasive methods for determining pregnancy, diet, nutrition, and stress among pronghorn antelope: implications for population monitoring [master's thesis]. Logan (UT): Utah State University.

Bodie WL. 1979. Factors affecting pronghorn fawn mortality in central Idaho [master's thesis]. Missoula (MT): University of Montana.

Boyd CS, Davis DM, Germino MJ, Garner L, Eiswerth ME, Boyte SP, Tekiela DR, Mayer KE, Pellant M, Pyke DA, Ielmini MR, Franklin S. 2021. Invasive Plant Species. In Remington TE, Deibert PA, Hanser SE, Davis DM, Robb LA, Welty JL, editors. Sagebrush Conservation Strategy—Challenges to Sagebrush Conservation. US Geological Survey Open-File Report 2020–1125. p. 99–120.

Bradley BA, Curtis CA, Chambers JC. 2016. Bromus response to climate and projected changes with climate change. In Germino MJ, Chambers JC, Brown CS, editors. Exotic brome-grasses in arid and semiarid ecosystems of the western US—Causes, consequences, and management implications. New York (NY): Springer, Springer Series on Environmental Management, p. 257–274.

Brown DE, Warnecke D, McKinney T. 2006. Effects of midsummer drought on mortality of doe pronghorn (Antilocapra americana). The Southwestern Naturalist 51(2):220–225.

Bruns EH. 1977. Winter behavior of pronghorns in relation to habitat. Journal of Wildlife Management 41(3):560–571.

Bukowski BE, Baker WL. 2013. Historical fire regimes, reconstructed from land-survey data, led to complexity and fluctuation in sagebrush landscapes. Ecological Applications 23(3):546–564.

Buttke D, Wild M, Monello R, Schuurman G, Hahn M, Jackson K. 2021. Managing wildlife disease under climate change. EcoHealth 18:406–410.

Byers JA., Byers AA, Dunn SJ. 2006. A dry summer diminishes mate search effort by pronghorn females: Evidence for a significant cost of mate search. Ethology 112(1):74–80.

Catalano AJ, Loikith PC, Aragon CM. 2019. Spatiotemporal variability of twenty-first-century changes in site-specific snowfall frequency over the northwest United States. Geophysical Research Letters 46:10122–10131.

Chambers JC, Bradley BA, Brown CS, D'Antonio C, Germino MJ, Grace JB, Hardegree SP, Miller RF, Pyke DA. 2014. Resilience to stress and disturbance, and resistance to *Bromus tectorum* L. invasion in cold desert shrublands of western North America. Ecosystems 17:360–375.

Chambers JC, Maestas JD, Pyke DA, Boyd CS, Pellant M, Wuenschel A. 2017. Using resilience and resistance concepts to manage persistent threats to sagebrush ecosystems and greater sage-grouse: Rangeland Ecology and Management 70(2):149–164.

Christie KS, Jensen WR, Schmidt JH, Boyce MS. 2015. Long-term changes in pronghorn abundance index linked to climate and oil development in North Dakota. Biological Conservation 192:445–453.

Clary WP, Beale DM. 1983. Pronghorn reactions to winter sheep grazing, plant communities, and topography in the Great Basin. Journal of Range Management 36:749–752.

Collins GH. 2016. Seasonal distribution and routes of pronghorn in the northern Great Basin. Western North American Naturalist 76(1):101–112.

Crenshaw JG. 1991. Pronghorn antelope management plan, 1991–1995. Boise (ID): Idaho Department of Fish and Game.

Crist MR, Belger R, Davies KW, Davis DM, Meldrum JR, Shinneman DJ, Mayer KE. 2021. Altered Fire Regimes. In Remington TE, Deibert PA, Hanser SE, Davis DM, Robb LA, Welty JL, editors. Sagebrush Conservation Strategy—Challenges to Sagebrush Conservation. US Geological Survey Open-File Report 2020–1125. p. 79–98.

Dalton KA. 2009. Pronghorn: migration triggers and resource selection in southeastern Oregon [master's thesis]. Pullman (WA): Washington State University.

Davis EB, Brakora KA, Lee AH. 2011. Evolution of ruminant headgear: a review. Proceedings of the Royal Society B 278:2857–2865.

Davis GG. 1946 April 2. Subject: Grassy Hill Antelope. Filer (ID): Personal letter from Davis GC, Conservation Officer, to Thoman PJ, Idaho Fish and Game Commissioner.

Deblinger RD, Alldredge AW. 1989. Management implications of variations in pronghorn social behavior. Wildlife Society Bulletin. 17(1):82–87.

Deguines N, Brashares JS, Prugh LR. 2017. Precipitation alters interactions in a grassland ecological community. Journal of Animal Ecology 86(2):262–272.

Eacker DR, Jakes AF, Jones PF. 2023. Spatiotemporal risk factors predict landscape-scale survivorship for a northern ungulate. Ecosphere 14:e4341.

Firchow KM. 1986. Ecology of pronghorn on the Pinon Canyon Maneuver Site, Colorado [master's thesis]. Blacksburg (VA): Virginia Polytech. Institute and St. University.

Gavin SD, Komers PE. 2006. Do pronghorn (Antilocapra americana) perceive roads as a predation risk? Canadian Journal of Zoology 84(12):1775–1780.

Gedir JV, Cain III JW, Harris G, Turnbull TT. 2015. Effects of climate change on long-term population growth of pronghorn in an arid environment. Ecosphere 6(10):189.

Gese EM, Bleke CA, Roberts SB, Atwood P, Terletzky PA. *In review*. Growth rates of pronghorn subpopulations in Idaho: influence of environmental factors, recruitment, and density dependence.

Gooch AMJ, Petersen SL, Collins GH, Smith TS, McMillan BR, Eggett DL. 2017. The impact of feral horses on pronghorn behavior at water sources. Journal of Arid Environments. 138:38–43.

Hailey TL. 1979. A handbook on pronghorn antelope management in Texas. Austin (TX): Texas Parks Wildlife Department, Federal Aid Wildlife Series 20.

Hennig JD, Beck JL, Gray CJ, Scasta JD. 2021. Temporal overlap among feral horses, cattle, and native ungulates at water sources. Journal of Wildlife Management 85(6):1084–1090.

Hofmann RR. 1989. Evolutionary steps of ecophysiological adaptation and diversification of ruminants: a comparative view of their digestive system. Oecologia 78:443–457.

Hoffman JD, Genoways HH, Jones RR. 2010. Factors influencing long-term population dynamics of pronghorn (*Antilocapra americana*): evidence of an Allee effect. Journal of Mammalogy 91(5):1124–1134.

Hohenlohe PA, Funk WC, Rajora OP. 2021. Population genomics for wildlife conservation and management. Molecular Ecology 30:62–82.

Hoskinson RL, Tester JR. 1980. Migration behavior of pronghorn in southeastern Idaho. Journal of Wildlife Management 44(1):132–144.

Idaho Department of Fish and Game (IDFG). 2015. Strategic Plan. Boise (ID): Idaho Department of Fish and Game.

Idaho Department of Fish and Game (IDFG). 2000. Policy for avian and mammalian predation management. Adopted by Idaho Fish and Game Commission, 24 August 2000. Boise (ID): Idaho Department of Fish and Game. http://idfg.idaho.gov/conservation/predators/policy-avian-mammalian (Accessed 9 Sep 2022).

Idaho Department of Fish and Game (IDFG). 2022a. Direction, FY2022–2025 Annual Strategic Plan. Boise (ID): Idaho Department of Fish and Game.

Idaho Department of Fish and Game (IDFG). 2022b. Idaho action plan (Version 4.0) for implementing the Department of the Interior Secretarial Order 3362: "Improving habitat quality in western big-game winter range and migration corridors". Boise (ID): Idaho Department of Fish and Game.

Idaho Department of Fish and Game (IDFG). 2022c. DRAFT Idaho State Wildlife Action Plan. Boise (ID): Idaho Department of Fish and Game.

Idaho Department of Labor (IDOL). 2021. Idaho 2020: Labor market and economic report. Boise (ID): Idaho Department of Labor. https://www.dol.gov/sites/dolgov/files/eta/Performance/pdfs/annual_economic_reports/2021/ID%20Labor_Market_Report_2020.pdf. (Accessed 23 September 2022).

Idaho Department of Parks and Recreation (IDPR). 2022. Statewide Comprehensive Outdoor Recreation (draft). Boise (ID): Idaho Department of Parks and Recreation. https://parksandrecreation.idaho.gov/wp-content/uploads/Draft-2023-SCORP.pdf (Accessed 23 September 2022).

Idaho Session Law. 1990. Chapter 370. In Cenarrusa PT, Secretary of State. General Laws of the State of Idaho. Boise (ID). p. 1007-1018. https://legislature.idaho.gov/wp-content/uploads/sessionlaws/sessionlaws_1990.pdf (Accessed 21 Sept 2022).

Jacques CN, Jenks JA, Grovenburg TW, Klaver RW. 2015. Influence of habitat and intrinsic characteristics on survival of neonatal pronghorn. PLoS ONE 10:e0144026.

Jakes AF. 2021. Pronghorn. In Remington TE, Deibert PA, Hanser SE, Davis DM, Robb LA, Welty JL, editors. Sagebrush Conservation Strategy—Challenges to Sagebrush Conservation. US Geological Survey Open-File Report 2020–1125. p. 37–42.

Jakes AF, Gates CC, DeCesare NJ, Jones PF, Goldberg JF, Kunkel KE, Hebblewhite M. 2018. Classifying the migration behaviors of pronghorn on their northern range. Journal of Wildlife Management 82: 1229–1242.

Jakes AF, DeCesare NJ, Jones PF, Gates CC, Story SJ, Olimb SK, Kunkel KE, Hebblewhite M. 2020. Multi-scale habitat assessment of pronghorn migration routes. PLoS ONE 15(12):e0241042.

Jesmer BR, Merkle JA, Goheen JR, Aikens EO, Beck JL, Courtemanch AB, Hurley MA, McWhirter DE, Miyasaki HM, Monteith KL, Kauffman MJ. 2018. Is ungulate migration culturally transmitted? Evidence of social learning from translocated animals. Science 361:1023–1025.

Johnson MK. 1979. Foods of primary consumers on cold desert shrub-steppe of southeastern Idaho. Journal of Range Management. 32:365–368.

Johnson M, MacGlover C, Peckham E, Killion H, Allen SE, Creekmore T, Edwards WH, Blaeser M, Davison M, Schwalbe E, Wray AK, Bragg TK, Sondgeroth KS, Malmberg JL. 2022. Source and seasonality of epizootic mycoplasmosis in free-ranging pronghorn (*Antilocapra americana*). Journal of Wildlife Diseases 58(3):524–536.

Jones NF, Pejchar L, Kiesecker JM. 2015. The energy footprint: How oil, natural gas, and wind energy affect land for biodiversity and the flow of ecosystem services. BioScience 65(3):290–301.

Jones PF, Hurly, TA, Jensen C, Zimmer K, Jakes A. 2017. Diel and monthly movement rates by migratory and resident female pronghorn. The Prairie Naturalist 49:3–12.

Jones PF, Jakes AF, Eacker DR, Hebblewhite M. 2020. Annual pronghorn survival of a partially migratory population. Journal of Wildlife Management 84:1114–1126.

Jones PF, Jakes AF, Vegter SE, Verhage MS. 2022. Is it the road or the fence? Influence of linear anthropogenic features on the movement and distribution of a partially migratory ungulate. Movement Ecology 10:37.

Kauffman, M.J., E.O. Aikens, S. Esmaeili, P. Kaczensky, A. Middleton, K.L. Monteith, T.A. Morrison, T. Mueller, H. Sawyer, and J.R. Goheen. 2021. Causes, consequences, and conservation of ungulate migration. Annual Review of Ecology, Evolution, and Systematics 52:453–478.

Kauffman MJ, Copeland HE, Berg J, Bergen S, Cole E, Cuzzocreo M, Dewey S, Fattebert J, Gagnon J, Gelzer E, et al. 2020. Ungulate migrations of the western United States, Volume 1. Reston (VA): US Department of the Interior, US Geological Survey Scientific Investigations Report 2020–5101.

Kauffman M, Lowrey B, Beck J, Berg J, Bergen S, Berger J, Cain J, Dewey S, Diamond J, Duvuvuei O, et al. 2022. Ungulate migrations of the western United States, Volume 2. Reston (VA): US Department of the Interior, US Geological Survey Scientific Investigations Report 2022–5008.

Keegan TW, Ackerman BB, Aoude AN, Bender LC, Boudreau T, Carpenter LH, Compton BB, Elmer M, Heffelfinger JR, Lutz DW, Trindle BD, Wakeling BF, Watkins BE. 2011. Methods for monitoring mule deer populations. Boise (ID): Western Association of Fish and Wildlife Agencies, Mule Deer Working Group.

Lambert MS, Sawyer H, Merkle JA. 2022. Responses to natural gas development differ by season for two migratory ungulates. Ecological Applications e2652. https://doi.org/10.1002/eap.2652.

Leu M, Hanser SE, Aldridge CL, Nielsen SE, Suring LH, Knick ST. 2011. Occurrence of large and medium-sized mammals: Occurrence but not count models predict pronghorn distribution. In Hanser SE, Leu M, Knick ST, Aldridge CL, editors. Sagebrush Ecosystem Conservation and Management: Ecoregional assessment tools and models for the Wyoming Basins. Lawrence (KS): Allen Press. p. 315–336.

Linnell J, Aanes R, Andersen R. 1995. Who killed Bambi? The role of predation in the neonatal mortality of temperate ungulates. Wildlife Biology 1:209–223.

Lowrey B, McWhirter DE, Proffitt KM, Monteith KL, Courtemanch AB, White PJ, Paterson JT, Dewey SR, Garrott RA. 2020. Individual variation creates diverse migratory portfolios in native populations of a mountain ungulate. Ecological Applications 30(5):e2106.

Mackie RJ. 1976. Interspecific competition between mule deer, other game animals, and livestock. In Low JB, editor. Mule deer decline in the west: a

symposium. Logan (UT): Utah State University, Agricultural Experiment Station. p. 49–54.
Malpeli KC. 2022. Ungulate migration in a changing climate—An initial assessment of climate impacts, management priorities, and science needs. Reston (VA): US Department of the Interior, US Geological Survey Circular 1493.
Marshall AM, Abatzoglou JT, Link TE, Tennant CJ. 2019. Projected changes in interannual variability of peak snowpack amount and timing in the western United States. Geophysical Research Letters 46:8882–8892.
Mattson DJ, Holton PB. 2022. Use of water sources by pronghorn in a semi-arid Arizona grassland ecotone. Mountain Lion Ecology Project, Technical Paper MLEP-TP-2022-2.
McInnis MI, Vavra M. 1987. Dietary relationships among feral horses, cattle, and pronghorn in southeastern Oregon. Journal of Range Management 40(1):60–66.
Miller RF, Knick ST, Pyke DA, Meinke CW, Hanser SE, Wisdom MJ, Hild AL. 2011. Characteristics of sagebrush habitats and limitations to long-term conservation. Studies in Avian Biology 38:145–184.
Milligan MC, Johnston AN, Beck JL, Taylor KL, Hall E, Knox L, Cufaude T, Wallace C, Chong G, Kauffman MJ. 2023. Wind-energy development alters pronghorn migration at multiple scales. Ecology and Evolution 13:e9687.
Moeller AK, Lukacs PM, Horne JS. 2018. Three novel methods to estimate abundance of unmarked animals using remote cameras. Ecosphere 9(8):e02331.
Monroe AP, Drietz V, McPherron HH, Wightman CS. 2021. Land Use and Development. In Remington TE, Deibert PA, Hanser SE, Davis DM, Robb LA, Welty JL, editors. Sagebrush Conservation Strategy—Challenges to Sagebrush Conservation. US Geological Survey Open-File Report 2020–1125. p. 179–190.
Monteith KL, Long RA, Bleich VC, Heffelfinger JR, Krausman PR, Bowyer RT. 2013. Effects of harvest, culture, and climate on trends in size of horn-like structures in trophy ungulates. Wildlife Monographs 183:1–26.
Murray TB. 1951. Statewide Trapping and Transplanting. Boise (ID): Idaho Department of Fish and Game. Completion Report Project W-75-D-4, 1 July 1950 to 30 June 1951.
Nelson ZJ, Weisberg PJ, Kitchen SG. 2014. Influence of climate and environment on post-fire recovery of mountain big sagebrush. International Journal of Wildland Fire 23(1):131–142.
O'Gara BW, Yoakum JD, editors. 2004. Pronghorn Ecology and Management. Boulder (CO): University Press of Colorado.
Office of Energy and Mineral Resources (OEMR). 2022. Idaho Energy Landscape. Boise (ID): Idaho Governor's Office of Energy and Mineral Resources.

Palencia P, Rowcliffe JM, Vicente J, Acevedo P. 2021. Assessing the camera trap methodologies used to estimate density of unmarked populations. Journal of Applied Ecology 58:1583–1592.

Panting BR, Gese EM, Conner MM, Bergen S. 2021. Factors influencing survival rates of pronghorn fawns in Idaho. Journal of Wildlife Management 85:97–108.

Pfannenstiel RS, Mullens BA, Ruder MG, Zurek L, Cohnstaedt LW, Nayduch D. 2015. Management of North American Culicoides biting midges: Current knowledge and research needs. Vector-Borne and Zoonotic Diseases 15(6):374–384.

Pfeffer SE, Spitzer R, Allen AM, Hofmeester TR, Ericsson G, Widemo F, Singh NJ, Cromsigt JPGM. 2018. Pictures or pellets? Comparing camera trapping and dung counts as methods for estimating population densities of ungulates. Remote Sensing in Ecology and Conservation 4:173–183.

Pfeiler SS, Conner MM, Mckeever JS, Stephenson TR, German DW, Crowhurst RS, Prentice PR, Epps CW. 2020. Costs and precision of fecal DNA mark-recapture versus traditional mark-resight. Wildlife Society Bulletin 44:531–542.

Pojar TM, Miller LLW. 1984. Recurrent estrus and cycle length in pronghorn. Journal of Wildlife Management 48:973–979.

Purse BV, Mellor PS, Rogers DJ, Samuel AR, Mertens PP, Baylis M. 2005. Climate change and the recent emergence of bluetongue in Europe. Nature Reviews Microbiology 3:171–181.

Reinking AK, Smith KT, Mong TW, Read MJ, Beck JL. 2019. Across scales, pronghorn select sagebrush, avoid fences, and show negative responses to anthropogenic features in winter. Ecosphere 10(5):e02722. 10.1002/ecs2.2722.

Rimbey NR, Gardner RL, Patterson PE. 1991. Wildlife depredation policy development. Rangelands 13(6):272–275.

Rivera NA, Varga C, Ruder MG, Dorak SJ, Roca AL, Novakofski JE, Mateus-Pinilla NE. 2021. Bluetongue and epizootic hemorrhagic disease in the United States of America at the wildlife-livestock interface. Pathogens 10:915.

Robb BS, Merkle JA, Sawyer H, JL Beck, Kauffman MJ. 2022. Nowhere to run: semi-permeable barriers affect pronghorn space use. Journal of Wildlife Management 86:e22212.

Rose H, Hoar B, Kutz SJ, Morgan ER. 2014. Exploiting parallels between livestock and wildlife: predicting the impact of climate change on gastrointestinal nematodes in ruminants. International Journal for Parasitology: Parasites and Wildlife. 3:209–219.

Rupp DE, Abatzoglou JT, Mote PW. 2017. Projections of 21st century climate of the Columbia River Basin. Climate Dynamics 49:1783–1799.

Samuel WM, Pybus MJ, Kocan AA, editors. 2001. Parasitic Diseases of Wild Mammals, Second Edition. Ames (IA): Iowa State University Press.

Sawyer H, Beckmann JP, Seidler RG, Berger J. 2019. Long-term effects of energy development on winter distribution and residency of pronghorn in the Greater Yellowstone Ecosystem. Conservation Science and Practice. 1:e83. https://doi.org/10.1111/csp2.83.

Sawyer H, Kauffman MJ. 2011. Stopover ecology of a migratory ungulate. Journal of Animal Ecology 80:1078–1087.

Sawyer H, Korfanta NM, Kauffman MJ, Robb BS, Telander AC, Mattson T. 2022. Trade-offs between utility-scale solar development and ungulates on western rangelands. Frontiers in Ecology and the Environment 20(6):345–351.

Sawyer H, Rodgers PA, Hart T. 2016. Pronghorn and mule deer use of underpasses and overpasses along U.S. Highway 191. Wildlife Society Bulletin 40(2):211–216.

Schoenecker KA, Doherty Jr PF, Hourt JS, Romero JP. 2018. Testing infrared camera surveys and distance analyses to estimate feral horse abundance in a known population. Wildlife Society Bulletin 42:452–459.

Schroeder C. 2018. Western state and province pronghorn state report, 2018. Proceedings of the Western States and Provinces Pronghorn Workshop 28:29–35.

Seidler RG, Long RA, Berger J, Bergen S, Beckmann JP. 2015. Identifying impediments to long-distance mammal migrations. Conservation Biology 29:99–109.

Shinneman DJ, McIlroy SK. 2016. Identifying key climate and environmental factors affecting rates of postfire big sagebrush (Artemisia tridentata) recovery in the northern Columbia Basin, USA. International Journal of Wildland Fire 25(9):933–945.

Smith KT, Taylor KL, Albeke SE, Beck JL. 2020. Pronghorn winter resource selection before and after wind energy development in south-central Wyoming. Rangeland Ecology and Management 73(2):227–233.

Stauber EH, Autenrieth R, Markham OD, Whitbeck V. 1980. A seroepidemiologic survey of three pronghorn (*Antilocapra americana*) populations in southeastern Idaho, 1975-1977. Journal of Wildlife Diseases 16(1):109–115.

Switalski A. 2018. Off-highway vehicle recreation in drylands—A literature review and recommendations for best management practices. Journal of Outdoor Recreation and Tourism 21:87–96.

Taylor JC, Bates SB, Whiting JC, McMillan BR, Larsen RT. 2021. Using camera traps to estimate ungulate abundance: a comparison of mark-resight methods. Remote Sensing in Ecology and Conservation 8(1):32–44.

Taylor KL, Beck JL, Huzurbazar SV. 2016. Factors influencing winter mortality risk for pronghorn exposed to wind energy development. Rangeland Ecology and Management 69:108–116.

Taylor AR, Knight RL. 2003. Wildlife responses to recreation and associated visitor perceptions. Ecological Applications 13(4):951–963.

Torbit SC, Gill RB, Alldredge AW, Liewer JC. 1993. Impacts of pronghorn grazing on winter wheat in Colorado. Journal of Wildlife Management 57:173–181.

Twin Falls Times News. 1946, March 11. 64 Antelope transplanted from Challis section to rolling prairie country southwest of Castleford. *Twin Falls Times News*, p. 1. https://twinfalls.newspaperarchive.com/twin-falls-times-news/1946-03-11/

US Department of Agriculture (USDA). 2021. National Agricultural Statistics Service Cropland Data Layer. Washington (DC): USDA-NASS. Available at https://nassgeodata.gmu.edu/CropScape/ (Accessed 06 September 2022).

Van Moorter B, Engen S, Fryxell JM, Panzacchi M, Nilsen EB, Mysterud A. 2020. Consequences of barriers and changing seasonality on population dynamics and harvest of migratory ungulates. Theoretical Ecology 13:595–605.

Weaver JH. 2013. The role of parasites, diseases, mineral levels, and low fawn survival in a declining pronghorn population in the Trans-Pecos region of Texas [master's thesis]. Alpine (TX):Sul Ross State University.

Weber KT. 2021. Historic Fires Database, version 4.0. Pocatello (ID):Idaho State University GIS Training and Research Center. Available at http://giscenter.isu.edu/research/Techpg/HFD/ (Accessed 12 October 2021).

White PJ, Davis TL, Barnowe-Meyer KK, Crabtree RL, Garrott RA. 2007. Partial migration and philopatry of Yellowstone pronghorn. Biological Conservation 135:502–510.

Wisdom MJ, Ager AA, Preisler HK, Cimon NJ, Johnson BK. 2004. Effects of off-road recreation on mule deer and elk. In Rahm J, editor. Transactions of the 69th North American Wildlife and Natural Resources Conference. Washington (DC): Wildlife Management Institute, Washington, DC. p. 531–550.

Woodruff SP, Lukacs PM, Christianson D, Waits LP. 2016. Estimating Sonoran pronghorn abundance and survival with fecal DNA and capture-recapture methods. Conservation Biology 30:1102–1111.

Xu W, Gigliotti LC, Royauté R, Sawyer H, Middleton AD. 2023. Fencing amplifies individual differences in movement with implications on survival for two migratory ungulates. Journal of Animal Ecology 00:1–13.

Yoakum JD, Jones PF, Cancino J, Guenzel RJ, Seidler R, Munguia-Vega A, Cassaigne I, Culver M. 2014. Pronghorn management guides, Fifth edition. Santa Ana Pueblo (NM): Western Association of Fish and Wildlife Agencies' Pronghorn Workshop and New Mexico Department of Game and Fish.

Zeller KA, Schroeder CA, Wan HY, Collins G, Deryter K, Jakes AF, Cushman SA. 2021. Forecasting habitat and connectivity for pronghorn across the Great Basin ecoregion. Diversity and Distributions 27(12):2315–2329.

Zuliani A, Massolo A, Lysyk T, Johnson G, Marshall S, Berger K, Cork SC. 2015. Modelling the northward expansion of Culicoides sonorensis (Diptera: Ceratopogonidae) under future climate scenarios. PLoS ONE 10(8): e0130294.