Idaho

# Moose Management Plan

2020-2025

*Prepared by* **IDAHO DEPARTMENT OF FISH AND GAME**

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# Executive Summary

Shiras moose (*Alces alces shirasi*) occur across much of Idaho, except in the southwest corner of the state. Moose are highly valued by both hunters and non-hunters, providing consumptive and non-consumptive opportunities which 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. Current survey data, anecdotal information, and harvest data indicate moose recently declined in parts of the state. Several factors may be impacting moose populations, both positively and negatively, including predation, habitat change (e.g., roads, development, and timber harvest), changing climate, disease, parasites, and combinations thereof.

The Idaho Department of Fish and Game (IDFG) was established to preserve, protect, perpetuate, and manage all of Idaho's fish and wildlife. As such, species management plans are written to set statewide management direction to help fulfill IDFG's mission. Idaho's prior moose management plan (IDFG 1990) addressed providing a quality hunting experience, vulnerability of moose to illegal harvest, habitat protection, 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 which will aid in conservation and management of moose populations and guide harvest 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 and will engage partners interested in moose management, including hunters, federal and state agencies, conservation organizations, tribes, and other interested individuals or groups in plan implementation. Partnerships can help IDFG accomplish goals to maintain sustainable populations, improve habitat, and provide hunting opportunities.

IDFG has identified the need to improve techniques to estimate population size and productivity, and address changes in these measures over time. Causes of population changes, and what management strategies can be employed to address these fluctuations, need to be addressed. Several factors, including predation, habitat, parasites, pathogens, changing climate, development, vehicle collisions, and harvest can impact moose survival and productivity. As portions of Idaho continue to change, identifying areas projected to experience the greatest changes in moose numbers relative to potential environmental changes will help prioritize research and management.

Moose use a wide variety of habitats in Idaho, including mesic habitats, aspen, dryland conifer, mountain shrub, and sagebrush steppe. During winter they use a variety of habitats, including sagebrush steppe and dense forest. Moose habitat can be broadly grouped into 3 types: coniferous forests of northern Idaho; mixed aspen and conifer forests of southeastern and central Idaho; and riparian cottonwood and willow communities found in parts of southern Idaho. Moose distribution was divided into 20 Data Analysis Units (DAUs) based on current knowledge of habitats, distribution, connectivity among populations, harvest, and other management concerns (e.g., social tolerance).

Hunters are allowed to harvest one antlered and one antlerless moose in Idaho in their lifetime, except Super Hunt tag winners and left-over tag holders may harvest a moose regardless of any other moose harvest. All tags are issued under a controlled hunt structure and are allocated through a random 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., unlawful harvest, hunting, and vehicle collisions) than other ungulates, 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 than other ungulates. Moose are polygamous, allowing for more male harvest than female harvest. However, male moose cannot be harvested at rates similar to deer and elk because of lower densities and breeding behavior.

Currently, more data are needed 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 management of moose populations. Implementation of all strategies will be subject to available funding and personnel.

Statewide moose management direction in this plan includes

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

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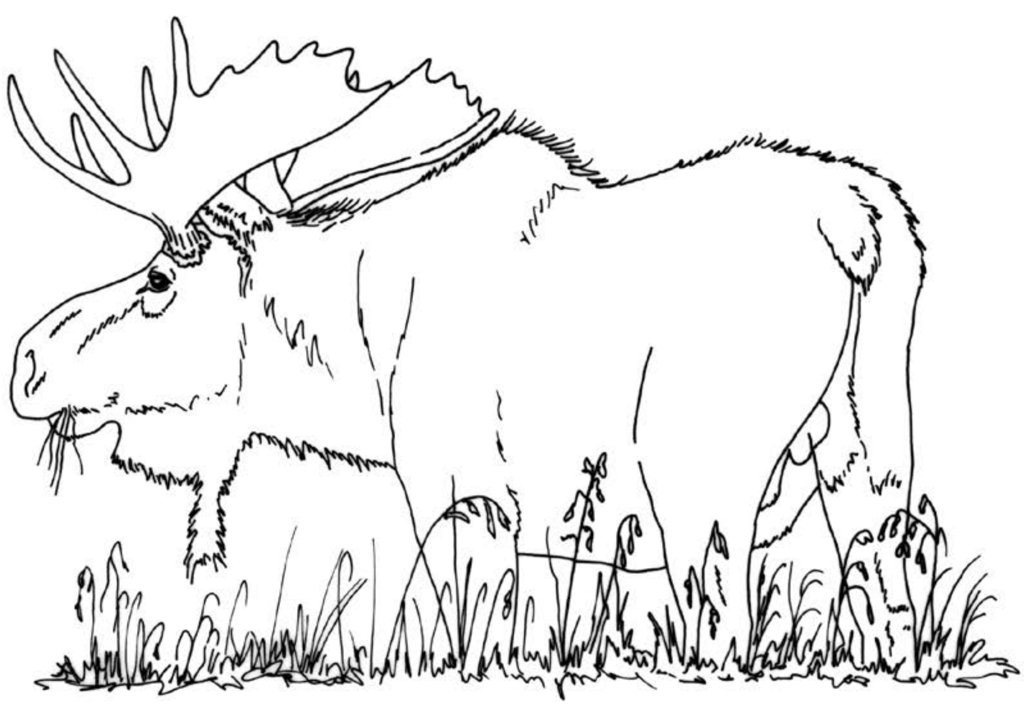

Moose Cow and Calf 

# Introduction

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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 which will aid in conservation and management of moose (see Appendix A for scientific names of organisms) populations 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, a situation not unique to Idaho. Concern over widespread declines in North American moose populations has increased 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 since been stable or declining in most areas of the state. Currently, IDFG requires more data to monitor population trends, identify causes of decline, and prescribe management actions. This plan identifies management direction and strategies to improve data collection and management of moose populations. Implementation of all strategies will be subject to available funding and personnel.

## Moose Management Plan (1990) Goals and Accomplishments

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

*Goal 1.* — Provide high-quality moose hunting and other moose-related recreational experiences for as many people as possible.

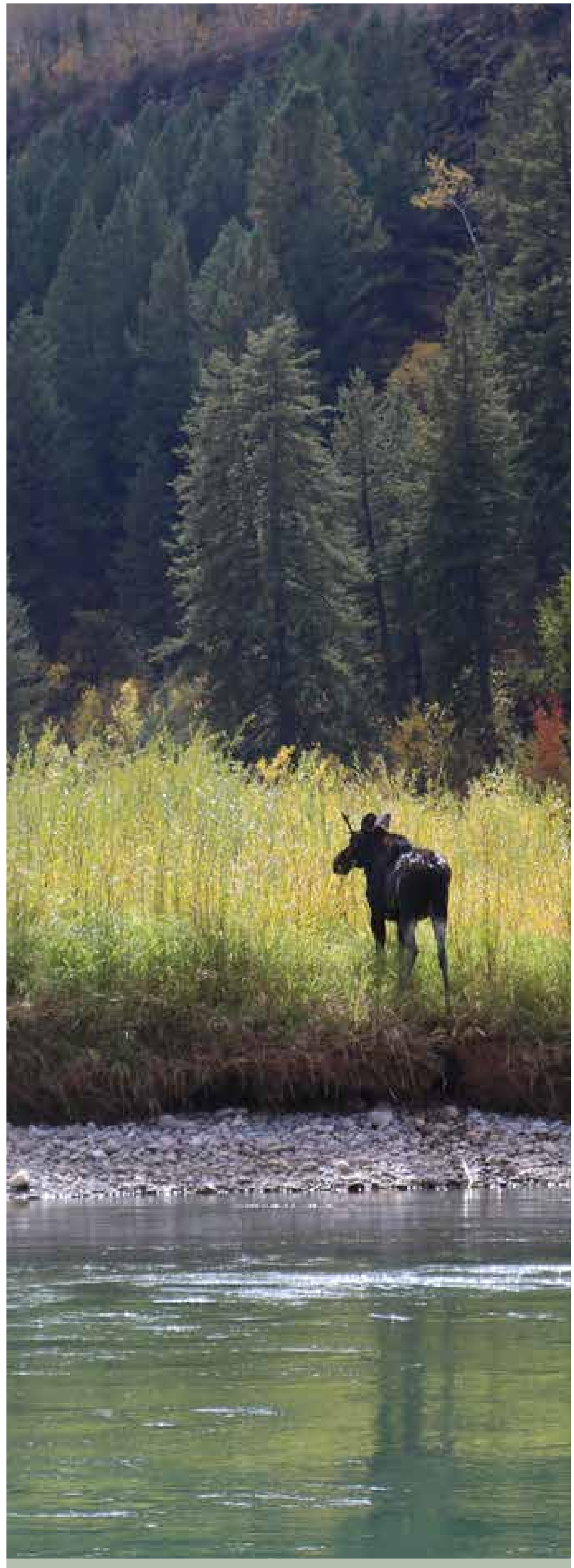
*Accomplishment.* — Between 1991 and 2018 hunters harvested 19,478 moose in Idaho. This number includes 16,575 antlered moose and 2,903 antlerless moose, some of which were calves harvested during antlerless hunts. These data represent a 74% overall harvest success rate based on number of tags available. Antler spread (width) of males harvested during antlered hunts averaged 91 cm (36 in). Hunting season length remained relatively long in most areas, allowing hunters to spend many days in the field.

*Goal 2*. — Assist expansion of moose populations into available habitat.

*Accomplishment.* — Between 1991 and 1995 moose hunting opportunities were added in 7 Game Management Unit (GMUs) across Idaho (from 41 to 48 GMUs), indicating moose populations with a harvestable surplus were expanding. As of 2019 moose hunting opportunities were available in 58 GMUs. This expansion has been assisted throughout the years by translocating nuisance moose into areas with available habitat, but low or 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 was made available whenever possible. In 1991 498 moose tags (antlered and antlerless) were available. Tags peaked in 2003 and 2004 at 1,235/year. Tag numbers have declined since; 634 moose tags were offered for the 2019 hunting season.



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# Population Management

Four subspecies of moose occur in North America (Franzmann 1978). The Shiras subspecies is found in Colorado, Idaho, Montana, Utah, Washington, Wyoming, and 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 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 moved south and west from Montana during the early 1800s, resulting in establishment of populations in Idaho. Theodore Roosevelt harvested a bull moose in the Bitterroot Range along the Idaho-Montana border in 1889.

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 family). Males, females, and young of the year are referred to as bulls, cows, and calves. Males annually grow antlers, which are shed in December or January. Adult males are larger than females (500–700 lbs) and can weigh up to 1,000 pounds. Moose can continue to gain weight their entire life, but very little growth occurs after age 9 for males or 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 rates similar to other ungulate species (e.g., deer and elk) because moose occur at lower densities and males spend more time with females during estrus. Thus, male:female ratios should be maintained at higher levels than those prescribed for most other ungulates.

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

IDFG has collected little information on pregnancy rates of moose; however, a few samples were collected over the years in Upper Snake and Clearwater regions. Muir (2006) found 76.5% of adult females were pregnant in the Moscow Mountain area (GMU 8) and 89% of females were pregnant on Sand Creek Wildlife Management Area (WMA). Additional testing at Sand Creek WMA demonstrated pregnancy rates were similar across years (93% [14 of 15] in 2010, 89% [23 of 26] in 2011, and 100% [6 of 6] in 2018)(IDFG, unpublished data). Although sample sizes were low, pregnancy rates of adult female moose in the Clearwater Region were more variable (21% [4 of 19] in 2011, 75% [3 of 4] in 2018) (IDFG, unpublished data). In Montana, pregnancy rate averaged 83% (range 80–87%) for cows aged ≥2.5 years, yearling pregnancy rates varied 0–44%, and twinning rates ranged 0–16% (DeCesare and Newby 2018). Robertson et al. (2018) reported pregnancy rates of 66–79% in Utah, and twinning rates ranged 0–10% across the state. In Wyoming, Oates (2016) reported pregnancy rates of 48–73%.

Moose are browsing ruminants, meaning they eat primarily forbs, shrubs, and trees (Hofmann 1973). Generalist browsers such as moose produce specific salivary proteins which aid in digestion of key foods such as willow, aspen, and birch. Moose eat leaves, twigs, bark, and buds of hardwood and softwood trees and shrubs. During spring and summer, their diet can be more diverse and include grasses. 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 U.S. (Noss et al. 1995) and, due to biomass of forage, these areas are important for 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. 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 moose distribution into 20 Data Analysis Units (DAUs) based on current knowledge of habitats, distribution, connectivity among populations, harvest, and other management concerns (e.g., social tolerance) (Figure 2). Additional information from marked individuals can be used to further refine these boundaries over time.

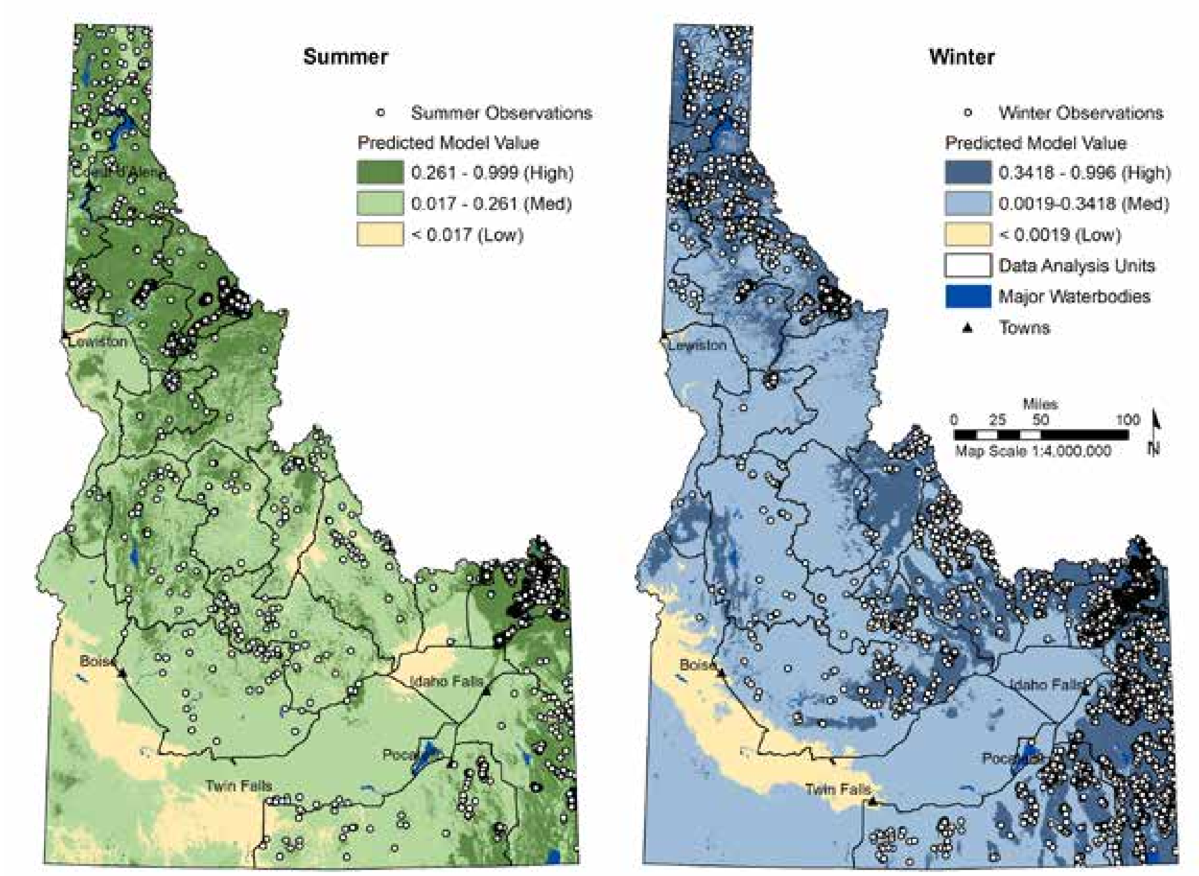


**Figure 1. Moose observations (1979–2019) and seasonal predicted distribution models in Idaho. Point data are from various Idaho Department of Fish and Game databases as of August 2019 and include targeted inventories and surveys, museum specimens and incidental observations. Distribution models were developed using maximum entropy methods and a subset of observations (see Appendix B).**

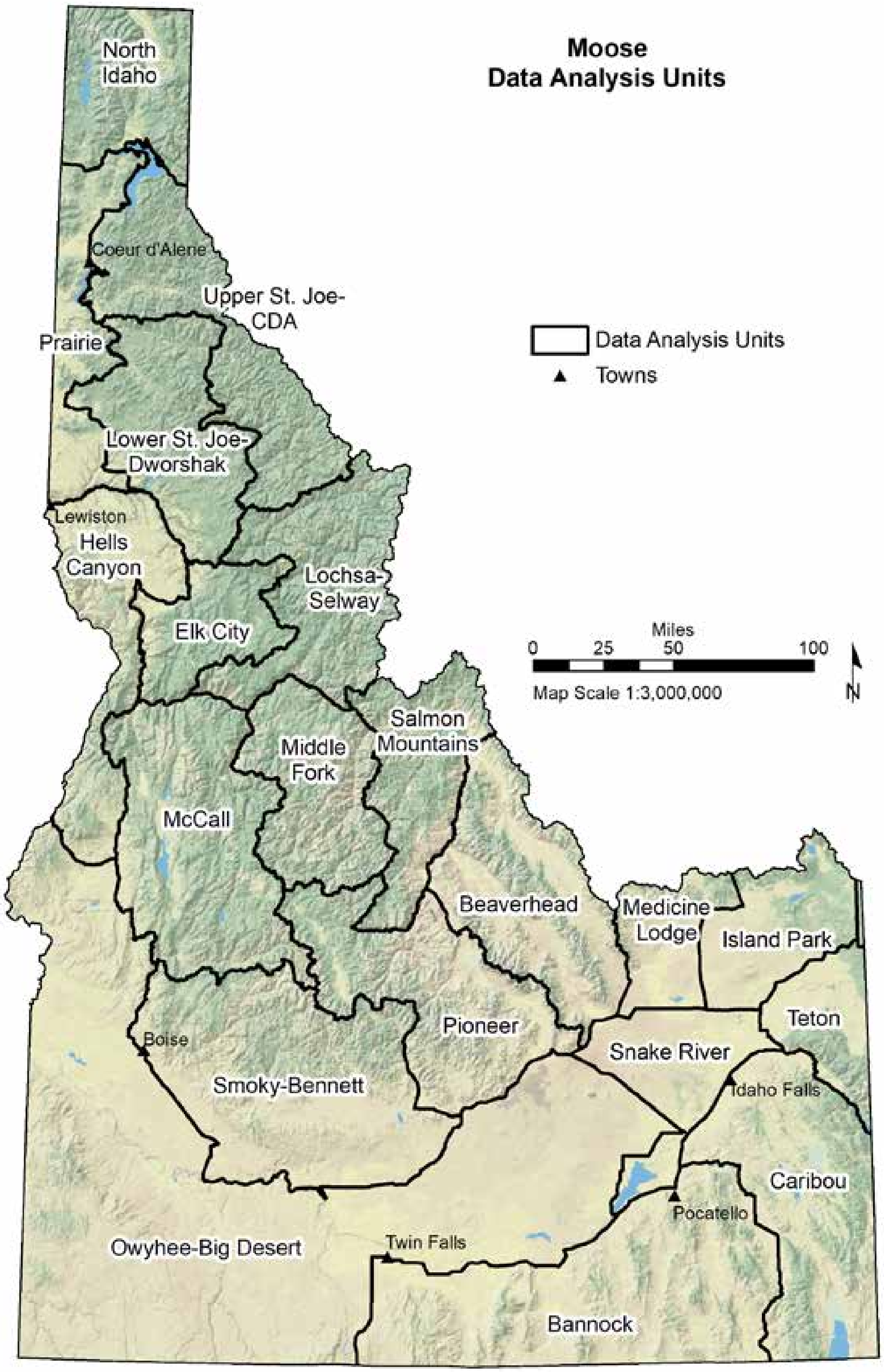


Figure 2. Data Analysis Units for moose, Idaho.

## Survival

Adult and calf survival have not been well documented in Idaho, although Muir (2006) found 100% (8/8) calf survival to approximately 5 months of age on Sand Creek WMA. In Montana, adult female survival was 85–93% across 3 study areas and calf survival (to age 1) was 34–52% (DeCesare and Newby 2018). Robertson et al. (2018) reported adult female survival in Utah of 83–91% and calf survival of 46–91%. Adult survival in Wyoming was 83–87% and calf survival (to 9 months) was 65–75% (Oates 2016). 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. Presence of prime-aged moose likely decreases susceptibility of a calf to predation, assists with learning forage areas, and minimizes energetic costs by breaking trail through deep snow (Markgren 1975, Jolicoeur and Crête 1988).

Nutritional status, and thus body condition, of ungulates impacts survival and productivity. Amount of rump fat provides a useful measure of overall body condition in moose (Stephenson et al. 1998, Van Ballenberghe and Ballard 2007, DeCesare and Newby 2018). Rump fat can be measured with ultrasonography at capture or harvest. Oates (2016) found adult females with body fat <5.5% during February experienced lower probabilities of survival, pregnancy, and parturition.

Between 2000 and 2018 just over 1,000 non-hunting moose mortalities were reported in the IDFG Big Game Mortality Report (BGMR) database. Although likely conservative in number, the top 4 sources of mortality were vehicle collision, illegal harvest, natural mortality (winter kill, predation, disease), and unknown causes. Importantly, not all moose mortalities are recorded in this database and some sources of mortality are more difficult to detect and monitor than others. Consequently, neither true magnitude of mortality nor actual mortality factors are known, and mortality is certainly higher than represented here. Management directions and strategies are identified in this plan to improve understanding of mortality factors.

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Additional data on vehicle collisions submitted to the Idaho Fish and Wildlife Information System (IFWIS) Roadkill database documents moose mortality apparently due to vehicle collision. However, as with predation mortality, vehicle collisions may mask underlying ultimate causes of mortality (e.g., disease, parasites, and old age). Vehicle collision data are collected differently than for BGMR reports and, although there may be redundancy between the 2 datasets, each offers a valuable, yet different, perspective on moose-vehicle collisions. From December 2000 to August 2019, 1,003 unique moose-vehicle collisions were reported in the IFWIS database. A hotspot analysis of these collision sites identified sections of Idaho roadways where higher levels of vehicle collisions occurred (Figure 3).

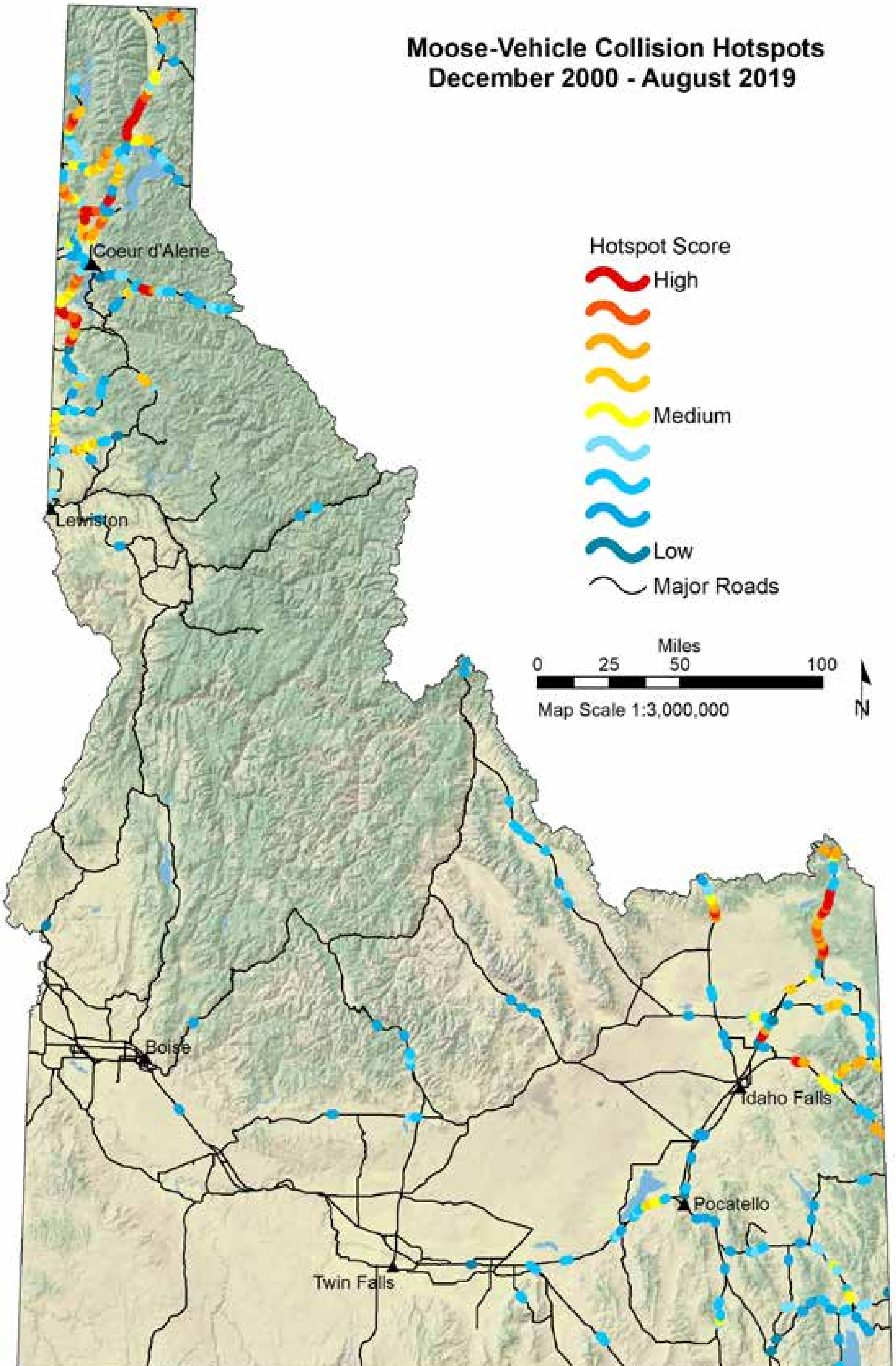


Figure 3. Hotspots of reported moose-vehicle collisions (n = 1,003), Idaho, December 2000 – August 2019. To automatically identify and locate 1-mile road segments with high densities of moose-vehicle collisions, a hotspot analysis was run using a beta version of the Automated Roadway Hotspot Analysis online tool (Shilling and Waetjen 2015). Data were sourced from 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 insights from local conservation officers and biologists. Resources to monitor moose are scarce, so data are limited. Moose are difficult to monitor because they are widespread and often occur in dense cover at low densities. First attempts to count 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 surveys. These techniques can be labor intensive and 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 suggest 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 implemented. Exploring survey methods that yield trend, demographic parameters, and population estimates is a priority for IDFG. Routine population monitoring will allow managers to evaluate effects of management actions (e.g., changes in tag numbers or season structure), increasing pressures from human recreation, disease, habitat conversion or loss, and changing climate on moose populations.

*Aerial Surveys.*— Most aerial surveys for ungulates in Idaho are conducted with a helicopter in winter and employ sightability methods which correct for observation bias due to group size and activity and environmental conditions (e.g., vegetation cover and snow cover). Survey design typically includes stratification of subunits based on expected animal density and subsampling among subunits within each strata. A helicopter with 2 observers is flown along elevation contours (typically at 300–500 ft intervals, depending on vegetation cover) in selected subunits. Anderson and Lindzey (1996) developed a sightability model for moose in western Wyoming.

IDFG has conducted a few moose population trend surveys in portions of GMUs via helicopter, but few aerial surveys specifically targeting moose have occurred in Idaho. Aerial surveys in southeastern Idaho collected information on distribution, population trend, gender ratios, and calf:cow ratios. However, most observations of moose were, and still are, collected incidental to deer and elk surveys and therefore limited to deer and elk survey units. Data gathered from incidental sightings is usually inconsistent among surveys and sometimes lacks demographic information which could be applied towards management. Information gathered from incidental observations is not used to determine population estimates, but can provide insight into gender and age composition, minimum number of moose present, and trend over time. Harris et al. (2015) conducted sightability surveys for moose in northeastern Washington and concluded coniferous forest cover produced low detection probabilities and sightability models yielded disparate estimates. Therefore, aerial survey techniques will likely be of limited use in northern Idaho due to extensive forest cover and wide distribution of moose across the landscape.

*Thermal Infrared Surveys.*— Thermal infrared surveys were attempted in northern Idaho in 2010. However, infrared does not penetrate dense vegetation cover, making detection of moose difficult in such areas. Further, thermal infrared imagery is generally not adequate for collecting demographic information. Thus, managers determined thermal infrared imagery surveys were not appropriate for monitoring moose in northern Idaho.

*Remote Cameras.*— Remote cameras have recently been used to determine population abundance for elk. Moeller et al. (2018) developed 3 methods (time-to-event, space-to-event, and instantaneous sampling) which utilized remote cameras to estimate populations of unmarked animals. Each method relies on an array of remote cameras placed throughout a defined study area (e.g., area occupied by a population of moose).

Depending on method, cameras are programmed to take photographs either when triggered by motion within their field of view or at pre-determined time intervals. Number and timing of animals captured in photographs and area of the cameras' field-of-view are then used to estimate abundance. The methods may produce separate abundance estimates for different gender and age classes of moose, allowing calculation of gender and age ratios. Currently, IDFG is investigating use of remote cameras to monitor moose populations in conjunction with other ungulates and carnivores.

Understanding population dynamics, such as survival, recruitment, and gender and age composition of moose allows for more informed management decisions. Little is known about vital rates of moose in Idaho. However, surrounding states have conducted research which provides insight into population dynamics in the region. Identifying primary population drivers for moose in Idaho will help inform management.

**Management Direction:** Improve ability to monitor moose status, trends, daily movements, and seasonal migrations across the state.

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

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

**Strategy:** Standardize data collected during all aerial surveys where moose may be encountered.

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

**Strategy:** Encourage hunters and other outdoor publics (federal, state, and tribal staff; recreationists; etc.) to record observations of moose presence and absence and associated information (date, location, activity, time spent in area, and number of moose by age and gender) in IFWIS.

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

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

**Strategy:** Capitalize on existing and future data from radio-collared moose to delineate daily movements and seasonal migrations, as well as identify mitigation strategies for reducing effects of land use (e.g., vehicle collisions, mining, timber harvest, and livestock grazing), recreation, and development on moose populations and habitat.

**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 roles of nutrition, predation, climate, disease, vehicle collisions, and harvest in recruitment, daily movements, seasonal migrations, habitat use, and survival.

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

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

**Strategy:** Continue to document all known moose mortalities in IDFG standardized databases, including harvest and non-harvest mortality (e.g., disease, predation, winter kill, etc.).

# Health Assessment and Disease

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

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

Previous testing of samples from post-mortem necropsies and live-captured moose indicate 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 in Idaho include winter tick, carotid artery worm, giant liver fluke, and infectious keratoconjunctivitis (pink eye).

Dead moose removal ©J. Nicholson FOR IDAHO FISH AND GAME

## 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 consequences of these parasites and pathogens on moose populations, including habitat loss and fragmentation, climate change, and increasing recreational pressure in areas previously unperturbed by human activity. Population-level effects on moose are unknown.

*Carotid Artery Worm.*— Carotid artery worm is a normal nematode parasite of mule deer in North America. The life cycle involves horseflies as the intermediate host. However, worms 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 nose and ears, deformed antlers, blindness, neurological symptoms, and death (Henningsen et al. 2012). Although increased prevalence rates are concerning, effects of carotid artery worms on individual moose remain unknown, and high prevalence in apparently healthy hunter-harvested moose suggests infection may not be incapacitating. However, negative effects of infection have also been repeatedly documented and could result in decreased survival. These reports suggest effects of infection on moose are quite complex and warrant further research (Henningsen et al. 2012).

*Meningeal Worm.*— Meningeal worm is likely the most important parasitic disease of moose in North America (Lankester 2010). However, the species 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, 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 North America). The disease, termed "moose sickness," has been known since the 1930s when it was first described in Minnesota.

*Giant Liver Fluke.*— Giant liver fluke generally infects moose in areas, including Idaho, where their range overlaps with white-tailed deer or elk, the normal hosts. In white-tailed deer, fluke eggs are passed in feces and 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, larvae migrate until they find another larva. Larval pairs 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, which can lead to liver failure (Pybus 2001). 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, including Idaho. 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 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 autumn (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 potential for eventual blindness associated with keratoconjunctivitis likely reduce survival of infected individuals. Keratoconjunctivitis has been documented in Idaho.

*Chronic Wasting Disease.*— Chronic wasting disease (CWD) is a prion disease of cervids and is uniformly fatal. The disease has not been detected in any species in Idaho. However, CWD 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. Although 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 4 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 baseline knowledge of moose health and understanding of diseases afflicting moose.

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 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 obtain samples from recently dead animals.

Live animals which 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 presence and prevalence of parasites and pathogens in moose.

Samples obtained from hunter-harvested moose have significant value. These biologic samples are acquired from apparently healthy animals and provide an opportunity to closely evaluate 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 translocation of moose. Moose translocation 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 winter 2001–2002, >100 moose were moved in Upper Snake Region.

**Management Direction:** Improve 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 roles of disease in recruitment, daily movements, seasonal migrations, 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 presence and prevalence of various parasites and pathogens in moose populations.

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

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

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

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

**Strategy:** Use banked DNA to establish a baseline of genetic diversity.

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

**Strategy:** Identify potential translocation areas based on several 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 projected 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 source and recipient populations. Do not move moose to areas with parasite and pathogen communities that differ from the source population.

**Strategy:** Monitor animals post-release to evaluate success.

# Predation

There are 4 species of large predators in Idaho: mountain lions, black bears, grizzly bears, and gray wolves. Density of these predator species varies dramatically across the state. Mountain lions are most widespread, occurring and harvested in every GMU in the state. Black bears are also quite common, occurring in nearly every GMU, but with very few individuals in the southwest corner of the state and no harvest south of I-84 and I-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 the eastern portion of the Upper Snake Region and northern portion of the Panhandle Region. Across the range of moose, predation by grizzly bears, mountain lions, and wolves includes all age classes, whereas predation by black bears is primarily limited to calves (Franzmann and Schwartz 2007).

As little cause-specific mortality data exist, extent of predation on moose in Idaho is not well documented. However, surrounding states have recently completed moose survival studies and offer some insight into the role predation plays in moose survival. Between 2013 and 2018 Montana Fish, Wildlife and Parks collared and monitored 141 adult female moose. During this period they documented 46 mortalities: 20% ($n$ = 9) of these were killed by predators, primarily wolves ($n$ = 6); 57% ($n$ = 26) of mortalities were health related (disease, malnutrition, etc.), and 24% ($n$ = 11) were attributed to other causes (e.g., accident, human-related, and unknown) (DeCesare and Newby 2018). In Utah, approximately 200 adult moose were monitored between 2013 and 2018 and 1 of these was killed by a mountain lion (Utah Department of Wildlife Resources, unpublished data). Further, annual survival rates for those adults ranged 83–91% and most adult mortality was attributed to health-related issues (disease, malnutrition, etc.). During this same period, approximately 80 moose calves (collared at 6–8 months old) were monitored and 2 (both of

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which were in extremely poor body condition) were killed by mountain lions. Grizzly bears were not present in the Utah study area and wolves were either not present or occurred at extremely low densities. From 2011 to 2014 in Wyoming, Oates (2016) collared and monitored survival and reproduction of 91 adult moose, 33 of which died from natural causes. Although cause-specific assessments of mortalities were not conducted, most (>75%) carcasses were undisturbed upon arrival to collect GPS collars, suggesting malnutrition, disease, or parasites were more likely contributors to mortality than predation. Moose declines in Minnesota were studied intensively in recent years; however, attribution of primary causes varied among studies. Lenarz et al. (2009) suggested temperature was the primary driver of moose population declines, whereas Mech and Fieberg (2014) felt an increasing wolf population likely contributed. Severud et al. (2019) monitored 40 radio-collared moose calves in Minnesota and predation accounted for 84% of all natural calf mortalities ($n$ = 26 of 31) through the first 9 months of life. Wolves accounted for 77% of these predation events ($n$ = 20 of 26) and black bears contributed 19% ($n$ = 5 of 26). From 2013 to 2017 Carstensen et al. (2018) documented >40% of adult moose killed by wolves were symptomatic for various health issues and predation only accounted for 32% of documented mortalities, whereas remaining mortalities were caused by disease (parasites or bacterial infections, 51%), other health issues (12%), accidents (3%), and harvest (2%).

More extensive research documenting predation on moose is available from outside the continental U.S. However, relevance of this data to Shiras moose is unknown and care should be taken in assuming similar effects due to different habitats, predator communities (higher densities), and prey communities (e.g., systems where moose are the only prey available). In Alaska, Boertje et al. (1988) documented predation by grizzly bears on both adult moose (3.3–3.9 adults/year killed by each adult male bear) and calves (5.4 calves/bear/year). Knopff et al. (2010) monitored mountain lions in Alberta, Canada via GPS collars from 1998 to 2008. Moose represented 6% and 37% of summer kills by adult female and male mountain lions, versus <1% and 11% in winter, respectively. Nearly 75% of all mountain lion kills were juvenile moose. Wolf predation rates during winter varied 1.1–5.5 moose/wolf/100 days in interior Alaska where moose were the sole ungulate prey species (Lake et al. 2013). Of 81 neonate moose collared and monitored for 1 year in Ontario, 16% were killed by predators (9% by black bears and 7% by wolves) and 11% succumbed to malnutrition, disease, or other health related issues (Patterson et al. 2013).

Predation, particularly on calves, can be a limiting factor for many moose populations (Patterson et al. 2013). In Idaho, a variety of ungulate prey species exists for large predator species and predation on moose may be secondary to other prey. However, because 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 limit populations in some areas.

Effects of wolves on moose populations in Idaho are largely undetermined, but the limited information available suggests effects vary through time and across the state. In 2008 IDFG began monitoring radio-collared moose in GMU 10 to determine mortality rates and causes of death in the presence of wolves. Although sample sizes of radio-marked moose never reached desired levels, results indicated wolves were not a significant cause of mortality for adult moose (1 of 23 killed by wolves). However, calf mortality due to wolves was high (6 of 12) in 2011 (IDFG 2013). In contrast, Muir (2006) documented 100% survival of 8 moose calves through 5 months at Sand Creek WMA.

Explaining apparent declines in moose populations is complex. Factors beyond predation, such as habitat degradation and disease, are affecting moose populations in many areas of the species range across different habitat types and with different suites of predators. For example, data from Minnesota suggest moose and wolves coexisted prior to documented declines in moose populations and unhealthy moose are more vulnerable to predation (Severud et al. 2019). Recent aerial surveys in southeastern Idaho indicated moose populations have declined even though there is not a measurable wolf population in this region. Enhancing the moose monitoring program in Idaho will provide valuable insights into complex roles predation, disease, habitat, and other factors play in moose population dynamics.

In 2000 the Idaho Fish and Game Commission implemented a “Policy for Avian and Mammalian Predation Management” to guide IDFG’s implementation of predator management activities. The policy directs IDFG to implement predator management if there is evidence predation is a significant factor preventing prey populations from meeting IDFG population management objectives. Furthermore, IDFG is directed to use best available scientific information to guide their actions concerning predator management.

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

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

**Strategy:** Use ongoing cause-specific mortality research to implement IDFG predation management policy, including updating predation management plans if necessary.

# Habitat

Habitat includes space and resources 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 which reduce digestibility for herbivores (Robbins et al. 1987) and moose have large salivary glands which produce tannin-binding proteins allowing them to feed on these plants. Moose diets are often comprised of relatively few plant species; however, moose can feed on a wide variety of plants (Shipley 2010), allowing them to inhabit a diversity of habitats. As forage becomes more nutritious in spring, diets can be more diverse and include forbs and grasses in addition to predominant shrubs and trees. Although winter is considered a major nutritional bottleneck for ungulates, summer and autumn nutrition are 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 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).

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Moose have substantial dispersal abilities, likely a result of their evolution in boreal forests of the northern hemisphere where individuals traveled to capitalize on recently burned areas which 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 potential to affect the nutritional landscape for moose (Schrempp et al. 2019) and impacts of these changes over time are important considerations in habitat management and planning. Although disturbance is needed to generate abundant forage in transitional habitats, mid- and late-seral habitats are also important, providing snow interception in winter and thermal refuge in summer (Peek 1997). Ensuring 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, pressures of encroaching urbanization, and increasing recreation activities.

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, which could affect nutritional levels and ultimately population dynamics. The extent to which moose are able to mitigate effects of warming temperatures remains unclear. 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): coniferous forests of northern Idaho, mixed aspen and conifer forests of southeastern and central Idaho, and riparian cottonwood and willow communities found in parts of southern Idaho. Remaining areas of southwestern Idaho do not support sufficient habitat to maintain persistent moose populations.

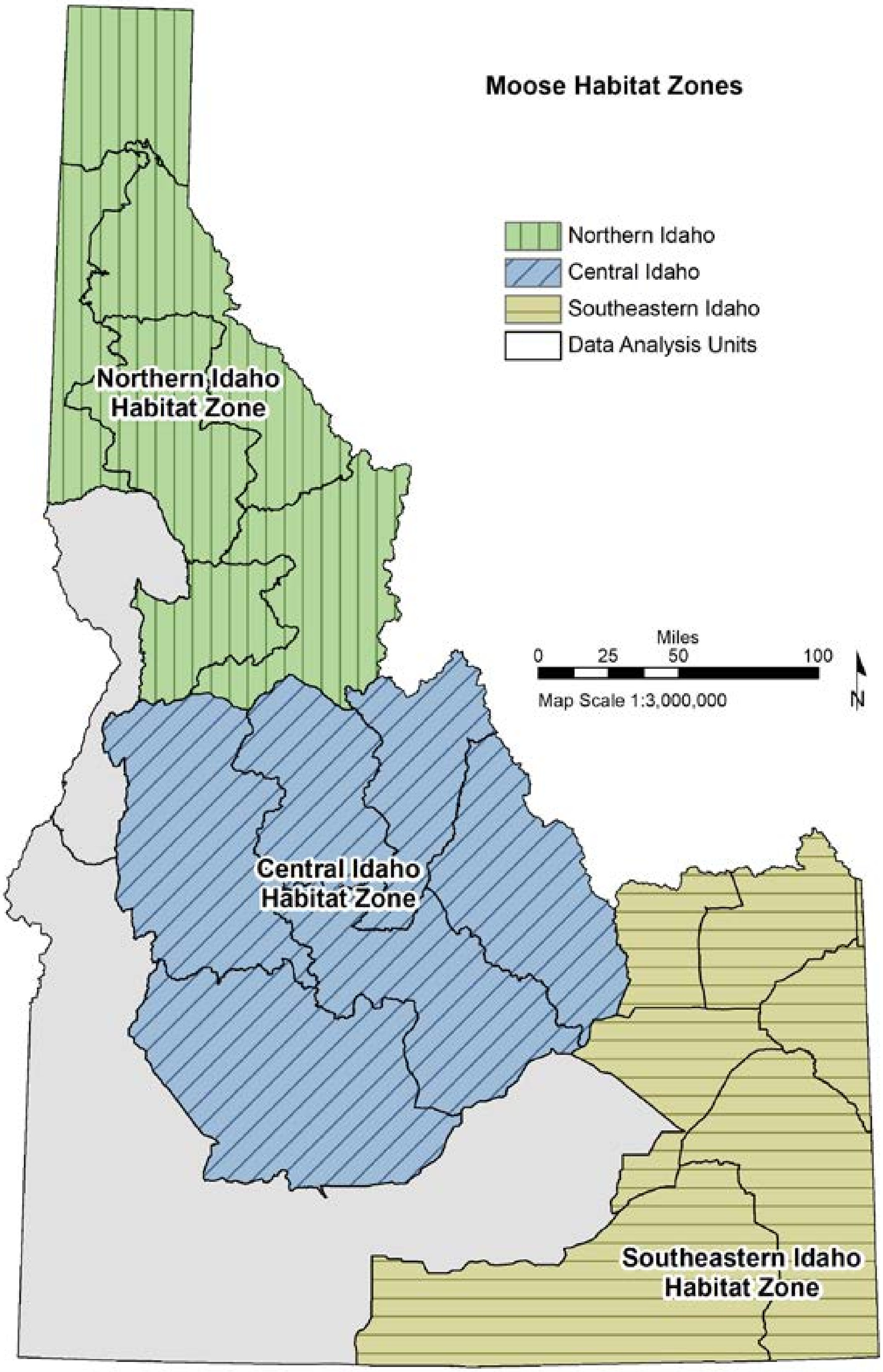


Figure 4. Moose habitat zones, Idaho.

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## Northern Idaho Habitat Zone (DAUs: North Idaho, Prairie, Upper St. Joe-CDA, Lower St. Joe-Dworshak, Hells Canyon, Elk City, Lochsa-Selway)

Northern Idaho includes a diverse mix of topography, from rolling hills dominated by dryland agriculture to remote and rugged areas such as 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.

Northern Idaho includes several Ecological Sections (see McNab et al. 2007 for section descriptions and IDFG 2017 for Idaho-specific information), including Okanogan Highlands, Bitterroot Mountains, Idaho Batholith, and Palouse Prairie. Northern DAUs receive >229 cm (90 in) of precipitation per year and volcanic ash has made them relatively productive. Southern DAUs, except Palouse Prairie regions, have generally shallow soils and deeply incised drainages.

*Habitat Characteristics.*— Dense coniferous forests of northern Idaho are typified by steep slopes and narrow, high-gradient streams, which 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 northern Idaho. Early seral shrub communities created by fire and logging are important spring, summer, and early winter foraging areas for moose. Mature conifer stands adjacent to foraging areas are important for snow interception in areas of deep snowfall, as well as providing 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 are also used for thermoregulation. Winter habitat includes high-elevation subalpine fir, lower-elevation clear-cuts and shrub fields, and closed-canopy grand fir forests with Pacific yew understories.

*Food Habits.*— Common forage species for moose in northern 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, as well as grasses, are also consumed at times. Trees commonly consumed include deciduous species, such as aspen and black cottonwood, and conifers such as 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 because they likely face a tradeoff between spending time searching out high-quality forage and acquiring enough to eat (quality vs. quantity). Forage quality and quantity are greatest during spring green-up and, consequently, diets are more diverse at this time. Diversity in diets declines as grasses and forbs senesce and quality decreases through summer and autumn.

*Impacts to Habitat.*— Fire and logging are critical to creating and maintaining quality foraging areas essential to moose populations. Between 1910 and 1960 >60% of northern Idaho burned in large forest fires, whereas 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 Department of Lands (IDL) properties found primarily in Lower St. Joe-Dworshak and Prairie DAUs; however, use of herbicides in some forest management practices might limit browse availability. More recently, significant fires have occurred in parts of Elk City and Lochsa-Selway

DAUs. However, little disturbance has occurred in other areas, resulting in a late-seral 'bulge,' which has likely reduced available forage across large areas of northern Idaho (Schrempp et al. 2019).

Changes in temperature and precipitation patterns have 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 northern Idaho is projected to transition from a snow-dominated system to a rain-dominated system, with earlier snow melt in 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 (Case and Lawler 2017, Murphy and Knetter 2019). However, magnitude of changes, and ability of moose to adapt to those changes, are difficult to predict.

Moose cow and calf CCBY IDAHO FISH AND GAME

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

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

Central Idaho consists of several Ecological Sections, including 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, particularly within Middle Fork and Salmon Mountains DAUs. However, significant riparian areas do occur within Pioneer, Beaverhead, and Smoky-Bennett DAUs and these areas are often shared with domestic livestock. These cottonwood-willow communities provide quality 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, whereas riparian species such as willows provide important summer forage.

*Impacts to Habitat.*— Timber harvest likely increased available forage within areas of closed-canopy forests, such as northern reaches of Salmon Mountains DAU. Although timber harvest and fire are commonly associated with quality moose habitat, conversion of certain climax vegetation types to early seral stages 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 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) after disturbance such as fire, especially moderate to severe fires (Ex et al. 2011), which could detrimentally affect moose for some time.

Riparian areas which 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 southeastern Idaho (Ritchie 1978). A large portion of riparian areas in lower elevations of this zone exist on privately owned lands and are subject to private land management. Health of these riparian areas is important for moose which depend on them; however, some are subject to habitat management that may not favor moose. For example, in Beaverhead and Pioneer DAUs, water diversions have relocated water from portions of valley streams to canals and ditches, resulting in gradual loss of riparian habitats, particularly cottonwood-willow communities, available to moose (Rood et al. 2003).

Changes in temperature and precipitation patterns have 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 central Idaho 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 harm 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 some areas, particularly Pioneer, Beaverhead, and Salmon Mountains DAUs, will continue to provide valuable black and narrowleaf cottonwood habitat into the future, which could be targeted for conservation and restoration actions (Murphy and Knetter 2019). Magnitude of changes, and ability of moose to adapt to those changes, are difficult to predict.

Bull Moose CCBY IDAHO FISH AND GAME

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

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

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

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 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 shrub and mountain mahogany communities as well as arid, sand hill areas where they feed on desert shrubs such as bitterbrush and chokecherry (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, lower-elevation plant communities receive less snow accumulation which, in turn, reduces moose energy cost for acquiring forage and increases forage availability, particularly for calves (Maier et al. 2005, Dou et al. 2013).

Food Habits.— Ritchie (1978) examined common forage species for moose in summer and winter in Fremont County. Woody browse, primarily willow species followed by aspen and bitterbrush, accounted for 56% of summer forage. Non-woody browse comprised 44% of summer diets and fireweed was the dominant forb. Winter diets consisted of 87% browse with a notable increase in occurrence of evergreen ceanothus and a 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 southeastern 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 and season of use), vegetation management (e.g., spraying and burning), water diversion, development (e.g., housing development), and changing climates could reduce their value to moose. Aspen stands which 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. Loss of these aspen stands is likely detrimental to moose populations.

Large areas of predominantly private property found in Island Park, Teton, Medicine Lodge, and Snake River DAUs make implementation of management actions across large areas difficult.

Migratory moose populations occur in Island Park DAU and development activities could potentially affect migration routes. Changes in temperature and precipitation patterns have 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 southeastern Idaho is projected to become hotter and drier, with earlier snow melt in 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 (Perry et al. 2012, Murphy and Knetter 2019). However, magnitude of changes, and ability of moose to adapt to those changes, are difficult to predict.

**Management Direction:** Collaborate with private landowners, land management agencies, forest managers, counties, 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 and management recommendations to partners in major land-use planning efforts and proposals (e.g., forest plan revisions, timber harvest proposals, urban development, and travel management plans) to benefit moose.

**Strategy:** Work with private landowners and land management agencies to implement wetland and riparian restoration projects and improve hydric soil function within systems (e.g., including installation of beaver dam analogs or reintroduction of beaver).

**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 and corporate timber managers to develop and implement habitat restoration projects (e.g., timber harvest to improve forage and thermal refugia, prescribed burns, riparian management and restoration, and restoration of aspen and other key forage species).

**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 and timber harvest) or where forest canopies have closed (e.g., GMUs 12, 15, 59, and 61).

**Strategy:** Investigate 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 extensively burned areas (e.g., Selway drainage).

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

**Strategy:** Investigate impacts of herbicide spraying and habitat management after logging on moose habitat (e.g., preferred forage habitat, thermal cover, etc.) and collaborate with corporate timber companies to manage habitat to benefit moose.

**Strategy:** Capitalize on existing and future data from radio-collared moose to delineate habitat use, daily movements, and seasonal migrations, as well as identify mitigation strategies for reducing effects of land use (e.g., vehicle collisions, mining, timber harvest, and livestock grazing), recreation, and development on moose populations and their habitat.

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

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

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

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# Climate

Long-term climate patterns can both directly (through physiological limitations and reduced energy reserves) and indirectly (through quality and abundance of forage, diseases, 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 long-term viability of moose populations at the southern extent of the range (e.g., Murray et al. 2006, Feldman et al. 2017, Nadeau 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 growing season is lengthening (Abatzoglou et al. 2014, Klos et al. 2014). Trends in precipitation were more variable but indicate increases in spring and winter precipitation with decreases in proportion of precipitation falling as snow, particularly at low to middle 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 with less precipitation falling as snow) 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 moose are most susceptible to warmer temperatures during spring and autumn 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 precipitation can positively and negatively affect moose populations through shifts in preferred habitat and changes in incidence of diseases or parasites. For example, warmer springs may provide earlier and more abundant forage (Grøtan et al. 2009), as do shallower snow depths during milder winters (Dou et al. 2013), whereas warmer summers and shorter springs can reduce forage quality (Monteith et al. 2015). In addition, changes in autumn leaf senescence, particularly due to drought, can alter nutrient availability (Estiarte and Peñuelas 2015). Improved forage quality and quantity, as well as reduced energetic costs (e.g., with <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 likely led to more favorable conditions for many parasites known to infect moose (see Health Assessment and Disease section). However, magnitude of effects of climate change 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]) autumns with little snow extend the larval questing period, thereby 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 snow fall or prolonged freeze (Holmes et al. 2018). Similarly, tick survival, abundance, and distribution can be enhanced by warm springs with early snow melt because 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). Effects of summer and autumn drought on egg and larval survival are less certain. In some tick species, lower relative humidity can result in desiccation of both eggs and larvae (see Knulle and Rudolph 1982, Addison et al. 2016 for review). However, nearly all tick species display water-conserving adaptations (Knulle and Rudolph 1982), and winter ticks are no exception (Drew and Samuel 1985, Yoder et al. 2016).

Given warming trends in Idaho over the last 4 decades, identifying areas projected to experience changes 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 1981–2010 baseline using data from Abatzoglou 2013 and Holden et al. 2015), with summer temperatures rising fastest (3.3–3.5° C, 5.9–6.3° F) and spring temperature increases most variable (2.6–3.4° C, 4.7–6.1° F) (Figure 5, Table 1). Although spring temperatures will increase statewide, all DAUs are projected to maintain 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). Increased spring temperatures 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 experience mean temperatures >14° C (57° F) and many areas, particularly in the south and west, will average >20° C (68° F). Autumn temperatures are projected to increase 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 temperature regime 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° C (23° F) and expansion of areas >0° C (32° F). Thus, moose may experience heat stress and, in absence of snow, tick larvae may persist longer without a host in these areas.

Projected changes in warming by mid-century will likely be coupled with slight increases in annual precipitation (<16 cm, 6 in) statewide, with 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 proportion of precipitation falling as snow in all DAUs (23–60% decrease), with the most substantial changes occurring in 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, potential effects of annual and seasonal time lags and daily and 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 relatively high with respect to temperature projections, particularly in early and mid-century, models of precipitation projections are much more variable, resulting in less certainty.

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 or 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) suggested when cooler microclimates are available, behavioral flexibility of moose may be sufficient to allow for persistence, and even expansion, in seemingly inhospitable areas. Given moose in Idaho currently occur at elevations near the average elevation in each region, individuals may have enough area available, at least in summer, to mitigate heat stress through behavioral adaptation if habitat conditions allow. However, moose also demonstrate characteristics indicative of species with low adaptive capacity, including longer generation times, lower reproductive rates, and limited genetic diversity. Even with possible local adaptations (Weiskopf et al. 2019), changes which lead to physiological stress or altered behavior can influence nutritional status and 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 complex relationships 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 understanding of existing and potential effects of changing climates, specifically changes in seasonal temperatures, on moose recruitment rates, survival, distribution, and 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 (e.g., $\leq$250 m x 250 m, 15 acres) for management of moose DAUs in Idaho.

**Strategy:** Engage partners in collaborative efforts to address threats to moose populations which may be compounded by effects of climate change.

**Strategy:** Work with land managers to provide or maintain habitat that contributes to climate resiliency.

Moose CCBY IDAHO FISH AND GAME

**Table 1. Baseline (1981–2010, B) and projected (2040–2069, P) mean seasonal temperatures (°C) and annual precipitation as snow (PAS, cm) averaged across moose DAUs.**

| Data Analysis Unit | Elevation Range (m) | Spring | | Summer | | Autumn | | Winter | | PAS | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | B[a] | P[b] | B | P | B | P | B | P | B[c] | P[c] |
| North Idaho | 525–2,346 | 5.7 | 8.4 | 15.7 | 19.1 | 5.8 | 8.7 | -3.2 | -0.2 | 40.4 | 22.7 |
| Prairie | 218–1,590 | 8.0 | 10.6 | 18.0 | 21.4 | 8.4 | 11.3 | -0.7 | 2.3 | 14.4 | 5.9 |
| Lower St. Joe -Dworshak | 291–2,078 | 7.1 | 9.7 | 17.2 | 20.7 | 7.8 | 10.7 | -1.3 | 1.6 | 28.1 | 12.4 |
| Upper St. Joe-CDA | 484–2,401 | 5.9 | 8.6 | 16.2 | 19.7 | 6.6 | 9.5 | -2.4 | 0.6 | 42.9 | 21.5 |
| Hells Canyon | 219–2,840 | 7.8 | 10.5 | 18.4 | 21.9 | 8.9 | 11.8 | -0.7 | 2.2 | 12.4 | 6.0 |
| Elk City | 372–2,708 | 6.0 | 8.8 | 16.4 | 19.8 | 7.0 | 9.9 | -2.2 | 0.7 | 28.0 | 16.4 |
| Lochsa-Selway | 415–2,744 | 4.5 | 7.3 | 15.0 | 18.5 | 5.4 | 8.4 | -4.0 | -1.1 | 48.1 | 30.8 |
| McCall | 514–3,224 | 4.3 | 7.2 | 15.5 | 19.0 | 5.8 | 8.8 | -4.5 | -1.5 | 43.9 | 29.9 |
| Smoky-Bennett | 748–3,540 | 6.4 | 9.4 | 18.0 | 21.5 | 7.7 | 10.7 | -3.1 | -0.1 | 22.8 | 13.0 |
| Owyhee-Big Desert | 549–2,561 | 8.2 | 11.2 | 19.8 | 23.3 | 9.1 | 12.1 | -1.8 | 1.4 | 6.3 | 2.5 |
| Bannock | 1,102–3,149 | 6.8 | 10.0 | 18.7 | 22.1 | 8.0 | 11.1 | -3.1 | 0.2 | 12.0 | 5.0 |
| Caribou | 1,344–3,012 | 4.7 | 8.1 | 16.8 | 20.2 | 6.1 | 9.2 | -5.5 | -2.4 | 22.0 | 12.5 |
| Teton | 1,475–3,044 | 4.3 | 7.6 | 16.2 | 19.5 | 5.5 | 8.6 | -6.2 | -3.3 | 24.5 | 15.0 |
| Island Park | 1,458–3,173 | 3.9 | 7.1 | 15.9 | 19.2 | 4.9 | 8.0 | -7.2 | -4.3 | 27.9 | 20.6 |
| Medicine Lodge | 1,454–3,471 | 4.7 | 7.9 | 16.9 | 20.3 | 5.7 | 8.8 | -6.6 | -3.6 | 14.4 | 8.9 |
| Snake River | 1,315–1,998 | 6.9 | 10.3 | 19.0 | 22.5 | 7.5 | 0.6 | -5.5 | -2.3 | 7.0 | 3.6 |
| Beaverhead | 1,170–3,817 | 3.3 | 6.4 | 15.1 | 18.6 | 4.6 | 7.7 | -6.9 | -3.9 | 19.7 | 13.1 |
| Pioneer | 1,452–3,844 | 2.9 | 6.0 | 14.6 | 18.1 | 4.6 | 7.6 | -6.6 | -3.6 | 31.8 | 22.2 |
| Salmon Mountains | 865–3,169 | 4.0 | 7.0 | 15.4 | 18.9 | 4.9 | 8.0 | -6.2 | -3.2 | 25.3 | 18.0 |
| Middle Fork | 644–3,145 | 3.4 | 6.3 | 14.5 | 18.0 | 4.7 | 7.7 | -5.7 | -2.8 | 43.4 | 32.6 |

[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 baseline data.

[c] Baseline PAS data are modeled at 1-km spatial resolution with projected values from an ensemble of 10 GCMs under RCP 8.5 (Wang et al. 2016).

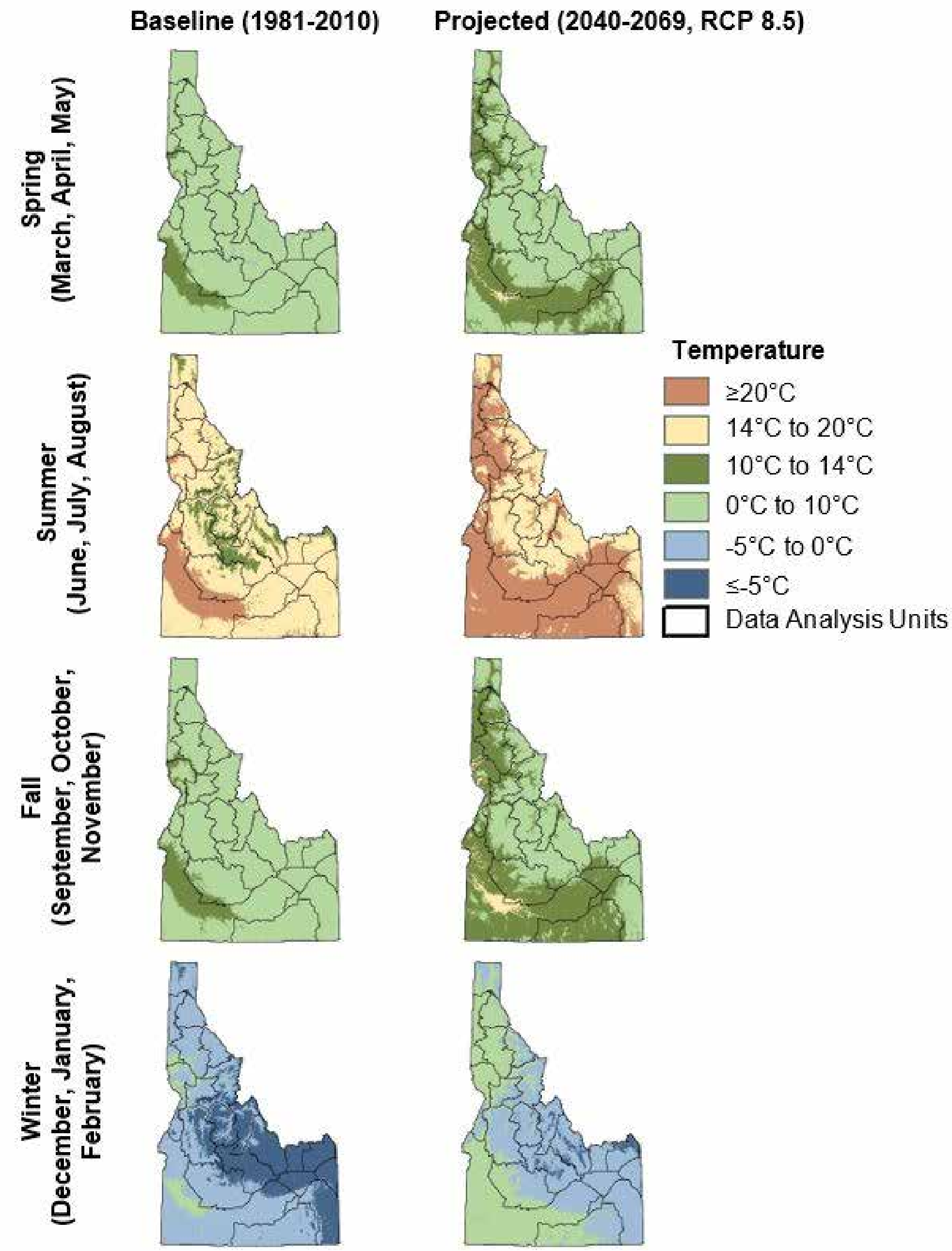


Figure 5. Baseline (1981–2010) and projected mid-century (2040–2069) mean seasonal temperatures, Idaho. Colors represent ambient temperature thresholds identified in the literature as important to moose (see text). Baseline temperature data represent mean values at 250-m spatial resolution (Holden et 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 baseline data.

# Harvest Management

The first formal hunting season for moose in Idaho was established in 1893 but was closed in 1898 because harvest was deemed unsustainable. Moose were not hunted for the next 46 years. 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 >50% of the state's moose population. Moose hunting opportunity remained low through 1971, but then increased with expanding populations until 2004. Due to decreasing hunter success and the assumption of correlated decreases in moose populations, opportunity declined in recent years (Figure 6).

## Hunting Opportunity

Population expansion allowed hunting opportunity in the state to grow from 30 tags in 1946 to a high of 1,235 tags in 2003 and 2004. Concerns about 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 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 since 2004. Most reduction in tags occurred in Panhandle, Clearwater, and Southeast regions.

Moose harvest management has been focused on offering high-quality hunting with opportunities to harvest mature bulls and 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. Chances of drawing a tag for an antlered moose averaged 22%; hunter success averaged 70%. Antlerless tag draw success averaged 31% with an average harvest success of 73%.

Antlerless moose hunting opportunity has been offered in Idaho since 1974. From 1974 through 1982 this opportunity came in the form

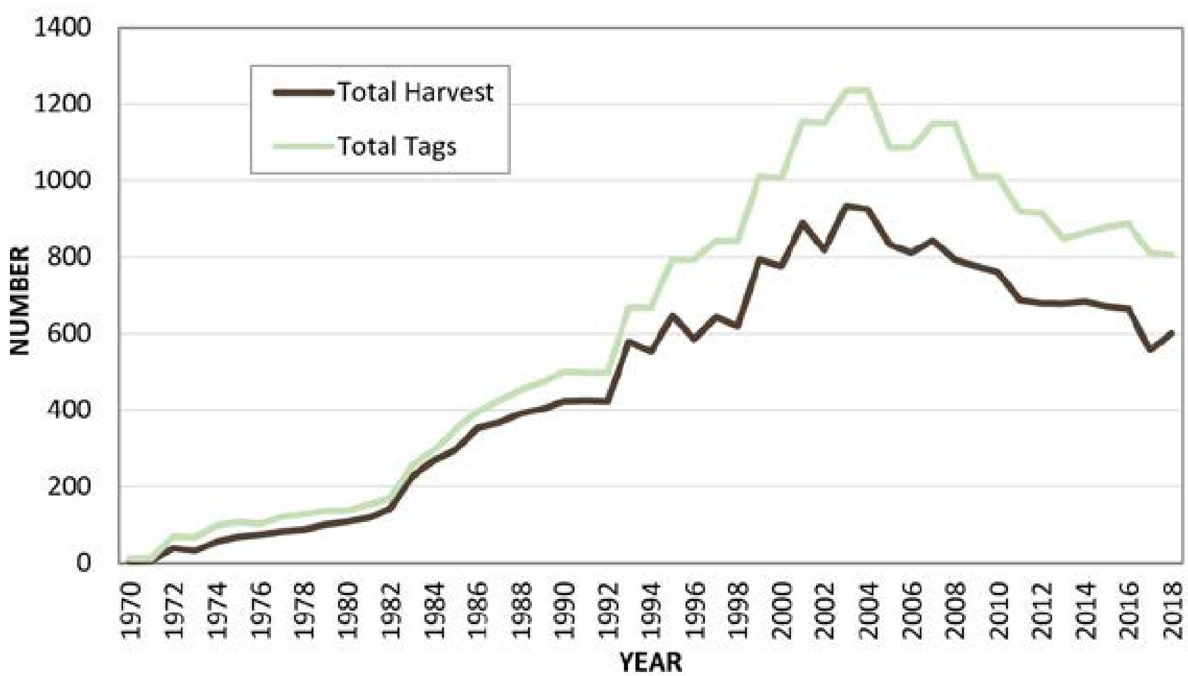


**Figure 6. Trend in moose tags and harvest, Idaho, 1970–2018.**

of either-sex controlled hunt tags in the Upper Snake Region. In 1982 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. Thus, in 1991 the first antlerless-only hunts were offered in Upper Snake and Southeast regions. In 1999 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. Implementation of antlerless-only 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 among 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 substantial human conflict and provide opportunity for hunter harvest in growing and expanding populations. In response to declining moose populations, IDFG has incrementally decreased antlerless tags to 74 for 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 random lottery system. To maintain modest drawing odds and more equitably distribute tags, individuals who choose to apply for moose tags are prohibited from applying for most other limited controlled hunts for other big game species in the same year. Those who successfully draw a tag but do not harvest a moose are prohibited from applying for a moose tag for 2 years.

## Harvest Monitoring

In hunted ungulate populations, many hunters select for larger antler or horn size (often prime-age animals). Due to limited opportunity for moose hunting in Idaho, this selection

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pressure could be amplified. Selective harvest of presumably mature males in the population may reduce ratios of adult bulls:females (Markgren 1969, Crête et al. 1981, Franzmann and Schwartz 2007), with potential consequences for breeding activity and productivity. However, Laurian et al. (2000) saw no reduction in reproduction and recruitment with <30% adult males in autumn populations. Monitoring of both male and female harvest is important to ensure mortality remains compensatory and does not reach a point where harvest has an additive effect on the state's moose population.

Antlerless harvest is an important management tool used by wildlife managers to accomplish multiple objectives, including population maintenance, reduction of vehicle-moose collisions, addressing public nuisance situations, and providing additional hunting opportunity. There are areas within the state where IDFG uses antlerless harvest to achieve these objectives. Ongoing moose research will help inform management decisions with respect to when and where antlerless harvest should occur.

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 gender, age, and antler measurements are collected, as well as location, date of harvest, and number of days hunted. In 2019 IDFG expanded biological sampling from harvested moose to better evaluate disease prevalence, genetic connectivity, and nutrition.

Since the early 1990s a mean antler spread of $\geq$89 cm (35 in) among all harvested bulls has been used as a management goal. According to literature, this antler spread indicates an average bull age of $\geq$4 years old (Gasaway et al. 1987). However, inconsistency in measuring methods may reduce dependability of spread as an indicator of bull age. In addition, density-dependence and habitat quality may be more influential than harvest in determining antler size and age structure of moose (Schmidt et al. 2007). Currently, IDFG is considering revised, more stringent, methods of collecting quantitative antler and age data to better describe moose harvest.

## Tribal Harvest

Coeur d'Alene Tribe, Kootenai Tribe of Idaho, Nez Perce Tribe, and Shoshone-Bannock Tribes regulate harvest of moose by their members on their respective reservations and on certain lands in their historical territories (off-reservation), where hunting rights were reserved or identified by treaty, executive order, or other agreement. These rights vary by tribe and IDFG has incomplete knowledge of tribal moose management and harvest; IDFG does not have data-sharing strategies with each tribe.

Coeur d'Alene Tribe regulates moose harvest by its members under a controlled hunt (lottery) system with mandatory reporting. Coeur d'Alene Tribe Wildlife Program and IDFG share their respective agency moose management plans and data (harvest records and annual population trend counts).

## Illegal Harvest

Extent of illegal harvest is difficult to accurately quantify due to low detection rates and a lack of reporting. The IDFG Report Management System and BGMR databases capture some illegal harvest, but detection levels are believed to be low and widely variable across the state. For example, since 2014 70 unlawfully taken moose have been documented, ranging from 1 in the Salmon Region to 26 in the Panhandle Region. Illegal harvest of moose results in lost opportunities for wildlife enthusiasts and hunters. Law enforcement options are available and are currently being employed by IDFG to reduce illegal moose harvest. Citizen and hunter reporting of suspicious activities may be the single best tool available to address illegal harvest.

**Management Direction:** Provide harvest opportunity while maintaining stable to increasing moose populations statewide.

> **Strategy:** Use research to inform management decisions on antlered and antlerless harvest strategies.

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

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

> **Strategy:** Continue mandatory check requirement for hunter-harvested moose, work with hunters to improve collection of biological samples from harvested moose, and improve estimates of hunter effort and success.

> **Strategy:** Explore revised, more stringent, methods of collecting quantitative antler and age data to better describe moose harvest and bull age structure.

**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 section).

> **Strategy:** Improve collaboration with tribes regarding monitoring efforts, including health and disease monitoring, and sharing harvest information.

> **Strategy**: Improve documentation of all known moose harvest mortalities in IDFG standardized databases.

# Data Analysis Units

Moose have occupied Idaho since early settlement and, over time, increased their range to include most of the state. They naturally expanded into new areas, moving west and south, and have also been translocated 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 (see Figure 2 for full map). Boundaries of DAUs are based on current knowledge of moose populations in these areas, including habitats, distribution, connectivity among populations, harvest, and other management issues (e.g., social tolerance and accessibility). A DAU can be made up of single, multiple, or partial GMUs. Two of the DAUs (Hells Canyon and Owyhee-Big Desert) do not have recognized moose populations, only occasional sightings within their boundaries.

## North Idaho DAU (GMU 1)

North Idaho DAU encompasses GMU 1 and spans Selkirk, Cabinet, and Purcell mountain ranges. The DAU is bordered by Canada, Washington, and Montana and lies just north of Lake Pend Oreille. North Idaho DAU is comprised largely of Okanogan Highlands Ecological Section, where precipitation averages 86 cm (34 in) and elevations range from approximately 518 m (1,700 ft) to 2,347 m (7,700 ft). Approximately 60% of North Idaho DAU is on Panhandle NF, with the remaining 40% split roughly equally between IDL and private land.

Predominant 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. Kootenai River valley occurs throughout the central portion of this DAU and is comprised largely of agricultural fields or landscape nurseries. Moose within this DAU use a variety of habitats, from high-elevation subalpine fir forests to open shrub fields and lower-elevation western hemlock forests.

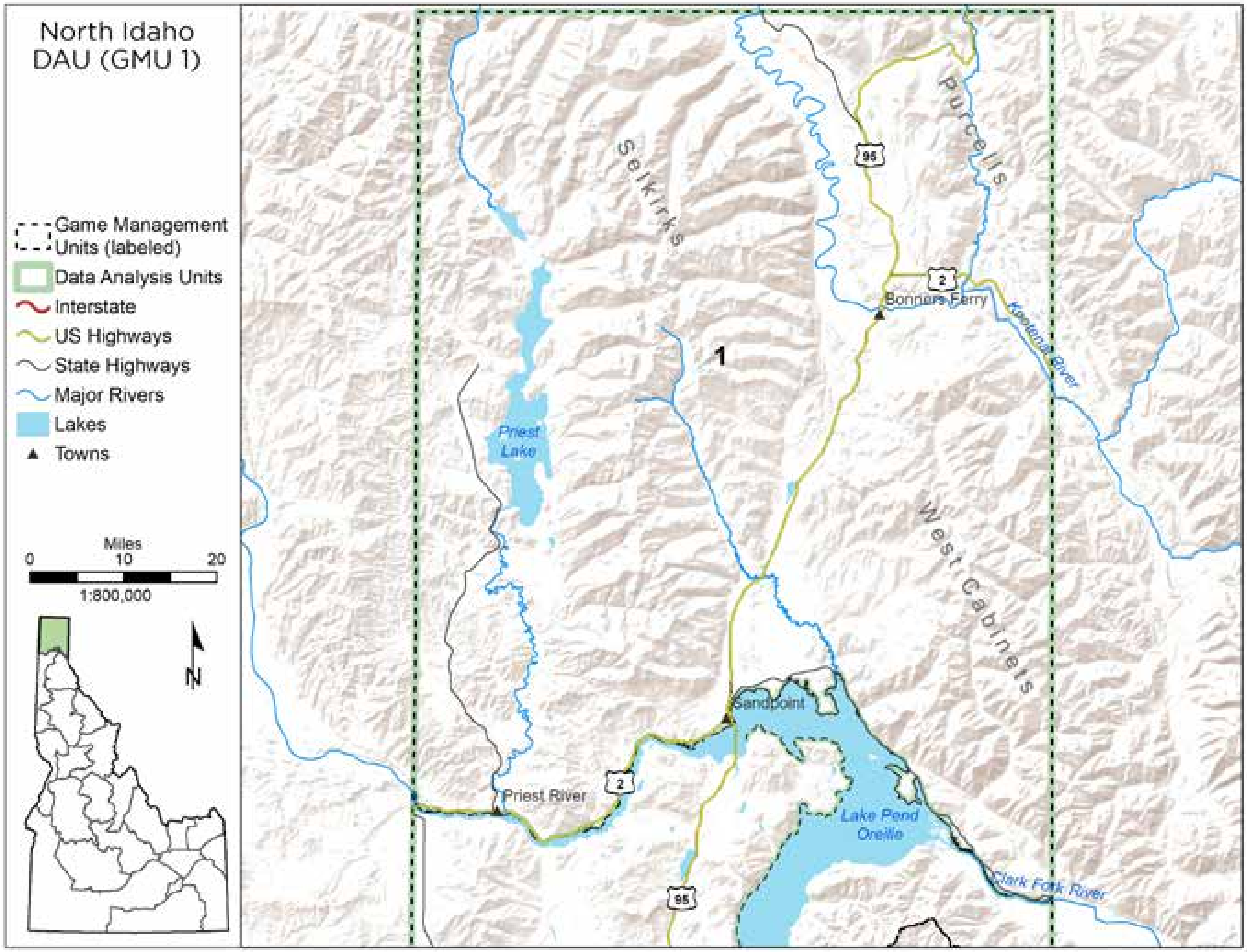
*Population and Monitoring*.— The first aerial monitoring efforts occurred in the Bonners Ferry area in 1993. The area surveyed was 35 mi² north and east of Moyie River. Records indicate estimated moose density (based on the elk sightability model) was 0.8 moose/mi². In January 2000 a survey was conducted in eastern Priest River drainage; the first intensive moose survey for the area. Population estimates ranged from 414 (1.1 moose/mi², based on the elk sightability model) to 546 (1.5 moose/mi², based on the moose sightability model developed in Wyoming [Anderson and Lindzey 1996]). 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, the survey was not completed. By extrapolation, biologists estimated approximately 0.8 moose/mi², a lower density than found in other areas in the DAU. No surveys have been conducted in North Idaho DAU since 2000. Aerial monitoring is difficult in this DAU due to dense forest cover and widespread, low-density moose populations.

*Harvest*.— The first hunts were initiated in 1970 when 2 controlled hunts totaling 3 antlered-only tags were offered in Kootenai River and Pend Oreille River drainages. By 1980 there were 4 hunts in GMU 1 with 11 tags. In 2001 9 hunt areas were condensed to 4 hunt areas; but tag levels increased from 88 to 155. In 2003, when populations were thought to be expanding, antlerless harvest was initiated in North Idaho DAU with 15 tags in Hunt Area 1-1. In 2005 2 new hunts, which ran 7 days, were added to existing hunt areas as a trial to improve drawing odds and determine how success rates changed. Hunting seasons changed again in 2007 and 2008, when all moose hunts were converted to

14-day seasons. Twenty-four controlled hunts were available, but all standard hunts were reduced from 86 days to 14 days to improve drawing odds. North Idaho DAU reached its highest tag levels in 2007 and 2008 seasons at 218 tags. Hunters liked increased chances of drawing tags for shorter hunts, but also wanted an option to apply for a longer controlled hunt. Therefore, after initial 14-day seasons, long-season hunts were reestablished in concert with shorter hunt seasons during 2009–2010. Because success rates and perceived hunt quality were declining, antlered tag levels were reduced and antlerless harvest was eliminated in GMU 1 in 2013. In 2017 hunting was closed in the northeast corner of GMU 1 due to decreased success rates and potential declining populations. Tags have continued to decline within this DAU due to low harvest success rates. There are currently 8 hunts (5 short-season, 3 long-season) available in North Idaho DAU, with a total of 95 tags.

*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 Kootenai Valley consists of agricultural fields and landscape nurseries. Over time a few moose have caused some damage to nursery plants, requiring IDFG to assist in removal of these animals. Many moose-vehicle collisions are reported in this DAU each year, primarily around McArthur Lake WMA (Figure 3). Additional data on tribal harvest would be helpful for management. Because this DAU is considered the primary moose producer in the Panhandle Region, improving methods to monitor moose to better understand population trends is important.

a

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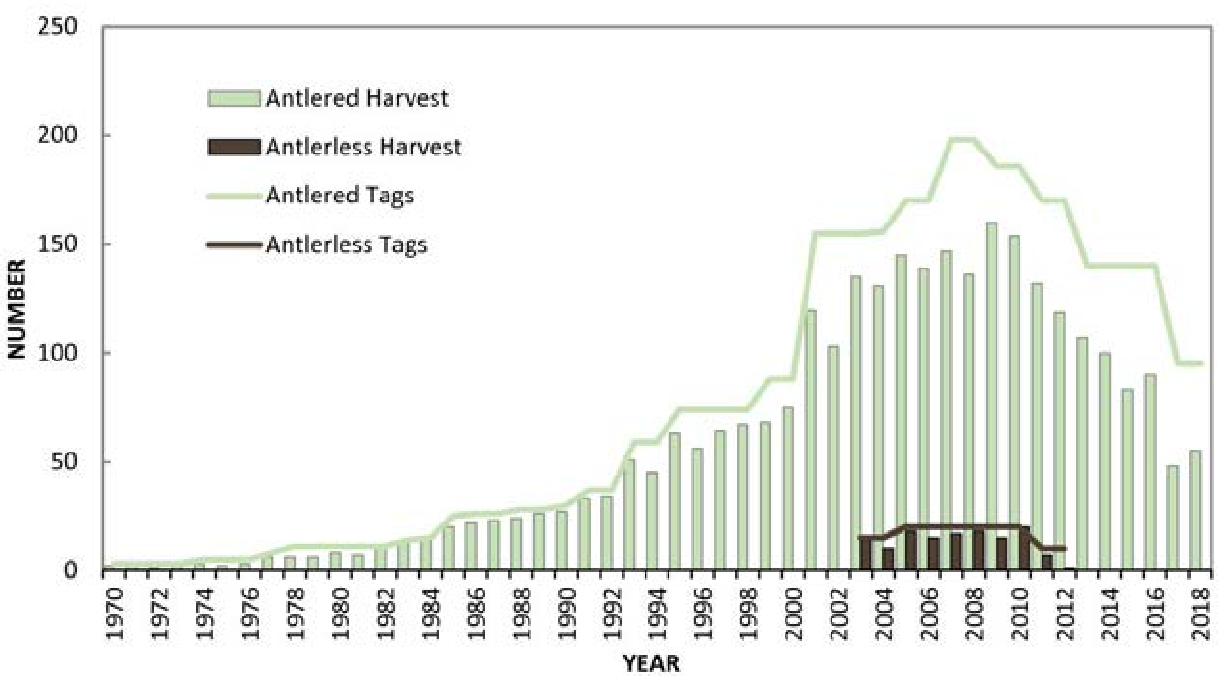


Figure 7. North Idaho DAU (a) area map and (b) moose harvest and tag allocation, 1970-2018.

## Prairie DAU (GMUs 2, 5, 8)

Prairie DAU contains GMUs 2, 5, and 8. The DAU borders Washington to the west and extends from Pend Oreille River south to the Clearwater River. Landownership is primarily private, including 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 (2,000 ft) to 1,555 m (5,100 ft). Coeur d'Alene Indian Reservation is located within this DAU and annually offers a limited number of moose tags to tribal members to use on the Reservation and ceded ground. A small portion of Nez Perce Indian Reservation is located within this DAU. Moose populations within this DAU are managed by Panhandle and Clearwater regions.

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

*Population and Monitoring*.— In December 2010 a helicopter survey was conducted in the northern portion of GMU 5, followed by a thermal infrared survey in March. The helicopter survey identified 68 moose in 18 search units. Population estimates for the Mica Peak area were 72–115 individuals. The infrared survey produced similar estimates to that of the helicopter survey; however, moose may have been missed if they were obscured by vegetation or if thermal differences between moose and the background were insufficient for detection. There have not been any recent surveys for moose by IDFG in this DAU. Coeur d'Alene Tribe has an active moose management plan and has conducted standardized ground-based surveys in portions of this DAU since 2005.

*Harvest.*— Antlered harvest started in 1986 in the DAU with 2 tags in GMU 2, followed by GMU 8 in 1990 and GMU 5 in 2007. In response to increasing moose-vehicle collisions due to an expanding population, antlerless permits were issued for the first time in 1999 (with 4 tags). The season ran from 15 October through 23 November. To address low drawing success, an experimental, short (1-week) hunt was offered in 2005 in GMU 2 in addition to a long-season hunt. In 2007 24 tags were issued in GMU 2 and 5 tags in GMU 5. Hunts in GMU 2 included both long- and short-season hunts. An antlerless hunt with 5 tags was added in GMU 5 in 2011, followed by the addition of 2 short-season hunts in 2015. Due to numerous moose-vehicle collisions and urban moose issues, antlerless tags peaked in GMU 2 in 2012 at 40 tags. As nuisance moose problems and vehicle collisions declined, antlerless tags were reduced to 20 in GMU 2 in 2017, and eliminated in 2019. Antlered tags were also reduced in 2019 in this DAU due to concerns about potential population declines. Coeur d'Alene Tribe Wildlife Program shares their moose harvest records with IDFG.

*Current Issues.*— The vast majority of this DAU consists of private property, creating significant challenges for implementing large-scale management actions for moose. However, collaboration with land management agencies and private forest landowners may provide opportunity to improve availability of early seral vegetation communities which moose prefer. Additional information about how forest management herbicide applications affect available moose habitat and forage is needed. Ascertaining impact of harvest on moose populations is difficult, although anecdotal evidence suggests harvest impact could be substantial. Additional data on tribal harvest would be helpful for management. Heavy tick loads have been documented on moose, particularly calves and yearlings; however, population-level impact of these parasites is not known. Symptomatic moose, which appear blind and uncoordinated, sometimes turning in circles, have also been recorded. Continuing to work with hunters to collect success rates, days to harvest, antler spread measurements, and various biological samples is vital. Urban moose issues can occur within this DAU, typically during winter or spring, but are infrequent. Moose are relocated from urban areas where public safety is a concern. Identifying vehicle collision hotspots and working with Idaho Transportation Department and land management agencies will improve safe passage for moose and other wildlife.

Moose CCBY IDAHO FISH AND GAME

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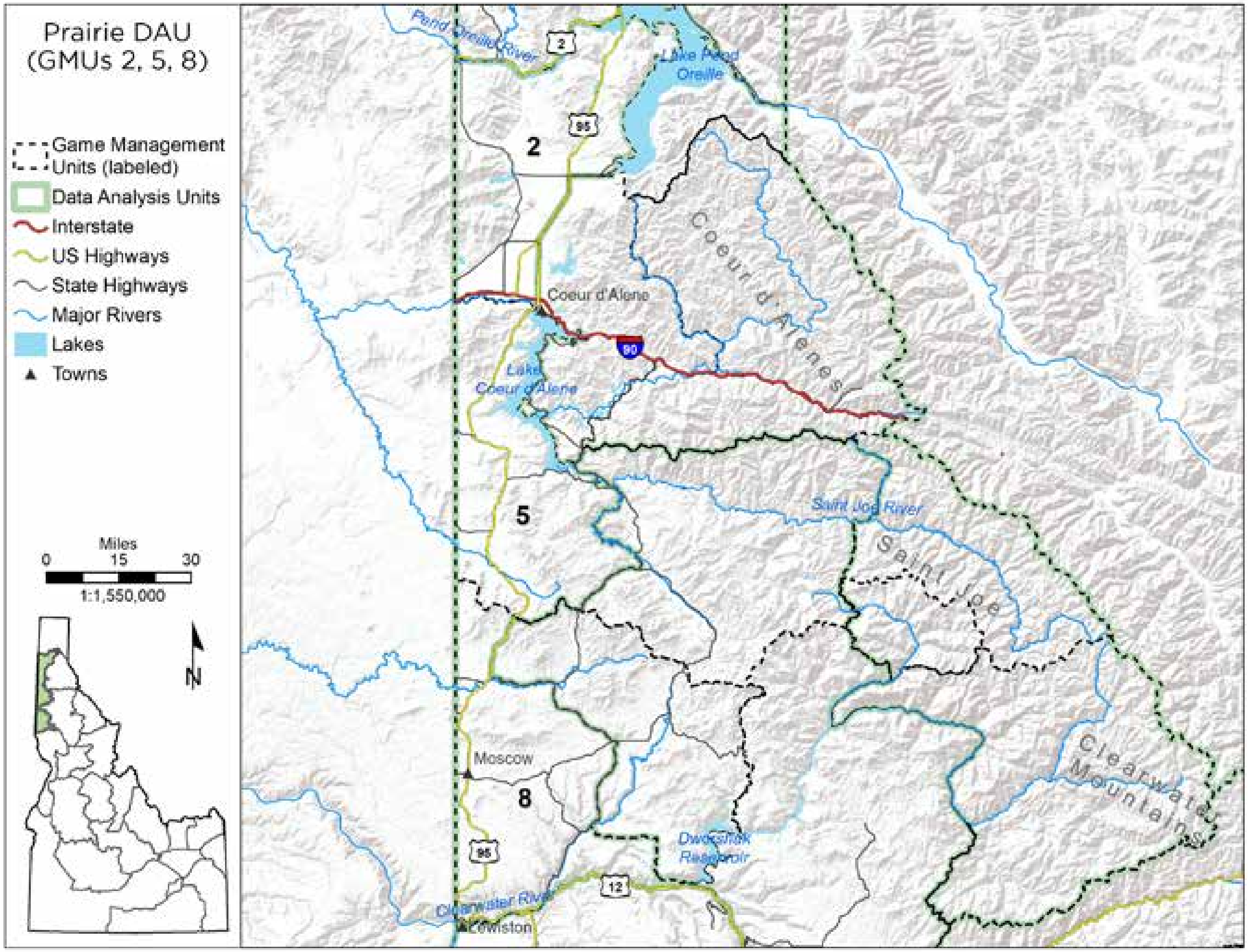


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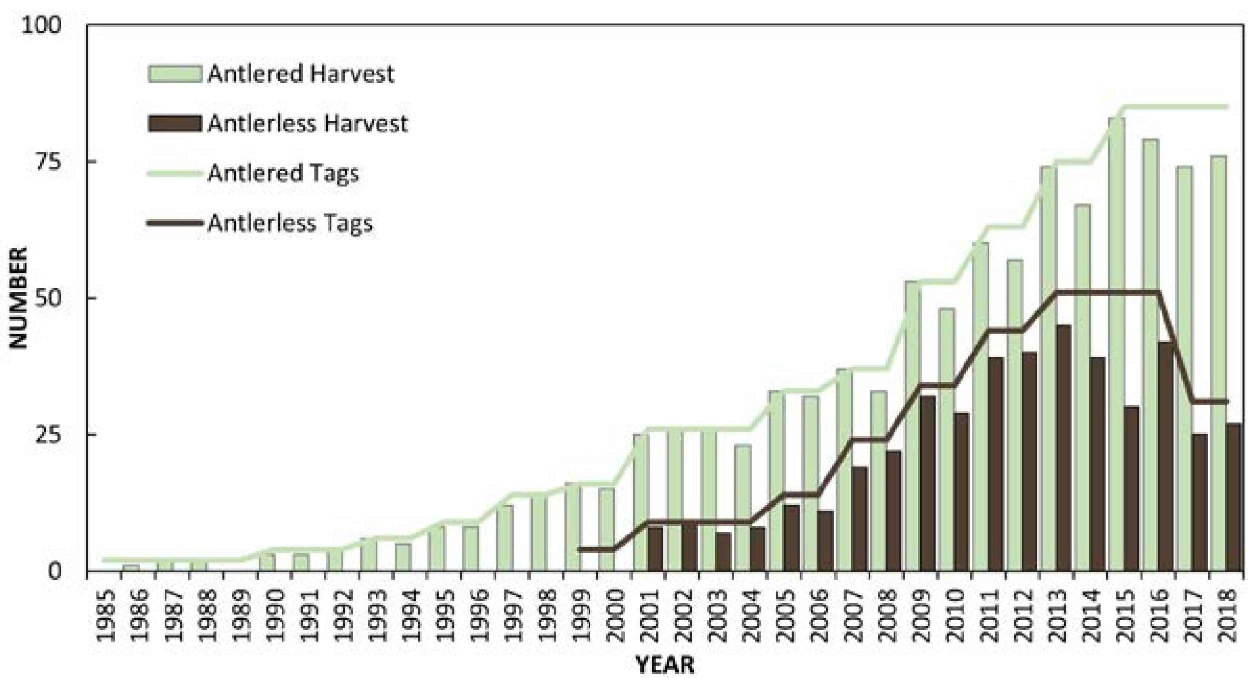


**Figure 8. Prairie DAU (a) area map and (b) moose harvest and tag allocation, 1985-2018.**

## Lower St. Joe-Dworshak DAU (GMUs 6, 8A, 10A)

The majority of moose habitat within the Lower St. Joe-Dworshak DAU is found within the Bitterroot Mountains Ecological Section. The DAU encompasses GMUs 6, 8A, and 10A and is bounded to the north by lower St. Joe River drainage and terminates to the south at the Clearwater River, encompassing Dworshak reservoir. Lower St. Joe-Dworshak DAU occurs within both Panhandle and Clearwater regions. Precipitation averages 84–97 cm (33–38 in) per year and elevations range from approximately 300 m (1,000 ft) to 1,920 m (6,300 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 one-half of the DAU is private land, with the remainder managed by either IDL or NF, including portions of St. Joe and Clearwater-Nez Perce NFs. 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, most moose occur on forested lands. Coeur d'Alene and Nez Perce reservation boundaries encompass small portions of this DAU. Terrain is of moderate ruggedness and can be broadly classified as frontcountry or midcountry areas with high levels of access, in contrast to more rugged and remote backcountry areas to the east.

Dominant forest types within this DAU include shade-tolerant tree species which 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 extensive, as they were in backcountry areas to the east. 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*.— Population surveys have not been conducted in this DAU; however, moose sightings are recorded incidental to elk surveys. Moose in northern Idaho typically occur at low densities and occupy densely forested lands, which make monitoring populations difficult. Moose commonly use closed-canopy forests to escape deep snow or warm temperatures, resulting in low detection probabilities which make sightability model estimates unreliable. Due to these challenges, harvest data, including percent success, number of days hunted, and antler spread have been used to adjust tag levels. For example, declining success rates and increasing hunter effort typically indicate a declining population; however, small sample sizes, accessibility, and individual hunter preferences can confound interpretation of harvest data. Alternatives to harvest data as the primary monitoring tool are needed. Currently, IDFG is monitoring adult cows in portions of this DAU to help understand population drivers.

*Harvest.*— Overall, harvest data indicates 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 GMU 6 in 1970 with 3 tags and continued through 1973. Hunting restarted in GMU 6 in 1988 with 2 tags. Hunts began in 1980 for GMU 10A and 1993 for GMU 8A (2 tags each). In 1999, when populations were thought to be expanding, a 40-day antlerless hunt was opened in GMU 8A with 4 tags to reduce vehicle collisions and conflicts with people. In 2005 an experimental 1-week antlered hunt consisting of 5 tags was added in GMU 6. The short-season framework was designed to provide more hunting opportunity and thus improve draw success compared to long-season hunts. However, in 2007 the 1-week hunt within GMU 6 was converted to a 2-week hunt. Hunters could choose either a long-season hunt with lower draw success or a short-season hunt with higher draw success. In 2009 hunters could apply for 1 long-season hunt which ran for 78 days or between 2 2-week season hunts with higher draw success. The hunt within GMU 8A remained an 84-day hunt. In 2015 GMU 6 reached its highest tag level with 30 tags and 10 tags were offered in GMU 8A. In 2019 all antlerless hunting opportunity was removed in this DAU and antlered tags were reduced 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. Coeur d'Alene Tribe Wildlife Program shares their moose harvest records with IDFG.

*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 increases early seral browse availability, corporate timber companies have started to spray herbicides on shrub species which grow after harvesting an area. Additional information about how these herbicide applications affect available moose habitat and forage is needed. Timber harvest practices have also resulted in loss of security and thermal cover for moose. Collaboration with private forest landowners and land management agencies may provide opportunities to improve availability of early seral vegetation communities which moose prefer.

Harvest rates have remained relatively stable throughout this DAU; however, with apparent declines in adjacent moose populations (and consequent tag reductions), managers will need to monitor productivity of moose populations with methods other than harvest data. Additional data on tribal harvest would be helpful for management. In addition, roles of predation, parasites, and disease are unknown and warrant further investigation. Statewide management directions aim to identify potential threats and mitigate negative impacts wherever possible.

Moose Cow CCBY IDAHO FISH AND GAME

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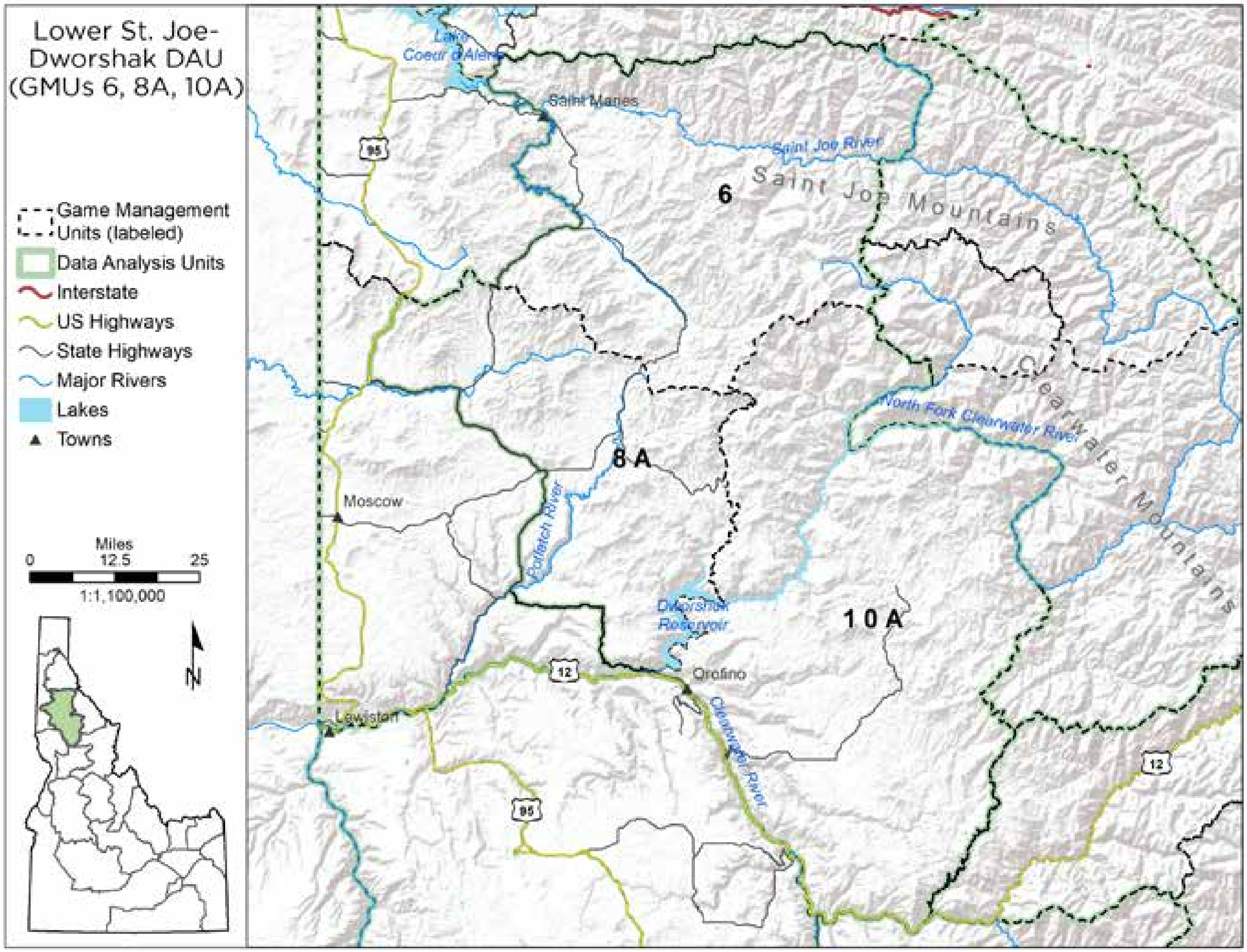


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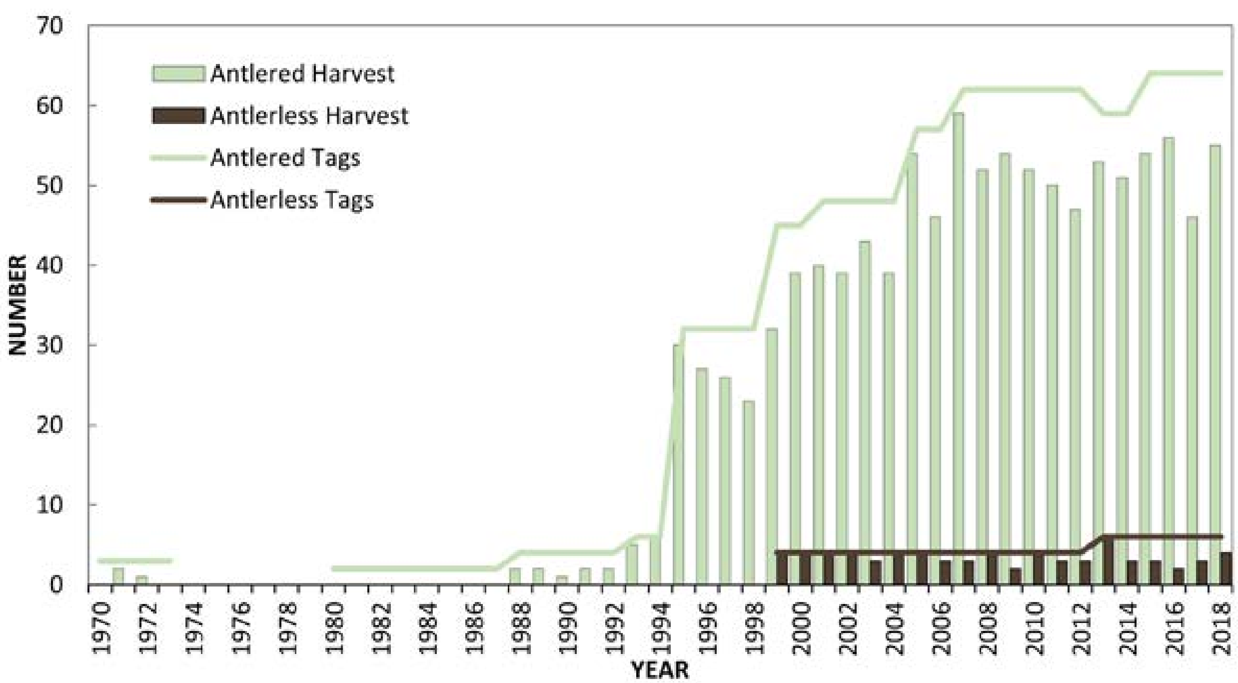


Figure 9. Lower St. Joe-Dworshak DAU (a) area map and (b) moose harvest and tag allocation, 1970-2018.

## Upper St. Joe-CDA DAU (GMUs 3, 4, 4A, 7, 9, 10)

Upper St. Joe-CDA DAU encompasses GMUs 3, 4, 4A, 7, 9, and 10. Ownership within this DAU is mostly public and managed by U.S. Forest Service (USFS), including Coeur d'Alene NF and portions of St. Joe and Nez Perce-Clearwater NFs. Coeur d'Alene Indian Reservation encompasses a small portion of this DAU. The western border includes urban areas of Coeur d'Alene and Hayden. The northern portion runs along Clark Fork River and continues south across I-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 >102 cm (40 in) per year, falling mostly as snow. Elevations range from approximately 610 m (2,000 ft) to 2,347 m (7,700 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, which offer little forage for moose. 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 which have persisted through time, particularly on southern aspects. Timber harvest also created early seral habitat throughout parts of the DAU. Mature conifer stands retained adjacent to foraging areas provide important cover for snow interception, as well as shade in summer. Despite deep snow, some moose within the southern portion of this DAU winter at high elevations in spruce-subalpine fir communities.

*Population and Monitoring*.— Population surveys have not been conducted in this DAU. However, incidental sightings of moose were documented during elk surveys in GMUs 4, 7, and 10. Incidental sightings would have more value if coupled with other demographic or population monitoring efforts. Aerial monitoring is difficult in northern Idaho due to dense forest cover and widespread occurrence of moose 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 I-90. An additional hunt was added in 1991 by splitting the hunt area in GMU 7. Also, GMU 3 was added into hunts that occurred within GMU 4 in 1991. In 1999 hunts that occurred within combined areas of GMU 3 and 4 were split into 2 new hunt areas. Hunting in GMU 4A started in 2007 with 5 tags. In 2007 2-week hunts were established within GMUs 3, 4, 7, and 9 in addition to long-season hunts. The short-season framework was incorporated to improve drawing odds by providing hunters a choice among 78-day seasons or 2-week seasons. Additional 2-week hunts were added to GMUs 3 and 4 in 2011. Hunter success has varied, but remained fairly high across these GMUs, ranging 60–100% in 2016. However, with relatively low tag levels, hunter success rates can vary drastically among years. Tag levels in GMU 10 gradually increased from 2 tags in 1975 to 32 tags in 2005. In 2013 tags were reduced to 27 because of population concerns. In 2019 additional decreases in tag levels occurred across much of the DAU in response to varying success rates and anecdotal observations of a declining moose population. Coeur d'Alene Tribe Wildlife Program shares their moose harvest records with IDFG.

*Current Issues*.— Many important early seral forage species, such as Ceanothus spp. and willow spp., 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 lack of timber harvest, particularly on NF lands, resulted in a late-seral bulge across much of this DAU, which likely reduced forage availability. This DAU has some of the highest precipitation rates in the state, resulting in productive forests which require

Bull Moose CCBY IDAHO FISH AND GAME

recurring disturbance to maintain early seral forage species. In addition to creating early seral habitats where they are limited, prescribed burning in existing shrub fields that are commonly decadent and provide little forage within browsing reach of moose would enhance forage availability.

Although generally beneficial, timber harvest practices influence 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 negate any forage benefits afforded by timber harvest and should be avoided. Working with corporate timber companies to reduce herbicide spraying impacts and enhance habitat management after logging would be beneficial.

Little is known about impacts 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 conducted 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 for adult moose. In contrast, calf mortality due to wolves was high (6 of 12 radio-marked animals) in the only year (2011) calves were collared (IDFG 2013).

Human development is not a major issue within this DAU; however, increased access in some areas, such as GMU 3, has increased potential for vehicle collisions and unlawful harvest. Additional data on tribal harvest would be helpful for management.

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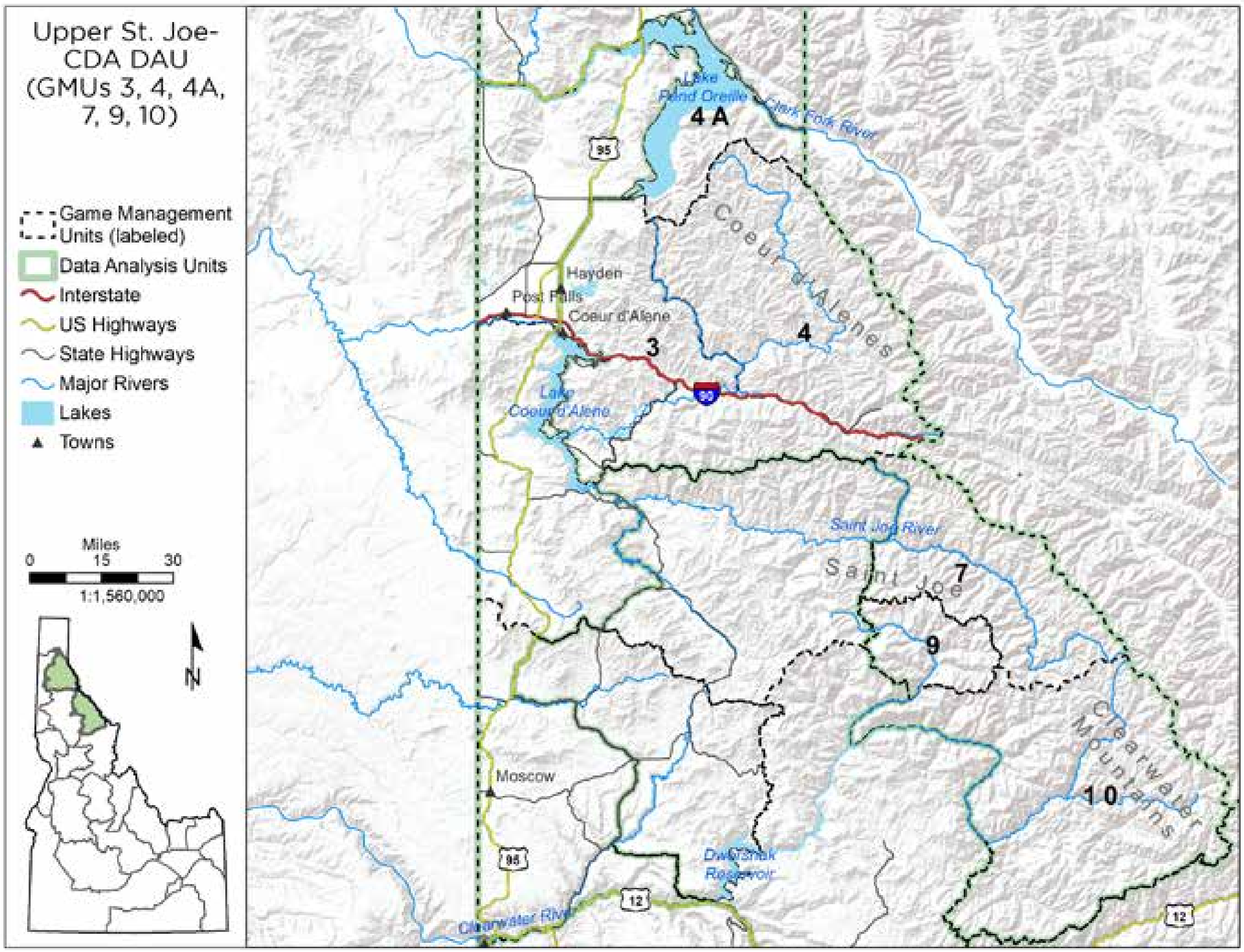


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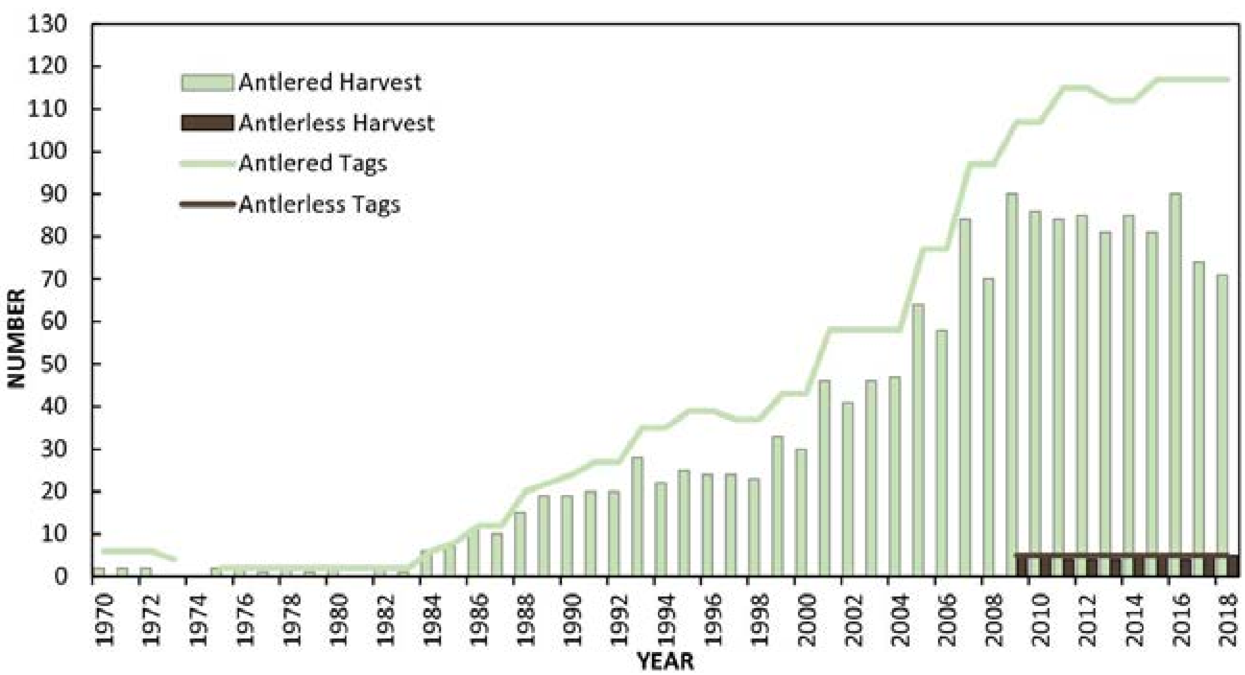


Figure 10. Upper St. Joe-Dworshak DAU (a) area map and (b) moose harvest and tag allocation, 1970-2018.

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

Hells Canyon DAU is comprised of GMUs that contain little suitable moose habitat. The northern one-half of the DAU (GMUs 11 and 11A) is 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 within the Nez Perce Indian Reservation. The agricultural landscape transitions to forested lands and dry, canyon grasslands to the southwest. The southern half of the DAU (GMUs 13, 18, 22) is within the Blue Mountains Ecological Section and precipitation ranges from as little as 23 cm (9 in) in valleys to >102 cm (40 in) in mountainous regions. Landownership is predominantly private in GMU 13, whereas 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.

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

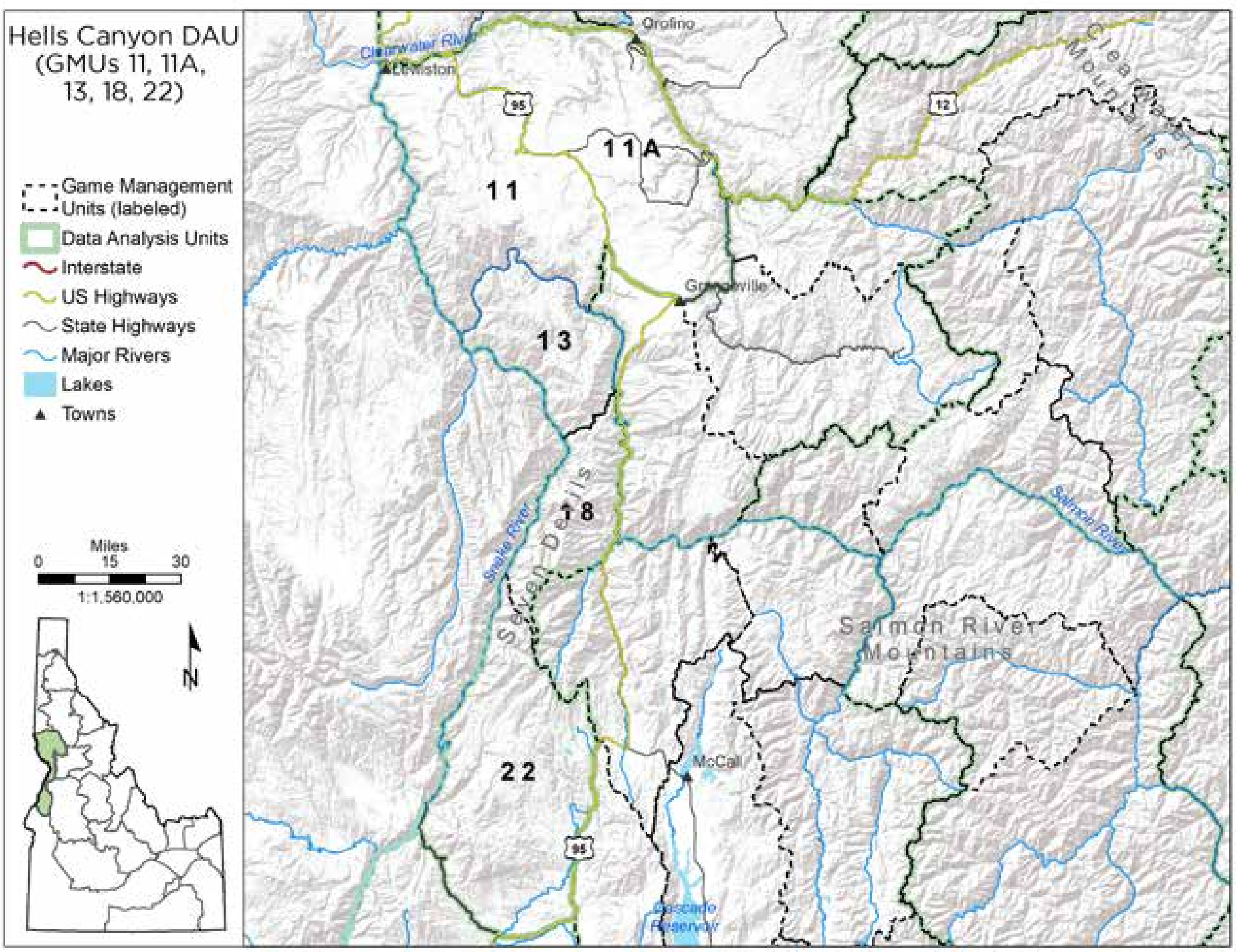


**Figure 11. Hells Canyon DAU area map**

## Elk City DAU (GMUs 14, 15, 16)

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. Precipitation averages approximately 76 cm (30 in) per year and elevations range from approximately 360 m (1,200 ft) to 2,440 m (8,000 ft). The dominant forest type is grand fir (GMUs 14, 15), whereas dry slopes along the western edge (GMU 14) are dominated by 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. More than 80% of this DAU is within Nez Perce-Clearwater NF, including approximately 140 $mi^2$ within the Gospel-Hump Wilderness Area, with remaining land privately owned. Terrain is moderately rugged with moderate to high access 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 which 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 in 2014 and 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. More than 80,000 acres have burned in GMU 14 since 2000. Areas burned by forest fires or affected by timber harvest activities generally support a greater abundance of high-quality forage, such as willow species and redstem ceanothus. Lower-quality forage species, such as 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, which provide important winter forage 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, whereas 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 of 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 interpretation of harvest data.

*Harvest*.— Moose harvest started with <10 antlered tags in the early 1970s. Anecdotal observations and harvest data suggested an underutilized population and 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.*— Based on harvest data, moose populations have declined tremendously since the 1980s, and identifying causes of these declines is a management priority. Lack of alternative monitoring tools, specifically in absence of any harvest data, limits IDFG's ability to monitor basic demographic trends. Development of additional population monitoring tools will be needed to evaluate effectiveness of any management strategies. Additional data on tribal harvest would be helpful for management.

Little disturbance has occurred in GMU 15 since the early 1900s and forest succession could be reducing 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 reinvigorating existing decadent shrubs fields. Investigation of alternatives to disturb decadent shrub fields, such as "conifer release" via chainsaw cutting and herbicide top kill, is warranted, particularly where prescribed burns are not feasible.

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

Moose Cow and Calf CCBY IDAHO FISH AND GAME

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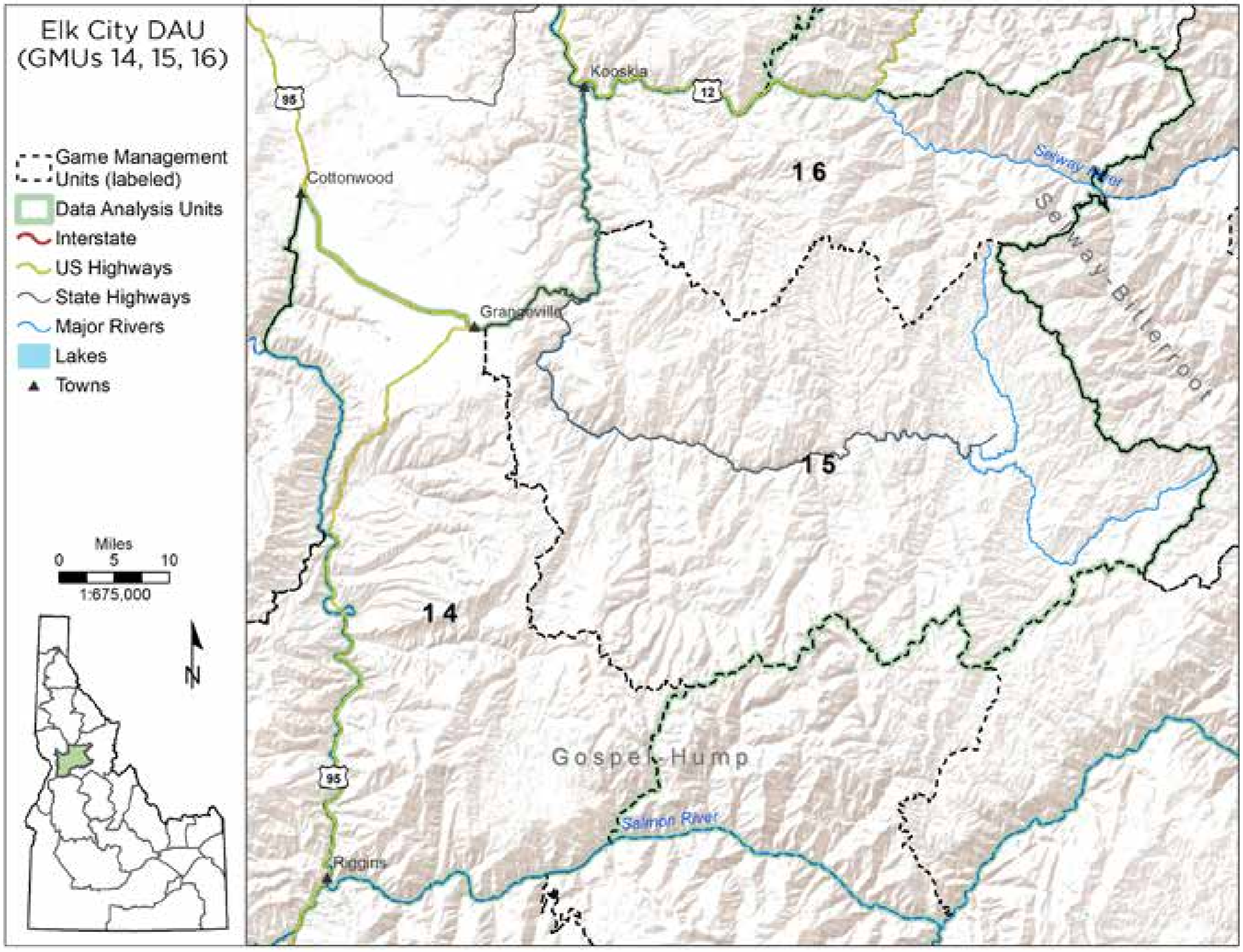


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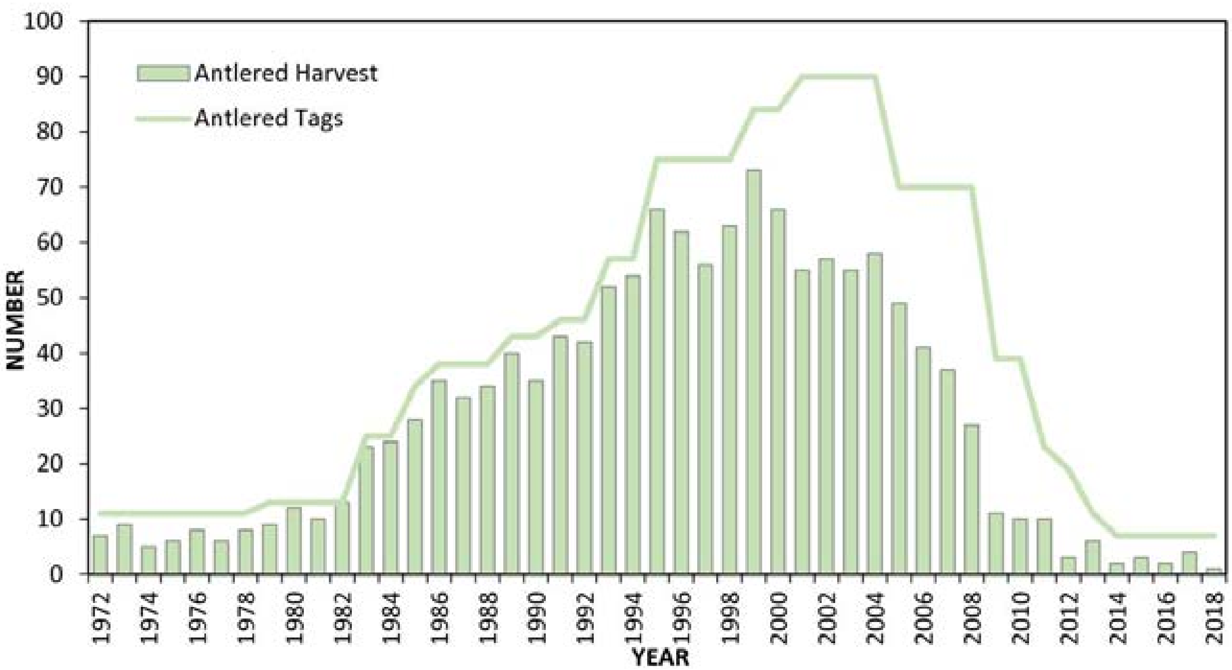


**Figure 12. Elk City DAU (a) area map and (b) moose harvest and tag allocation, 1972-2018.**

## Lochsa-Selway DAU (GMUs 12, 16A, 17, 19, 20)

Lochsa-Selway DAU lies primarily 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) farther south. Elevation ranges from approximately 430 m (1,400 ft) to >2,440 m (8,000 ft). Western red cedar forest types are found north of the Lochsa River, whereas subalpine fir is the dominant forest type to the south. Significant amounts of Douglas-fir are found at lower elevations on dry aspects along Selway and Salmon rivers, frequently transitioning to grand fir at higher elevations, followed by subalpine fir. Landownership within Lochsa-Selway DAU is almost entirely Nez Perce-Clearwater NF, including >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 due to limited access and rugged terrain, resulting in forest fires as the dominant form of disturbance. Large forest fires burned vast areas in the early 1900s, creating abundant moose habitat. During the past 2 decades, forest fires have only burned large areas within the Selway-Bitterroot Wilderness Area, leaving much of the DAU in late-seral forest types. Moose in 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, which make monitoring populations difficult. Moose commonly use closed-canopy forests to escape deep snow or warm temperatures, resulting in low detection probabilities, which make sightability model estimates unreliable. Due to these challenges, harvest data, including percent success, number of days hunted, and antler spread, is used to adjust tag levels. Declining success and increasing hunter effort typically indicate a declining population; however, small sample sizes, accessibility, and individual hunter preferences can confound interpretation of harvest data. No moose surveys are conducted in this DAU, but incidental observations are recorded during elk sightability surveys. Incidental counts are of limited value because of low detectability and not all moose habitat is surveyed.

*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 with the understanding 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 tags were gradually increased until peaking in the mid-1990s at 134 antlered tags. In response to declining hunter success, tags were reduced to 100 in 2001. Hunter success did not improve and further cuts were made until hunts were closed in 2013 in GMUs 16A, 17, 19, and 20. Tag levels were also reduced in GMU 12, although declines were not as severe as in populations further south, and 16 antlered tags currently remain.

*Current Issues.*— Based on harvest data, moose populations have declined tremendously, and identifying causes of these declines is a management priority. Most of the DAU no longer supports hunting and lack of monitoring tools limits IDFG's ability to monitor basic demographic trends. Development of additional population monitoring tools will be needed to evaluate effectiveness of any management strategies. Additional data on tribal harvest would be helpful for management.

Little disturbance has occurred in GMU 12 since the early 1900s and forest succession could be reducing 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 reinvigorating existing decadent shrubs fields. 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 forage conditions for moose; however, without a population monitoring tool, responses of moose to these burns is unknown. 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 elevations, which could exclude or delay establishment of forage shrubs post disturbance. Finally, roles of predation, parasites, and disease are unknown and warrant further investigation.

Moose CCBY IDAHO FISH AND GAME

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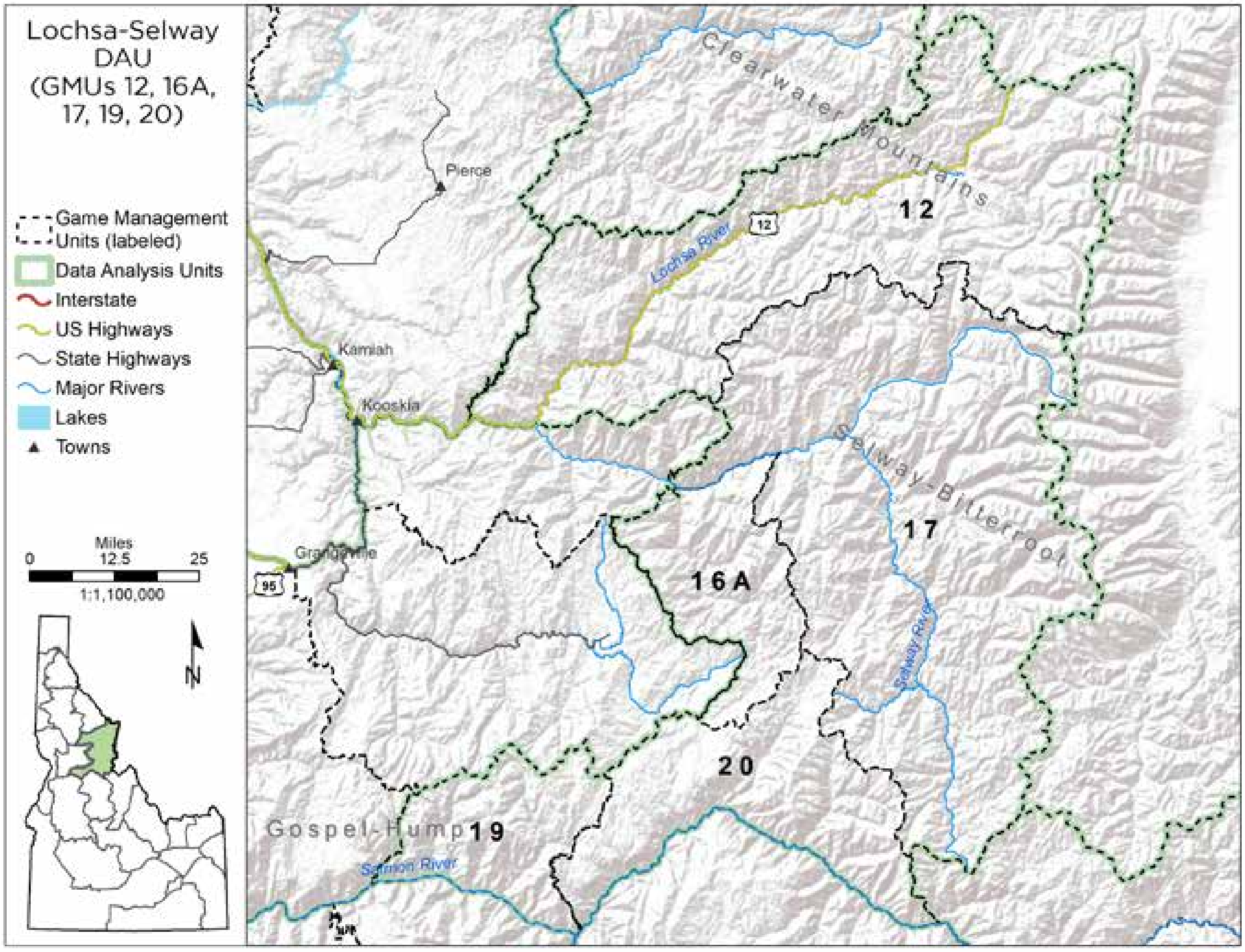


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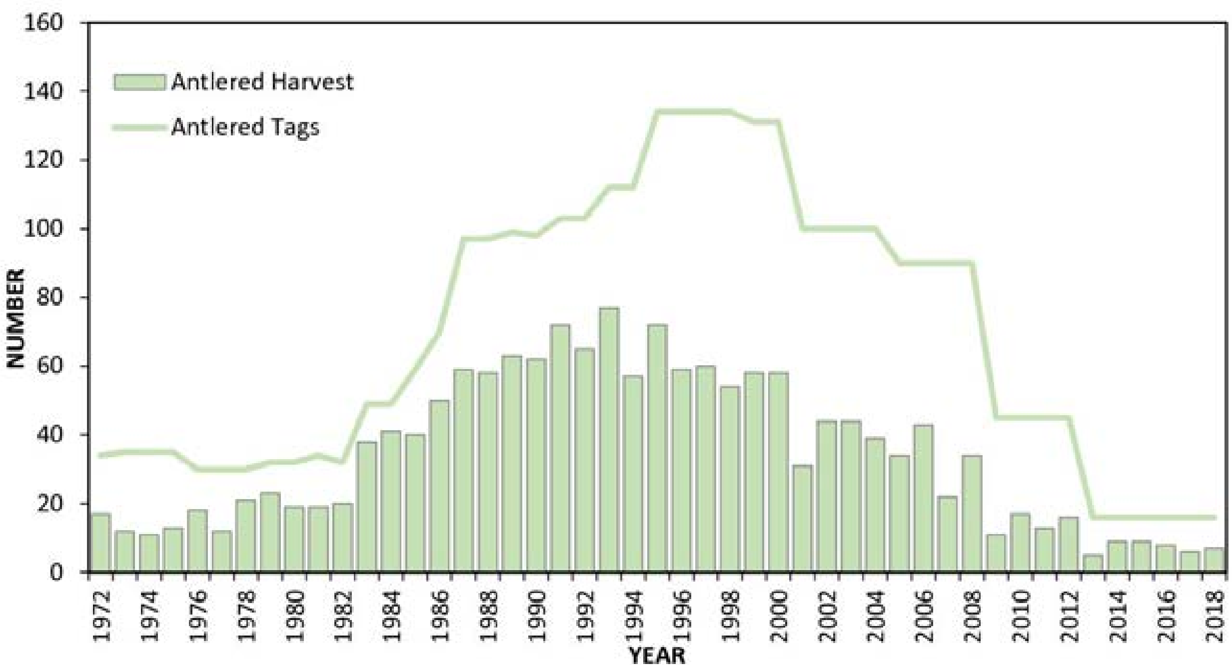



Figure 13. Lochsa-Selway DAU (a) area map and (b) moose harvest and tag allocation, 1972-2018.

## McCall DAU (GMUs 19A, 23, 24, 25, 32A, 33, 34, 35)

McCall DAU supports low densities of resident moose and contains little suitable moose habitat. The DAU is almost entirely within the Idaho Batholith Ecological Section, with smaller portions in the Owyhee Uplands Ecological Section. Precipitation ranges from <25 cm (10 in) in Owyhee Uplands to >76 cm (30 in) in mountainous regions. Public land is common, including large portions of Payette and Boise NFs. Lower-elevation valleys are predominantly private land but 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 densities of moose occur in more mountainous areas farther east. These areas receive more 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, alder, serviceberry, willow, and others. During summer, moose frequently utilize 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 managers determined 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 winter and 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. Both hunts were closed in 2011 due to poor harvest rates 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. However, IDFG will continue to trap, sample, and relocate moose that wander into urban areas and take advantage of opportunities to sample for disease.

Moose CCBY IDAHO FISH AND GAME

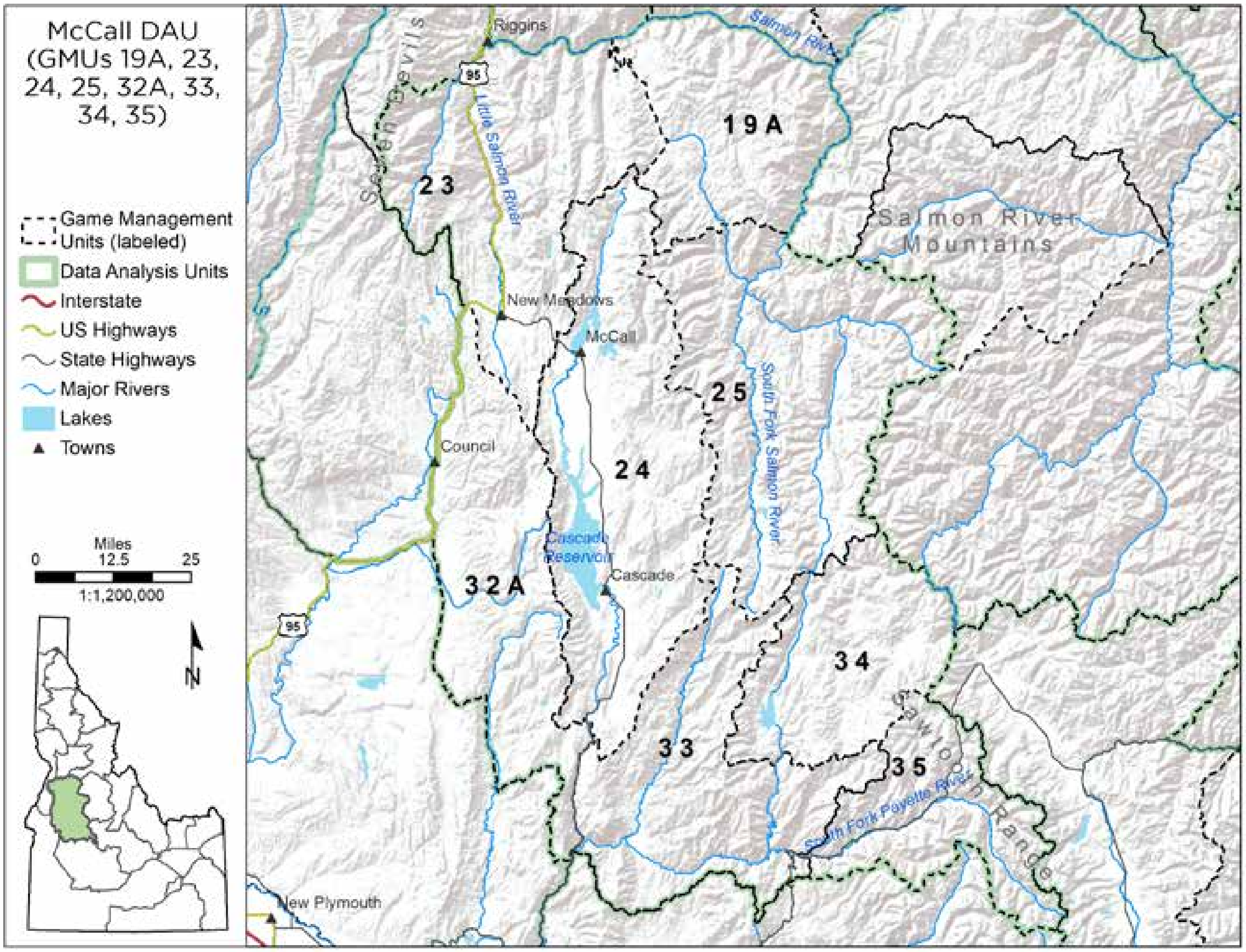



Figure 14. McCall DAU area map.

Bull Moose CCBY Bill Brophy

## Smoky-Bennett DAU (GMUs 39, 43, 44, 45, 48, 52)

Smoky-Bennett 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 upper reaches of South Fork Boise River and Big Wood River watersheds. Several mountain ranges occur in the DAU, including Boise Mountains (GMU 39), Trinity Mountains (GMUs 39 and 43), Soldier and Smoky mountains (GMUs 43 and 44), Boulder Mountains (GMU 48), and Bennett Mountains (GMU 45). More than 65% of the DAU is managed by federal and state agencies, including Sawtooth and Boise NFs, BLM, and IDL.

Smoky-Bennett DAU falls within 4 ecological sections: Idaho Batholith, Owyhee Uplands, Challis Volcanics, and Snake River Basalts. Due to diverse topography and elevation gradients within the DAU, precipitation varies widely. Northern and more mountainous portions can receive up to 89 cm (35 in) of precipitation per year, whereas the southern expanse may receive <30 cm (12 in) per year. Elevation ranges from <762 m (2,500 ft) along the Snake River to >3,350 m (11,000 ft) in the upper Big Wood watershed. Douglas-fir, mixed dry conifer, and spruce are dominant forest types throughout the northern part of the DAU. At low elevations, 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 mid- to higher elevations provide forage 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 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 to 2000, 31 moose were released in GMUs 43 and 44. Translocations 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 in 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. Currently, moose numbers appear 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.

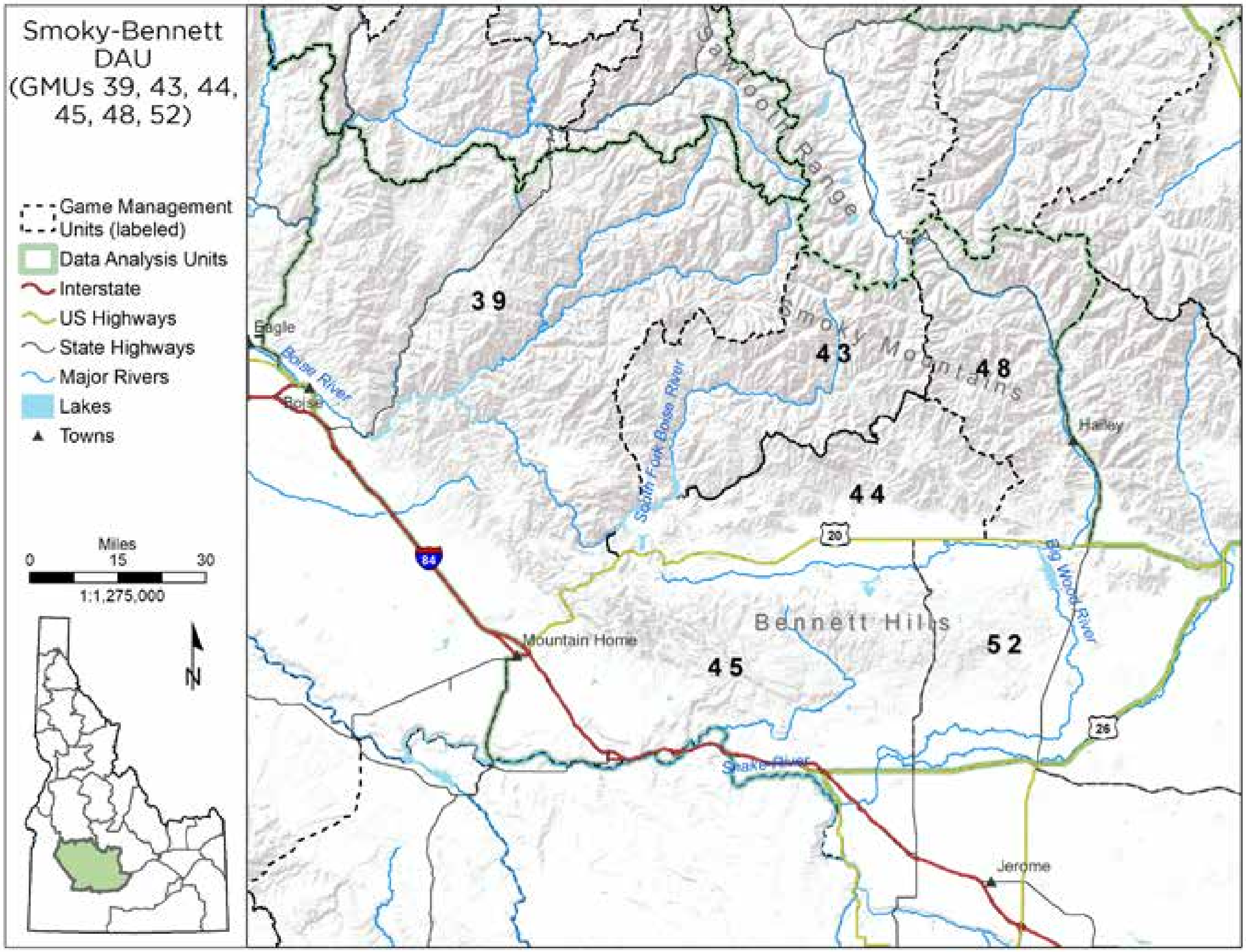
Population surveys of moose have not been conducted in the Smoky-Bennett DAU due to low densities and difficulty in finding individuals across a large area. However, opportunistic documentation of moose during aerial surveys for deer and elk provided a small dataset on moose numbers, locations, and demographics. Due to differences in winter habitat selection by moose in comparison to deer and elk, some habitat patches used by moose are likely not surveyed, thereby reducing utility of these data to make inferences about population trajectories. Historically, harvest data (hunter success rates, days hunted, and antler spread) and 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 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 one-half of Silver Creek Valley, Hunt Area 44 boundary was expanded in 2019 and includes the northern portion of GMU 52.

*Current Issues*.— A deficiency in baseline knowledge of moose populations within the Smoky-Bennett DAU has made management decisions regarding moose challenging. Improving survey methods for monitoring moose populations would improve understanding of population dynamics and habitat use within the DAU and increase 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 develop management strategies to improve conditions for moose throughout the DAU. Additional data on tribal harvest would be helpful for management.

Moose CCBY IDAHO FISH AND GAME

**a**

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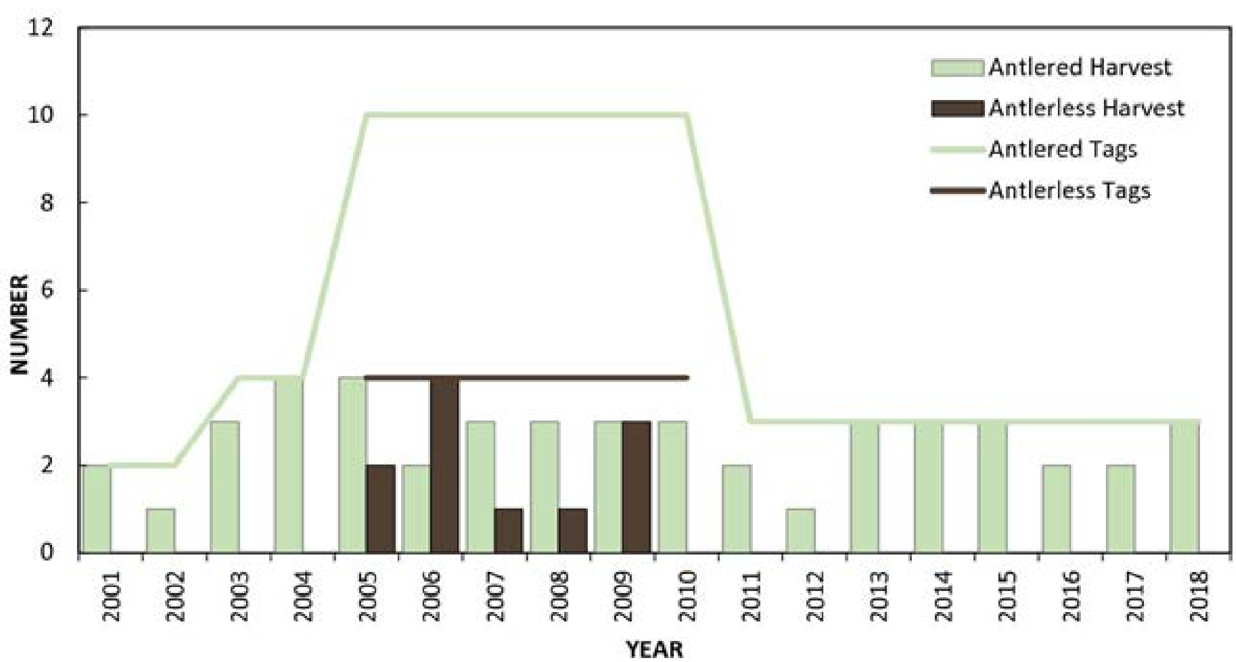



**Figure 15. Smoky-Bennett DAU (a) area map and (b) moose harvest and tag allocation, 2001-2018.**

## Owyhee-Big Desert DAU (GMUs 31, 32, 38, 40, 41, 42, 46, 47, 52A, 53, 68)

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 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 2,620 m (8,600 ft) in the Owyhee Mountains to just over 610 m (2,000 ft) in the Owyhee River canyon. The Snake River, from below American Falls Reservoir to the Oregon border, bisects the DAU and Owyhee Mountains occupy the southwestern corner. Deep canyons and vast expanses of sagebrush and western juniper cover most of the area. Large wildfires in the past decade have converted >1 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 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 primarily limited to moose immigrating from adjacent DAUs with higher moose densities. Transient moose in urban areas along the Snake River Plain 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 incidental observations of moose, mostly 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 daily movements, seasonal migrations, 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. However, IDFG will continue to trap, sample, and relocate moose that wander into urban areas.

Moose CCBY IDAHO FISH AND GAME

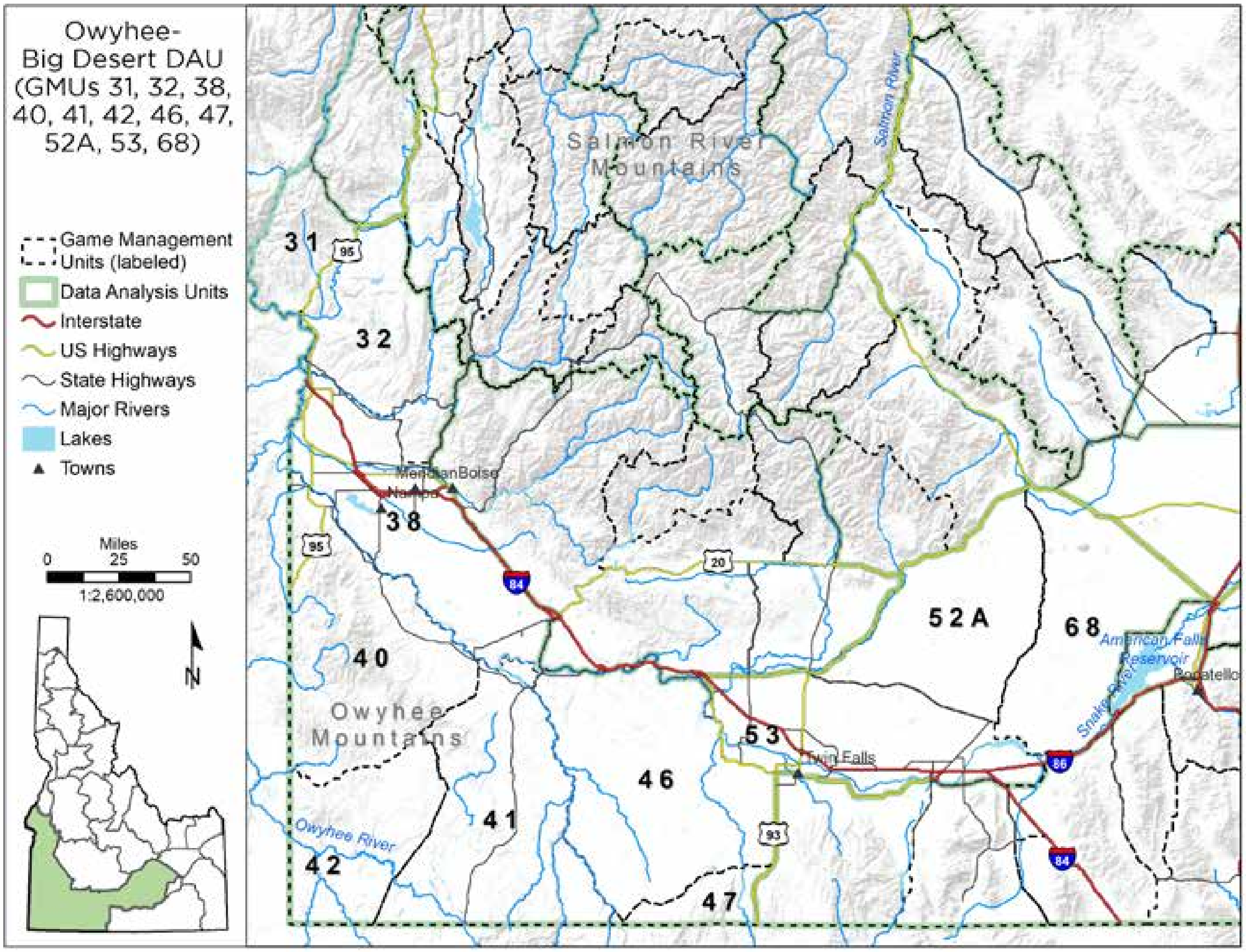



Figure 16. Owyhee DAU area map.

## Bannock DAU (GMUs 54, 55, 56, 57, 70, 71, 73, 73A, 74)

Bannock DAU is comprised of several southern Idaho mountain ranges: South Hills (GMU 54), Albion (GMU 55), Sublett (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 Caribou-Targhee and Sawtooth NFs, Twin Falls and Idaho Falls BLM districts, and IDL.

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 and agriculture dominate valley bottoms; Utah juniper, desert shrub, and sagebrush dominate mid-elevations; and habitats at higher elevations include sagebrush, aspen, and spruce-fir.

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

*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. Expansion of moose in the DAU occurred from east to west over a period of years or decades. In several GMUs, 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 present (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 were documented (location, numbers, age, and gender of adults) during mule deer population surveys. Because these surveys were not moose-specific, much of the area potentially inhabited by wintering moose was not surveyed, reducing utility of these data to make inferences about population change. 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, 5 in GMU 74, and an additional 5 in a new hunt in 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 season was implemented in GMUs 56, 73, and 73A (5 tags combined). In 2011 antlered-only 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 to 6 antlered-only tags and an antlerless hunt began (2 tags). In 2015 tag levels were reduced in some areas for the first time (to 6 antlered and 5 antlerless tags in GMU 71). However, the 2015 season was the first time every GMU in the Bannock DAU offered moose hunting opportunities, including an antlered-only season in GMU 54 (1 tag) and antlerless harvest seasons in GMUs 73 (3 tags) and 74 (2 tags). In 2019 antlerless tags in GMU 71 were reduced to 3, antlered tags in GMU 54 were increased to 3, and the hunt in GMUs 55, 56, and 57 was split (3 tags in GMU 56 and 3 tags in 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 remained more stable, with a peak of 29 individuals in 2013. Antlerless harvest ranged from a minimum of 2

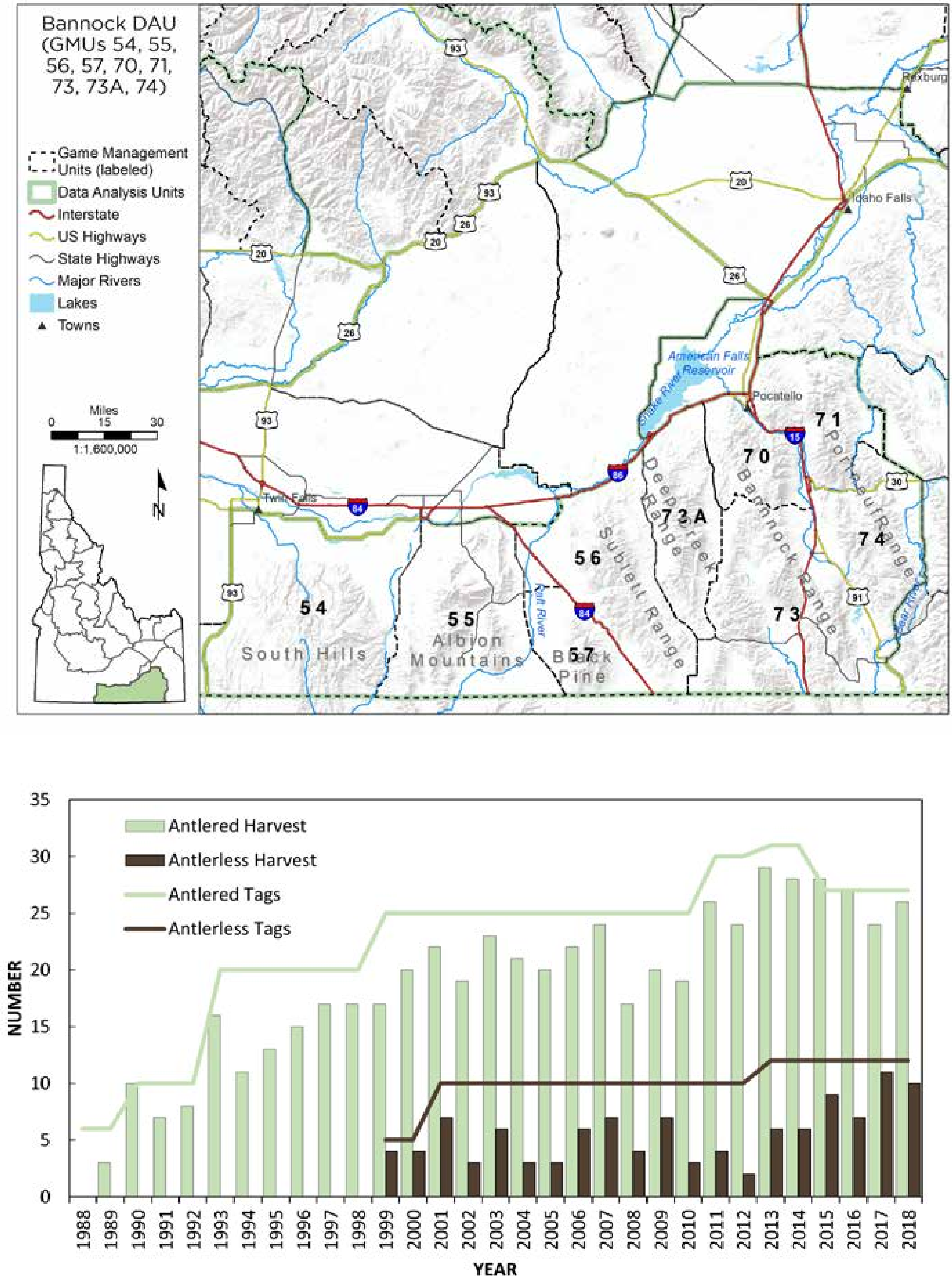



Figure 17. Bannock DAU (a) area map and (b) moose harvest and tag allocation, 1988-2018.

individuals in 2012 to a maximum of 11 individuals in 2017.

*Current Issues.*— Moose populations in the Bannock DAU appear 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. Levels of non-harvest mortalities across the DAU are concerning and apparently increased in recent years. Managers feel these mortalities may be disease related. This DAU includes several human population centers and IDFG staff annually respond to complaints and relocate moose out of urban settings. Harvest management of moose in this DAU occurs at GMU and grouped GMU levels and is more conservative in the western portions. This difference in harvest intensity resulted from hunter interest and input on these populations. Additional data on tribal harvest would be helpful for management.

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

Caribou DAU is comprised of several southeastern Idaho mountain ranges: 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 Caribou-Targhee NF, Idaho Falls BLM District, and IDL.

Caribou DAU is comprised of 2 main ecological sections; Overthrust Mountains on the east and Northwestern Basin and Range to the west. Average annual precipitation 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 1,370 m (4,500 ft) to >2,743 m (9,000 ft). In general, lower-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 shrub, Utah and Rocky Mountain juniper, maple, and small aspen patches occur throughout much of the DAU. Mid-elevations are dominated by mountain shrub, sagebrush, and mountain mahogany communities, whereas higher elevations are dominated by sagebrush, aspen, spruce, Douglas-fir, and pine communities.

Moose regularly use most of the DAU, except for lower-elevation areas which are urbanized or occupied by irrigated agriculture. Moose utilize mid- to high-elevation habitat throughout the year, and lower elevations which are mixed sagebrush, mountain shrub, and aspen during winter. Although summer habitat use is likely tied to riparian corridors and other mesic zones, moose also use aspen and mountain-shrub communities, spruce-Douglas-fir communities, and sagebrush communities. 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 shrub and mountain mahogany communities, 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. 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, population growth concurrent with this range expansion likely stopped in the mid-2000s and populations in these areas have since declined. Other GMUs likely continued to experience relatively stable populations through present.

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 moose populations in the state and provides insight into moose population changes in the area. Although moose-specific surveys became significantly less common after 2002, a 2018 survey (repeating surveys from 2000 to 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 gender) during mule deer and elk population surveys. Because these surveys were not moose-specific, much of the area potentially inhabited by wintering moose was not surveyed, reducing utility of these data to make inferences about population change. In addition to surveys, harvest data (hunter success rates, number of days hunted, and antler spread) have been used to make inferences about population status.

*Harvest*.— The first season in a portion of the Caribou DAU occurred in 1959 (5 antlered-only tags in 1 hunt area combining portions of GMUs 66, 66A, and 76). By 1962 there were 3 hunts (13 total tags) occurring in GMUs 66, 66A, and 76, which was then 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 was 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. In 1983 a harvest season was opened in Bear River Range (GMUs 75, 77, and 78). The 1988 season marked the first time a hunt occurred in all GMUs in Caribou DAU, and by 1990 seasons included 114 antlered-only tags spread across 12 hunt areas and 35 either-sex tags among 5 hunt areas. In 1991 either-sex opportunities were converted to antlerless-only opportunities (25 tags across 5 hunt areas); 134 antlered-only tags were offered across 13 hunt areas. Tag levels increased over time to a peak in 2003 and 2004 at 239 antlered-only tags across 13 hunt areas and 95 antlerless-only tags across 10 hunt areas. Since those peak levels, tags were reduced over the next 15 years to current (2019) levels: 99 antlered-only tags and 15 antlerless-only tags (in only 3 hunt areas).

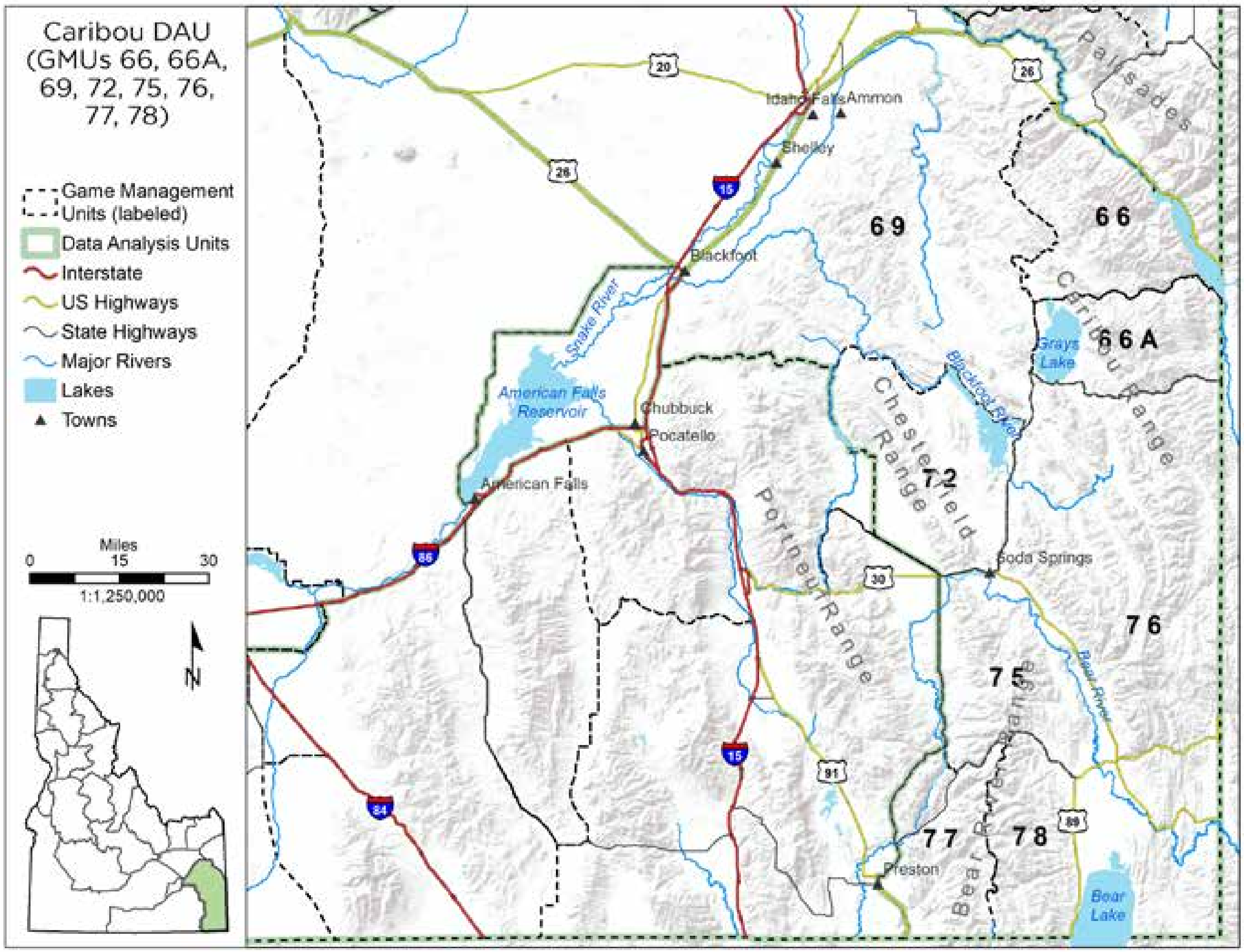
Little harvest data are available for the Caribou DAU prior to 1974. Antlered harvest in the Caribou DAU increased rapidly from 19 individuals in 1974 to 112 individuals in 1984. Harvest remained somewhat stable through 1990 (119 individuals) and then again increased rapidly through 2003 (265 individuals).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

*Current Issues.*— Moose populations in the Caribou DAU likely declined over the last 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 were apparently impacted more than other GMUs. Levels of non-harvest mortalities across the DAU are concerning and apparently increased in recent years. Managers feel these mortalities may be disease related. In response to concerns about population health, harvest of females was dramatically reduced in recent years, particularly in more southern GMUs. Harvest management of moose in this DAU occurs at partial GMU, GMU, and grouped GMU levels. Additional data on tribal harvest would be helpful for management.

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

| Year | Bull:Cow:Young | Number Classified | GMUs | Notes |
|---|---|---|---|---|
| 1978–1979 | 81:100:57 | 212 | 66A/76 | *Phosphate Mining Study |
| 1979–1980 | 74:100:51 | 256 | 66A/76 | *Phosphate Mining Study |
| 1980–1981 | 76:100:51 | 399 | 66A/76 | *Phosphate Mining Study |
| 1984–1985 | 47:100:60 | 199 | 66A/76 | *Entire GMU 66A count of 131 |
| 1986–1987 | 100:100:58 | 93 | 66A/76 | |
| 1987–1988 | 58:100:52 | 189 | 76 | |
| 1988–1989 | 42:100:37 | 210 | 66A | *Entire GMU |
| 1988–1990 | 35:100:55 | 205 | 76 | |
| 1990–1991 | 50:100:54 | 291 | 66A | *Entire GMU |
| 1990–1991 | 49:100:60 | 136 | 76 | *Entire Hunt Area 76-3 |
| 1992–1993 | 75:100:37 | 104 | 76 | *1/2 of Hunt Area 76-2 |
| 1993–1994 | 42:100:42 | 90 | 76 | *8 of 30 search units in 76-1 |
| 1994–1995 | 67:100:43 | 159 | 66A | *13 of 19 search units in 66A |
| 1995–1996 | 55:100:40 | 121 | 76 | *11 of 13 search units in 76-3 |
| 1996–1997 | 85:100:44 | 89 | 76 | *13 of 28 search units in 76-2 |
| 1999–2000 | 135:100:57 | 286 | 76 | *19 of 30 search units in 76-1 |
| 2001–2002 | 64:100:39 | 152 | 66A | *13 of 19 search units in 66A |
| 2001–2002 | 117:100:34 | 104 | 76 | *10 of 13 search units in 76-3 |
| 2017–2018 | 85:100:56 | 178 | 66A/76 | *Portions of 66A, 76-1, 76-2, 76-3 |

**a**

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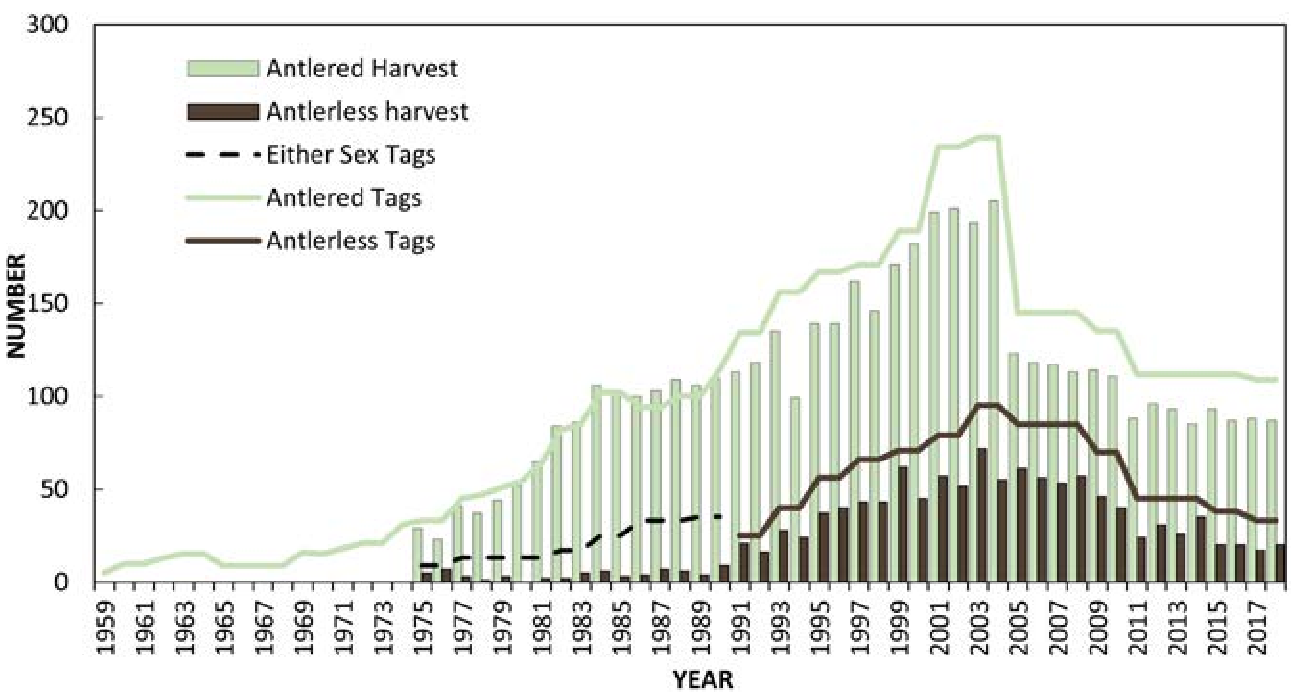



**Figure 18. Caribou DAU (a) area map and (b) moose harvest and tag allocation, 1959-2018.**

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

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

The majority of Teton DAU is comprised of 3 ecological sections: Snake River Basalts to the north, Northwestern Basin and Range to the southwest, and Overthrust Mountains to the southeast. Precipitation increases from approximately 30 cm (12 in) in Snake River Basalts Ecological Section to approximately 71 cm (28 in) within Overthrust Mountains Ecological Section. Elevation ranges from approximately 1,460 m (4,800 ft) to >2,740 m (9,000 ft). Sagebrush is the dominant vegetation within the Snake River Basalts portion of the DAU, transitioning into the Douglas-fir forest type in mountains to the south.

Very little disturbance occurs on timbered lands within this DAU other than on some private and IDL properties. Some private agricultural lands are found within the Teton Valley portion of GMUs 62 and 65, as well as the western portion of GMU 64 and southern portion of GMU 67. Terrain is of moderate ruggedness and can be broadly classified as frontcountry or midcountry 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 use much of the DAU at some time during the year. They move down in elevation slightly during winter months, yet there are year-round residents on South Fork Snake and Teton rivers. Mountains and wet valleys of this area provide many options for moose. They utilize river corridors, riparian stringers, aspen and mountain-shrub communities, spruce-fir communities, Douglas-fir-sagebrush communities, mountain mahogany, and private wet meadows on the valley floor.

*Population and Monitoring*.— Moose have occupied Teton Basin and Swan Valley areas since settlement first occurred. In July 1872 Hayden Geological Survey collected 3 moose near the Idaho-Wyoming border in Teton Canyon (Hayden 1873:668). Trappers' journals and early homesteaders mention moose in river corridors and moving into lower valleys during winter months.

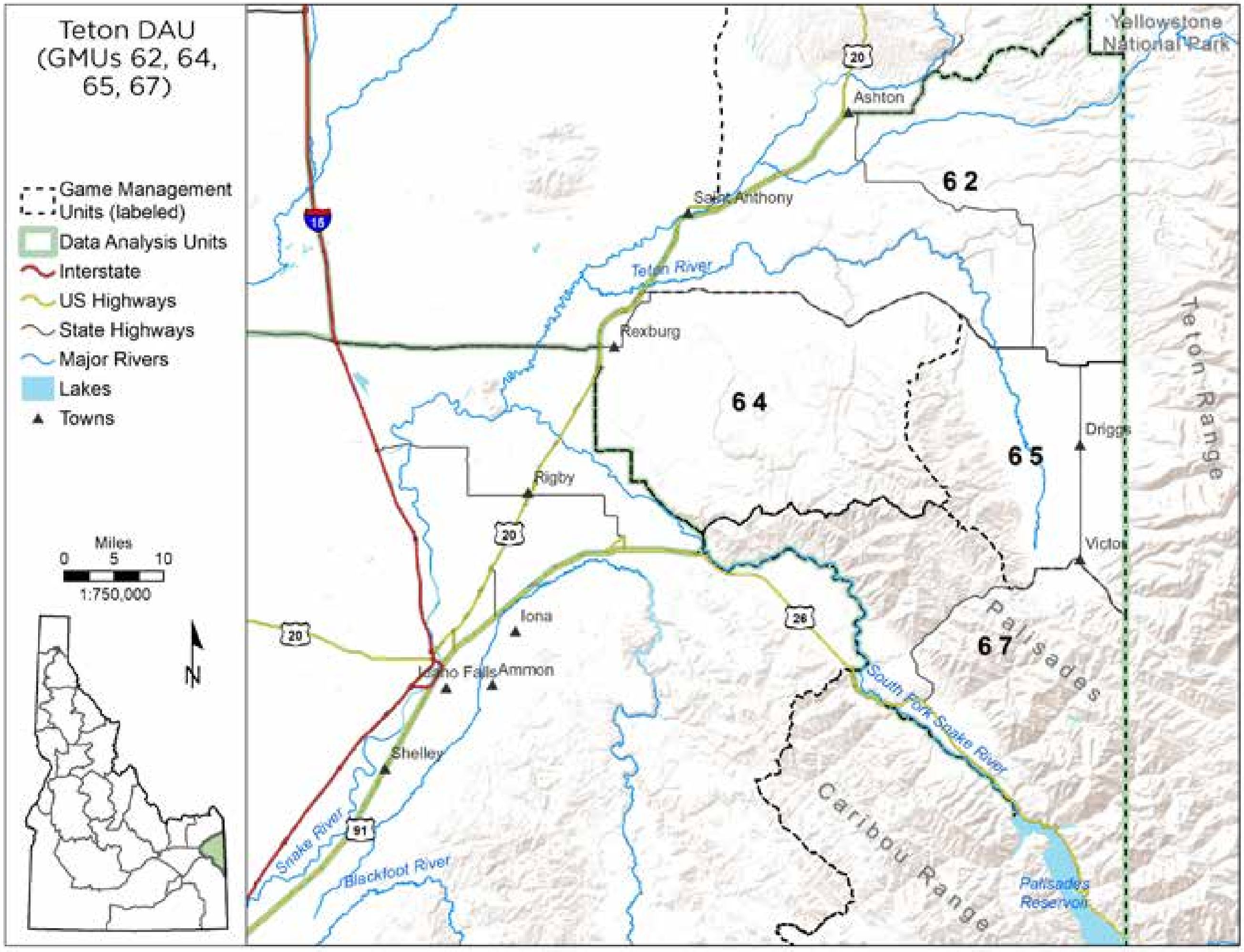
A fixed-wing aerial survey was conducted in GMUs 64, 65, and 67 in 1984; 255 moose were observed (65 unclassified as to gender). A population survey was conducted in GMU 62 during December 2000. The final population estimate was 366 moose, including 180 cows, 109 bulls, and 77 calves. This total compares to fixed-wing counts of 218 and 81 moose observed during 1989 and 1990, respectively. Moose have also been documented (location, numbers, age, and gender of adults) during mule deer and elk population surveys. Because these surveys were not moose-specific, much of the area potentially inhabited by wintering moose was not surveyed, reducing utility of these data to make inferences about population change. 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 occurred throughout the DAU. Either-sex moose tags were offered in GMUs 64 and 65 from 1986 to 1990. These seasons were offered, in part, to experiment with and monitor gender ratios of harvested moose under either-sex bag limits. Most harvested moose were antlered; only 10.2% of harvested moose were antlerless. Harvest and tag allocation peaked between 2000 and 2005. Harvest management of moose in this DAU occurs at GMU and grouped GMU levels and difference in harvest intensity resulted from hunter interest and input on these populations. Many moose with exceptionally large antlers (i.e., eligible for record books) have been harvested in this DAU.

*Current Issues.*— Moose populations in this DAU appear relatively stable. Moose in lower areas (Teton River and South Fork Snake River) reside on mostly private property, making implementation of large-scale management actions difficult. Moose that live near human population centers within this DAU often require IDFG staff to respond to complaints and relocate them. Some newer housing developments impacting moose have occurred since 2000 in Teton County. As homes encroach on foothills of Teton Valley, more moose conflicts occur, resulting in removal of moose out of historical moose habitat. The areas along Idaho Highway 33 and Wyoming Highway 22 (state line) are noted for high occurrence of moose-vehicle collisions. Moose, particularly calves and yearlings, have been documented with heavy tick loads; however, population level impacts of these outbreaks are not known. Symptomatic moose, which appear blind and uncoordinated, sometimes turning in circles, also were recorded. Additional data on tribal harvest would be helpful for management.

Moose CCBY IDAHO FISH AND GAME

a

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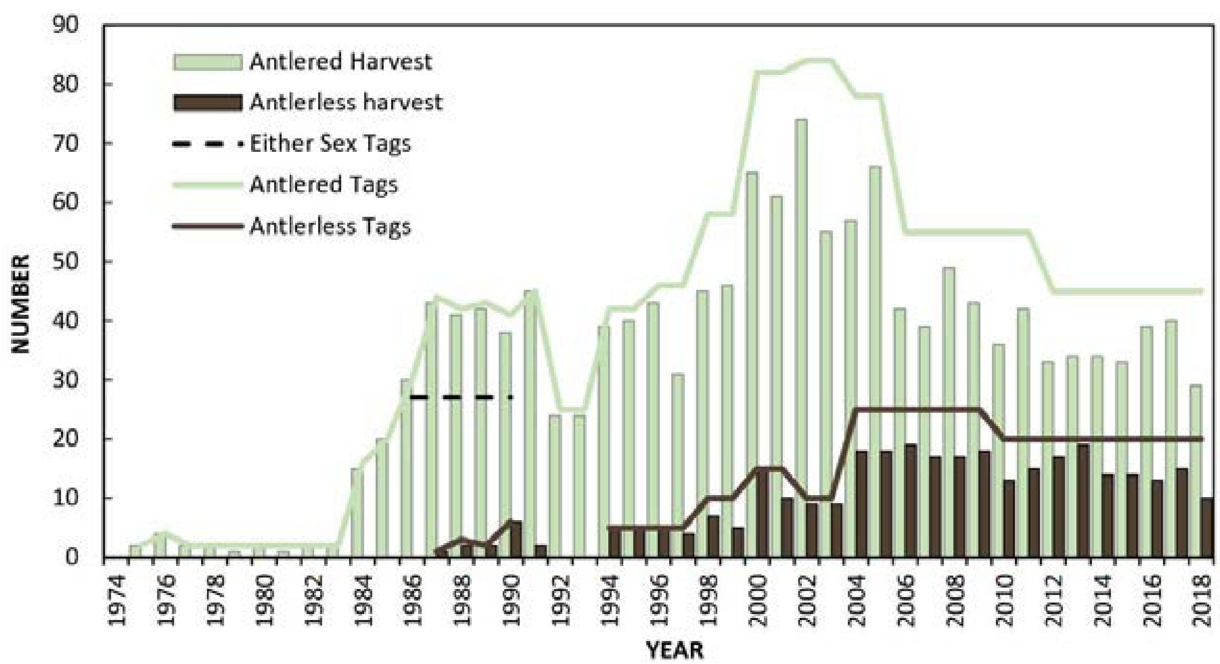


Figure 19. Teton DAU (a) area map and (b) moose harvest and tag allocation, 1974-2018.

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

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

The majority of Island Park DAU is within Snake River Basalts Ecological Section, whereas the northern portion is within Beaverhead Mountains Ecological Section, and the eastern portion is within Yellowstone Highlands Ecological Section. Precipitation within 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 Centennial Mountains and Yellowstone Highlands. Elevation ranges 1,460 m (4,800 ft) to >2,740 m (9,000 ft). Low-elevation hills and valley floors are dominated by sagebrush and mountain shrub, whereas Douglas-fir forests dominate 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 some private and IDL properties. Some private agricultural lands are found within southern portions of GMUs 60 and 60A. Terrain is of moderate ruggedness and can be broadly classified as frontcountry or midcountry 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 infestations of mountain pine bark beetles. In some areas, these clearcuts stimulated aspen regeneration which likely benefitted summering moose.

Moose utilize most habitats within the Island Park DAU. Although summer habitat is likely tied to higher timbered elevations and other mesic zones, moose utilize aspen and mountain shrub communities, Douglas-fir communities, and sagebrush-chokecherry communities during winter months. Some moose in Island Park DAU migrate and others do not. 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 higher elevations of Island Park caldera to winter. The lower portion of GMU 60A includes Henry's Fork River which provides year-round habitat for moose.

*Population and Monitoring*.— Idaho offered its first hunting season 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 is the only moose population in the world known to winter in a desert habitat. Tall mountain-shrub

Moose CCBY IDAHO FISH AND GAME

communities, including chokecherry and antelope bitterbrush, are believed to sustain this wintering population. More than 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; the second highest occurred in 1989 with 570 individuals. A herd composition count was conducted on Big Bend Ridge, Fall River Ridge, and Sand Creek desert portions of this DAU (GMUs 60, 60A) in 1991. Observers tallied 345 moose, with a bull:cow:calf ratio of 67:100:65. Also in 1991, a helicopter survey along Henry's Fork River in GMU 60A yielded 37 moose. Compared to many other DAUs, Island Park yielded some of the most consistent and highest counts. In addition to moose-specific surveys, moose were documented (location, numbers, age, and gender of adults) during mule deer and elk population surveys. Because these surveys were not moose-specific, much of the area potentially inhabited by wintering moose was not surveyed, reducing utility of these data to make inferences about population change. 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.

Three research projects concentrated on moose in this DAU: Ritchie (1978) studied ecology of moose; Muir (2006) focused on reproduction and habitat selection; and Andreasen et al. (2014) examined highway crossing by radio-collared cows. Work by Andreasen et al. (2014) demonstrated moose in this DAU employ 2 strategies for winter habitat selection. Some stay year-round at high elevations in the Island Park caldera and others migrate from the Island Park caldera to lower Sand Creek desert. A few even moved from Sand Creek desert in winter to use lower Henry's Fork River as calving and summer range. Incidence of moose-vehicle collisions is high in this DAU along U.S. Highways 20 and 87 within the Island Park caldera (Figure 3), with an estimated 62 moose mortalities 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 hunting occurred throughout the entire DAU and continued until 2008. Managers noted reductions in hunter success rates 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 GMUs 61 and 62A. The highest antlerless tag allocations in this DAU occurred from 2003 through 2005. Harvest rates were lower at this time due to unsold tags because some hunters preferred not to choose antlerless hunts for their once-in-a-lifetime harvest. Current harvest management of moose in this DAU occurs at GMU and grouped GMU levels and differences in harvest intensity across the DAU resulted from hunter 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. Although data are not available to indicate whether current illegal harvest occurs at those levels, illegal harvest is still occurring.

*Current Issues.*— The vast majority of Island Park DAU is public land in the Island Park caldera and Sand Creek desert. Moose populations in this DAU appear relatively stable. U.S. Highway 20 intersects Island Park caldera and is a hot spot for moose mortality (Figure 3). Additional data on tribal harvest would be helpful for management. Moose in the lower area of this DAU (Henry's Fork River in GMU 60A) reside on private property, making implementation of large-scale management actions difficult. Moose living near human population centers within this DAU often require relocation.

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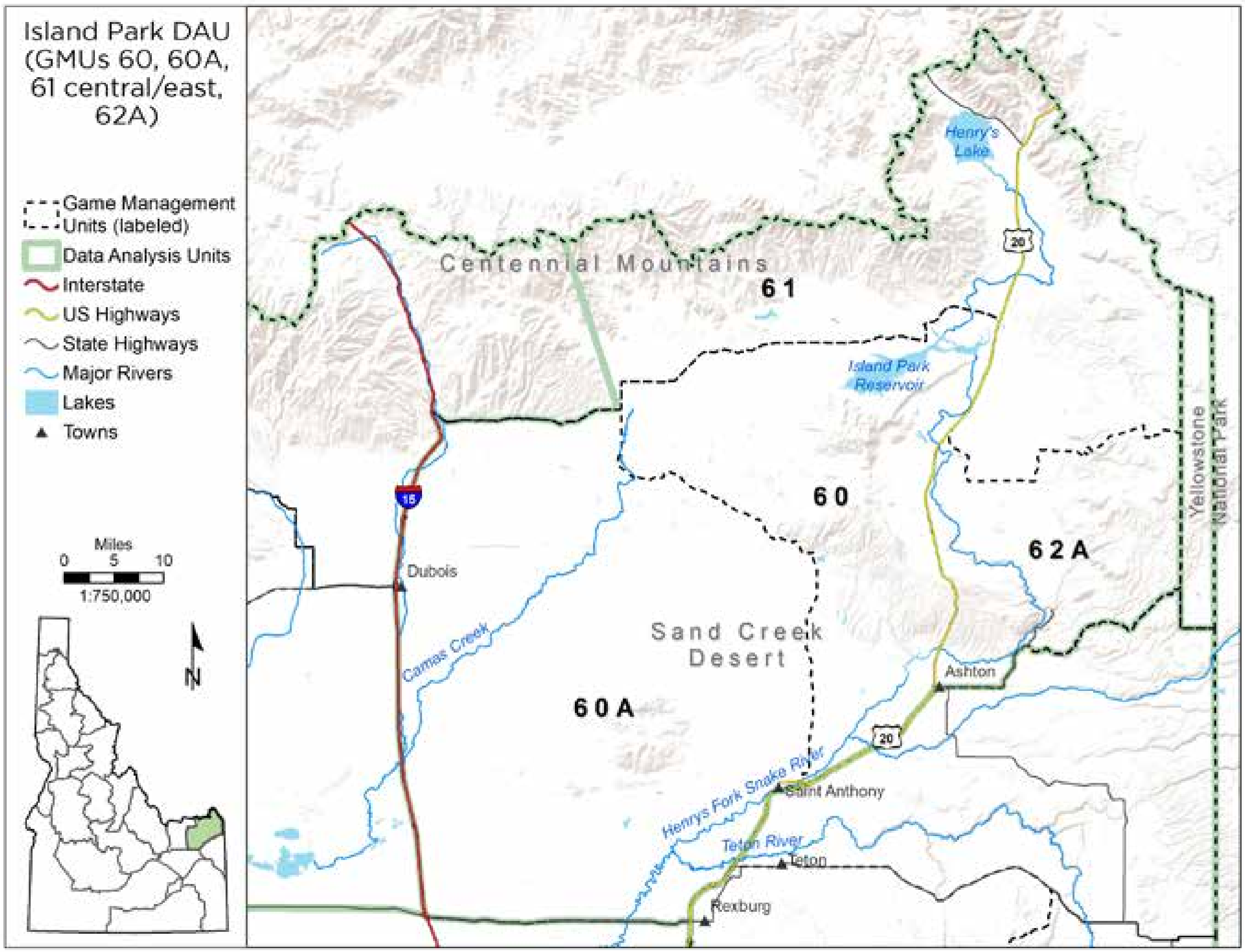


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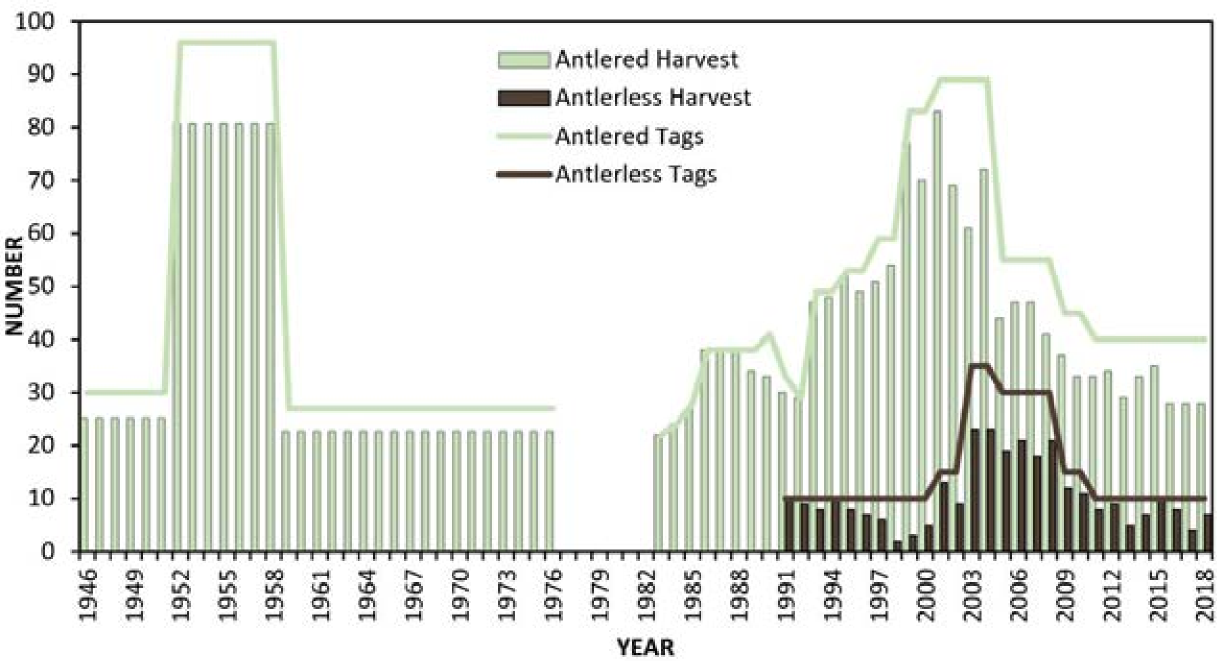


Figure 20. Island Park DAU (a) area map and (b) moose harvest and tag allocation, 1946-2018.

## Medicine Lodge DAU (GMUs 59, 59A, 61 west, 63 north)

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

Medicine Lodge DAU is comprised mostly of Beaverhead Mountains Ecological Section to the north and west, whereas the southeastern portion of the DAU is within 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 1,460 m (4,800 ft) to >3,350 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 are 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 Mud Lake WMA. Camas NWR is managed by U.S. Fish and Wildlife Service as a wetland complex.

Very little disturbance occurs on timbered lands within this DAU other than on some private and IDL properties. Some private agricultural lands are found within southern portions of GMUs 59 and 59A. Most of GMU 63 is privately owned. Terrain is of moderate ruggedness and can be broadly classified as frontcountry or midcountry areas with high levels of access.

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

Moose using Camas NWR and Mud Lake are less migratory and live on and around agricultural lands surrounding these riparian areas. Wetlands

Moose 

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, 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, but populations expanded into the mid-1990s. As populations expanded, so did hunting opportunity and harvest. Expansion of moose populations in the DAU occurred from east to west over a period of years or decades. In several GMUs, population growth concurrent with this range expansion likely stopped in the late 1990s and populations in these areas likely remain stable.

The first documented moose survey in the DAU occurred in 1984 when 64 moose were counted in GMUs 59 and 59A. Observers counted 179 moose during a trend survey in these same GMUs in 1994. A fixed wing survey in the GMU 61 portion of this DAU in 1990 to 1991 yielded 101 moose and a second survey the following year found 77 moose. In January 2016 observers counted 22 moose in a survey of the Mud Lake area in GMU 63. Moose were also documented (location, numbers, age, and gender of adults) during mule deer population surveys. Because these surveys were not moose-specific, much of the area potentially inhabited by wintering moose was not surveyed, reducing utility of these data to make inferences about population change. 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 began with an antlered-only hunt in 1974 in GMUs 59 and 59A. In 1977 a hunt in a portion of GMU 61 was opened. This portion of GMU 61 was open to 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 number of tags offered, in the mid-1980s. Unit 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 heavily hunted in GMU 63 from 2003 to 2009. In 2009 antlerless harvest was closed in GMU 63 due to declining moose populations on Mud Lake WMA and Camas NWR and concerns over fewer observations of moose by hunters and others. Hunting reopened in GMU 63 with 2 antlered tags annually from 2013 to 2018. Harvest is currently closed due to low moose numbers. Harvest management of moose in this DAU occurs at GMU and grouped GMU levels and differences in harvest intensity resulted from hunter interest and input on these populations.

*Current Issues*.— Moose populations in this DAU appear relatively stable, except in GMU 63 (Mud Lake WMA and Camas NWR) where a decline is indicated based on best judgement. The GMU 63 portion of this DAU resides primarily on private property, making implementation of large-scale management actions difficult. The vast majority of the DAU resides on public lands in Dubois Ranger District of Caribou-Targhee NF. Strong collaborations with land management agencies (USFS, BLM, IDL) to create mosaics of early and late-seral habitat (e.g., via prescribed fire and timber harvest) in areas lacking disturbance, particularly in GMUs 59 and 61, would likely benefit moose populations. Levels of non-harvest mortalities across the DAU are concerning and apparently increased in recent years. Managers feel these mortalities may be disease related. Additional data on tribal harvest would be helpful for management. Moose reside in and near human population centers within this DAU and IDFG staff annually respond to complaints and relocate moose from urban settings.

Moose CCBY IDAHO FISH AND GAME

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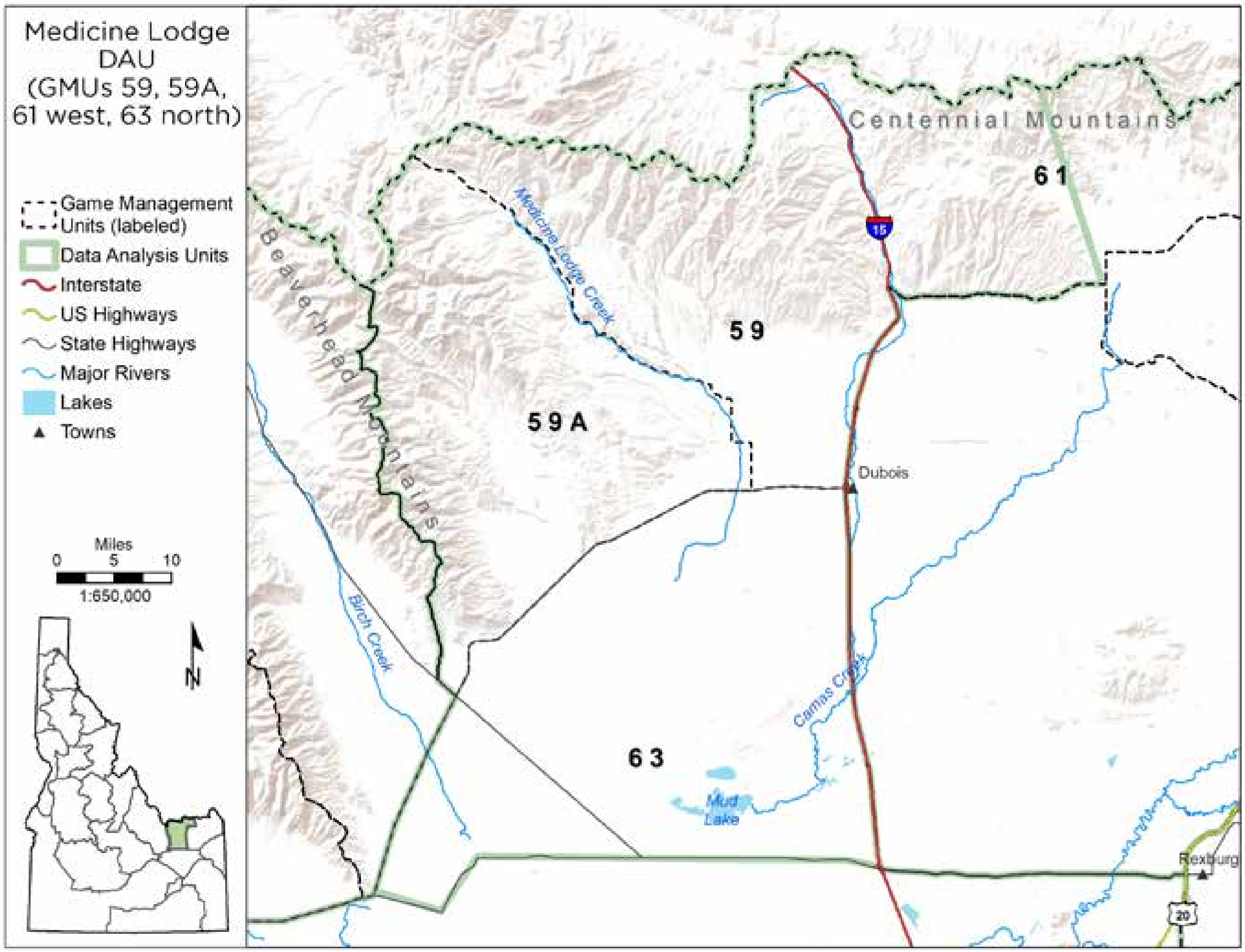


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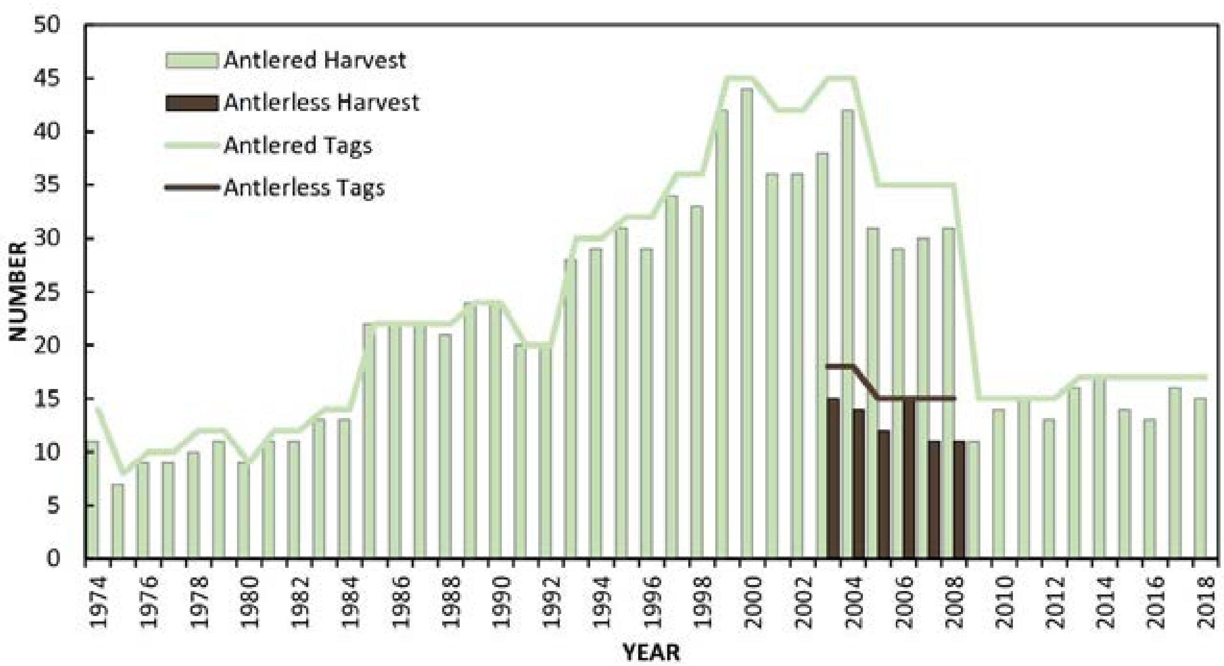


Figure 21. Medicine Lodge DAU (a) area map and (b) moose harvest and tag allocation, 1974-2018.

## Snake River DAU (GMUs 63 south, 63A, 68A)

Snake River DAU encompasses GMUs 63 (southern portion), 63A, and 68A. Ownership consists of mostly federal lands (BLM and Department of Energy), followed by private, Shoshone-Bannock Tribes, IDL, and IDFG. Located in the southern portion of Upper Snake Region and northern portion of Southeast Region, the DAU includes lands along the main stem of the Snake River on the southeastern edge with American Falls Reservoir on the south end, and extends westward into sagebrush steppe toward the south end of Lost River Range.

Snake River DAU is almost entirely within Snake River Basalts Ecological Section, receiving approximately 30 cm (12 in) of precipitation per year. Terrain is primarily rolling hills to flat with elevations ranging from approximately 1,280 m (4,200 ft) to 1,524 m (5,000 ft). Sagebrush steppe and riparian narrowleaf cottonwood gallery forests are dominant native habitats, with agricultural lands on most private land. The DAU can be broadly classified as frontcountry 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 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.

*Population and Monitoring*.— Moose-specific population surveys have not taken place in the Snake River DAU due to relatively low densities. However, moose were documented (location, numbers, age, and gender of adults) during other big game surveys. Because these surveys were not moose-specific, much of the area potentially inhabited by wintering moose was not surveyed, reducing utility of these data to make inferences about population change. 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. Unit 63 was included in the hunt area with GMU 63A in 1999; but the GMUs were split into 2 separate hunts in 2003. Currently 15 antlered and 10 antlerless tags are offered in GMU 63A. Archery-only moose hunts were opened in GMU 68A in 2015 with 2 antlered and 2 antlerless tags; each hunt offers 4 tags at present.

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*.— Moose populations in this DAU appear relatively stable. The vast majority of moose habitat within the Snake River DAU is on private property, making implementation of large-scale management actions difficult. Levels of non-harvest mortalities across the DAU are concerning and apparently increased in recent years. Managers feel these mortalities may be disease related.

Moose reside in and near human population centers within this DAU and IDFG staff annually respond to and relocate moose from urban settings. Harvest management of moose in this DAU occurs at GMU and grouped GMU levels. Differences in harvest intensity resulted from hunter interest and input on these populations. Additional data on tribal harvest would be helpful for management.

Moose CCBY IDAHO FISH AND GAME

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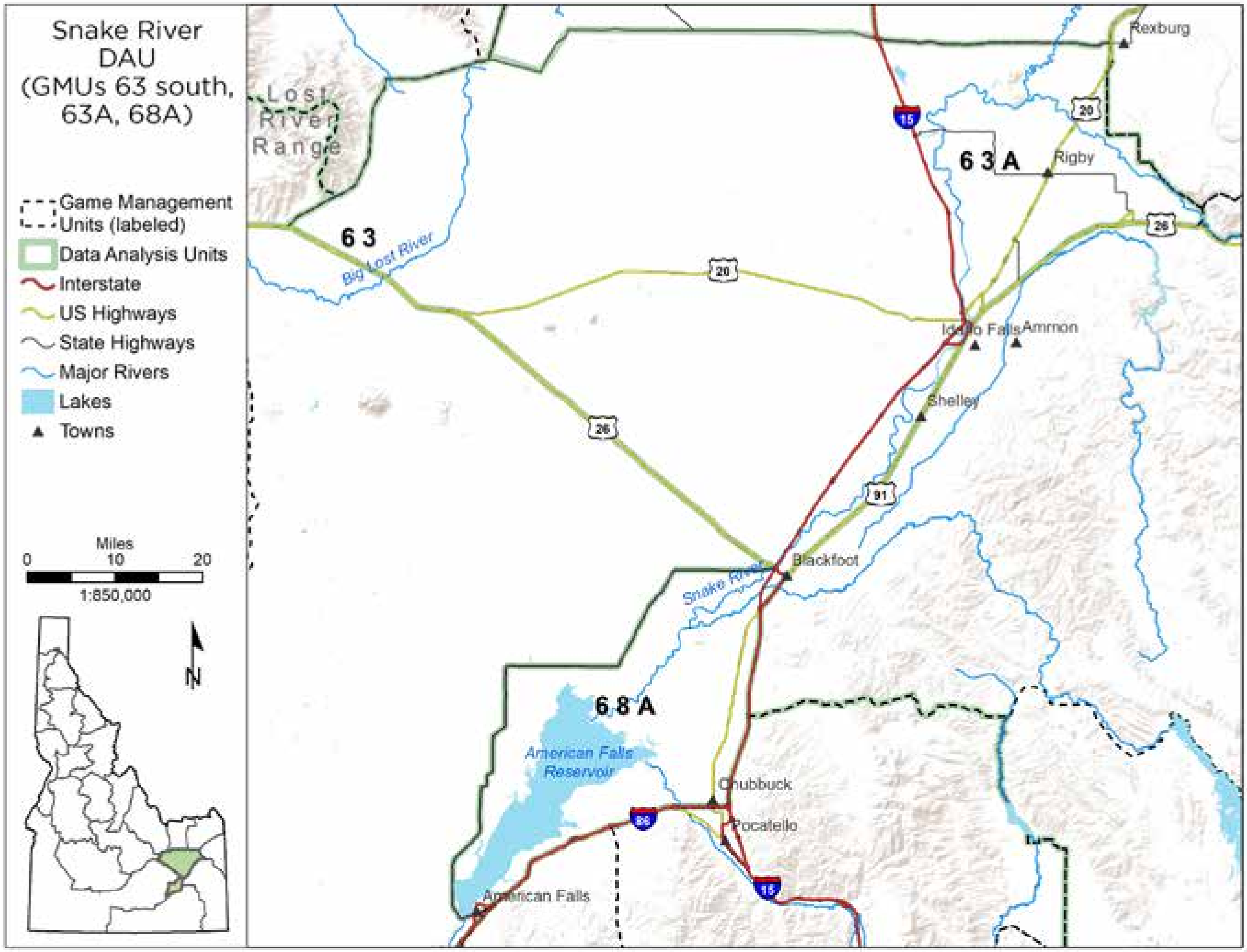


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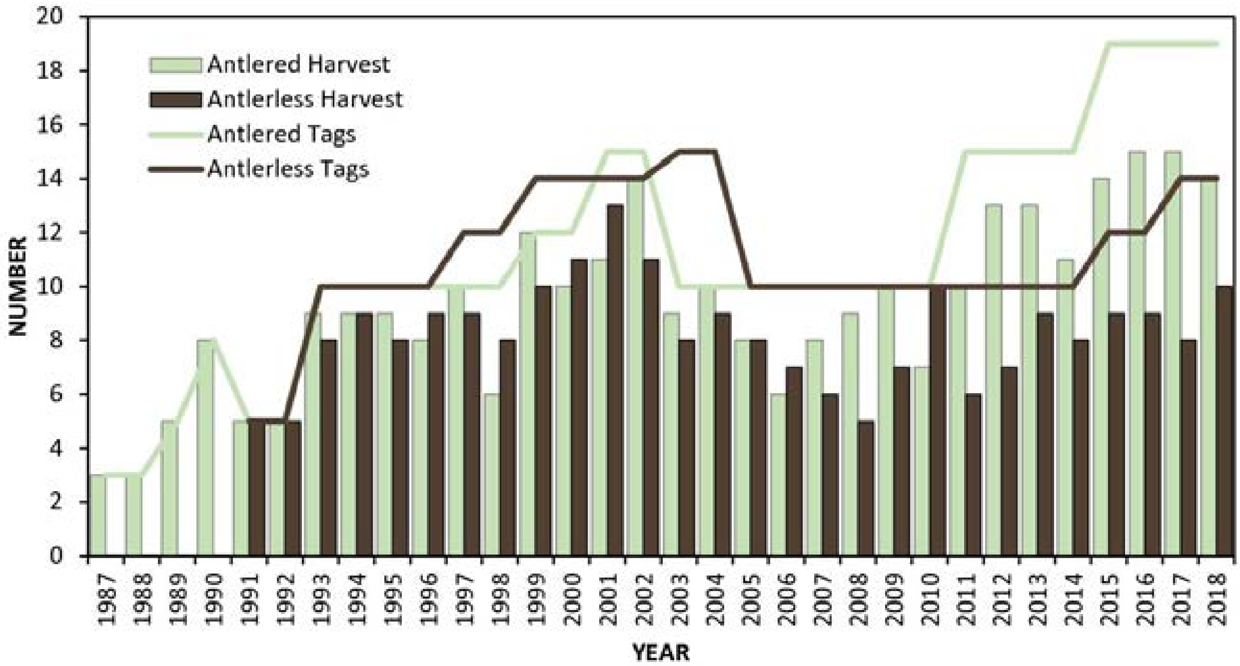


Figure 22. Snake River DAU (a) area map and (b) moose harvest and tag allocation, 1987-2018.

## Beaverhead DAU (GMUs 29, 30, 30A, 37, 37A, 51, 58)

Beaverhead DAU is comprised of 3 mountains ranges: Lost River Range (GMUs 37 and 51); Lemhi Range (GMUs 29, 37A, 51, and 58); and Beaverhead Mountains (GMUs 30 and 30A). Public lands within the DAU are managed by Salmon-Challis and Caribou-Targhee NFs; Salmon, Challis, and Idaho Falls BLM Field Offices; and IDL.

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 1,219 m (4,000 ft) near Salmon to 3,859 m (12,662 ft) at Idaho's highest peak, Mount Borah. Beaverhead Mountains Ecological Section experiences a continental climate, with cold, relatively dry winters influenced by the rain-shadow effect of central Idaho mountains. Average annual precipitation varies from >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, whereas summers are comparatively dry. Riparian habitat, sagebrush-steppe habitat, and agricultural lands dominate valley bottoms. Mixed-conifer forests, ranging from lodgepole pine to ponderosa pine and Douglas-fir, dominate mid-elevations. Higher elevations are dominated by subalpine fir, limber pine, and alpine meadow systems.

Moose use scattered patches of suitable habitat seasonally throughout the Beaverhead DAU. Although 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 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 willow-dominated riparian habitat.

*Population and Monitoring*.— There is little information on historical populations; however, existing populations likely derived from immigration from Montana and eastern Idaho. In early 1980 moose were translocated to GMU 58. This population was then bolstered with relocation of nuisance moose to the area in 2001–2002. Expansion of this translocated population likely bolstered populations in 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 Beaverhead DAU due to low densities. However, moose were documented (location, numbers, age, and gender of adults) during mule deer and elk population surveys. Because these surveys were not moose-specific, much of the area potentially inhabited by wintering moose was not surveyed, reducing utility of these data to make inferences about population change. 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 began in 1991 in GMUs 29 and 37A and is ongoing. Units 30 and 30A saw their first antlered moose hunt in 1993. Unit 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 hunt through 2018, 307 moose were legally harvested under controlled hunts and 1 moose was harvested through the Super Hunt program. The bulk of harvest has historically occurred in GMUs 30 (50%) and 51 (22%).

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

*Current Issues*.— Moose populations in the Beaverhead DAU appear relatively low, but stable. Low density of moose is likely due to 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. Additional data on tribal harvest would be helpful for management. No evidence currently supports an increase in population or options to provide increased hunting opportunity.

Bull Moose CCBY IDAHO FISH AND GAME

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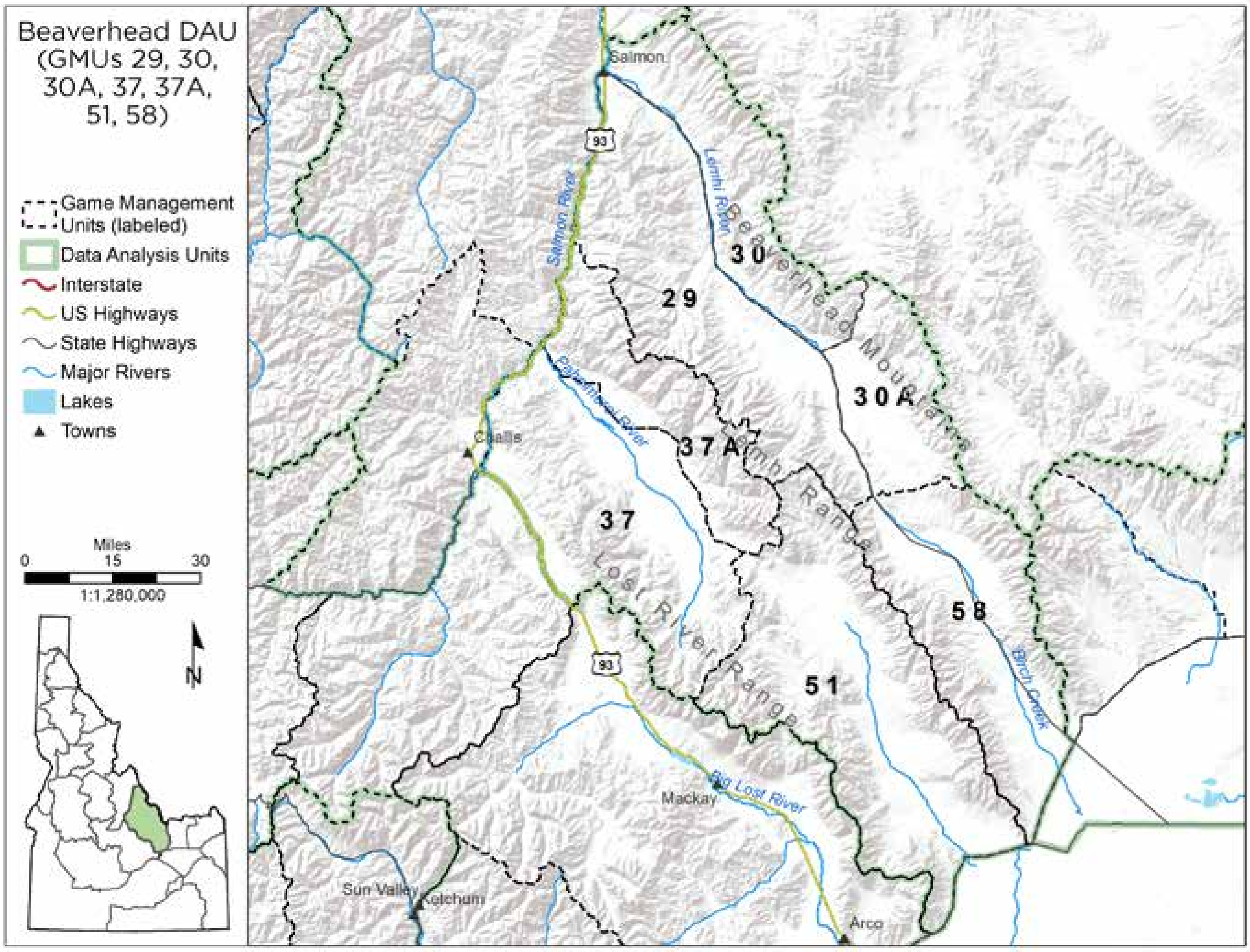


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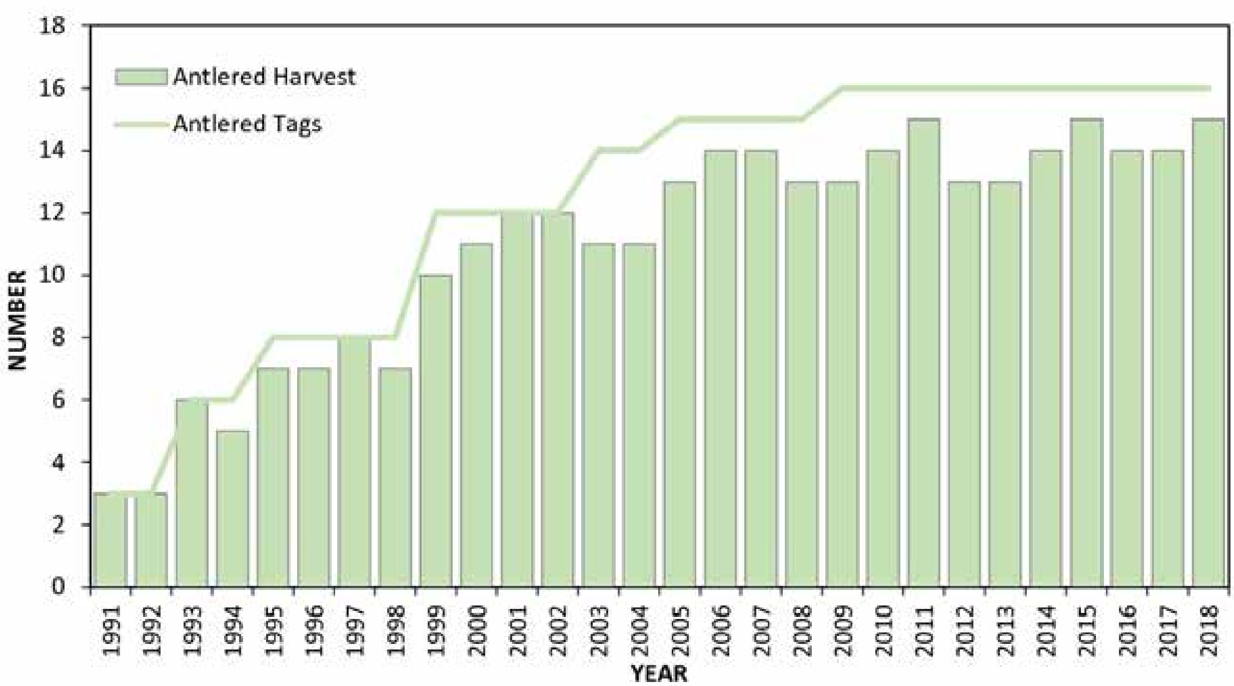



Figure 23. Beaverhead DAU (a) area map and (b) moose harvest and tag allocation, 1991-2018.

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

Pioneer DAU encompasses the southeastern portion of GMU 36 and all of GMUs 36A, 49, and 50. The DAU is dominated by rugged mountains, including Pioneer (GMUs 49 and 50), Boulder and White Cloud (GMU 36A), and Sawtooth (GMU 36) ranges. Approximately 81% of the DAU is publicly owned, with most managed by USFS, including Sawtooth NF, Sawtooth National Recreation Area, and Salmon-Challis NF. Jim McClure-Jerry Peak, White Clouds, and Hemmingway-Boulders wilderness areas are located within the DAU. The BLM oversees tracts of land in 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 Challis Volcanics Ecological Section, receiving approximately 71 cm (28 in) of precipitation per year. The eastern portion of the DAU falls within Beaverhead Mountains Ecological Section, which receives approximately 50 cm (20 in) of precipitation per year. Elevation ranges 1,460 m (4,800 ft) to >3,350 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 local wetter and more southerly aspects.

Pioneer DAU includes several major riparian corridors, including 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 established additional moose habitat. Moose are not known to undertake long migrations between summer and winter ranges in the Pioneer DAU; however, moose densities in Wood River valley increase in 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 Big Lost River (GMU 50). Additional translocations have occurred periodically since then.

Population surveys for moose have not been conducted in the Pioneer DAU. However, opportunistic documentation of moose during aerial surveys for deer and elk provided a small dataset of moose numbers, locations, and demographics. Due to differences in winter habitat selection by moose in comparison to deer and elk, some habitat patches inhabited by moose were likely not surveyed, thereby reducing 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.

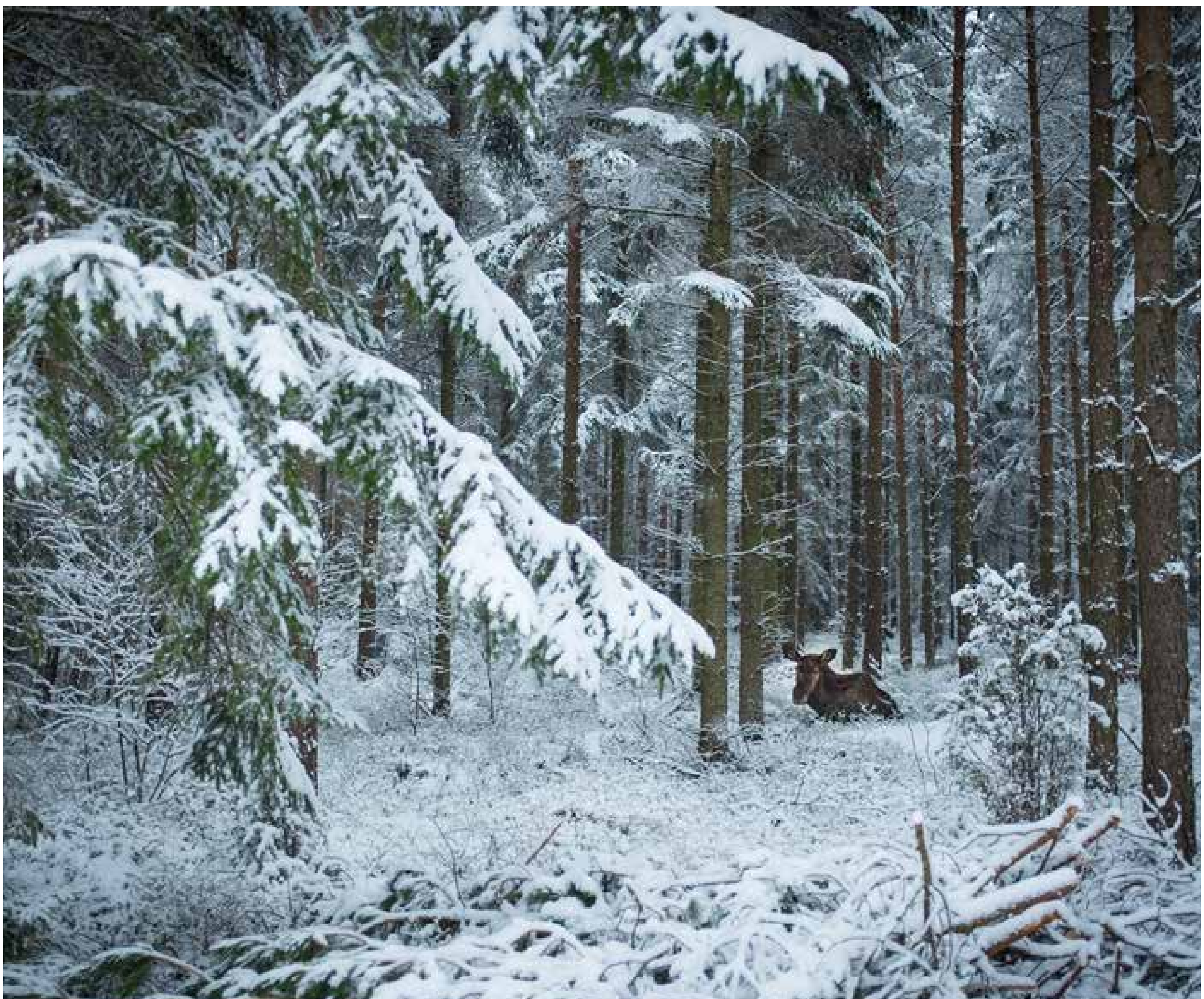
*Harvest*.— Due to changing hunt area boundaries over time and unaligned boundaries between GMUs and the DAU, tracking harvest specific to Pioneer DAU is difficult.

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. 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 >85%. See Smoky-Bennett DAU for 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: Opportunity to harvest a moose in GMU 36A was first made available during the 2005 season, with 1 antlered-only tag, which continues to present.

*Current Issues.*— Improving survey methodologies for monitoring moose populations would advance understanding of population dynamics and habitat use within the DAU. This understanding will be increasingly important as the human population and interest in outdoor recreation expand throughout certain areas of the DAU. Collaboration with private landowners may provide opportunity to improve quality and quantity of riparian vegetation communities which moose prefer. Additional data on tribal harvest would be helpful for management.



Moose CCBY IDAHO FISH AND GAME

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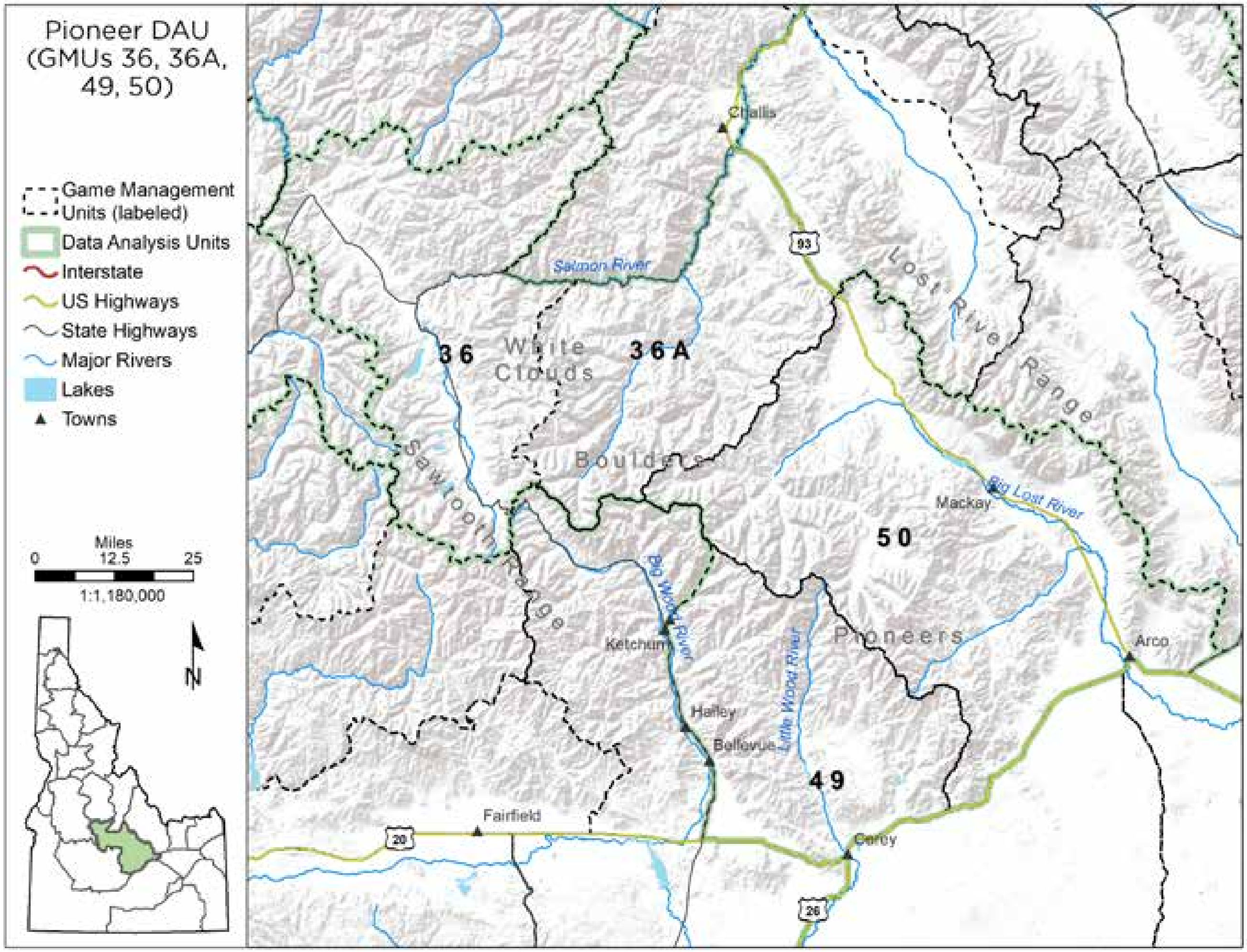


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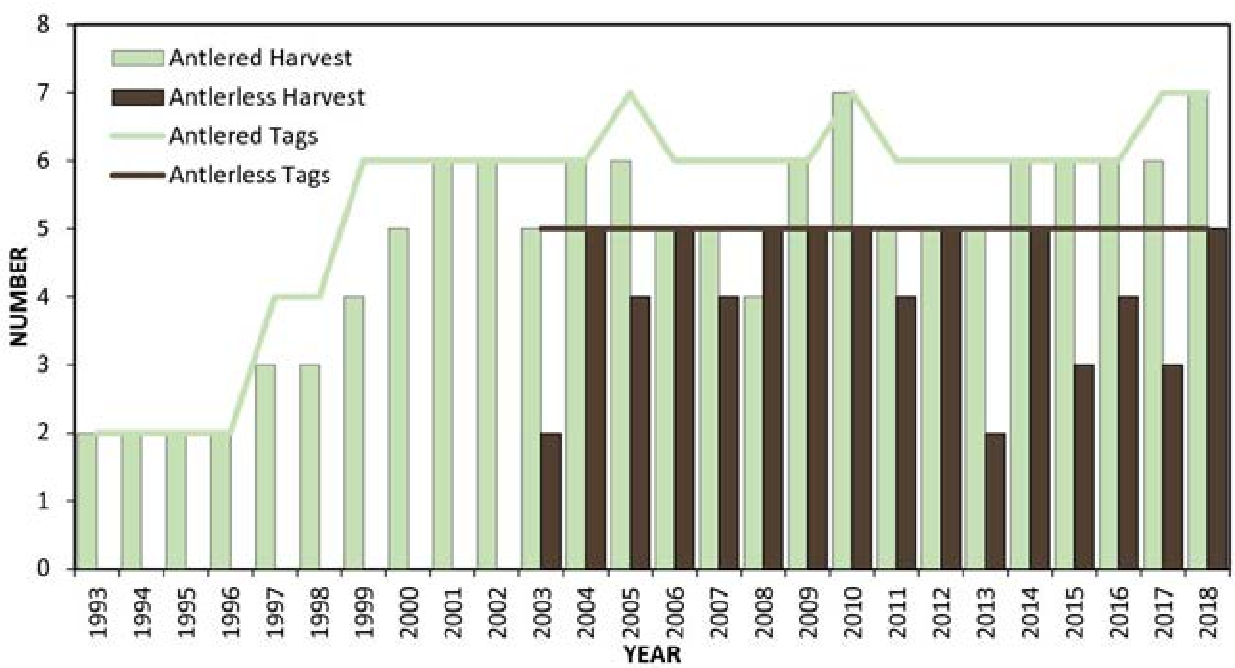


Figure 24. Pioneer DAU (a) area map and (b) moose harvest and tag allocation, 1993-2018.

## Salmon Mountains DAU (GMUs 21, 21A, 28, 36B)

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

Salmon Mountains DAU falls within Challis Volcanics, Beaverhead Mountains, and Idaho Batholith ecological sections. Elevations in this DAU range from 914 m (3,000 ft) to 3,170 m (10,400 ft) and vary widely in habitats. Annual precipitation ranges from 20 cm (8 in) in 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 valley bottoms. Mixed-conifer forests, ranging from lodgepole pine to ponderosa pine and Douglas-fir dominate mid-elevations. Higher elevations are dominated by subalpine fir and alpine meadow systems.

Moose utilize much of the lower- to mid-elevation suitable habitat within the Salmon Mountains DAU. Although summer habitat use by moose is generally associated with riparian corridors and other mesic habitats throughout much of this DAU, moose in GMUs 21 and 21A likely use 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-shrub and riparian willow communities.

*Population and Monitoring.*— There is little information on historical populations; however, existing populations likely resulted from immigration from Montana into GMUs 21 and 21A. As populations expanded, so did hunting opportunity. Expansion of moose populations in 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 low densities. However, moose were documented (location, numbers, age, and gender of adults) during mule deer and elk population surveys. Because these surveys were not moose-specific, much of the area potentially inhabited by wintering moose was not surveyed, reducing utility of these data to make inferences about population change. 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 Salmon Mountains DAU is limited to the 20-year period when a season existed in Hunt Area 21 (GMUs 21 and 21A). There has not been an open season in GMU 28 or 36B due to extremely low abundance of moose. No antlerless hunting opportunity occurred in the Salmon Mountains DAU.

Antlered opportunity in Hunt Area 21 consisted of 3 tags from 1990 to 1994, 4 tags from 1995 to 2008, and 2 tags in 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. No moose were harvested in 2009 or 2010. Due to decreasing hunter success and limited population data this season was closed in 2011.

*Current Issues*.— Moose populations in the Salmon Mountains DAU appear relatively low, but stable. 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 examined in this DAU and are unknown at this time. Additional data on tribal harvest would be helpful for management. At this point, no evidence supports an increase in population or options to provide hunting opportunity.

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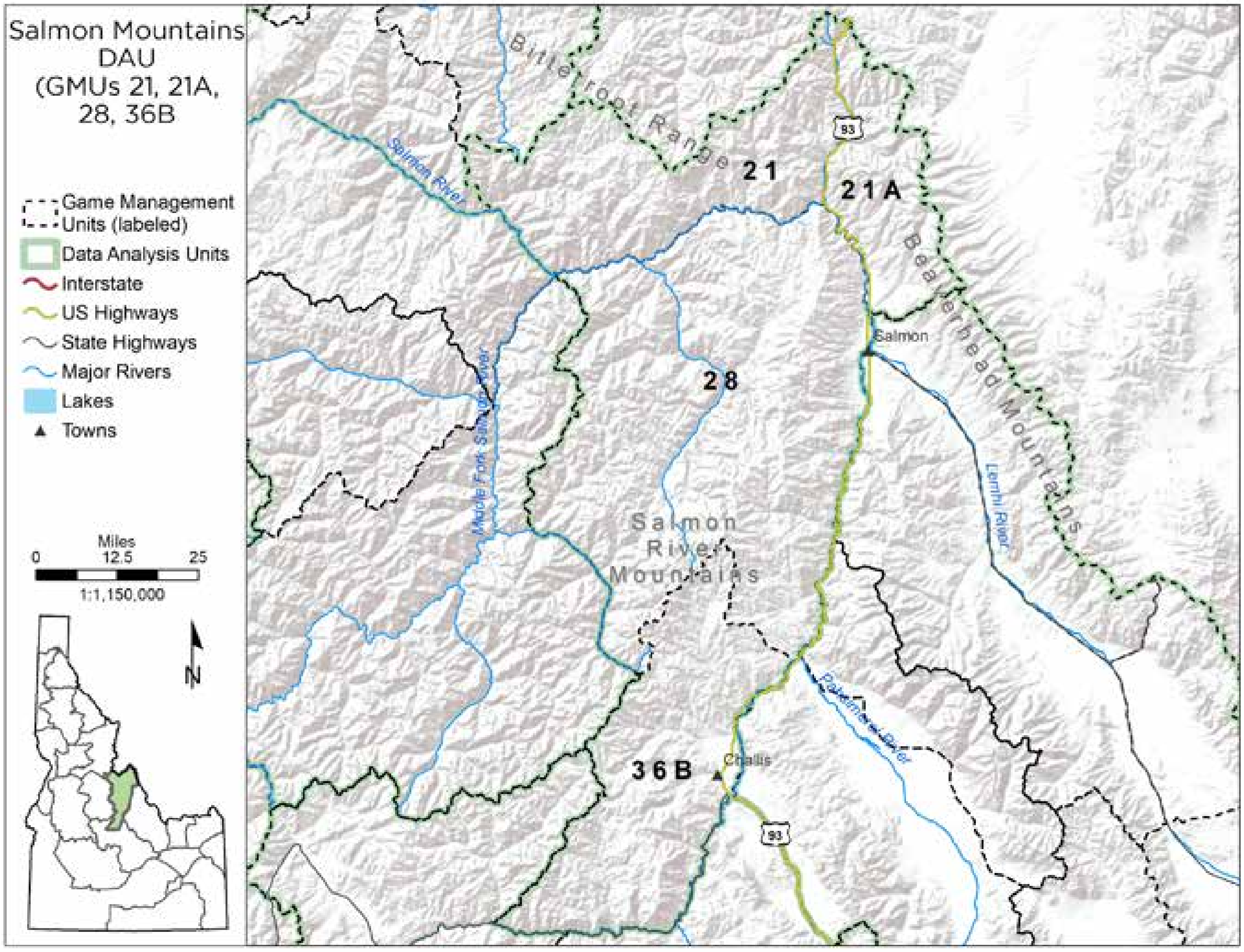


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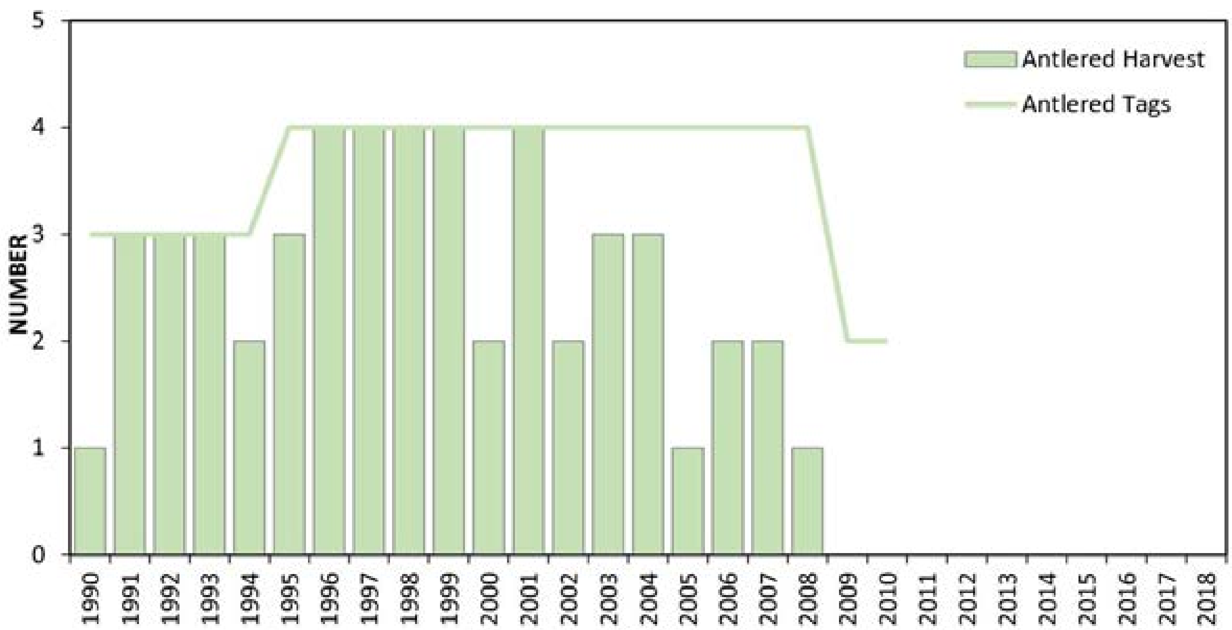



Figure 25. Salmon DAU (a) area map and (b) moose harvest and tag allocation, 1990-2018.

## Middle Fork DAU (GMUs 20A, 26, 27)

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

The northern two-thirds of the Middle Fork DAU are within Idaho Batholith Ecological Section, whereas the southern portion is within Challis Volcanics Ecological Section. Challis Volcanics Ecological Section experiences average annual precipitation of approximately 71 cm (28 in), whereas 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 640 m (2,100 ft) to >3,048 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 scattered throughout higher-elevation meadow complexes and riparian corridors. Moose in Middle Fork DAU likely do not undertake major migrations but move shorter distances to suitable winter habitat. These winter habitats are dominated by mountain-shrub and riparian willow communities.

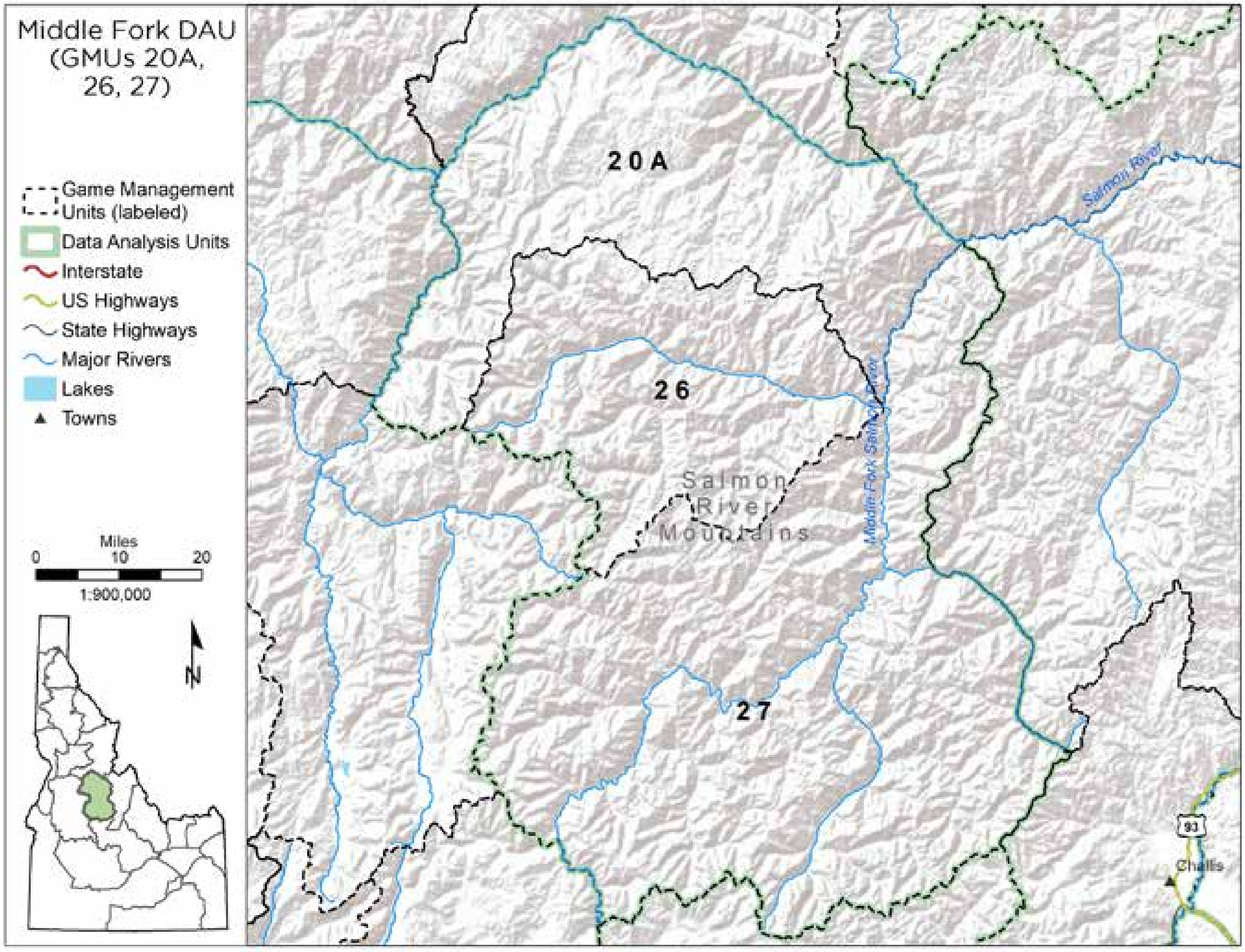
*Population and Monitoring.*— There is little information on historical populations; however, existing populations likely resulted from immigration from surrounding DAUs. Expansion of moose populations in Middle Fork DAU is sporadic at best, with very limited data outside of incidental observations.

Moose-specific population surveys have not taken place in the Middle Fork DAU due to low densities. However, moose were documented (location, numbers, age, and gender of adults) during mule deer and elk surveys. Because these surveys were not moose-specific, much of the area potentially inhabited by wintering moose was not surveyed, reducing utility of this data to make inferences about population change. 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 adding a hunt in GMU 26, which resulted in 9 tags being allocated and a peak harvest of 8 moose in 1997. 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, followed by 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. In response 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 limited access and backcountry nature of this DAU, and this holds true for the single tag currently offered in GMU 27.

*Current Issues.*— Moose populations in the Middle Fork DAU appear low, but stable. However, these are judgement-based determinations. Low density of moose is likely due to limited high-quality habitat. Low-quality moose habitat results in low carrying capacity for moose within this DAU. Disease issues and cause-specific mortality have not been examined in this DAU and are unknown at this time. Although not specifically evaluated, predation may be a factor in low population levels. Additional data on tribal harvest would be helpful for management. At this point, no evidence supports an increase in population or options to provide additional hunting opportunity.

a




b

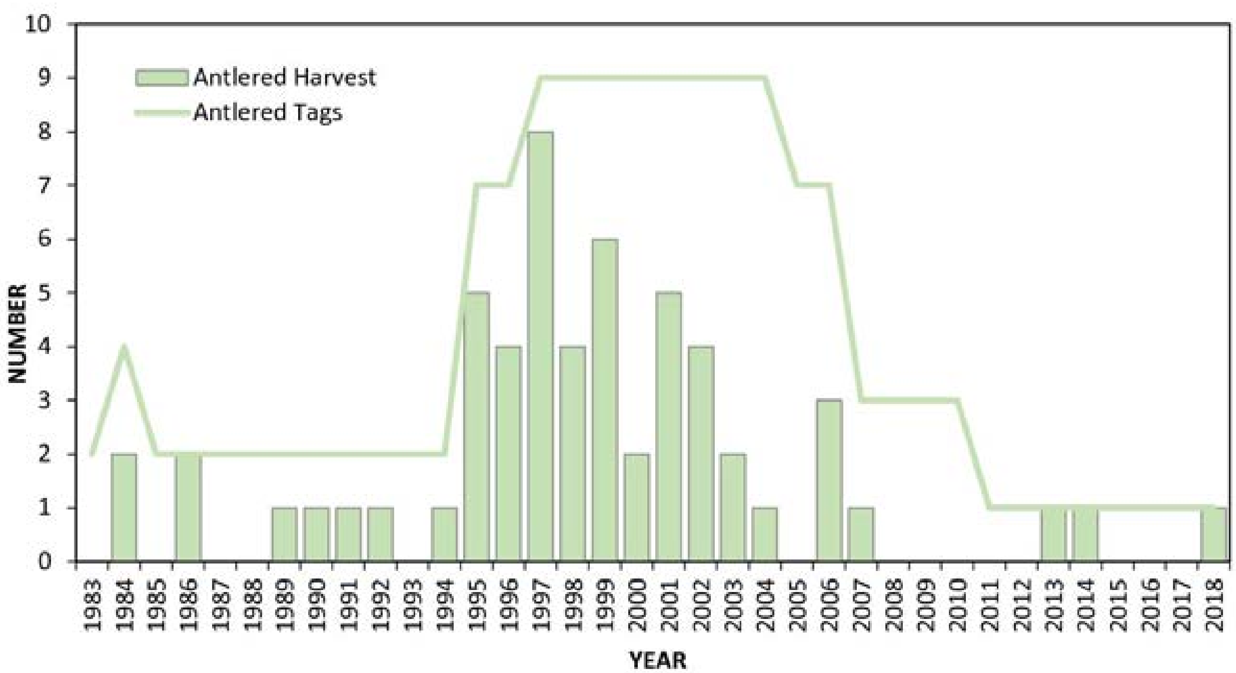



Figure 26. Middle Fork DAU (a) area map and (b) moose harvest and tag allocation, 1983-2018.

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Bull Moose CCBY IDAHO FISH AND GAME

# Appendix A

Common and scientific names of species mentioned in the text (primary sources Mammal Diversity Database 2020, NRCS 2020).

| Taxa | Common Name | Scientific Name |
|---|---|---|
| Mammal | Moose | *Alces alces shirasi* |
| Mammal | Gray wolf | *Canis lupus* |
| Mammal | American beaver | *Castor canadensis* |
| Mammal | Elk | *Cervus canadensis* |
| Mammal | Mule deer | *Odocoileus hemionus* |
| Mammal | White-tailed deer | *Odocoileus virginianus* |
| Mammal | Mountain lion | *Puma concolor* |
| Mammal | Black bear | *Ursus americanus* |
| Mammal | Grizzly bear | *Ursus arctos* |
| Invertebrate | Bark beetle | *Dendroctonus* spp. |
| Invertebrate | Winter tick | *Dermacentor albipictus* |
| Invertebrate | Carotid artery worm | *Elaeophora schneideri* |
| Invertebrate | Giant liver fluke | *Fascioloides magna* |
| Invertebrate | Face fly, Horn fly | *Subfamily Muscinae* |
| Invertebrate | Meningeal worm | *Parelaphostrongylus tenuis* |
| Invertebrate | Horsefly | *Tabanus* spp. |
| Grass | Cheatgrass | *Bromus tectorum* |
| Grass | Medusahead | *Taeniatherum caput-medusae* |
| Forb | Fireweed | *Chamerion angustifolium* |
| Forb | Horsetail | *Equisetum* spp. |
| Forb | Pond weed | *Potamogeton* spp. |
| Forb | Water lily | *Nymphaea* spp. |
| Shrub | Serviceberry | *Amelanchier alnifolia* |
| Shrub | Big sagebrush | *Artemisia tridentata* |
| Shrub | Mountain big sagebrush | *Artemisia tridentata vaseyana* |
| Shrub | Ceanothus | *Ceanothus* spp. |
| Shrub | Redstem ceanothus | *Ceanothus sanguineus* |
| Shrub | Snowbrush (shiny-leaf) ceanothus | *Ceanothus velutinus* |
| Shrub | Curl-leaf mountain mahogany | *Cercocarpus ledifolius* |
| Shrub | Menziesia | *Menziesia ferruginea* |
| Shrub | Mallow ninebark | *Physocarpus malvaceus* |
| Shrub | Bitter cherry | *Prunus emarginata* |
| Shrub | Chokecherry | *Prunus virginiana* |
| Shrub | Bitterbrush | *Purshia tridentata* |
| Shrub | Huckleberry | *Vaccinium membranaceum* |
| Shrub/Tree | Maple | *Acer* spp. |
| Shrub/Tree | Rocky mountain maple | *Acer glabrum glabrum* |

| Taxa | Common Name | Scientific Name |
|---|---|---|
| Shrub/Tree | Douglas maple | *Acer glabrum douglasii* |
| Shrub/Tree | Alder | *Alnus* spp. |
| Shrub/Tree | Birch | *Betula* spp. |
| Shrub/Tree | Redosier dogwood | *Cornus sericea* |
| Shrub/Tree | Willow | *Salix* spp. |
| Shrub/Tree | Scouler's willow | *Salix scouleriana* |
| Shrub/Tree | Mountain-ash | *Sorbus* spp. |
| Tree | Grand fir | *Abies grandis* |
| Tree | Subalpine fir | *Abies lasiocarpa* |
| Tree | Rocky Mountain juniper | *Juniperus scopulorum* |
| Tree | Utah juniper | *Juniperus osteosperma* |
| Tree | Western juniper | *Juniperus occidentalis* |
| Tree | Spruce | *Picea* spp. |
| Tree | Lodgepole pine | *Pinus contorta* |
| Tree | Limber pine | *Pinus flexilis* |
| Tree | Pinyon pine | *Pinus monophylla* |
| Tree | Ponderosa pine | *Pinus ponderosa* |
| Tree | Narrowleaf cottonwood | *Populus angustifolia* |
| Tree | Quaking aspen | *Populus tremuloides* |
| Tree | Black cottonwood | *Populus trichocarpa* |
| Tree | Douglas-fir | *Pseudotsuga menziesii* |
| Tree | Pacific yew | *Taxus brevifolia* |
| Tree | Western red cedar | *Thuja plicata* |
| Tree | Western hemlock | *Tsuga heterophylla* |

# 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 U.S. and Canada (e.g., Maier et al. 2005, Baigas et al. 2010, Feldman 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 (Scott et al. 2002, USGS-GAP 2017).

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 correlations between each variable and presence data, compares those correlations with the range of environmental conditions available in the modeled region, and develops a continuous model of 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 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 (30 m x 30 m), and extent; then exported data as ASCII files for input into R (R Core Team 2018) and Maxent.

### App. B: Moose Observations

All known observations of moose in Idaho as of August 2019 were compiled for this modeling effort. The data set included observations from numerous collared animal studies (2004–2019), helicopter and fixed-wing survey efforts, remote camera survey detections, records in the USFS Natural Resource Information System database and in IDFG regional data files, and reports previously stored in IFWIS Species Diversity Database (including museum specimens, older survey efforts, and incidental observations). Compiled data were uploaded to 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 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 (<500 m) for our modeling purposes. However, compiled observation data such as these are prone to errors of sampling bias, both geographically and environmentally. Given most observations came from collared animal studies in Regions 2, 5, and 6, 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 presence data is often suggested as a solution (Phillips et al. 2009, Veloz 2009, Kramer-Schadt et al. 2013, Boria et al. 2014, Radosavljevic and Anderson 2014). The key to spatial filtering is to randomly subsample presence data with a minimum distance separating sample points, thereby limiting spatial autocorrelation and reducing environmental bias caused by uneven sampling. That minimum distance is somewhat arbitrary and depends on environmental conditions of the study area as well as resolution of data used for modeling. We reduced locally dense sampling of moose by randomly subsampling with a minimum distance of 1,000 m. These filtering procedures (verified or trusted, <500-m accuracy, within Idaho, and >1,000-m separation) resulted in a total of 1,427 summer and 2,914 winter observations available for use in our modeling effort (Figure B1).

## App. B: 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, Feldman et al. 2017, Murray et al. 2017, Jung et al. 2018, Wattles et al. 2018). Given limited time constraints for our effort, we selected similar variables from a subset of fine-scale (30-m resolution) topographic, climatic, edaphic, and landscape covariates (Table B1) which were already developed for use in other statewide modeling projects (L. K. Svancara, IDFG, unpublished data).

Topographic variables generally act as surrogates for factors influencing plant growth (e.g., temperature, light, and 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 National Elevation Data (30 m) (USGS 2016). The CTI, a steady-state wetness index, measures catenary topographic position represented by both slope and catchment size and aims to model soil water content (Moore et al. 1993). Roughness, like terrain ruggedness index (Riley et al. 1999), calculates amount of elevation difference between a grid cell and its neighbors; essentially variance of elevation within the neighborhood (8×8 cells in this analysis). The VRM, which measures terrain heterogeneity within a neighborhood (9×9 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 (2012), both freely available ArcGIS tools. All these topographic variables, to varying degrees, were selected to reflect temperature, water, and light resources which 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. 2009), whereas 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 (~1 km) 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 (250 m) for the Northern Rocky Mountains (Holden et al. 2015) in combination with precipitation data (originally 800 m, resampled to 250-m resolution using cubic convolution to match 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 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, 2011; Anderson and Gonzalez 2011; Stanton et al. 2012; 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 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 characteristics for plant establishment, we used a weighted average based on percent composition for aggregations 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, NRCS 2016a), with missing areas filled in with the U.S. General Soils database (STATSGO2, NRCS 2016b), following national standard methodology and tools used for similar products (e.g., gSSURGO) (NRCS 2015).

Vegetation characteristics typically identified as important to moose include canopy cover, height, and presence of forage shrubs. We developed several variables from the most recent LANDFIRE 2016 land cover classification (USGS 2019): height of all trees and shrubs; tree canopy cover;

distance to dense (>60%) tree canopy cover; percent natural land cover within 300 m, percent natural land cover within 1,000 m, and percent of moose forage shrubs within 270 m. 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 National Hydrography Data (USGS 2017) (FCodes 46006 and 46003, respectively).

## App. B: Current Habitat Suitability

We supplied Maxent with occurrence data as described above, as well as background points consisting of 10,000 randomly generated pseudo-absences across Idaho which were >1,000 m apart, >1,000 m from presence locations, and outside of waterbodies. Following recommended approaches, we addressed collinearity and calculated species-specific model parameters for the 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 <1%. Correlated variables with $P > 0.75$ were also removed, keeping the variable with higher permutation importance. This process of model optimization, development, and variable ranking and removal was repeated until remaining variables displayed a minimum importance of >2%. Final models represent the average of 10 replicates using the optimized parameters and most important variables.

We imported mean model output into ArcGIS 10.6.1 (ESRI 2017) and, for comparative purposes, binned 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). Although both thresholds are easily interpretable, they likely overestimate (Radosavljevic and Anderson 2014), particularly medium and high suitability classes.

## App. B: Results and Discussion

Maxent accurately predicted moose summer (Area Under Curve [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 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 were generally characterized by 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 270 m (in order of permutation importance) (Figure B3). Jackknife tests indicated 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 which were generally characterized by 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 selected thresholds described above, our final moose summer model predicted 5.3 million acres of low suitability habitat, 32.5 million acres of medium suitability habitat, and 15.6 million acres of high suitability habitat across the state. The majority of summer habitat classified as high suitability is predicted to occur in Clearwater (28%), Panhandle (23%), and Upper Snake (18%) regions. Similarly, the final moose winter model predicted 3.5 million acres of low suitability habitat, 33.2 million acres of medium suitability habitat, and 16.8 million acres of high suitability habitat across the state, with the majority of high suitability habitat in Upper Snake (28%), Panhandle (19%), and Southeast (18%) regions.

## App. B: Future Model Refinements

Given time constraints under which these models were developed, we strongly recommend additional biologic and programmatic model refinements be considered. Biologically, developing region-specific models would address the sometimes dramatically different landscapes used by moose across the state. For example, moose occurrences in Salmon and Southeast regions average >1,900 m (range 1,005–3,099 m) elevation year-round, whereas those in Panhandle and Clearwater regions average <1,400 m (range 374–2,141 m). Programmatically, further refinement of background data, as well as inclusion of different covariates, may result in better fitting models. Because Maxent uses background locations where presence or absence of target species is unknown or unmeasured, choice of background data influences what is modeled and perceptions about results (Elith et al. 2011, Merow et al. 2013). By default, Maxent assumes 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 prior expectations for species distribution (Merow et al. 2013). Assessing a range of background extents, instead of just full statewide extent of our preliminary models, may result in increased model performance (e.g., VanDerWal et al. 2009, Anderson and Raza 2010, Iturbide et al. 2015). Similarly, including additional covariates such as landscape disturbance, Normalized Difference Vegetation Index, 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.

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

| Type | Variable | Code | Units | Source |
|---|---|---|---|---|
| Topography | Aspect | Asp | Degree | 3D Elevation Program (USGS 2016), Evans et al. (2014) [CTI and Rough8], Sappington et al. (2007) [VRM] |
| | Slope | Slp | Degree | |
| | Elevation | Elev | m | |
| | Compound Topographic Index | CTI | Index | |
| | Roughness (8 neighbor cells) | Rough8 | m | |
| | Vector Ruggedness Measure (9 neighbor cells) | VRM | Index | |
| Climate | Mean annual temperature | Bio1 | °C | Holden et al. (2015), PRISM (2012), *dismo* package in R. |
| | Mean diurnal range | Bio2 | °C | |
| | Isothermality (bio2 / bio7) (*100) | Bio3 | % | |
| | Temperature seasonality (std deviation * 100) | Bio4 | °C | |
| | Maximum temperature of warmest month | Bio5 | °C | |
| | Minimum temperature of coldest month | Bio6 | °C | |
| | Temperature annual range (bio5 – bio6) | Bio7 | °C | |
| | Mean temperature of the wettest quarter[1] | Bio8 | °C | |
| | Mean temperature of the driest quarter[1] | Bio9 | °C | |
| | Mean temperature of warmest quarter[1] | Bio10 | °C | |
| | Mean temperature of coldest quarter[1] | Bio11 | °C | |
| | Total annual precipitation | Bio12 | mm | |
| | Precipitation of wettest month | Bio13 | mm | |
| | Precipitation of driest month | Bio14 | mm | |
| | Precipitation seasonality (coefficient of variation) | Bio15 | % | |
| | Precipitation of wettest quarter[1] | Bio16 | mm | |
| | Precipitation of driest quarter[1] | Bio17 | mm | |
| | Precipitation of warmest quarter[1] | Bio18 | mm | |
| | Precipitation of coldest quarter[1] | Bio19 | mm | |
| | Annual mean growing degree days | gdd | n | |
| Soils | Percent clay | Clay025 | % | SSURGO and STATSGO2 (NRCS 2016a, *b*), weighted average of all map units in top 0–25cm of soil |
| | Percent sand | Sand025 | % | |
| | Percent silt | Silt025 | % | |
| | Available water capacity in top 25 cm | Aws025 | cm | |
| Land Cover | Tree canopy cover | TreeCC | % | LANDFIRE 2016 (USGS 2019) |
| | Distance to >60% tree canopy cover | D2CC60 | m | |
| | Tree and shrub height | TSHght | m | |
| | Natural land cover (within 300 m) | Nat300 | % | |
| | Natural land cover (within 1000 m) | Nat1000 | % | |
| | Moose forage shrubs (within 270 m) | MSh270 | % | |
| Water | Distance to all perennial streams and lakes | D2Peren | m | National Hydrography Dataset (USGS 2017) |
| | Distance to intermittent streams | D2Inter | m | |

[1] **Quarter is any 3-month time period.**

**Table B2. Maxent modeled thresholds used in aiding interpretation of habitat suitability. Values used in displaying final models are highlighted in bold.**

| Threshold | Summer Threshold | Winter Threshold |
|---|---|---|
| Prevalence | 0.2475 | 0.3274 |
| **Minimum training presence** | **0.0170** | **0.0019** |
| **10 percentile training presence** | **0.2610** | **0.3418** |
| Equal training sensitivity and specificity | 0.4257 | 0.5373 |
| Maximum training sensitivity plus specificity | 0.3896 | 0.3980 |
| Balance training omission, predicted area and threshold value area | 0.0857 | 0.1064 |
| Equate entropy of thresholded and original distributions | 0.1949 | 0.2054 |

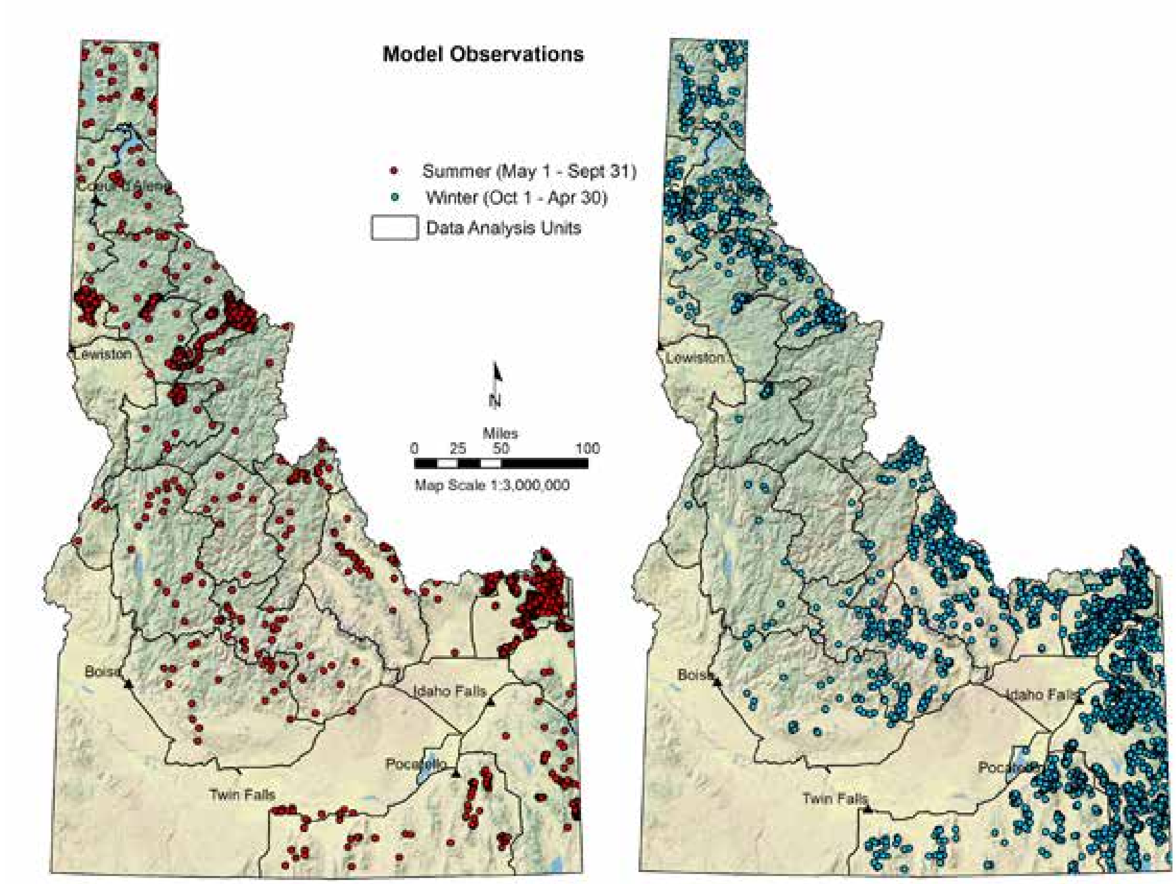
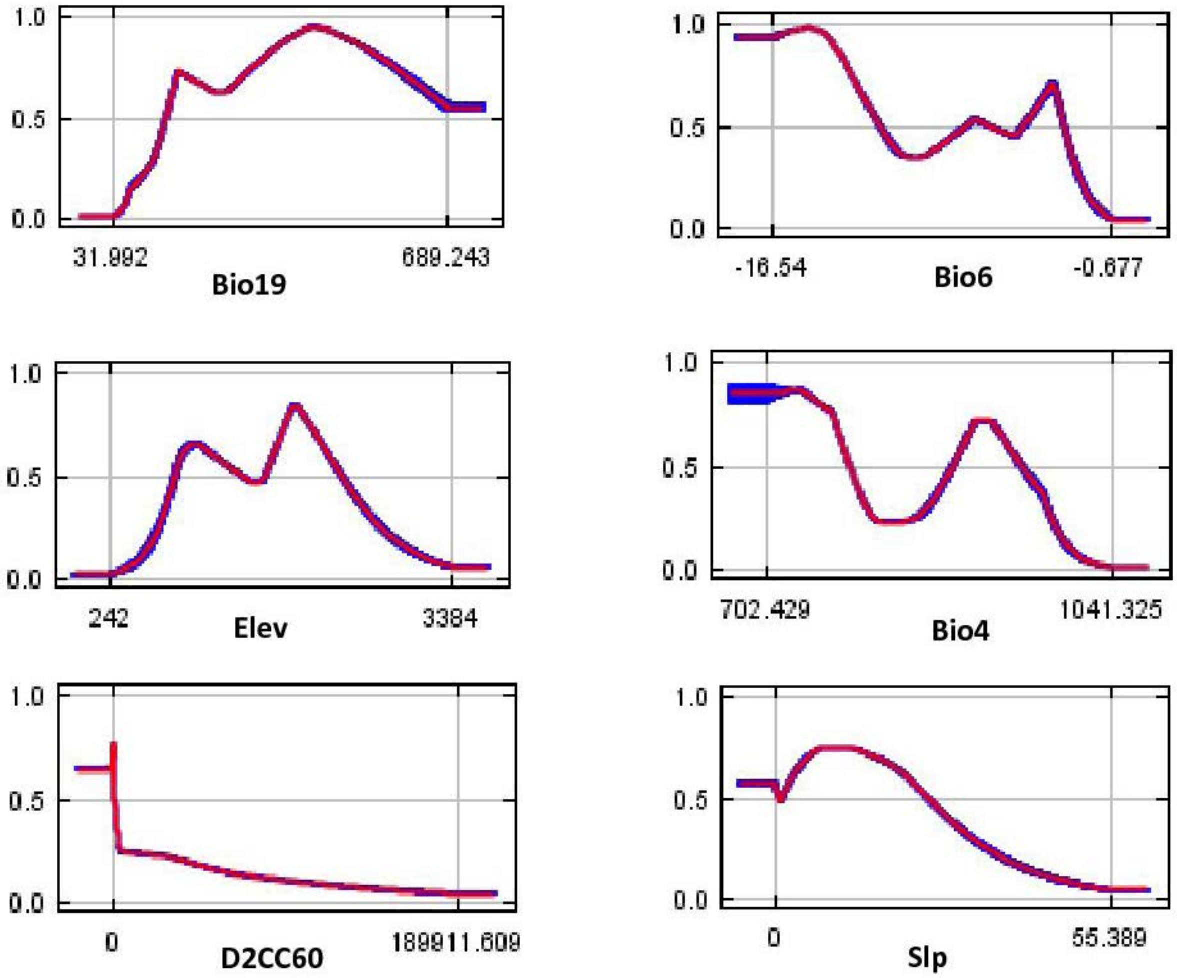
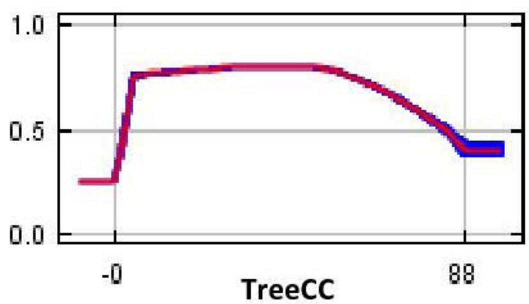


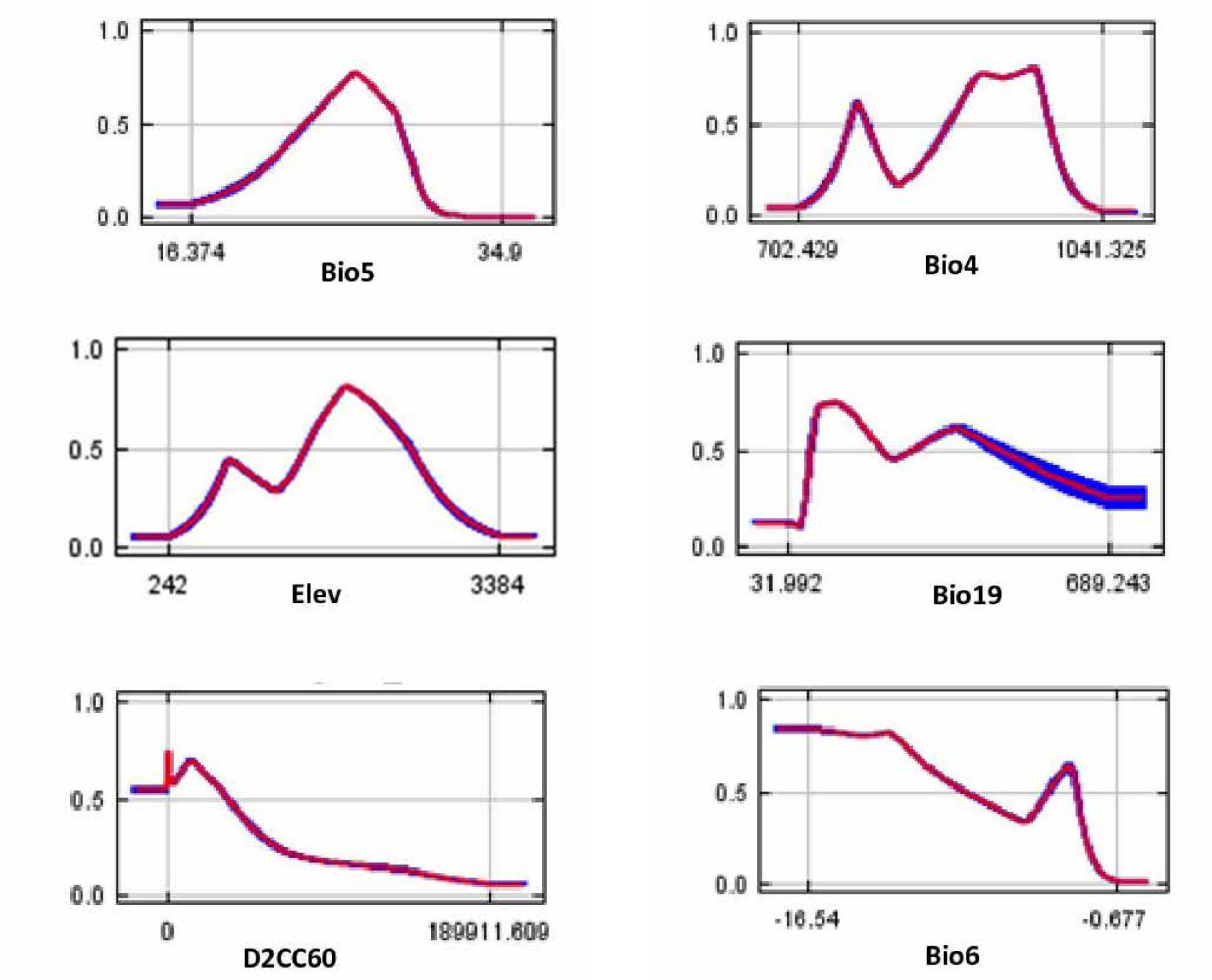

**Figure B1. Summer (left) and winter (right) moose observations used in distribution modeling in Idaho. Point data are from various Idaho Department of Fish and Game databases as of August 2019 and are filtered to include only verified or trusted locations with <500-m accuracy and >1,000 m apart.**

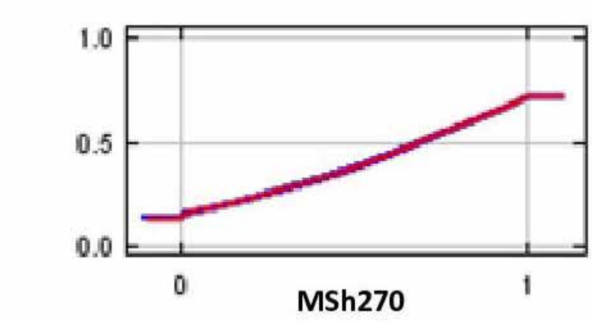



| Variable | Permutation Importance |
|---|---|
| Bio19 | 40.5 |
| Bio6 | 25.5 |
| Elev | 12.7 |
| Bio4 | 7.0 |
| D2CC60 | 5.7 |
| Slp | 5.3 |
| TreeCC | 3.3 |

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 dependence of predicted suitability both on the selected variable and on dependencies induced by correlations among selected variable and other variables. Mean response of 10 replicate runs is in red and mean +/- 1 standard deviation is in blue.




| Variable | Permutation Importance |
|---|---|
| Bio5 | 34.2 |
| Bio4 | 32.9 |
| Elev | 12.9 |
| Bio19 | 8.1 |
| D2CC60 | 4.9 |
| Bio6 | 3.7 |
| MSh270 | 3.4 |

**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 dependence of predicted suitability both on the selected variable and on dependencies induced by correlations among selected variable and other variables. Mean response of 10 replicate runs is in red and mean +/- 1 standard deviation is in blue.**

# Appendix C

## Public Input Summary

The draft plan was available for comment on the IDFG website for 31 days from 12 December 2019 to 12 January 2020. An email encouraging interested individuals to comment on the plan was sent to 12,294 people and, in addition, an estimated 24,257 people were reached through social media (Facebook, Twitter). We also directly emailed USFS, BLM, IDL, tribes, neighboring state wildlife agencies, and several other interested organizations to solicit feedback.

The draft moose management plan webpage was visited by 2,061 users, who spent an average of 4 minutes 28 seconds on the site. Of these users, 179 individuals responded to the comment form (after removal of 5 comments determined to be either duplicates or spam). Users found the survey through a combination of social media, email traffic, and search engines (Google, etc.), with roughly 40% of traffic originating from social media. Ninety-two percent of commenters identified themselves as Idaho residents. More than 75% of respondents either generally supported ($n$ = 74) or supported with concerns ($n$ = 62) the draft management plan (Table C1). Fifteen percent ($n$ = 27) did not support the plan.

Seventy-nine percent of people (n = 142) left additional comments regarding the plan. The most frequently mentioned topics were general support of the draft management plan (29 comments), support for increased research and monitoring (27 comments), support for reduced or changed harvest (88 comments), and a desire for additional focus on predation (70 comments) (Figure C1). Respondents' suggestions for reduced harvest included reducing antlerless harvest (35 comments) and reducing harvest of both genders (28 comments). Suggested changes to harvest regulations (26 comments) included increasing antler size restrictions, changing seasons, decreasing nonresident tags, implementing point systems, and increasing hunting opportunities. Many respondents who did not support the plan provided comments addressing the role of predation, harvest reduction, nonresident tag allocation, or season timing and length.

Additionally, IDFG received written comments from Coeur d'Alene Tribe, Nez Perce Tribe, USFS (Sawtooth NF), Idaho Wildlife Federation, Theodore Roosevelt Conservation Partnership, Greater Yellowstone Coalition, Mile High Outfitters, and PEW Charitable Trusts.

After considering all public comments, the draft plan was modified and prepared for consideration by the Commission.

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**Table C1. Level of support for the plan based on online comments (*n* = 179).**

| Level of Support | Respondents (*n*) | Proportion of Respondents (%) |
|---|---|---|
| Generally support | 74 | 41.3 |
| Support with concerns | 62 | 34.4 |
| Neutral | 16 | 8.9 |
| Do not support | 27 | 15.0 |

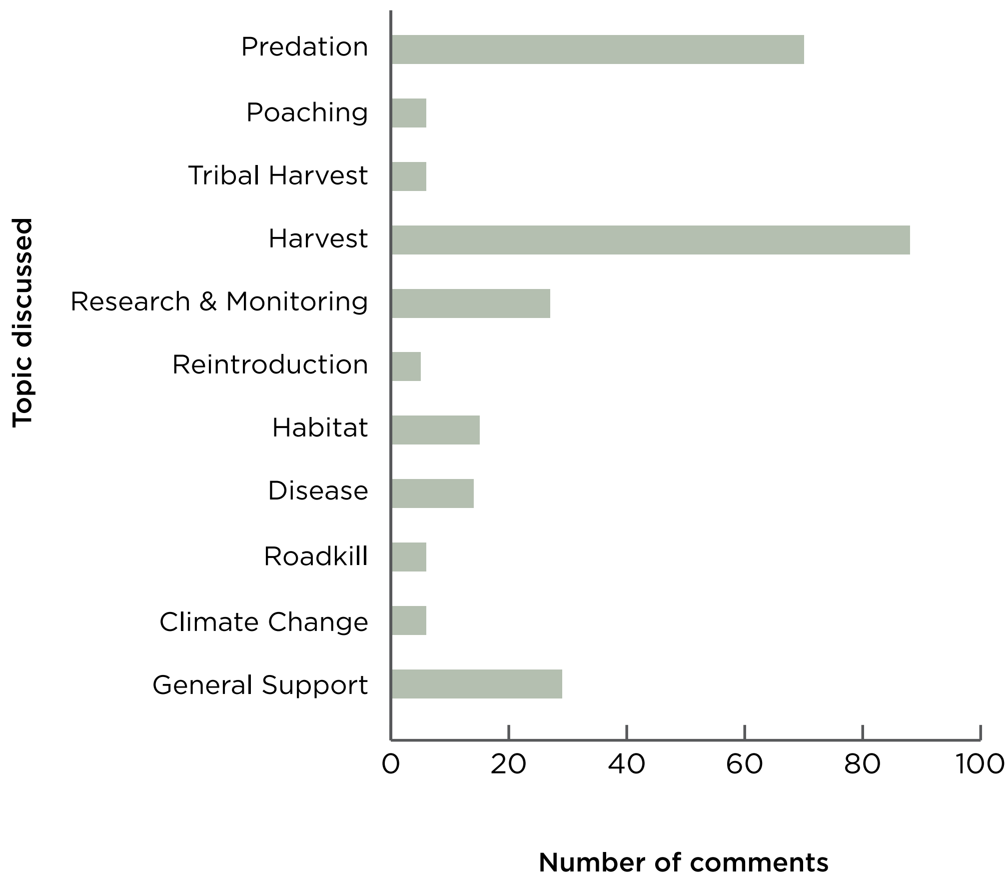


**Figure C1. Topics discussed by online users who opted to leave a comment (*n* = 142).**

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Idaho

# Moose Management Plan

2020-2025