Idaho Moose Management Plan
2020-2025

DRAFT
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EXECUTIVE SUMMARY

Shiras Moose (*Alces alces shiras*) occur across much of Idaho, except for the southwest corner of the state. Moose are highly valued by both hunters and non-hunters, providing consumptive and non-consumptive opportunities that have economic and aesthetic value. Over the past century their known range has expanded from small areas of northern and eastern Idaho to their current distribution. Population size also increased during this time, likely peaking around the late 1990s or early 2000s. The Idaho Department of Fish and Game (IDFG) is concerned that current survey data, anecdotal information and harvest data indicate moose have recently declined in parts of Idaho. Several factors may be impacting moose populations both positively and negatively including predation, habitat change (e.g., roads, development, timber harvest), changing climate, disease or parasites and combinations thereof.

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. Idaho’s prior moose management plan (Idaho Department of Fish and Game 1990) addressed providing a quality hunting experience, the vulnerability of moose to illegal harvest, protecting their habitat, improving controlled hunt drawing odds and expanding moose populations into suitable ranges. The intent of this revision to the 1990 Moose Management Plan is to provide guidance for IDFG and their partners to implement management actions that will aid in protection and management of moose populations in Idaho and guide harvest season recommendations for the next 6 years. This plan directs IDFG to maintain or increase moose populations and hunting opportunities across the state. To accomplish this goal, IDFG has identified statewide management directions and strategies. IDFG will engage partners interested in moose management including hunters, federal and state agencies, conservation organizations, tribes and other interested individuals and groups as this plan is implemented. Partnerships can help IDFG accomplish goals to maintain sustainable populations, healthy habitat and hunting opportunity.

IDFG has identified a need to improve our ability to estimate population size and productivity and changes in these measures over time. We also need to be able to identify the causes of increases and decreases in populations and what management strategies we can employ to address these issues. Habitat, parasites, pathogens, predators, changing climate, development, etc. could all impact moose survival and productivity. As portions of Idaho continue to change, identifying areas projected to experience the greatest increases and decreases in moose numbers relative to the potential changes will help prioritize research and management.

Moose use a wide variety of habitats in Idaho including mesic, aspen and dryland conifer, mountain brush and sagebrush steppe. During winter they will use a variety of habitats including sagebrush steppe and dense forest. Moose habitat in Idaho can be broadly grouped into 3 types; coniferous forests of north Idaho, mixed aspen and conifer forests of southeast and central Idaho and riparian cottonwood and willow communities found in parts of southern Idaho. We divided the moose distribution into 20 Data Analysis Units (DAUs) based on our current knowledge of habitats, distribution and connectivity among populations, harvest, and other management concerns (e.g., social tolerance).
Hunters are allowed to harvest one bull and one cow moose in Idaho in their lifetime, except Super Hunt tag winners and left-over tag holders may harvest a moose regardless of any previous moose harvest. All tags are issued under a controlled hunt structure and are allocated through a lottery system. Relatively few tags are offered and they are highly sought after with demand having increased over time. Moose are more vulnerable to human exploitation (e.g., poaching, hunting, vehicle collisions) than other ungulate species such as elk (Cervus canadensis) or deer (Odocoileus spp.) due to their large size, high visibility, low population densities, habit of frequenting roadsides and tendency to be less wary. Moose are polygamous, allowing for more male harvest than female harvest. However, male moose cannot be harvested at as high of rates as other ungulate species, like deer and elk, because of lower densities and breeding behavior.

Currently, Idaho suffers from a lack of data to monitor population and productivity trends, identify causes of decline and prescribe management actions. This plan identifies management direction and strategies to gather data and improve our ability to manage moose populations. Implementation of all strategies will be subject to available funding and personnel.

Statewide moose management direction in this plan includes:

- Increase our knowledge of moose survival, recruitment, habitat use, genetics and the impacts of disease, habitat changes, predation and recreational activities.
- Improve the quality of moose population monitoring data to better evaluate population trends. Create guidelines for moose translocations in Idaho.
- Collaborate with private landowners and land management agencies to incorporate measures in land use and resource management plans that benefit moose.
- Provide harvest opportunity while maintaining stable to increasing moose populations statewide.
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INTRODUCTION

The Idaho Department of Fish and Game (IDFG) was established to preserve, protect, perpetuate and manage fish and wildlife in the state. Statewide species management plans provide an overview of current status and set statewide management direction to help fulfill that mission.

The intent of this revision to the 1990 Moose Management Plan is to provide guidance for IDFG and their partners to implement research and management actions that will aid in protection and management of moose populations in Idaho and guide harvest season recommendations. This plan will set overall direction for moose management and research, including work plan development and program prioritization, during the next 6 years (2020-2025). This plan will also provide guidance on development of regulatory recommendations.

Idaho is experiencing a declining trend in some moose populations in the state. This situation is not unique to Idaho. Concern over widespread declines in North American moose populations has risen in recent years, particularly in the southern portion of their range. Idaho moose populations likely peaked in the late 1990s or early 2000s and have been stable or declining in most areas of the state since that time. Currently, Idaho suffers from a lack of data to monitor population trends, identify causes of decline and prescribe management actions. This plan identifies management direction and strategies to gather data and improve our ability to manage moose populations. Implementation of all strategies will be subject to available funding and personnel.

Moose Management Plan (1990) Goals and Accomplishments

The primary goals of the previous moose plan (1991-1995) were 1) to provide high quality moose hunting and other moose-related recreational experiences for as many people as possible, 2) to assist the expansion of moose populations into available habitat and 3) to increase tag numbers where possible.

Goal 1: Provide high quality moose hunting and other moose-related recreational experiences for as many people as possible.
Accomplishment: Between 1991 and 2018, hunters harvested 19,478 moose in Idaho. This number includes 2903 cows and 16,575 bulls, some of which were calves harvested on antlerless hunts. These data represent a 74% overall harvest success rate based on the number of tags available. Moose harvested on antlered hunts averaged 91 cm (36 in) in width. Hunting season length has remained relatively long in most areas, allowing hunters to spend many days in the field.

Goal 2: Assist the expansion of moose populations into available habitat.
Accomplishment: Between 1991 and 1995, moose hunting opportunities were added in 7 GMUs across the state (from 41 to 48 GMUs), indicating that moose populations with a harvestable surplus were expanding. As of 2019, moose hunting opportunities are available in 58 GMUs across the state. This expansion has been assisted throughout the years by translocating nuisance moose into areas with available habitat, but low/non-existent moose populations.
Goal 3: Increase tag numbers where possible.
Accomplishment: As moose populations expanded in different areas of the state, additional hunting opportunity has been made available whenever possible. In 1991, 498 moose tags (antlered and antlerless) were available in Idaho. Tag numbers then peaked in 2003 and 2004 at 1235 tags each year. Tag numbers have decreased since 2004, with 634 moose tags available during the 2019 hunting season.
POPULATION MANAGEMENT

Four subspecies of moose occur in North America (Franzmann 1978). The Shiras subspecies (*Alces alces shirasi*) can be found in Colorado, Idaho, Montana, Utah, Washington, Wyoming and the southern parts of British Columbia and Alberta (Franzmann 1978). Moose were uncommon in Idaho during the early 1800s. Native Americans told the Lewis and Clark expedition that moose could be found in portions of the Salmon River drainage. However, many fur trappers traveling through southern and eastern Idaho failed to mention moose in their accounts. Similarly, few moose were believed to exist in the Yellowstone and Jackson Hole areas prior to 1850. Some researchers believe moose in Idaho established from moose emigrating from Montana. President Theodore Roosevelt harvested a bull moose in the Bitterroot mountain range along the Idaho-Montana border in 1887.

Moose are considered individualistic animals (Franzmann and Schwartz 2007) usually keeping to themselves with a low degree of sociability. They are the largest of the cervids (deer species). Males, females and young of the year are referred to as bulls, cows and calves, respectively. Males have antlers that are shed in December or January. Adult males are larger than females (500-700lbs) and can weigh up to 1000 pounds. Moose can continue to gain weight their entire life but very little growth occurs after age 9 for males and after age 4 for females (Franzmann and Schwartz 2007). Moose are polygamous, allowing for more male harvest than female harvest. However, male moose cannot be harvested at as high of rates as other ungulate species (e.g., deer and elk) because of lower densities and because they spend more time with a cow during estrus so bull to cow ratios need to be higher due to breeding behavior.

Breeding season occurs between mid-September and mid-October and calves are generally born in late May following a 231-day gestation period. The age at which a cow moose breeds is related to her growth and body size (Saether and Haagunrud 1983). Moose calves do not breed; however, yearling females can reproduce if quality of habitat allows the moose to reach sexual maturity (Saether and Haagunrud 1985). In areas with excellent forage, many yearling females ovulate and become pregnant, generally give birth to singletons (Saether and Haagunrud 1985, Schwartz and Hundertmark 1993). Most cows do not typically start breeding until 3 years of age. Fertility remains high throughout the life of most females with maximum reproductive output between ages 4 and 7 years (Sylven 1980, Saether and Haagunrud 1983, Schwartz and Hundertmark 1993). Twinning rates vary widely across North America and has been correlated to habitat quality (Gasaway et al. 1992) and triplets are considered rare. Data from Peek (1962), Houston (1968) and Stevens (1970) suggest that Shiras moose may have a lower reproductive rate than the other subspecies.

IDFG has little information on pregnancy rates of moose; however, a few samples have been collected over the years on Sand Creek WMA in southern Idaho and in the Clearwater Region. Muir (2006) found 76.5% of adult moose pregnant in the Moscow Mountain area (GMU 8) and 89% adult moose pregnant on Sand Creek WMA. Of those tested by IDFG on Sand Creek WMA in 2010, 2011 and 2018, 93% (n=14/15), 89% (n=23/26) and 100% (n=6/6), respectively, were found pregnant. In the Clearwater Region, in 2011, 21% (n=4/19) and, in 2018, 75% (n=3/4) of adult female moose were pregnant (IDFG unpublished results). In Montana, documented pregnancy rate averaged 83% (range 80-87%) for cows aged ≥2.5 years, yearling pregnancy
rates varied from 0-44% and twinning rates ranged from 0-16% (DeCesare and Newby 2018). Robertson et al. (2018) reported pregnancy rates in Utah between 66-79% and twinning rates varied from 0-10% across the state. In Wyoming, Oates et al. (2016) reported pregnancy rates between 48-73%.

Moose are browsing ruminants, meaning they eat primarily forbs, shrubs and trees (Hofmann 1973). Generalist browsers such as moose have specific salivary proteins that help in the digestion of key foods such as willow, aspen and birch (see Appendix A for scientific names). They will eat leaves, twigs, bark and buds of hardwood and softwood trees and shrubs. In the summer, moose in Idaho feed predominantly on shrubs, some trees and forbs. When available, moose will forage in lakes and ponds for aquatic plants such as water lilies and pond weed, which are rich in minerals. Riparian areas are one of the most threatened habitats in the United States (Noss et al. 1995) and, due to the biomass of forage, these areas are critical for the persistence of moose populations.

Distribution

Moose are typically found in marshy areas and meadows during spring and summer, although given the limited amount of mesic habitat in Idaho, they also occur in upland areas with similarly abundant forage and cover. Individuals display different habitat preferences during winter, with some animals moving into heavily timbered areas and others utilizing sagebrush steppe. In Idaho moose have been observed throughout most of the state (Figure 1).

Moose distribution for this plan is defined as the geographic range regularly or periodically occupied by moose. Not all areas within this range have sufficient suitable habitat to support persistent populations and moose move outside this area. We divided the moose distribution into 20 Data Analysis Units (DAUs) based on our current knowledge of habitats, distribution and connectivity among populations, harvest, and other management concerns (e.g., social tolerance) (Figure 2). Additional information on marked individuals could further refine these boundaries.
Figure 1. Moose observations (1979-2019) and seasonal predicted distribution models in Idaho. Point data are from various Idaho Department of Fish and Game databases as of August 2019 and include targeted inventories and surveys, museum specimens and incidental observations. Distribution models were developed using maximum entropy methods and a subset of observations (see Appendix B for more information).
Figure 2. Data Analysis Units (DAU) for moose in Idaho.
Survival
Factors affecting moose survival can be divided into natural or human-caused mortality. Natural mortality can occur from weather, predation, accidents and disease. Examples of human-caused mortality include hunting and vehicle collisions. Adult and calf survival have not been well documented in Idaho, although Muir (2006) found 100% (8/8) calf survival at approximately 5 months of age on the Sand Creek Wildlife Management Area (WMA). In Montana, adult female survival was estimated between 85-93% across 3 study areas and calf survival (calves that survived their first year of life) were reported between 34-52% (DeCesare and Newby 2018). Robertson et al. (2018) reported adult female survival in Utah of 83-91% and calf recruitment between 21-41%. In Wyoming, Oates et al. (2016) reported adult survival between 83-87% and calf survival (9 months) was 65-75%. Calves remain with their mothers through their first winter and her presence is thought to increase calf survival. Older calves (>6 months), if orphaned, can survive almost as well as non-orphans if they can find other moose with which to associate. The presence of prime-aged moose likely decreases the susceptibility of a calf to predation, assists with learning of forage areas, and minimizes nutritional costs by breaking trail through deep snow (Markgren 1975, Jolicoeur and Crête 1988).

Nutritional condition of ungulates has been shown to impact survival and productivity. The amount of rump fat is a good indication of overall body condition in moose (Stephenson et al. 1998, DeCesare and Newby 2018, Van Ballenberghe and Ballard 2007). It can be measured by using ultrasonography at the time of capture or harvest. Oates et al. (2016) found that adult females with a percent body fat lower than 5.5% during February had lower probabilities of survival, pregnancy and parturition.

Between 2000 and 2018, just over 1000 non-hunting moose mortalities were reported in the IDFG Big Game Mortality Report (BGMR) database. Although likely conservative in number, the reported information suggests the top 4 sources of mortality are roadkill, illegal harvest, natural mortality (winter kill, predators, disease) and unknown causes. It is important to note that not all moose mortalities are recorded in this database and that some sources of mortality are more difficult to detect and monitor than others. Consequently, the true magnitude of mortality or the mortality factors is not known and likely higher than represented here. Management directions and strategies are identified in this plan to improve our understanding of mortality factors.

Additional data on roadkill submitted to the Idaho Fish and Wildlife Information System (IFWIS) Roadkill database indicates that collision with vehicles is a substantial source of mortality for Idaho moose. These data are collected differently than the BGMR reports and, while there may be redundancy between the two datasets, each offers a valuable yet different perspective on moose-vehicle collisions in Idaho. From December 2000 to August 2019, 1003 unique moose roadkills were reported in the IFWIS Roadkill database. A hotspot analysis of
these moose-vehicle collisions identified areas with higher levels of vehicle collisions on Idaho roadways (Figure 3).

Figure 3. Reported moose roadkill hotspots in Idaho from December 2000-August 2019. A hotspot analysis of moose-vehicle collisions in Idaho demonstrates the high level of collisions on roadways. Clusters were analyzed at a one-mile neighbor radius and plotted in one-mile road segments. A hotspot score of one indicates a low level of wildlife-vehicle collision (WVC) clusters on that road segment and a score of 10 indicates the highest relative value of WVC clustering. The hotspot analysis was run using the UC Davis Road Ecology Center’s beta version of the Automated Roadway Hotspot Analysis online tool (Shilling and Waetjen 2015). Data were sourced from the Idaho Fish and Wildlife Information System Roadkill database.
Population Monitoring

Monitoring moose populations is important for directing appropriate management efforts. Current population monitoring is based on hunter harvest statistics, aerial surveys, hunter opinion surveys and local insight from conservation officers and biologists. Resources to monitor moose are scarce, so data are limited. Moose are difficult to monitor because they are widespread, occur in dense cover and at low densities. The first attempts to census moose occurred in 1952 in southeastern Idaho. These surveys have continued sporadically using helicopters. Typical monitoring efforts used across areas occupied by moose include pellet or track counts, ground counts, thermal infrared surveys, aerial counts or hunter phone surveys. These techniques can be labor intensive, cost prohibitive and may not yield dependable population estimates (Karns 2007, Timmerman and Buss 2007).

Recent hunter harvest data, aerial survey data and anecdotal information suggests moose populations are declining in some areas of the state. To understand and identify population declines and direct moose management strategies, standardized guidelines for monitoring moose need to be in place. Exploring survey methods which yield trend, demographic parameters and population estimates is a priority for IDFG. Routine population monitoring will allow managers to evaluate the effects of management actions (i.e., tag increases or decreases), increasing pressures from human recreation, disease, habitat conversion or loss and changing climate on moose populations.

Aerial Surveys

IDFG has conducted a few moose population trend surveys in portions of Game Management Units (GMUs) via helicopter. However, most counts occur as incidental observations during surveys for deer and elk and therefore are limited in area to deer and elk survey units. Data gathered from incidental sighting is usually inconsistent between surveys and sometimes lacking demographic information that could be applied towards management. Few, if any, aerial surveys specifically targeting moose occur on an annual basis for IDFG. Aerial surveys flown in southeastern Idaho collect information on distribution, population trend, sex ratios and cow:calf ratios. Harris et al. (2015) conducted sightability surveys in northeastern Washington, which is similar habitat to northern Idaho and concluded that coniferous forest cover produced low detection probabilities and the sightability models produced disparate estimates. Therefore, aerial survey techniques will be of limited use in northern Idaho due to extensive forest cover and the wide distribution of moose across the landscape.

Surveys are flown in a helicopter with two observers who record the number of moose, demographic information, activity type and snow cover. Aerial surveys occur during winter. They are flown on contours throughout designated sub-units until it is surveyed completely. Information gathered from incidental observations is not used to determine population estimates, but to give insight into composition of groups and trend over time.

Infrared surveys were attempted in northern Idaho in 2010. It was determined that thermal infrared imagery surveys are not appropriate for monitoring moose in areas with dense conifer cover. Infrared does not penetrate vegetation cover, making it difficult to detect moose. Thermal infrared surveys do not collect demographic information.
Remote Cameras
Remote cameras have recently been used as a method to determine population abundance for elk. Moeller et al. (2018) developed three methods (time-to-event, space-to-event and instantaneous sampling) that utilize remote cameras to estimate populations of unmarked animals. Each of the methods rely on an array of remote cameras placed throughout the defined study area (e.g., the area occupied by a population of moose). Depending on the method, the cameras are either programmed to take pictures when they are triggered by motion within their field of view or at pre-determined time intervals. The number and timing of animals captured in pictures and the area of the cameras’ field-of-view are then used to estimate abundance. The methods may produce separate abundance estimates for different sex and age classes of moose, allowing the calculation of sex and age ratios. Currently, IDFG is investigating the use of remote cameras to monitor moose populations in conjunction with ungulate and carnivore populations.

Understanding population dynamics, such as survival, recruitment and sex and age composition of moose allow for more informed management decisions. Little is known about vital rates of moose in Idaho; however, surrounding states have conducted research providing some insight into population dynamics. Identifying primary population drivers for moose in Idaho will help inform management.

Management Direction: Improve ability to monitor moose status and trends across the state.

**Strategy:** Continue investigating alternative monitoring techniques, such as the use of remote cameras to estimate population size and recruitment.

**Strategy:** Evaluate occupancy modeling to detect changes in distribution. Implement in areas if deemed beneficial and resources are available to gather data for modeling.

**Strategy:** Collaborate with transportation agencies to document and report moose mortalities, especially roadkill, in IDFG standardized databases (e.g., IFWIS).

**Strategy:** Work with federal and state transportation officials on mitigation measures to help reduce vehicle collisions.

**Strategy:** Continue to document all known moose mortalities in the BGMR database, including harvest and non-harvest mortality such as disease, winter kill, etc.

**Strategy:** Continue to conduct aerial surveys where habitat conditions are appropriate.

**Strategy:** Collect data on incidental moose observations during aerial surveys for other species (i.e., elk, deer) and record in IFWIS.

**Strategy:** Encourage hunters and other outdoor publics (federal, state and tribal staff, recreationalists, etc.) to record observations of moose presence and absence, as well as associated information (date, areas of use, activity, time spent in area and number of moose by age and sex observed) in IFWIS.
**Strategy:** Standardize data collected during all aerial surveys where moose may be encountered.

**Strategy:** Continue to collect success rates, days to harvest, antler spread measurements and report in the BGMR database.

**Strategy:** Explore methods to evaluate bull quality metrics and age.

**Management Direction:** Identify primary population drivers for moose across Idaho to inform management and improve population performance.

**Strategy:** Conduct research to evaluate cause-specific mortality and assess the role of nutrition, predation, climate, disease and harvest in recruitment, seasonal movements, habitat use and survival.
HEALTH ASSESSMENT AND DISEASE

Data documenting prevalence and impacts of disease on moose populations in Idaho are limited. However, moose are known to be susceptible to a wide variety of parasites and pathogens and a better understanding of the impacts of disease would likely improve management of this species. Although moose afflicted by a variety of disease conditions have been reported for over 100 years, recent data indicate that prevalence and impacts may be increasing in many parts of moose range in North America.

While a variety of diseases can affect moose, parasitic diseases are most commonly recognized or identified. The solitary nature and low population densities of moose could limit disease transmission between individuals. Many reports of diseased or deceased moose in Idaho involved descriptions of blindness or eye discharge, excessive salivation, baldness from rubbing and/or emaciation. Unfortunately, definitive diagnoses or causes of death are rarely obtained.

Previous testing of samples from post-mortem necropsies and live-captured moose in Idaho indicate the presence and varying prevalence of various diseases (Bovine Respiratory Syncytial Virus, Bovine Viral Diarrhea, Parainfluenza, Hydatid Disease caused by *Echinococcus* tapeworms, other tapeworm infections, etc.). Many of these pathogens do not appear to be associated with major health problems or mortality in moose, although they may cause clinical signs. Several additional diseases are known to affect moose in North America, but have not been documented in Idaho (e.g., chronic wasting disease and meningeal worm). Other diseases and parasites considered a health concern for moose and documented in Idaho include winter ticks, carotid artery worm, giant liver fluke and infectious keratoconjunctivitis (pink eye).

**Parasites and Pathogens**

Parasites and pathogens likely to have the greatest effect on moose health are discussed below, although not all have been detected in Idaho. Several proximate factors may magnify the consequences these parasites and pathogens have on moose populations, including habitat loss and fragmentation, climate change and increasing recreational pressure in areas previously unperturbed by human activity. The population-level effects on moose in Idaho are unknown.

**Carotid Artery Worm**

The carotid artery worm is a normal nematode parasite of mule deer in North America. The life cycle involves horseflies as the intermediate host. However, it can use moose as a definitive host (Madden et al. 1991). Carotid artery worms have been documented in many western states, including Idaho. Research in western Wyoming documented carotid artery worms in 49% of 168 hunter harvested moose in 2009 (Henningsen et al. 2012). This high prevalence seems significant when compared to previous research showing very low prevalence rates (<5%) and suggestions of minimal importance of elaeophorosis in moose (Worley 1975). Clinical signs of infection in moose can include cropped or dry gangrene of the nose and ears, deformed antlers, blindness, neurological symptoms and death (Henningsen et al. 2012). While increased prevalence rates are concerning, effects of carotid artery worms on individual moose remain unknown and high prevalence in apparently healthy hunter harvested moose suggest that infection may not be incapacitating. However, negative effects of infection have also been repeatedly documented and
could result in decreased survival. These reports suggest that the effects of infection on moose are quite complex and warrant further research (Henningsen et al. 2012).

**Meningeal Worm**
The meningeal worm is likely the most important parasitic disease of moose in North America (Lankester 2010). However, it is not known to occur in moose in Idaho. Meningeal worm is a normal parasite of white-tailed deer. The life cycle requires a gastropod (snail or slug) intermediate host. After larvae are consumed by ruminants they migrate through the central nervous system to the brain, where they molt into adults. In ruminants other than white-tailed deer and some elk the migration occurs through the spinal cord, which causes neurological symptoms ranging from hind limb weakness and paralysis, to circling and lack of coordination and ultimately death. Meningeal worm has been found in moose in areas with high densities of white-tailed deer (i.e., moose range in eastern half of North America). The disease, termed “moose sickness”, has been known since the 1930s when it was first described in Minnesota.

**Giant Liver Fluke**
The giant liver fluke generally infects moose in areas where their range overlaps with white-tailed deer or elk, the normal hosts. In white-tailed deer, fluke eggs are passed in feces and the immature flukes hatch and infect aquatic snails. Larval flukes encyst on vegetation, are ingested and migrate through the rumen wall to the liver. In the liver, the larvae migrate until they find another larva. The larval pair encyst in the liver and develop into adults. When larval flukes are ingested by moose, a dead-end host, they continuously migrate through the liver and cause extensive damage including bloody tracts, fibrosis and tissue hypertrophy that can lead to liver failure (Pybus 2001). The population impacts of giant liver flukes on moose are unknown (Pybus 2001, Lankester 2010).

**Winter Tick**
Winter ticks are found in most areas where moose occur in North America. High tick burdens (>30,000 ticks) combined with other stressors (e.g., severe winter, diminished forage availability, other pathogens, etc.) may cause morbidity or mortality (Jones et al. 2018). Clinical signs associated with winter tick infestation include increased grooming, restlessness, weight loss and extensive hair loss from rubbing, all of which can contribute to mortality (Samuel 1991). Moose are believed to be most susceptible to tick infestations as calves and yearlings (Lankester 2010). Mortality related to tick infestation can be limited to individuals or be widespread throughout a population, although large die-offs are expected to be short-lived as they are likely associated with high densities of moose (Samuel 1991). Severe outbreaks of ticks are precipitated by warmer and shorter winters and particularly delayed onset of winter conditions in the fall (Jones et al. 2018).

**Keratoconjunctivitis**
This disease is caused by one of several bacteria species in the eye. These bacteria are transmitted by face or horn flies among individual hosts. In cattle, the disease is known as pink eye. Clinical signs of infection include discharge from eyes, corneal opacity or ulceration and blindness (Dubay et al. 2000). Prolonged infection and the potential for eventual blindness associated with keratoconjunctivitis likely reduce survival of infected individuals.
**Chronic Wasting Disease**

Chronic wasting disease (CWD) is a prion disease of cervids and is uniformly fatal. CWD has not been detected in any species in Idaho. However, it has been detected in moose in free ranging populations of Colorado, Montana and Wyoming. Diagnosis of CWD is generally obtained from sampling and testing the obex or retropharyngeal lymph nodes. While the solitary nature of moose likely precludes populations from extremely high prevalence rates, this fatal disease remains a concern for all afflicted species.

**Genetic Diversity**

Moose display low to moderate levels of genetic diversity (Hundertmark and Bowyer 2004). Lack of heterozygosity (low genetic diversity) could compromise a population’s ability to respond to environmental changes and disease. Further genetic work is needed to measure and evaluate genetic diversity in Idaho moose. If genetic variation is low, management direction and strategies to increase genetic variation may be warranted.

**Monitoring**

To increase understanding of moose health and diseases affecting moose in Idaho, IDFG personnel have opportunities to obtain samples for disease investigations in four settings: 1) Reports of deceased moose, 2) Moose translocated from urban settings, 3) Hunter harvested moose and 4) Live-capture of moose for research purposes. Each offers opportunity to sample, diagnose and otherwise increase our baseline knowledge of moose health and our understanding of diseases afflicting moose in Idaho.

At present, moose mortalities are reported infrequently by the public or are found by agency personnel. Most moose carcasses reported are in advanced stages of decomposition and determination of the cause of death is nearly impossible. A concerted effort to ask the public to report dead moose and for staff to respond to these reports and to mortality signals from radio-collared animals will help to obtain samples from recently dead animals.

Live animals that are moved from urban areas or captured for research or other management purposes should be sampled (blood, ocular swabs, feces, ectoparasites, etc.) to obtain data on the presence and prevalence parasites and pathogens in moose throughout Idaho.

Samples obtained from hunter harvested moose have significant value. These biologic samples are from apparently healthy animals and provide an opportunity to closely evaluate the health and presence of parasites and pathogens in moose from a much wider area in Idaho than any other sampling method. Moose are large animals and asking hunters to obtain samples or bring large organs or parts of the carcass to regional offices can be problematic. However, because these samples provide the best opportunity for collecting baseline health data and disease information at a statewide level, we have prioritized a voluntary hunter harvest sampling program as a strategy for sample collection.

**Translocation**

Recent concerns of disease transmission and continued human development of moose habitat have raised questions about IDFG’s moose translocation program. Moose translocation in Idaho is generally a result of nuisance animals being moved from urban areas or private properties to more remote locations. Starting in the 1980s, increasing nuisance moose complaints from eastern
Idaho and improved immobilization drugs provided opportunity for IDFG to re-locate nuisance moose to unoccupied habitats in south-central Idaho. Successful translocations can provide additional opportunity for harvest and viewing and may be substantial in some areas. For example, in the winter of 2001-2002, over 100 moose were moved in the Upper Snake Region.

**Management Direction:** Improve our understanding of existing and potential effects of disease on moose recruitment rates, survival and distribution.

**Strategy:** Conduct research to evaluate cause-specific mortality and assess the role of disease in recruitment, seasonal movements, habitat use and survival.

**Strategy:** Develop and integrate health and disease monitoring protocols into moose management activities including capture operations, hunter harvest, urban moose issues, observations of symptomatic moose and incidental mortalities.

**Strategy:** Document the presence and prevalence of various parasites and pathogens in Idaho moose populations.

**Strategy:** Develop strategies for managing populations that are negatively impacted by elevated levels of parasites or pathogens.

**Strategy:** Better our ability to assess causal factors of mortality in moose. Improve sampling and sample transport procedures, standardize and prioritize diagnostic testing, and improve reporting of results so that factors contributing to death can be evaluated to assess cause-specific mortality.

**Management Direction:** Measure levels of genetic diversity in moose populations across Idaho.

**Strategy:** Collect and bank moose DNA from captures, necropsied and harvested animals.

**Strategy:** Use banked DNA to establish a baseline of genetic diversity in Idaho’s moose.

**Management Direction:** Develop a moose translocation protocol.

**Strategy:** Identify release/translocation areas based on a number of factors including, but not limited to: habitat suitability, land ownership, proximity to human development and roadway infrastructure, status of existing moose and potential predator populations and current or ongoing resource or land management issues.

**Strategy:** Implement an animal health assessment before translocation to avoid introducing pathogens or disease. Consider parasite and pathogen presence or absence in both the source and recipient populations. Do not move moose to areas with parasite and pathogen communities that differ from the source population.

**Strategy:** Monitor animal post-release to evaluate success.
PREDATION

The large predator community in Idaho is comprised of 4 species: mountain lions, black bears, grizzly bears and gray wolves. The density of these predator species varies dramatically across the state. Mountain lions are the most widespread, occurring and harvested in every GMU in the state. Black bears are also quite common in Idaho, occurring in nearly every GMU but with very few individuals in the southwest corner of the state and no harvest south of Interstate-84/86 and west of I-15. Wolf distribution is quite similar to that of black bears, although there is not a resident wolf population in the southeast corner of the state where black bears are present. Grizzly bears are present in low densities and limited to the Panhandle and Clearwater Regions and the eastern portion of the Upper Snake Region. Predation by black bears is primarily limited to moose calves, while grizzly bears, mountain lions and wolves prey on adult moose.

The extent of predation on moose in Idaho is not well understood as little cause-specific mortality data exists for moose. However, surrounding states have recently completed moose survival studies and offer some insight into predation. Between 2013 and 2018, Montana Fish Wildlife and Parks collared and monitored 141 adult female moose. Of these, 9 (~6%) were killed by predators, the majority of these being wolves (DeCesare and Newby 2018). In Utah, ~200 adult moose were monitored between 2013 and 2018 and 1 of these was killed by a mountain lion. During this same period, ~80 moose calves were monitored and 2 were killed by mountain lions, both of which were in extremely poor body condition (Utah DWR, unpublished data). Contrasting these seemingly low predation rates, 6 of 16 (38%) adult moose transplanted into central Utah in 1995 were killed by mountain lions. From 2011-2014 in Wyoming, Oates et al. (2016) collared and monitored survival and reproduction of 91 adult moose and there were 33 naturally caused mortalities. Although cause-specific assessments of mortalities were not conducted, most (>75%) carcasses of individuals were undisturbed upon arrival to collect the GPS collar, suggesting that malnutrition, disease or parasites were more likely contributors to mortality than predation. Grizzly bears were not known to be present in the Utah study area and wolves were either not present or occurred at extremely low densities. Moose declines in Minnesota have been studied intensively in recent years and contrasting opinions exist over the role of wolves. Lenarz et al. (2009) suggested temperature was the primary driver of moose population declines while Mech and Fieberg (2014) felt that an increasing wolf population likely contributed.

More extensive research exists documenting predation on moose outside of the continental United States. However, the pertinence of this data to Shiras moose in Idaho is unknown and care should be taken in assuming similar effects. Research in Alaska documented predation by grizzly bears on both adult (3.3-3.9 adult moose/year killed by each adult male grizzly) and calf (5.4 moose calves/year killed by each adult bear) moose (Boertje et al. 1988). Mountain lions in Alberta, Canada were monitored via GPS collars from 1998-2008 (Knopff et al. 2010). Moose represented 6% and 37% of summer kills by adult female and male mountain lions, respectively versus <1% and 11% in winter, respectively. Nearly 75% of all lion kills were juvenile moose. Other data documented wolf predation rates during winter between 1.1-5.5 moose/wolf/100days in a system where moose were the sole ungulate prey species (Lake et al. 2013). Of 81 neonate moose collared and monitored for 1 year in Ontario, 11% were killed by black bears and 7% were killed by wolves (Patterson et al. 2013).
Predation, particularly on calves, can be a limiting factor for many moose populations (Patterson et al. 2013). This scenario is likely most common in systems where moose are the sole ungulate prey species. In Idaho, a variety of ungulate prey species exists for large predator species and it is likely that predation on moose is secondary to other prey. However, as moose occur at relatively low densities and populations are subjected to increasing stressors (e.g., reduction in habitat quality and quantity, increasing recreation, increasing temperatures, changing predator populations, etc.), predators may be limiting populations in some areas.

The effects of wolves on moose populations in Idaho are largely undetermined. In 2008, IDFG began monitoring radio-collared moose in GMU 10 to determine mortality rates and causes of death in the presence of wolves. This work was done in conjunction with a wolf-elk interaction research project in the Lolo Zone. While sample sizes of radio-marked moose never reached desired levels, results indicated wolves were not a significant cause of mortality on adult moose. However, calf mortality due to wolves was high (6 of 12 radio-marked animals) in the only year that calves were collared (2011) (IDFG 2012). IDFG does not currently have data concerning the extent or impacts of predation on moose. Future research should focus on this aspect of moose biology.

**Management Direction:** Characterize the extent and evaluate the effect of predation on moose behavior, distribution, habitat use and productivity.

**Strategy:** Conduct research to evaluate cause-specific mortality and assess the role of predation in moose recruitment, seasonal movements, habitat use and survival.
HABITAT

Habitat includes the space and resources that individuals utilize to survive and reproduce (Hall et al. 1997). Moose balance multiple factors when selecting habitat resources and predominant population drivers that influence resource use include nutrition, weather and predation.

Moose rely on stored body fat to survive winter and they tend to select habitats with an abundance of forage (van Beest et al. 2010). In contrast to smaller ungulates, moose can persist on relatively low-quality forage given sufficient quantities. Tannins are plant compounds that reduce digestibility for herbivores (Robbins et al. 1987) and moose have large salivary glands that produce tannin-binding proteins that allow them to feed on these plants. The majority of moose diets are comprised of relatively few plant species; however, moose can feed on a wide variety of woody shrubs and trees (Shipley 2010), allowing them to inhabit a diversity of habitat. Although winter is considered a major nutritional bottleneck for ungulates, summer and autumn nutrition is likely as important if not more so (e.g., mule deer, Hurley et al. 2014). Not only must females recoup body mass lost over winter, but the increased nutritional needs of pregnancy and lactation also must be met. Inadequate nutrition can lead to reproductive pauses (Boertje et al. 2007), reduced twinning rates (Franzmann and Schwartz 1985) and smaller calves, which in turn can influence survival and recruitment (Monteith et al. 2015).

Moose have substantial dispersal abilities, likely a result of their evolution in the boreal forests of the northern hemisphere where individuals traveled to capitalize on recently burned areas that provided abundant forage. Disturbance regimes create and maintain important early seral forage species, especially for transitional habitats where vegetation succeeds to closed canopy forests. Historically, forest fires were the dominant disturbance; however, timber harvest activities can also be used to manage successional stage. Changes in forest management activities, including fire suppression and timber harvest, have the potential to affect the nutritional landscape for moose (Schrempf et al. 2019) and the impact of these changes over time is an important consideration in habitat management and planning. Although disturbance is needed to generate abundant forage in transitional habitats, mid- and late-seral habitats also are important, providing snow interception in winter and thermal refuge in summer (Peek 1997). Ensuring that moose have access to a mosaic of seral habitats may be particularly important in areas where moose are already compromised by other stressors such as disease, malnutrition, or pressures felt by encroaching urbanization and increasing recreation in the front and backcountry.

Moose are well adapted to deep snow and cold temperatures; however, they are sensitive to warm temperatures and have difficulty dissipating heat due to their size and limited capacity to sweat (Schwartz and Renecker 1997). A growing body of research has reported heat stress influencing habitat use (Schwab and Pitt 1991, Muir 2006, McCann et al. 2013) and individual fitness (van Beest and Milner 2013). Heat stress could cause moose to face a tradeoff between foraging and thermoregulation that could affect nutritional levels and ultimately population dynamics. It is not yet clear the extent to which moose are able to mitigate the effects of warming temperatures. In addition to heat stress, predation risk also might cause moose to use foraging habitat sub-optimally if concealment cover is inadequate, which could be particularly important for cows with calves (Langley and Pletscher 1994).
Moose habitat in Idaho can be broadly grouped into 3 zones (Figure 4), the coniferous forests of north Idaho, the mixed aspen and conifer forests of southeast and central Idaho and the riparian cottonwood and willow communities found in parts of southern Idaho. Remaining areas of southwestern Idaho do not have sufficient habitat to support persistent moose populations.

Figure 4. Moose habitat zones for Idaho.
North Idaho Habitat Zone (DAUs: North Idaho, Prairie, Upper St. Joe-CDA, Lower St. Joe-Dworshak, Hells Canyon, Elk City, Lochsa-Selway)

North Idaho includes a diverse mix of topography, from rolling hills dominated by dryland agriculture to remote and rugged areas like the Selway-Bitterroot wilderness. Landownership is mixed, with private property and corporate timberland common in the west and primarily National Forest (NF) land to the east.

North Idaho includes several ecological sections (see McNab et al. 2007 for section descriptions and IDFG 2017 for Idaho-specific information) including the Okanogan Highlands, Bitterroot Mountains, Idaho Batholith and Palouse Prairie. Northern DAUs receive upwards of 203 cm (80 in) of precipitation per year and volcanic ash has made them relatively productive. Southern DAUs, except the Palouse Prairie regions, have generally shallow soils and deeply incised drainages.

**Habitat Characteristics**
The dense coniferous forests of north Idaho are typified by steep slopes and narrow, high gradient streams that limit riparian areas (Pierce and Peek 1984). Historically these closed canopy forests provided little forage and accounts from the 1800s indicated very few moose occurred in north Idaho. Seral shrub communities created by fire and logging are important spring, summer and early winter foraging areas for moose. Mature conifers retained adjacent to foraging areas are important for snow interception in areas of deep snowfall as well as provide shade in summer (Peek 1997). Mid-seral forests can provide both thermal refugia and forage for moose. Although limited, riparian areas along rivers and streams, as well as ponds, lakes and marshes are readily used by moose, particularly in summer. These aquatic habitats not only provide food but also are used for thermoregulation. Winter habitat varies from high elevation subalpine fir, to lower elevation clear-cuts and shrub fields, as well as closed canopy grand fir forests with Pacific yew understories.

**Food Habits**
Common forage species for moose in north Idaho include Scouler’s willow, redstem ceanothus, evergreen ceanothus, Pacific yew, serviceberry, red-osier dogwood, alder species, mallow ninebark, bitter cherry, mountain-ash and Rocky mountain maple. Forbs such as fireweed, horsetail and ferns also are consumed at times. Trees commonly consumed include deciduous trees like aspen and black cottonwood as well as conifers western hemlock, western red cedar, subalpine fir and Douglas-fir. These forage species can occur in great abundance, which is important for large browsers like moose that likely face a tradeoff between spending time searching out high quality forage and acquiring enough to eat (quality versus quantity). Forage quality and quantity is greatest during spring green-up and subsequently diets are more diverse at this time, afterwards diversity declines as grasses and forbs senesce and quality decreases through summer and fall.

**Impacts to Habitat**
Fire and logging are key to creating and maintaining quality foraging areas essential to moose populations in north Idaho. Between 1910 and 1960 over 60% of north Idaho burned in large forest fires while only 12% burned between 1961 and 2000. Similarly logging on national forest lands declined substantially since the 1980s. Logging is still common on private land and Idaho
state endowment lands found primarily in the Lower St. Joe-Dworshak and Prairie DAUs; however, the use of herbicides in some forest management practices might limit browse availability. More recently, significant fires have occurred in parts of the Elk City and Lochsa-Selway DAUs; however, other areas have lacked disturbance resulting in a late seral ‘bulge’ that has likely reduced available forage across large areas of north Idaho (Schrempp et al. 2019).

Changes in temperature and precipitation patterns have the potential to alter moose habitat across Idaho. Short-term impacts include changes in plant phenology and senescence, which could be positive for moose (e.g., increased growing season) or negative (e.g., more rapid declines in forage quality). Long-term impacts could include changes in plant species composition and distribution. Much of North Idaho is projected to transition from a snow-dominated system to a rain-dominated system with earlier snow melt in the spring and later onset of winter (Figure 5, Table 1). This change in timing and duration of precipitation, as well as increased summer temperatures, may significantly affect preferred moose habitats in the region particularly Pacific yew, grand fir, western red cedar and black cottonwood communities (Murphy and Knetter 2019, Case and Lawler 2017). However, the magnitude of changes and the ability of moose to adapt to those changes, is difficult to predict.

Central Idaho Habitat Zone (DAUs: McCall, Middle Fork, Salmon Mountains, Beaverhead, Pioneer, Smoky-Bennett)

Central Idaho includes expansive remote and rugged areas including the Frank Church-River of No Return and Sawtooth Wilderness Areas, which cover portions of the Boise, Payette, Sawtooth and Salmon-Challis NFs. In addition to national forest lands, Bureau of Land Management (BLM) and Idaho Department of Lands (IDL) properties are widespread.

Central Idaho consists of several Ecological Sections including the Idaho Batholith, Beaverhead Mountains, Challis Volcanics, Owyhee Uplands and Snake River Basalts, resulting in wide-ranging topography. Precipitation rates can be as low as 30 cm (12 in) per year to as high as 203 cm (80 in), with generally higher precipitation amounts in northern mountainous areas.

Habitat Characteristics

Habitat characteristics within central Idaho vary from lower elevation river bottoms to sagebrush-steppe to pine and spruce-fir forests at higher elevations. At mid-elevations, aspen-conifer-shrub communities are common. Extensive riparian willow bottoms are not common, especially within the Middle Fork and Salmon Mountains DAUs; however, significant riparian areas do occur within the Pioneer, Beaverhead and Smoky-Bennett DAUs and these areas are often shared with domestic livestock. These cottonwood-willow communities provide good summer and winter habitat.

Food Habits

Aspen is commonly consumed within higher elevation mixed aspen-conifer forests. Conifers such as Douglas-fir, spruce and lodgepole pine have been documented in moose diets elsewhere. Mountain mahogany communities provide food and shelter for wintering moose while riparian species such as willows are important summer forage.

Impacts to Habitat
Timber harvest likely increased available forage within closed canopy forested areas, such as the northern reaches of the Salmon Mountains DAU. Although timber harvest and fire are commonly associated with quality moose habitat, the conversion of certain climax vegetation types to early seral can be detrimental to moose. Adequate cover for snow interception as well as shade in summer can be very important for moose. Mid-seral conifer forests and mixed aspen-conifer forests can provide both shelter and forage and are important transitional habitats in summer and winter.

Relatively static habitats found in areas with limited precipitation, such as mountain mahogany stands, will recover slowly (e.g., 100+ years) from disturbance such as fire, especially moderate to severe fires (Ex et al. 2011), which could detrimentally affect moose for some time.

Riparian areas that provide important summer habitat are relatively stable; however, livestock grazing has potential to impact these areas and moose use was greater in lightly grazed areas compared to heavily grazed areas in southeast Idaho (Ritchie 1978). A large portion of riparian areas in the lower elevations of this zone exist on privately owned lands and are subject to private land management. The health of these riparian areas is important for moose that depend on them; however, some are subject to habitat management that may not favor moose. For example, in the Beaverhead and Pioneer DAUs water diversions have relocated water from portions of valley streams to canals and ditches resulting in the gradual loss of riparian habitats, particularly cottonwood-willow communities, available to moose (Rood et al. 2003).

Changes in temperature and precipitation patterns have the potential to alter moose habitat across Idaho. Short-term impacts include changes in plant phenology and senescence, which could be positive for moose (e.g., increased growing season) or negative (e.g., more rapid declines in forage quality). Long-term impacts could include changes in plant species composition and distribution. Much of the Central Idaho Habitat Zone is projected to experience increased warming and increased variability in both temperature and precipitation throughout the year (Figure 5, Table 1). These changes may both benefit and hinder preferred moose habitats depending on associated effects such as bark beetles and wildfire (Bentz et al. 2010) and changes in riparian black cottonwood and narrowleaf cottonwood communities (Murphy and Knetter 2019). Although reduced from current conditions, climate projections suggest that some areas of central Idaho, particularly the Pioneer, Beaverhead, and Salmon Mountains DAUs, will continue to provide valuable black and narrowleaf cottonwood habitat into the future that could be targeted for conservation and restoration actions (Murphy and Knetter 2019). The magnitude of changes, and the ability of moose to adapt to those changes, is difficult to predict.

**Southeast Idaho Habitat Zone (DAUs: Medicine Lodge, Island Park, Teton, Snake River, Caribou, Bannock)**

Most forested areas within southeast Idaho occur on the Targhee, Caribou and Sawtooth NFs but also on IDL and BLM lands. Foothills and valley floors are predominantly private or BLM. Cattle ranching is common along valley bottoms as well as areas of irrigated farmland.

Several Ecological Sections are found in Southeast Idaho including the Beaverhead Mountains, Snake River Basalts, Northwestern Basin and Range and the Overthrust Mountains. This area of
Idaho receives relatively little precipitation, ranging from 30 cm (12 in) per year within the Snake River Basalts Ecological Section to 71 cm (28 in) within the Overthrust Mountains Ecological Section.

**Habitat Characteristics**

Moose summer range in southeastern Idaho includes aspen communities interspersed with conifers such as Douglas-fir and lodgepole pine (Ritchie 1978, Peek 1997) and open areas with big sagebrush, chokecherry and other mountain brush shrub species. These aspen-conifer-shrub communities produce food and provide shelter in summer. In mountainous areas moose tend to move down in elevation to winter in ranges dominated by aspen-mountain brush and mountain mahogany communities as well as feeding on desert shrubs such as bitterbrush and chokecherry found in the arid sand hill region (Ritchie 1978, Muir 2006). Precipitation increases with elevation resulting in cooler temperatures and generally more abundant summer forage at higher elevations. At lower elevations forage is more abundant in riparian corridors and other mesic areas. Extensive narrowleaf cottonwood and willow communities along portions of the Snake River provide year-round habitat. During winter the lower elevation plant communities receive lower snow accumulation which, in turn reduces moose energy loss for acquiring forage and increases forage availability, especially for the previous year's calves (Maier et al. 2005, Dou et al. 2013).

**Food Habits**

A food habits study in Fremont County (Ritchie 1978) reported common forage species for moose in summer and winter. Summer forage was 56% woody browse, mainly willow species followed by aspen and bitterbrush. Non-woody browse comprised 44% of summer diets and fireweed was the dominant forb. Winter diets were 87% browse with a notable increase in the occurrence of evergreen ceanothus and decline in non-woody forage species. Other documented forage species in southeastern Idaho include chokecherry, serviceberry, maple, Douglas-fir and subalpine fir.

**Impacts to Habitat**

Riparian areas within southeast Idaho are often used by both moose and livestock. Riparian narrowleaf cottonwood and willow communities are important to moose in these areas and impacts to these communities through changes in grazing practices (e.g., stocking rates, season of use), vegetation management (e.g., spraying, burning), water diversion, development (e.g., housing development) and changing climates could reduce their value to moose. Aspen stands that provide important summer habitat have been in decline within this zone. Aspen health has declined for several reasons including fire suppression and resulting conifer encroachment as well as mining activities. The loss of these aspen stands is likely detrimental to moose populations.

Large areas of predominantly private property found in the Island Park, Teton, Medicine Lodge and Snake River DAUs make implementation of management actions across large areas difficult. Migratory moose populations occur in the Island Park DAU. Development activities could potentially affect these migration routes.
Changes in temperature and precipitation patterns have the potential to alter moose habitat across Idaho. Short-term impacts include changes in plant phenology and senescence, which could be positive for moose (e.g., increased growing season) or negative (e.g., more rapid declines in forage quality). Long-term impacts could include changes in plant species composition and distribution. Much of the southeast zone is projected to become hotter and drier with earlier snow melt in the spring and later onset of winter (Figure 5, Table 1). These extended warmer temperatures and increased frequency of drought may reduce quantity and quality of some preferred moose habitats, particularly riparian narrowleaf cottonwood and aspen communities (Murphy and Knetter 2019, Perry et al. 2012). However, the magnitude of changes and the ability of moose to adapt to those changes, is difficult to predict.

**Management Direction:** Partner and collaborate with private landowners, land management agencies, forest managers, tribes, hunters and other interested parties to improve moose habitat and minimize threats such as recreational impacts, barriers to dispersal and development.

**Strategy:** Continue to provide technical assistance to partners and formally engage in major land use planning efforts and proposals (e.g., forest plan revisions, timber harvest proposals, urban development, travel management plans) to benefit moose.

**Strategy:** Work with private landowners on wetland and riparian restoration as well as improve hydric function within systems including installation of beaver dam analogs.

**Strategy:** Respond to landowner concerns about moose depredations in a timely manner to help increase social tolerance for moose on private land.

**Strategy:** Prioritize areas where habitat management would most benefit moose and collaborate with land management agencies and private/corporate timberlands to develop and implement habitat restoration projects (e.g., wildlife-oriented timber harvest, prescribed burns, riparian management/restoration, aspen restoration/regeneration).

**Strategy:** Work with state and federal land management agencies to create mosaics of early and late seral moose habitat in areas lacking disturbance (e.g., prescribed fire, timber harvest) or where forest canopies have closed (e.g., GMUs 12, 15, 59, 61).

**Strategy:** Investigate alternative options to disturb decadent shrub fields such as “conifer release” via chainsaw cutting and herbicide top kill.

**Strategy:** Work with land management agencies to retain adequate cover adjacent to disturbed areas such as the extensively burned areas (e.g., the Selway drainage).

**Strategy:** Work with land management agencies to combat noxious weeds that compete with native vegetation and reduce available forage for moose.

**Strategy:** Investigate the impacts of herbicide spraying and habitat management after logging and collaborate with corporate timber companies to manage habitat to benefit moose.
**Strategy:** Capitalize on existing and future data from radio-collared moose to develop mitigation strategies for reducing the effects of land use (e.g., roadkill, mining, timber harvest, livestock grazing), recreation and development on moose populations and habitat.

**Management Direction:** Improve our understanding of habitat quality and nutrition and potential impacts on moose reproduction, survival and population performance.

**Strategy:** Conduct research to assess the role of nutrition and habitat in moose recruitment, seasonal movements, habitat use and survival.

**Strategy:** Integrate knowledge of moose habitat requirements with current statewide vegetation surveys, to identify changes in habitat quality that may be acting on moose populations.
CLIMATE

Long-term climate patterns can both directly (through physiological limitations, reduced energy reserves) and indirectly (through quality and abundance of forage, disease and parasites) affect moose reproduction, recruitment, survival, population dynamics and distribution (see Weiskopf et al. 2019 for review). Changes in long-term climatic patterns, particularly warming trends in recent decades, have increased concern for the long-term viability of moose populations at the southern extent of the range (e.g., Murray et al. 2006, Nadeau et al. 2017, Feldman et al. 2017).

In Idaho, mean annual temperature has increased approximately 0.2°C (0.4°F)/decade since 1975. Summer and winter temperatures are increasing more than other seasons, daily minimum temperatures are rising faster than daily maximums, extreme heat waves are becoming more common and the growing season is lengthening (Abatzoglou et al. 2014, Klos et al. 2014). Trends in precipitation have been more variable but indicate increases in spring and winter precipitation with decreases in the proportion of precipitation falling as snow, particularly at low-to mid-elevations (Abatzoglou et al. 2014, Klos et al. 2014, Mote et al. 2018). Following current trends, projected changes over the next 50–70 years indicate progressively hotter, drier summers and warmer, wetter—but less snowy—winters in the state (Wang et al. 2016, Rupp et al. 2017). In many areas of the northwest, consecutive years of snow drought will be more common, as will earlier peak snowpack and an upward elevational shift in snow levels (Catalano et al. 2019, Marshall et al. 2019). However, estimating these trends in some habitats can be challenging due to substantial local variability in both temperature and precipitation, particularly in complex terrain (e.g., Ford et al. 2013, Silverman and Maneta 2016, Catalano et al. 2019).

As moose are well-adapted to colder temperatures, ambient temperatures of -5°C (23°F) in winter and 14°C (57°F) in summer are suggested critical thresholds above which captive adult moose exhibit signs of thermal stress including increased respiration and metabolic rates (Renecker and Hudson 1986, 1990). However, in free-ranging animals reported thresholds are more variable (e.g., 17°C [63°F], 20°C [68°F], 24°C [75°F] in summer) depending on several factors including wind, canopy cover and individual activity and health (Broders et al. 2012, McCann et al. 2013, Melin et al. 2014, Olson et al. 2014, Ditmer et al. 2018). Some studies suggest that moose are most susceptible to warmer temperatures during spring and fall when shedding or developing their winter coat (Dou et al. 2013, Melin et al. 2014, Ditmer et al. 2018, Wattles et al. 2018). Increased air temperatures in all seasons often result in modified behavior including changes in habitat selection, activity times (e.g., more nocturnal in summer) and movements (see Weiskopf et al. 2019 for review), although not always (Lowe et al. 2010, Montgomery et al. 2019).

Indirectly, changes in patterns of temperature and/or precipitation can positively and negatively affect moose populations through shifts in preferred habitat and changes in incidence of disease or parasites. For example, warmer springs may provide earlier and more abundant forage (Grøtstan et al. 2009), as do shallower snow depths during milder winters (Dou et al. 2013), while warmer summers and shorter springs can reduce forage quality (Monteith et al. 2015). In addition, changes in fall leaf senescence, particularly due to drought, can alter nutrient availability (Estiarte and Penuelas 2015). Improved forage quality and quantity, as well as reduced energetic costs (e.g., from <50 cm [20 in] snow, Geist 1998), may offset some negative consequences of
warming. For example, changes in shrub habitats in the northern portion of the range have resulted in expansion of moose distribution in recent decades (Tape et al. 2016) as well as in some southerly populations (Wattles et al. 2018). Conversely, shifts in habitat and several other factors have contributed to range contractions along the southern distribution (Murray et al. 2006; Lenarz et al. 2009, 2010; Dou et al. 2013).

Changes in climate conditions have likely led to more favorable conditions for many parasites known to infect moose (see Disease Section), although the magnitude of effects on parasites in general is complex and variable, often depending on many factors including their life cycle, intermediate hosts and mode of transmission (see Utaaker and Robinson 2015 for review). Several parasites including giant liver flukes (Malcicka 2015), carotid artery worms (Henningsen et al. 2012) and winter ticks (Drew and Samuel 1986, Holmes et al. 2018, Jones et al. 2018) likely have, and will continue to, benefit from shorter, milder winters in Idaho, as will parasites that do not yet occur in the state (e.g., meningeal worm; Pickles et al. 2013, Feldman et al. 2017, Lankester 2018). Winter ticks, in particular, benefit from warming trends. Long, warm (≥10°C [50°F]) falls with little snow extend the larval questing period, increasing moose exposure (Drew and Samuel 1985). Although tick larvae can tolerate short-term exposures to extreme temperatures (~25°C to 46°C [-13°F to 115°F]), they show greatly reduced activity at ≤0°C (32°F) and are freeze intolerant (Drew and Samuel 1985, Holmes et al. 2018). Therefore, winter survival requires finding a host before the first snowfall and/or prolonged freeze (Holmes et al. 2018). Similarly, tick survival, abundance and distribution can be enhanced by warm springs with early snow melt as engorged adult females that drop off moose can survive variable temperatures but typically die when in contact with snow (Drew and Samuel 1986, Samuel 2007). The effect of summer and fall drought on egg and larval survival is less certain. In some tick species, lower relative humidity can result in desiccation of both eggs and larvae (see Addison et al. 2016, Knulle and Rudolph 1982 for review); however, nearly all tick species have water conserving adaptations (Knulle and Rudolph 1982) and winter ticks are no exception (Drew and Samuel 1985, Yoder et al. 2016).

As portions of Idaho continue to get warmer, identifying areas projected to experience changes in the mean temperatures relative to potential direct and indirect effects on moose may help prioritize research and management. Assuming a “business-as-usual” emission scenario (resource concentration pathway [RCP] 8.5), mean annual temperatures across the state are projected to increase 2.9-3.3°C (5.2-5.9°F) by mid-century (as compared to the 1981-2010 baseline using data from Holden et al. 2015, Abatzoglou 2013) with summer temperatures rising fastest (3.3-3.5°C, 5.9-6.3°F) and spring temperatures most variable (2.6-3.4°C, 4.7-6.1°F) (Figure 5, Table 1). Although spring temperatures increase statewide, all DAUs are projected to continue to have mean temperatures below the suggested heat stress threshold (<14°C, 57°F) for moose. Projections for south Idaho indicate a greater increase in mean spring temperatures than areas in the north with some DAUs averaging >10°C (50°F). This may result in earlier snow melt in these areas, thereby contributing to increased survival of adult female winter ticks. In summer, all DAUs are projected to have mean temperatures >14°C (57°F) and many areas, particularly in the south and west, average >20°C (68°F). Fall temperatures are projected to increase the most in southcentral DAUs and, although all area projections remain at <14°C (57°F) on average, substantial expansion of areas with >10°C (50°F) is projected. This may result in winter tick larvae being active in more areas and persisting longer in the season. Finally,
projections indicate a substantial reduction in area of mean winter temperatures <\(-5^\circ C\) (23° F) and expansion of areas >\(0^\circ C\) (32° F). Thus, moose may experience heat stress and, in the absence of snow, tick larvae may persist longer without a host in these areas.

The considerable changes in warming by mid-century will likely be coupled with slight increases in annual precipitation (<16 cm, 6 in) statewide, with the greatest increases occurring in spring and winter, decreases in summer and increases in inter-annual variability in all seasons (Rupp et al. 2017). These changes co-occur with a decline in the proportion of precipitation falling as snow in all DAUs (23-60% decrease) with the most substantial changes occurring in the Panhandle and Clearwater Regions (Wang et al. 2016; Table 1). Even with these declines, recent projections suggest much of Idaho will continue to receive at least some snow throughout the 21st century (Catalano et al. 2019). In addition, changes in both temperature and precipitation are expected to be accompanied by greater overall variability (e.g., record cold temperatures even as record highs become increasingly frequent) (Meehl et al. 2009, Rupp et al. 2017). Given these estimates represent 30-year averages in climate and not annual, monthly, or daily variability in weather, the potential effects of annual/seasonal time lags and daily/hourly cumulative heat stress are not incorporated (e.g., Samuel 2007, Lenarz et al. 2009, Lowe et al. 2010, Monteith et al. 2015). Similarly, although model agreement is fairly high with temperature projections, particularly in early and mid-centuries, models of precipitation projections are much more variable, resulting in less certainty.

The ability of moose to adapt to these ongoing and projected changes is uncertain. In general, moose are thought to be highly adaptable (Hundertmark and Bowyer 2004) and exhibit several attributes typical of species with a high adaptive capacity (Nicotra et al. 2015) including being a generalist forager with high dispersal capacity, living in well-dispersed populations and displaying great behavioral flexibility. As mentioned above, moose can alter behavior (e.g., select areas of increased forest canopy cover, higher elevation) with increasing temperatures, although this varies by individual (e.g., Melin et al. 2014), population (Lowe et al. 2010, Montgomery et al. 2019) and habitat availability. Wattles et al. (2018) suggest that, when cooler microclimates are available, the behavioral flexibility of moose may be sufficient to allow for persistence and even expansion in seemingly inhospitable areas. Given that moose in Idaho currently occur at elevations near the average elevation in each region, individuals may have sufficient area available, at least in summer, to mitigate heat stress through behavioral adaptation as long as habitat conditions allow. However, moose also demonstrate characteristics indicative of species with low adaptive capacity including having longer generational times, lower reproductive rates and limited genetic diversity. In addition, Idaho moose occur near their range margins and appear to be experiencing population declines in some areas. Even with possible local adaptations (Weiskopf et al. 2019), changes that lead to physiological stress and/or changes in behavior can influence nutritional status, individual fitness and result in decreased survival and density (Murray et al. 2006, Lenarz et al. 2009, van Beest et al. 2012, van Beest and Milner 2013, Monteith et al. 2015). A better understanding of the complex relationship between temperature and moose population dynamics at local levels, including direct and indirect effects as well as individual- and population-level responses in Idaho is needed to fully understand and appropriately manage moose populations under changing climatic conditions.
**Management Direction:** Improve our understanding of existing and potential effects of changing climates, specifically changes in seasonal temperatures on moose recruitment rates, survival and distribution, as well as habitat responses.

**Strategy:** Identify and support collaborative research, standardization of methods and development of opportunities focused on identifying and understanding changes in climatic conditions that could affect moose populations.

**Strategy:** Work with researchers to develop climate models at appropriate scales for management of moose DAUs in Idaho.

**Strategy:** Engage partners in collaborative efforts to address threats to moose populations that may compound, or be compounded by, the effects of climate change.

**Strategy:** Work with land managers to provide and/or maintain habitat that contributes to climate resiliency.
Table 1. Baseline (1981-2010) and projected (2040-2069) mean seasonal temperatures (TAvg) and annual precipitation as snow (PAS) averaged across moose data analysis units.

<table>
<thead>
<tr>
<th>Data Analysis Unit</th>
<th>Elevation Range (m)</th>
<th>Spring TAvg (°C)</th>
<th>Summer TAvg (°C)</th>
<th>Fall TAvg (°C)</th>
<th>Winter TAvg (°C)</th>
<th>PAS (cm)</th>
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<tr>
<td>North Idaho</td>
<td>525-2346</td>
<td>5.7</td>
<td>8.4</td>
<td>15.7</td>
<td>19.1</td>
<td>-3.2</td>
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<td>10.6</td>
<td>18.0</td>
<td>21.4</td>
<td>8.4</td>
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<td>Lower St. Joe-Dworshak</td>
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<td>9.7</td>
<td>17.2</td>
<td>20.7</td>
<td>7.8</td>
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<tr>
<td>Upper Joe and CDA</td>
<td>484-2401</td>
<td>5.9</td>
<td>8.6</td>
<td>16.2</td>
<td>19.7</td>
<td>6.6</td>
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<tr>
<td>Hells Canyon</td>
<td>219-2840</td>
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<td>10.5</td>
<td>18.4</td>
<td>21.9</td>
<td>8.9</td>
</tr>
<tr>
<td>Elk City</td>
<td>372-2708</td>
<td>6.0</td>
<td>8.8</td>
<td>16.4</td>
<td>19.8</td>
<td>7.0</td>
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<td>7.3</td>
<td>15.0</td>
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<td>7.2</td>
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<td>9.4</td>
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<td>11.2</td>
<td>19.8</td>
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<td>9.1</td>
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<tr>
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<td>10.0</td>
<td>18.7</td>
<td>22.1</td>
<td>8.0</td>
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<td>7.9</td>
<td>16.9</td>
<td>20.3</td>
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<td>6.4</td>
<td>15.1</td>
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<td>4.6</td>
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<td>4.6</td>
</tr>
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<td>4.9</td>
</tr>
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<td>644-3145</td>
<td>3.4</td>
<td>6.3</td>
<td>14.5</td>
<td>18.0</td>
<td>4.7</td>
</tr>
</tbody>
</table>

a Baseline temperature data represent mean values at 250 m spatial resolution (Holden et al. 2015).

b Projected mid-century values are based on an ensemble of 20 general circulation models (GCM) under a “business-as-usual” emission scenario (representative concentration pathway [RCP] 8.5) (Abatzoglou 2013) superimposed on the baseline data.

c Baseline PAS data are modeled at 1km spatial resolution with projected values from an ensemble of 10 GCMs under RCP8.5 (Wang et al. 2016).
Figure 5. Baseline (1981-2010) and projected mid-century (2040-2069) mean seasonal temperatures in Idaho. Colors represent ambient temperature thresholds identified in the literature as important to moose (see text). Baseline temperature data represent mean values at 250m spatial resolution (Holden et al. 2015). Projected mid-century values are based on an ensemble of 20 general circulation models (GCM) under a “business-as-usual” emission scenario (representative concentration pathway [RCP] 8.5) (Abatzoglou 2013) superimposed on the baseline data.
HARVEST MANAGEMENT

The first formal hunting season for moose in Idaho was established in 1893 but was closed in 1898 as it was viewed as unsustainable. Moose were not hunted for the next 46 years in Idaho. During this time period, moose populations expanded across most of the central, northern and eastern portions of the state.

Moose hunting was reestablished in 1946 through a limited tag system. Thirty tags were allocated for Fremont County. At the time, Fremont County was believed to harbor over half of the state’s moose population. Moose hunting opportunities continued to increase with expanding populations until 2004. Due to decreasing hunter success and the assumption of correlated decreases in moose populations, opportunity has declined in recent years (Figure 6).

Figure 6. Trend in Idaho moose tags and harvest from 1970 to 2018.

Hunting Opportunity

Population expansion allowed hunting opportunity in the state to grow from 30 tags in 1946 to a high of 1235 tags in 2003 and 2004. Concerns of population declines in some parts of the state, as indicated by decreased hunter success rates, decreased incidental moose observations and lower counts during aerial surveys have led to a decrease in tag allocations. In 2018, 805 tags were offered statewide. This represents a 41% decrease in antlerless tags and a 33% decrease in antlered tags statewide over the last 14 years. Most of the reduction in tags occurred in the Panhandle, Clearwater and Southeast Regions.

Moose harvest management in Idaho has been focused on offering high quality hunting with the opportunity to harvest older age class bulls and to do so with moderate to high success rates. As a result of Idaho’s relatively low moose densities, harvest strategies have traditionally been conservative. In 2018, 88 antlered and 24 antlerless moose hunts offering 669 antlered and 136 antlerless tags were available via controlled hunts. The odds of drawing an antlered tag averaged
22% with an average of 70% harvest success. Antlerless draw odds averaged 31% with an average harvest success of 73%.

Antlerless moose hunting opportunity has been offered in Idaho since 1974. From 1974 through 1992 this opportunity came in the form of either-sex controlled hunt tags. These either-sex tags were solely in the Upper Snake Region until 1982 when 8 either-sex tags were offered in GMU 76 in the Southeast Region. The either-sex tag format resulted in low levels of female harvest due to hunter selection for bulls. The first antlerless-only hunts were offered in 1991 in the Upper Snake and Southeast Regions. In 1999 a total of 8 antlerless-only tags were offered in GMUs 8 and 8A of the Clearwater Region. Additional antlerless-only tags were added in the Panhandle Region in 2001. The transition to antlerless-only focused hunts resulted in an increase in overall female moose harvest. The most robust increase in antlerless hunting opportunity occurred in 2003 when 84 tags were added between the 3 regions. Antlerless tag allocations continued to trend upward to a high of 232 in 2008. Antlerless harvest was used to slow population growth in areas with a high amount of human conflict and to provide opportunity for hunter harvest in growing and expanding populations. In response to declining moose populations, IDFG has steadily decreased antlerless tags to 74 tags during the 2019 hunting season.

Hunting Tag Allocation Strategies

Hunters are allowed to harvest one bull and one cow moose in Idaho in their lifetime, except Super Hunt tag winners and left-over tag holders may harvest a moose regardless of any previous moose harvest. All tags are issued under a controlled hunt structure and are allocated through a limited lottery system. To maintain modest drawing odds and more equitably distribute tags, individuals that choose to apply for moose tags are prohibited from applying for all other limited controlled hunts for other species in the same calendar year. Those that successfully draw a tag but are unsuccessful at harvesting a moose are prohibited from applying for a moose tag in Idaho for a period of 2 years.

Harvest Monitoring

In most hunted ungulate populations, hunters select for larger antler size and often older animals to harvest. Due to the limited opportunity nature of moose hunting in Idaho, this selection is often amplified. The selective harvest of presumably older males in the population may lead to a skewed sex ratio in favor of females (Markgren 1969, Crête et al. 1981, Franzmann and Schwartz 2007). Monitoring of both male and female harvest is important to ensure harvest remains compensatory and does not reach a point where it has an additive effect on most of the state’s moose population. Although there may be isolated incidents within the state where the goal is to reduce moose populations, none of these situations currently exist in Idaho.

In 1982, IDFG implemented a mandatory check for all harvested moose. Successful hunters must have their animal checked by an IDFG representative within 10 days of harvest. Biological data such as sex, age and antler measurements are collected as well as location, time of harvest and days to harvest. In 2019, IDFG expanded biological sampling from harvested moose to better evaluate disease prevalence, genetic connectivity and nutrition.

Since the early 1990s a mean average antler spread of ≥ 89 cm (35 in) among all harvested bulls has been used as a management goal. According to literature this antler spread indicates an
average harvested bull age of ≥4 years old (Gasaway et al. 1987). However, inconsistency in measuring methods may result in this metric not being a dependable indicator of average harvested bull age. In addition, it has been shown that density-dependence and habitat quality may be more influential than harvest on determining antler size and age structure of moose (Schmidt et al. 2007). Currently, IDFG is looking at revised, more stringent methods of collecting quantitative antler and age data to better describe Idaho’s moose harvest.

**Unregulated Harvest**

Unregulated harvest is defined as all human related mortality outside of the current controlled hunt system and/or selective removal by IDFG officials. Major sources of mortality in this category include illegal harvest and tribal harvest. The extent of mortality in each of these areas is hard to accurately quantify due to poor detection rates and/or a lack of reporting. Tribal harvest may be recorded and reported in some areas; however, IDFG does not consistently receive this information. The IDFG BGMR database captures some illegal harvest but detection levels are believed to be low and widely variable across the state.

**Management Direction:** Improve and expand collection methods of harvest data to help inform management.

**Strategy:** Conduct research to evaluate cause-specific mortality and assess the role of harvest on recruitment, seasonal movements, habitat use and survival.

**Strategy:** Continue the mandatory check requirement for hunter harvested moose and work with hunters to improve collection of biological samples from harvested moose.

**Strategy:** Explore revised, more stringent methods of collecting quantitative antler and age data to better describe Idaho’s moose harvest and bull quality.

**Management Direction:** Improve availability of data including population estimates, harvest data, survival rates and productivity across the state to better inform harvest management (see strategies in Population Management chapter).

**Strategy:** Collaborate with tribes on monitoring efforts and sharing information on tribal harvest.
DATA ANALYSIS UNITS

Moose have occupied Idaho since early settlement and, over time, have increased their range to include most of Idaho. They naturally expanded into new areas, moving west and south, and have also been transplanted to supplement, re-establish or introduce moose into different areas.

The following descriptions provide additional information on moose habitat, populations, monitoring, harvest and current issues in DAUs across Idaho (see Figure 2 for full map). DAU boundaries are based on our current knowledge of moose populations in these areas including habitats, distribution, connectivity among populations, harvest and other management issues (e.g., social tolerance, accessibility). A DAU can be made up of a single, multiple, or partial GMU. Three of the DAUs (Hells Canyon, Owyhee-Big Desert and McCall) do not have recognized moose populations, only occasional sightings within their boundaries.

North Idaho DAU (GMU 1)

The North Idaho DAU encompasses GMU 1 and spans the Selkirk, Cabinet and Purcell Mountain Ranges. It is bordered by Canada, Washington and Montana and lies just north of Lake Pend Oreille. The North Idaho DAU is comprised largely of the Okanogan Highlands Ecological Section, where precipitation averages 86 cm (34 in) and elevations range from approximately 518 m (1700 ft) to 2347 m (7700 ft). Approximately 60% of the North Idaho DAU is on the Panhandle NF with the remaining 40% split roughly equal between IDL and private land.

The predominant potential natural vegetation types are western hemlock at lower elevations and subalpine fir at higher elevations, with some western red cedar occurring on wetter sites and Douglas-fir and ponderosa pine occurring on drier slopes. Timber harvest has been moderate throughout this DAU, occurring mainly on state or corporate properties. The Kootenai River valley occurs throughout the central portion of this DAU and is comprised largely of agriculture fields or landscape nurseries. Moose within this DAU use a variety of habitats from high elevation subalpine fir forests, open brush fields to lower elevation western hemlock forests.

Population and Monitoring

The first aerial monitoring efforts appear to be from the Bonners Ferry area in 1993. The area surveyed was 35 mi² north and east of the Moyie River. Records indicate moose densities were estimated at 0.8 moose per mi², using the elk sightability model. In January of 2000 a survey was conducted using a Hughes 500 in the Priest River drainage east of Priest River. This was the first intensive moose survey for the area and using the elk sightability model it was predicted to have 414 moose (1.1 moose per mi²) or using the moose sightability model developed by Wyoming yielded an estimate of 546 moose (1.5 moose per mi²). Another sightability survey was conducted on the east side of the Selkirk Mountains in December 2000, but due to inclement weather and a helicopter crash in another region, survey periods were cut short. It was extrapolated that there would be approximately 0.8 moose per mi², a lower density than other
areas in the GMU. No surveys have been conducted since 2000 in the North Idaho DAU. Aerial monitoring is difficult in this DAU due to dense forest cover and moose being widespread and occurring at low densities.

**Harvest**
The first hunts were initiated in 1975 when two controlled hunts totaling 5 tags (antlered-only) were enacted in the Kootenai River drainage and the Pend Oreille River drainage. By 1980 there were 4 hunts in GMU 1 that totaled 11 tags. Hunting closed after 1982 and was reinstated in 1986 with 7 hunts totaling 26 tags. In 2001, 9 hunt areas were combined down to 4 hunt areas; but tag levels increased from 88 to 155. Antlerless harvest was initiated in the North Idaho DAU in 2003, when 15 tags were available in Hunt Area 1-1. In 2005, 2 new hunts that ran 7 days were added to hunts that already existed as a trial to increase drawing odds and see how success rates changed. Hunting seasons changed again in 2007 and 2008, when all moose hunts went to 14-day seasons. Twenty-four controlled hunts were available, but all hunts went from an 86-day seasons to 14 days to increase drawing odds. The North Idaho DAU reached its highest tag levels in the 2007 and 2008 seasons at 218 tags. Hunters liked the increase in drawing odds for shorter hunts, but also wanted an option to put in for a longer controlled hunt. Therefore, after the initial 14-day seasons, long-season hunts were reestablished with shorter hunt seasons during 2009-2010. Antlered tag levels started to decrease and antlerless harvest was stopped in GMU 1 in 2013, when success rates and hunt quality were thought to be declining. In 2017 hunting was closed in the northeast corner of GMU 1, due to decreased success rates and potential declining populations. There are currently 8 hunts (5 short-season, 3 long-season) available in the North Idaho DAU with a total of 95 tags. Hunting tags have continued to decline within this DAU due to low harvest success rates.

![Figure 7](image-url)  
**Figure 7.** Moose harvest and tag allocation in the North Idaho DAU.

**Current Issues**
Moose are thought to be declining in most portions of this DAU, but information regarding populations is lacking and no survey has been attempted since 2000. Most of the Kootenai Valley consists of agricultural fields and landscape nurseries and over the years there have been a few moose that have caused damage on nursery plants. Sometimes that has required IDFG to assist in removal of these animals. There are a large number of roadkill moose reported in this DAU on an annual basis, focused around the McArthur Lake WMA (Figure 3). Since this DAU is considered the primary moose producer in the Panhandle Region it is important to determine a trend regarding moose populations.

Prairie DAU (GMUs 2, 5, 8)

The Prairie DAU contains GMUs 2, 5 and 8. The DAU borders Washington to the west and extends from the Pend Oreille River south to the Clearwater River. Landownership is primarily private including the large urban areas of Coeur d’Alene, Moscow and Lewiston as well as large tracts of agricultural property. Precipitation averages approximately 76 cm (30 in) per year with elevations ranging from approximately 610 m (2000 ft) to 1555 m (5100 ft). The Coeur d’Alene Indian Reservation is located within this DAU and offers a limited number of moose tags annually to tribal members to use on ceded ground. Moose populations within this DAU are managed by the Panhandle and Clearwater Regions.

The Prairie DAU consists of 3 Ecological Sections, the Palouse Prairie, Okanogan Highlands and Bitterroot Mountains. Most of the moose habitat occurs on forested sites found within the Okanogan Highlands and Bitterroot Mountains Ecological Sections, whereas dryland agriculture dominates the Palouse Prairie Ecological Section. Moose habitat within this DAU occurs predominantly within the western red cedar and western hemlock forest types found above the valley floors. Disturbance in the form of timber harvest activities is fairly common and important in creating early seral foraging areas for moose.

Population and Monitoring

In December 2010, an aerial helicopter survey was flown in the northern portion of GMU 5. Additionally, a thermal infrared survey was conducted in March over the same section of GMU 5. The aerial helicopter survey identified 68 moose over 18 search units. Population estimates for the Mica Peak area were estimated to be between 72-115 individuals. The infrared survey produced similar estimates to that of the aerial helicopter survey; however, moose may have been missed if they were obscured by vegetation or if thermal differences between moose and the background were not large enough. There have not been any recent surveys for moose in this DAU.

Harvest

Antlered harvest started in 1986 in the DAU, specifically in GMU 2 with 2 tags across a long season. Antlered harvest began in GMUs 5 and 8 in 2007 and 1990 respectively. Antlerless hunting occurred for the first time in GMUs 8 and 2 in 1999 and 2001 with 4 and 5 tags respectively. The season ran from October 15 through November 23. To address low drawing odds, an experimental short 1-week hunt was tested in 2005 in GMU 2, in addition to a long-
season hunt. It was not until 2007 that antlered harvest occurred for the first time in GMU 5. That year there were 24 tags issued in GMU 2 and 5 tags in GMU 5. Hunts in GMU 2 were made up of long- and short-season hunts. An antlerless hunt with 5 tags was added in GMU 5 in 2011. Due to numerous moose-vehicle collisions and urban moose issues, antlerless tags peaked in GMU 2 in 2012 at 40 tags. Two new short-season hunts were added to GMU 5 in 2015. In 2017, antlerless tags were cut to 20 once nuisance moose problems and vehicle collisions appeared to be declining within GMU 2. In 2019, all antlerless tags were removed and antlered tags were reduced across the DAU.

Figure 8. Moose harvest and tag allocation in the Prairie DAU.

Current Issues
The vast majority of this DAU resides on private property making it difficult to implement large-scale management actions for moose. However, collaboration with land management agencies and private forest landowners may provide opportunity to improve the availability of early seral vegetation communities that moose prefer. Additional information on how forest management herbicide applications affect available moose habitat and forage is needed. It is also difficult to ascertain the impact that tribal harvest is having on moose populations, although anecdotal evidence suggests it could be substantial. Moose, particularly calves and yearlings, have been documented with heavy tick loads; however, the population level impact of these outbreaks is not known. Symptomatic moose that appear blind and uncoordinated, sometimes turning in circles, also have been recorded. Continuing to work with hunters to collect success rates, days to harvest, antler spread measurement and various biological samples is vital as is collaborating with Coeur d’Alene Tribe on monitoring efforts and tribal harvest. Urban moose issues occur within this DAU, typically during winter or spring. Moose are somewhat regularly relocated from urban areas where public safety is a concern. Identifying roadkill mortality hotspots and working with ITD and land management agencies will improve safe passage for moose and other wildlife.
Lower St. Joe-Dworshak DAU (GMU 6, 8A, 10A)

The majority of moose habitat within the Lower St. Joe-Dworshak DAU is found within the Bitterroot Mountains Ecological Section. The Lower St. Joe-Dworshak DAU encompasses GMUs 6, 8A and 10A. The DAU is bounded to the north by the Lower Saint Joe River drainage and terminates to the south at the Clearwater River, encompassing Dworshak reservoir. The St. Joe-Dworshak DAU occurs within both the IDFG Panhandle and Clearwater Regions. Precipitation averages 84-97 cm (33-38 in) per year and elevations range from approximately 300 m (1000 ft) to 1920 m (6300 ft). The dominant forest type is western red cedar followed by grand fir. Douglas-fir is found at lower elevations on dry slopes and some western hemlock forest types occur in the far northern portion of the DAU. Approximately half of the DAU is private land with the remaining either IDL or NF, including portions of the St. Joe and Clearwater-Nez Perce NF. Timber harvest is the main source of disturbance and occurs frequently on IDL and private forests. Some private agricultural lands are found within the southern portion of GMU 10A and western portion of GMU 8A; however, the majority of moose occur on the forested lands. The terrain is of moderate ruggedness and can be broadly classified as front or mid-country areas with high levels of access, in contrast to the more rugged and remote back-country areas to the east.

The dominant forest types within this DAU include shade-tolerant tree species that require moist soils and result in generally good growing conditions for moose browse following canopy-opening disturbance. Historically forest fires were not as common nor as extensive as they were in back-country areas to the east. The lack of fire, in combination with better access and more timber-oriented landowners, has resulted in timber harvest being the primary source of disturbance. Lower elevation sites can support timber harvest rotations as short as 30 years, necessitating frequent disturbance to maintain shade-intolerant forage species.

Population and Monitoring

There have never been any population surveys conducted in this DAU; however, moose sightings are recorded incidental to elk surveys. Moose in northern Idaho typically occur at low densities and occupy dense forested lands that make monitoring populations difficult. Moose commonly use closed canopy forests to escape deep snow or warm temperatures, resulting in low detection probabilities that make sightability model estimates unreliable. Due to these challenges, harvest data including percent success, number of days hunted and antler spread are used to adjust tag levels. For example, declining success and increasing hunter effort indicate a declining population; however, small sample sizes, accessibility and individual hunter preferences can confound the interpretation of harvest data. Alternative monitoring tools to harvest data are needed.

Harvest

Overall, harvest data indicates that moose populations increased from the 1980s through the early 2000s. Hunter success began to decline in GMU 10A in the mid-2000s indicating a decline in moose and tags were reduced accordingly. Recent harvest data for GMUs 8A and 6 indicates a stable population. Antlered harvest under the controlled hunt framework started in GMUs 6, 8A
and 10A in 1988, 1993 and 1980 respectively, each with 2 tags. A 40-day antlerless harvest hunt started in GMU 8A in 1999 with 4 tags. In 2005 an experimental 1-week antlered hunt consisting of 5 tags was added in GMU 6. It was thought that the short-season hunt would have higher drawing odds than long-season hunts and provide more hunting opportunity. However, in 2007, the short-season hunt within GMU 6 was turned into a 2-week short-season hunt. Hunters had the opportunity to select either a long-season hunt with lower drawing odds or a short-season hunt with higher drawing odds. In 2009, hunters had the choice of applying for 1 long-season hunt that ran for 78 days or between 2 2-week season hunts with higher drawing odds. The hunt within GMU 8A remained an 84-day hunt. In 2015, GMU 6 reached its highest tag level with 30 tags and GMU 8A had 10 tags. In 2019 all antlerless hunting opportunity was removed in this DAU and antlered tags were cut by 7 in response to population concerns. There are currently 3 hunts totaling 25 tags in GMU 6, 5 hunts with 24 tags in GMU 10A and 1 hunt with 8 tags in GMU 8A.

![Figure 9](image.png)

**Figure 9.** Moose harvest and tag allocation in the Lower St. Joe-Dworshak DAU.

**Current Issues**

Much of the land ownership within this DAU consists of private corporate timberland. Over time, forests have been drastically altered through timber harvest. Although timber harvest in closed-canopy forests typically increase early seral browse availability, corporate timberland companies have started to spray herbicides on shrub species that grow after harvesting an area. This spraying may result in loss of useable habitat and forage for moose. IDFG needs to understand how herbicide spraying may impact available moose habitat and forage in the future. Timber harvest practices have also resulted in loss of security and thermal cover for moose.

Harvest rates have remained relatively stable throughout this DAU; however, with moose populations declining around most of the state and a reduction in hunting tags, management will need to monitor the productivity of moose populations with other methods besides harvest data. In addition, the role of predation and parasites and disease are unknown and warrant further
investigation. Statewide management directions aim to identify potential threats and mitigate negative impacts wherever possible.

**Upper Joe and CDA DAU (GMUs 3, 4, 4A, 7, 9, 10)**

The Upper Joe and CDA DAU encompasses GMUs 3, 4A, 4, 7, 9 and 10. The DAU covers the Coeur d’Alene NF and portions of the St. Joe and Clearwater NF. Ownership within this DAU is mostly public and managed by the United States Forest Service (USFS). The western border includes the urban areas of Coeur d’Alene, Post Falls and Hayden. The northern portion runs along the Clark Fork river and continues south across Interstate 90 into the upper portion of the St. Joe NF. The southern boundary includes the North Fork Clearwater River drainage located in GMU 10 and the eastern edge extends to the Montana border. This DAU is almost entirely within the Bitterroot Mountains Ecological Section. Precipitation ranges from 76 cm (30 in) to over 102 cm (40 in) per year, mostly as snow and elevations range from approximately 610 m (2000 ft) to 2130 m (7000 ft). Streams are generally steep and deeply incised. The northern area of GMUs 3, 4 and 4A are predominantly western hemlock forest types, although grand fir and at high elevations, subalpine fir also occur. Further south, western red cedar dominates low elevation sites transitioning to mountain hemlock and finally subalpine fir at higher elevations.

The majority of this DAU succeeds to closed canopy forests at climax that offer little forage for moose and both timber harvest and fire have played influential roles in creating early seral moose habitat. Large forest fires in the early 1900s burned across the majority of this DAU and established abundant early seral shrub communities that have persisted through time, especially on southern aspects. Timber harvest also created early seral habitat throughout parts of the DAU. Mature coniferous stands retained adjacent to foraging areas provide important cover for snow interception as well as shade in summer. Moose within the southern portion of this DAU also winter at high elevations in spruce–subalpine fir communities despite deep snow.

**Population and Monitoring**

There have never been any population surveys conducted in this DAU besides incidental sightings of moose during elk surveys in GMUs 4, 7 and 10. Incidental sightings have little value when not coupled with other demographic or population monitoring efforts. Aerial monitoring is difficult in northern Idaho due to the dense forest cover and moose occurring widespread at low densities.

**Harvest**

Antlered harvest under the controlled hunt framework started in 1975 in GMU 10 (2 tags) and 1998 in GMUs 4 (4 tags), 7 (2 tags) and 9 (2 tags). Two hunts took place in GMU 4, one north and one south of Interstate 90. An additional hunt was added in 1991 that split 2 hunts between GMU 7. Also, GMU 3 was added into the hunts that occurred within GMU 4 in 1991. In 1999 hunts that occurred within the combined areas of GMU 3 and 4 were split apart into 2 new hunting areas. Hunting in GMU 4A started in 2007 with 5 tags. In 2007 there were 2-week hunts established within GMU 3, 4, 7 and 9 in addition to long-season hunts. The short-season hunts were aimed at increasing drawing odds. The 2-week experimental hunts ended in 2009 and
hunters had the option to choose between a 78-day season or 2-week seasons with better drawing odds in GMUs 3, 4, 7 and 9. Additional 2-week hunts were added to GMUs 3 and 4 in 2011. These hunts were instituted to increase drawing odds and provide more hunting opportunity. Hunter success has varied, but remained fairly high across these GMUs, ranging from 60-100% in 2016. However, with relatively low tag levels, hunter success rates can vary drastically between years. Tag levels were gradually increased in GMU 10 from 2 tags in 1975 to 32 tags in 2005, until 2013 when tags were reduced to 27 due to population concerns. In 2019, tag levels were cut across much of the DAU due to varying success rates and anecdotal observations of a declining moose population.

![Figure 10](image.png)

*Figure 10. Moose harvest and tag allocation in the Upper St. Joe and CDA DAU.*

**Current Issues**

Many important early seral forage species such as Ceanothus spp. and willow species are fire adapted and require disturbance to persist on the landscape. Although large forest fires and timber harvest were common sources of disturbance in the past, fire suppression and a lack of timber harvest, particularly on national forest lands have resulted in a late-seral bulge across much of this DAU, which has likely reduced forage availability. This DAU has some of the highest precipitation rates in the state, which results in productive forests that require reoccurring disturbance to maintain early seral forage species. In addition to creating early seral habitats where it is limited, existing shrub fields created by past forest fires are commonly decaden and provide little forage within browsing reach of moose; these shrub fields would greatly benefit from prescribed burns.

Although generally beneficial, timber harvest practices influence the vegetation communities that establish post-harvest, which in turn influences their value to moose. Burning of slash post-harvest is beneficial for establishment of willow species and is a requirement for Ceanothus spp. Applications of herbicides to reduce shrub competition with planted trees should be avoided and
negates any forage benefits afforded by the timber harvest. Working with corporate timber companies on herbicide spraying impacts and habitat management after logging would be beneficial.

Little is known about the impact of predation on moose population performance; however, limited data are available for moose in GMU 10. In 2008, IDFG began monitoring radio-collared moose to determine survival and cause of death in the presence of wolves. This work was done in conjunction with a wolf-elk interaction research project in GMU 10. Unfortunately, sample sizes of radio-marked moose never reached statistically robust levels; however, results indicated wolves were not a significant cause of mortality on adult moose. Calf mortality due to wolves in contrast was high (6 of 12 radio-marked animals) in the only year (2011) that calves were collared (IDFG 2012).

Human development is not a major issue within this DAU; however, increased access in some areas, such as GMU 3, has increased potential for vehicular collisions and increased poaching.

**Hells Canyon DAU (GMUs 11, 11A, 13, 18, 22)**

The Hells Canyon DAU is comprised of GMUs that contain little suitable moose habitat. The northern half of the DAU (GMUs 11 and 11A) are mostly within the Palouse Prairie Ecological Section and receives approximately 76 cm (30 in) of precipitation per year. The majority of GMU 11A as well as the northern and eastern portions of GMU 11 consist of private agricultural lands that transition to forested lands and dry canyon grasslands to the southwest. The southern half the DAU (GMUs 13, 18, 22) are within the Blue Mountains Ecological Section and precipitation ranges from as little as 23 cm (9 in) in valleys to over 102 cm (40 in) in mountainous regions. Landownership is predominantly private in GMU 13 while the majority of GMU 18 is within the Hells Canyon National Recreation Area and Hells Canyon Wilderness Area and GMU 22 is within the Payette NF.

Occasionally moose are reported in limited riparian areas interspersed amongst agricultural areas; however, most incidental observations occur within the higher elevation forested areas of GMUs 11 and 22. Reports are typically of young individuals that likely dispersed to the area. There does not appear to be a substantial resident population, which suggests that survival in these areas is likely low.

**Population and Monitoring**

Monitoring has not occurred in the DAU due to low moose densities.

**Harvest**

No hunting seasons have been implemented within the Hells Canyon DAU.

**Current Issues**

Moose are not actively managed in the Hells Canyon DAU. Incidental observations of mortality include vehicle collisions, poaching and tribal harvest.
Elk City DAU (GMUs 14, 15, 16)

The Elk City DAU is predominantly within the Idaho Batholith Ecological Section with a very small amount of primarily agricultural land in the Palouse Prairie Ecological Section to the northwest. Therefore, most of the moose habitat in this DAU occurs within the Idaho Batholith Ecological Section. Precipitation averages about 76 cm (30 in) per year and elevations range from approximately 360 m (1200 ft) to 2440 m (8000 ft). The dominant forest type is grand fir (GMUs 14, 15) while dry slopes along the western edge (GMU 14) are Douglas-fir. High-elevation areas along the southern edge of the DAU (GMUs 14, 15) are dominated by subalpine fir forest types, whereas the northern portion of the DAU (GMU 16) is dominated by western red cedar forest types. Over 80% of this DAU is within the Nez Perce-Clearwater NF, including approximately 140 square miles within the Gospel-Hump Wilderness Area, with the remaining land privately owned. Terrain is moderately rugged with moderate to high accessibility across much of the DAU outside the Gospel-Hump Wilderness Area.

The northern portion of this DAU (GMU 16) is most associated with low elevation western red cedar forests that generally support a greater abundance of moose forage than less productive grand fir forests to the south (Schrempp et al. 2019). Approximately 40,000 acres burned from 2014-2015 along the Selway River, creating abundant early seral vegetation. Fire has been largely absent in GMU 15 since the early 1900s and logging has been the primary disturbance. Over 80,000 acres have burned in GMU 14 since 2000. Areas burned by forest fires or as part of timber harvest activities generally support a greater abundance of high-quality forage like willow species and redstem ceanothus. Lower quality forage species like huckleberry, alder and menziesia are common shade tolerant forage species. Portions of this DAU, particularly within GMU 15, support pacific yew thickets beneath mature grand fir canopies that are important winter forage species for moose, particularly when snow depth precludes foraging in more open shrub fields and clear-cuts. The majority of habitat within GMU 14 is at higher elevations, while lower elevations are predominantly dry canyon grasslands unsuitable for moose.

Population and Monitoring

In 2000, a helicopter sightability survey was attempted in GMU 15 but dense forest canopies resulted in low probability moose detections and grossly inflated population estimates. Due to these challenges, harvest data including percent success, number of days hunted and antler spread are used to adjust tag levels. However, small sample sizes, hunter accessibility and individual hunter preferences can confound the interpretation of harvest data.

Harvest

Moose harvest started with fewer than 10 antlered tags in the early 1970s. Anecdotal observations and harvest data suggested an underutilized population and so tag numbers were gradually increased until peaking in the early 2000s at 90 antlered tags. In response to declining hunter success, tag levels were reduced in 2005. Hunter success did not improve and further cuts were made until hunts were closed in GMU 15 in 2013. Currently there are 7 antlered tags offered between GMUs 14 and 16.
Current Issues
Moose populations have declined tremendously since the 1980s based on harvest data and identifying the causes of these declines is a management priority. The lack of alternative monitoring tools, especially in the absence of any harvest data, handicaps IDFG’s ability to monitor even basic demographic trend data. Development of additional population monitoring tools will be needed to evaluate the effectiveness of any management strategies.

Little disturbance has occurred in GMU 15 since the early 1900s and forest succession could be reducing the quantity and quality of available moose forage. Timber harvest and prescribed fire would likely benefit moose in this area by reducing forest canopy and creating early seral vegetation as well as reinvigorate existing shrubs fields that have become decadent. Investigation into alternative options to disturb decadent shrub fields, such as “conifer release” via chainsaw cutting and herbicide top kill, is warranted especially where prescribed burns are not feasible.

Pacific yew is an important winter forage in GMU 15 and does not tolerate full sun, therefore, mature grand fir forests should be preserved in areas of deep snow to retain the Pacific yew understories. In contrast to much of GMU 15, significant portions of 14 and 16 have burned since 2000. These fires have created good foraging conditions for moose; however, without a population monitoring tool, it is unknown how moose are responding to these burns. Finally, the role of predation and parasites and disease are unknown and warrant further investigation.

Figure 11. Moose harvest and tag allocation in the Elk City DAU.
Lochsa-Selway DAU (GMUs 12, 16A, 17, 19, 20)

The Lochsa-Selway DAU is almost entirely within the Idaho Batholith Ecological Section with a small portion within the Bitterroot Mountains Ecological Section. Precipitation averages 100 cm (40 in) per year in the northern portion of the DAU and 74 cm (29 in) further south. Elevation ranges from approximately 430 m (1400 ft) to over 2440 m (8000 ft). Western red cedar forest types are found north of the Lochsa River whereas subalpine fir is the dominate forest type to the south. Significant amounts of Douglas-fir are found at lower elevations on dry aspects along the Selway and Salmon Rivers, frequently transitioning to grand fir at higher elevations followed by subalpine fir. Landownership within the Lochsa-Selway DAU is almost entirely Nez Perce-Clearwater NF including over 1 million acres within the Selway Bitterroot Wilderness Area. Terrain is rugged with very little access beyond primary administrative roads.

The northern portion of this DAU receives substantially more precipitation than the southern portion. Higher precipitation rates, combined with higher quality soils, result in more productive forests and generally higher quality moose habitat in GMUs 12 and 16A. Timber harvest has been relatively uncommon within this DAU due to the limited access and rugged terrain, resulting in forest fires as the dominate form of disturbance. Large forest fires burned vast areas within this DAU in the early 1900s, creating the majority of early seral moose habitat. More recent forest fires in the past 2 decades have burned large areas within the Selway Bitterroot Wilderness Area. Moose within this DAU use a variety of habitats, from large shrub fields to lodgepole pine forests to high elevation subalpine fir forests.

**Population and Monitoring**
Moose in northern Idaho typically occur at low densities and occupy dense forested lands that make monitoring populations difficult. Moose commonly use closed-canopy forests to escape deep snow or warm temperatures, resulting in low detection probabilities that make sightability model estimates unreliable. Due to these challenges, harvest data including percent success, number of days hunted and antler spread are used to adjust tag levels. Declining success and increasing hunter effort indicate a declining population; however, small sample sizes, accessibility and individual hunter preferences can confound the interpretation of harvest data. No moose surveys are conducted within this DAU but incidental observations are recorded during elk sightability surveys. Incidental counts are of little value because of aforementioned low detectability and not all moose habitat is flown.

**Harvest**
Moose vulnerability to harvest is lower in this DAU relative to more accessible DAUs due to the rugged and remote landscape. With lower overall vulnerability, management has generally offered additional opportunity understanding that hunter success will be lower. Between 25 and 30 antlered tags were offered between 1972 and 1982. Anecdotal observations and harvest data suggested an underutilized population and so tags were gradually increased until peaking in the mid-1990s at 134 antlered tags. In response to declining hunter success, tag levels were reduced to 100 tags in 2001. Hunter success did not improve and further cuts were made until hunts were
closed in 2013 for GMUs 16A, 17, 19 and 20. Tag levels were also reduced in GMU 12 although declines were not as severe as populations further south and 16 antlered tags currently remain.

![Moose harvest and tag allocation in the Lochsa-Selway DAU.](image)

**Figure 12.** Moose harvest and tag allocation in the Lochsa-Selway DAU.

**Current Issues**
Moose populations have declined tremendously based on harvest data and identifying the causes of these declines is a management priority. Most of this DAU no longer supports hunting and the lack of alternative monitoring tools handicaps IDFG’s ability to monitor even basic demographic trend data. Development of additional population monitoring tools will be needed to evaluate the effectiveness of any management strategies.

Little disturbance has occurred in GMU 12 since the early 1900s and forest succession could be reducing the quantity and quality of available moose forage. Timber harvest and prescribed fire would likely benefit moose in this area by reducing forest canopy and creating early seral vegetation as well as reinvigorate existing shrubs fields that have become decadent. In contrast to much of GMU 12, significant portions of GMU 16A and particularly GMUs 17, 19 and 20 have burned since 2000. At low- to mid-elevations, these fires have created good foraging conditions for moose; however, without a population monitoring tool, it is unknown how moose are responding to these burns. The lack of thermal cover in extensively burned areas might limit moose use of these areas during summer. In addition, noxious weeds have expanded within this DAU, particularly at lower elevation sites, which could possibly exclude or delay the establishment of forage shrubs post disturbance. Finally, the role of predation and parasites and disease are unknown and warrant further investigation where feasible.
McCall DAU (GMUs 19A, 23, 24, 25, 32A, 33, 34, 35)

The McCall DAU is comprised of GMUs that support low densities of resident moose and contain little suitable moose habitat. The DAU is almost entirely within the Idaho Batholith Ecological Section with smaller portions within the Owyhee Uplands Ecological Section. Precipitation ranges from less than 25 cm (10 in) in the Owyhee Uplands to over 76 cm (30 in) in the mountainous regions of the Idaho Batholith Ecological Section. Public land is common, including large portions of the Payette and Boise NFs. Lower elevation valleys are predominantly private but do include some BLM and IDL lands. The majority of the DAU is rugged with limited access.

The western portion of this DAU does not have adequate habitat to support resident moose populations; however, low density moose populations do occur in the more mountainous areas further east. These areas receive higher amounts of precipitation and consist of Douglas-fir, spruce-fir and lodgepole pine forest types. More open forest stands support various woody understory shrubs such as huckleberry species, alder species, serviceberry, willow species and others. During the summer months, moose frequently utilize limited riparian areas and water bodies for thermoregulation and foraging.

Population and Monitoring

In the northeast portion of the DAU, observations of moose began to increase starting in the 1980s. Many of these were believed to be a result of pioneering populations from the Middle Fork DAU. By the late 1990s, it was determined that a portion of the area could support a hunt. The population declined in the late-2000s.

Monitoring has not occurred in the DAU due to low moose densities. Some limited moose observations in this DAU have come from aerial surveys of deer and elk during the winter and also from public sightings.

Harvest

Hunts in GMUs 19A and 25 were opened in 1999 with 2 tags each. Hunter success remained high through the mid-2000s, but then began to decline. These hunts were closed after 2010 due to poor harvest trend and a lack of field reports of observed moose. No hunting seasons currently occur within the McCall DAU.

Current Issues

Moose are not actively managed in the McCall DAU. IDFG will continue to trap, sample and relocate moose that wander into urban areas and take advantage of opportunities to sample for disease.
Smoky-Bennett DAU (GMUs 39, 43, 44, 45, 48, 52)

The Smoky-Bennett Moose DAU encompasses a diverse landscape, ranging from low elevation sagebrush steppe in the Snake River Plain to high elevation dry conifer forests and alpine habitats in the upper reaches of the South Fork Boise and Big Wood watersheds. Several mountain ranges striate the DAU, including the Boise Mountains (GMU 39), Trinity Mountains (GMUs 39 and 43), Soldier and Smoky Mountains (GMUs 43 and 44), Sawtooth Mountains (GMU 48) and the Bennett Mountains (GMU 45). Over 65% of the DAU is managed by federal and state agencies, including the Sawtooth and Boise NFs, Twin Falls and Boise BLM districts and IDL.

The Smoky-Bennett DAU falls within 4 ecological sections: the Idaho Batholith, Owyhee Uplands, Challis Volcanics and the Snake River Basalts. Due to the diverse topography and elevation gradients within the DAU, precipitation varies widely. The northern and more mountainous portions of the DAU can receive up to 89 cm (35 in) of precipitation per year, while the southern expanse may receive less than 30 cm (12 in) per year. Elevation ranges from less than 762 m (2500 ft) along the Snake River near Hamnett to over 3350 m (11,000 ft) in the upper Big Wood watershed. Douglas-fir, mixed dry conifer and spruce are the dominant forest types throughout the northern part of the DAU. At low elevations, the hills and valleys in the southern portion of the DAU are dominated by sagebrush steppe, transitioning into mountain big sagebrush, mixed shrub and aspen communities at mid-elevations.

Riparian corridors and vegetation communities associated with the mid- to higher elevations provide foraging and thermal cover, particularly during summer. Moose in the Smoky-Bennett DAU are not known to migrate long distances; however, they do travel down in elevation to suitable winter habitat. Winter habitat is composed of aspen/sagebrush, mixed shrub and black cottonwood-willow-dominated riparian communities.

Population and Monitoring
Prior to 1990, transient moose were recorded throughout the Magic Valley Region, but there were no viable, resident populations. From 1986-2000, 31 moose were released in GMUs 43 and 44. The reintroductions were marginally successful due to illegal harvest or emigration out of the area; however, natural reproduction of animals that remained, as well as some immigration from neighboring populations, resulted in an established population within the northern portions of the DAU. Moose populations appear to have increased until approximately 2008 when moose harvest (and incidental observations) began to decline. In 2011, moose tags were reduced considerably, including elimination of antlerless tags. Since that time moose appear to be stable and possibly increasing throughout the DAU. Consistently high harvest success rates and continued anecdotal observations, including human-moose interactions in urban areas and roadway mortality on US Highway 20 and State Highway 75, support this suspected trend.

Population surveys of moose have not been conducted in the Smoky-Bennett DAU due to low densities and the difficulty in finding individuals across a large area. However, opportunistic documentation of moose during aerial surveys for deer and elk has provided a small dataset on moose numbers, locations and demographics. Due to differences in winter habitat selection by
moose in comparison to deer and elk, it is likely that some habitat patches inhabited by moose are not surveyed, thereby reducing the utility of these data to make inferences about population trajectories. Historically, harvest data (hunter success rates, days hunted and antler spread) as well as anecdotal information have been used to evaluate population status.

**Harvest**

Two tags were offered for the first time in Hunt Area 44 (which included part of GMU 44 and all of GMUs 48 and 49) in 2001. As moose populations increased, hunting opportunity was expanded. Two antlerless hunts, offering 2 tags each, were created in Hunt Areas 44 and 48 in 2005. Due to declining hunter success rates and an apparent population decline, antlerless opportunity was eliminated, antlered tags were reduced from 10 to 3 and a new hunt area encompassing GMUs 44, 48 and 49 was created for the 2011 hunting season. Since 2011, antlered tags have remained at 3 and no antlerless hunting opportunities have been offered. Hunter success rates have been in high since 2011, averaging 88%. In response to increasing moose numbers in the southern half of the Silver Creek Valley, the Hunt Area 44 boundary was amended in 2019 to include the northern portion of GMU 52.

![Figure 13. Moose harvest and tag allocation in the Smoky-Bennett DAU.](image)

**Current Issues**

A deficiency in baseline knowledge of moose populations within the Smoky-Bennett DAU has made management decisions regarding moose challenging. Improving survey methodologies for monitoring moose populations would improve our understanding of population dynamics and habitat use within the DAU and increase the ability to detect areas of importance for moose. This information would help managers identify limiting factors and potential threats to moose populations and habitat and to develop management strategies to improve conditions for moose throughout the DAU.
Owyhee-Big Desert DAU (GMUs 31, 32, 38, 40, 41, 42, 46, 47, 53, 52A, 68)

The Owyhee-Big Desert DAU is comprised of GMUs that support low densities of resident moose and contain little suitable moose habitat. The DAU is composed of the Owyhee Uplands and Snake River Basalts Ecological Sections, which on average receive 18-38 cm (7-15 in) of precipitation annually. Elevation ranges from just under 2620 m (8600 ft) in the Owyhee mountain range to just over 610 m (2000 ft) in the Owyhee River canyon. The Snake River from below American Falls Reservoir to the Oregon border bisects the DAU. The Owyhee Mountains run through the southwestern corner of the DAU. Deep canyons and vast expanses of sagebrush and western juniper cover most of the area. Large wildfires in the past decade have converted over a million acres of sagebrush shrublands into grassland. In many areas, invasive plant species including winter annual grasses, such as cheatgrass and medusahead, have become well established post wildfire. Riparian corridors and aspen stringers can be found in drainage bottoms. The few moose that do occupy the DAU are confined to canyon bottoms and isolated riparian corridors along rivers.

Population and Monitoring
Moose have rarely been reported within the DAU and are mostly limited to moose immigrating from adjacent DAUs with higher moose densities. Transient moose in urban areas along the Snake River Plain (portions of Cassia, Minidoka and Twin Falls counties) are common annual occurrences. These moose are often trapped and relocated to suitable habitat in neighboring DAUs (i.e., Smoky-Bennett and Bannock).

Monitoring has not occurred in the DAU due to low moose densities. There have been limited anecdotal observations of moose, even during winter aerial surveys for deer and elk. However, moose that are relocated out of urban areas within the DAU are sampled for disease, ear tagged and sometimes fitted with radio collars to monitor seasonal movements and survival.

Harvest
No hunting seasons have been implemented within the Owyhee-Big Desert DAU. Other sources of mortality include vehicle collisions, fence entanglements and disease.

Current Issues
Moose are not actively managed in the Owyhee-Big Desert DAU. IDFG will continue to trap, sample and relocate moose that wander into urban areas.
The Bannock DAU is comprised of several southern Idaho mountain ranges. These include the South Hills (GMU 54), Albions (GMU 55), Subletts (GMU 56), Black Pine (GMU 57), Deep Creek Range (GMU 73A), Bannock Range (GMUs 70 and 73) and Portneuf Range (GMUs 71 and 74). Public lands within the DAU are managed by the Caribou-Targhee and Sawtooth NF, Twin Falls and Idaho Falls BLM districts and IDL.

The Bannock DAU falls mostly within the Northwestern Basin and Range Ecological Section, which averages 41 cm (16 in) of precipitation annually, mostly in the form of winter snowfall. This land area is among the driest in the state where moose and their habitat are present. Sagebrush steppe habitat and agriculture dominate the valley bottoms while Utah juniper, desert shrub and/or sagebrush dominate the mid-elevations and habitats at higher elevations include sagebrush, aspen and spruce-fir.

Moose use much of the mid- to higher elevation habitat within the Bannock DAU. While summer habitat use by moose in these areas is likely tied to riparian corridors and other mesic zones, moose also use aspen and mountain brush communities, spruce-fir communities and sagebrush communities. Moose in the Bannock DAU likely do not undertake major migrations, but move shorter distances to suitable winter habitat, predominantly aspen/mountain brush and juniper/mahogany communities in the DAU.

Population and Monitoring
Prior to the 1950s, there were too few moose in southeastern Idaho to justify harvest. As populations expanded, so did hunting opportunity and harvest. The expansion of moose populations in the Bannock DAU occurred from east to west over a period of years or decades. In several GMUs, the population growth concurrent with this range expansion likely stopped in the mid-2000s and populations in these areas may have declined since that time (e.g., GMU 71). Other GMUs have likely continued to see population growth or relatively stable populations through the present time (e.g., GMU 54).

Moose-specific population surveys have not taken place in the Bannock DAU due to relatively low moose densities over a vast geographical area. However, moose have been documented (location, numbers, age and sex of adults) during mule deer population surveys. Because these surveys were not moose-specific, much of the area that might be inhabited by wintering moose was not surveyed, reducing the utility of these data to make inferences about population growth/decline. Generally, harvest data (hunter success rates, number of days hunted and antler spread) and professional judgement have been used to make inferences about population status.

Harvest
Moose harvest in the Bannock DAU began in 1988 with seasons in GMUs 71 and 74 (3 tags per GMU, antlered-only). By 1993, tag numbers had increased to 10 in GMU 71, to 5 in GMU 74 and an additional 5 tag hunt was added to GMU 70. In 1999, the first antlerless harvest season in the Bannock DAU was implemented with 5 tags in GMU 71 (expanded to 10 tags in 2001) and
an antlered-only harvest season was implemented in GMUs 56, 73 and 73A (5 tags combined). In 2011, antlered-only harvest seasons were implemented in GMUs 73 and 73A (5 tags combined) and GMUs 55, 56 and 57 (5 tags combined). In 2013, hunting opportunity in GMU 70 was expanded with the number of antlered-only tags increasing to 6 and the addition of 2 antlerless tags. In 2015, tag levels decreased in some areas for the first time (to 6 antlered and 5 antlerless tags in GMU 71). However, the 2015 harvest season was the first time every GMU in the Bannock DAU offered moose hunting opportunities including an antlered-only harvest season in GMU 54 (1 tag) and antlerless harvest seasons in GMUs 73 (3 tags) and 74 (2 tags). In 2019, the number of antlerless tags in GMU 71 was reduced to 3, the number of antlered tags in GMU 54 was increased to 3 and the hunt in GMUs 55, 56 and 57 was split (3 tags in GMU 56 and 3 tags in the combined GMUs 55 and 57).

Antlered harvest in the Bannock DAU increased somewhat rapidly from 3 individuals in 1989 (first year with available data) to 23 individuals in 2003. Between 2003 and 2018, harvest has remained more stable, with a peak of 29 individuals in 2013. Antlerless harvest has ranged from a minimum of 2 individuals in 2012 to a maximum of 11 individuals in 2017.

![Figure 14. Moose harvest and tag allocation in the Bannock DAU.](image)

**Current Issues**

Moose populations in the Bannock DAU appear to be relatively stable. Exceptions to this may be an expanding moose population on the western edge of the DAU (GMU 54) and a slightly declining population on the eastern edge of the DAU (GMUs 71 and 74), but these are judgement-based determinations. Recent non-harvest mortalities across the DAU are concerning and seem to have increased in recent years. Managers feel that these mortalities may be disease related. Several GMUs in the Bannock DAU include population centers and IDFG staff respond to and relocate a number of moose annually out of urban settings. Harvest management of moose in this DAU occurs at the GMU and grouped GMU levels and is more conservative in the
western portions. This difference in harvest intensity is the result of sportsmen interest and input on these populations.

**Caribou DAU (GMUs 66, 66A, 69, 72, 75, 76, 77,78)**

The Caribou DAU is comprised of several southeastern Idaho mountain ranges including the Chesterfield Range (GMU 72), Bear River Range (GMUs 75, 77 and 78) and Caribou Range (GMUs 66, 66A, 69 and 76). Public lands within the DAU are managed by the Caribou-Targhee NF, Idaho Falls BLM District and IDL.

The Caribou DAU is comprised of 2 main ecological sections, the Overthrust Mountains Ecological Section on the east and the Northwestern Basin and Range Ecological Section to the west. Average annual precipitation for these sections is approximately 40 cm (16 in) in the Northwestern Basin and Range Ecological Section and 70 cm (28 in) in the Overthrust Mountains Ecological Section. Elevations range from 1370 m (4500 ft) to over 2743 m (9000 ft). In general, the lowest elevation areas are urbanized or dominated by irrigated agriculture. However, lowland areas of slightly higher elevation with agriculture (mostly dryland small-grain production) interspersed with sagebrush, mountain brush, Utah and Rocky Mountain juniper, maple and small aspen patches occur throughout much of the DAU. Mid-elevations are dominated by mountain brush, sagebrush and mahogany communities, while higher elevations are dominated by sagebrush, aspen and spruce/Douglas-fir/pine communities.

Moose regularly use most of the DAU, except for the lowest elevation areas that are urbanized or irrigated agriculture. Moose utilize much of the mid- to higher elevation habitat within the Caribou DAU throughout the year and lower elevations that are mixed sagebrush, mountain brush and aspen during winter. While summer habitat use by moose is likely tied to riparian corridors and other mesic zones, moose utilize aspen and mountain brush communities, spruce-Douglas-fir communities and sagebrush communities as well. Moose in the Caribou DAU likely do not undertake major migrations but move shorter distances to suitable winter habitat. These winter habitats are dominated by aspen/mountain brush and mahogany communities in the Caribou DAU, although winter use of conifer communities is also common.

**Population and Monitoring**

Prior to the 1950s, there were too few moose in Southeastern Idaho to justify harvest. As moose populations continued to expand, so did hunting opportunity and harvest. The expansion of moose populations in the Caribou DAU likely occurred from east to west over a period of years or decades with highest densities occurring in GMUs 66, 66A, 69 and 76. In several GMUs, the population growth concurrent with this range expansion likely stopped in the mid-2000s and populations in these areas have declined since that time. Other GMUs have likely continued to experience relatively stable populations through the present time.

Moose surveys have taken place in portions of the Caribou DAU since the late 1970s (Table 2). This monitoring has been quite intensive when compared to most of the moose populations in the state and provides insight into moose population growth and declines in the area. Although moose-specific surveys became significantly less common after 2002, a 2018 survey (repeating
surveys from 2000-2002) demonstrated a reduction in moose populations in GMUs 66A and 76 (~55% fewer moose observed in 2018 than in the same area in 2000-2002). Moose have also been documented (location, numbers, age and sex) during mule deer and elk population surveys. Because these opportunistic surveys were not moose-specific, much of the area that might be inhabited by wintering moose was not surveyed, reducing the utility of these data to make inferences about population growth/decline. In addition to utilizing surveys, harvest data (hunter success rates, number of days hunted and antler spread) have been used to make inferences about population status.

Table 2. Results of moose surveys in various portions of the Caribou DAU since the late 1970s.

<table>
<thead>
<tr>
<th>Year</th>
<th>Bull:Cow:Young</th>
<th>Number Classified</th>
<th>GMUs</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1978-1979</td>
<td>81:100:57</td>
<td>212</td>
<td>66A/76</td>
<td>* Phosphate Mining Study</td>
</tr>
<tr>
<td>1979-1980</td>
<td>74:100:51</td>
<td>256</td>
<td>66A/76</td>
<td>* Phosphate Mining Study</td>
</tr>
<tr>
<td>1980-1981</td>
<td>76:100:51</td>
<td>399</td>
<td>66A/76</td>
<td>* Phosphate Mining Study</td>
</tr>
<tr>
<td>1984-1985</td>
<td>47:100:60</td>
<td>199</td>
<td>66A/76</td>
<td>*entire GMU 66A count of 131</td>
</tr>
<tr>
<td>1986-1987</td>
<td>100:100:58</td>
<td>93</td>
<td>66A/76</td>
<td></td>
</tr>
<tr>
<td>1987-1988</td>
<td>58:100:52</td>
<td>189</td>
<td>76</td>
<td></td>
</tr>
<tr>
<td>1989-1990</td>
<td>35:100:55</td>
<td>205</td>
<td>76</td>
<td></td>
</tr>
<tr>
<td>1990-1991</td>
<td>49:100:60</td>
<td>136</td>
<td>76</td>
<td>*entire Hunt Area 76-3</td>
</tr>
<tr>
<td>1993-1994</td>
<td>42:100:42</td>
<td>90</td>
<td>76</td>
<td>*8 of 30 search units in 76-1</td>
</tr>
<tr>
<td>1995-1996</td>
<td>55:100:40</td>
<td>121</td>
<td>76</td>
<td>*11 of 13 search units in 76-3</td>
</tr>
<tr>
<td>1996-1997</td>
<td>85:100:44</td>
<td>89</td>
<td>76</td>
<td>*13 of 28 search units in 76-2</td>
</tr>
<tr>
<td>1999-2000</td>
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<td>76</td>
<td>*19 of 30 search units in 76-1</td>
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<tr>
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<td>66A</td>
<td>*13 of 19 search units in 66A</td>
</tr>
<tr>
<td>2001-2002</td>
<td>117:100:34</td>
<td>104</td>
<td>76</td>
<td>*10 of 13 search units in 76-3</td>
</tr>
</tbody>
</table>

Harvest
The first harvest season in a portion of the Caribou DAU was in 1959 (5 antlered-only tags in 1 hunt area combining portions of GMUs 66, 66A and 76). By 1962, there were 3 harvest seasons (13 total tags) occurring in GMUs 66, 66A and 76, which had expanded to 15 total tags by 1970. In 1975, the first opportunity to harvest antlerless moose in the Caribou DAU was offered (4 either-sex hunts in GMUs 76 and 66A with 9 total tags). Antlered-only hunting opportunity had expanded to 5 hunts in GMUs 66, 66A and 76 with 33 total tags. By 1980, 54 antlered-only tags were offered across 6 hunt areas and 13 either-sex tags were offered across 4 hunt areas. By 1985, 102 antlered-only tags were offered across 10 hunt areas and 25 either-sex tags were offered across 4 hunt areas. During this time period (1983), a harvest season was opened in the Bear River Range (GMUs 75, 77 and 78). The 1988 harvest season was the first time every GMU in the Caribou DAU had a harvest season and, by 1990, seasons included 114 antlered-only tags spread across 12 hunt areas and 35 either-sex tags across 5 hunt areas. In 1991, harvest seasons previously either-sex were changed to be antlerless-only. During this hunting season 134...
antlered-only tags were offered across 13 hunt areas and 25 antlerless-only tags were offered across 5 hunt areas. By 1995, 167 antlered-only tags were offered across 13 hunt areas and 56 antlerless-only tags were offered across 5 hunt areas. By 2000, 199 antlered-only tags were offered across 13 hunt areas and 71 antlerless-only tags were offered across 6 hunt areas. During the 2003 and 2004 harvest seasons, tag allocation in the Caribou DAU was at its maximum. During these years 239 antlered-only tags were offered across 13 hunt areas and 95 antlerless-only tags were offered across 10 hunt areas. By 2010, antlered-only tag allocation had decreased to 135, while antlerless tag allocation had decreased to 70. By 2015, tag allocation had decreased to 112 antlered-only tags and 38 antlerless-only tags (reduced to 7 hunt areas). Most recently (2019 harvest season), 99 antlered-only tags and 15 antlerless-only tags (reduced to 3 hunt areas) were allocated in the Caribou DAU.

Little harvest data is available for the Caribou DAU prior to 1974. Antlered harvest in the Caribou DAU increased rapidly from 19 individuals in 1974 to 112 individuals in 1984. Harvest remained somewhat stable through 1990 (119 individuals) and then again increased rapidly through 2003 (265 individuals). From 2003 to present harvest has decreased somewhat dramatically, with 107 individuals being harvested in 2018.

![Figure 15. Moose harvest and tag allocation in the Caribou DAU.](image)

**Current Issues**
Moose populations in the Caribou DAU have likely declined over the past 10-15 years. Causes for this decline are currently unknown. Furthermore, while populations throughout the DAU have likely contracted during this time, GMUs 66A and 76 seem to have been impacted worse than the others. Recent non-harvest mortalities across the DAU are concerning and seem to have increased in recent years. Managers feel that these mortalities may be disease related. Harvest management of moose in this DAU occurs at the partial GMU, GMU and grouped GMU levels.
In response to concerns about population health, harvest of females has been dramatically reduced in recent years, particularly in the more southern GMUs.

**Teton DAU (GMUs 62, 64, 65, 67)**

On the east side of the Upper Snake Region, the Teton DAU encompasses GMUs 62, 64, 65 and 67. It includes part of the Caribou-Targhee NF. Ownership consists of mostly public lands (USFS and BLM) followed by private, IDL and lands owned/managed by IDFG. The DAU is bounded to the east by Wyoming and on the northeast by Yellowstone National Park.

The majority of the Teton DAU is comprised of 3 different ecological sections, the Snake River Basalts Ecological Section to the north, the Northwestern Basin and Range Ecological Section to the southwest and the Overthrust Mountains Ecological Section to the southeast. Precipitation increases from approximately 30 cm (12 in) in the Snake River Basalts Ecological Section to approximately 71 cm (28 in) within the Overthrust Mountains Ecological Section. Elevation ranges from about 1460 m (4800 ft) to over 2740 m (9000 ft). Sagebrush is the dominant vegetation within the Snake River Basalts portion of the DAU transitioning into the Douglas-fir forest type in the mountains to the south.

Very little disturbance occurs on timbered lands within this DAU other than on private and some IDL properties. Some private agricultural lands are found within the Teton Valley portion of GMU 62 and 65 as well as the western portion of GMU 64 and southern portion of GMU 67. The terrain is of moderate ruggedness and can be broadly classified as front or mid-country areas with high levels of access. The area of GMU 67 along the Wyoming boundary is mostly rock outcroppings with little standing water at high elevations.

Moose utilize most of this DAU at some time during the year. They move down elevation slightly during winter months yet there are year-round residents on the South Fork Snake and Teton rivers. The mountains and wet valleys of this area provide many options for moose. They utilize the river drainages, riparian stringers, aspen and mountain brush communities, spruce-fir communities, Douglas-fir/sagebrush communities, mountain mahogany and private wet meadows in on the valley floor.

**Population and Monitoring**

Moose have occupied the Teton Basin and Swan Valley areas since settlement first occurred. In July 1872, the Hayden Geological Survey collected three moose near the Idaho-Wyoming line in the Teton Canyon (Hayden 1873). Trappers’ journals and early homesteaders mention moose in the river corridors and moving into the lower valleys during winter months.

A fixed-wing aerial survey was conducted in GMUs 64, 65 and 67 in 1984. A total of 255 moose were observed with 65 of them unclassified by sex. A population survey was conducted in GMU 62 during December 2000. The final population estimate was 366 moose including 180 cows, 109 bulls and 77 calves (Table 4). This total compares to fixed wing censuses of 218 cows and 81 bulls observed during 1989 and 1990, respectively. Few moose-specific population surveys
have occurred in the Teton DAU due to their relatively low densities. However, moose have been documented (location, numbers, age and sex of adults) during mule deer and elk population surveys. Because these surveys were not moose-specific, much of the area that might be inhabited by wintering moose was not surveyed, reducing the utility of these data to make inferences about population growth/decline. Generally, harvest data (hunter success rates, number of days hunted and antler spread) and professional judgement, have been used to make inferences about population status.

**Harvest**

Moose harvest began in the Teton DAU in 1974 in GMUs 64, 65 and part of 67. By 1983 moose hunting included all of the area within this DAU. Either-sex moose tags were offered in GMU 64 and 65 from 1986 to 1990. This was done in part to experiment and monitor the sex ratio of either-sex moose hunting. Most harvested moose were antlered with only 10.2% of harvested moose being antlerless. Harvest and tag allocation peaked between 2000 and 2005. Harvest management of moose in this DAU occurs at the GMU and grouped GMU levels and difference in harvest intensity is the result of sportsmen interest and input on these populations. Many record book moose have been harvested in this DAU.

![Figure 16. Moose harvest and tag allocation in the Teton DAU.](image-url)

**Current Issues**

Moose populations in this DAU appear to be relatively stable. Moose in the lower area of this DAU (Teton River and South Fork Snake River) reside on mostly private property making it difficult to implement large scale management actions for moose. Moose that live near population centers within this DAU often require IDFG staff to respond to and relocate them annually. Some newer housing developments impacting moose have occurred since 2000 in Teton County. As homes encroach on the foothills of the Teton Valley, more moose conflicts occur resulting in removal of moose out of historical moose habitat. Moose, particularly calves
and yearlings, have been documented with heavy tick loads; however, the population level impacts of these outbreaks is not known. Symptomatic moose that appear blind and uncoordinated, sometimes turning in circles, also have been recorded.

**Island Park DAU (GMUs 60A, 60, 61 central/east, 62A)**

On the north end of the Upper Snake Region, the Island Park DAU encompasses GMUs 60A, 60, most of 61 and 62A. It includes the Henry’s Fork River drainage and Henry’s Lake, Island Park and Ashton reservoirs. Ownership consists of mostly public lands (Caribou-Targhee NF, BLM) followed by private, IDL and lands owned/managed by IDFG.

The majority of Island Park DAU is within the Snake River Basalts Ecological Section whereas the northern portion is within the Beaverhead Mountains Ecological Section and the eastern portion is within the Yellowstone Highlands Ecological Section. Precipitation within the Snake River Basalts Ecological Section is approximately 30 cm (12 in) per year, increasing to approximately 50 cm (20 in) and 76 cm (30 in) within the Centennial Mountains and Yellowstone Highlands Ecological Sections, respectively. Elevation ranges from about 1460 m (4800 ft) to over 2740 m (9000 ft). The low elevation hills and valley floor are dominated by sagebrush and mountain shrub while Douglas-fir forests dominate the mountainous areas to the east and Douglas-fir and spruce-fir forest types are common to the north.

Very little disturbance occurs on timbered lands within this DAU other than on private and some IDL properties. Some private agricultural lands are found within the southern portion of GMUs 60 and 60A. The terrain is of moderate ruggedness and can be broadly classified as front or mid-country areas with high levels of access. The DAU is bounded to the north by Montana and on the east by Yellowstone National Park and Wyoming.

Extensive clearcut logging of lodgepole pine occurred on Targhee NF land in GMUs 60, 61 and 62A from the 1970s through early 1990s in response to infestation of mountain pine bark beetles. In some areas these clearcuts stimulated aspen regeneration which was probably beneficial to summering moose.

Moose utilize most of the habitat within the Island Park DAU. While summer habitat is likely tied to higher timbered elevations and other mesic zones, moose utilize aspen and mountain brush communities, Douglas-fir communities and sagebrush/chokecherry communities during winter months. Some moose in the Island Park DAU migrate and others do not. The Sand Creek desert is within this DAU and is a high elevation desert with large amounts of chokecherry, antelope bitterbrush, ceanothus and other mountain shrubs. Moose readily utilize this area and some migrate from Yellowstone National Park to this desert. Other moose stay in the higher elevations of the Island Park caldera to winter. The lower portion of GMU 60A includes the Henry’s Fork River which provides year-round habitat for moose.

**Population and Monitoring**
Idaho offered its first hunting season, in the first managed moose hunting area in Idaho, in portions of the Island Park DAU (Fremont County) in 1893 (Ritchie 1978). Populations notably declined and the season was closed after 1898. Populations increased throughout the Yellowstone ecosystem and moose were soon found on the Sand Creek desert wintering along with mule deer and elk. This wintering population is the only known desert wintering moose population in the world. It is believed the tall mountain shrub communities including chokecherry and antelope bitterbrush sustain this wintering population. Over 600 moose have been observed in the Sand Creek desert during winter aerial flights.

Fixed-wing aerial surveys were conducted in much of this DAU beginning in 1952 and continuing into the late 1980s. The highest count was 677 individuals in 1952 with the second highest in 1989 with 570 individuals counted. A herd composition count was done on the Big Bend Ridge, Fall River Ridge and Sand Creek desert portion of this DAU (GMU 60, 60A) in 1991. A total of 345 moose were counted with the bull/cow/calf ratio being 67:100:65. In 1991, a helicopter survey along the Henry’s Fork River in GMU 60A was conducted. A total of 37 moose were counted in this survey. Compared to many other DAUs across Idaho, Island Park has had some of the most consistent and highest counts. In addition to moose surveys, moose have been documented (location, numbers, age and sex of adults) during mule deer and elk population surveys. The Sand Creek desert is a known wintering area for this population and nearly 500 moose have been counted on one survey during winter months on this desert area alone. Because these surveys were not moose-specific, much of the area that might be inhabited by wintering moose was not surveyed, reducing the utility of these data to make inferences about population growth/decline. Generally, harvest data (hunter success rates, number of days hunted and antler spread) and professional judgement have been used to make inferences about population status.

There have been 3 studies of moose in this DAU; one in 1978 studying the ecology of moose, another in 2005 focusing on cow and calf survival and finally, in 2009, a study examining highway crossing by radio-collared cows. The 2009 study showcased moose in this DAU migrate 2 ways. Some stay year-round at high elevations in the Island park caldera and others migrate from the Island park caldera to the lower Sand Creek desert. A few even moved from the Sand Creek desert in winter to use the lower Henry’s Fork River as calving and summer range. Roadkill is high in this DAU along US Highways 20 and 87 within the Island Park caldera (Figure 3) with an estimated 62 moose reported from 2000 to 2019.

Harvest
Moose harvest began in portions of this DAU in 1893 and ran until 1898. No legal hunting occurred from 1899 to 1945. Controlled hunts began again in 1946 and continued until 1976 with an average of 47 tags annually. In 1956 and 1957, general elk hunting was open in the Island Park area and many moose were illegally killed (Ritchie 1978). From 1977 until 1982 all moose hunting in Fremont County was stopped due to concerns of declining moose populations. Beginning in 1983, both antlered and antlerless moose tags occurred throughout the entire DAU until 2008. Hunter success was lower for both tag types in the early 2000s. Hunter effort (hunter days) was similar to previous years yet harvest was lower. In 2009, antlerless tags were removed from GMU 61 and 62A. The highest antlerless tag allocation in this DAU was from 2003 through 2005. Success rates were lower at this time due to unsold tags because sportsman had to
choose antlered or antlerless for the *Super Hunt* moose tag. Current harvest management of moose in this DAU occurs at the GMU and grouped GMU levels and the difference in harvest intensity across the DAU is the result of sportsmen interest and input on these populations.

Illegal harvest has historically been high in this DAU with 45 and 40 documented illegal kills in 1975 and 1981, respectively. Current illegal harvest does not occur at this level but is still occurring.

Figure 17. Moose harvest and tag allocation in the Island Park DAU.

**Current Issues**
The vast majority of the Island Park DAU is public land in the Island Park caldera and Sand Creek Desert. Moose populations in this DAU appear to be relatively stable. Moose research in 2005 indicated high adult cow mortality and the ITD study in 2009 indicated highway collisions were a major cause of moose mortality. It is also difficult to understand the degree tribal harvest is affecting moose populations although anecdotal evidence suggests it could be substantial on the Sand Creek desert. Moose in the lower area of this DAU (Henry’s Fork River-GMU 60A) reside on private property making it difficult to implement large scale management actions. Moose living near population centers within this DAU often require relocation.
Medicine Lodge DAU (GMUs 59, 59A, 61 west, 63 north)

In the northwest portion of the Upper Snake Region, the Medicine Lodge DAU encompasses GMUs 59, 59A, the west portion of 61 and the north portion of 63. It is bounded to the north by Montana and includes part of the Caribou-Targhee NF, the Camas National Wildlife Refuge (NWR) and Mud Lake WMA. Ownership consists of mostly public lands (USFS, BLM) followed by private, IDL and lands owned/managed by IDFG.

The majority of Medicine Lodge DAU is comprised mostly of the Beaverhead Mountains Ecological Section to the north and west while the southeastern portion of the DAU is within the Snake River Basalts Ecological Section. Annual precipitation ranges from approximately 50 cm (20 in) in the north to approximately 30 cm (12 in) in the south. Elevation ranges from about 1460 m (4800 ft) to over 3350 m (11,000 ft). Douglas-fir is the dominant forest type to the north, followed by lodgepole pine, whereas sagebrush dominates in the south. On the southern end of this DAU is Camas NWR and Mud Lake WMA. This complex of wetlands is an approximately 11,000-acre island of riparian vegetation in an agriculture/sagebrush-dominated landscape. Much of Mud Lake is managed by IDFG as the Mud Lake WMA. The Camas NWR is managed by the FWS as a wetland complex.

Very little disturbance occurs on timbered lands within this DAU other than on the private and some IDL properties. Some private agricultural lands are found within the southern portion of GMU 59 and 59A. Most of GMU 63 is privately owned. The terrain is of moderate ruggedness and can be broadly classified as front or mid-country areas with high levels of access.

Moose utilize the higher elevations in the DAU and move down elevation slightly during winter months. While summer habitat use by moose in these areas is likely tied to riparian corridors and other mesic zones, moose also utilize aspen and mountain brush communities, Douglas-fir/lodgepole pine communities and sagebrush communities. The winter habitats are dominated by aspen/mountain brush and mountain mahogany communities in the Medicine Lodge DAU.

The moose using Camas NWR and Mud Lake are less migratory and live on and around the agricultural lands surrounding these riparian areas. The wetlands in GMU 63 include Mud Lake and Camas NWR which consist of deep waterbodies as well as shallow emergent and semi-marsh habitats. Willow species and narrowleaf cottonwood trees along with other riparian species exist in these wetlands.

Population and Monitoring

Prior to the 1970s, there were too few moose in the Medicine Lodge DAU to justify harvest. As populations expanded, harvest seasons began to be offered. Moose numbers expanded into the mid-1990s and so did hunting opportunity and harvest. The expansion of moose populations in the DAU occurred from east to west over a period of years or decades. In several GMUs, the population growth concurrent with this range expansion likely stopped in the late 1990s and populations in these areas were thought to remain stable.
The first documented moose survey in the DAU was in 1984. A total of 64 moose were counted in GMU 59 and 59A. A moose trend count was flown in these same GMUs in 1994 with a total of 179 moose counted. A fixed wing survey occurred in the GMU 61 portion of this DAU in 1990 to 1991 and again in 1991 to 1992. A total of 101 and 77 moose were observed in this area, respectively. In January 2016, a moose survey was conducted in the Mud Lake area of GMU 63. A total of 22 moose were counted. Moose-specific population surveys have not taken place in the Medicine Lodge DAU due to their relatively low densities. However, moose have been documented (location, numbers, age and sex of adults) during mule deer population surveys. Because these surveys were not moose-specific, much of the area that might be inhabited by wintering moose was not surveyed, reducing the utility of these data to make inferences about population growth/decline. Generally, harvest data (hunter success rates, number of days hunted and antler spread) and professional judgment have been used to make inferences about population status.

**Harvest**

Moose hunting first started in the Medicine Lodge DAU with an antlered-only hunt in 1974 in GMUs 59 and 59A. In 1977 a hunt in GMU 61 portion of this DAU was opened. This portion of GMU 61 had moose hunting before 1974, but total tags and harvest numbers are not available due to combination with other hunt areas. Moose hunter success declined, as did the number of tags offered in the mid-1980s. GMU 59A was closed to hunting in 1978 and reopened in 1983. Prior to 2003, the portion of GMU 63 included in this DAU was part of GMU 63A (Snake River DAU). Moose were hunted heavily in GMU 63 from 2003 to 2009. In 2009, antlerless harvest was discontinued closed in GMU 63 due to declining moose population on Mud Lake WMA and Camas NWR areas and concerns of fewer moose observed from sportsmen and incidental observations. The GMU opened back up in this area with 2 antlered tags annually from 2013 to 2018. It is currently closed again due to low moose numbers. Harvest management of moose in this DAU occurs at the GMU and grouped GMU levels and difference in harvest intensity is the result of sportsmen interest and input on these populations.
**Current Issues**

The GMU 63 portion of this DAU resides on mostly private property making it difficult to implement large scale management actions for moose. Moose populations in this DAU appear to be relatively stable except in GMU 63 (Mud Lake WMA and Camas NWR) where a decline is indicated based on best judgement. The vast majority of the Medicine Lodge DAU resides on public lands in the Dubois Ranger district of the Caribou Targhee NF. Strong collaborations with land management agencies (USFS, BLM, IDL) to create mosaics of early and late seral moose habitat in areas lacking disturbance (e.g., prescribed fire, timber harvest), particularly in GMUs 59 and 61, would likely benefit these populations. Recent non-harvest mortalities across the DAU are also concerning and seem to have increased in recent years. Managers feel that these mortalities may be disease related. It is also difficult to understand the degree tribal harvest (on federal lands) is affecting moose populations, although anecdotal evidence suggests it could be substantial. Moose reside in and near population centers within this DAU and IDFG staff respond to and relocate a number of moose annually in urban settings.

![Figure 18. Moose harvest and tag allocation in the Medicine Lodge DAU.](image)
The Snake River DAU encompasses GMUs 63 (south portion), 63A and 68A. Ownership consists of mostly federal lands (BLM and Department of Energy [DOE]), followed by private, Shoshone-Bannock Tribes, IDL and IDFG. The Snake River DAU is on the southern portion of the Upper Snake Region and northern portion of the Southeast Region. It is bounded along the main stem of the Snake River with American Falls Reservoir on the south end.

The Snake River DAU is almost entirely within the Snake River Basalts Ecological Section, receiving about 30 cm (12 in) of precipitation per year. The terrain is primarily rolling hills to flat with elevations ranging from approximately 1280 m (4200 ft) to 1524 m (5000 ft). Sagebrush steppe and riparian narrowleaf cottonwood gallery forests are the dominant native habitats with agricultural lands on most private ground. The DAU can be broadly classified as front country areas with very high levels of access.

Moose in the Snake River DAU primarily use riparian narrowleaf cottonwood habitats adjacent to the Snake River. This river corridor is comprised of a narrowleaf cottonwood riparian system that is surrounded by agriculture. Moose utilize riparian areas and agricultural lands year-round in this DAU. The portion of GMU 63 included within this DAU is not suitable habitat for moose with few moose being observed in this area.

**Population and Monitoring**
Moose-specific population surveys have not taken place in the Snake River DAU due to their relatively low densities. However, moose have been documented (location, numbers, age and sex of adults) during other big game population surveys. Because these surveys were not moose-specific, much of the area that might be inhabited by wintering moose was not surveyed, reducing the utility of these data to make inferences about population growth/decline. Generally, harvest data (hunter success rates, number of days hunted and antler spread) and professional judgement have been used to make inferences about population status.

**Harvest**
Moose hunting was initiated in 1987 in GMU 63A. GMU 63 was added with GMU 63A for 1 hunt area in 1999 and was then split into two separate hunts (GMUs 63 and 63A) in 2003. The moose hunt in GMU 68A is archery-only and opened in 2015. It had 2 antlered and 2 antlerless tags the first 2 years and now has 4 of each.

Harvest and tag allocation have been nearly equal for antlered and antlerless opportunity in this DAU. The area has high urban conflict potential and harvest strategies were implemented to harvest moose to reduce or sustain populations in this DAU.
**Current Issues**

The vast majority of moose habitat within the Snake River DAU is on private property making it difficult to implement large scale management actions for moose. Moose populations in this DAU appear to be relatively stable except in GMU 63 (Mud Lake WMA and Camas NWR) where a decline is suggested based on professional judgment. Recent non-harvest mortalities across the DAU are concerning and seem to have increased in recent years. Managers feel that these mortalities may be disease related. It is also difficult to understand the degree tribal harvest is affecting moose populations although anecdotal evidence suggests it could be substantial.

Moose reside in and near population centers within this DAU and IDFG staff respond to and relocate a number of moose annually out of urban settings. Harvest management of moose in this DAU occurs at the GMU and grouped GMU levels. This difference in harvest intensity is the result of sportsmen interest and input on these populations.

*Figure 19.* Moose harvest and tag allocation in the Snake River DAU.
Beaverhead DAU (GMUs 29, 30, 30A, 37, 37A, 51, 58)

The Beaverhead DAU is comprised of 4 mountains ranges, including the Lost River Range (GMU 37, 51), Pahsimeroi Mountains (GMU 37), Lemhi Range (GMU 29, 37A, 51, 58) and the Beaverhead Mountains (GMUs 30, 30A). Public lands within the DAU are managed by Salmon-Challis NF, Caribou-Targhee NF, Salmon, Challis and Idaho Falls BLM Field Offices and IDL.

The Beaverhead DAU falls within the Beaverhead Mountains Ecological Section and is characterized by high, steep mountains with sharp alpine ridges, glacial and fluvial valleys and flood plains. Soils formed in sedimentary and volcanic rocks and major vegetation types consist of sagebrush, lodgepole pine and Douglas-fir cover types. Elevations in this DAU range from 1219 m (4,000 ft) near the city of Salmon to 3859 m (12,662 ft) at Idaho’s highest peak Mount Borah. The Beaverhead Mountains Ecological Section experiences a continental climate with cold, relatively dry winters influenced by the rain shadow effect of the central Idaho Mountains. Average annual precipitation varies from over 127 cm (50 in) at the Beaverhead Mountains crest to 20–40 cm (8–16 in) across most of the section. Most precipitation occurs as snow during winter and early spring, while summers are comparatively dry. Riparian habitat, sagebrush steppe habitat and agricultural lands dominate the valley bottoms. Mixed conifer forest stands ranging from lodgepole pine to ponderosa pine and Douglas-fir dominate the mid-elevations. Higher elevations are dominated by subalpine fir, limber pine and alpine meadows systems.

Moose use scattered patches of suitable habitat seasonally throughout the Beaverhead DAU. While summer habitat use by moose in these areas is generally associated with riparian corridors and higher elevation mesic habitats throughout much of this DAU, moose in GMUs 30, 30A and 58 likely utilize high quality summer habitat on the Idaho/Montana divide. Moose in the remainder of the Beaverhead DAU likely do not undertake major migrations but move shorter distances to suitable summer and winter habitat. Winter habitat within this DAU is characterized by mountain shrub communities and/or willow dominated riparian vegetation.

Population and Monitoring

Population and Monitoring

There is little information on historical populations; however, it is believed that they were likely a result of immigration from early populations in Montana and eastern Idaho. In early 1980 moose were relocated to GMU 58. This population was then bolstered with the relocation of nuisance moose to the area in 2001-2002. As this population expanded it likely bolstered the populations in the Beaverhead DAU and, with increased incidental observations during deer and elk aerial surveys, moose hunting opportunity was initiated.

Moose-specific population surveys have not taken place in the Beaverhead DAU due to their low densities. However, moose have been documented (location, numbers, age and sex of adults) during mule deer and elk population surveys. Because these surveys were not moose-specific, much of the area that might be inhabited by wintering moose was not surveyed, reducing the utility of these data to make inferences about population growth/decline. Generally, harvest data
(hunter success rates, number of days hunted and antler spread) and professional judgment, have been used to make inferences about population status.

**Harvest**

Moose harvest in the Beaverhead DAU started in 1991 in GMUs 29 and 37A and is currently ongoing. GMUs 30 and 30A saw their first antlered moose hunt in 1993. GMU 51 was the next to follow suit with an antlered hunt in 1999. An antlered hunt was also initiated in GMU 58 in 2003 in response to increased incidental observations but was subsequently closed in 2005. From the first initiated hunt through 2018 a total of 307 moose have been legally harvested under the controlled hunts structure and 1 moose through the *Super Hunt* program. The bulk of the harvest, approximately 50%, historically occurs in GMU 30. The next highest harvest level is in GMU 51 at 22%.

Due to low moose densities, hunting opportunity has always been conservative and restricted to antlered-only. The largest increase in tags in this DAU came in 1999 with the addition of the GMU 51 hunt. Since the addition of GMU 51, the DAU has only seen an increase of 4 tags. These increases have occurred due to increased incidental sightings paired with high hunter success rates. The overall success rate in this DAU averages 90% with only one drop below this average in 2003 and 2004 when it dipped to 79%.

![Figure 20. Moose harvest and tag allocation in the Beaverhead DAU.](image)

**Current Issues**

Moose populations in the Beaverhead DAU appear to be relatively low but stable. The low density of moose is likely due to the low prevalence of high-quality moose habitat in this DAU. Disease issues and cause-specific mortality have not been determined in this DAU and are
unknown at this time. No evidence currently supports an increase in population and/or the options to provide increased hunting opportunity.

**Pioneer DAU (GMUs 36,36A, 49, 50)**

The Pioneer DAU encompasses the southeastern portion of GMU 36 and all of GMUs 49, 50 and 36A. The DAU is dominated by rugged mountains, including the Pioneers (GMUs 49 and 50), the Boulder and White Cloud ranges (GMU 36A) and the Sawtooth range (GMU 36). Approximately 81% of the DAU is publicly owned with most of that managed by the USFS, including the Sawtooth NF, Sawtooth National Recreation Area and the Salmon-Challis NF. The Jim McClure-Jerry Peak, White Clouds and Hemmingway-Boulders Wilderness areas are located within the DAU. The BLM oversees tracts of land in the southern parts of GMUs 49 and 50. Smaller sections of land managed by IDL are scattered throughout the DAU.

Most of the Pioneer DAU is within the Challis Volcanics Ecological Section, receiving approximately 71 cm (28 in) of precipitation per year. The eastern portion of the DAU falls within the Beaverhead Mountains Ecological Section, which receives about 50 cm (20 in) of precipitation per year. Elevation ranges from about 1460 m (4800 ft) to over 3350 m (11,000 ft). Lower elevation areas to the south and east are dominated by sagebrush shrublands whereas mountainous areas are dominated by Douglas-fir and spruce. Aspen stands can be found throughout the DAU but are commonly restricted to wetter locals and more southerly aspects.

The Pioneer DAU includes several major riparian corridors including the Big Wood, Little Wood, Salmon and Big Lost River drainages, which provide good foraging habitat and thermal cover for moose. Early to mid-seral habitats created by fire in forested landscapes have established additional moose habitat. Moose are not known to undertake long migrations between summer and winter ranges in the Pioneer zone; however, moose densities in the Wood River valley increase in the winter. Lower elevation aspen-sagebrush steppe and riparian areas provide moose with important winter habitat throughout the DAU.

**Population and Monitoring**

Translocations of moose have occurred over the last 3-4 decades throughout the Pioneer DAU. In 1980, 6 moose were released near North Fork of the Big Lost River (GMU 50). Additional transplants have occurred periodically since this time.

Population surveys for moose have not been conducted in the Pioneer DAU due to the difficulty in finding individuals across a large area. However, opportunistic documentation of moose during aerial surveys for deer and elk has provided a small dataset on moose numbers, locations and demographics. Due to differences in winter habitat selection by moose in comparison to deer and elk, it is likely that some habitat patches inhabited by moose were not surveyed, thereby reducing the utility of these data to make inferences about population trajectories. Historically, harvest data (hunter success rates, hunter days and antler spread) as well as anecdotal evidence have been used to judge population status.
**Harvest**

Due to changing hunt area boundaries over time and unaligned boundaries between GMUs and the DAU, tracking harvest specific to the Pioneer DAU is difficult.

Hunt Areas 44 and 48: Moose hunting in the GMU 49 portion of the Pioneer DAU began in 2005. Hunt Area 48 included parts of GMU 48 and all of GMU 49 for 2 antlered and 2 antlerless moose. In response to declining moose numbers, Hunt Area 48 was dissolved and combined with Hunt Area 44 in 2011. All antlerless tags were eliminated and 3 tags were issued for antlered moose only. The hunt area boundary remained unchanged until 2019 when the Silver Creek Valley portion of GMU 52 was added. Tag levels have remained unchanged since 2011 and harvest success rates have remained high, averaging over 85%. See the Smoky-Bennett DAU harvest information in Unit 49.

Hunt Area 50: A new antlered-only hunt was initiated in GMU 50 in 1993, with both tag holders harvesting moose. As the moose population in Hunt Area 50 increased, hunting opportunity was expanded. Four tags were offered in 1997, increasing to 6 tags in 1999. In 2003, 5 antlerless tags were offered in addition to 6 antlered tags. Since 2005, 10 tags (5 antlered and 5 antlerless) have been offered in the hunt area.

Hunt Area 36A: The opportunity to harvest a moose in GMU 36A was first made available during the 2005 hunting season, during which 1 antlered-only tag was offered. In 2010, 2 antlered-only tags were offered, before dropping back down to 1 tag in 2011. Only 1 antlered-only tag has been offered since 2011.

![Figure 21](image-url) Moose harvest and tag allocation in the Pioneer DAU.

**Current Issues**
Improving survey methodologies for monitoring moose populations would advance our understanding of population dynamics and habitat use within the DAU. This will be increasingly important as the human population and interest in outdoor recreation expand throughout certain areas of the DAU.

**Salmon Mountains DAU (GMUs21, 21A, 28, 36B)**

Moose habitat in the Salmon Mountains DAU is comprised of 3 mountains ranges, including the Salmon River Mountains (GMUs 28 and 36B), the Bitterroot Range (GMU 21) and the northern portion of the Beaverhead Mountains (GMU 21A). Public lands within the DAU are managed by the Salmon-Challis NF, Salmon BLM Field Office and IDL.

The Salmon Mountains DAU falls within the Challis Volcanics, Beaverhead Mountains and Idaho Batholith Ecological Sections. Elevations in this DAU range from 914 m (3000 ft) to 3170 m (10,400 ft) and vary widely in habitats. Annual precipitation ranges from 20 cm (8 in) in the valley floors to 119 cm (47 in) in the higher elevations and comes primarily in the form of winter and early spring snowfall. Riparian habitat, sagebrush steppe habitat and agricultural lands dominate the valley bottoms. Mixed conifer forest stands ranging from lodgepole pine to ponderosa pine and Douglas-fir dominate the mid-elevations. Higher elevations are dominated by subalpine fir and alpine meadows systems.

Moose utilize much of the lower to mid elevation suitable habitat within the Salmon Mountains DAU. While summer habitat use by moose in these areas is generally associated with riparian corridors and other mesic habitats throughout much of this DAU, moose in GMUs 21 and 21A likely utilize high quality summer habitat on the Idaho/Montana divide. Moose in the remainder of the Salmon Mountains DAU likely do not undertake major migrations but move shorter distances to suitable winter habitat. These winter habitats are dominated by mountain brush and riparian willow communities in the Salmon Mountains DAU.

**Population and Monitoring**

There is little information on historical populations; however, it is believed they were likely a result of immigration from Montana into GMUs 21 and 21A. As populations expanded, so did hunting opportunity. The expansion of moose populations in the Salmon Mountains DAU is sporadic with very limited data outside of incidental observations.

Moose-specific population surveys have not taken place in the Salmon Mountains DAU due to their low densities. However, moose have been documented (location, numbers, age and sex of adults) during mule deer and elk population surveys. Because these surveys were not moose-specific, much of the area that might be inhabited by wintering moose was not surveyed, reducing the utility of these data to make inferences about population growth/decline. Generally, harvest data (hunter success rates, number of days hunted and antler spread) and professional judgement, have been used to make inferences about population status.

**Harvest**
Moose harvest in the Salmon Mountains DAU is limited to the 20-year period that a season existed in Hunt Area 21 (GMU 21 and 21A). There has not been an open season in GMUs 28 or 36B due to extremely low abundance of moose. No antlerless hunting opportunity has been historically provided in the Salmon DAU.

Antlered opportunity in Hunt Area 21 historically consisted of 3 tags from 1990 to 1994, 4 tags from 1995 to 2008 and 2 tags in the 2009 and 2010 seasons. Harvest success averaged 81% from 1990 to 2004. From 2005 to 2008 success dropped to an average of 38% triggering a reduction of tags allocated to 2. From 2009-2010 no moose were harvested. Due to decreasing hunter success rates and limited population data this season was closed in 2011.

**Figure 22.** Moose harvest and tag allocation in the Salmon Mountains DAU.

**Current Issues**

Moose populations in the Salmon Mountains DAU appear to be relatively low but stable. The low density of moose is likely due to late successional conifer forest being the dominant habitat in the DAU. This low-quality moose habitat results in a low carrying capacity for moose within this DAU. Disease issues and cause-specific mortality have not been looked at in this DAU and are unknown at this time. At this point there is no evidence that supports an increase in population and/or the options to provide hunting opportunity.
Middle Fork DAU (GMUs 20A, 26, 27)

The Middle Fork DAU is within the Salmon River Mountains and almost entirely encompassed within the Frank Church-River of No Return Wilderness Area. Over 99% public, these lands are managed by the Salmon-Challis NF and Payette NF.

The northern two-thirds of the Middle Fork DAU are within the Idaho Batholith Ecological Section while the southern portion is within the Challis Volcanics Ecological Section. The Challis Volcanics Ecological Section has an average annual precipitation of about 71 cm (28 in) whereas the Idaho Batholith Ecological Section receives approximately 89 cm (35 in) per year. Most of this precipitation comes in the form of winter and early spring snowfall. Elevation ranges from about 640 m (2100 ft) to over 3048 m (10,000 ft). Lodgepole pine is the dominant vegetation type in this DAU.

Moose habitat in the Middle Fork DAU is limited with small patches of seasonal habitat being scattered throughout the higher elevation meadow complexes and riparian corridors. Moose in the Middle Fork DAU likely do not undertake major migrations but move shorter distances to suitable winter habitat. These winter habitats are dominated by mountain brush and riparian willow communities.

Population and Monitoring
There is little information on historical populations; however, it is believed that they were likely a result of immigration from surrounding DAUs. The expansion of moose populations in the Middle Fork DAU is sporadic at best with very limited data outside of incidental observations.

Moose-specific population surveys have not taken place in the Middle Fork DAU due to their low densities. However, moose have been documented (location, numbers, age and sex of adults) during mule deer and elk population surveys. Because these surveys were not moose-specific, much of the area that might be inhabited by wintering moose was not surveyed, reducing the utility of this data for make inferences about population growth/decline. Generally, harvest data (hunter success rates, number of days hunted and antler spread) and professional judgement, have been used to make inferences about population status.

Harvest
Moose hunting opportunity in the Middle Fork DAU started in 1983 with a 2-tag season in GMU 20A and was maintained at a minimal level until 1994. In 1995, increases in moose sightings led to the subdivision of GMU 20A into 3 hunt areas (20A-1, 20A-2, 20A-3) and, in 1997, a hunt in GMU 26 which resulted in 9 tags being allocated and a peak harvest peak in 1997 of 8 moose. In following years, moose sightings and hunter success declined. The result was a continued reduction of hunting opportunity in GMUs 20A and 26. The 3 hunt areas in 20A were consolidated into 2 hunt areas with a total of 4 tags and further consolidation in 2007 to a single, GMU-wide hunt area with 2 tags. The 2-tag allocation was maintained until all moose hunting was terminated in GMU 20A in 2011. Hunter success in GMU 26 plummeted and the season was terminated in 2007. Due to increased incidental observations a 1-tag season was initiated in GMU 27 in 2005. Harvest success has always been relatively low and sporadic due to the limited
backcountry access nature of this DAU and this holds true for the single tag currently offered in GMU 27.

Figure 23. Moose harvest and tag allocation in the Middle Fork DAU.

**Current Issues**
Moose populations in the Middle Fork DAU appear to be low but stable. However, these are judgement-based determinations. The low density of moose is likely due to limited high-quality habitat. The low-quality moose habitat results in a low carrying capacity for moose within this DAU. Disease issues and cause-specific mortality have not been determined in this DAU and are unknown at this time. Although not specifically evaluated, it is believed that predation may be a major factor in the reduced populations as well. At this point no evidence supports an increase in population and/or the options to provide additional hunting opportunity.
LITERATURE CITED


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APPENDIX A: Common and scientific names of all species mentioned in the text.

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<th>Common Name</th>
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<td>Populus trichocarpa</td>
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<tr>
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<tr>
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<td>Salix scouleriana</td>
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<td>Thuja plicata</td>
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<tr>
<td>Tree</td>
<td>Western hemlock</td>
<td>Tsuga heterophylla</td>
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</table>
APPENDIX B: Modeling potential summer and winter distribution of moose in Idaho

Although several modeling approaches have been used for understanding moose distributions in the US and Canada (e.g., Maier et al. 2005, Baigas et al. 2010, Feldmen et al. 2017, Murray et al. 2017, Jung et al. 2018, Wattles et al. 2018), none provide seasonal distribution information for moose in Idaho nor do they make use of Idaho observation data. The only statewide distribution models for moose currently available are deductive habitat models developed by the Gap Analysis Project (USGS-GAP 2017, Scott et al. 2002).

To aid in development of this management plan, we created preliminary models of moose summer and winter distribution using maximum entropy methods (Maxent 3.4.1; Phillips et al. 2006, Phillips and Dudík 2008, Phillips et al. 2017). Given a set of environmental variables and species presence locations, Maxent identifies the correlations between each variable and the presence data, compares that with the range of environmental conditions available in the modeled region and develops a continuous model of the relative likelihood, or probability, of suitable habitat across the study area based on environmental similarity to known occupied sites. Our modeling process incorporated all available occurrence data and several environmental variables hypothesized to influence the distributions of moose in the previously mentioned modeling efforts. Conducting all spatial analyses in ArcGIS 10.6.1 (ESRI 2017), we ensured spatial data were in a common geographic coordinate system, spatial resolution (30mX30m) and extent, then exported as ASCII files for input into R (R Core Team 2018) and Maxent.

Moose Observations
All known observations of moose in Idaho as of August 2019 were compiled for this modeling effort. This included data from numerous collared animal studies (2004-2019), helicopter and fixed-wing survey efforts, remote camera survey detections, incidental observations recorded in the USFS Natural Resource Information System (NRIS) database and in IDFG regional data files and observations previously stored in the Idaho Fish and Wildlife Information System (IFWIS) Species Diversity Database (including museum specimens, older survey efforts and incidental observations). Compiled data were uploaded the IFWIS Species Diversity Database for long-term data storage and accessibility.

We carefully evaluated all data for use in the distribution model to ensure observational, spatial and temporal accuracy. Nearly all the 315,856 compiled observations were categorized as verified (e.g., specimen, DNA, or photograph) or trusted (e.g., documented by a biologist, researcher, or taxonomic expert) and as having sufficient spatial accuracy (≤500m) for our modeling purposes. However, compiled observation data such as these are prone to errors of sampling bias, both geographically and environmentally. Given that the vast majority of observations came from collared animal studies in Regions 2, 5 and 6, the data exhibited spatial clustering at fine scales in these portions of the state. Species distribution models can be sensitive to such bias and spatial filtering of the presence data is often suggested as a solution (Phillips et al. 2009, Veloz 2009, Kramer-Schadt et al. 2013, Radosavljevic and Anderson 2013, Boria et al. 2014). The key to spatial filtering is to randomly subsample presence data with a minimum distance separating the sample points, thereby limiting spatial autocorrelation and reducing the environmental bias caused by uneven sampling. That minimum distance is somewhat arbitrary...
and depends on the environmental conditions of the study area as well as the resolution of the data used for modeling. We reduced the locally dense sampling of moose by randomly subsampling with a minimum distance of 1000m. These filtering procedures (verified or trusted, ≤500m accuracy, within Idaho and >1000m separation) resulted in a total of 1427 summer and 2914 winter observations available for use in our modeling effort (Figure B1).

Environmental Variables

Previous modeling efforts have focused on topographic, vegetative, edaphic, climatic and disturbance suites of environmental covariates at a variety of spatial scales (Maier et al. 2005, Baigas et al. 2010, Feldmen et al. 2017, Murray et al. 2017, Jung et al. 2018, Wattles et al. 2018). Given the limited time constraints for our effort, we selected similar variables from a subset of fine-scale (30m resolution) topographic, climatic, edaphic and landscape covariates (Table B1) that were already developed for use in other statewide modeling projects (Svancara, unpublished data).

Topographic variables generally act as surrogates for factors influencing plant growth (e.g., temperature, light, soils), but can also directly account for differences in local climate and be important in species distribution models (SDMs) (Luoto and Heikkinen 2008, Austin and Van Niel 2011). We developed several topographic variables including elevation, slope, aspect, compound topographic index (CTI), roughness and vector ruggedness measure (VRM) from the National Elevation Data (30m) (USGS 2016). The CTI, a steady-state wetness index, measures the catenary topographic position represented by both slope and catchment size and aims to model soil water content (Moore et al. 1993). Roughness, similar to the terrain ruggedness index (Riley et al. 1999), calculates the amount of elevation difference between a grid cell and its neighbors, essentially the variance of elevation within the neighborhood (8x8 cells in this analysis). The VRM, which measures terrain heterogeneity within a neighborhood (9x9 cells in this analysis), captures variability in both slope and aspect into a single measure (Sappington et al. 2007). We calculated CTI and roughness using Evans et al. (2014) and VRM using Sappington et al. (2012), both freely available ArcGIS tools. All of these topographic variables, to varying degrees, were selected to reflect temperature, water and light resources that may contribute to moose distributions either directly (e.g., temperature) or indirectly (e.g., habitat). For example, CTI and roughness may serve as proxies for local temperature patterns (e.g., cold air drainage, Dobrowski et al. 2008) while VRM, slope and aspect act as surrogates for light or solar radiation.

Climatic variables typically used in SDMs rely on temperature and precipitation at moderate (~1km) spatial resolution (Hijmans et al. 2005, Daly et al. 2008, Wang et al. 2012). To better represent Idaho climate we used more recent temperature data developed at finer spatial resolution (250m) for the Northern Rockies (Holden et al. 2015) in combination with precipitation data (originally 800m, resampled to 250m resolution using cubic convolution to match the temperature data) from the Parameterized Regression on Independent Slopes Model (PRISM, Version 14.1-20140502-1000) (PRISM Climate Group 2012, Daly et al. 2015). Both of these datasets represent monthly 30-year normals covering the period 1981-2010, from which we calculated 19 bioclimatic variables following Nix (1986) and Hijmans et al. (2005). These bioclimatic variables have been used extensively in SDMs for decades (e.g., Elith et al. 2010, Elith et al. 2011, Anderson and Gonzalez 2011, Stanton et al. 2011, Booth et al. 2014) and
characterize climatic conditions best related to species physiology (O’Donnell and Ignizio 2012, Booth et al. 2014).

Edaphic measures developed were characteristics known to either affect the availability of nutrients or exert direct physiological limitations, or both, on plants and included percent sand, percent silt, percent clay and available water supply. To focus on the most critical soil for plant establishment, we used a weighted average based on percent composition for aggregating across all soil map units in the top 0-25 cm (0-10 in). These data were developed primarily from the Soil Survey Geographic database (SSURGO, USDA NRCS 2016a), with missing areas filled in with the U.S. General Soils database (STATSGO2, USDA NRCS 2016b), following the national standard methodology and tools used for similar products (e.g., gSSURGO) (USDA NRCS 2016c).

Vegetation characteristics typically identified as important to moose include canopy cover, height and presence of forage shrubs. We developed several variables including height of all tree and shrubs, tree canopy cover, distance to dense (>60%) tree canopy cover, percent of natural land cover within 300m, percent of natural land cover within 1000m and percent of moose forage shrubs within 270m from the most recent LANDFIRE 2016 land cover classification (USGS 2019). Moose forage shrubs included any mapped land cover type that contained Amelanchier spp., Cornus spp., Populus spp., Sorbus spp., Salix spp., Prunus spp., Physocarpus spp., Ceanothus spp., Alnus spp., or Betula spp. In addition, we included distance to intermittent streams and distance to perennial streams and waterbodies based on the National Hydrography Data (USGS 2017) (FCodes 46006 and 46003, respectively).

Current Habitat Suitability
We supplied Maxent with the occurrence data as described above, as well as background points consisting of 10,000 randomly generated pseudoabsences across Idaho that were >1000m apart, >1000m from presence locations and outside of waterbodies. Following recommended approaches, we then calculated species-specific model parameters with regard to collinearity, regularization multiplier and feature types.

In an iterative approach, we optimized each model for regularization multiplier (values tested included 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, 6, 7, 8, 9, 10) and feature types (linear, quadratic, product, threshold, hinge and interactions) using the enmSdm package (Smith 2017) in R 3.5.0 (R Core Team 2018) and selected the best performing combination based on AICc (Warren and Seifert 2011, Wright et al. 2015). Beginning with a full model inclusive of all covariates (n=38), we implemented 10-fold cross-validation with jackknifing to measure importance of each variable to the resulting model. Variables were then ranked based on their permutation importance and removed if less than 1%. Correlated variables with P>0.75 were also removed keeping the variable with the higher permutation importance. This process of model optimization, development and variable ranking and removal was repeated until all variables had a minimum importance of 2% or greater. The final models represent the average of 10 replicates using the optimized parameters and most important variables.

We imported the mean model output into ArcGIS 10.6.1 (ESRI 2017) and, for comparative purposes, binned the model values using Maxent calculated thresholds to identify low, medium
and high habitat suitability. To separate low and medium suitable habitat we used the ‘minimum training presence’ threshold, which identifies the lowest predicted suitability value that includes all training locations. To separate medium and high suitable habitat we used the ‘10 percentile training presence’ threshold, which identifies the model value that excludes 10% of training locations having the lowest predicted value (Table B2). While both thresholds are easily interpretable, they likely overestimate (Radosavljevic and Anderson 2013), particularly the medium and high suitability classes.

Results and Discussion
Maxent accurately predicted moose summer (AUC = 0.853) and winter (AUC = 0.803) distributions. The best fit summer model based on AICc employed linear, quadratic, product and hinge features with a regularization multiplier of 1.0. Averaged over replicate runs, the most important variables were precipitation in the coldest quarter (bio19), minimum temperature of the coldest month (bio6), elevation, temperature seasonality (bio4), distance to areas with ≥60% tree canopy cover, slope and tree canopy cover (in order of permutation importance) (Figure B2). Jackknife tests indicated that precipitation in the coldest quarter (bio19) had the most useful information by itself and minimum temperature of the coldest month (bio6) had the most information that was not present in other variables. Predicted moose suitability in summer was greatest in areas of moderate elevation and slope and closer to dense canopy. These areas generally had lower temperature seasonality, lower winter minimum temperatures and moderate winter precipitation.

The best fit winter model based on AICc employed linear, product and hinge features with a regularization multiplier of 0.5. Averaged over replicate runs, the most important variables were maximum temperature of the warmest month (bio5), temperature seasonality (bio4), elevation, precipitation of the coldest quarter (bio19), distance to areas with ≥60% tree canopy cover, minimum temperature of the coldest month (bio6) and percent of forage shrubs within 270m (in order of permutation importance) (Figure B3). Jackknife tests indicated that maximum temperature of the warmest month (bio5) had the most useful information by itself and temperature seasonality (bio4) had the most information that was not present in other variables. Predicted moose suitability in winter was greatest in lower elevation areas that generally had lower maximum summer temperatures, higher temperature seasonality, greater precipitation in winter, higher minimum winter temperatures, greater distances to dense canopy cover and a greater percentage of preferred forage shrubs.

Because selection of specific model thresholds is somewhat arbitrary and biologically meaningful thresholds can be difficult to determine, careful consideration of resulting model accuracy is necessary and reporting a range of threshold values, or none at all, is often recommended (Liu et al. 2005, Merow et al. 2013). Using the selected thresholds described above, our final moose summer model predicted 5.3 million acres of low suitability, 32.5 million acres of medium suitability and 15.6 million acres of high suitability across the state. The majority of classified high suitability summer habitat is predicted to occur in the Clearwater (28%), Panhandle (23%) and Upper Snake (18%) Regions. Similarly, the final moose winter model predicted 3.5 million acres of low, 33.2 million acres of medium and 16.8 million acres of high suitability across the state with the majority of highly suitable habitat in the Upper Snake (28%), Panhandle (19%) and Southeast (18%) Regions.
**Future Model Refinements**

Given the time constraints under which these models were developed, it is strongly recommended that additional biologic and programmatic model refinements are considered. Biologically, developing region-specific models would address the sometimes dramatically different landscapes used by moose across the state. For example, moose occurrences in the Salmon and Southeast Regions average >1900m (range 1005-3099m) elevation year-round, while those in the Panhandle and Clearwater Regions average <1400m (range 374-2141m). Programmatically, further refinement of the background data as well as inclusion of different covariates may result in better fitting models. Because Maxent uses background locations where the presence or absence of the target species is unknown or unmeasured, the choice of background data influences what is modeled and perceptions about the results (Elith et al. 2011, Merow et al. 2013). By default, Maxent assumes that the species is equally likely to be anywhere in the study extent (Phillips and Dudík 2008), thus, modifying the background sample is equivalent to modifying the prior expectations for the species distribution (Merow et al. 2013). Assessing a range of background extents, instead of just the full statewide extent of our preliminary models, may result in increased model performance (e.g., Iturbide et al. 2015, Anderson and Raza 2010, VanDerWal et al. 2009). Similarly, including additional covariates such as landscape disturbance, NDVI, solar radiation, snow depth and multi-scale variations of these covariates, may improve model performance as in other efforts (e.g., Baigas et al. 2010). Lastly, assessing potential future changes in modeled distribution of moose under various climate change scenarios would be beneficial.
Literature Cited
doi:10.1371/journal.pone.0141140
ESRI. 2017. ArcGIS 10.5.1. ESRI, Inc. Redlands, California


https://doi.org/10.1007/s10344-018-1184-z


https://doi.org/10.1371/journal.pone.0176706


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Table B1. Environmental variables used in modeling moose distributions in Idaho.

<table>
<thead>
<tr>
<th>Type</th>
<th>Variable</th>
<th>Code</th>
<th>Units</th>
<th>Source</th>
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<tr>
<td>Topography</td>
<td>Aspect</td>
<td>Asp</td>
<td>Degree</td>
<td>3D Elevation Program (USGS 2016), Evans et al. (2014) [CTI and Rough8], Sappington et al. (2007) [VRM]</td>
</tr>
<tr>
<td></td>
<td>Slope</td>
<td>Slp</td>
<td>Degree</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Elevation</td>
<td>Elev</td>
<td>Meters</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Compound Topographic Index</td>
<td>CTI</td>
<td>Index</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Roughness (8 neighbor cells)</td>
<td>Rough8</td>
<td>Meters</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vector Ruggedness Measure (9 neighbor cells)</td>
<td>VRM</td>
<td>Index</td>
<td></td>
</tr>
<tr>
<td>Climate</td>
<td>Mean annual temperature</td>
<td>Bio1</td>
<td>°C</td>
<td>Holden et al. (2015), PRISM (2012), dismo package in R.</td>
</tr>
<tr>
<td></td>
<td>Mean diurnal range</td>
<td>Bio2</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Isothermality (bio2 / bio7) (*100)</td>
<td>Bio3</td>
<td>Percent</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Temperature seasonality (std deviation * 100)</td>
<td>Bio4</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Maximum temperature of warmest month</td>
<td>Bio5</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Minimum temperature of coldest month</td>
<td>Bio6</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Temperature annual range (bio5 – bio6)</td>
<td>Bio7</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean temperature of the wettest quarter¹</td>
<td>Bio8</td>
<td>°C</td>
<td></td>
</tr>
<tr>
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<td>Mean temperature of the driest quarter¹</td>
<td>Bio9</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean temperature of warmest quarter¹</td>
<td>Bio10</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean temperature of coldest quarter¹</td>
<td>Bio11</td>
<td>°C</td>
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<tr>
<td></td>
<td>Total annual precipitation</td>
<td>Bio12</td>
<td>Millimeters</td>
<td></td>
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<td></td>
<td>Precipitation of wettest month</td>
<td>Bio13</td>
<td>Millimeters</td>
<td></td>
</tr>
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<td></td>
<td>Precipitation of driest month</td>
<td>Bio14</td>
<td>Millimeters</td>
<td></td>
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<td></td>
<td>Precipitation seasonality (coefficient of variation)</td>
<td>Bio15</td>
<td>Percent</td>
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<td></td>
<td>Precipitation of wettest quarter¹</td>
<td>Bio16</td>
<td>Millimeters</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Precipitation of driest quarter¹</td>
<td>Bio17</td>
<td>Millimeters</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Precipitation of warmest quarter¹</td>
<td>Bio18</td>
<td>Millimeters</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Precipitation of coldest quarter¹</td>
<td>Bio19</td>
<td>Millimeters</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Annual mean growing degree days</td>
<td>gdd</td>
<td>Number</td>
<td></td>
</tr>
<tr>
<td>Soils</td>
<td>Percent clay</td>
<td>Clay025</td>
<td>Percent</td>
<td>SSURGO and STATSGO2 (USDA NRCS 2016a,b), weighted average of all mapunits in top 0-25cm of soil</td>
</tr>
<tr>
<td></td>
<td>Percent sand</td>
<td>Sand025</td>
<td>Percent</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Percent silt</td>
<td>Silt025</td>
<td>Percent</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Available water capacity in top 25cm</td>
<td>Aws025</td>
<td>Centimeter</td>
<td></td>
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<tr>
<td>Land cover</td>
<td>Tree canopy cover</td>
<td>TreeCC</td>
<td>Percent</td>
<td>LANDFIRE 2016 (USGS 2019)</td>
</tr>
<tr>
<td></td>
<td>Distance to &gt;60% tree canopy cover</td>
<td>D2CC60</td>
<td>Meters</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tree and shrub height</td>
<td>TSHght</td>
<td>Meters</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Percent natural land cover (within 300m)</td>
<td>Nat300</td>
<td>Percent</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Percent natural land cover (within 1000m)</td>
<td>Nat1000</td>
<td>Percent</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Percent moose forage shrubs (within 270m)</td>
<td>MSh270</td>
<td>Percent</td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>Distance to all perennial streams and lakes</td>
<td>D2Peren</td>
<td>Meters</td>
<td>National Hydrography Dataset (USGS 2017)</td>
</tr>
<tr>
<td></td>
<td>Distance to intermittent streams</td>
<td>D21Inter</td>
<td>Meters</td>
<td></td>
</tr>
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¹ Quarter is any 3-month time period
Table B2. Maxent modeled thresholds used in aiding interpretation of habitat suitability. Values used in displaying the final models are highlighted in bold.

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<thead>
<tr>
<th>Threshold</th>
<th>Summer threshold</th>
<th>Winter threshold</th>
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<tr>
<td>Prevalence</td>
<td>0.2475</td>
<td>0.3274</td>
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<tr>
<td><strong>Minimum training presence</strong></td>
<td><strong>0.0170</strong></td>
<td><strong>0.0019</strong></td>
</tr>
<tr>
<td><strong>10 percentile training presence</strong></td>
<td><strong>0.2610</strong></td>
<td><strong>0.3418</strong></td>
</tr>
<tr>
<td>Equal training sensitivity and specificity</td>
<td>0.4257</td>
<td>0.5373</td>
</tr>
<tr>
<td>Maximum training sensitivity plus specificity</td>
<td>0.3896</td>
<td>0.3980</td>
</tr>
<tr>
<td>Balance training omission, predicted area and threshold value area</td>
<td>0.0857</td>
<td>0.1064</td>
</tr>
<tr>
<td>Equate entropy of thresholded and original distributions</td>
<td>0.1949</td>
<td>0.2054</td>
</tr>
</tbody>
</table>

**Figure B1.** Summer (left) and winter (right) moose observations used in distribution modeling in Idaho. Point data are from various Idaho Department of Fish and Game databases as of August 2019 and are filtered to include only those verified or trusted locations with ≤500m accuracy and >1000m apart.
Figure B2. Response curves and permutation importance for the most important variables (see Table B1 for codes) in the final summer distribution model for moose. Each of the curves represents a model created using only that variable, thus these plots reflect the dependence of predicted suitability both on the selected variable and on dependencies induced by correlations between the selected variable and other variables. The mean response of the 10 replicate runs is in red and the mean +/- one standard deviation is in blue.
Figure B3. Response curves and permutation importance for the most important variables (see Table B1 for codes) in the final winter distribution model for moose. Each of the curves represents a model created using only that variable, thus these plots reflect the dependence of predicted suitability both on the selected variable and on dependencies induced by correlations between the selected variable and other variables. The mean response of the 10 replicate runs is in red and the mean +/- one standard deviation is in blue.