

APPENDIX A – Draft Bison and Elk Management Plan

DRAFT

***Bison and Elk Management Plan
National Elk Refuge***

August 28, 2026



The mission of the U.S. Fish and Wildlife Service is working with others to conserve, protect, and enhance fish, wildlife, plants, and their habitats for the continuing benefit of the American people.



The mission of the National Wildlife Refuge System is to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans.

Draft

Bison and Elk Management Plan

National Elk Refuge

Wyoming

August 28, 2026

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Glossary and Abbreviations

°F: degrees Fahrenheit

BEMP: Bison and Elk Management Plan

Bridger-Teton: Bridger-Teton National Forest

CCP: Comprehensive Conservation Plan; a document that describes the desired future conditions of a Refuge or planning unit and provides long-range guidance and management direction to achieve the purposes of the Refuge; helps fulfill the mission of the Refuge System; maintains and, where appropriate, restores the ecological integrity of each refuge and the Refuge System; helps achieve the goals of the National Wilderness Preservation System; and meets other mandates (602 FW 1, Exhibit 1).

conservation easement: a voluntary legal agreement between a landowner and a government agency or qualified conservation organization that restricts the type and amount of development that may take place on a property in the future. Conservation easements aim to protect habitat for birds, fish and other wildlife by limiting residential, industrial or commercial development. Contracts may prohibit alteration of the natural topography, conversion of native grassland to cropland, drainage of wetland and establishment of game farms. Easement land remains in private ownership.

CWD: chronic wasting disease

fire management plan: a plan that identifies and integrates all wildland fire management and related activities in the context of approved land/resource management plans. Such a plan defines a program to manage wildland fires (wildfire and prescribed fire). It is supplemented by operational plans, including preparedness plans, preplanned dispatch plans, prescribed fire burn plans, and prevention plans. Fire management plans assure that wildland fire management goals and components are coordinated.

forbs: Flowering plants (excluding grasses, sedges, and rushes) that do not have a woody stem and die back to the ground at the end of the growing season

goal: A goal is a descriptive, open-ended, and often broad statement of desired future condition(s) that conveys a purpose but does not define measurable units (602 FW 1, Exhibit 1).

Grand Teton: Grand Teton National Park

GYE: Greater Yellowstone Ecosystem

Jackson Hole Cooperative Elk Studies Group: The Group

LDME: long distance migratory elk

NPS: National Park Service

NWR: National Wildlife Refuge

NWRS: National Wildlife Refuge System

objective: an objective is a concise statement of what we want to achieve, how much we want to achieve, and when and where we want to achieve it. Objectives derive from goals and provide the basis for determining strategies, monitoring refuge accomplishments, and evaluating the success of strategies. Objectives are specific, measurable, achievable, results-oriented, and time-fixed (SMART) descriptions about how we will accomplish conservation (602 FW 1, Exhibit 1).

prescribed fire: Any fire intentionally ignited by management actions in accordance with applicable laws, policies, and regulations to meet specific objectives.

Refuge System: National Wildlife Refuge System

riparian area: long strips of vegetation adjacent to streams, rivers, lakes, reservoirs, and other inland aquatic systems that affect or are affected by the presence of water. This vegetation contributes to unique ecosystems that perform a large variety of ecological functions.

SDME: short distance migratory elk

SDM: structured decision making

Service: U.S. Fish and Wildlife Service

strategy: a strategy is a specific action, tool, technique, or combination of actions, tools, and techniques used to meet objectives (602 FW 1, Exhibit 1).

USDA: U.S. Department of Agriculture

DOI: U.S. Department of the Interior

USFS: U.S. Forest Service

Service: U.S. Fish and Wildlife Service

WGFD: Wyoming Game and Fish Department

Yellowstone: Yellowstone National Park

This draft Bison and Elk Management Plan is built around Alternative D as outlined in the draft Environmental Impact Statement. This plan details how bison and elk would be managed on the Refuge under Alternative D and actions that are common to all action alternatives. This plan will be updated after public review and comment based on the final alternative selected.

Chapter 1. Introduction

This draft, updated Bison and Elk Management Plan (BEMP) provides long-term guidance for managing bison and elk on the National Elk Refuge (Refuge). It reflects new scientific information and changed conditions since the original plan was adopted in 2007, including the recent detection of chronic wasting disease (CWD) on the Refuge and in the greater Jackson area.

The U.S. Fish and Wildlife Service (Service) initiated this planning process in fall 2023, working in close coordination with cooperating agencies: the National Park Service (NPS), U.S. Forest Service (USFS), and Wyoming Game and Fish Department (WGFD). Each agency has distinct roles and responsibilities in managing the Jackson bison and elk herds (see Chapter 3) and contributed significantly to the development of this plan. However, each retains independent decision-making authority based on their respective mandates.

This BEMP outlines the Service's decisions and strategies for managing bison and elk on the Refuge. The planning process also included extensive opportunities for input from Tribal governments and organizations, local agencies, nongovernmental organizations, and the public.

WHAT HAS CHANGED SINCE THE PREVIOUS BISON AND ELK MANAGEMENT PLAN WAS ADOPTED?

The distribution of the elk herd has changed; more elk stay closer to town and in urban areas. Additionally, the landscape and community of Jackson has changed, which include shifts in population dynamics and land use. Along with the environmental and ecological changes on the landscape, CWD has been detected in the Jackson elk herd on the Refuge. The best available science suggests that this disease will have significant negative effects on the Jackson elk herd over time, and that supplemental feeding will exacerbate these effects.

National Wildlife Refuge System Mission and Guiding Laws

The National Wildlife Refuge System (Refuge System) is guided by the National Wildlife Refuge Administration Act of 1966, as amended by the National Wildlife Refuge System Improvement Act of 1997 (Administration Act, 16 United States Code [U.S.C.] 668dd et seq.), the Refuge Recreation Act of 1962 and selected portions of the Code of Federal Regulations and the U.S. Fish and Wildlife Service manual.

The mission of the NWRS, as outlined by the Administration Act is:

... to administer a national network of lands and waters for the conservation, management and, where appropriate, restoration of the fish, wildlife and plant resources and their habitats within the United States for the benefit of present and future generations of Americans.

The Administration Act directs the Secretary of the Interior to ensure that refuges are fulfilling the intended mission of the Refuge System and the purposes of individual refuges (16 U.S.C. 668dd(5)(a)(3)(A-M)).

Other requirements of the Administration Act are to (1) ensure that the biological integrity, diversity, and environmental health of the Refuge System are maintained; (2) recognize that wildlife-dependent recreational uses, such as hunting and wildlife viewing, are legitimate and appropriate public uses of the Refuge System when these uses are compatible with the Refuge System mission and refuge purposes; (3) provide opportunities for compatible wildlife-dependent recreation within the Refuge System; and (4) coordinate the development of plans with relevant state conservation plans for wildlife.

WHAT ARE THE CORE GUIDING PRINCIPLES OF THE NATIONAL ELK REFUGE?

Conservation of native species and their habitats is the core management mission of the National Wildlife Refuge System and purposes of the National Elk Refuge. Recreational public use of refuge land must align with and support the main goal of conserving native species and their habitats. This means that any activities allowed on these lands must help protect wildlife and their environments rather than harm them. This is an important distinction compared to how other public lands, like national parks, are managed, where the focus might also include conserving historical sites and scenic views for everyone to enjoy.

National Elk Refuge Purposes

The Refuge was established by various Acts of Congress, executive orders, and other documents to provide, preserve, restore, and manage lands for wintering elk, other big game animals, birds, and the general conservation of fish and wildlife:

- The Refuge was established in 1912 as a “winter game (elk) reserve” (37 Stat. 293, 16 United States Code [U.S.C.] 673).
- In 1913, the U.S. Congress designated the area “a winter elk refuge” (37 Stat. 847).
- In 1921, all lands included in the Refuge or that might be added in the future were reserved and set apart as “refuges and breeding grounds for birds” (Executive Order 3596), which was affirmed in 1922 (Executive Order 3741).
- In 1927, the Refuge was expanded to provide “for the grazing of, and as a refuge for, American elk and other big game animals” (44 Stat. 1246, 16 U.S.C. 673a).

Over the years, several parcels have been added to the Refuge specifically for the conservation of fish and wildlife (Fish and Wildlife Act of 1956), opportunities for recreational development oriented to fish and wildlife, the protection of natural resources, and the conservation of threatened or endangered species (Refuge Recreation Act of 1962, 16 U.S.C. 460k–l).



Figure 1. Three bull elk in the snow on the National Elk Refuge. Photo Credit: Gannon Castle/USFWS

Chapter 2. Background

Location of the Refuge and Role in the Landscape

The 24,778-acre Refuge is nestled in the valley known as Jackson Hole in northwestern Wyoming and lies right at the edge of the town of Jackson, Wyoming. The Refuge represents one of the last undeveloped low-elevation areas in Jackson Hole. The Refuge is 6 miles at its widest point and 10 miles from southwest to northeast; elevations range from 6,200 to 7,200 feet. The northern half of the Refuge consists of steep rolling hills. The southern half is glacial outwash material, with one resistant formation (Miller Butte) rising approximately 500 feet above the valley floor. The town of Jackson borders the Refuge on the south, and the town of Kelly lies near its northern boundary. Lands to the south and west are mostly privately owned. Lands east of the Refuge are administered as part of the Bridger-Teton National Forest (Bridger-Teton), administered by the USFS, including the nearby Gros Ventre Wilderness. Grand Teton National Park (Grand Teton), administered by the NPS, borders the Refuge on the north and northwest.



Figure 2. The National Elk Refuge in the fall. Photo Credit: Gannon Castle/USFWS

Jackson Hole is characterized by long, cold winters with deep snow accumulations, and short, cool summers. January is the coldest month with an average daily maximum temperature of 24°F and a minimum temperature of 1°F at low elevations. Temperature extremes vary from summer highs of 92°F to 98°F to winter lows of -40°F to -63°F. Precipitation levels are relatively steady throughout the year, with a total average annual accumulation of 15.2 inches in Jackson Hole. Average monthly precipitation levels range between 1 and 2 inches, with May and December being wettest, and July and February driest. Jackson Hole averages 90 inches of snowfall per year, accounting for 60% of annual precipitation. Snowfall varies considerably throughout the area of the Jackson elk herd. On the Refuge, average snowfall ranges from 6 to 18 inches at the southern end and up to 48 inches at the northern end.

The National Elk Refuge lies at the heart of the Greater Yellowstone Ecosystem (GYE), an 18-million-acre mosaic of Federal, State, and private lands that supports the largest concentration of wild ungulates (hoofed animals) and large carnivores in the contiguous United States. The Refuge serves as a critical wintering area and migration terminus for several iconic large mammal species.

The Jackson bison and elk herds—among the largest free-ranging ungulate populations in North America—currently number approximately 538 bison and 9,870 elk (2025 winter counts). The bison herd migrates between the Refuge and Grand Teton National Park, while the elk herd ranges across multiple jurisdictions, including Grand Teton, southern Yellowstone National Park, Bridger-Teton



Figure 3. Bison, elk, and pronghorn are three species that have seasonal migrations that terminate on the Refuge. Photo Credit: Gannon Castle/USFWS

National Forest, Bureau of Land Management lands, and State and private properties, before wintering primarily on the Refuge.

Other migratory species also rely on the Refuge. Portions of the Jackson bighorn sheep herd winter on Miller Butte and Curtis Canyon and summer in the Gros Ventre Mountains. Pronghorn antelope summer on the Refuge and migrate to wintering grounds near Pinedale, Wyoming—one of the longest land mammal migrations in the Western Hemisphere.

Bison and elk play vital ecological roles in the southern GYE due to their abundance, broad distribution, influence on vegetation, and importance to predators and scavengers. Elk are the Refuge's priority species, as they are specifically identified in its enabling legislation.

Additional background on the Refuge's history, environment, and management can be found in its Comprehensive Conservation Plan (CCP).

The Role of Elk in the Landscape



Figure 4. A bull elk, the most iconic species on the Refuge, in the snow. Photo Credit: Gannon Castle/USFWS

While Jackson Hole is probably best known for the splendor and ruggedness of the Teton Range, the Jackson bison and elk herds rank among the top characterizing features of the valley. Both figure prominently in Jackson Hole’s history and culture, although bison were absent from the valley for about 100 years between the mid-1800s and mid-1900s.

Historically, the Jackson elk herd ranged more broadly. Prior to Euro-American settlement, some elk wintered in southern Jackson Hole—now the site of the Refuge and the town of Jackson—and may have used areas as far as the Green River, Wind River, and Snake River basins. However, by the late 19th century, overhunting, land development, and habitat loss had largely confined the herd to Jackson Hole, where harsh winters led to significant mortality. In response, local residents and officials began winter feeding in 1910–1911. Congress formally supported this effort in 1912 by appropriating funds to establish a “winter game (elk) reserve,” which became the National Elk Refuge. The Refuge’s supplemental feeding program continues as a legacy of this history.

Today, the Jackson elk herd faces reduced access to historic winter range, altered migration patterns, and behavioral conditioning due to long-term feeding. The herd mostly occupies approximately 8,000 km² in the upper Snake River watershed north of Jackson, Wyoming (see Figure 5). Much of the herd is migratory, moving seasonally between distinct summer and winter ranges. Primary wintering areas include the National Elk Refuge, Buffalo Valley, lower elevations of the Gros Ventre River drainage, and adjacent Bridger-Teton National Forest lands. Summer ranges span five general regions: Grand Teton National Park, Yellowstone National Park, the Gros Ventre

drainage, Teton Wilderness, and the Southwest Boundary area, which includes both public and private lands near Grand Teton’s southwest boundary.

The herd now includes both long-distance and short-distance migrants. Long-distance migrant elk (LDME) travel extensively across the Greater Yellowstone Ecosystem, contribute to predator-prey dynamics, support recreational hunting, and play a key ecological role. Short-distance migrant elk (SDME), by contrast, typically winter on the Refuge and summer in the Snake River corridor between Wilson and Moose, Wyoming—primarily on private lands and southern Grand Teton. SDME are more likely to interact with livestock, increasing the risk of disease transmission, and may compete with LDME for limited winter range (see Figure 5 for migration routes).

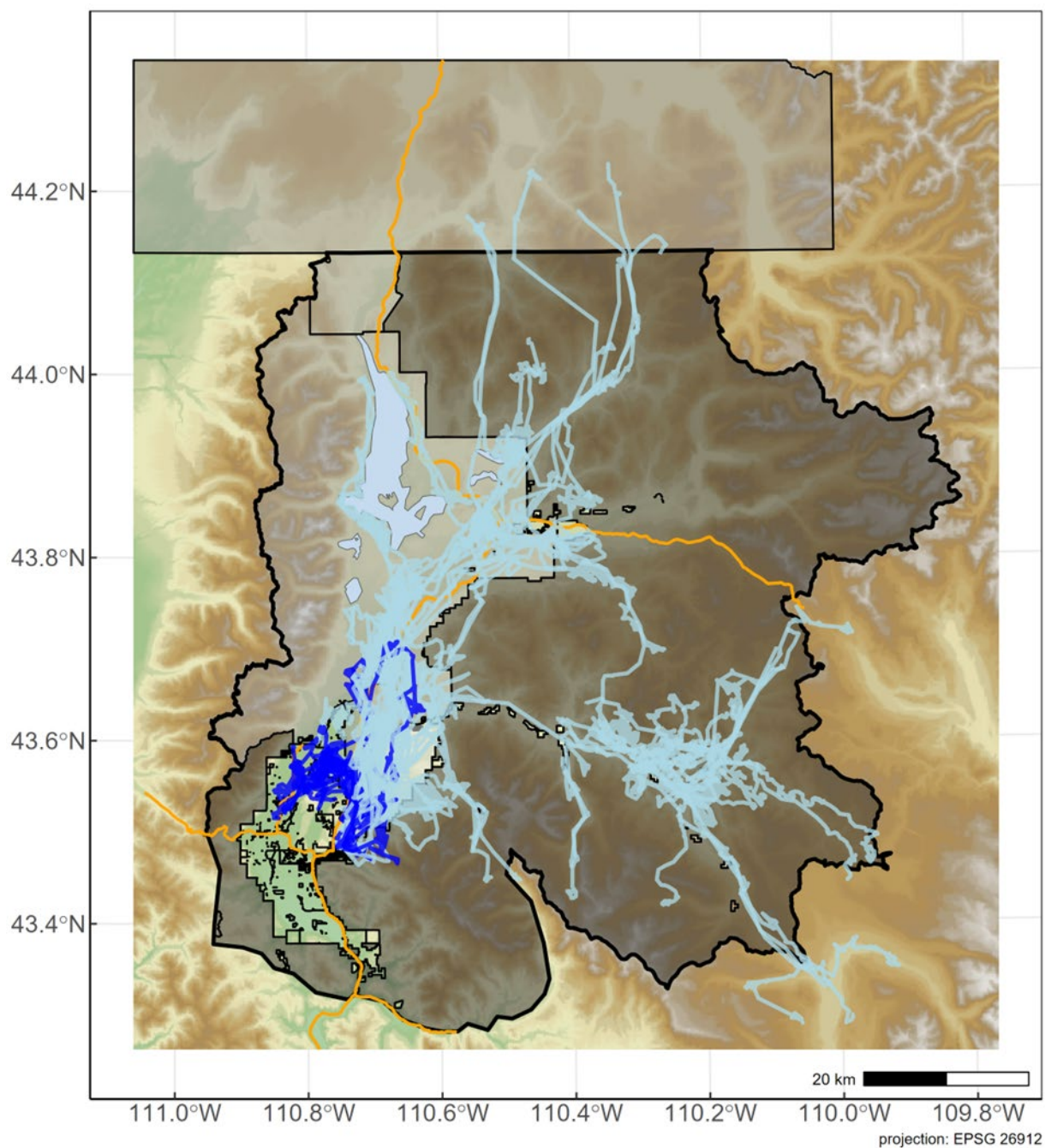


Figure 5. Elk migration near the National Elk Refuge. Jackson elk herd migrations around the National Elk Refuge are show in dark blue (SDME) and light blue (LDME). Elk migrations cross Federal, State, and public lands. The map was generated by the USGS using data from the USGS Data Release Kauffman and others, 2020.

Draft National Elk Refuge Bison and Elk Management Plan (2026)

Currently the Jackson elk herd population fluctuates near 10,000 animals, with approximately 7,500 elk wintering on the Refuge in a given year (See Figure 6 for the Jackson elk herd population over time).

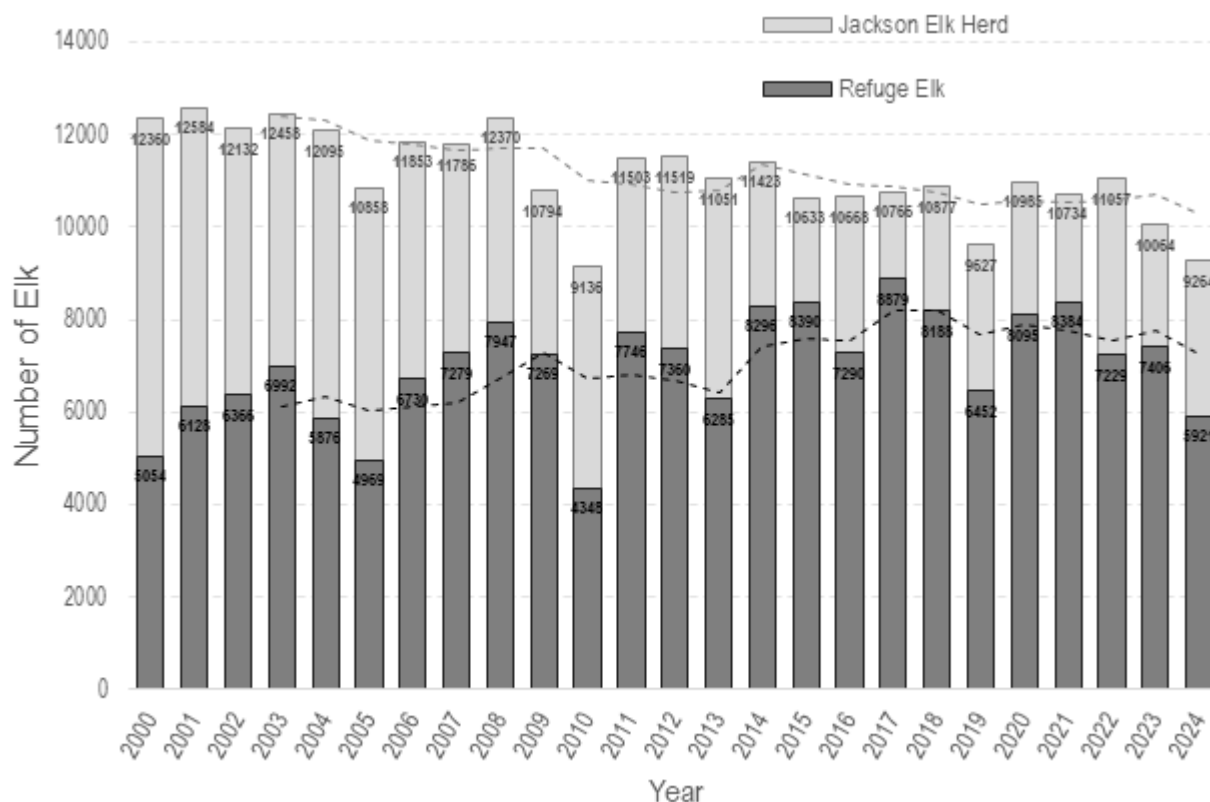


Figure 6. Winter counts for the entire Jackson elk herd (light grey), and for the subset of elk occupying the Refuge (dark grey) 2000-2024

Elk remain central to the Jackson Hole community and economy. Visitors observe them up close on Refuge sleigh rides, and thousands of pounds of shed antlers are auctioned annually in Jackson. Elk also support hunting, wildlife viewing, and backcountry recreation, underscoring their ecological and cultural importance.

The Role of Bison in the Landscape

An iconic symbol of the American West, bison are also popular with visitors and residents. Because so few opportunities remain to see bison in the wild, viewing and photographing them in Grand Teton with the Teton Range in the background is a treasured opportunity for many of the valley's visitors. Similar to elk, there is also a high level of interest in bison hunting. Bison are of particular interest to nearby Native American Tribes and Tribes in other parts of the United States because the animals are central to their culture and tradition.



Figure 7. The Jackson bison herd has been wintering on the Refuge since 1975. Photo Credit: Gannon Castle/USFWS

Bison are native to Jackson Hole, as evidenced by prehistoric remains found throughout the valley. However, by the mid-1880s, they were nearly extirpated outside Yellowstone due to unregulated hunting. In 1948, 20 bison from Yellowstone were reintroduced to the 1,500-acre Jackson Hole Wildlife Park near Moran—a nonprofit facility supported by the New York Zoological Society, Jackson Hole Preserve, Inc., and the Wyoming Game and Fish Department (WGFD). A small herd was maintained in captivity until 1963, when brucellosis was detected. Most adults were culled, but a few vaccinated yearlings and calves were retained.

In 1964, twelve brucellosis-free bison from Theodore Roosevelt National Park were added. By 1968, the herd—then reduced to 11 animals—escaped confinement. In 1969, the decision was made to allow them to roam freely, consistent with National Park Service wildlife management policy following the 1950 expansion of Grand Teton.

Initially, the herd remained small and wintered in the Snake River bottoms. In 1975, bison began wintering on the Refuge. Their use of natural forage was considered acceptable, but in 1980, they began utilizing supplemental feed intended for elk. This access led to a sharp increase in population growth (see Figure 9).

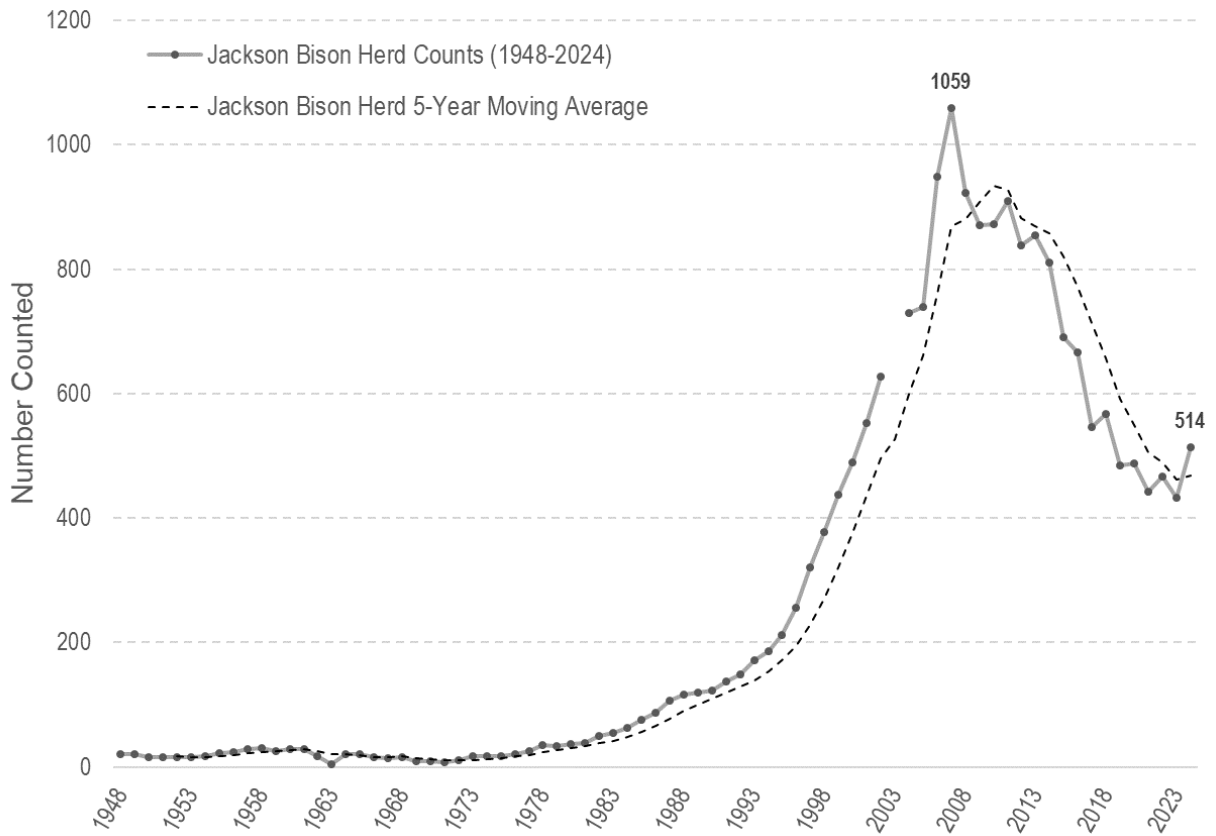


Figure 8. Bison counts for the Jackson bison herd, including the 5-year moving average, 1948-2024.

The discovery of supplemental feed had several consequences. Bison began disrupting elk feeding operations, displacing and occasionally injuring elk. In response, managers established separate feedlines for bison in 1984. However, as the herd grew, separating the two species became increasingly difficult. A variety of feeding strategies are now used to minimize conflict and reduce elk displacement.

Draft National Elk Refuge Bison and Elk Management Plan (2026)

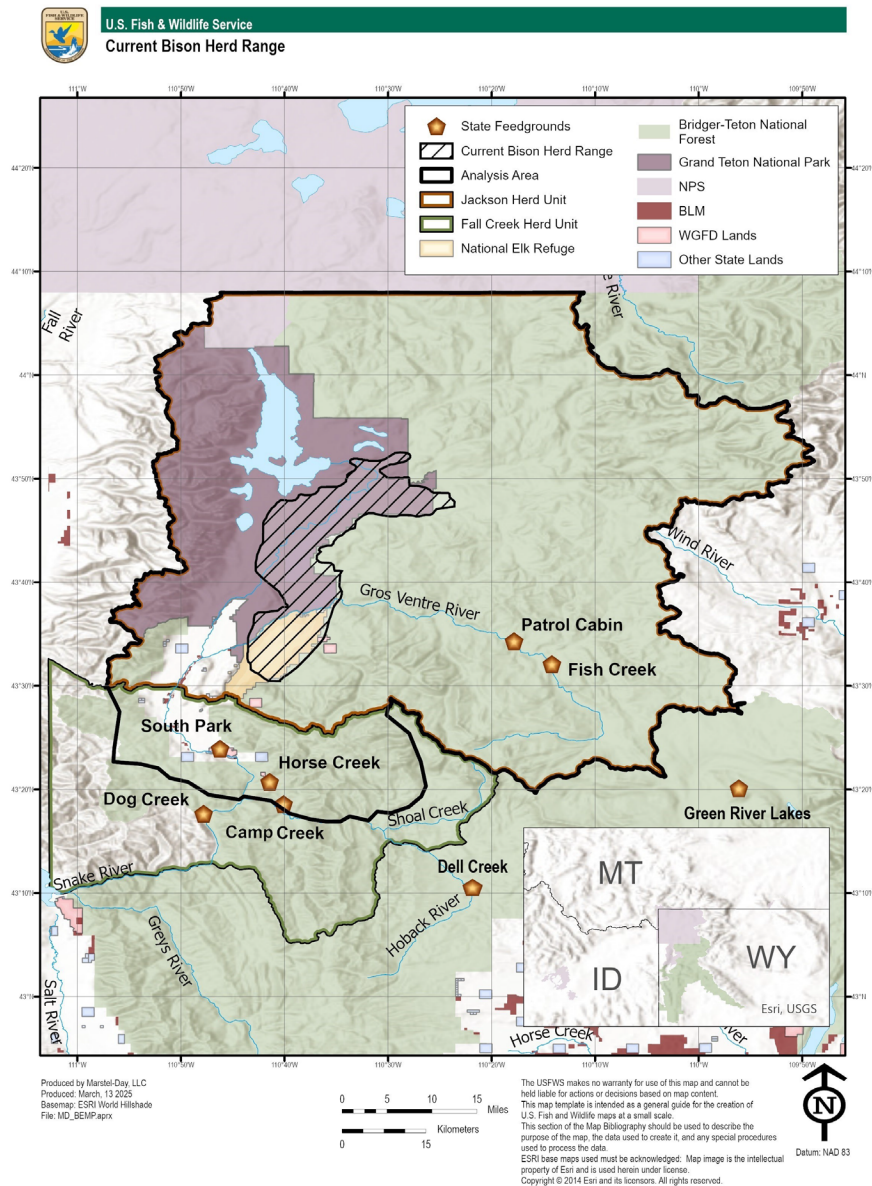


Figure 9. Map of the Jackson bison herd range. The Jackson bison herd's range is almost entirely within Grand Teton and the Refuge, with some bison distributing onto Bridger-Teton, as well as State and private lands in the vicinity.

To manage population growth and reduce conflicts, the 2007 BEMP called for reducing the herd from nearly 1,200 animals to approximately 500 through WGFD-administered hunting programs. At peak population levels, bison frequently interfered with feeding operations, sleigh rides, and approached the town of Jackson. Hunting remains the primary tool for maintaining population objectives and influencing bison distribution.

The Jackson bison herd is now primarily distributed within Grand Teton and the Refuge, with some individuals ranging onto Bridger-Teton, and nearby State and private lands near Kelly and north of Jackson (see Figure 9). Prior to 2018, over 90% of the herd overwintered on or near the Refuge.

Since then, winter use of Refuge feedgrounds has varied significantly—from 0% during the mild winter of 2018 to 83% in 2023.



Figure 10. Bison and elk on the Refuge's feedline. Photo Credit: Kari Cieszkiewicz/USFWS

The Jackson bison herd was identified in the 2017 International Union for Conservation of Nature Red List Assessment as one of only two American plains bison herds fully functioning as wild in the lower 48 United States, along with a third herd identified in Canada. Key criteria for the Assessment included “range area and resources can sustain and minimum viable population or larger population without supplementation.” (Aune, Jorgensen, & Gates, 2017).

While there have been many benefits associated with wintering large numbers of elk and bison on the Refuge, high animal concentrations have created an unnatural situation that has contributed to an increased risk for potentially major outbreaks of exotic diseases, which is demonstrated in the high level of brucellosis in the elk and bison herds. It has also resulted in damage to and loss of habitat due to browsing of willow, cottonwood, and aspen stands and thereby reducing availability of these habitats to other wildlife as well as unusually low winter mortality, which has affected predators and other species and has required intensive hunting programs.

Chapter 3. Native American Tribes and the Refuge

The Service acknowledges that the Refuge, along with the lands and waters of the Greater Yellowstone Ecosystem (GYE) have been home to Indigenous peoples since time immemorial. Numerous Tribes consider the Greater Yellowstone Ecosystem a part of their ancestral homelands. The most prominent groups that occupied the eastern Idaho and western Wyoming area before settlement by Euro-Americans were the Niimi/Bannock, Newe/Eastern Shoshone, and Newe/Northern Shoshone tribes. Other American Indian tribal groups have some historical or continued association with lands now within the National Elk Refuge: Den'a/Athabascans, ~~Namunuu~~/Comanche, Apsáalooke/Crow, Aaniiih/Gros Ventre, Cáuigú/Kiowa, Ksanka/Kootenai, Teton Sioux/Lakota, Nimiipuu/Nez Perce, Qłispé/Upper Pend d'Oreille, Séliš/Bitterroot Salish, Weyíiletpuu/Cayuse, Imatalamłáma/Umatilla, Núuchi/Ute Nations, Walúulapam/Walla Walla, Akaitikka/Lemhi, Anishinaabeg/Little Shell Chippewa, Nakoda/Assiniboine. In addition, the Hinonoeino/Arapaho, Niitsitapi/Blackfeet, Tsitsistas/Cheyenne, and other Siouan groups and people of the Plains made excursions into the region for hunting, warfare, and trade (Walker, 2005)

The Shoshone-Bannock Tribes have called the lands that now make up the National Elk Refuge and surrounding areas, including Yellowstone, home since time-immemorial (Smoak, 1997). The archaeological records and historical documentation undeniably prove that the Tribes lived upon and utilized these lands for subsistence hunting, fishing, and gathering to provide for their Tribal membership long before westward expansion and settlement (Smoak, 1997)).

The Shoshone-Bannock Tribes and the United States executed a treaty known as the 1868 Fort Bridger Treaty, which reserved the right of the Tribes to hunt upon the unoccupied lands of the United States TREATY WITH THE EASTERN BAND SHOSHONI AND BANNOCK, 1868., 15 Stat. 673.

In the early 2000s the Shoshone-Bannock Tribes and the Service worked together to establish a tribal bison hunt to recognize the cultural significance of the land and resources of the Refuge to the Shoshone-Bannock Tribes.

The tribal bison hunt has been expanded to include the Eastern Shoshone Tribe, also a party to the 1868 Fort Bridger Treaty.

In addition to the tribal bison hunt, the Shoshone-Bannock Tribes also gather culturally significant resources on the Refuge for their use. This recognition of Tribal rights and priorities strengthens the trust relationship between the Tribes and Service, and the important cultural and legal connection to the lands that still exist today.

Trust Resources and Native American Policies

The United States government has a unique legal relationship with federally recognized American Indian Tribes, based on the recognition of the inherent powers of Tribal sovereignty and self-government. The Service is committed to upholding this special relationship and implementing its activities in a manner consistent with it. The United States government has an Indian trust responsibility to protect and maintain rights reserved by or granted to Indian Tribes or individuals by treaties, statutes, and executive orders. The Service shares in this responsibility. The Service has unique responsibilities to Tribes, including under the National Historic Preservation Act (54 U.S.C. 306101 *et seq.*); the American Indian Religious Freedom Act (42 U.S.C. 1996); Native American Graves Protection and Repatriation Act (25 U.S.C. 3001 *et seq.*); and the Religious Freedom Restoration Act of 1993 (42 U.S.C. 2000bb *et seq.*). For the purposes of this section, we apply the term “Tribal” or “Tribe(s)” generally to federally recognized Tribes and Alaska Native Tribal entities.

WHAT IS THE CULTURAL IMPORTANCE OF THE BISON HERD?

For over 500 human generations and 1,500 bison generations, Indigenous Peoples have relied on, honored, and stewarded the buffalo across the North American continent. For millennia prior to European colonization, an estimated 30-60 million bison sustained a substantial proportion of the 4 million Indigenous People in what is now the United States, Canada, and Mexico. Bison and Indigenous Peoples became inextricably interconnected through ecological and cultural lifeways that sustained diverse and thriving human communities and natural systems at a globally significant scale.

Bison were vital to sustaining rich and resilient ecosystems, creating habitat for a myriad of wildlife species, promoting biodiversity, and contributing to nutrient cycling, water and soil health, and wildfire behavior. Individual Tribes sustained deep cultural connections to the buffalo through song, prayer, ceremony, dance, art, and language. Buffalo are widely regarded by many Indigenous Peoples, quite literally, as relatives who were and still are central to cultural, material, and spiritual life.

-Department of Interior, 2024 Bison Shared Stewardship Strategy



Figure 11. Bison within the Refuge with snow-covered Tetons in the background. Photo Credit: Kari Cieszkiewicz/USFWS

Tribal Consultation

On March 25, 2024, the Service initiated Government-to-Government consultation by reaching out to 25 Tribes with historic ties to the Jackson Hole area to inform them of the intent to update the BEMP and prepare an EIS. To date, the Eastern Shoshone, Northern Arapaho, and Shoshone-Bannock Tribes have responded.

The Service met with the Eastern Shoshone Tribal Council on February 20, 2024, to discuss the cultural bison hunt and the initiation of the BEMP planning process. A joint meeting with the Eastern Shoshone and Northern Arapaho Inter-Tribal Business Council followed on October 9, 2024, during which the Council encouraged the Service to host public meetings. In response, the Service held meetings on the Wind River Reservation on November 12 (Ethete) and November 13 (Fort Washakie), 2024, to share information on the Refuge, current management issues, and proposed alternatives. Coordination with Shoshone and Arapaho Fish and Game Departments has continued throughout the planning process.

The Service also met with the Shoshone-Bannock Tribal Business Council on February 29 and April 19, 2024, to discuss the cultural bison hunt and the BEMP. Formal consultation occurred on November 14, 2024, at Fort Hall, Idaho. Following that meeting, the Tribe submitted formal requests, including:

1. Recognition in the BEMP of the Refuge and surrounding areas as traditional Shoshone-Bannock homelands (included on page 11);
2. Revision of bison and elk population objectives in the draft alternatives to allow for increased Tribal harvest opportunities; and
3. Ongoing formal Government-to-Government consultation throughout the finalization of the BEMP and EIS (letter dated November 25, 2024; see Appendix J).

In response, a representative of the Shoshone-Bannock Tribes joined the interdisciplinary team drafting the BEMP and EIS to support development, review, and ensure accuracy of content related to the Tribe's interests. The Shoshone-Bannock Tribes provided formal comments on the preliminary draft of the EIS on December 9, 2025. Their feedback re-emphasize concerns from the 2024 letter they sent centered around treaty rights, cultural continuity, and trust responsibilities, as well as concerns about how current alternatives prioritize state interests over Tribal rights. Several of the Tribes' concerns are outside the scope of the management issues addressed in this updated BEMP; however, the Service remains committed to continued consultation with Tribes on these important issues.

Any Tribe wishing to engage directly in the planning process will continue to be provided the opportunity to do so. All consultations and communications will be treated as confidential to the extent permitted by the Freedom of Information Act and other applicable laws. Beyond this planning effort, the Service is also interested in exploring future opportunities for co-stewardship of the Refuge's natural resources with Tribal partners.



Figure 12. View from the Refuge towards the town of Jackson. Photo Credit: Gannon Castle/USFWS

Chapter 4. Cooperating Agency Roles and Coordination

Because the Jackson bison and elk herds migrate across several jurisdictional boundaries (see Figure 13), several agencies have various management roles and responsibilities: the Service, WGFD, NPS, and USFS. As such the Refuge coordinates and collaborates with these agencies on a regular basis.

In this chapter, we describe the various management roles, responsibilities, and cooperative efforts of these agencies.

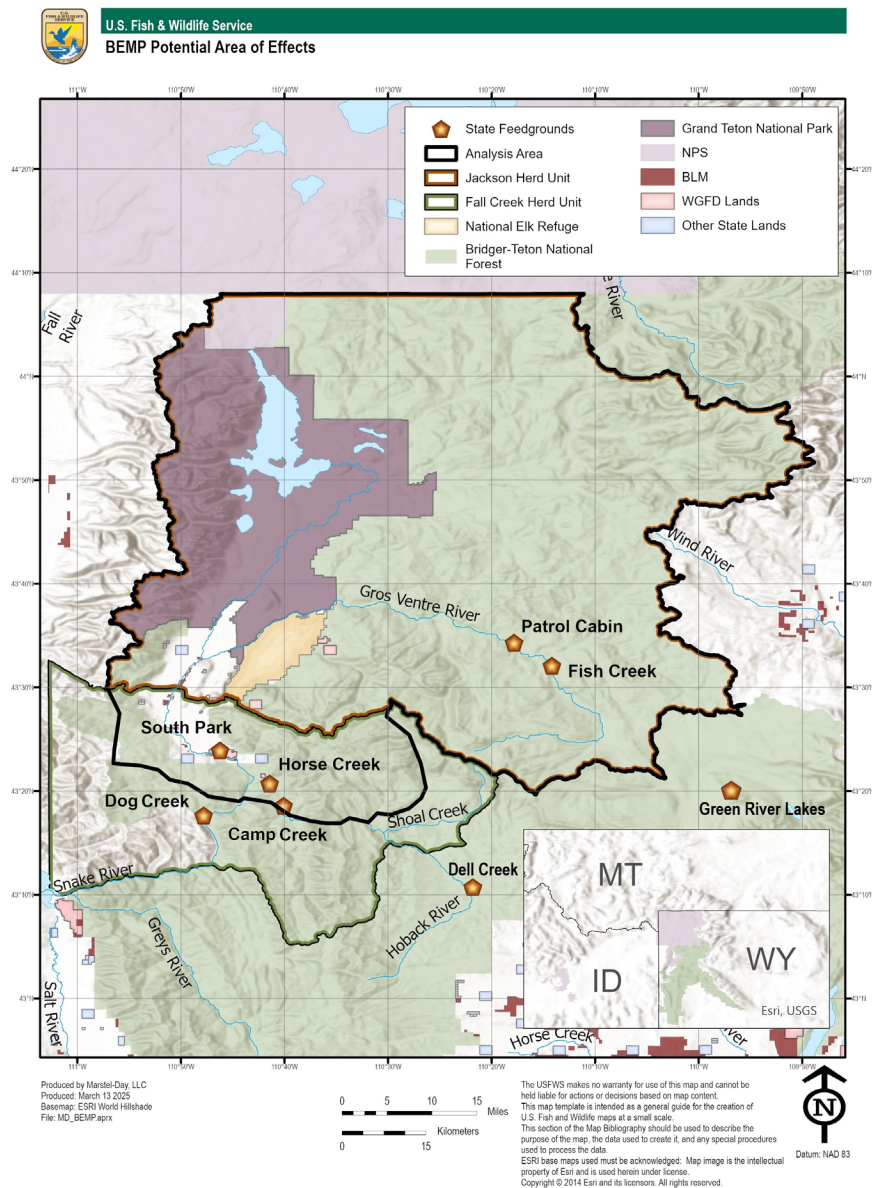


Figure 13. The map shows area of potential impacts of bison and elk management, showing the area (black polygon) composed of the Jackson elk herd unit (orange polygon), part of the Fall Creek herd unit (green polygon). the Refuge, Grant Teton, and Bridger-Teton NF.

U.S. Fish and Wildlife Service (National Elk Refuge)

The Service is responsible for managing bison, elk, and their habitats within the boundaries of the Refuge in accordance with the Refuge's establishment purposes, the mission of the Refuge System, and other applicable Federal statutes, regulations, and policies. Some of our collaborative work in managing the Jackson bison and elk herds include:

- Collaborates with NPS, WGFD, and USFS on elk research as part of the Jackson Hole Cooperative Elk Studies Group.
- Convenes annual Jackson Hole Cooperative Elk Studies Group meetings.
- Works across our boundaries to coordinate on human-wildlife conflict issues across Highway 89 and on other private lands within the Jackson Hole community (e.g. fencing, hazing, North 89 Highway Wildlife Crossing Project).
- Collaborates with WGFD to set Refuge elk and bison hunting seasons and harvest levels.
- Coordinates with WGFD and NPS to test bison harvested on the Refuge for specific diseases including *Mycoplasmopsis bovis* strains.

Wyoming Game and Fish Department

The WGFD is responsible for managing bison and elk in the State of Wyoming according to the population objectives and other guidelines set by the Wyoming Game and Fish Commission and other applicable State statutes, regulations, and policies. Some of the agency's collaborative work in managing the Jackson bison and elk herds includes:

- Collaborates with all partners in the Jackson Hole Cooperative Elk Studies Group (discussed further below) and conducts and collaborates on other research projects.
- Monitors elk and bison distribution, numbers and population trends.
- Collaborates with Cooperating Agencies on bison and elk hunting opportunities and reduction programs on Federal lands.
- Mitigates for and responds to private land conflicts and damages. Compensates private landowners for damage caused by big game, including elk, in accordance with state statute and Wyoming Game and Fish Commission regulation.
- Collaborates with the Service on measuring forage availability to determine when supplemental feeding should begin and end; funds half the annual feed pellet costs.
- Collaborates with the Service to set elk and bison hunting seasons and harvest levels on the Refuge.
- Responds to wildlife conflict situations, including wildlife on HWY 89 and motorist safety, and injured animals due to vehicle collisions or fence engagements
- Completes the laboratory work and shares the results for CWD samples from elk harvested or found dead on the Refuge. Calculates and reports herd unit CWD prevalence annually.
- Partners with the Refuge on the restoration of lower Nowlin Creek which includes exclusion of elk and bison from restoration site.

National Park Service (Grand Teton National Park)

The NPS is responsible for managing the bison and elk herd within the boundaries of Grand Teton in accordance with the NPS's Organic Act of 1916, as amended (16 U.S.C. 1 2 3, and 4) and other

applicable Federal statutes, regulations, and policies. Grand Teton’s enabling legislation further underscores this mandate by explicitly recognizing the protection and conservation of the Jackson Hole elk herd as a purpose of the park. In support of these authorities, the NPS undertakes a range of collaborative management actions for the Jackson bison and elk herds and for ecosystem protection as funding and support allows and where most effective, including:

- Continuing restoration of the Kelly Hayfields (and possible other locations) opportunistically in the southern portion of Grand Teton to enhance habitat for elk, bison, and other wildlife as well as native sagebrush and grass species in the ecosystem.
- Jointly establishing with the WGFD quotas and seasons for the Elk Reduction Program, when needed for the proper management and protection of the elk herd, consistent with Grand Teton National Park’s enabling legislation and management responsibilities.
- Managing the Elk Reduction Program within Grand Teton.
- Administering remaining grazing leases on park lands to maintain healthy rangelands reduce the risk of disease transmission between bison and cattle.
- Completing laboratory work and sharing results for CWD samples collected from elk harvested or found dead within Grand Teton.
- Serving as an active member of the Jackson Hole Cooperative Elk Studies Group, working jointly with partner agencies to coordinate research, monitoring, and adaptive management of the Jackson elk herd across jurisdictional boundaries.
- Implementing various management strategies including temporary or seasonal closures, fencing or other tactics to support wildlife life history and/or movements, forage condition and availability, and habitat conditions.

U.S. Forest Service (Bridger-Teton National Forest)

The USFS is responsible for managing habitat adequate to meet the needs of dependent fish and wildlife populations, including bison and elk herds, within the boundaries of Bridger-Teton in accordance with the 1990 Bridger-Teton Land and Resource Management Plan and based on the National Forest Management Act of 1976 and Multiple-Use Sustained Yield Act of 1960. Some of the agency’s collaborative work in managing the Jackson bison and elk herds include:

- Collaborates with WGFD to manage elk and bison populations, habitat, and other resources on Bridger-Teton.
- Issues permits to the Wyoming Game and Fish Commission (WGFC) for WGFD to conduct elk management activities on Bridger-Teton, including the operation of seven elk feedgrounds.
- Manages year-round or seasonal motorized and non-motorized access to protect vital big game habitats for winter range and calving, as well as migration corridors.
- Collaborates with all partners in the Cooperative Elk Studies Group.

Due to these ongoing partnerships, these agencies are “cooperating agencies” on this BEMP and associated EIS. As cooperating agencies, these agencies have participated in the planning process by providing technical data, expertise, comment, and review, and generally contributed their subject matter expertise to the development of this plan and EIS. However, each agency has

independent decisions to be made related to their contribution to the conservation of the bison and elk management based on their unique roles and responsibilities.

Given the wide range of authorities and interests, the Service has used, and will continue to use, a cooperative approach to management planning involving all associated Federal agencies and the WGFD.

The Jackson Hole Cooperative Elk Studies Group

The Jackson Hole Cooperative Elk Studies Group (Group) was formally established in 1958 as a multi-agency framework to coordinate research, monitoring, and management of the Jackson Elk Herd. The original Memorandum of Understanding (MOU), signed jointly by the Wyoming Game and Fish Commission, the U.S. Forest Service, the National Park Service, and the U.S. Fish and Wildlife Service, articulated a structure built around two interdependent committees: an Advisory Council composed of agency administrators with legal management authority, and a Technical Committee made up of biologists and other specialists from each participating agency. The Advisory Council was charged with providing policy direction, maintaining clarity around agency jurisdictions, coordinating interagency planning efforts, and determining which land use and management actions merited technical review. The Technical Committee, in turn, was responsible for developing and coordinating scientific studies, sharing results among agencies, and recommending research needs and potential management actions.

In its early years, the Group functioned as a leadership-driven body, with the Advisory Council—consisting of the Grand Teton National Park Superintendent, the Bridger-Teton National Forest Supervisor, the Jackson Wyoming Game and Fish Department Supervisor, and the National Elk Refuge Manager—providing primary direction for elk research and management coordination, while the Technical Committee served in an advisory and implementation role.

This structure reflected the needs of the time: the Jackson Elk Herd was, and remains, a major ecological and economic resource shared across multiple jurisdictions, requiring coordinated leadership supported by a common scientific foundation.

Over subsequent decades, the Group's emphasis shifted. As ecological research and long-term monitoring expanded in scope and complexity, the Technical Committee assumed a larger share of day-to-day coordination. By the late 20th and early 21st century, the technical team of agency biologists effectively became the group's primary operational component—leading research coordination, conducting and overseeing field studies, and facilitating ongoing interagency information exchange. Meanwhile, the Advisory Council's formal leadership role, though never rescinded, became less central in routine operations. As a result, modern descriptions of the Group have sometimes blurred the distinction between the group's original structure and its contemporary practice.

Recognizing both the enduring importance of formal interagency leadership in adaptive management of the bison and elk herds and the essential role of technical collaboration, this plan proposes to restore the balanced governance model envisioned in the 1958 MOU while preserving the effective scientific coordination developed over subsequent decades. Under this framework, the Technical Committee will meet annually to review current science, management information, and ecological conditions, and will meet with the Advisory Council to develop coordinated

interagency recommendations to support adaptive management of both the Jackson elk and bison herds.

DRAFT

Chapter 5. Management Direction

Nestled below the majestic Teton Range, adjacent to the historic gateway town of Jackson, the National Elk Refuge provides crucial wintering habitat for big game in the Greater Yellowstone Ecosystem. Visitors can view wintering elk and other wildlife populations balanced with their habitats across the Refuge's grassland, wetland, woodland, and sagebrush shrubland communities. The public enjoys quality hunting and fishing, as well as year-round interpretative opportunities. Effective outreach and strong public and private partnerships ensure understanding and protection of refuge resources for future generations.

-Vision of the Refuge



Figure 14. The Refuge supports a variety of habitats and wildlife and provides multiple recreation opportunities for visitors. Photo Credit: Gannon Castle/USFWS

Comprehensive Conservation Plan Goals

In 2016, the Refuge completed its first Comprehensive Conservation Plan (CCP) to provide long-term guidance for management decisions, help achieve the goals needed to accomplish the Refuge's purposes and describe predicted future needs. The CCP was intended to complement,

not replace, the Bison and Elk Management Plan. The Bison and Elk Management Plan must be consistent with the CCP goals, which are:

- **Habitat and Wildlife Management Goal:** Adaptively manage bison, elk, and other wildlife populations and habitats as outlined in the Bison and Elk Management Plan and the CCP. Contribute to the conservation of healthy native wildlife populations and their habitats. Restore and sustain a native fishery that provides quality fishing opportunities.
- **Cultural Resources Goal:** Preserve and interpret cultural resources in a way that allows visitors to connect to the area's rich history and conservation heritage.
- **Visitor Services Goal:** Enable a diverse audience to understand and appreciate the Refuge's wildlife conservation role in Jackson Hole, while safely enjoying year-round opportunities for wildlife-dependent recreation.
- **Visitor and Employee Safety and Resource Protection Goal:** Provide for the safety, security, and protection of visitors, employees, natural and cultural resources, and facilities throughout the Refuge.
- **Administration Goal:** Provide facilities and effectively use and develop staff resources, funding, partnerships, and volunteer opportunities to maintain the long-term integrity of habitats and wildlife resources of the Refuge.

Purpose and Need for Bison and Elk Management on the Refuge

The purpose of the Bison and Elk Management Plan (BEMP) is to provide long-term management objectives and strategies for ensuring healthy and sustainable populations of bison and elk on the Refuge. This plan complies with the Refuge's purposes, the mission of the Refuge System, and other applicable laws and policies. The needs for managing bison and elk on the Refuge include:

- Maintaining sustainable populations of fish, wildlife, and plants, and associated habitat on the Refuge.
- Preserving the genetic diversity of the bison and elk herds.
- Maintaining ecosystem fluctuations and processes associated with bison and elk in the Greater Yellowstone Ecosystem.
- Managing bison and elk populations to reduce long-term impacts of diseases such as chronic wasting disease, brucellosis, bovine tuberculosis, *M. bovis*, septicemic pasteurellosis, scabies, and other novel diseases.
- Reducing the risk of invasive species introduction associated with bison and elk management activities on the Refuge and surrounding land.
- Protecting and restoring the chemical, physical, and biological quality of water resources on the Refuge.
- Maintaining opportunities for wildlife-dependent recreation.
- Minimizing human-wildlife conflicts in the area.
- Reducing long-term costs of bison and elk management activities for the Service and other cooperating agencies.
- Maintaining local economic benefits associated with bison and elk presence on the Refuge and surrounding lands.
- Providing opportunities for Tribes to engage in activities related to their buffalo culture.

Objectives

To meet the goals outlined in the Refuge's CCP and address the above-stated needs for managing bison and elk, the Service has the following objectives for implementation of this plan:

1. Reduce the portion of the Jackson elk herd wintering on the Refuge to approximately 5,000 individuals by year ten.
2. Minimize elk starvation during winter by focusing on reducing the population on the Refuge through hunter-harvest, redistribution, and enhancing natural forage through the irrigation program.
3. Moderate the prevalence and spread of CWD in the Jackson elk herd by reducing the reliance of the Jackson elk herd on supplemental feed on the Refuge.
4. Utilize adaptive strategies and leverage partnerships to minimize human-wildlife conflict and damage to private lands and the risk of disease transmission to livestock in the area.
5. Provide supplemental feed to bison utilizing the Refuge to ensure WGFD population objective can be maintained in the Jackson bison herd.
6. Restore sustainable populations of fish, wildlife and plants, and associated degraded habitat on current elk feedgrounds on the Refuge over the next 20 years.
7. Reduce the Service's long-term costs of managing bison and elk.
8. Support WGFD's Jackson Feedground Management Action Plan.



Figure 15. Hunter on the Refuge in winter. Photo Credit: USFWS

Strategies

Strategy 1: Adaptive Management Approach to Reduce Overwintering Elk on the Refuge

The Service will work together with cooperating agencies over the next ten years to reduce the number of elk that overwinter on the Refuge to approximately 5,000 animals by increasing hunter-harvest opportunities, altering hunting seasons, adjusting the feeding end dates, and/or redistributing elk across the surrounding landscape as the Wyoming Game and Fish Commission (WGFC) population objective allows.

- Efforts will focus on reducing the SDME and a portion of the Grand Teton LDME segments of the Jackson herd. Most harvest pressure will target SDME, with a lesser focus on Grand Teton elk, to help reach the goal of 5,000 elk wintering on the Refuge.
- The Service and WGFD would prioritize hunter-harvest strategies consistent with the Wyoming Feedground Management Plan. This may include changes to hunting

opportunities on the Refuge, such as adjusting season length, timing, or areas open to hunting, to better target SDME elk.

- These efforts on the Refuge may be furthered by extending or adjusting hunting seasons or units within Bridger-Teton and Grand Teton to further target SDME and facilitate redistribution of the elk off the Refuge during winter to the north and east of the Refuge.
- If hunter-harvest strategies prove insufficient to accomplish these objectives, the Service could adapt strategies in cooperation and coordination with other cooperating agencies and partners to include management hunts, cooperative harvest agreements, fertility control, culling, or other novel methods.

Adaptive Management. Because the success of this plan is dependent on actions of our cooperating agencies outside the control and jurisdiction of the Service, this alternative will use adaptive management strategies to ensure we are meeting the BEMP's goals and objectives. As such, the Service and WGFD, and other cooperating agencies will continue to implement monitoring efforts to assess the success of our cooperative efforts as related to overall population, herd segment sizes, and CWD prevalence trends in the Jackson elk herd and make additional management decisions based on the results of the monitoring as described further below under Strategy 2. Ability to carry out these monitoring efforts will be dependent on the Service's and other cooperating agencies' staff capacity and funding. For more information on the monitoring efforts the Service and its partners will be taking, see "Chapter 5: Monitoring and Evaluation."

Strategy 2: Adaptive Management Approach to Supplemental Feeding of Elk

The Service will convene the Cooperative Elk Studies Group annually in June, or more frequently as necessary, to evaluate the effectiveness of cooperative management strategies and any adjustments or new management strategies needed to manage healthy populations of the Jackson bison and elk herds. Based on the best available science and information available at the time of that meeting (see "Determining Factors" below), the Service will determine whether adjustments



Figure 16. Elk on the Refuge in winter. Photo Credit: Kari Cieszkiewicz/USFWS

are needed to current management strategies on the Refuge, including whether to end or adjust supplemental feeding by the next feeding season.

Determining Factors. The Service will consider the following factors in determining whether adjustments are needed to current management strategies:

- all available CWD prevalence data in the Jackson elk herd, and adjacent herd units, and other cervids.
- current best available science on CWD and its impacts on elk in current and future years, and assessment of CWD as a source of additive mortality within the herd if empirically feasible.
- data and best available science on other disease (e.g. brucellosis, *Mycoplasma* *bovis*) related to elk and bison health
- the population size, trend, and demographics (e.g., survival, calf ratios) of the Jackson elk herd relative to the WGFC objectives, including proportion of SDME and LDME within the herd, and summer classification data specific to the SDME and LDME segments if available.
- the number of elk still reliant on supplemental feeding on the Refuge.
- availability of overwintering range outside the Refuge.
- potential elk damage to private property, disease transmission to livestock, and negative economic impacts to livestock producers in the area.
- WGFD progress in implementing their Jackson Elk Feedground Management Action Plan and adherence to the WGFC Feedground Management Plan Sideboards.
- Cooperating agency progress in how respective management actions are meeting their respective goals and objectives.
- Any new or emerging issues.

Public Notice. Cooperating agencies will publish a summary of the annual Cooperative Elk Studies Group meeting, including CWD data and prevalence for the Jackson elk herd, in late summer or early Fall of each year. The Service will also notify the public of any changes to management of the bison and elk herds on the Refuge because of these meetings.

WILL THE JACKSON ELK HERD DECLINE WHETHER THE REFUGE KEEPS FEEDING ELK OR NOT? WHY?

Yes, the size of the Jackson elk herd is projected to decline over time whether the Refuge continues to feed elk or not. Currently, supplemental feeding supports a higher number of elk than would be supported with natural forage alone. So, ending feeding will result in a lower elk population. On the other hand, supplemental feeding exacerbates the spread and prevalence of CWD. CWD is predicted to result in a high mortality of elk that will cause the elk population decline overtime. Studies predicts that the Jackson elk herd population will begin to decline at a CWD prevalence rate of 7%. It's important to understand that a decline in the current elk herd may not be a negative long-term outcome. A lower elk population is more in balance with available habitat and will be more sustainable in the future.

Strategy 3: Reducing Feed Season Length

The Service will reduce the feed season length by ending feeding two weeks earlier than the annually calculated traditional end date. Ending feeding earlier in the spring reduces elk contact rates (Janousek, et al., 2021) and potentially reduces brucellosis transmission in elk (Cross, et al., Probable Causes of Increasing Brucellosis in Free-Ranging Elk of the Greater Yellowstone Ecosystem, 2010a) (Cotterill, et al. 2018). As demonstrated during implementation of the 2019 BEMP Step-down Plan, ending the feed season earlier does not result in higher elk mortality or increased elk movements to surrounding private land (Cole & Warren, 2024).



Figure 17. Elk and bison on the Refuge feedlines. Photo Credit: Kari Cieszkieswcz/USFWS

Strategy 4: Continuing Irrigation for Forage Production

The Refuge will continue to irrigate approximately 4,500 acres of grassland on the south half of the Refuge as staffing, water availability, and resources allow.

Irrigation is a common habitat management tool that is used on the Refuge to increase both the quantity and quality of forage available to elk and bison. The Refuge has used irrigation to produce forage for many years on the National Elk Refuge as a technique to reduce the reliance of wintering elk on supplemental feeding. Water available for irrigation depends more on snowpack than precipitation over the growing season. Two to three times as much forage is produced in irrigated compared to non-irrigated areas, and Refuge-wide forage production is 10-20% higher each year because of irrigation.



Figure 18. Irrigation of grasslands on the Refuge can help provide natural forage for elk and bison throughout the year. Photo Credit: Hannah Bradburn/USFWS

WHAT ARE THE MAIN CONCERNS ABOUT HUMAN-WILDLIFE CONFLICT WITH THE JACKSON BISON AND ELK HERDS?

Human-wildlife conflict occurs when interactions between people and wildlife lead to negative outcomes for safety, property, or natural resources. For the Jackson bison and elk herds, key concerns include:

- *Property Damage.* Bison and elk can damage fences, landscaping, and infrastructure when they move into residential or agricultural areas.
- *Livestock Conflicts.* When bison or elk commingle with livestock, they may compete for forage, damage fencing, or potentially transmit diseases like brucellosis.
- *Public Safety Risks.* Wildlife entering urban or suburban areas can lead to dangerous encounters with people and increase the risk of vehicle collisions.

Strategy 5: CWD Response

Supplemental feeding has occurred in all but 10 winters on the Refuge since 1912, and although this strategy minimizes winter elk mortality from starvation, contributes to Wyoming state elk herd objectives, eliminates commingling with livestock, and keeps elk off adjacent roadways, elk occur at numbers and densities well in excess of carrying capacity (Smith, Cole, & Dobkin, 2004) (Lubow & Smith, 2004). These higher densities increase the potential for disease transmission, such as brucellosis (in bison and elk) and CWD (in elk). Therefore, as part of its bison and elk management the Refuge implements several strategies to reduce disease risk and transmission related to CWD and brucellosis.

WHAT IS CHRONIC WASTING DISEASE (CWD)?

CWD is a fatal neurological illness that affects members of the deer family, including elk. It's caused by abnormal proteins called prions, which can be shed by infected animals and persist in the environment for years—sometimes over a decade.

CWD was first detected in captive deer in Colorado in the 1960s and in wild deer by 1981. Since the 1990s, it has spread widely across Colorado and into southern Wyoming. As of early 2024, CWD has been confirmed in 32 U.S. states and 4 Canadian provinces.

There is currently no cure or effective treatment for CWD at the individual, herd, or ecosystem level. Because of this, prevention and early detection are critical tools for managing the disease and protecting wildlife health.

Chronic Wasting Disease. To minimize the spread of CWD, the Service will continue to adhere to The National Elk Refuge [Response Strategy](#) for the Presence of Chronic Wasting Disease in the Jackson Elk Herd (updated 2026) which includes the following actions:

- Continue to sample any elk that die on the Refuge due to hunting or natural causes for CWD. This effort results in high sample sizes that should allow us to detect changes in CWD prevalence over time.
- Euthanize and sample any elk that exhibits CWD symptoms.
- Incinerate carcasses from elk that die on the Refuge to prevent the carcasses from contaminating the ground with CWD prions.



Figure 19. Refuge biologist sampling for CWD in a dead elk. Photo Credit: Kari Cieszkieswcz/USFWS

WHAT IS BRUCELLOSIS AND WHY IS IT A CONCERN?

Brucellosis is a bacterial disease that affects elk, bison, and domestic livestock in the Greater Yellowstone region. It spreads most commonly in spring, especially when animals encounter infected aborted fetuses.

The risk of transmission is especially high on winter feedgrounds, where animals gather in large numbers. Despite efforts to reduce disease spread in these settings, results have been limited.

Brucellosis. As discussed above, while the Service continues supplemental feeding of elk on the Refuge, the Refuge will continue to work with WGFD to end supplemental feeding two weeks earlier than the historic end date. This management strategy can help reduce transmission among elk on feedgrounds and disperse elk away from the southern portion of the Jackson Valley, earlier in the year, to reduce comingling with local livestock producers.

Bison Management

Strategy 1: Continue Feeding of Bison as Necessary

The Refuge will continue to feed bison as necessary to maintain a sustainable Jackson bison herd in coordination with cooperating agencies, absent new or emerging disease concerns.

- The Refuge will continue to feed bison as it traditionally has while it also continues to feed elk by feeding bison first in the McBride Feedground and providing a heavy feed ration (typically 20 lbs. per bison per day) to prevent interference with elk feeding.
- If/when feeding of elk ceases, the Refuge will continue to feed bison as necessary to prevent human-wildlife conflict and maintain the population objective of 500 bison, although the locations and the timing of this feeding could differ.
- The Refuge will monitor the distribution of bison for indications that supplemental feeding may be necessary to avoid human-wildlife conflict and commingling of bison and cattle. Bison movement would be monitored by Refuge staff daily once bison start arriving on the Refuge.
- When bison behavior and movements suggest it is likely that bison may leave the Refuge to adjacent private land, the Service will coordinate with WGFD on initiation of supplemental feeding.
- The Service would evaluate the duration of feeding needed based on current disease conditions that may impact bison (such as *Mycoplasmopsis bovis* disease), cattle, or other wildlife and would cease supplemental feeding at any time conditions no longer warranted feeding.



Figure 20. Feeding bison on the Refuge in winter. Photo Credit: Kari Cieszkieswcz/USFWS

Strategy 2: Continue Disease Monitoring and Adaptive Management

- The Service will continue to conduct post-mortem disease monitoring of bison through hunter harvest and non-hunting mortality events on the Refuge.
- Additionally, the Service will partner with land management agencies and other conservation partners to conduct additional disease monitoring as needed.
- The Service will continue to research and use results of monitoring efforts to determine if new and emerging diseases that may threaten the bison



Figure 21. Sunrise at Nowlin Ponds. Photo Credit: Kari Cieszkieswcz/USFWS

population and adapt feeding and management practices accordingly to protect the herd.

Strategy 3: Continued Bison Harvest on the Refuge

- *Tribal Bison Hunt.* The Refuge will continue to offer the Shoshone-Bannock and the Eastern Shoshone Tribes the opportunity to hunt bison annually on the National Elk Refuge. All special National Elk Refuge regulations governing personal conduct during bison hunting shall also apply to tribal members. The National Elk Refuge manager has the authority to close hunting seasons to prevent resource (soil and vegetation) damage during inclement weather or to ensure public safety.
- *General Public Bison Hunt.* The National Elk Refuge will administer a bison hunting program for the public licensed by the WGFD in accordance with the 2015 CCP. Consideration would be given to later end dates that are commensurate with delayed feeding, and possible escorted hunting in the South Unit to help with distribution. Special limited hunts designed to discourage bison from attempting to leave the Refuge via the south boundary into the town of Jackson will also be considered.

Habitat Management

Strategy 1: Restore Degraded Habitat on the Refuge

Habitat restoration will continue on the western portion of Nowlin Creek, and the Service would initiate restoration of riparian areas on the remainder of Nowlin, Flat, Sheep and Twin Creeks as logistics and resources allow. Fencing may be utilized to prevent future degradation of stream banks and riparian areas due to continued winter grazing pressure from elk and bison. Additionally, the Service will initiate habitat restoration of former prairie/shrub dominated feedgrounds if

deemed possible within the context of continued winter elk grazing pressure. Exclosures or other techniques may be utilized to create localized patches of habitat that benefit other wildlife species. Other management techniques may be incorporated as needed to ensure efficiency and success.



Figure 22. Aspen and Cottonwood Grove on the Refuge. Photo Credit: Gannon Castle/USFWS

HOW MANY BISON AND ELK CAN THE LAND CAN SUPPORT?

Estimates suggest that during an average winter about 5,000 elk and 500 bison could be supported by natural vegetation on the Refuge and would not require supplemental feeding. As a result of higher animal density than this on the Refuge, over-browsing has led to the degradation of bunchgrass communities, sagebrush lands.

Strategy 2: Early Detection and Rapid Response Protocol to Manage Invasive Species

An invasive species is defined as a species that is nonnative to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health (National Invasive Species Council, 2025). Invasive plant species spread easily, replace native habitat, reduce diversity, and cause great expenditure of financial and human resources. Invasive grasses, forbs, and woody species are of concern because they diminish the quality and suitability of habitat and reduce its potential to support many native wildlife species. Invasive plants also fail to protect and hold soil because they generally have a shallow root system,

leading to increased erosion and sedimentation in streams. This in turn affects water quality, reduces aquatic habitat, and may lead to decreases in fish production.

- The Refuge utilizes a multifaceted approach to habitat management, with Integrated Pest Management (IPM) techniques at the forefront of our invasive species program.
- Once a new infestation is identified, the Early Detection and Rapid Response (EDRR) protocol will be initiated, which includes a structured approach to managing invasive weeds by using a combination of cultural, biological, mechanical, and chemical tools.
- Past efforts have included mapping, treating, and monitoring invasive species. Treatment methods for invasive weeds vary with species, daily environmental conditions, plant growth stage, and time of year.
- The Refuge will continue their partnership and funding agreement with Teton County Weed and Pest to treat invasive plant species in accordance with the [CCP](#).

Since 2010, Teton County Weed and Pest has spot treated, via various techniques, an average of 37.10 acres (range = 12.91 to 82.34 acres) of invasive plant species each year. In addition, in 2020 and 2023, 1,145 acres and 1,070 acres of cheatgrass were treated via helicopter, respectively. Focal species include, but are not limited to:

- Perennial pepperweed (*Lepidium latifolium*)
- Spotted knapweed (*Centaurea maculosa*)
- Dalmatian toadflax (*Linaria dalmatica*)
- Whitetop (*Cardaria pubescens*)
- Musk thistle (*Carduus nutans*)
- Cheatgrass (*Bromus tectorum*).

Other identified invasive species will also be treated, including but not limited to:

- Bindweed (*Convolvulus arvensis*)
- Oxeye daisy (*Leranthemum vulgare*)
- Scotch thistle (*Onopordum acanthium*)
- Black henbane (*Hyoscyamus niger*)
- Diffuse knapweed (*Centaurea diffusa*)
- Bull thistle (*Cirsium vulgare*), houndstongue (*Cynoglossum officinale*)
- Russian knapweed (*Rhaponticum repens*)
- Woolly mullein (*Verbascum thapsus*)
- Canada thistle (*Cirsium arvense*)
- Marsh sow thistle (*Cirsium palustre*)
- Scentless chamomile (*Tripleurospermum inodorum*)
- Yellow toadflax (*Linaria vulgaris*)
- Common tansy (*Tanacetum vulgare*).

Novel invasive species appearing on the Refuge will be evaluated and targeted for early detection and rapid response, as needed.



Figure 23. Native lupine on the Refuge, one of the many native wildflower species on the Refuge. Photo Credit: Kari Cieszkieswcz/USFWS wildflower species on the Refuge.

Strategy 3: Utilize Prescribed Burning to Increase Landscape Resiliency

The Refuge will continue to use prescribed fire as a habitat management tool to mimic natural processes and increase landscape resiliency.



Figure 24. The Refuge uses prescribed fire, such as this one from 2022 on the McBride unit, to mimic historic fire intervals and improve habitat conditions on the Refuge. Photo Credit: Kari Cieszkieswicz/USFWS.

The Refuge will continue to use prescribed fire, in accordance with the [Fire Management Plan for the National Elk Refuge and Jackson National Fish Hatchery \(2019\)](#) (as updated when necessary) and [Comprehensive Conservation Plan for the National Elk Refuge \(2015\)](#), as a habitat management tool to mimic natural processes to maintain a naturally functioning ecosystem and increase resiliency of the landscape. When appropriate, prescribed fire will be used to reduce excessive litter layers and stimulate the production of natural forage that can be utilized by elk, bison and other ungulates and wildlife species.

Human-Wildlife Conflict Mitigation

Strategy 1: Haze Elk and Bison as Appropriate to Protect Livestock, Human Health and Safety, and Forage Production

Refuge staff will continue to work with WGFD staff to haze elk and/or bison when practical if they represent a disease threat to livestock; present human health and safety concerns; or to increase forage production on the Refuge.

Strategy 2: Pursue Infrastructure Improvements to Minimize Human-Wildlife Conflict

The Refuge will continue to explore infrastructure improvements on the Refuge throughout the life of this plan to further minimize human-wildlife conflicts. Underpasses and overpasses provide safe crossing opportunities, and they may also reduce the likelihood that animals breach the fences as there is a more convenient way to reach the other side of the highway (Teton County, 2018).

- The Service will maintain the cattle guard on the Refuge Road that helps prevent bison and elk herds from entering the Town of Jackson.
- As staffing and funding allow, the Service will explore further opportunities for wildlife fences and crossing, particularly in the area north of Jackson to the Jackson National Fish Hatchery, a priority area for infrastructure improvements to mitigate traffic hazards from elk, mule deer, and other wildlife as identified in the 2018 Teton County Wildlife Crossings Master Plan.
- In 2022, Teton County allocated voter-approved SPET funds for wildlife crossings to a design project encompassing three priority areas as identified in the Wildlife Crossings Master (Teton County, 2025). As of summer 2025, this project was at 30% design for three wildlife crossings including one on the section of highway 89 extending north from the town of Jackson to the Jackson National Fish Hatchery (Teton County, 2025).



Figure 25. Refuge fencing along Highway 89 to protect wildlife-vehicle collisions. Photo Credit: Kari Cieszkieswcz /USFWS

Strategy 3: Implement a Variety of Methods to Mitigate Human-Wildlife Conflict on Private Lands

The Refuge will work to implement the use of fencing in strategic locations on the Refuge to reduce the human-wildlife conflict.



Figure 26. A view of elk across fencing on the Refuge. Photo Credit: Kari Cieszkieswcz/USFWS

Partnership-Driven Actions to Manage the Jackson Bison and Elk Herds

The conservation of bison and elk in the GYE reaches far beyond the Refuge's boundary and successful conservation of these herds requires coordination, communication, and collaboration with not only the other cooperating agencies, but also private landowners, guides and outfitters, Tribes, community members, and non-profit organizations. The Service plans to continue to strengthen these partnerships as we implement the BEMP.

- **Bison Carrying Capacity Study:** As resources become available, the Service will work with cooperating agencies, NGOs, universities, Tribes and other stakeholders to formulate and implement a study to determine the ecological and social carrying capacities for the Jackson bison herd. This information can be used to inform future management actions for this herd.
- **Kelly Hayfields:** Restoration efforts began in 2008 to restore previously irrigated and cultivated grassland in Grand Teton to native plant communities. Substantial progress has been made, with 1,550 acres of previously cultivated lands under restoration treatment. Of the 1,550 acres undergoing treatment, 1,440 acres has been seeded with native grass,

shrub, and select forb mixes. The NPS continues to seek funding for restoration of the remaining areas as well as maintenance of the restored pastures.

- **Private Lands Partnerships:** The Service and cooperating agencies seeks to explore options with partners to expand winter forage habitat for elk outside Refuge boundaries. There are many ways to reduce the effects of elk and bison on private lands, including targeted fencing, long-term leases or “elk occupancy agreements,” conservation easements, or direct compensation to support certain actions (e.g., removing cattle from certain areas during the winter and spring when they may be particularly vulnerable to brucellosis transmission). The Service and its partners will continue to explore these and other ways to partner with private landowners in management of bison and elk in the Jackson Hole landscape.
- **Outreach and Education:** The Refuge will explore opportunities to increase public information about bison and elk ecology and management. other cooperating agencies, non-governmental organizations and partners explore opportunities to increase information available to the public concerning bison and elk ecology and management, living with bison and elk and wildlife diseases.

Visitor Use and Experience

The Service is committed to continuing to provide high-quality wildlife-dependent recreational opportunities on the Refuge, so that visitors continue to enjoy the bison, elk, and other abundant wildlife on the Refuge. The Refuge offers unparalleled wildlife watching seasonally through free-driving tours, self-guided experiences, and horse-drawn sleigh rides. Visitors to the Refuge can experience their wildlife refuge through various other activities, including hunting, fishing, hiking, cycling, and visitor center programs.



Figure 27. Naturalists guiding a wildlife tour on the Refuge during winter. Photo Credit Joe Lieb

Funding and Personnel

The ability of the Service to carry out the management actions outlined in this BEMP is contingent on having adequate staff and funding. Operational costs will continue to escalate due to inflation. Efforts to increase harvest of SDME on the Refuge, and the associated disease sampling, will require additional staffing resources and funding, above and beyond the current funding level. Similarly, costs associated with the continuation of supplemental feeding of elk and bison will increase, noting that the cost for purchasing feed is not allocated in the Refuge's annual budget and is taken off the top of the regional Refuge budget. Earlier cessation of feeding would reduce overall costs associated with feeding and dead animal disposal due to disease. When feeding ends or is no longer necessary, habitat restoration will require additional funding for the duration of restoration efforts and post-restoration treatments. This is expected to take place for a period of five to ten years.

Chapter 5. Monitoring and Evaluation

The Service, in partnership with other agencies, will continue to monitor the following to understand current and future conditions of the bison and elk herds, as well as evaluate the effectiveness and consequences of any management actions taken as capacity and funding allows. Below is a list of current and future planned monitoring efforts.

- Proportion Jackson elk herd on the Refuge
- Proportion of elk that winter on the Refuge and summer on the South Snake River and other summering segments of interest
- Elk and bison winter distribution and use of private lands
- Number of wolf packs in the Jackson Elk Herd unit
- Estimated total wolf numbers in Jackson Elk Herd unit
- Estimated number of wolves using the Refuge in winter
- Total Refuge herbaceous forage biomass
- Elk and bison winter mortality on the Refuge
- Snow depth and cover
- Available forage relative to supplemental feed start dates (if applicable)
- Refuge feeding records and daily feeding ground estimates of elk and bison (if applicable)
- Summary of Refuge feeding (start date, end date, amount fed to elk and bison, elk and bison fed days, elk and bison feed rate)
- Gros Ventre feeding start date
- Elk harvest by Hunt Area
- CWD prevalence

For more information on these monitoring efforts please see the [Refuge's 2024 Inventory and Monitoring Plan](#).

The Service will re-evaluate its management strategies for bison and elk based on the results of these monitoring efforts on an annual basis with cooperating agencies and change management strategies as necessary to continue to try to achieve the goals outlined in this plan.



Figure 28. View of Refuge over Romney Ponds. Photo Credit: Kari/USFWS

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**APPENDIX B – U.S. Geological Survey, Chapter A of
Scientific Investigations Report 2024–5119:**

Decision Framing Overview and Performance of
Management Alternatives for Bison and Elk Feedground
Management at the National Elk Refuge in Jackson,
Wyoming

**Ecosystems Mission Area—Biological Threats & Invasive Species Research Program,
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**Prepared in cooperation with the U.S. Department of Agriculture, National Park Service, U.S.
Fish and Wildlife Service, and Wyoming Game and Fish Department**

Decision Framing Overview and Performance of Management Alternatives for Bison and Elk Feedground Management at the National Elk Refuge in Jackson, Wyoming

Chapter A of

**Decision Analysis in Support of the National Elk Refuge Bison and
Elk Management Plan**

Scientific Investigations Report 2024–5119

**U.S. Department of the Interior
U.S. Geological Survey**

Cover. A single bull walking across a field on the National Elk Refuge. Photograph taken by Kari Cieszkiewicz, U.S. Fish and Wildlife Service, January 2021.

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Abbreviations

“BEMP”	“Bison and Elk Management Plan”
CWD	chronic wasting disease
FS	U.S. Department of Agriculture—Forest Service
FWS	U.S. Fish and Wildlife Service
GYE	Greater Yellowstone Ecosystem
JHU	Jackson Elk Herd Unit
NER	National Elk Refuge
PrP ^{CWD}	misfolded prion protein
SD	standard deviation
WGFD	Wyoming Game and Fish Department

Decision Framing Overview and Performance of Management Alternatives for Bison and Elk Feedground Management at the National Elk Refuge in Jackson, Wyoming

By Jonathan D. Cook¹, Gavin G. Cotterill¹, Margaret C. McEachran¹, Tabitha A. Graves¹, Eric K. Cole², Paul C. Cross¹

Executive Summary

This report was developed to evaluate the performance of a set of proposed alternatives for *Cervus elaphus canadensis* (Excelsior, 1777; elk) and *Bison bison* (Linnaeus, 1758, bison) management at the National Elk Refuge (NER) in Wyoming, U.S.A., and to inform a National Environmental Policy Act Environmental Impact Statement focused on developing the next “Bison and Elk Management Plan” (“BEMP”). The U.S. Geological Survey facilitated a structured decision-making process for the U.S. Fish and Wildlife Service (FWS) to develop the alternatives and the criteria (performance metrics) for evaluating the alternatives.

The effects of proposed bison and elk supplemental feeding alternatives were estimated for a 20-year period. The study considered outcomes related to bison and elk population abundance, chronic wasting disease (CWD) prevalence in elk, human-wildlife conflict indicators, as well as effects on NER visitors, visitor spending, and hunting-associated revenues. The NER managers developed five future management alternatives:

1. *Continue feeding*.—The NER will continue to provision supplemental food to bison and elk during winter months based on forage availability and number of conflicts.
2. *No feeding*.—The NER will immediately stop provisioning food to bison and elk during winter months.
3. *Increase harvest, then stop feeding (increase harvest)*.—The NER will continue to provision food to bison and elk during winter months for the next 5 years, then stop feeding. During those 5 years, the NER will work with the Wyoming Game and Fish Department (WGFD) to increase elk harvest and attempt to reduce the population of elk that overwinter at the NER to 5,000 animals.

4. *Reduce feeding, then stop feeding (reduce feeding)*.—

The NER will provision a reduced ration to elk during winter months for the next 5 years to reduce the elk population size prior to feedground closures. Exclosures will be designed to protect aspen stands in the south region of the NER, and for willow and cottonwood north of the NER.

5. *Stop feeding after 3 percent CWD prevalence is measured in Jackson elk (disease threshold)*.—The NER will continue to provision food to bison and elk during winter months until CWD sampling reveals 3 percent prevalence in the Jackson elk herd, at which point all feeding activities will cease at the NER.

Since at least 1907, elk have been fed in the area that is now the NER during the winter to reduce overwinter mortality. After bison “discovered” supplemental food at the NER in the 1980s, a portion of the herd has overwintered there. In addition to reducing bison and elk overwinter mortality, supplemental feeding may limit human-wildlife conflicts in winter months, including vehicle collisions and private property use by bison and elk. However, it also encourages aggregations of bison and elk that increases the potential for intraspecific disease transmission, such as brucellosis (in bison and elk) and CWD (in elk). Chronic wasting disease is a prion infection that was recently detected in the Jackson Elk Herd Unit (JHU). Out of 1,485 elk tested for CWD between 2020 and 2023 there has been one confirmed positive case. Despite the apparent low prevalence as of 2024, experts expect that prevalence will increase and that the effects of CWD on Jackson elk will exceed what has been observed in other wild elk populations given the dense aggregations of animals that occur at the NER and the long-term persistence and infectivity of the CWD prions in the environment.

Given the benefits and potential drawbacks of supplemental feeding, the alternatives were evaluated under advisement of three separate technical teams. Each team was composed of experts with specific, local knowledge of system attributes; one team focused on wildlife effects (bison and elk), another

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focused on physical landscape effects, and the third on human dimensions, visitor dynamics, and local economic effects. The technical teams helped to develop the methods, provided feedback on assumptions required by the analyses, and provided data. The study area boundaries were created through an expert elicitation process and included the entirety of the JHU, Grand Teton National Park, NER, and the northern third of the Fall Creek Elk Herd Unit, which included three other State elk feedgrounds.

Chapter A (this chapter) provides scoping details of the “BEMP”, a summary of the 19 metrics that are used to evaluate the performance of each of 5 alternatives, and methodological details of 2 performance metrics that were not covered in other technical chapters. Additional technical details, results, and interpretations are briefly covered in this chapter, but are mostly contained in chapters B–E.

The two metrics covered solely in chapter A are the costs of feedground management to FWS and the risk of invasive species introduction and spread at the NER (for example, *Bromus tectorum*). For evaluating costs, the study calculated that managing the feedground program requires FWS to expend between \$15,213 and \$16,448 per day of feeding activities for the direct costs of feed, labor, fuel, and maintenance of machinery. These daily cost estimates were used to predict that the continue feeding alternative will have an average cumulative cost of \$19,335,000 over 20 years. The reduce feeding and increase harvest alternatives would have an average 20-year cost estimate of \$4,839,000 and the disease threshold would cost \$2,189,000. Finally, the study assumed no additional costs to FWS under the no feeding alternative and did not include any costs associated with constructing exclosures under the reduce feeding alternative.

The cumulative number of feeding days over 20 years were used as a proxy measure to estimate the relative invasive plant species introduction and spread risk across the alternatives. It was assumed that more feeding would require more mechanical damage by feedground equipment and an elevated use of localized areas by bison and elk. The disturbance would negatively affect existing vegetation (mostly sagebrush communities) and allow more opportunities for invasive plant species, such as cheatgrass (*Bromus tectorum*), to expand and establish in new areas. The highest number of feeding days were estimated under the continue feeding alternative (average of 1,243 days) and intermediate feeding days under the reduce feeding and increase harvest (311 days) and disease threshold (140 days). The no feeding alternative was assumed to have 0 feed days on NER over the next 20 years.

Chapter B analyzes elk population and CWD dynamics under the five alternatives. Elk populations are predicted to decline under all alternatives, but timing, cause, and magnitude of those declines differ among alternatives. Alternatives that halt the feeding program had more immediate population declines but fared better by year 20 by partially mitigating future CWD effects. The no feeding alternative resulted in a larger elk population size in 70 out of 100 simulations, with a median elk population decline of 39 percent from the current size, whereas the continue feeding alternative led to a median decline of 55 percent from the current size. The other alternatives resulted in intermediate declines. The

continue feeding alternative was predicted to result in a higher CWD prevalence by year 20 in 83 out of 100 simulations, with a median CWD prevalence of 36 percent compared to 23 percent for the no feeding alternative.

Chapter C evaluates elk space-use based on data collected from global positioning system collars on elk and expert elicitation for scenarios with limited data. The resource selection function for fed and unfed elk during average and severe winters was estimated and then used to evaluate metrics including elk use of private property and sensitive vegetation communities at monthly timesteps and under varying winter conditions. Then, monthly estimates of elk under each alternative from chapter B were distributed over the predictive resource selection surfaces developed in this chapter. The continue feeding alternative minimized time spent by elk on private property and brucellosis transmission risk from elk to cattle compared to other alternatives. However, the increase harvest and reduce feeding alternatives minimized elk damage to sensitive aspen, cottonwood, and willow vegetation communities during winter compared to other alternatives. Following the projected population declines, the negative consequences of elk space-use declined by 35–57 percent over the 20 years, and differences among alternatives ranged from 6 to 20 percent.

Chapter D evaluates bison population dynamics, conflict, and harvest patterns under the five alternatives. The bison population is predicted to maintain current population sizes under the continue feeding alternative (median size in year 20 of 541 bison), but it is expected to decline over the next 20 years under all alternatives in which the NER halts feeding (median sizes in year 20 ranged from 469 to 473). Further, these declines are likely to lead to a reduction in available bison harvest by resident, nonresident, and Tribal hunters; the continue feeding alternative leads to a median cumulative harvest estimate across 20 years of 1,879, and the no feeding alternative had a median cumulative harvest estimate of 1,292. Finally, following from results of an expert panel, human-bison conflicts were predicted to increase under no feeding alternatives because bison may venture onto private lands in greater numbers if feed is not provisioned during winter months.

Chapter E assesses social and economic consequences. The alternatives are anticipated to affect bison and elk population abundance and space use dynamics, with potential effects on the wildlife-related recreation and tourism in the area, including winter-season visitors to NER, and hunters and outfitters in the JHU. Limited evidence was found to suggest that NER visitation rates were correlated with historical elk counts at the NER. Projecting this forward, limited differences were found among alternatives in visitation metrics relative to the uncertainty within predictions for each alternative. Larger differences were estimated for elk tag license sales, hunter-associated spending, and outfitter revenues, but these are subject to strong assumptions about human responses to predicted elk changes. The increase harvest alternative was predicted to have higher average revenue from elk tag sales (\$6.6 million compared to \$4.8–5.5 million, on average, for the other alternatives), spending by elk hunters (\$101.3 million compared to \$73.0–88.5 million, on average,

for the other alternatives), and outfitter revenues (\$14.5 million, on average, compared to \$10.4–12.6 million for the other alternatives) because more elk were harvested under this alternative instead of dying from other causes (for example, CWD, severe winters).

The analyses in this report estimated 19 performance metrics that were important to decision makers. No single alternative performed best for all metrics. The next step in a structured decision analysis could be to weight the relative importance of different objectives against one another, such that the overall performance of each alternative can be summarized including all sources of prediction uncertainty.

Introduction

The U.S. Fish and Wildlife Service (FWS) manages the 24,700-acre National Elk Refuge (NER or the Refuge), situated in the Greater Yellowstone Ecosystem (GYE) in northwestern Wyoming (fig. A1). The Refuge was initially established in 1912 as a winter game reserve (16 U.S.C. 673) and later expanded to include the management of habitats for breeding birds, fish, and other big game animals, as well as the conservation of threatened and endangered species. These management purposes have resulted in the protection of important habitats for many species including *Cervus elaphus canadensis* (Excelsior, 1777; elk), *Bison bison* (Linnaeus, 1758; bison), *Canis lupus* (Linnaeus, 1758; grey wolves), *Ursus arctos* (Linnaeus, 1758; grizzly bears), *Cygnus buccinator* (Richardson, 1831; trumpeter swans), *Haliaeetus leucocephalus* (Linnaeus, 1766; bald eagles), *Ovis canadensis* (Shaw, 1804; bighorn sheep), and *Oncorhynchus clarkii* (Richardson, 1836; cutthroat trout), and have provided recreational opportunities for visitors.

To guide the management of bison and elk populations on NER, FWS has developed a series of planning documents, including a “Bison and Elk Management Plan” (“BEMP”; FWS and National Park Service [NPS], 2007) and a “Step-Down Plan for Bison and Elk Management” (“Step-Down Plan”; FWS, 2019). One of the major elements of the “BEMP” and “Step-Down Plan” is the provisioning of pelleted feed to bison and elk on 5,000 acres of Refuge land during winter months, typically between January and April. Between 2018–2021, the NER fed an average of 7,540 elk out of a population in the Jackson Elk Herd Unit (JHU) that exceeded 12,000 total individuals (fig. A2). Over a similar period (2016–20), NER fed an average of 317 bison out of a total of 550 individuals in the Jackson bison herd (U.S. Fish and Wildlife Service, written comm., 2024).

A total of 22 elk feedground locations in western Wyoming are primarily managed by Wyoming Game and Fish Department (WGFD); the NER feeding program is the only one under the authority of FWS (Wyoming Game and Fish Department, 2024b). Winter feeding is used to reduce overwinter mortality, maintain elk numbers near population objectives, reduce competition between bison and elk, ensure harvest opportunities, and reduce human-wildlife conflicts, such as disease transmission risk among livestock, elk, and bison (Wyoming Game and Fish Department, 2024b). While

winter feeding is successful in sustaining animals during harsh winter conditions and sequestering them to reduce private property conflict, the practice also elevates local densities and animal-to-animal contact, thereby increasing the potential for intraspecific disease transmission (National Academies of Sciences, Engineering, and Medicine, 2020; Janousek and others, 2021). Diseases that may be transmitted more quickly in feedground settings include chronic wasting disease (CWD) in elk and brucellosis (caused by *Brucella abortus*) in bison and elk.

The arrival of CWD to the Jackson elk herd, combined with the potential for accelerated spread in dense aggregations of fed elk, has motivated a reevaluation of existing bison and elk feedground management. Chronic wasting disease is a fatal neurodegenerative disease caused by a misfolded prion protein (PrP^{CWD}) that affects members of the *Cervidae* family (elk, *Odocoileus virginianus* [Zimmerman, 1780; white-tailed deer], *Odocoileus hemionus* [Rafinesque, 1817; mule deer], and *Alces alces* [Linnaeus, 1758; moose]). The disease is transmitted directly during social contact among animals and indirectly when susceptible animals contact a prion-contaminated environment. The PrP^{CWD} protein remains infectious in environments for extended periods of time, possibly years (Williams and Young, 1980; Williams and others, 2002; Miller and others, 2004). As of early 2024, no effective treatments for CWD at the individual, population, or landscape level exist. Previous research has shown population declines in mule deer and white-tailed deer that were correlated with CWD prevalence (Edmunds and others, 2016; DeVivo and others, 2017), and the Jackson elk population was predicted to decline when prevalence reaches 7–13 percent (Monello and others, 2017; Galloway and others, 2021).

Brucellosis, another bacterial disease transmitted in feedground settings, affects elk, bison, and domestic livestock in the Yellowstone region. The disease is mainly transmitted in the spring prior to calving by contact with fetuses aborted from infectious individuals (NAS, 2020). Previous analyses of brucellosis seroprevalence in elk on feedgrounds suggested that longer feeding seasons and higher elk densities were correlated with higher seroprevalence (Cross and others, 2007). Subsequent attempts to mitigate brucellosis transmission on feedgrounds, however, had little success (Cotterill and others, 2020). In addition, increases in brucellosis seroprevalence in elk populations that do not overwinter on feedgrounds suggests that this disease will persist even in the absence of supplemental feeding (Cross and others, 2010a; 2010b; Brennan and others, 2017).

Beyond the disease concerns surrounding fed bison and elk, these species are valued by the many stakeholders for their roles in healthy ecosystems, as a charismatic species for wildlife viewers, and as game. Regionally, bison and elk support local economies and provide viewing and harvest opportunities for Tribes, members of the public, and outfitters. Elk hunting alone has generated more than \$4.9 million in annual income and 269 jobs in Teton County, Wyoming, according to Koontz and Loomis (2005). A more recent study

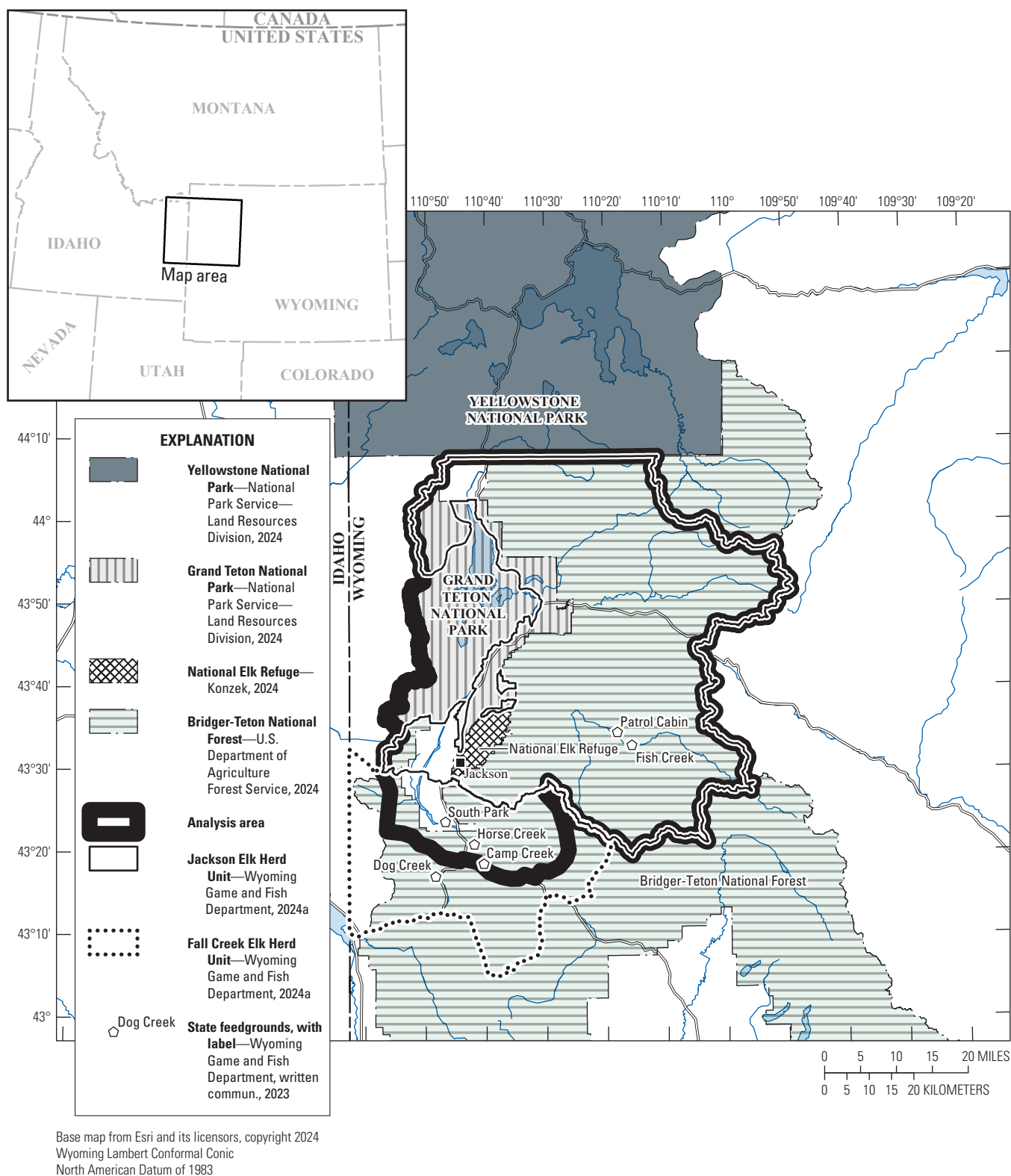


Figure A1. Map showing the study area. The analysis area (thick black polygon) is composed of the Jackson Elk Herd Unit (thin black polygon), part of the Fall Creek Herd Unit (dotted border polygon), the National Elk Refuge and Grand Teton National Park. Also included are the locations of six State feedgrounds, Patrol Cabin, Fish Creek, South Park, Horse Creek, Camp Creek, and Dog Creek, that were considered in the analyses of this report.

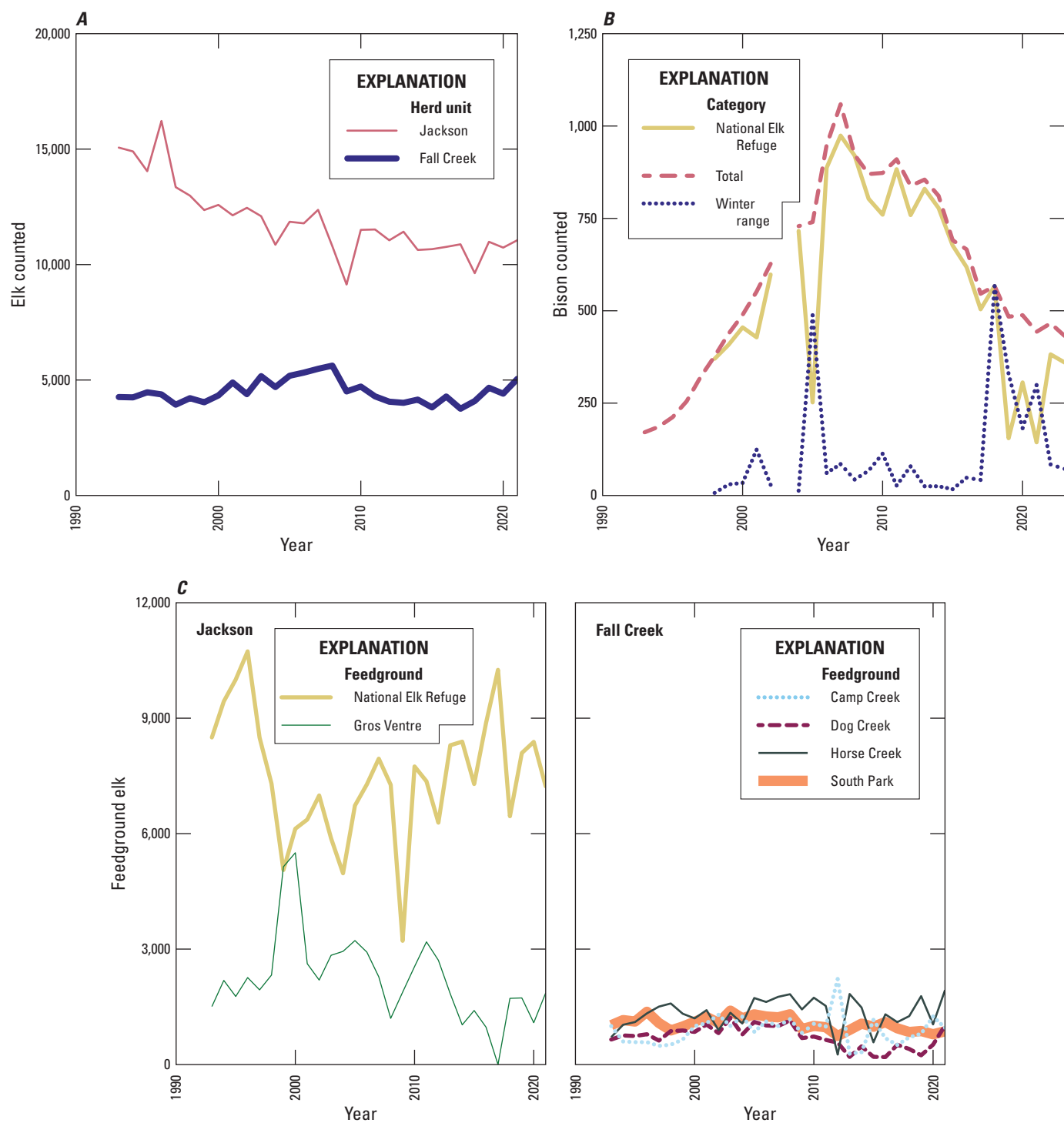


Figure A2. Line graphs showing the population counts of elk (A and C) and bison (B) in the Jackson region from 1993 to 2021 (shown by herd unit [A], and by feedground [C]). The Gros Ventre feedground in panel C includes Patrol Cabin and Fish Creek feedgrounds.

by Dietsch and others (2020) found that visitors continue to visit the NER for opportunities to hunt, fish, and ride horse-drawn sleighs, and that these activities may be affected by any changes to winter feeding of bison and elk.

This multichapter report describes a structured decision-making process that was led by the U.S. Geological Survey to evaluate potential management alternatives and support the drafting of the next “BEMP”. This chapter covers the detailed decision-framing elements of the “BEMP” decision, an abbreviated description of methods employed to evaluate alternatives, and presents summarized results for each of four technical chapters on elk disease and population dynamics (Cross and others, 2025, this volume, chap. B), elk space-use patterns including private land use patterns (Cotterill and others, 2025, this volume, chap. C), bison population dynamics and conflict potential (Cook and others, 2025, this volume, chap. D), and human effects including nonhunting and hunting visitation trends and economic effects (McEachran and others, 2025, this volume, chap. E).

Decision Framing

The process of structured decision making was used to frame and evaluate the set of potential bison and elk management alternatives on a set of objectives that were identified by FWS. Structured decision making is a normative process that helps break down and analyze distinct components of decisions using a series of steps. The steps include (and are described in this chapter) defining the problem and identifying objectives, alternatives, consequences, and trade-offs (Hammond and others, 1998).

The decision problem can be described using a formal problem statement that articulates important scoping details about the decision. The details about the following elements are typically included:

- A specific description of the decision itself;
- The decision maker;
- The decision maker’s authority to act;
- The scale of the decision (including spatial and temporal scoping); and,
- Any aspects that might make the decision difficult.

Next, the fundamental objectives describe the complete set of concerns that a decision maker has when making a management decision. Fundamental objectives are designed to be a direct expression of the mission and goals of an agency, their motivations, and any relevant values or desires of stakeholders as related to the specific decision context. Then, performance metrics are developed for each fundamental objective to evaluate the performance of the alternatives and to make comparisons against one another. The consequence assessment measures that performance and provides a quantitative comparison of each alternative relative to the others. Finally,

tools and strategies from decision analysis can be used to help decision makers evaluate trade-offs and identify the alternative that best meets the full range of concerns specific to the decision context. The process of structured decision making has been successfully used in natural resources settings (for example, refer to Runge and others, 2015), including a recent application to another feedground decision on nearby Bridger-Teton National Forest (fig. A1; Cook and others, 2023). Using this process implemented in a series of facilitated discussions, the following “Problem Statement,” “Fundamental Objectives and Performance Metrics,” and “Management Alternatives” were developed.

Problem Statement

The physical, biological, and cultural resources of the NER are managed in accordance with several location-specific acts of Congress (for example, 16 U.S.C. 673, establishing an elk reserve), executive orders, and other Federal legislation, such as the National Wildlife Refuge System Administration Act of 1995 (16 U.S.C. 668dd), National Wildlife Refuge System Improvement Act of 1997 (Public Law 105-57), and Endangered Species Act of 1973 (16 U.S.C. 1531). A primary focus of the NER (FWS, 2019) is to help manage the bison and elk herds—both are culturally and ecologically important at the Refuge and throughout the region. To guide the management of these species, FWS uses an existing “BEMP” (FWS and NPS, 2007), and “Step-Down Plan” (FWS, 2019). Decisions at the NER are under the direct authority of the Refuge manager and other leadership of FWS; however, close partnerships exist across State, Federal, local, and Tribal leaders in the GYE that also influence management decisions.

As of 2024, bison and elk are fed at the NER during winter months to reduce overwinter mortality of elk, reduce human-wildlife conflicts, and minimize competition between bison and elk. The NER distributes pelleted feed on 5,000 acres during the months of January–April to offset a loss of native winter range because of human development. Bison and elk feeding is also considered an effective tool to reduce human-wildlife conflicts that can occur when animals seek out alternative food resources in nearby urban areas or come into contact with livestock and thereby increase risk of wildlife-to-livestock disease transmission. However, the concentration of elk on feedgrounds has led to loss of diverse woody plant communities that provide habitat for other species and may increase disease transmission as animals are aggregated in high densities on feedgrounds. In addition to feeding, the Refuge acts to improve habitat quality, including large-scale restoration projects and the irrigation of as much as 4,500 acres (FWS, 2019).

The spread of CWD across Wyoming and into the GYE has motivated a reevaluation of bison and elk management, including the practice of bison and elk feeding. Given the potential for CWD to alter the system, the complex setting under which management decisions are made, and the 17 years since the last “BEMP” was drafted, the NER seeks to revise the plan (FWS, 2023) in a manner that considers new knowledge

and science, as well as the elevated threat that CWD presents to the Jackson elk herd. The Refuge also wants to better understand the effects that management alternatives might have on bison, physical and cultural resources, and human activities. The temporal scope of the “BEMP” metrics was 20 years to approximately align with the period of implementation for the prior plan. The spatial scope of the “BEMP” is the Refuge, but managers are also interested in considering the effects of the management alternatives on surrounding Federal, State, and private lands (herein called the analysis area, [fig. A1](#)). The analysis area was first proposed by WGFD staff using WGFD datasets and local expertise. The analysis area was later confirmed with the interagency team of science experts, including members from the FWS, U.S. Department of Agriculture—Forest Service (FS), National Park Service (NPS), and WGFD.

Fundamental Objectives and Performance Metrics

As established by the NER, fundamental objectives describe the unique set of concerns that a decision maker wants to (or is mandated to) achieve when making a decision (Gregory and others, 2012). As such, the set of fundamental objectives, when comprehensively analyzed, may help a decision maker understand how each alternative might perform and select the option that is expected to provide the best outcomes. The National Elk Refuge used a series of meetings facilitated by the U.S. Geological Survey, as well as feedback from other agencies, stakeholders, and public comments to identify nine fundamental objectives. Many are drawn directly from an interpretation of the mission of the National Elk Refuge and guiding documents such as 16 U.S.C. 673, establishing the NER as an elk reserve, the National Wildlife Refuge System Administration Act of 1995 (16 U.S.C. 668dd), National Wildlife Refuge System Improvement Act of 1997 (Public Law 105-57), as well as prior Refuge plans including the existing “BEMP” (FWS and NPS, 2007) and “Step-Down Plan” (FWS, 2019).

Fundamental Objective 1. *Maximize the health and well-being of wildlife.*—According to the National Wildlife Refuge System Administration Act of 1995 (16 U.S.C. 668dd) and National Wildlife Refuge System Improvement Act of 1997 (Public Law 105-57), FWS will manage refuge resources to “ensure that the biological integrity, diversity, and environmental health * * * are maintained for the benefit of present and future generations of Americans.” The introduction and spread of CWD in elk populations will lead to sick and dying animals and a departure from management goals related to the health and conservation of elk. Further, if elk repeatedly aggregate in the same geographic location because of management activities like supplemental feeding, the NER lands may be contaminated by infectious pathogens, including CWD prions, leading to locally elevated indirect disease transmission and further negative effects.

Performance metric 1a.—Minimize the prevalence of CWD in elk after 20 years.

Performance metric 1b.—Maximize the population size of elk after 20 years.

Performance metric 1c.—Minimize the suffering of elk during the first 5 years of implementation of a new management plan as defined by the cumulative number of natural and disease-induced elk deaths during the winter months (November through March) of the first 5 years.

Performance metric 1d.—Maximize the population size of bison after 20 years.

National Elk Refuge managers were interested in maintaining long-distance elk migrations (Cole and others, 2015). However, elk population size was used as a proxy because of the high uncertainty in how the management alternatives could affect migration patterns. National Elk Refuge managers were also interested in maintaining the genetic diversity of the bison herd in alignment with the Department of Interior Bison Conservation Initiative (2020), for which bison population size in year 20 was used as a proxy.

Fundamental Objective 2. *Maintain ecosystem fluctuations and processes associated with bison and elk.*—Big game populations, including bison and elk, are important to the structure and composition of plant and animal communities across the GYE. For example, elk forage heavily on riparian *Salix* L. (willow) during winter months and reduce the availability of willow for other species, including songbirds and *Castor canadensis* (Kuhl, 1820; beaver). The reduction of beavers heavily alters landscapes because beaver dams create ponds, wetlands, and stream channels that retain moisture and create habitat for a diversity of other plants and biota, both terrestrial and aquatic (FWS and NPS, 2007). Bison and elk herbivory similarly affects other woody plants and grasslands, including *Populus tremuloides* (quaking aspen), *Populus angustifolia* (narrowleaf cottonwood), and willow.

Performance metric 2a.—Minimize elk use of aspen stands on and around NER over the next 20 years.

Performance metric 2b.—Minimize elk use of cottonwood stands on and around NER over the next 20 years.

Performance metric 2c.—Minimize elk use of willow stands on and around NER over the next 20 years.

Fundamental Objective 3. *Minimize the risk of invasive species introduction and spread associated with bison and elk management activities.*—Human activities associated with bison and elk feeding have the potential to introduce or further spread invasive plant species and alter the dynamics of sensitive ecosystems.

Performance metric 3a.—Minimize the number of feeding days at the Refuge over the next 20 years as a proxy for invasive plant species introduction and spread risk from mechanized disturbance.

Fundamental Objective 4. *Protect and restore the chemical, physical, and biological quality of water resources.*—The NER has a legal mandate and trust responsibility to protect and restore lands and waters for the conservation and enhancement of fish and wildlife, and for the benefit of current and future Americans (National Wildlife Refuge System Administration Act of 1995 [16 U.S.C. 668dd] and National Wildlife Refuge System Improvement Act of 1997 [Public Law 105-57]). Aggregations of big game animals, including bison and elk, can affect the water quality and morphology of waterways in areas of high use (FWS and NPS, 2007). Excessive nutrient inputs from the biological waste of bison and elk may elevate nutrients, fuel algal growth, and elevate the risk of cyanotoxins and harmful algal blooms. Grazing along rivers and stream beds can further affect water quality and morphology by increasing erosion and suspended sediment and altering habitat for riparian plants and aquatic species (FWS and NPS, 2007). In addition, bison and elk aggregations may lead to an elevated prevalence of wildlife diseases whose pathogens can be introduced into streams and rivers, either directly or by surface water runoff (FWS and NPS, 2007). This fundamental objective was raised as important by NER managers (in alignment with FWS and NPS, 2007); however, subject matter experts from the FWS, NPS, FS, and WGFD expected that the effects of bison and elk on the chemical, physical, and biological properties of water resources at the Refuge would be the same under all alternatives and therefore this objective was not considered further in this report.

Fundamental Objective 5. *Maintain and enhance multiple use opportunities and public enjoyment.*—Abundant and healthy populations of bison and elk help to preserve the multiple uses of cultural, biological, and physical resources of the NER. At the NER, hunting, education, and wildlife viewing are important wildlife-oriented activities to maintain and are listed in the comprehensive conservation plan (FWS, 2015).

Performance metric 5a.—Maximize the number of elk harvested in the JHU over the next 20 years.

Performance metric 5b.—Maximize the number of visitors using the NER over the next 20 years.

Fundamental Objective 6. *Minimize human-wildlife conflicts.*—During winter months, bison and elk management has been primarily focused on minimizing human-wildlife conflict and maximizing overwinter survival during harsh winter conditions. The bison and elk supplemental feeding program was established to

provide forage, given the large-scale loss of historical winter range because of human developments. If feeding were to stop, bison and elk may redistribute across the landscape in search of other sources of winter forage. The search for winter feed might increase depredation on private haystacks and suburban landscaping. Additionally, it is possible that elk might come into more frequent contact with livestock, and thus increase local rates of brucellosis transmission.

Performance metric 6a.—Minimize the use of private lands by elk over the next 20 years.

Performance metric 6b.—Minimize the number of bison expected to conflict with humans over the next 20 years.

Performance metric 6c.—Minimize the risk of brucellosis transmission events from elk to livestock over the next 20 years. Only the risk that elk present to livestock was evaluated because elk were identified as the primary source of brucellosis transmission in the GYE (NAS, 2020).

NER managers were interested in measuring bison and elk caused vehicle collisions under each alternative (FWS, oral comm., 2024), but data and expert knowledge to inform behavioral responses of bison and elk to feedground operations at fine spatial and temporal scales were unavailable at the time of this study.

Fundamental Objective 7. *Minimize costs of bison and elk management activities.*—Management activities at the NER are limited by annual budgets. Currently, bison and elk management activities require annual monetary costs exceeding \$500,000 (FWS, written comm., 2023). These budgetary allocations compete with other activities and programs, including habitat restoration, public education and outreach, and species conservation.

Performance metric 7a.—Minimize direct monetary costs to FWS for bison and elk management activities over the next 20 years.

Fundamental Objective 8. *Maximize local economic benefits associated with bison and elk presence at the NER and surrounding lands.*—Bison, elk, and other big game animals at the NER are valued among visitors, residents, and Tribes (FWS and NPS, 2007). Bison and elk support local and regional economies by providing millions of dollars in annual revenues to businesses associated with hunting or viewing big game animals (lodging, restaurants, hunting guides, outfitters, and others; FWS and NPS, 2007).

Performance metric 8a.—Maximize the annual economic value of elk hunting as measured by harvest tag sales over the next 20 years.

Performance metric 8b.—Maximize annual spending, in dollars, by elk hunters in the JHU and by nonhunting visitors to the NER over the next 20 years.

Performance metric 8c.—Maximize annual economic value for outfitters and outfitted hunts over the next 20 years.

Fundamental Objective 9. *Maximize opportunities for Tribes to engage in activities related to their buffalo culture.*—Bison are important to the traditional cultures, beliefs, and practices of Tribes (Department of Interior Bison Conservation Initiative, 2020). Decisions on how to manage bison and elk must consider how management practices affect opportunities for Tribes to maintain their traditional practices and interactions with bison. This objective also captures bison harvest opportunities for nonTribal resident and nonresident Wyoming hunters.

Performance metric 9a.—Maximize the number of harvested bison over the next 20 years.

Management Alternatives

Consistent with the development of the fundamental objectives, the NER used a series of meetings facilitated by U.S. Geological Survey to develop five management alternatives that explore a range of management actions that could be effective at achieving some (or all) of the fundamental objectives. The text in parentheses are the short names for these alternatives.

- *Continue feeding.*—The NER will continue to provision food to bison and elk during winter months. Hunting practices are assumed to remain the same, but the rate of female elk harvest is assumed to decline to zero from current levels if the elk population approaches 80 percent of the Jackson or Fall Creek Herd Unit objectives.
- *No feeding.*—The NER will immediately stop provisioning food to bison and elk during winter months. Following cessation of feeding, restoration will take place on former feedground locations to improve conditions for native plant regeneration.
- *Increase harvest then stop feeding (Increase harvest or increased harvest).*—The NER will continue to provision food to bison and elk during winter months for the next 5 years, during which time the NER will work with WGFD to increase elk harvest and attempt to reduce population of elk that overwinter on NER feedgrounds to 5,000. After year 5, feeding is ceased. Restoration will occur after year 5 on feedground locations to improve conditions for native plant regeneration. Note that this alternative requires adjustment to the current harvest rates of the JHU and thus is not fully under the authority of FWS.
- *Reduce feeding then stop feeding (Reduce feeding or reduced feeding).*—The NER will provision a fixed daily ration to bison and elk during winter months

for the next 5 years to reduce elk population size prior to feedground closures. After 5 years feeding will stop. Restoration will occur after year 5 on feedground locations to improve conditions for native plant regeneration. Exclosures may be put into place to protect aspen stands in the southern region of the NER, and for willow and cottonwood in the northern region of the NER.

- *Stop feeding after 3 percent CWD prevalence (Disease threshold).*—The NER will continue to provision food to bison and elk during winter months until CWD sampling reveals 3 percent prevalence in the Jackson elk herd, at which point all feeding activities will cease at the NER. Following cessation of feeding, restoration will take place on former feedground locations to improve conditions for native plant regeneration.

Overview of Analytical Methods Used to Evaluate Consequences of Alternatives

The alternatives were evaluated using several interagency panels of subject matter experts (including staff of FWS, NPS, FS, and WGFD) who focused on physical landscapes and habitats, wildlife effects, hunter and nonhunting visitor groups, and economic effects of bison and elk management. Two expert panels were assembled that used formal methods of elicitation to estimate important but unknown relationships that may affect the performance of management alternatives. The methods are briefly described here (table A1), but full details can be found in Cross and others (2025, this volume, chap. B), Cotterill and others (2025, this volume, chap. C), Cook and others (2025, this volume, chap. D), and McEachran and others (2025, this volume, chap. E; table E1).

To simulate elk population dynamics, CWD, and elk harvest under each alternative, Cross and others (2025, this volume, chap. B) developed a sex- and age-structured population model that included direct and indirect CWD transmission. The model followed several previous studies, including Cross and Almberg (2019), Rogers and others (2022), and Cook and others (2023). The model tracked seven different elk population segments in the Jackson region. The JHU was split into the following three subpopulations: elk that come to the NER in winter, elk that are fed in the Gros Ventre drainage at Patrol Cabin and Fish Creek feedgrounds (fig. A1), and all other elk in the herd unit (referred to as unfed elk). The Fall Creek herd unit was split into four subpopulations—fed and unfed elk inside the analysis area and fed and unfed elk outside the analysis area (fig. A1). Then, the subpopulation results across the JHU or across the analysis area were summarized. The results of Cross and others (2025, this volume, chap. B) were also used to inform population projections for Cotterill and others (2025, this volume, chap. C) and McEachran and others (2025, this volume, chap. E).

Table A1. Bison and Elk Management Plan objectives and performance metrics related to the bison and elk feeding program. The table also includes a citation for the chapter in this report that develops the technical methods to estimate each performance metric.

[Fundamental objective four was raised as important by NER managers (in alignment with FWS and NPS, 2007); however, subject matter experts from the FWS, NPS, FS, and WGFD expected that the effects of bison and elk on the chemical, physical, and biological properties of water resources at the Refuge would be the same under all alternatives and therefore this objective was not considered further]

Performance metric number	Performance metric	Performance metric units	Reference chapter
Objective 1—Maximize the health and well-being of wildlife			
1a	Minimize prevalence of CWD in elk	CWD prevalence in elk in 20 years	Cross and others, 2025 (this volume, chap. B)
1b	Maximize population size of elk	Number of elk in 20 years	Cross and others, 2025 (this volume, chap. B)
1c	Minimize suffering of elk	Natural and CWD elk mortality in first 5 years	Cross and others, 2025 (this volume, chap. B)
1d	Maximize bison population	Number of bison in 20 years	Cook and others, 2025 (this volume, chap. D)
Objective 2—Maintain ecosystem fluctuations and processes associated with bison and elk			
2a	Minimize use of aspen habitats	Cumulative elk-use days across 20 years	Cotterill and others, 2025 (this volume, chap. C)
2b	Minimize use of cottonwood habitats	Cumulative elk-use days across 20 years	Cotterill and others, 2025 (this volume, chap. C)
2c	Minimize use of willow habitats	Cumulative elk-use days across 20 years	Cotterill and others, 2025 (this volume, chap. C)
Objective 3—Minimize risk of invasive species introduction associated with bison and elk management activities			
3a	Minimize invasive species introduction and spread risk	Cumulative feeding days across 20 years	Developed in this chapter
Objective 4—Protect and restore the chemical, physical, and biological quality of water resources			
Objective 5—Maintain and enhance multiple use opportunities and public enjoyment			
5a	Maximize elk harvested	Cumulative number of elk harvested over 20 years	Cross and others, 2025 (this volume, chap. B)
5b	Maximize NER visitors	Cumulative number of NER visitors over 20 years	McEachran and others, 2025 (this volume, chap. E)
Objective 6—Minimize human-wildlife conflicts			
6a	Minimize the use of private lands by elk	Cumulative elk-days across 20 years	Cotterill and others, 2025 (this volume, chap. C)
6b	Minimize the use of private lands by bison	Cumulative number of conflict bison across 20 years	Cook and others, 2025 (this volume, chap. D)
6c	Minimize the risk of brucellosis transmission	Cumulative number of elk abortions on sensitive properties	Cotterill and others, 2025 (this volume, chap. C)
Objective 7—Minimize costs of bison and elk management activities			
7a	Minimize direct monetary costs of bison and elk management	Cumulative cost in U.S. dollars across 20 years	Developed in this chapter
Objective 8—Maximize local economic benefits associated with bison and elk presence at the NER and surrounding lands			
8a	Maximize hunting revenues	Cumulative hunting license sale revenue	McEachran and others, 2025 (this volume, chap. E)
8b	Maximize local economic revenues	Cumulative hunting- and nonhunting-associated revenues	McEachran and others, 2025 (this volume, chap. E)
8c	Maximize hunting revenues	Cumulative revenues of outfitters	McEachran and others, 2025 (this volume, chap. E)
Objective 9—Maximize opportunities for Tribes to engage in activities related to their buffalo culture.			
9a	Maximize bison available to be harvested	Cumulative bison harvested across 20 years	Cook and others, 2025 (this volume, chap. D)

To predict elk space-use under each alternative, Cotterill and others (2025, this volume, chap. C) developed a resource selection model that distributed the numbers of elk projected by Cross and others (2025, this volume, chap. B) at monthly intervals. The resource selection model generally followed Cook and others (2023) but, importantly, incorporated additional environmental covariates suggested by subject matter experts. Separate models were developed for “fed” and “unfed” elk that varied according to relative winter severity. Differences among alternatives resulted from varying abundance under the elk CWD model, if and when NER ceased winter feeding operations, and additional assumptions informed by the expert elicitation process. Elk use of sensitive vegetation communities at the NER and across important elk wintering areas in the region were estimated. The number of elk predicted to use private lands and properties where cattle overwinter, as a proxy for brucellosis risk, were summarized.

To model bison population dynamics, harvest, and conflict potential, Cook and others (2025, this volume, chap. D) adapted an existing sex- and age-structured matrix model of ungulate population dynamics (Cross and Almborg, 2019; Cook and others, 2023; Cross and others, 2023). The adapted model incorporated information from the subject matter expert team who had expertise in bison ecology and wildlife management principles. The team described expected changes to bison space-use and population dynamics under the alternatives. Cook and others (2025, this volume, chap. D) then used published literature and expert judgment to estimate vital rates, harvest statistics, and other parameters necessary to predict abundance, harvest, and bison conflicts under the management alternatives.

McEachran and others (2025, this volume, chap. E) integrated bison and elk population and harvest projections, as well as elk space-use patterns, to estimate economic and visitor-related effects that included NER visitation and visit-related spending, and hunting-related spending in the Jackson region. Monthly NER visitor center counts were modeled using predictors typically associated with visits to refuges (Loomis and Caughlan, 2004) and projected changes to visitation and spending according to relationships that these response variables had with elk abundance at the Refuge. McEachran and others (2025, this volume, chap. E) also evaluated the potential for the alternatives to affect sleigh ride businesses using historical data and future elk projections. Lastly, McEachran used harvest projections from Cross and others (2025, this volume, chap. B) and estimates of hunter behavior from Koontz and Loomis (2005), which used best-practice survey methodology, to project future economic revenues from hunting and hunting-associated activities.

Finally, the methods used to calculate the direct costs of the feedground program to FWS (fundamental objective 7) and the total number of feeding days (proxy for fundamental objective 3) are briefly covered in this chapter because they are not covered in a separate technical chapter. First, to estimate costs for each alternative, the average monetary expense of the feedground operations per year for feeding season 2021–22 and 2022–23 was calculated (FWS, written comm., 2024). The annual cost was then divided by the total number of feed days for each of those years to get a cost per day of feedground operations.

Finally, those costs were projected across the 20 years by multiplying the cost per day by 20 randomly drawn feed season lengths from the historical data from 2004 to 2023 and summing the total (FWS, written comm., 2023). Net present value or future expectations about monetary inflation were not adjusted for. The sum of the 20 randomly drawn feed season lengths were used to calculate the proxy measure for invasive species (fundamental objective 3).

Important Modeling Assumptions

All models are simplifications of complex processes that are intended to capture only the most important factors. As such, the following assumptions were made in this study’s models:

- The reduction in elk populations because of not feeding at the NER was enforced by the severe winters reducing unfed elk survival rates. Our model’s assumptions were based on Hobbs and others (2003), but the frequency and severity of these winter effects are uncertain along with the potential redistribution of previously fed elk to other regions, or potentially other feedgrounds.
- Climate change projections were not incorporated, despite projections of 30–40 percent reductions in April snowpacks in the study area by midcentury (Hostetler and others, 2021). The reduced snowpack may result in shorter feeding seasons under the continue feeding alternative. Other climate effects on bison and elk may include elevated summer temperatures, increasing severity and frequency of drought, shifting forage phenology, and possibly reducing summer growth of winter forage (MacNulty and others, 2020).
- The potential effects that predators, such as wolves and cougars, may have on elk CWD dynamics were not included (Krumm and others, 2010; Brandell and others, 2022). If predators preferentially kill infected individuals and shorten the infectious period, they may reduce transmission and prevalence. However, substantial uncertainty remains in the selectivity of predators for diseased individuals and the relative timing of transmission and disease symptoms (Brandell and others, 2022).
- Other diseases besides CWD and brucellosis and their potential interactions were not evaluated. Other pathogens that this study lacked the data to include but may be important in the future are *Fusobacterium necrophorum* (Flügge, 1886; Moore and Holdeman, 1969) in elk and *Mycoplasma bovis* (Hale et al., 1962; Askaa and Erno, 1976) in bison. It is likely that animal aggregations that result from supplemental feeding may increase the transmission of both diseases.
- Evolutionary changes in either elk or CWD were not included. Some elk genotypes progress to disease and CWD-induced death more slowly than others (Moore

and others, 2018). Similarly, some CWD strains develop and cause mortality more quickly than others depending on host genotype and species (Pritzkow, 2022). The evolution and interaction of hosts and strains are still unclear.

- Any management changes other than those evaluated by NER or attempts to predict land-use changes that may affect bison and elk habitat selection were also not included. Many potential management actions could be taken by agencies that manage bison, elk, as well as public and private lands, which could affect the performance of the alternatives. For example, although concern exists over the potential for increases in traffic accidents, it was unclear whether and how surrounding land management agencies would respond to any changes in bison and elk distribution (for example, erect new fencing, conduct hazing operations).
- For the socioeconomic analyses, historical relationships between wildlife presence and visitation to the NER were assumed to adequately predict future dynamics, and that historical patterns in visitors' trip purpose, general spending patterns, and drivers of visitation are maintained in the future. It is possible that persistent declines in the number of elk available for viewing or hunting in the area could uncouple these relationships in ways not captured by our analyses. Changes in hunting were also assumed to be directly proportional to changes in elk numbers according to historical relationships; in other words, a decline in animals harvested predicted by the elk population model would result in a proportionate decline in hunter spending in the region.

Consequences

We present a summarized set of findings (consequences) for each of the performance metrics under the five alternatives. For complete details and description of the consequences, please refer to Cross and others (2025, this volume, chap. B), Cotterill and others (2025, this volume, chap. C), Cook and others (2025, this volume, chap. D), and McEachran and others (2025, this volume, chap. E; table E1).

The no feeding and disease threshold alternatives had the lowest CWD prevalence estimates in elk at year 20 (table A2). They were 24 (Standard deviation [SD]=8) and 23 percent (SD=7), respectively (Cross and others, 2025, this volume, chap. B). The continue feeding alternative had the highest 20-year CWD prevalence of 35 percent (SD=6), and the reduce feeding and increase harvest alternatives had intermediate values of 26 to 27 percent (SD=9 and 10). Further, the Jackson elk population is predicted to decline under all management alternatives. The continue feeding alternative resulted in the largest declines of elk on average, 54 percent, from 14,500 to 6,700 elk (SD=1,600), whereas the disease threshold alternative

resulted in the smallest decline of 40 percent to 8,600 (SD=1,600; table A2). The no feeding alternative performed similarly to the disease threshold alternative and only had a few hundred less individuals in year 20. The reduce feeding and increase harvest alternatives resulted in intermediate outcomes between continue feeding and disease threshold alternatives. Finally, the increase harvest alternative had the lowest number of CWD and natural elk mortalities in the first 5 years of plan implementation (mean=7,100, SD=700), and the continue feeding had intermediate values (mean=8,000, SD=700). The disease threshold, reduce feeding, and no feeding alternatives were all expected to perform worse than continue feeding and increase harvest alternatives in terms of elevating natural mortality from a variety of sources, not limited to harsh winter conditions, increasing human-elk conflicts, and competition with other large ungulates (fig. A3).

For bison population performance, the continue feeding alternative would result in the largest population of bison after 20 years (median=541, SD=57), and the no feeding (median=469, SD=65), disease threshold (median=470, SD=67), increase harvest (median=472, SD=70), and reduce feeding (median=473, SD=65) alternatives had smaller population size estimates that were indistinguishable from one another (Cook and others, 2025, this volume, chap. D).

Negative effects of elk space-use declined over time as elk numbers fell. For sensitive vegetation communities at the NER, effects were reduced by all alternatives that ceased feeding compared to continuing to feed. Across the broader study area, the alternatives had a mixed performance where the continue feeding alternative performed better for willow and worse for aspen (Cotterill and others, 2025, this volume, chap. C). Considering the degree of variation across simulations, increase harvest and reduce feeding were the alternatives that most consistently performed well for these metrics. Importantly, the reduce feeding alternative called for exclosures to be installed surrounding aspen, willow, and cottonwood stands at the NER, which primarily improved the performance of this alternative with respect to aspen.

For invasive species introduction and spread risk, the number of feeding days over the next 20 years was highest under the continue feeding alternative with an average of 1,243 days (SD=100). Fed days were intermediate under the reduced feeding and increased harvest (311 days, SD=50) and disease threshold (140 days, SD=43) alternatives. The no feeding alternative was assumed to have 0 fed days at the Refuge over the next 20 years.

The effect of elk monthly counts on visitation was small and the Bayesian posterior substantially overlapped 0. The small effect size (median=0.03) led to no differences among alternatives even when elk numbers changed substantially in the underlying data. Although it is certainly possible that elk abundance changes at the NER influence winter visitation under the alternatives, the historical data do not support that conclusion (FWS, written comm., 2023).

For human-wildlife conflicts, the continue feeding alternative had the least private land use by elk, whereas disease threshold and no feeding had the highest use of private lands (in other words, performed the worst; Cotterill and others, 2025, this

Table A2. Consequence table showing the performance metrics and alternatives.

[See Table A1 for full performance metric details. Measures for 1a -c were rounded to two significant figures. Fundamental objective four was raised as important by NER managers (in alignment with FWS and NPS, 2007); however, subject matter experts from the FWS, NPS, FS, and WGFD expected that the effects of bison and elk on the chemical, physical, and biological properties of water resources at the Refuge would be the same under all alternatives and therefore this objective was not considered further. min., minimum; CWD, chronic wasting disease; max., maximum SD, standard deviation]

Performance metric, direction and unit	Continue feeding		Disease threshold		Reduced feeding		Increase harvest		No feeding	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Objective 1—Maximize the health and well-being of wildlife										
1a, CWD prevalence, min. at year 20	0.35	0.05	0.26	0.06	0.27	0.08	0.28	0.08	0.26	0.07
1b, elk population size, max. at year 20	6,700	1,600	8,600	1,600	7,700	1,800	7,600	1,900	8,400	1,700
1c, minimize elk suffering, min. mortality in first 5 years	8,000	730	8,100	830	8,100	740	7,100	650	8,100	850
1d, bison population size, max. at year 20	546	57	464	67	469	65	467	70	462	65
Objective 2—Maintain ecosystem fluctuations and processes associated with bison and elk										
2a, elk use of aspen, min. cumulative elk days ^{1,2}	616	61	585	48	539	51	518	44	532	43
2b, elk use of cottonwood, min. cumulative elk days ^{1,2}	1,615	179	1,657	187	1,591	178	1,547	154	1,616	198
2c, elk use of willow, min. cumulative elk days ^{1,2}	385	36	441	39	406	40	393	35	440	36
Objective 3—Minimize risk of invasive species introduction associated with bison and elk management activities										
3, invasive species risk, min. cumulative feeding days ¹	1,243	100	140	43	311	50	311	50	0	0
Objective 5—Maintain and enhance multiple-use opportunities and public enjoyment										
5a, elk harvest, max. cumulative elk harvested ¹	13,181	1,885	13,215	2,082	11,834	2,036	14,276	1,467	12,603	2,071
5b, number of visitors, max. visitors ^{1,3}	3.4	0.8	3.3	0.8	3.3	0.8	3.3	0.8	3.3	0.8
Objective 6—Minimize human-wildlife conflicts										
6a, elk use of private lands, min. elk days ^{1,3}	12.4	1.0	13.8	1.2	13.1	1.2	12.8	1.0	13.8	1.2
6b, human-bison conflict, min. number of conflict bison	143	16	905	482	756	442	756	473	1,077	474
6c, Brucellosis risk, min. abortions on private lands ¹	161	16	181	21	173	19	170	17	180	21
Objective 7—Minimize costs of bison and elk management activities										
7, cost of management, min. dollars ^{1,3}	19.3	1.6	2.2	0.7	4.8	0.8	4.8	0.8	0	0
Objective 8—Maximize local economic benefits associated with bison and elk presence on the NER and surrounding lands										
8a, elk harvest tags, max. dollars ^{1,3}	5.5	0.6	5.2	0.7	4.8	0.8	6.6	0.6	5.0	0.8
8b, regional economic inputs for hunting activities, max. dollars ^{1,3}	88.6	12.2	82.0	14.3	73.0	14.1	101.3	9.6	76.1	14.8
8b, regional economic inputs for nonhunting, max. dollars ^{1,3}	3.0	0.7	2.9	0.7	2.9	0.7	2.9	0.7	2.9	0.7
8c, revenue of outfitters, max. dollars ^{1,3}	12.6	1.7	11.7	2.0	10.4	2.0	14.5	1.4	10.9	2.1
Objective 9—Maximize opportunities for Tribes to engage in activities related to their buffalo culture										
9, bison harvest, max. bison harvested	1,879	197	1,387	248	1,508	234	1,496	245	1,292	247

¹Cumulative across the 20-year simulation.

²Rounded, in thousands.

³Rounded, in millions.

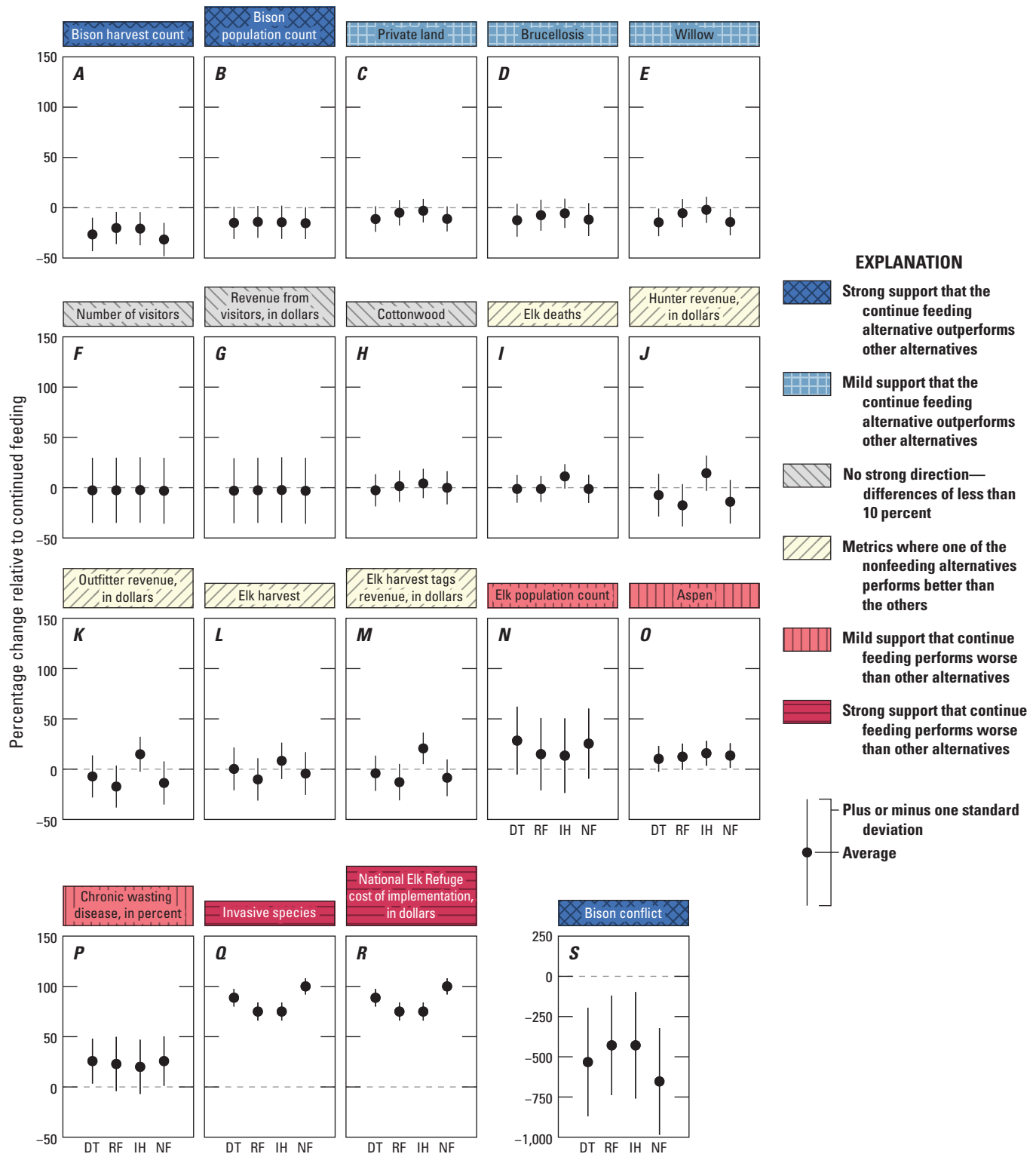


Figure A3. Graphs showing the percentage change in different performance metrics across management alternatives relative to the continue feeding alternative. Performance metrics where minimizing the value is preferred were multiplied by -1 so that negative values indicate the alternative does worse than continue feeding, but positive values indicate that the alternative does better than continue feeding across all metrics. Note that bison conflict is on a different scale for the y-axis. DT=disease threshold; RF=reduce feeding; IH=increase harvest; NF=no feeding.

volume, chap. C). However, the differences between continue feeding, reduce feeding, and increase harvest were small considering the overall magnitude of the estimates, declines in elk numbers, and the associated uncertainty in outcomes. In contrast, substantial differences, in terms of the potential for human-bison conflict, were found between the continue feeding alternative and the other four alternatives that stopped feeding. Over the next 20 years under the continue feeding alternative, 143 bison were estimated to be involved in conflict, whereas between 756 and 1,077 bison were in conflict under reduce feeding, disease threshold, increase harvest, and no feeding alternatives (Cook and others, 2025, this volume, chap. D). Finally, the brucellosis risk to livestock was assessed to be lowest under the continue feeding alternative (Cotterill and others, 2025, this volume, chap. C); however, the median estimates across all five alternatives were similar considering the uncertainty across simulations (table A2).

For the monetary costs of bison and elk management activities, the program was calculated to cost the FWS between \$15,210 and \$16,450 per day of feeding activities for the direct costs of feed, labor, fuel, and maintenance for machinery. In terms of feed season length, days of feeding varied between 0 days in 2017–18 to 101 days in 2010–11. The average length was 62 days (SD=24). In terms of total costs over 20 years, the continue feeding alternative was the most expensive, with an average cost of \$19.3 million (SD=1.6 million), and the lowest cost was no feeding, which was assumed to have no direct costs (in other words, \$0). The other alternatives varied according to the number of years until feeding stopped with reduce feeding and increase harvest alternatives costing \$4.8 million (SD=\$0.78 million) over the next 20 years and disease threshold having a cumulative 20-year cost of \$2.2 million (SD=\$0.67 million). The cost of exclosures that are included in the reduce feeding alternative was not considered.

Elk harvest tag sales, spending by hunters, and outfitter revenues were found to be highest under the increase harvest alternative. Although the increase harvest alternative did have initial hunting rates and hunting-related revenues that were higher than the other alternatives, revenues dropped after a few years. When considering changes over time, the increased harvest alternative had higher predicted tag revenues (mean=\$6.60 million, SD=\$574,000) and hunter-related spending (mean=\$101.3 million, SD=\$9.6 million), but like other performance metrics, the estimated ranges of the alternatives overlapped.

Projecting effects on outfitters over the next 20 years, the increase hunting alternative had the highest predicted number of clients with an average estimate of 3,758 clients (SD=416 clients) served over the next 20 years and a cumulative outfitter revenue of \$14.5 million (SD=\$1.4 million). The next highest performing alternative was the continue feeding alternative with an average of 3,480 clients (SD=565 clients) and \$12.6 million (SD=\$1.7 million) in revenue, followed by the disease threshold alternative, with an average of 3,319 clients (SD=627 clients) and \$11.7 million (SD=\$2.0 million) in revenue. The lowest cumulative number clients and revenues were predicted under the reduce feeding alternative, with 2,879 clients (SD=575 clients) and \$10.4 million (SD=\$2.0 million) in revenue over the next 20 years.

The last fundamental objective associated with bison harvest and Tribal ceremonial take had the best performance under the continue feeding alternative (median=1,879 bison harvested; SD=197) and the worst performance under the no feeding alternative (mean=1,292, SD=247). The reduced feeding (mean=1,508, SD=234), increase harvest (mean=1,496, SD=245), and disease threshold (mean=1,387, SD=248) all performed intermediate between continue feeding and no feeding.

In terms of tradeoffs, the largest differences among alternatives were measured in bison and elk population sizes at year 20, the cumulative invasive species risk as measured by feeding days, cumulative number of bison that conflict with humans, management costs, and cumulative harvest of bison. The continue feeding alternative was the worst alternative for elk population size, CWD prevalence, invasive species, and NER costs but was the best alternative for bison abundance, bison harvest, bison conflict, private land issues, and disease risks to cattle. The management alternatives did not have notably different consequences for visitor numbers, visitor spending, or effects on cottonwoods (fig. A3). The increased harvest alternative tended to perform best on elk harvest metrics as well as minimizing natural and CWD mortality of elk in the first 5 years.

Conclusions and Science Directions

Our results suggest that Jackson elk abundance will decline under all evaluated alternatives but that the mechanism, timing, and degree of declines depend on the specific management actions being taken. Under continue feeding, it is expected that chronic wasting disease (CWD) prevalence will increase over time and reduce abundance from the current population size of around 11,000 down to a median of 4,900 elk in year 20. In contrast, no feeding alternatives may lead to more rapid declines in the near term from natural, harvest, and conflict-associated causes, but after 20 years are projected to have a median size of 6,700 elk. The near-term consequences on elk populations from no longer feeding and the longer term effects of increases in disease mortality crossover between years 7 and 13. The continue feeding alternative predicts more elk initially, but the no feeding alternative predicts the highest elk abundance in year 20.

The disease dynamics that drive these patterns for fed and unfed elk were provided by an expert panel that estimated that direct transmission of CWD would be 1.9 times higher and indirect transmission would be 4 times higher in feedground settings (Cook and others, 2023). These transmission dynamics among fed and unfed elk resulted in the no feeding alternative performing better (in other words, have lower prevalence) than continue feeding in 70 percent of model simulations (Cross and others, 2025, this volume, chap. B). Further, the expert panel was convened to consider CWD dynamics on State feedgrounds that host fewer elk than the National Elk Refuge (NER). The NER elk may have higher (or lower) transmission rates depending on local aggregations of elk, social dynamics, and feed season lengths.

The effect of severe winters on elk mortality, however, remains a source of substantial uncertainty as it is unclear how snowfall and snowpack might affect elk populations under no feeding alternatives. For the purposes of this study, the results of Hobbs and others (2003) were used to enforce a severe winter penalty that led to higher mortality rates with an annual probability of 0.25 once NER stopped feeding operations. This increase in mortality resulted in an average of 38 percent declines projected for Jackson herd elk, compared to estimates of 23 percent for elk in other western Wyoming herd units (Cook and others, 2023). Although the true magnitude of declines remains uncertain, it seems reasonable to expect the Jackson Elk Herd Unit to perform worse than other units that have more critical winter range available relative to the number of elk overwintering in those units.

The population effects and the spatial structuring of different elk populations across the study area under the different alternatives led to some consistent patterns in elk use of private lands and sensitive habitats. Continue feeding is predicted to result in having fewer elk days on private property and lower brucellosis risk (measured by number of abortions on private property where cattle overwinter) across the 20 years of plan implementation. However, continue feeding also led to a higher degree of use of sensitive areas, particularly at the NER. Further, across all alternatives, the negative effects associated with Jackson elk are predicted to decrease because of population declines projected in the elk CWD model. Depending on the alternative, these declines resulted either from CWD, elevated natural mortality associated with severe winters, or in conjunction with specific management efforts to reduce elk abundance.

Translating the proxy measure of brucellosis risk to an actual change in the magnitude of risk to cattle producers is difficult because there has not been a documented instance of elk infecting cattle in the Jackson region. Doing so would require data to inform the connection between the number of abortions and a successful elk-to-cattle transmission event in the Jackson Elk Herd Unit. As a result, it is unclear how meaningful 19 or 20 additional abortions projected under the no feeding or disease threshold alternatives are compared to continuing to feed.

In terms of bison, the continue feeding alternative is predicted to be best, on average, for the three metrics associated with population size, harvest, and conflict potential. However, it is important to acknowledge the limitations of the available data in this study. First, data from the Yellowstone region was relied on to inform bison vital rates. These vital rates produced model behavior (in other words, harvest, population performance) that matched historical data, but may not necessarily be reflective of future conditions. Second, there was a high degree of uncertainty expressed by the expert panels in how human-bison conflicts might occur, and change, over time. As a result, two hypotheses about trends in those conflicts were incorporated: one where conflicts were stable over time, and another where human-bison conflicts changed according to learned behavior or active management activities. It is unclear which hypothesis is a better representation of future dynamics. Finally, it was assumed that there were no high mortality events from *Mycoplasma bovis* over the 20 years in either fed or unfed bison populations

because it is uncommon in free-ranging wildlife ungulates (Malmberg and others 2020), even though the bacterial disease has led to 20–40 percent mortality in captive bison herds elsewhere (Janardhan and others 2010).

No discernable pattern for sleigh ride participation or NER visitation rates or spending was found under the different alternatives; however, elk could change their distribution under no feeding alternatives in unpredictable ways such that they become less visible to sleigh riders without supplemental feeding. Further, predicting future visitation to NER is difficult based on the projected changes in bison and elk numbers and the small effect that these species have relative to broader system dynamics, like U.S. human population size and economic conditions that have a greater influence on travel. As expected, NER feeding costs were minimized by alternatives that limited feeding. The increased harvest alternative tended to perform best on elk harvest metrics as well as minimizing the number of natural or CWD-related elk deaths in the first 5 years. As of 2024, however, it is not clear whether increasing harvest tags alone would successfully reduce the number of elk using the NER in winter to 5,000 individuals in 5 years.

Additional work may include NER managers, cooperating agencies, and other stakeholders navigating the tradeoffs embedded in this decision on whether and how to feed bison and elk under threat of CWD and given the range of other effects that are presented in this work. Deliberative tools from decision analysis (for example, swing weighting) could be used to estimate the relative value of the objectives against one another and develop an overall score for each alternative given those weights. This weighting could also help to fully incorporate the many sources of uncertainty embedded in these analyses and explore the role that those uncertainties have on distinguishing the best performing alternative for the next “Bison and Elk Management Plan.”

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**APPENDIX C – U.S. Geological Survey, Chapter B of
Scientific Investigations Report 2024–5119:
Predictions of Elk and Chronic Wasting Disease
Dynamics in the National Elk Refuge in Jackson,
Wyoming, and Surrounding Areas**

Ecosystems Mission Area—Biological Threats & Invasive Species Program and the Environmental Health Program

Prepared in cooperation with the U.S. Department of Agriculture, National Park Service, U.S. Fish and Wildlife Service, and Wyoming Game and Fish Department

Predictions of Elk and Chronic Wasting Disease Dynamics in the National Elk Refuge in Jackson, Wyoming, and Surrounding Areas

Chapter B of
Decision Analysis in Support of the National Elk Refuge Bison and Elk Management Plan

Scientific Investigations Report 2024–5119

**U.S. Department of the Interior
U.S. Geological Survey**



Cover. A group of bull elk at the McBride Feedground. Photograph taken by Gannon Castle, U.S. Fish and Wildlife Service, March 2020.

Predictions of Elk and Chronic Wasting Disease Dynamics in the National Elk Refuge in Jackson, Wyoming, and Surrounding Areas

By Paul C. Cross, Jonathan D. Cook, and Eric K. Cole

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Conversion Factors

International System of Units to U.S. customary units

Multiply	By	To obtain
Length		
kilometer (km)	0.6214	mile (mi)
Area		
square kilometer (km²)	247.1	acre
square kilometer (km²)	0.3861	square mile (mi²)

Abbreviations

CWD	chronic wasting disease
FCHU	Fall Creek Elk Herd Unit
JHU	Jackson Elk Herd Unit
NER	National Elk Refuge
WGFD	Wyoming Game and Fish Department

Predictions of Elk and Chronic Wasting Disease Dynamics in the National Elk Refuge in Jackson, Wyoming, and Surrounding Areas

By Paul C. Cross,¹ Jonathan D. Cook,¹ and Eric K. Cole²

Abstract

The U.S. Fish and Wildlife Service National Elk Refuge (NER) in Jackson, Wyoming, supplementally feeds *Cervus elaphus canadensis* (Erxleben, 1777; elk) and *Bison bison* (Linnaeus, 1758; American bison) during winter months, but the costs and benefits of this management strategy are being reevaluated considering the potential effects of chronic wasting disease (CWD) on elk. U.S. Geological Survey scientists worked with the U.S. Fish and Wildlife Service on a structured decision-making process that considered five alternative feeding strategies and their effects on bison, elk, and humans. This chapter focuses on elk population dynamics and CWD using computer models. Our modeling results highlight a short-versus long-term tradeoff between the continue feeding and no feeding alternatives. Management alternatives associated with a cessation of supplemental feeding were assumed to make elk more susceptible to severe winters, resulting in initially lower population sizes and less CWD transmission. The increased CWD prevalence and transmission associated with the continue feeding alternative resulted in lower elk population sizes by year 20 (mean=6,700, standard deviation=1,600 in the analysis area) in 70 percent of simulations compared to no feeding (mean=8,400, standard deviation=1,500). No feeding alternatives resulted in higher elk populations than the continue feeding alternative between years 7 and 13 when CWD prevalence exceeded 20 percent in the Jackson elk herd. The increased harvest alternative minimized CWD and natural mortality in 83 out of 100 simulations compared to the continue feeding alternative.

Introduction

The National Elk Refuge (NER) in Jackson, Wyoming (fig. B1), is managed by the U.S. Fish and Wildlife Service. The NER has been supplementally feeding *Cervus elaphus canadensis* (Erxleben, 1777; elk) during the winter for over a century (16 U.S.C. §673, Wyoming Elk Reserve). Supplemental feeding was intended to mitigate elk mortality during severe winters and reduce

private-property damage in and around Jackson, Wyoming, but aggregates thousands of elk in the NER, which may increase the transmission of pathogens such as chronic wasting disease (CWD). Chronic wasting disease was detected in elk at Grand Teton National Park for the first time in 2020 and has the potential to alter the costs and benefits of the NER supplemental feeding program.

Chronic wasting disease is spread through direct contact with an infectious individual and by way of environmental contamination with prions, which can persist for years in the environment (Miller and others, 2004). Chronic wasting disease prevalence has been observed as much as 29 percent in free-ranging elk of Wind Cave National Park (Sargeant and others, 2021). Galloway and others (2021) predicted that a CWD prevalence of more than 7 percent would lead to elk population declines in the Jackson elk herd even without a harvest. The predicted sensitivity of the Jackson elk herd to CWD is due, in part, to the low recruitment rates of elk calves that are observed in the region (Foley and others, 2015).

Previous studies of free-ranging *Odocoileus virginianus* (Zimmerman, 1780; white-tailed deer) suggest that CWD transmission is not strongly correlated with regional measures of host density (Storm and others, 2013) likely because broad-scale changes in population size may not correlate with changes in local measures of density or group size (Cross and others, 2009). The discovery of CWD on captive Cervidae (Goldfuss, 1820; cervid) farms typically results in immediate quarantine of the premises and herd depopulation (Haley and others, 2021). The few available studies of affected cervid farms show higher CWD prevalence in captive populations compared to free-ranging populations but typically lack data on how long the disease was present prior to sampling. Keane and others (2008) found a CWD prevalence of 79 percent in a captive white-tailed deer population. Peters and others (2000) found that 67 percent of the 17 elk (average age 2.6 years) tested in a captive facility were infected. Haley and others (2020) found a CWD prevalence of over 37 percent in a captive elk herd (approximately 450 elk in a 14 square kilometer [km²] facility [32 elk per km²]) and over 60 percent in some genotypes. Williams and others (2014) noted that 37 out of 39 elk died from CWD in their study of captive elk at the Tom Thorne/Beth Williams Wildlife Habitat Management Area in Wheatland, Wyoming. The median lifetime of the captive elk in the Williams and others (2014) study was 4.1 years for methionine-methionine at codon 132 in the prion protein gene

¹U.S. Geological Survey.

²U.S. Fish and Wildlife Service.

B2 Predictions of Elk and Chronic Wasting Disease Dynamics

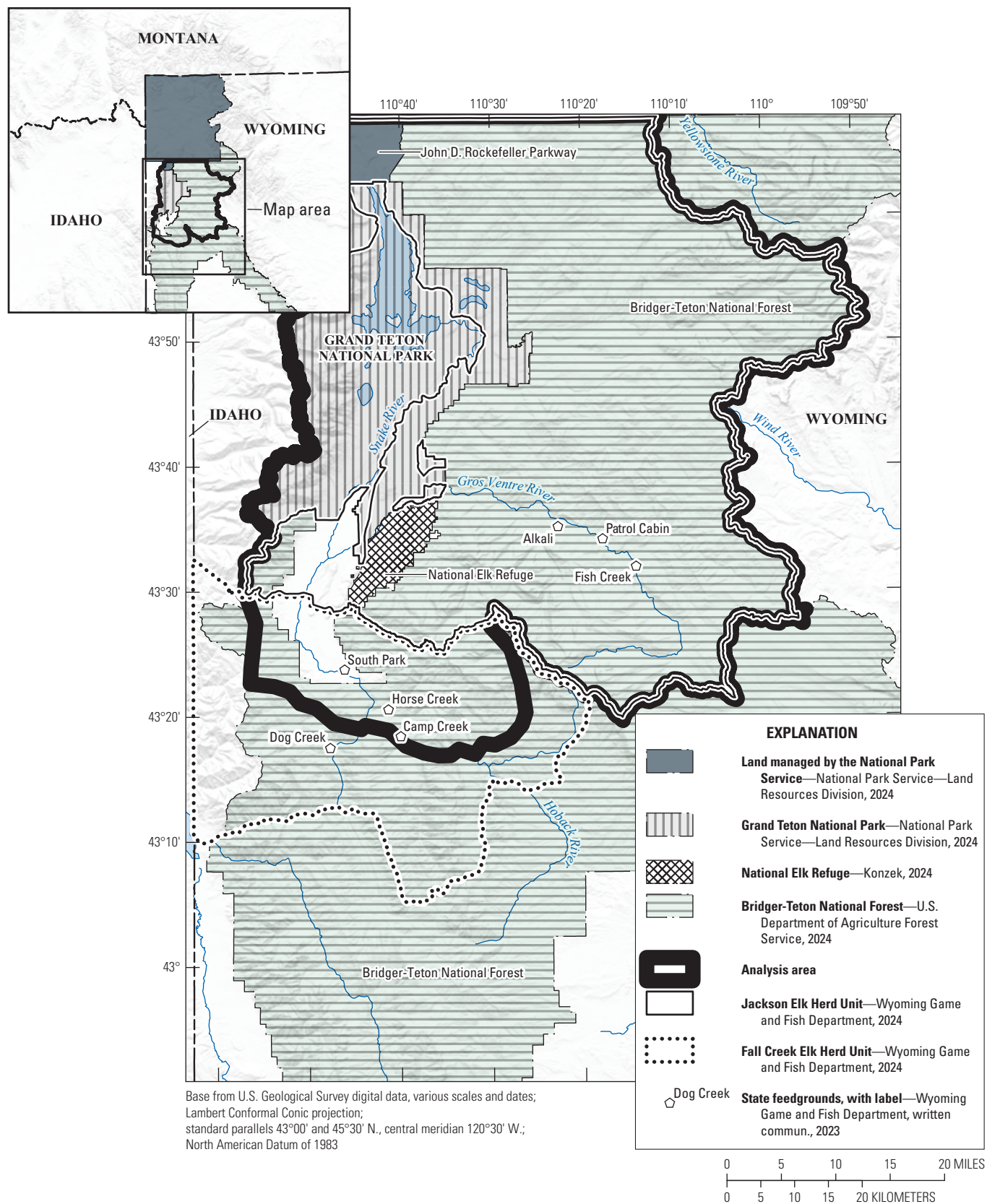


Figure B1. Map showing the location of the National Elk Refuge, Grand Teton National Park, Jackson Elk Herd Unit, Fall Creek Elk Herd Unit, and feedgrounds within the study analysis area.

and 7.1 years for methionine-leucine or leucine-leucine genotypes. These observations from captive populations suggest that local host densities may enhance CWD transmission in a high-density feedground. Previous studies of elk suggest that contact rates among elk on feedgrounds can be many times higher than among individuals overwintering on native winter ranges (Creech and others, 2012; Cross and others, 2013; Janousek and others, 2021). These higher rates are likely because of short-term densities on feedgrounds, such as the NER, reaching as high as 1,089 elk per km² (Graves and others, 2022). The repeated visitation of the same areas and the potential for the long-term persistence of CWD prions in the environment may also increase transmission. Therefore, CWD could reach higher prevalence and have a larger effect on the Jackson elk herd than has been observed in other free-ranging elk herds if the herd continues to be supplementally fed.

Chapter A of this volume provides context on the NER, CWD, and the structured decision-making process used to develop the management alternatives, objectives, and metrics for the supplemental winter feeding of *Bison bison* (Linnaeus, 1758; American bison) and elk (this volume, Cook and others, 2025). The structured decision-making process identified five management alternatives: (1) continue feeding, (2) no feeding, (3) increase elk harvest for five years and then stop winter feeding (increase elk harvest), (4) reduce the amount of feed for five years and then stop winter feeding (reduce feeding), and (5) phase out feeding after 3 percent CWD prevalence. In this chapter, we develop a computer-simulation model to assess the potential effects of these alternatives on future CWD dynamics and the Jackson elk herd over the next 20 years. We first describe the overall model structure (in the “General Model Structure” subsection of the “Methods” section) and how the model structure represents the five management alternatives (refer to the “Modeling Management Alternatives” subsection of the “Methods” section). The model’s temporal predictions of elk numbers and CWD prevalence were used to inform the elk space-use metrics in chapter C (this volume, Cotterill and others, 2025) and some of the socioeconomic metrics in chapter E (this volume, McEachran and others, 2025). The CWD model was developed in consultation with the NER Environmental Impact Statement wildlife subject matter expert team.

Methods

The CWD model was developed to simulate elk and CWD dynamics over time based on several previously published papers (Cross and Almborg, 2019; Brandell and others, 2022; Rogers and others, 2022; and Cook and others, 2023). The model included an environmental transmission component, as in Cook and others (2023), and multiple interacting populations within an elk herd unit. The model is written in R (version 4.4.0; R Core Team, 2024) and is available online (Cross and Cook, 2024).

General Model Structure

The CWD model tracks elk according to their age, winter location, sex, and disease status—susceptible or infectious. The CWD model is stochastic with a discrete monthly timestep, and

all simulations begin in May. The model assumes that all births occur in June and hunting occurs only in November. The CWD model has the following order of operations: births and aging individuals, direct CWD transmission, indirect CWD transmission, natural mortality, severe winter mortality, hunting mortality, and disease-induced mortality. Disease transmission and deaths occur in every monthly iteration of the model, but hunting, births, and increasing the age of individuals occur once per year.

Within the model, the category of infectious elk is divided into 10 subcategories of disease progression. We assumed elk would die of CWD when individuals exit the 10th infectious subcategory but not beforehand. Infectious elk that are hunted or died from natural causes are not considered CWD deaths. By assuming individuals progress through multiple stages of infection before dying of disease, substructuring infected categories allows the time for disease-induced death to have an initial delay and then peak later (Wearing and others, 2005). Multiple infectious categories result in a gamma distribution for the time to disease-induced death. As in Cook and others (2023), the probability of progressing to later stages of infection was assumed to be 28 percent such that the time from infection to CWD-induced death was, on average, 2.8 years (standard deviation [SD]=5.29). Twelve age classes were grouped into 5 categories (*i*) that had similar vital rates: calves (0–1 year, *i*=1), male yearlings (1–2 years, *i*=2), female yearlings (1–2 years, *i*=3), male adults (>2 years, *i*=4), and female adults (>2 years, *i*=5). Elk transitioned between stages according to sex- and age-specific vital rates as defined in Cook and others (2023) unless otherwise noted (app. B1, table B1.1).

The CWD model was structured into *k* winter subpopulations within two different herd units—the Jackson Elk Herd Unit (JHU) and Fall Creek Elk Herd Unit (FCHU; this volume, chap. A, fig. A1 of Cook and others, 2025). State Highway 22 in Wyoming forms the boundary of these herd units and has historically been a strong barrier to elk movement. The wildlife subject matter expert team believed that if feeding were stopped or reduced in the NER, more elk would relocate from the JHU to the FCHU. We used an expert elicitation process to estimate those potential movement rates (app. B2). The JHU was divided into three groups: elk that winter in the NER (*k*=1); elk that are fed in the Gros Ventre River drainage (Patrol Cabin, Fish Creek, and the now-closed Alkali feedgrounds [*k*=2]); and elk that are unfed in the JHU (*k*=3). The FCHU was divided into four groups: fed and unfed elk that are inside and outside of the analysis area. Within the analysis area were elk fed at South Park, Horse Creek, or Camp Creek feedgrounds [*k*=4] and an unfed FCHU elk subpopulation (*k*=5). Outside the analysis area were elk fed at Dog Creek (*k*=6) and an unfed elk subpopulation (*k*=7). We assumed the proportion of unfed elk in the FCHU that were in the analysis area was the same as the proportion of the FCHU area that was within the analysis area (36 percent). We summed subpopulations *k*≤5 to provide results for the analysis area and *k*≤3 for just the JHU.

In developing our model, we assumed elk could be infected through direct contact with infectious individuals and indirectly through contact with a prion-contaminated environment. These transmission parameters were estimated by an expert panel and reported in Cook and others (2023). As in Cook and others (2023), there were two scenarios for the transmission of CWD among

fed and unfed elk subpopulations, and both scenarios were included in the model with equal likelihood by combining an equal number of simulations from each scenario. The first scenario was that elk could transmit CWD between fed and unfed subpopulations within a herd unit during the summer months. In this scenario, fed elk had a higher direct CWD transmission rate during winter months than unfed elk, and the direct CWD transmission rate during the summer months was calculated as the average of fed and unfed elk weighted by the population sizes at the start of the simulation. The second scenario assumed that CWD transmission occurred only within a subpopulation and not among subpopulations. Thus, fed elk would have higher rates of transmission year-round compared to unfed elk. Indirect transmission was assumed to increase linearly during the 20 years of the simulation for fed and unfed elk, where the maximum indirect transmission rate was provided by expert elicitation (Cook and others, 2023). For further modeling details on disease transmission, refer to Cook and others (2023).

The model includes two density-dependent mechanisms to avoid exponential growth or decline of the elk populations. First, calf survival (ϕ_1) depends on the previous year's annual population size in each herd unit, and declines from a maximum of 0.6 to a minimum of 0.05 when the population size is at the herd unit carrying capacity (K_{HU} , [app. B1](#)), given by the following equation:

$$\phi_1 = \max(\phi_{\max}(1 - c(N_{j-1}/K)^\delta, \phi_{\min})) \quad (\text{B1})$$

where

- ϕ_1 is the annual calf survival rate in the herd unit;
- c is the proportion reduction when population was at carrying capacity;
- N_{j-1} is the January population size for the previous year in the herd unit;
- K is a parameter related to the carrying capacity of fed and native winter range elk in each herd unit;
- δ controls the shape of density dependence;
- $\phi_{\max}$ is the maximum calf survival rate; and
- $\phi_{\min}$ is the minimum calf survival rate.

Parameters c and δ were drawn from uniform distributions ([0.5, 0.8] and [2, 4], respectively) each year. Carrying capacity, K , was set to 1.3 times the population objective of the herd unit so that the population equilibrated at the population objective in the absence of CWD. These parameters resulted in a ratio of calves per adult female at the end of the winter (calf:cow) that ranged from a maximum of 0.6 when populations were less than 5,000 to between 0.3 and 0.5 when the population was at the population objective. The emergent calf:cow ratio in the model was in rough agreement with the maximum calf:cow ratio observed in other Wyoming elk herds. The Northern Bighorn Herd Unit in Wyoming is an example of an increasing elk herd and had a calf:cow

ratio of 0.58 in 2015. The elk population of the Clark's Fork Herd Unit has been stable to slightly decreasing from 2010 to 2020 and had a minimum observed calf:cow ratio of 0.11 (Wyoming Game and Fish Department, written commun., 2010–19; Wyoming Game and Fish Department, 2020). For a visual representation of calf survival expressed as a function of herd unit population size, refer to [figure B1.1](#) in [appendix B1](#).

While tuning the CWD model to the JHU information, the harvest rates were set to match the percentage of different age and sex categories hunted in the JHU from 2016 through 2021, which were approximately 7 percent for female elk and 28 percent for adult male elk (Wyoming Game and Fish Department, written commun., 2016–19; Wyoming Game and Fish Department, 2020, 2021b), and the parameters controlling calf survival ([eq. B1](#)) were modified to result in the low calf:cow ratio observed in the Jackson herd (mean=22:100; Wyoming Game and Fish Department, written commun., 2000–19; Wyoming Game and Fish Department, 2021a). This parameter combination, along with the other vital rates set to the values in [table B1.1](#) ([app. B1](#)), resulted in a declining population size, which suggests that there may be biases in observed data or some of the vital rates in [table B1.1](#) ([app. B1](#)) were not representative of elk in the JHU. The parameter sets used in the CWD model prioritized matching the model results to the elk harvest rates instead of the calf:cow ratios because the elk harvest rates are used by McEachran and others (2025, this volume, chap. E) for some of the economic assessments of the feeding decision. Therefore, the yearling male and adult female harvest rates ([app. B1](#)) were matched to observed values, but the density-dependent calf survival rate was allowed to result in a calf:cow ratio that is higher than the ratio that is commonly observed. Yearling females were assumed to be harvested at the same rate as adult female elk. The bull harvest rate was reduced from the observed 28 percent to 8 percent because bulls are commonly in smaller groups that tend to be undercounted.

We assumed that the percentage of female elk harvested annually would decline linearly from a maximum when the elk population was equal to or more than the population objective to zero when the population was at 80 percent of the population objective. The changes to the female harvest rate occurred annually but were based on the previous 3-year average population size in February. This approximates the Wyoming Game and Fish Department harvest setting process (Wyoming Game and Fish Department, oral commun., 2023). Bull harvest rates were assumed to be constant for the duration of each simulation.

One hundred simulations for each management alternative started with elk population sizes drawn from a normal distribution with a coefficient of variation of 0.05, which matches the 2016–21 variation in the JHU. Simulations began with a stable age and sex structure, which we calculated from a Leslie matrix with annual rates using the popbio package (Stubben and Milligan, 2007) in R version 4.4.0 (R Core Team, 2024). We then simulated 5 years of burn-in to reach a stable age and sex structure using the monthly survival rates and seasonal pulses of reproduction and hunting before introducing CWD and recording the results for the subsequent 20 years. The average starting population sizes of fed elk equaled the 2016, 2018, 2019, 2020, and 2021 observed

averages. The 2017–18 winter was excluded from these averages because it was a nonfeeding year for the NER and not representative of typical feeding year counts. The starting population size of the unfed elk subpopulations ($k \in \{3, 5, 7\}$) was multiplied by 1.48 to account for the likely undercounting of native winter-range elk (Lubow and Smith, 2004).

All simulations began with a starting CWD prevalence of 1 percent. Setting the prevalence of the modeling analyses modestly higher than current levels was a deliberate choice intended to account for the delay between the completion of analyses, finalization of the Environmental Impact Statement, and any future implementation of management alternatives. Preliminary analyses suggested that model results were not sensitive to starting prevalence because of our assumptions about how indirect transmission of CWD from the environment was modeled as a constantly increasing risk of infection starting at year 1 (Cook and others, 2023).

The effects of severe winters were included in the model to account for the potential demographic effects of not feeding on elk survival. Hobbs and others (2003) estimated elk mortality during different winter conditions based on forage availability in the JHU and across a variety of population sizes. We extrapolated those results across a broader distribution of population sizes (app. B1, fig. B1.2). To use these relationships in the FCHU, the population sizes in each herd unit were converted to the winter range elk density based on the total area of available native winter range (calculated in Cook and others, 2023). In the model, severe winters were included as a random draw with probability ω , which resulted in additional mortality beyond all other causes of death in unfed elk subpopulations ($k \in \{3, 5, 7\}$).

The probability ω of severe winters in the model determined the demographic penalty associated with not feeding in the absence of CWD. Severe winters also affect the spatial distribution of elk

(this volume, chap. C, Cotterill and others, 2025). Winter calf mortality in the NER exceeded 5 percent in 4 of the last 15 years (27 percent) when direct measures of snow in the NER were available (fig. B2). In addition, a visual inspection suggested that 5 of 19 years were severe in terms of constraining the movements of elk in the NER (this volume, chap. C, Cotterill and others, 2025). For the model, we assumed that severe winters occurred with an annual probability of 25 percent.

Modeling Management Alternatives

The NER managers defined the following five management alternatives for the elk and bison feeding program (this volume, chap. A, Cook and others, 2025): continue feeding; no feeding; increase elk harvest, then stop feeding (increase harvest alternative); reduce feeding, then stop feeding (reduce feeding alternative); and phase out feeding after a 3 percent CWD prevalence (disease threshold alternative). This section describes how the CWD model incorporated these management alternatives; for a more thorough description of the alternatives, refer to chapter A of this volume (Cook and others, 2025).

Continue Feeding Alternative

In this management alternative, supplemental feeding continues without any changes for 20 years. It was assumed that elk remained in the fed or unfed subpopulations they originated from and did not move across herd unit boundaries. Unfed elk populations were subjected to the demographic effects of severe winters with a probability of 0.25 per year, but supplementally fed subpopulations were unaffected by severe winters.

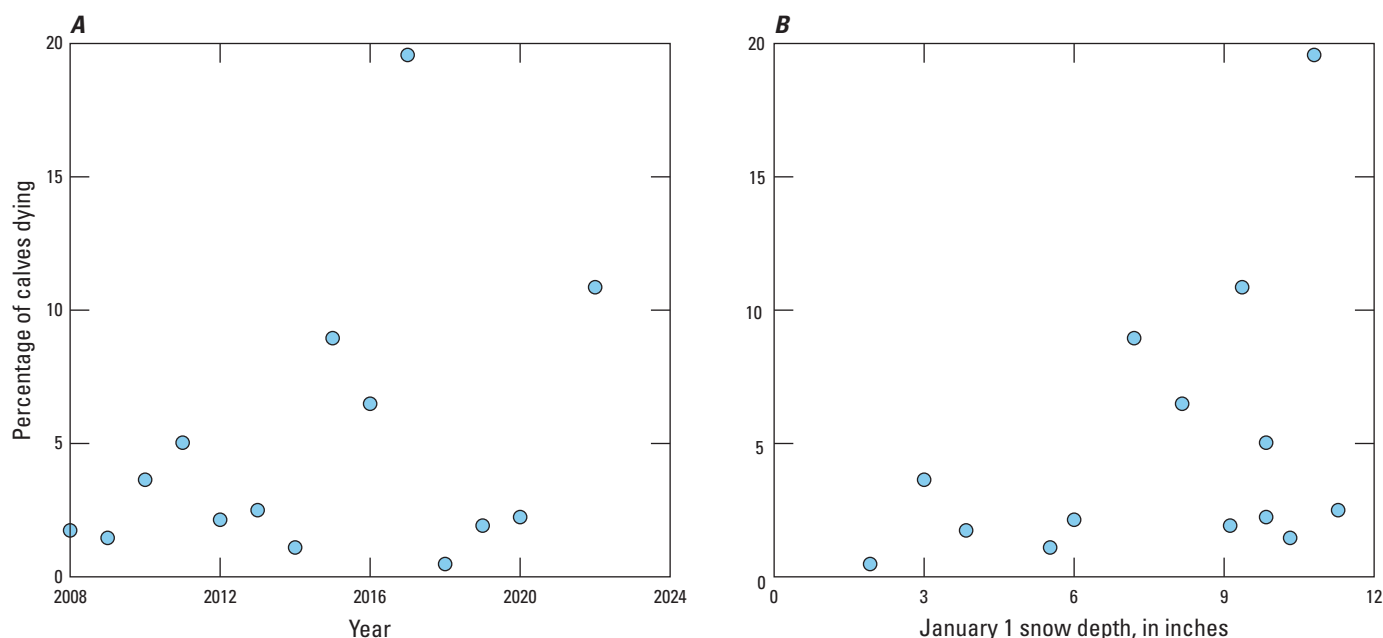


Figure B2. Scatterplots of the percentage of elk calves dying on the National Elk Refuge, Jackson, Wyoming. A, during the winter from 2008 to 2022 or, B, as a function of snow depth on January 1.

No Feeding Alternative

In the no feeding alternative, the wildlife subject matter expert team expected that elk would redistribute to other areas if the NER stopped feeding elk. To quantify this expectation, we invited a panel of eight experts with specific and localized knowledge about elk behavior and movement dynamics in this ecosystem. We developed a series of questions (app. B2) to inform necessary parameters of the model and used the panel's expert judgment to estimate the percentage of elk that may move from the NER to Gros Ventre feedgrounds ($k=2$); other areas of the JHU ($k=3$); and South Park, Horse, or Camp Creek feedgrounds in the FCHU ($k=4$). We also asked the panel for their estimates of the proportion of elk that would continue to come to the NER even when supplemental feed was not provisioned (app. B2).

A modified Delphi method (Hanea and others, 2017) and four-point Speirs-Bridge elicitation protocol were used to develop estimates (Speirs-Bridge and others, 2010). The four-point estimates were an expert's low, high, and best estimates of a parameter and their confidence that the actual value would fall within the low and high values (figs. B2.1 and B2.2). Each expert's quantiles (based on the expert's four-point estimates) were used to fit a probability distribution by finding the parameters for a beta distribution, which minimized the sum of square differences between the elicited and fitted quantiles. Individual expert distributions were then aggregated by fitting a single Dirichlet distribution, which ensured that the sum of each estimated beta distribution included the upper limit of 1 for the proportional data we elicited (Conroy and Peterson, 2013).

In the no feeding alternative, NER elk were assumed to move to other subpopulations ($k \in \{2, 3, 4\}$) according to the expert panel estimates prior to the start of the simulation. Those elk that we assumed would return to the NER, even though there was no feeding, were treated as unfed elk with lower CWD transmission rates but were exposed to the effects of severe winters.

Increase Harvest Alternative

In the increase harvest alternative, the NER managers' objective was to lower the number of elk using the NER ($k=1$) to 5,000 within 5 years through increased harvest. The NER would then discontinue the feeding program after those 5 years. To accomplish this in the model, the harvest rate of all age and sex classes was increased by 2.5 times for the NER group compared to the rates in table B1.1 (app. B1). It was assumed that after year 5, the NER would no longer feed elk and elk would redistribute to other subpopulations ($k \in \{2, 3, 4\}$) according to the expert panel estimates (app. B2). Unfed elk at the NER were subjected to the effects of severe winters if they did not move to an alternate feedground where they were fed. After year 5, harvest rates were assumed to return to previous levels, which depended on the herd unit population size relative to the population objective. After year 5, elk that returned to the NER were assumed to have CWD transmission rates of unfed elk.

Reduce Feeding Alternative

In the reduce feeding alternative, the amount of feed provided to elk in the NER was reduced during the first 5 years and discontinued after year 5. We assumed that the reduced feed would be sufficient to mitigate the effects of severe winters on adult elk but that calves would access less food and would, therefore, be exposed to the effects of severe winters. After year 5 of the simulation, the NER halted all feeding. Elk were then redistributed to the other subpopulations ($k \in \{2, 3, 4\}$) as defined by the expert elicitation process (app. B2). After year 5, the elk returning to the NER were assumed to have the CWD transmission rates of unfed elk (table B1.1 of app. B1).

Disease Threshold Alternative

Finally, we modeled an alternative in which feeding in the NER stopped after CWD prevalence reached a disease threshold of 3 percent in the Jackson herd elk. Chronic wasting disease prevalence was estimated based on 400 randomly sampled hunted elk across the JHU, which was approximately the number tested per year from 2020 to 2022 (Wyoming Game and Fish Department, 2020, 2021b, 2022b). If CWD prevalence exceeded 0.03 in that sample, then feeding was halted in the subsequent winter and elk were redistributed to the other subpopulations ($k \in \{2, 3, 4\}$) as defined by the expert elicitation process (app. B2).

Results

The expert panel estimated that 50 percent (SD=8 percent) of the elk fed at the NER would continue to spend their winters in the NER even when no supplemental feed is provided ($k=1$; app. B2; fig. B3). Eighteen percent (SD=7 percent) of the elk fed at the NER were predicted to move to the Gros Ventre feedgrounds and be fed there (Fish Creek or Patrol Cabin, $k=2$), and 19 percent (SD=6 percent) would spend winter in other areas of the JHU ($k=3$; fig. B3). Fourteen percent of the elk from the NER were predicted to move to feedgrounds in the FCHU ($k=4$) with the South Park feedground being the most likely destination.

Model Checks

To assess the demographic effects associated with severe winters when elk were not being fed, the model was run without disease by setting CWD transmission parameters to zero and evaluating three scenarios. In the first scenario (fig. B4A), we assumed continued feeding and that the fed populations would be unaffected by severe winter effects. This scenario established that the model parameters result in a stable population size in the absence of CWD. In the second scenario (fig. B4B), we assumed no feeding with severe winters and female elk hunting rates that declined linearly to zero as the population declined from the initial population size to 80 percent of the population objective of 11,000 elk. In the third scenario (fig. B4C), we

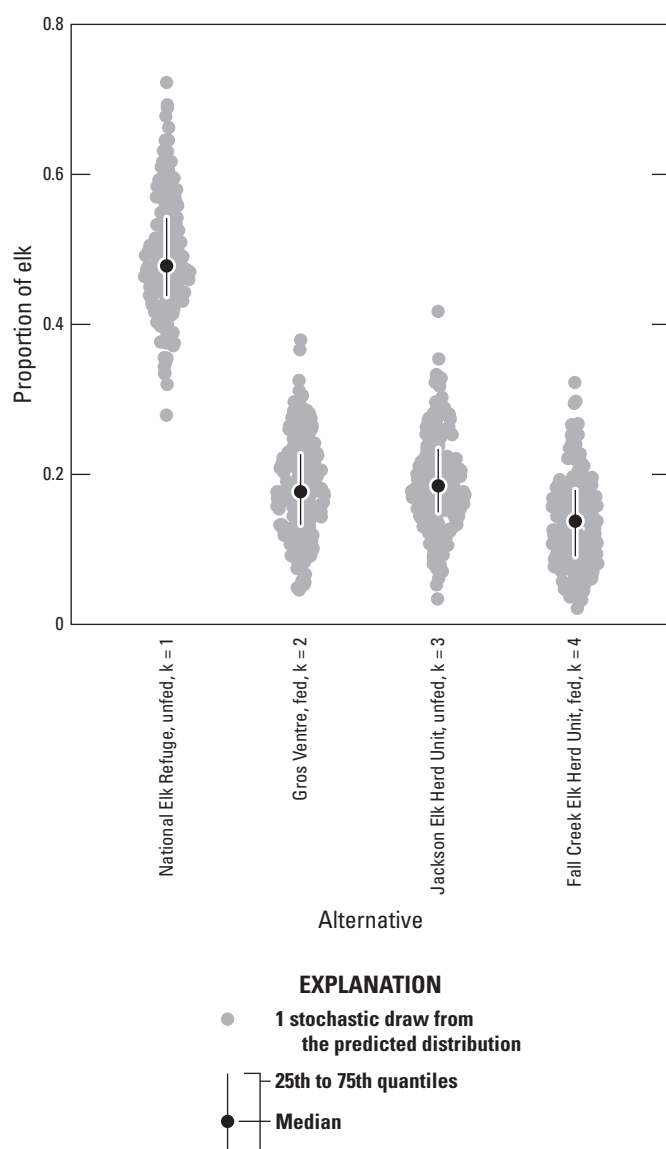


Figure B3. Simulated distributions of the expert elicitation results of how elk may redistribute themselves to other areas if supplemental feeding in the National Elk Refuge (NER) in Jackson, Wyoming, is discontinued. On average, 50 percent of the elk were expected to continue using the NER during the winter (subpopulation [$k=1$]). The remaining elk were expected to move to the Gros Ventre feedgrounds ($k=2$), native winter ranges within the Jackson Elk Herd Unit ($k=3$), or feedgrounds in the Fall Creek Elk Herd Unit ($k=4$). No elk were expected to move to the unfed elk population of the Fall Creek Elk Herd Unit ($k=5$).

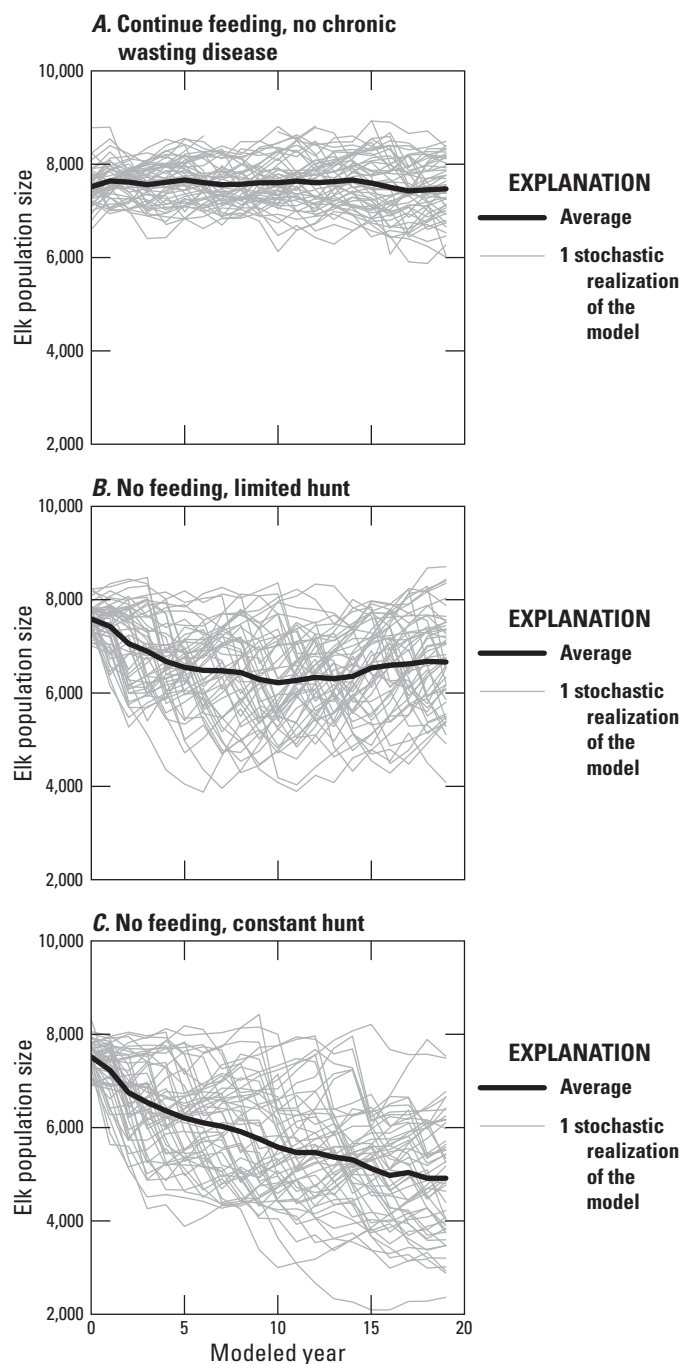


Figure B4. Line graphs showing scenarios describing the demographic effect of severe winters on elk population size over 20 years in the absence of chronic wasting disease (CWD): *A*, severe winters are not included; *B*, severe winters occur with a probability of 0.25, but hunting rates of female elk decline with population size; and, *C*, hunting rates are held constant and severe winters occur with a probability of 0.25. In this example, only a single population starting at 7,500 elk was modeled.

B8 Predictions of Elk and Chronic Wasting Disease Dynamics

assumed no feeding with severe winters and hunting rates for both sexes that remained at a constant proportion of animals. For demonstration purposes, these scenarios were run for just those elk that visit the NER in winter ($k=1$) and did not include displacement to other regions.

Simulations with severe winters showed some years when elk populations declined sharply, followed by an increase in calf survival (figs. B4B, C) and reduced hunting (fig. B4B), which led to some population recovery after severe winters. The effect of no feeding reduced the NER elk population by about 14 percent in the absence of CWD when harvest pressure was also reduced in response to the population decline. The elk population in the NER declined by, on average, 38 percent when there was no feeding and harvest rates across both sexes were

constant. When a similar analysis was made across all regions and allowed for displacement to other regions according to figure B3, we found that the elk population within the analysis area ($k \leq 5$) declined by an average of 21 percent. The effects of severe winters were applied to all elk that were not fed during the winter in the JHU and FCHU.

Model Predictions with Chronic Wasting Disease

Figure B5 shows the results of the increase harvest alternative in which elk are hunted aggressively in the first 5 years to reach an objective of 5,000 elk in the NER in winter. Increasing the harvest rate 2.5 times resulted in an average population size of 5,170 (SD=500) by year 5. The average predicted female elk

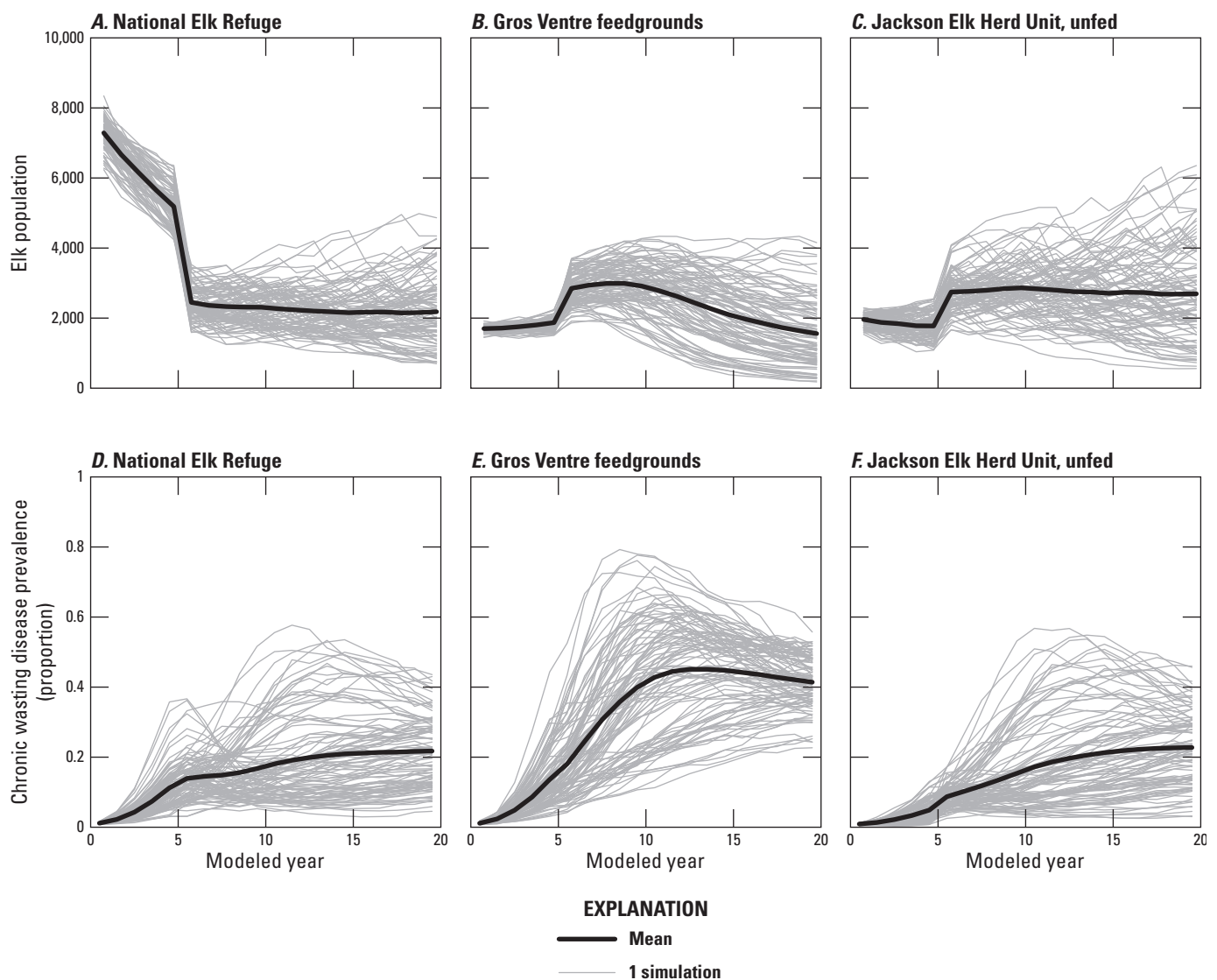


Figure B5. Line graphs showing predicted elk population sizes for, A, the National Elk Refuge (NER), B, Gros Ventre feedgrounds, and, C, Jackson Elk Herd Unit (JHU); and chronic wasting disease prevalence for, D, the NER, E, the Gros Ventre feedgrounds, and, F, the JHU during the 20 modeled years for the three subpopulations within the JHU (subpopulation $k = \{1, 2, 3\}$) with the increase harvest alternative. At year 5, elk move to other areas of the JHU ($k = \{2, 3\}$) and Fall Creek Elk Herd Unit ($k=4$), and the disease transmission in the NER is assumed to be reduced thereafter to levels commensurate with unfed elk populations.

harvest was 840 in the first year, declining to 570 by year 5. The number of female elk hunted in the entire JHU averaged 450 from 2016–21 and 850 from 2000–2004 (Wyoming Game and Fish Department, written commun., 2000–2004; Wyoming Game and Fish Department, 2020, 2021b). Feeding was halted after year 5, and the NER elk were redistributed to other areas of the JHU (fig. B5) or to feedgrounds in the FCHU (not

shown). A fraction of elk was assumed to continue their use of the NER after feeding stopped in year 5, but CWD prevalence and transmission remain lower there than on the Gros Ventre feedgrounds, where elk continue to be fed (fig. B5).

Overall, predicted elk population sizes for the JHU and the analysis area declined across all five management alternatives (table B1; fig. B6). In the JHU, the continue

Table B1. Summary of elk and chronic wasting disease performance metrics for the Jackson Elk Herd Unit and the analysis area in western Wyoming.

[CWD, chronic wasting disease; SD, standard deviation; %, percent; SQ, status quo; —, not applicable]

Alternative	Modeled year 20 elk population size			Modeled year 20 CWD prevalence			First 5 modeled years of winter elk deaths		
	Mean	SD	% less than SQ ¹	Mean	SD	% less than SQ	Mean	SD	% less than SQ
JHU									
Continue feeding	5,200	1,500	—	0.35	0.06	—	6,100	540	—
No feeding	6,700	1,600	26	0.24	0.08	86	5,800	600	65
Increase harvest ²	6,000	1,800	30	0.27	0.10	79	5,200	470	88
Reduce feeding ²	6,100	1,700	36	0.26	0.09	84	6,200	580	43
3% disease threshold	6,900	1,400	22	0.23	0.07	91	5,900	620	59
Analysis area ³									
Continue feeding	6,700	1,600	—	0.35	0.05	—	8,000	730	—
No feeding	8,400	1,700	30	0.26	0.07	83	8,100	850	45
Increase harvest	7,600	1,900	31	0.28	0.08	76	7,100	650	83
Reduce feeding	7,700	1,800	37	0.27	0.08	87	8,100	740	47
3% disease threshold	8,600	1,600	23	0.26	0.06	89	8,100	830	46

¹Percentage of simulations in which the metric was less than the status quo of continued feeding.

²This alternative assumes there is no feeding after year 5.

³The analysis area includes elk from the JHU and elk within the analysis boundary in the Fall Creek Elk Herd Unit in western Wyoming.

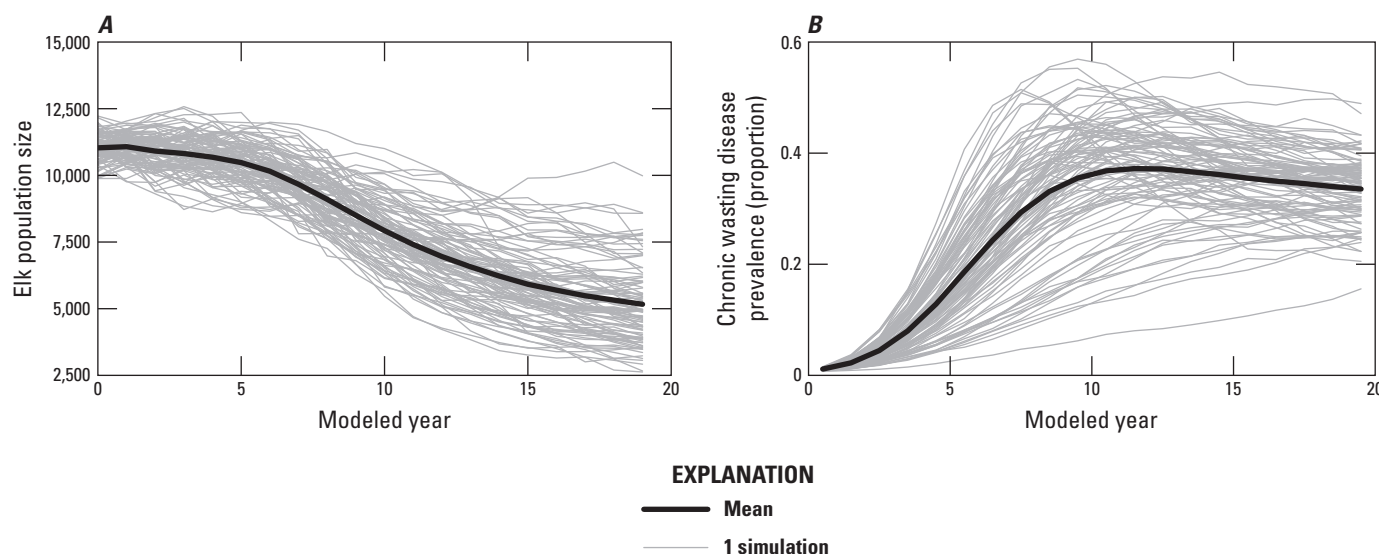


Figure B6. Line graphs of, *A*, predicted elk population size and, *B*, chronic wasting disease prevalence through 20 years for the three populations of the Jackson Elk Herd Unit (subpopulation $[k] = \{1, 2, \text{ and } 3\}$) assuming continued feeding.

feeding alternative resulted in an average decline of 53 percent in population size to 5,200 and a median CWD prevalence of 0.35 (SD=6 percent; [fig. B6](#)).

By year 20, the no feeding and disease threshold alternatives resulted in larger populations in the JHU and the larger analysis area ([fig. B7A, B](#)). The no feeding alternative started at a lower population size in the JHU than other alternatives because we assumed that elk were already redistributed to the larger analysis area at the start of each simulation of this alternative ([fig. B7A](#)). Given the starting CWD prevalence of 1 percent and prior estimates of potential CWD transmission on feedgrounds (Cook and others, 2023), the simulated population in the disease threshold alternative reached 3 percent or greater within the first several years, at which time feeding was stopped. The no feeding and disease threshold alternatives resulted in similar elk and CWD dynamics after the phaseout of NER feeding ([figs. B7A–C](#)). The no feeding alternative resulted in an average population size at year 20 of 6,700 (SD=1,600, [fig. B7A](#)) and an average CWD prevalence of 24 percent (SD=8 percent, [fig. B7C](#)).

The continue feeding alternative usually resulted in lower population sizes and higher CWD prevalence than the other alternatives by year 20 ([figs. B7 and B8](#)). Although the model produced a variety of outcomes, the no feeding alternative resulted in lower CWD prevalence than the continue feeding alternative in 86 percent of the simulations ([table B1](#); [fig. B8B](#)). In addition, the elk population size in the analysis area was larger in year 20 for the no feeding alternative in 70 percent of simulations compared to the continue feeding alternative ([table B1](#); [fig. B8A](#)). The other alternatives can be grouped according to how quickly feeding is ceased, whereby the increase harvest and reduce feeding alternatives resulted in a phaseout of feeding at year 5 whereas the no feeding and 3 percent disease threshold alternatives had earlier phaseouts, which corresponded to differences in year 20 elk population sizes and CWD prevalence ([figs. B7 and B8](#)).

The NER managers were also interested in minimizing winter elk mortality and CWD deaths during the first 5 years (this volume, chap. A, Cook and others, 2025). The number and types of elk deaths were tallied across all ages and sexes during the winter months of November through March to exclude baseline summer calf mortality and highlight those deaths that are more likely to be observed by the public. As expected, the increase harvest alternative resulted in higher hunting mortality and lower natural mortality than the other alternatives ([fig. B9](#)). The increase harvest and no feeding alternatives tended to have fewer CWD mortalities than the other management alternatives. For CWD and natural deaths, the increase harvest alternative resulted in fewer deaths than the continue feeding alternative in 83 percent of simulations across the analysis area, whereas the other alternatives were approximately equivalent to the continue feeding alternative ([table B1](#)).

[Figure B10](#) shows elk mortalities from November through March of every year due to different causes (CWD, [fig. B10A](#); natural, [fig. B10B](#); and hunting, [fig. B10C](#)) shifting over time. Model predictions suggested that the number of elk harvested would decline through time for all alternatives. By year 20, the

elk harvest was predicted to be about a quarter of 2022 levels and similar in magnitude to the number of CWD deaths from November to April every year ([figs. B9A, C](#)). The higher CWD deaths in the continue feeding alternative coincide with lower harvests by year 20 on average compared to other management alternatives ([figs. B10A, C](#)).

Discussion

We incorporated empirical evidence and formal expert elicitation into our mathematical models of elk and CWD dynamics in Jackson, Wyoming. We then tailored the CWD model to the five supplemental feeding management alternatives identified by the National Elk Refuge managers. The predicted elk population size decreased through time by 42–54 percent for all management alternatives, and the number of elk harvested declined by approximately 75 percent ([figs. B7 and B10](#)). The management alternatives associated with cessation of supplemental feeding resulted in lower elk population sizes during the first 5–10 years but higher population sizes by year 20 compared to the continue feeding alternative ([figs. B7A, B](#)). The prevalence and effects of CWD were predicted to increase during the 20 years that were modeled, resulting in lower elk population sizes. The predicted elk population size in the analysis area (subpopulations $k \leq 5$) declined by 54 percent, on average, by year 20 in the continue feeding alternative and was lower than the no feeding alternative in 70 percent of the simulations ([table B1](#)). The crossover point, when the no feeding or phase-out alternatives resulted in higher populations than the continue feeding alternative, occurred between years 7 and 13 ([fig. B7C](#)). The predicted CWD prevalence in year 20 was higher in the continue feeding alternative, 35 percent on average in the JHU, compared to all other alternatives in 80–90 percent of the simulations ([table B1](#)). The other management alternatives resulted in an average CWD prevalence of 23 and 27 percent CWD by year 20 ([table B1](#)), which is high compared to some free-ranging elk populations (Monello and others, 2017). This high predicted CWD prevalence in the JHU is due, in part, to the assumption that 2,000–3,000 elk would continue to be fed at the Gros Ventre feedgrounds ([fig. B5](#)).

Several lines of evidence support the high predicted CWD prevalence and large population declines predicted by the CWD model. First, supplemental feeding results in elk contact rates that are 2–4 times higher than when they are not being fed in winter (Cross and others, 2013; Janousek and others, 2021), which is of similar magnitude to the estimates of increased CWD transmission due to feeding by a panel of experts (Cook and others, 2023). Second, previous work on a free-ranging elk population in Wind Cave National Park in South Dakota estimated an overall CWD prevalence of 18 percent, but as much as 30 percent in some areas (Sargeant and others, 2021). Third, captive cervid farm data suggest that CWD can reach more than 60 percent prevalence when elk are artificially aggregated (Peters and others, 2000; Haley and others, 2020; Williams and others, 2014). Williams and others (2014) noted that 37 out of 39 elk died from CWD in their study of captive elk.

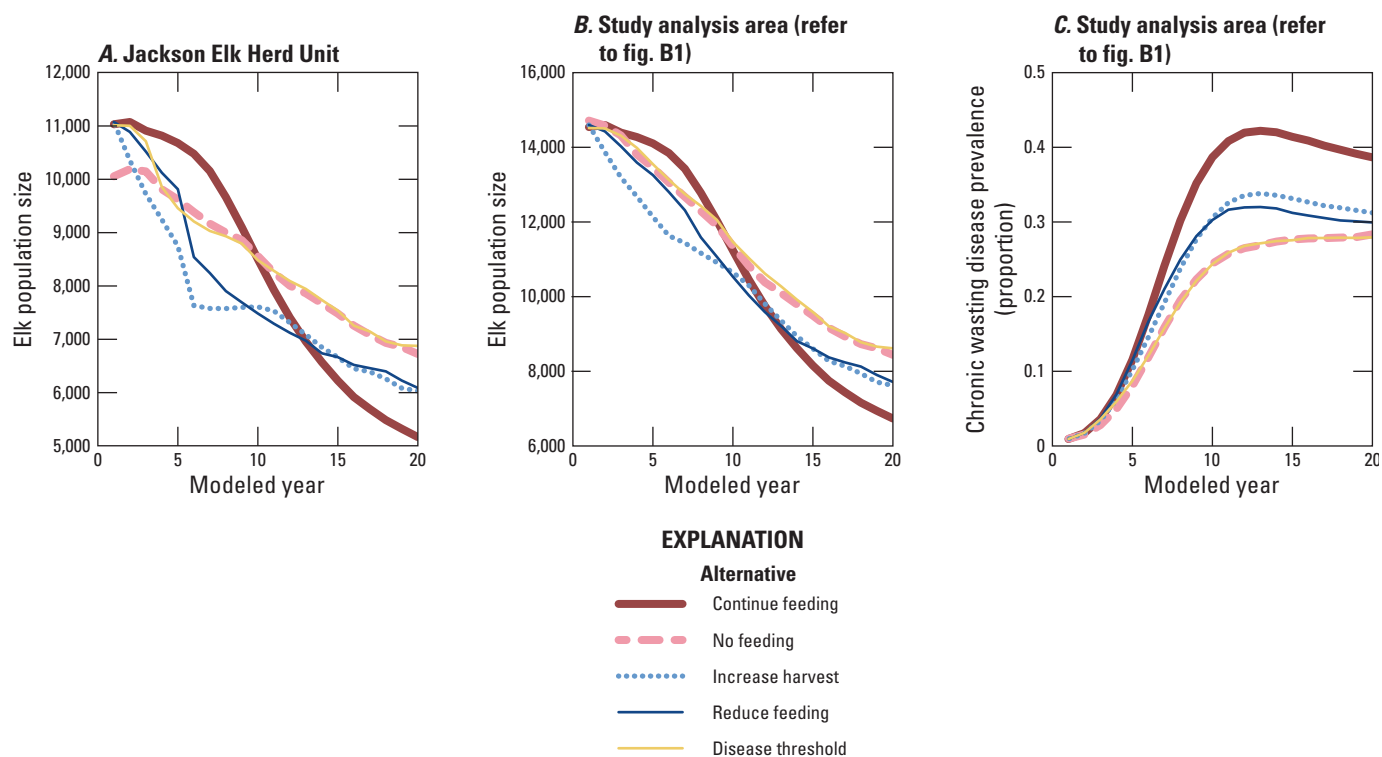


Figure B7. Line graphs of average elk population size in, *A*, the Jackson Elk Herd Unit and, *B*, analysis area; and, *C*, average chronic wasting disease prevalence in the study analysis area for 20 years for the five management alternatives and all simulations.

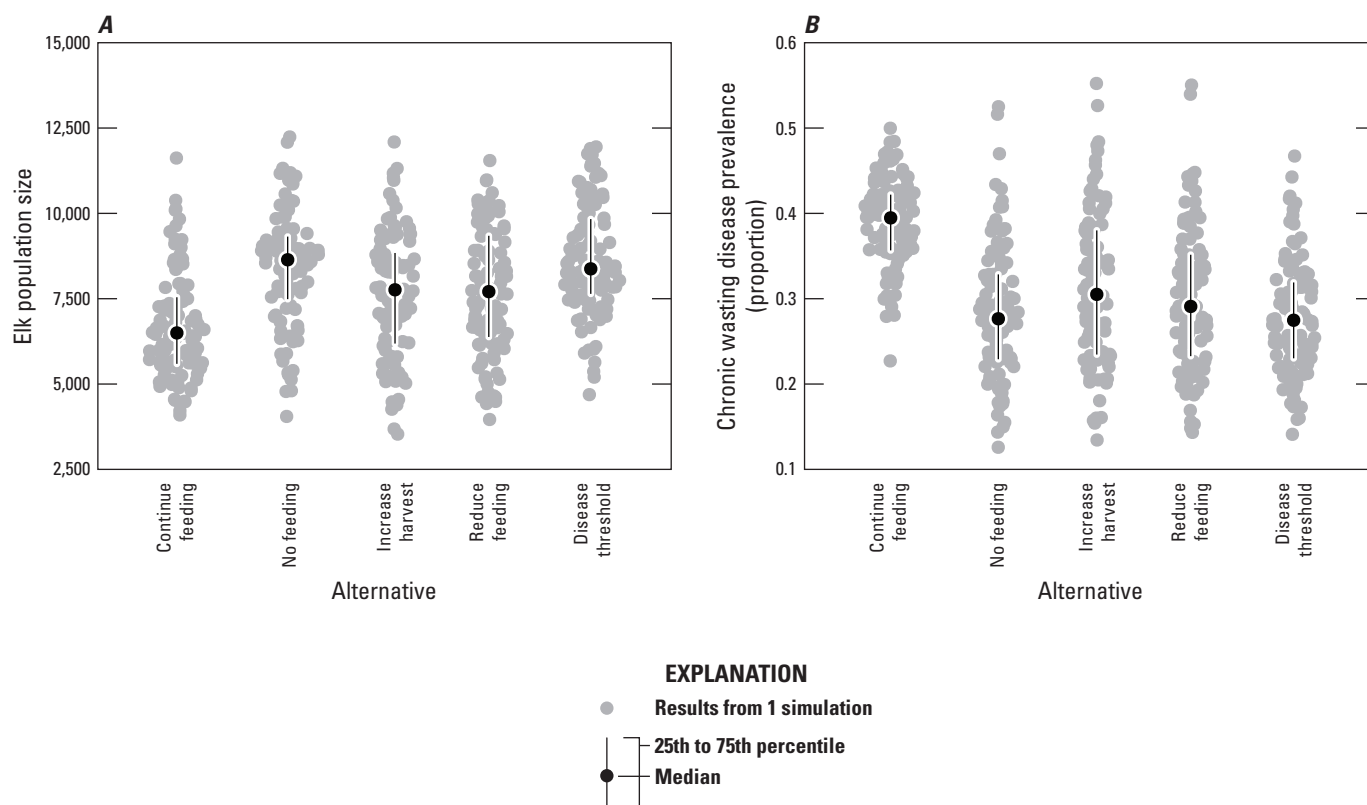


Figure B8. Graphs of the distribution of, *A*, elk population size across five management alternatives, and, *B*, chronic wasting disease prevalence at modeled year 20 for the analysis area (subpopulation $[k] \leq 5$).

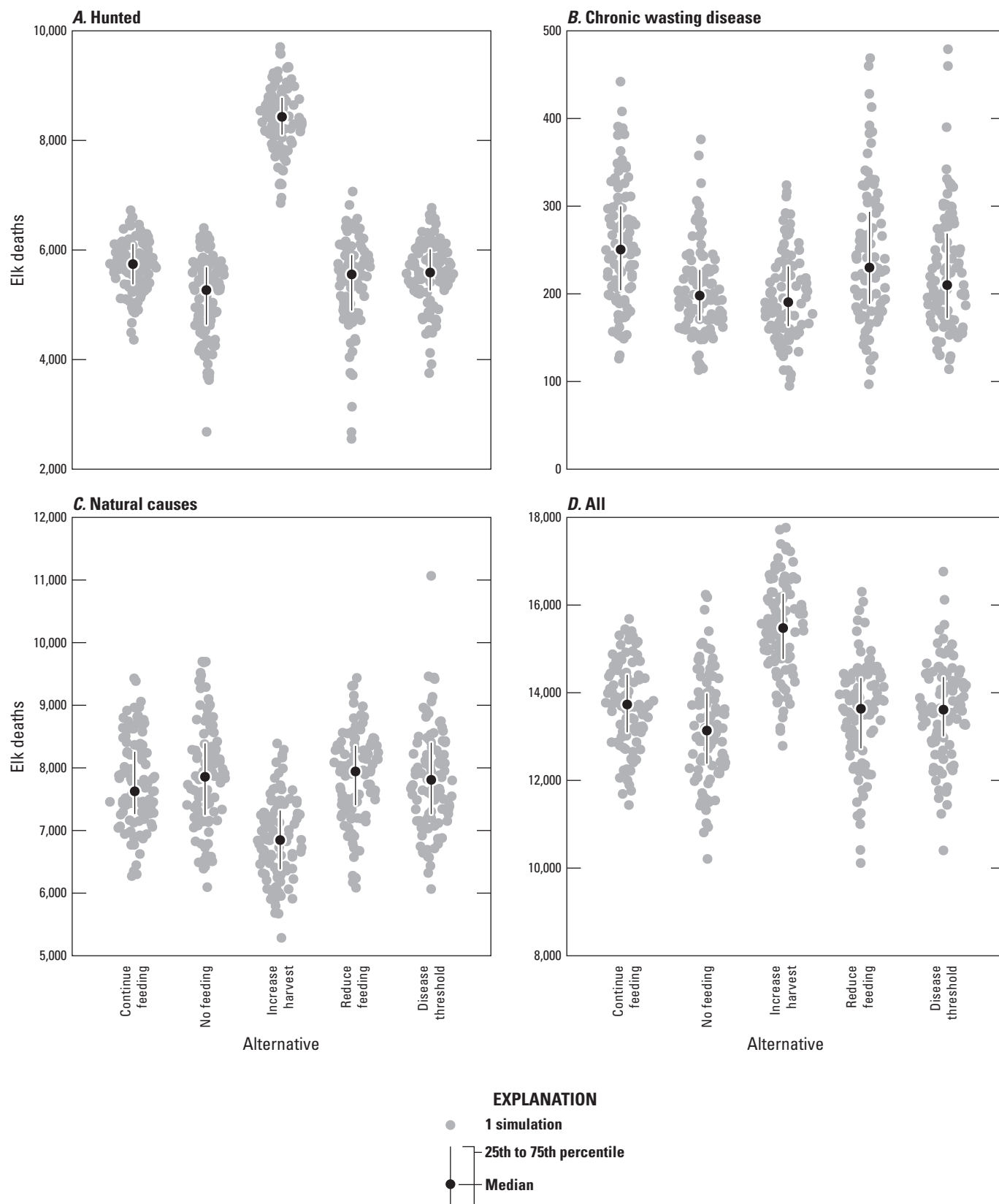


Figure B9. Graphs of the distribution of cumulative elk deaths for the first 5 modeled years by type: *A*, hunting, *B*, chronic wasting disease (CWD), *C*, natural causes, and, *D*, all deaths for the five management alternatives in the analysis area (subpopulation $[k] \leq 5$).

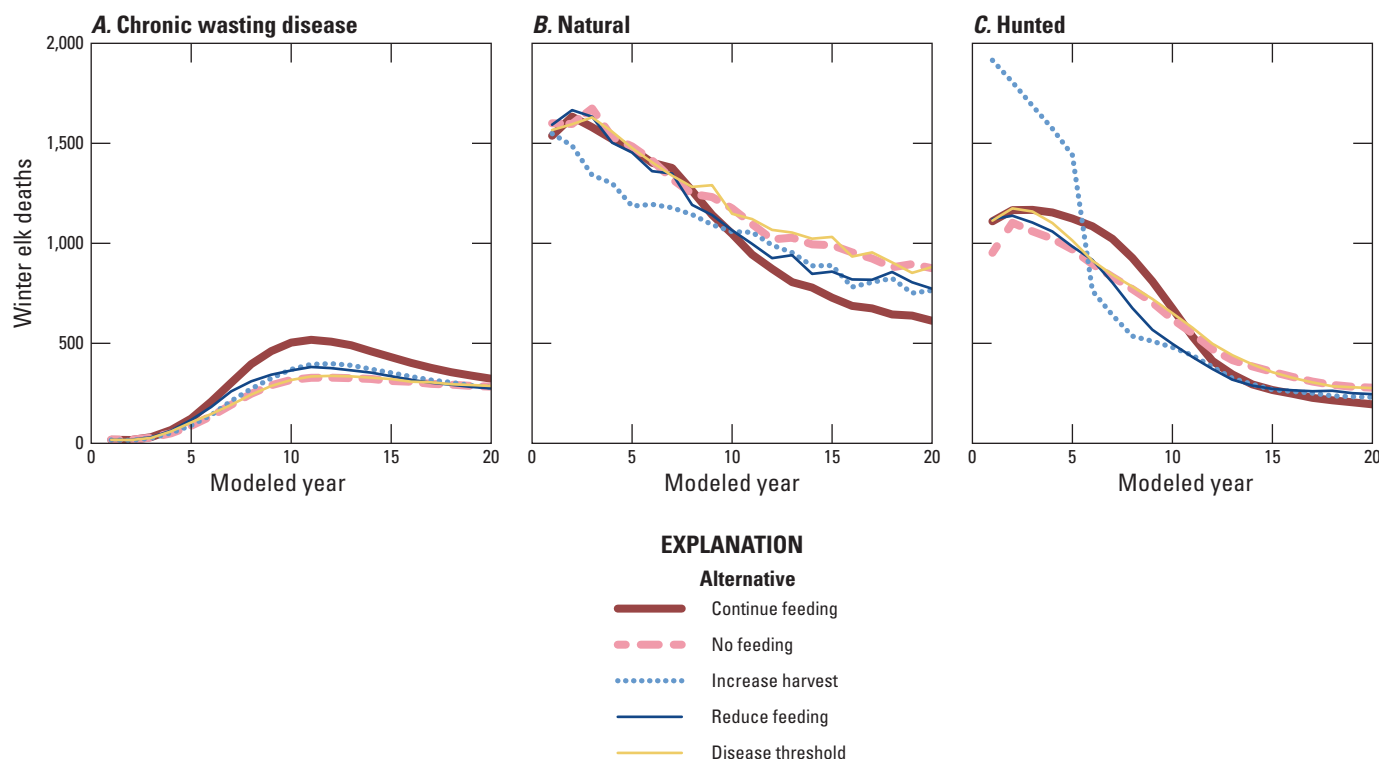


Figure B10. Line graphs showing the average number of elk deaths attributable to, *A*, late-stage chronic wasting disease, *B*, natural causes, or, *C*, hunting, from November through March during the modeled years for the five management alternatives.

In that study, the median elk lifetimes were 4–7 years depending on the elk’s genotype, in the absence of predation, starvation, or hunting mortality, whereas MacNulty and others (2020) found that the average age of adult female elk killed by wolves in Yellowstone National Park was 13–16 from 1995–2016.

The CWD model included several important assumptions. First, the demographic penalty for not feeding elk depends on the frequency of severe winters, which reduces the survival of unfed elk in the model. These winter impacts were intended to capture the multiple ways that elk mortality may increase (for example, by vehicle accidents or additional hunts on private lands) if feeding ends so that these mechanisms did not have to be built into the model independently. Wyoming herd units with feedgrounds have higher densities of elk on winter range than the herd units without feedgrounds (Cook and others, 2023), but the evidence that feedgrounds increase elk productivity in Wyoming is mixed (Foley and others, 2015). The no feeding penalty during severe winters in our model resulted in a median decline in elk populations in the NER of 38 percent in the absence of CWD, movement to other feedgrounds, and constant hunting (fig. B4.4, *C*). This penalty is higher than the 23 percent no-feeding penalty predicted in Cook and others (2023), which was based on the average difference in winter elk densities in fed and unfed herd units of western Wyoming. The increase from 23 percent to 38 percent may be appropriate given the much higher number of elk that use the NER and the proximity of human development compared to other Wyoming feedgrounds. Nevertheless, the effects of stopping NER supplemental feeding on elk survival rates is an important source of uncertainty in the model.

The second important assumption was that model simulations started with a CWD prevalence of 1 percent across all sex and age classes because this matched the conditions and model given to the panel of experts (Cook and others, 2023) to predict transmission rates for a fed elk population. However, only one elk has been documented as CWD positive out of the 1,209 elk tested from 2020 to 2022 in the JHU (0.1 percent, 95-percent confidence interval=[0.002 percent, 0.5 percent]; Wyoming Game and Fish Department, 2020, 2021a, 2022a). The 1 percent CWD prevalence that was previously used in Cook and others (2023) was deliberately maintained to account for the delay between the completion of analyses, finalization of the Environmental Impact Statement, and any future implementation of management alternatives. We explored the sensitivity of our model results to starting at 0.1 percent CWD prevalence instead of 1 percent. The results at 0.1 percent prevalence were not noticeably different than the results at 1 percent prevalence because of the assumption that environmental transmission linearly increases as a function of time and does not depend on the starting prevalence (Cross and Cook, 2024). If CWD transmission from the environment grows exponentially rather than linearly, then it would take a similar amount of time for CWD to increase from 0.1 percent to 1 percent as it does from 1 percent to 10 percent, which was about 4–10 years for fed elk in this model. Our model predictions are for the 20 years after reaching a prevalence of 1 percent, which may not occur for several more years.

Our third assumption was that both the female elk harvest rate and the elk calf survival rate would change depending on the elk population size in the herd unit. The CWD model resulted

in higher elk recruitment rates (as indexed by the number of elk calves per adult female) than what has been observed in the JHU. From 2000 to 2021 the proportion of adult female elk with calves (calf:cow) averaged 0.22 (minimum=0.18 and maximum=0.29), whereas our model without the effects of CWD and a stable elk population had a calf:cow ratio of approximately 0.4 (minimum 0.25; maximum 0.5). This difference in elk recruitment may be due to observational biases in classification surveys or other discrepancies between modeled and actual elk vital rates in the JHU. Our modeled calf:cow ratio increased to 0.5 as the elk population declined due to CWD; this is similar to the calf:cow ratios in the Northern Bighorn Herd Unit of Wyoming when that population was growing rapidly from 2005 to 2015 (Wyoming Game and Fish Department, written commun., 2005–15). Due to the high calf:cow ratios, the CWD model predicted that the elk population could remain stable even when CWD prevalence reached 20 percent, whereas Galloway and others (2021) predicted that the NER elk would begin to decline when CWD prevalence reached 7 percent using a model with a constant low elk recruitment rate.

There are several other factors, in addition to supplemental feeding and CWD, likely to affect elk during the next 20 years in the JHU and that we did not include in our analyses. Climate change may increase the frequency and intensity of summer droughts, thus reducing the quality of summer forage (Rickbeil and others, 2019) and reducing snowpack in winter (Hostetler and others 2021), which may reduce the duration of supplemental feeding (Cross and others, 2007). In addition, our modeling approach did not account for the effect of predators on CWD (Miller and others, 2008; Wild and others, 2011; Brandell and others, 2022) or evolutionary changes to either elk (Monello and others, 2017) or CWD prions (Velásquez and others, 2020). Uncertainties remain on all these issues that were beyond what could be addressed in this report. Future work could assess the value of reducing these uncertainties (for example, Maxwell and others, 2015).

Summary

Modeling results for 20 years indicated a short- versus long-term tradeoff between the continue feeding and no feeding alternatives for elk in the National Elk Refuge and Jackson Elk Herd Unit. Continuing to supplementally feed elk at the National Elk Refuge was predicted to result in a chronic wasting disease (CWD) prevalence of 35 percent and a coincident decline in the elk population of 54 percent on average by year 20 of the model. The cessation of elk supplemental feeding was predicted to result in early declines in elk populations during the first 5–10 years but more stable elk populations thereafter coincident with a lower CWD prevalence than the continue feeding alternative. The no feeding alternative for the National Elk Refuge still resulted in a CWD prevalence of, on average, 24 percent due, in part, to supplemental feeding on other feedgrounds in the Jackson Elk Herd Unit. Given the predicted decline in the elk population, elk harvest was also predicted to decline by approximately 75 percent

across all management alternatives. The model predicted that by year 20, CWD-induced deaths in winter would be approximately equal to the number of elk harvested.

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Appendix B1. Additional Model Details

Elk harvest and vital rates in the chronic wasting disease (CWD) model were modified from Cook and others (2023) to match the observed data more closely in the Jackson Elk Herd Unit (JHU; table B1.1).

Annual calf survival rates were assumed to be a nonlinear function of elk population size relative to the carrying capacity (K_{HU}) of the herd unit (fig. B1.1). In addition, calf and adult elk survival rates in unfed subpopulations were stochastically reduced in 25 percent of the 20 model years due to severe winters (fig B1.2). The additional severe winter mortality in figure B1.2 was extrapolated from Hobbs and others (2003). To apply the function in figure B1.2 to the Fall Creek Elk Herd Unit (FCHU), elk population size was converted to population density based on the amount of elk winter habitat in the herd unit (JHU=837 km², FCHU=499km²; fig. B1.1; table 4 of Cook and others 2023; Wyoming Game and Fish Department, 2021a).

Table B1.1. Elk vital and harvest rate estimates used in the elk chronic wasting disease model.

[Parameter notation relates to the model code in Cross and Cook (2024) and the model developed by Cook and others (2023). SD, standard deviation; ϕ , phi; γ , gamma; h , harvest]

Vital rate	Notation	Mean	Parametric SD ¹	Process SD ²
Maximum calf survival	ϕ_1	0.6	0.103	0.0385
Juvenile survival ^{3,4}	ϕ_{2-3}	0.88	0.0085	0.0042
Adult male survival ^{3,4}	ϕ_4	0.95	0.017	0.0034
Adult female survival ^{3,4}	ϕ_5	0.93	0.0085	0.0034
Calf reproduction ^{3,4}	γ_1	0	0	0
Yearling female reproduction ⁵	γ_3	0.25	0.033	0.035
Adult female reproduction ⁵	γ_5	0.82	0.033	0.035
Harvest mortality calf ⁶	h_1	0.06	0.007	0.005
Harvest mortality yearling male ⁶	h_2	0.01	0.007	0.005
Harvest mortality yearling female ⁶	h_3	0.07	0.007	0.005
Harvest mortality adult female ⁶	h_5	0.07	0.007	0.005
Harvest mortality adult male ⁶	h_4	0.08	0.007	0.005

¹Parametric variation created different mean values across simulations.
²Process variation resulted in parameter variation between years within a simulation.
³Data were approximated from Galloway and others (2021).
⁴Data were approximated from Raithel and others (2007).
⁵Data were approximated from Cotterill and others (2018).
⁶Data were approximated from the Jackson Elk Herd Unit from 1993 to 2020 (Wyoming Game and Fish Department, 2021b, and references therein).

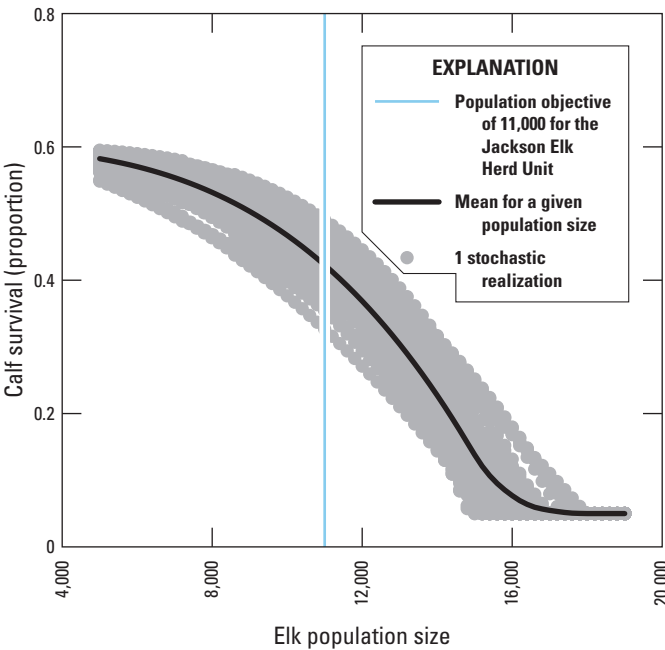


Figure B1.1. Line graph showing the assumed annual calf survival as a function of the Jackson Elk Herd Unit (JHU) population size (table 4 of Cook and others, 2023; Wyoming Game and Fish Department, 2021a).

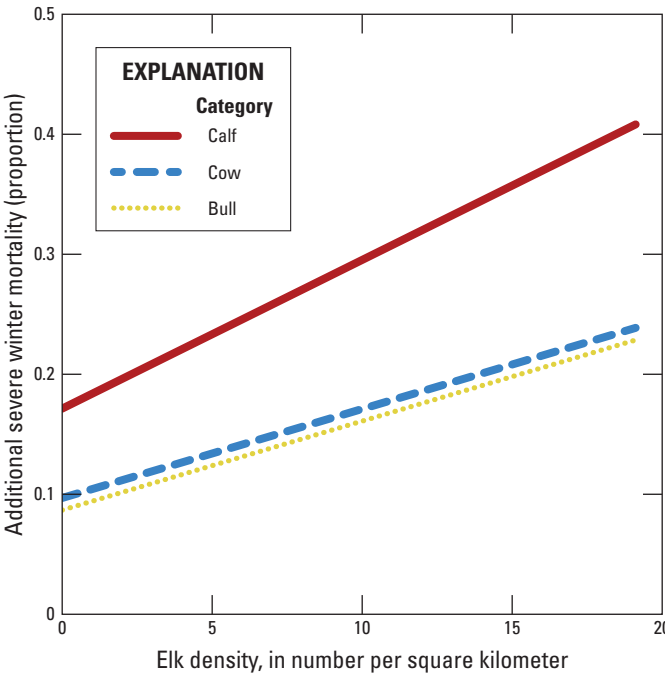


Figure B1.2. Line graph showing the modeled effects of severe winter on the mortality of elk in different age and sex classes beyond natural and hunting mortality as a function of elk population size in the Jackson Elk Herd Unit. These relationships were derived from Hobbs and others (2003).

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Appendix B2. Expert Elicitation

We elicited parameter estimates from a panel of eight experts for how *Cervus elaphus canadensis* (elk) would move to other subpopulations if the National Elk Refuge (NER) discontinued winter feeding. The initial elicitation focused on parameters of interest under two conditions. One condition represented the expectations of experts for elk transitions in the years immediately preceding elk feedground management action. The second condition was focused on longer term dynamics of elk habitat selection and were presented as a separate set of questions. In total, we included 12 questions focused on parameter values, relationships, and estimates that were unknown but necessary to estimate elk movement and resource selection under different alternatives for the Environmental Impact Statement on the NER. Because the differences between the immediate transition and longer term (in other words, equilibrium) set were minor, we included only the estimates from the immediate transition in our modeling work. We report only the raw and fitted distributions for questions that were used in this chapter.

Elk Spatial Transitions Without National Elk Refuge Feeding

For each of the questions about elk redistribution during immediate transition from feeding, assume an average snowfall year in duration of season and sustained snow depths. Also, assume that elk that are the focus of these questions may have learned behavioral responses to feeding that were acquired under normal feeding operations. This includes the annual return of individuals to the NER with an expectation that supplemental food will be provisioned when forage becomes scarce.

Assuming the NER no longer provisions food to elk on the Refuge, the specific questions were:

1. What proportion of the NER feedground elk will hold on native winter range in the same year that the NER does not provision supplemental feed? (Fig. B2.1A; questions 1, 2, 3, 4, and 5 are linked together such that central and (or) best guess estimates should sum to approximately 1.)
 - 1a. Of the NER elk that do not transition to State feedgrounds, what proportion will hold on native winter range in the NER when the Refuge does not provision supplemental feed? (Questions 1a and 1b are linked so that central estimates should sum to 1.)
 - 1b. Of the NER elk that do not transition to State feedgrounds, what proportion will transition to private lands conflict areas and winter range off the Refuge when the NER does not provision supplemental feed? (Questions 1a and 1b are linked so that central estimates should sum to 1.)
2. What proportion of the NER feedground elk will relocate to Gros Ventre feedgrounds (Patrol Cabin and Fish Creek) in the same year that the NER does not provision supplemental feed? (Fig. B2.1B; questions 1, 2, 3, 4, and 5 are linked together such that central and (or) best guess estimates should sum to approximately 1.)
3. What proportion of the NER feedground elk will relocate to South Park feedground in the same year that the NER does not provision supplemental feed? (Fig. B2.1C; questions 1, 2, 3, 4, and 5 are linked together such that central and (or) best guess estimates should sum to approximately 1.)
4. What proportion of the NER feedground elk will relocate to Horse Creek feedground in the same year that the NER does not provision supplemental feed? (Fig. B2.1D; questions 1, 2, 3, 4, and 5 are linked together such that central and (or) best guess estimates should sum to approximately 1.)
5. What proportion of the NER feedground elk will relocate to Camp Creek feedground in the same year that the NER does not provision supplemental feed? (Fig. B2.1E; questions 1, 2, 3, 4, and 5 are linked together such that central and (or) best guess estimates should sum to approximately 1.)

Expert Panel Responses

The results of each expert's answers to the questions above are shown in figures B2.1 and B2.2. (Expert 6 did not respond to questions 1a and 1b.) The four-point estimates were an expert's low, high, and best estimates of a parameter and their confidence that the actual value would fall within the low and high values. The individual expert estimates were aggregated to provide the prediction in figure B2. Distributions were then aggregated by fitting a single Dirichlet distribution, which ensured that the sum of each estimated beta distribution included the upper limit of one for the proportional data we elicited (Conroy and Peterson, 2013).

Reference Cited

Conroy, M.J., and Peterson, J.T., 2013, Decision making in natural resource management—A structured, adaptive approach: Hoboken, N.J., John Wiley and Sons, Ltd., 456 p. [Also available at <https://doi.org/10.1002/9781118506196>.]

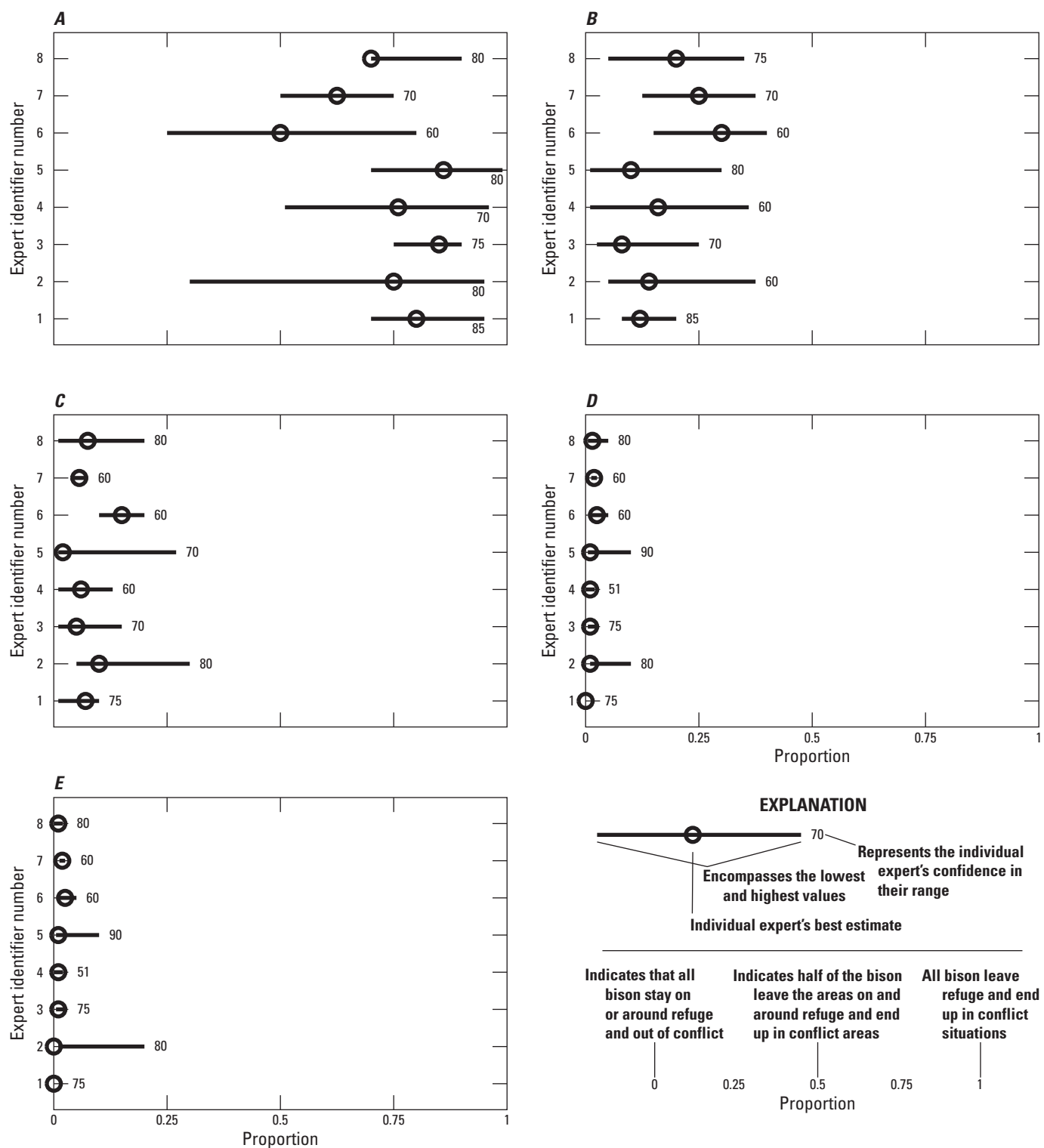


Figure B2.1. Charts showing raw expert responses to questions 1–5 related to elk redistribution between the National Elk Refuge (NER) and other feedgrounds. *A*, results of question 1, *B*, results of question 2, *C*, results of question 3, *D*, results of question 4, and, *E*, results of question 5.

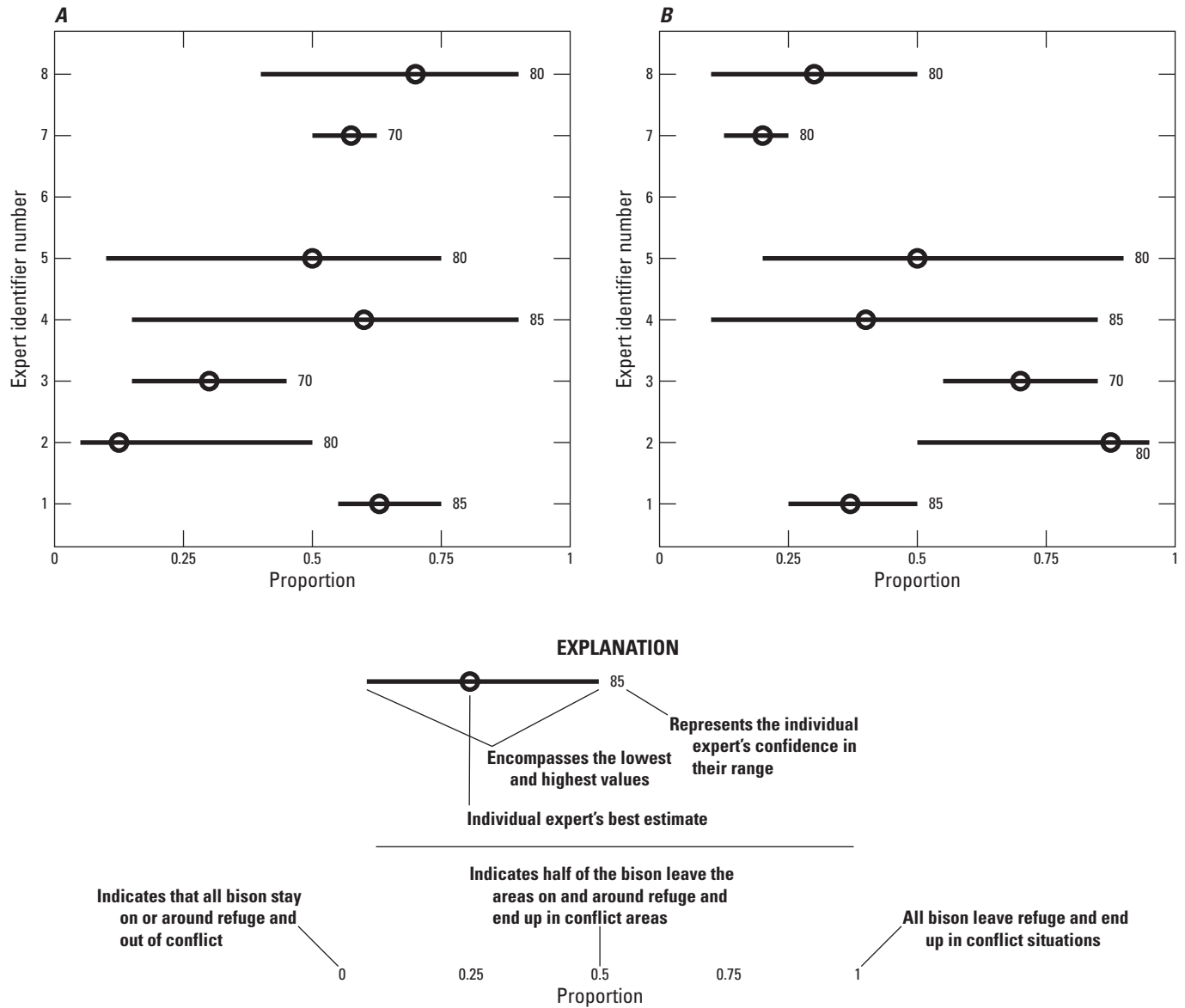


Figure B2.2. Chart showing raw expert panel responses to questions 1a and 1b related to elk redistribution between National Elk Refuge (NER) and conflict areas: *A*, results of question 1a: Of the NER elk that do not transition to State feedgrounds, what proportion will hold on native winter range in the NER when the refuge does not provision supplemental feed?; *B*, results of question 1b: Of the NER elk that do not transition to State feedgrounds, what proportion will transition to private lands conflict areas and winter range off the refuge when the NER does not provision supplemental feed?

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APPENDIX D – U.S. Geological Survey, Chapter C of Scientific Investigations Report 2024–5119:

Evaluating Elk Distribution and Conflict Under Proposed
Management Alternatives at the National Elk Refuge in
Jackson, Wyoming

Ecosystems Mission Area—Biological Threats & Invasive Species Research Program and the Species Management Research Program

Prepared in cooperation with the U.S. Department of Agriculture, National Park Service, U.S. Fish and Wildlife Service, and Wyoming Game and Fish Department

Evaluating Elk Distribution and Conflict Under Proposed Management Alternatives at the National Elk Refuge in Jackson, Wyoming

Chapter C of
Decision Analysis in Support of the National Elk Refuge Bison and Elk Management Plan

Scientific Investigations Report 2024–5119

**U.S. Department of the Interior
U.S. Geological Survey**

Cover. A group of elk congregates at the Nowlin Feedground on the National Elk Refuge. The Nowlin Feedground is one of four areas on the National Elk Refuge where elk are fed alfalfa pellets during most winters. Photograph taken by Lori Iverson, U.S. Fish and Wildlife Service, March 2019.

Evaluating Elk Distribution and Conflict Under Proposed Management Alternatives at the National Elk Refuge in Jackson, Wyoming

By Gavin G. Cotterill, Paul C. Cross, Eric K. Cole, Jonathan D. Cook, Margaret C. McEachran, and Tabitha A. Graves

Chapter C of
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Edited by Jonathan D. Cook and Paul C. Cross

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Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
	Length	
foot (ft)	0.3048	meter (m)

International System of Units to U.S. customary units

Multiply	By	To obtain
	Length	
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
meter (m)	1.094	yard (yd)
	Area	
square kilometer (km²)	247.1	acre
square kilometer (km²)	0.3861	square mile (mi²)

Datums

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Supplemental Information

Elk global positioning system (GPS) collar data from the National Park Service, U.S. Fish and Wildlife Service, and Wyoming Game and Fish Department come from sources as cited. At the time of writing, not all reports from these agencies were available online; for elk GPS collar data from nonpublic documents, contact the respective agency. Likewise, not all vegetation type data from the U.S. Fish and Wildlife Services and U.S. Department of Agriculture Forest

Service were available online; for vegetation type data from nonpublic documents, contact the respective agency.

Abbreviations

CWD	chronic wasting disease
FWS	U.S. Fish and Wildlife Service
GIS	geographic information system
GPS	global positioning system
GVTA	Gros Ventre Transition Area
JHU	Jackson Elk Herd Unit
NER	National Elk Refuge
NFCHU	Northern Fall Creek Elk Herd Unit
NWRTA	Native Winter Range Transition Area
RSF	resource selection function
SDM	structured decision-making
WGFD	Wyoming Game and Fish Department
WSMET	Wildlife Subject Matter Expert Team

Evaluating Elk Distribution and Conflict Under Proposed Management Alternatives at the National Elk Refuge in Jackson, Wyoming

By Gavin G. Cotterill,¹ Paul C. Cross,¹ Eric K. Cole,² Jonathan D. Cook,¹ Margaret C. McEachran,¹ and Tabitha A. Graves¹

Abstract

We evaluated measurable attributes describing the current and future distribution of *Cervus elaphus canadensis* (elk) across a region surrounding Jackson, Wyoming, for five feedground management alternatives proposed by the U.S. Fish and Wildlife Service as a revision to the 2007 “Bison and Elk Management Plan” of the National Elk Refuge. A resource selection function evaluated measurable attributes of interest to managers, including elk use of private property and sensitive habitat types at monthly timesteps and varying winter conditions. The study area boundaries were created through an expert elicitation process and consist of the Jackson Elk Herd Unit, Grand Teton National Park, the National Elk Refuge, and the northern third of the Fall Creek Elk Herd Unit. For each of the five alternatives, we distributed monthly elk numbers calculated in a concurrent analysis that simulated chronic wasting disease dynamics in this system for 20 years. Measurable attributes representing potential elk use of (1) private property, (2) cattle properties as an index of *Brucella abortus* risk, and sensitive habitats consisting of (3) *Populus tremuloides* Michx. (quaking aspen), (4) *Populus angustifolia* E. James (narrowleaf cottonwood), and (5) *Salix* L. (willow) in core winter use areas all closely followed the declines of elk abundance projected by the elk chronic wasting disease model. After 20 years, the continue feeding alternative ranked most favorably in terms of limiting elk days on private property and reducing brucellosis risk from elk to cattle because this alternative concentrated elk on the National Elk Refuge and resulted in the lowest elk population sizes. However, other management alternatives, including increase harvest and reduce feeding, tended to limit elk use of sensitive quaking aspen, narrowleaf cottonwood, and willow habitats during winter (December–April).

Introduction

This analysis provides scientific support for the U.S. Fish and Wildlife Service (FWS) regarding management decisions at the National Elk Refuge (NER) in Jackson, Wyoming. The NER has fed most of the Jackson elk herd for part of the winter for more than a century. *Cervus elaphus canadensis* (Erxleben, 1777; elk) abundance has changed over time, but the average number fed at the NER each winter during 2017–22 was approximately 7,500 elk, 70 percent of the Jackson elk herd (Wyoming Game and Fish Department [WGFD], 2022b). Previous research has shown that winter feeding operations create large, dense aggregations of animals that facilitate the transmission of multiple pathogens, including *Brucella abortus* (which causes brucellosis; Cross and others, 2007), *Psoroptes* spp. (scabies species; Samuel and others, 1991), and *Pasteurella multocida* (which causes pasteurellosis; Franson and Smith, 1988). Chronic wasting disease (CWD), which is always fatal to hosts, affects ungulates (including elk, *Alces alces* [Linnaeus, 1758; moose], and deer) and can lead to population declines (Edmunds and others, 2016). In 2020, the first CWD-positive elk was detected in Grand Teton National Park. In Wind Cave National Park, CWD has reached prevalence as high as 18–29 percent in elk (Sargeant and others, 2021). Chronic wasting disease is spread directly through animal-to-animal contact and indirectly through environmental exposure to prions, the malformed PrP proteins that are the infectious agent of CWD (Miller and others, 2004). Prions can persist for years, if not decades in the environment. Accordingly, CWD could have a larger effect on the Jackson elk herd than that observed in other populations because feeding at the NER greatly increases elk contact rates and elk densities (Galloway and others, 2017; Janousek and others, 2021).

The FWS is writing an environmental impact statement and revising its Bison and Elk Management Plan (U.S. Fish and Wildlife Service and National Park Service, 2007) in consideration of the disease risk to the herd. A structured decision-making (SDM) process, facilitated by the U.S. Geological Survey, provides scientific support for this revision (this volume, chap. A, Cook and others, 2025). Briefly, the management alternatives under consideration include (1) continue feeding, (2) immediate cessation of feeding

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²U.S. Fish and Wildlife Service.

(hereafter referred to as no feeding), (3) increase elk harvest for a 5-year period to reduce the NER winter elk population to 5,000 animals, followed by feed cessation (hereafter referred to as increase harvest), (4) attempt to lower the number of elk to 5,000 by reducing the feed provisioned to elk at the NER for a 5-year period, followed by feed cessation (hereafter referred to as reduce feeding), and (5) continue feeding until CWD prevalence in the Jackson elk herd is estimated to be 3 percent, followed by feed cessation (hereafter referred to as disease threshold).

This analysis predicted future elk space-use (the areas that elk will occupy) during a 20-year period in the vicinity of Jackson, Wyoming, under the proposed alternatives. The overall approach closely followed previous research in the Bridger-Teton National Forest (Cook and others, 2023), wherein a resource selection function (RSF) was fit to elk global positioning system (GPS) collar data. The RSFs were used to estimate the per capita probability of use across the study area for various population segments of elk at monthly timesteps (Cotterill and Graves, 2024). Elk abundance estimates were derived from a dynamic population and disease simulation model (hereafter, elk CWD model) under the management alternatives (this volume, chap. B, Cross and others, 2025) and projected across the study area using the RSFs. The elk CWD model, in conjunction with the RSFs, formed the basis for the calculation of what we refer to as our measurable attributes, the metrics of interest to decision-makers defined during the SDM process (this volume, chap. A, Cook and others, 2025).

Most of the future alternatives under consideration included novel conditions for which scant or no relevant elk GPS collar data exist. For example, winter feeding operations at the NER have never been experimentally discontinued to allow researchers to observe elk behavior and population dynamics in the absence of feeding. However, decades of research in this study area provided insights into the potential future behavior of elk under the no feeding alternative. Relevant situations included (1) a mild winter with substantial forage resources during which no feeding occurred at the NER, (2) attempts to reduce the duration of feeding by initiating feeding later in the season and ending feeding earlier in the season, and (3) one occasion where underestimating the number of elk in the NER caused elk to be fed reduced rations (Janousek and others, 2021; FWS, 2019). We used a formal expert-elicitation process to collate these insights to parameterize the elk space-use models. Expert judgment is a quantitative expression of an expert's belief, based on relevant system knowledge, and when elicited by a formal process designed to minimize cognitive biases, can result in reliable predictions when empirical information is impossible or infeasible to collect (Adams-Hosking and others, 2016; Martin and others, 2012; O'Hagan and others, 2006; Runge and others, 2011; Speirs-Bridge and others, 2010). The resulting models integrated the expert-provided information from the Wildlife Subject Matter Expert Team (WSMET; this volume, chap. A, Cook and others, 2025) with elk collar data such that model predictions closely matched expected outcomes from the expert elicitation process.

The analysis area under consideration was delineated by the WSMET and consists of two contiguous regions, the Jackson Elk Herd Unit (JHU) and the Northern Fall Creek Elk Herd Unit

(NFCHU). Refer to [appendix C1](#) for a map of the analysis area ([fig. C1.2](#)). The JHU matches the Jackson Elk Herd Unit as designated by the Wyoming Game and Fish Department and generally extends north from State Highway 22 and Jackson to encompass Grand Teton National Park, the National Elk Refuge, and other lands up to the southern Yellowstone National Park boundary and east to the Continental Divide (WGFD, 2022a). The NFCHU is the northern third of the Fall Creek Elk Herd Unit (WGFD designation; WGFD, 2022a; refer to this volume, chap. A, [fig. A1](#) in Cook and others, 2025). The WSMET included the NFCHU to consider potential effects from elk movements under alternatives with reduced feeding. Public entities, including the U.S. Department of Agriculture Forest Service, the National Park Service, the FWS, and the State of Wyoming, manage much of the analysis area. However, in addition to the NER, other low-elevation areas that ungulates use in winter tend to be private property, mostly developed for agricultural or residential purposes. Of immediate concern was the potential conflict resulting from negative effects elk could have on private property, livestock, and sensitive vegetation communities if the NER were to cease winter feeding operations. The measurable attributes evaluating these negative effects consisted of the estimated elk use of private property, the *Brucella abortus* transmission risk from elk to cattle on private property, and elk use of core *Populus tremuloides* Michx. (quaking aspen), *Populus angustifolia* E. James (narrowleaf cottonwood), and *Salix* L. (willow) sensitive vegetation communities.

Methods

The NER has never experimentally discontinued feeding, and therefore, we could not fit models to the full suite of conditions that characterized the management alternatives. Yet, a primary goal of this work was to make quantitative predictions of elk redistribution if the NER ceases feeding elk in winter. To bridge this knowledge gap, a hybrid approach of fitting a resource selection function to data was used where possible, and then predictions were adjusted under the alternatives based on information about current and future elk movements from the expert-elicitation process.

An RSF was first estimated based on a use-availability design (Johnson and others, 2006), which measures where an animal has been compared to where an animal could have been. This RSF predicted space-use patterns that closely matched recent conditions and expert knowledge using data for two elk subpopulations: (1) elk fed during winter and (2) elk not fed in winter. To match the structure of the elk CWD model, monthly probability of use was predicted based on elk GPS collar locations. Fed and unfed population segments were pooled for May through November because the WSMET believed summer range selection patterns were not significantly different for these population segments. Winter was defined as December through April, and we further differentiated between average and severe winters. Severe winters were characterized as winters during which snowfall patterns concentrated more elk on feedgrounds (locations where wildlife

agencies feed elk in winter), the NER had to provision larger amounts of feed to elk, and winter elk calf mortality exceeded 5 percent even with additional feed. These criteria were met in approximately 25 percent of recent observed years (this volume, chap. B, Cross and others, 2025). These combinations of variables created 27 monthly elk location datasets, consisting of 7 summer month (May–November) datasets and 20 winter month datasets (December–April). Each of the 5 winter months had fed and unfed population segments and both average and severe winter conditions ($5[\text{months}] \times 2[\text{fed, unfed}] \times 2[\text{average, severe winter}] = 20$ datasets). The RSFs were fit to each dataset of elk locations separately to produce 27 predictive maps, each representing the study area as a grid of 1,020 by 1,020-meter (m) cells with values corresponding to the broad-scale RSFs' per capita probability of use. Thus, the values of the cells in a predictive map sum to one. We estimated the number of elk in each cell by multiplying the number of elk from the elk CWD model (this volume, chap. B, Cross and others, 2025) by the matching predictive map. To express monthly elk use in daily figures, we calculated elk days by multiplying the number of elk estimated to use a given area by the number of days in each month. For alternatives that included feed cessation at the NER, we developed a set of rules for modifying the predictive maps once feeding stopped to match the elk CWD model assumptions and expert judgment (this volume, chap. B, Cross and others, 2025).

The overarching goal of the analysis was to calculate how elk distribution changes influenced measurable attributes, indicating issues of concern to managers. The measurable attributes, identified during the SDM process, can be used to evaluate the performance of the alternatives against one another. Most attributes reflected concerns at the scale of the study area. The reduce feeding alternative included a provision that elk exclosures (fenced areas that exclude elk) be built in the NER to protect sensitive areas—vegetation communities, including quaking aspen, narrowleaf cottonwood, and willow—during winter. The NER is significantly smaller than the full study area, and the proposed exclosures were small relative to the resolution of the broad-scale RSF across the full study area. To evaluate the local effects of exclosures on the quaking aspen, narrowleaf cottonwood, and willow species in the NER, a second (fine-scale) RSF was estimated at a 30 by 30 m resolution for the NER during winter. The broad-scale RSF projected the numbers of elk in the NER, and the fine-scale RSF distributed the numbers of elk across the NER.

Implementation of the Alternatives

The effects of the feedground management alternatives were accounted for through three avenues: (1) alternatives changed elk-population sizes for categories representing herd units and fed or unfed elk status, as detailed in “Predictions of elk and chronic wasting disease dynamics on the National Elk Refuge and surrounding areas in Jackson, Wyoming—Chapter B of National Elk Refuge Feedground Management Alternatives” (this volume, Cross and others, 2025), (2) when feeding stopped on the NER, some elk from the NER moved to the Gros Ventre River drainage north and east of the NER or to non-feedground

areas based on expert elicitation results, and (3) for the reduce feeding alternative, predicted elk space-use that fell within the boundaries of proposed elk exclosures in the NER was subtracted when calculating sensitive area measurable attributes.

The elk CWD model accounted for elk redistribution in the absence of feeding by transitioning elk to other herd units or changing their status from fed to unfed. Based on the expert-elicitation process, the elk CWD model assumes that roughly 50 percent of previously fed elk become unfed elk that still used the NER extensively. The remainder of the previously fed elk either became unfed elk that overwinter on native winter range—land away from the feedgrounds—or moved to other State feedgrounds in the Jackson or Fall Creek Elk Herd Units and became fed elk there (roughly in equal proportion; this volume, chap. B, Cross and others, 2025). Additionally, the elk CWD model used random draws in each year of every simulation to determine whether the winter was characterized as severe or average. The combination of population segment, winter condition, and time of year dictated which of the 27 predictive maps (corresponding to the datasets) was used to distribute elk numbers across the study area.

We assumed that our RSFs did not change during the 20 years of simulations for non-winter months and for unfed elk during winter. However, during the winter months of December through April, predicted fed elk space-use was adjusted to match expert-elicited predictions and the elk CWD model assumptions for broad-scale movements in the absence of feeding (this volume, chap. B, Cross and others, 2025).

Lastly, predicted elk space-use falling within proposed elk exclosures on the NER was subtracted from the calculations pertaining to sensitive vegetation community effects under the reduce feeding alternative. Predicted elk use inside the exclosures was not removed from the NER, but we assumed that these elk did not affect sensitive areas outside the exclosures.

Measurable Attributes

A total of five measurable attributes were determined for each of the management alternatives: (1) the number of elk days on private property, (2) the risk of *Brucella abortus* transmission from elk to cattle, expressed as the number of *Brucella*-caused elk abortions on private properties in the region where cattle could overwinter and (3–5) the number of elk days on sensitive vegetation communities during winter. The cumulative number of elk days on sensitive vegetation communities was further divided to capture specific effects on (3) quaking aspen, (4) narrowleaf cottonwood, and (5) willow species vegetation communities. Each of the sensitive vegetation calculations was restricted to winter months and to the portion of the study area that was defined as highly used wintering elk habitat based on expert judgment (refer to [app. C1](#)). Under the reduce feeding alternative, which included building the proposed elk exclosures, the elk days in sensitive vegetation communities (measurable attributes 3–5) were recalculated across the NER using the fine-scale NER winter RSF. Predicted elk space-use falling within proposed exclosures was subtracted from the total. This approach assumed that exclosures were designed to avoid displacing elk onto unprotected sensitive

quaking aspen, narrowleaf cottonwood, or willow vegetation communities within the NER. The elk CWD model performed 100 simulations for each alternative. The elk spatial measurable attributes were calculated for each simulation and the summarized distributions of these results are presented in this chapter.

Publicly available private property data were obtained from Teton County (Teton County, Wyoming, 2023) and included the winter cattle properties contributing to the brucellosis risk measurable attribute. Winter cattle properties were defined through personal communication with WGFD personnel. Sensitive areas (quaking aspen, narrowleaf cottonwood, and willow vegetation communities) were defined based on vegetation types included in map layers from Grand Teton National Park (Cogan and others, 2005), the NER (FWS, written commun., 2023), Teton County (Cogan and Johnson, 2013), and Bridger-Teton National Forest (Forest Service, written commun., 2023). These sensitive vegetation layers were verified, and the assessment scales were identified using input from the National Park Service, FWS, and WGFD staff.

Brucella abortus is transmitted among hosts through direct contact with the products of *Brucella*-induced abortions. Elk primarily abort during the spring (Cross and others, 2015). To estimate brucellosis risk from elk to cattle, we used the same methods as in Cook and others (2023): the predicted number of *Brucella*-caused abortions in elk on properties used for overwintering cattle was calculated by multiplying the number of female elk on the identified cattle properties in each month by the monthly brucellosis abortion hazard for elk (Cross and others, 2015), assuming a constant pregnancy rate of 80 percent in sexually mature females and an average brucellosis seroprevalence (the percentage of sampled elk with detectable antibodies) of 30 percent.

Elk Global Positioning System (GPS) Data

The elk GPS collar data within the study area were provided by the FWS, Grand Teton National Park, and WGFD (FWS, written commun., 2024; National Park Service, written commun., 2024; WGFD, written commun., 2024). Observations from GPS were collected between 2006–23 with most individuals being collared at the NER in winter months between 2016–22. The total number of observations exceeded 2.2 million (table C1).

Broad-Scale Resource Selection Function

State Highway 22 likely creates a partial barrier to elk movement between the two regions of our study area (the Jackson and Fall Creek Elk Herd Units). Elk rarely crossed this highway in the GPS dataset; however, there were limited data available for elk in the Fall Creek Elk Herd Unit, and the WSMET agreed that more elk are likely to move across this boundary if the NER stops feeding. The elk CWD model accounted for this movement between regions (this volume, chap. B, Cross and others, 2025). The spatial models in this chapter subsequently used the projected number of elk in each region in all simulations of the alternatives from Cross and others (this volume, chap. B, 2025) and assumed

Table C1. The number of adult female *Cervus elaphus canadensis* (Erxleben, 1777; elk) and the number of elk-years with global positioning system (GPS) locations from 2006 to 2023 data in Jackson, Wyoming, that contributed to estimating habitat selection across spatial and seasonal categories in our models.

[An elk-year is defined as any time that an individual elk had a working GPS collar during the corresponding seasons, regardless of whether the full period was observed. Retention of data in the models estimating habitat selection was not conditional on being observed for full monthly or seasonal periods. Winters are defined as December through April, summers are May through November. Severe winters were characterized as winters during which snowfall patterns concentrated more elk on feedgrounds, the National Elk Refuge had to provision larger amounts of feed to elk, and winter elk calf mortality exceeded 5 percent even with additional feed. Winters not meeting these criteria were defined as average. NA, not applicable]

Season	Severity	Number of female elk	Number of elk-years
Fall Creek Elk Herd Unit			
Summer elk	NA	24	47
Winter-fed elk	Average	17	20
Winter-fed elk	Severe	4	4
Winter-unfed elk	Average	3	3
Winter-unfed elk	Severe	4	4
Jackson Elk Herd Unit			
Summer elk	NA	236	650
Winter-fed elk	Average	183	325
Winter-fed elk	Severe	204	241
Winter-unfed elk	Average	31	48
Winter-unfed elk	Severe	23	23

that elk remained within those herd units. The habitat covariates used by Cook and others (2023) from Maloney and others (2020) were also used in this study, namely the annual integrated Normalized Difference Vegetation Index, elevation, density of roads within a 2.5 kilometers (km) buffer of the location, maximum snow water equivalent, and the percentage of forest and percentage of native herbaceous cover within a 2.5 km buffer of the location (Cross and others, 2023; Maloney, 2020). Other habitat covariates included the distance to feedgrounds, calculated as the distance from the centroids of the four feeding areas on the NER and State feedgrounds in the JHU and NFCHU. With feedback from the WSMET, two continuous variables for aspect were added, where northness was the cosine-transformed radians and eastness was the sine-transformed radians. Other variables added based on WSMET feedback included the location’s distance to water (Dewitz and U.S. Geological Survey, 2021; Yan and others, 2019); distance to grass and distance to barren ground (Dewitz and U.S. Geological Survey, 2021); distance to agriculture (Forest Service, written commun., 2023; Cook, 2005; Teton County, Wyoming, 2023); and average minimum January temperature (Thornton and others, 2022). For fed elk in winter months, covariates included a binary feedground raster map for the NER; all raster maps were created at or resampled to a 1,020-m resolution (Cotterill and

Graves, 2024). This resolution required fewer modifications to the original GIS data, was computationally practical, and was deemed appropriately precise considering multiple sources of uncertainty in the elk CWD model and our spatial analysis.

Elk habitat selection coefficients, β , were estimated by employing a use-availability design and logistic regression. For each cell, l , we computed the resource selection probability function (Johnson and others, 2006), w , as the following equation:

$$w_{ljk} = \exp(\beta_{0jk} + x_{1ljk}\beta_{1jk} + \dots + x_{nljk}\beta_{nljk}),$$

where

- x is a vector of mean values of each environmental variable within each cell,
- j is the month, and
- k is an indicator variable for fed ($k=1$) or unfed elk ($k=2$).

Equation C1 estimated the per capita probability of use in each cell, $U(x_j)$, as the following equation:

$$U(x_{ljk}) = w(x_{ljk}) / \sum w(x_{ljk}), \quad (C1)$$

and equation C2 estimated the number of elk, n , in each cell as the following equation:

$$n_{ljk} = N_{jkt} U(x_{ljk}), \quad (C2)$$

where

- N_{jkt} is the predicted number of fed or unfed elk in month j and year t from the elk CWD model.

For measurable attributes associated with the number of elk days in a particular location, the number of elk estimated in each cell was multiplied by the number of days in the month.

Because the NFCHU region had limited data (from as few as three elk; table C1), we assumed elk in both regions respond similarly to habitat and supplemental feed availability and estimated habitat selection coefficients using data combined across the regions. Each monthly elk GPS dataset contributing to these models was randomly thinned to 6,072 locations, the smallest number of locations in any dataset, because the number of GPS locations varied greatly across datasets, and the total number of cells in the study area was only 6,000 at the 1,020-m resolution. Standardizing the sample size across datasets provided comparable estimates across models in terms of effect magnitude, because the ratio of used-to-available points influences model intercepts. Next, within each region, the per capita probability of elk space-use map was estimated using equation C3:

$$U(x_{ljkR}) = w(x_{ljkR}) / \sum w(x_{ljkR}), \quad (C3)$$

where

- R refers to the region either the JHU or NFCHU.

One of the covariates in x , the binary raster map of the NER only exists in the JHU, but we reasoned that the three State feedgrounds in the NFCHU hold a similar level of attraction for fed elk during winter. Therefore, in the per capita probability of elk use calculations for winter-fed elk in the NFCHU, the NER covariate was replaced with a binary raster map representing South Park, Horse Creek, and Camp Creek feedgrounds. Further information supporting this assumption can be found in appendix C2.

Defining available habitat for RSF studies is fraught even under ideal circumstances (Northrup and others, 2013; Warton and Shepherd, 2010), but frequently employed methods include defining availability according to seasonal elk space-use based on home-range or kernel-density estimator methods (Manly and others, 2002). In our case, the GPS dataset likely does not include a representative sample of unfed elk in the system, particularly when divided into monthly timesteps and differing levels of winter severity. As a result, following those conventions could omit habitats occupied by segments of the elk population in our study area, a factor that was considered when the expert elicitation process defined the study area (this volume, chap. A, Cook and others, 2025). Another common convention in use-availability RSF designs is to sample availability at 10 times the number of used locations (Lowrey and others, 2021), but this convention is inadequate when the resolution of the considered areas is coarse (in other words, areas have fewer cells to sample). Most of these concerns are motivated by ensuring accurate estimation of specific habitat selection coefficients and reducing bias from autocorrelated habitat features (Northrup and others, 2013), some of which can be improved through even sampling (for example, a census) of the landscape to represent the full availability of habitats (Benson, 2013). In this analysis, no inference is based on individual selection coefficients, nor is there an inference to habitat selection of elk outside of our study system. The primary goal of the RSF was to predict elk space-use that closely matched observed elk selection patterns and expert judgment in the study area or in segments of the elk population where no comparable observational data existed. To fully represent the available conditions, one available point per cell was sampled in the study area (number of cells in the study area and number of available locations used in the model [n]=6,000).

Experts predicted that once the NER stops feeding elk, NER fed-elk will (1) move to State feedgrounds in the Gros Ventre River drainage, (2) become unfed-elk, or (3) move to the NFCHU. The elk CWD model moves elk to separate population segments to match the proportions of elk that experts identified as likely to transition to each segment (refer to this volume, chap. B, Cross and others, 2025). No further adjustments to the RSF were needed to accommodate the transition of NER elk to the NFCHU because this area had separate predictive maps. To implement the remaining changes for elk-space use predictions, we adjusted the probability of elk use in the NER and two transition areas. The following are cells identified to include in transition areas: (1) areas in the Gros Ventre River drainage surrounding State feedgrounds predicted to be used by fed elk and (2) other winter range areas away from feedgrounds predicted to be used by unfed elk (Native Winter Range Transition Area; NWRTA). The Gros Ventre Transition Area (GVTA) consisted of cells with greater than 0.0001 per capita

probability of use for fed elk in February in the Gros Ventre River drainage and comprised 82.2 square km. The NWRTA consisted of cells with greater than 0.0001 per capita probability of use for unfed elk in February. The NWRTA included areas in the Gros Ventre River drainage farther from feedgrounds, private property in the area around Jackson, Wyoming, and other areas near the NER (encompassing 131 square km), excluding the GVTA and NER (app. C3). The RSF initially overestimated elk space-use in the GVTA and underestimated NER elk space-use compared to the elk CWD model. Because of these over and underestimations, a portion of GVTA elk was moved to the NER during winter months. Then, under the alternatives where feeding on the NER was discontinued, portions of predicted fed elk space-use in the NER were transitioned to the GVTA or NWRTA in accordance with expert judgment and the elk CWD model once feeding stopped (fig. C1). As feeding stoppage varied by alternative, this transition was made at various time points according to the alternative: (1) under the no feeding alternative, the NER elk transitioned to the GVTA or NWRTA in the first year; (2) under the increase harvest and reduce feeding alternatives, the elk transitioned at the beginning of the sixth year; (3) under the disease threshold alternative, the elk transitioned at the beginning of the third year because this year was when most elk CWD model simulations predicted that the 3 percent prevalence threshold of CWD in the Jackson elk herd was met. The proportions of fed elk being assigned onto or away from the NER during winter did not change according to winter severity. However, the average and severe winter RSFs made different predictions for the initial distributions of elk in the winter months before the relocation.

Fine-Scale National Elk Refuge Winter Resource Selection Function

To evaluate the measurable attributes pertaining to elk use of sensitive areas in the NER, including evaluating the effects of proposed elk exclosures under the reduce feeding alternative, winter elk space-use in the NER was modeled at a fine-scale resolution (30-m cells). We followed the same use-availability design described in the “[Broad-Scale Resource Selection Function](#)” section, fitting models only to data falling within the NER boundary between December and April (the winter months). Fitting models to these data excluded most of the unfed elk data previously used in the broad-scale RSF. However, during the unprecedentedly mild winter of 2017–18, feeding was never initiated in the NER. Therefore, in fitting this RSF, the unfed elk datasets were augmented with the GPS observations collected on any elk in the NER that winter. This augmentation precluded the possibility of modeling differences in elk space-use according to winter severity because of inadequate data. The fine-scale NER RSF featured fewer covariates than the broad-scale study area RSF. The unfed-elk RSF model included continuous aspect variables (northness and eastness), distance to grass, elevation, and slope at 30-m resolution (National Aeronautics and Space Administration Jet Propulsion Laboratory [NASA JPL], 2013). The fed-elk model included all covariates of the unfed-elk model and a distance to feeding area covariate, which was calculated using the four designated

feeding areas in the NER. The number of used locations was randomly thinned to equal the dataset with the least number of observations ($n=8,018$), and 1 available point was sampled per cell ($n=112,988$). As with the broad-scale RSF, monthly per capita predicted elk use maps were generated for fed and unfed elk (5 months $\times$ 2 population segments=10 maps).

Calculating the measurable attributes for the NER in winter was a multistep process based on the 100 simulations of abundances by population segment output by the elk CWD model (this volume, chap. B, Cross and others, 2025). First, the broad-scale RSF, in conjunction with abundances from the elk CWD model, was used to predict the number of fed and unfed elk in the NER at every winter monthly timestep in the simulations. Next, the numbers of elk in the NER were projected according to the selection coefficients of the fine-scale RSF (fig. C1). Finally, the per capita probability of elk use was calculated using [equation C1](#), where the NER boundary defined the area available. Under the reduce feeding alternative, zero elk days were assumed to fall within elk exclosure boundaries.

Results

The broad-scale RSF predicted more fed elk in the NER and State feedgrounds in midwinter compared to December and April when more animals are moving toward or away from feedgrounds in the JHU (fig. C2) and NFCHU (fig. C3) portions of the study area. Predicted elk space-use of the NER by fed and unfed Jackson elk closely matched the GPS locations (fig. C4). Predicted elk using the NER, State feedgrounds located in the Gros Ventre River drainage, and native winter range closely matched numbers from the elk CWD model during the 20 years of simulations across alternatives (figs. C5, C3.2, C3.3). Information about the summer RSF predictions can be found in [appendix C4](#) (figs. C4.1, C4.2).

During the 20 years of simulations, the number of elk days on private property and sensitive vegetation communities reflected the changes in abundance projected in chapter B (this volume, Cross and others, 2025). However, the relative performance of alternatives varied among measurable attributes. The continue feeding alternative produced median estimates with the fewest cumulative elk days on private property and the least brucellosis risk from elk to cattle, although the interquartile ranges from 100 simulations overlapped across most alternatives, especially the increase harvest and reduce feeding alternatives (fig. C6). The no feeding and disease threshold alternatives produced the highest median estimates for these two measurable attributes. In terms of elk days in sensitive vegetation communities, the continue feeding alternative ranked well for narrowleaf cottonwood and willow when calculated with the broad-scale RSF but poorly for quaking aspen (fig. C7). The four alternatives that featured feeding cessation on the NER projected less impact on quaking aspen, narrowleaf cottonwood, and willow in the NER than the continue feeding alternative. Following feed cessation, the fine-scale winter RSF for the NER predicted lower elk densities in the National Elk Refuge. Further information can be found in [appendix C5](#) (fig. C5.1).

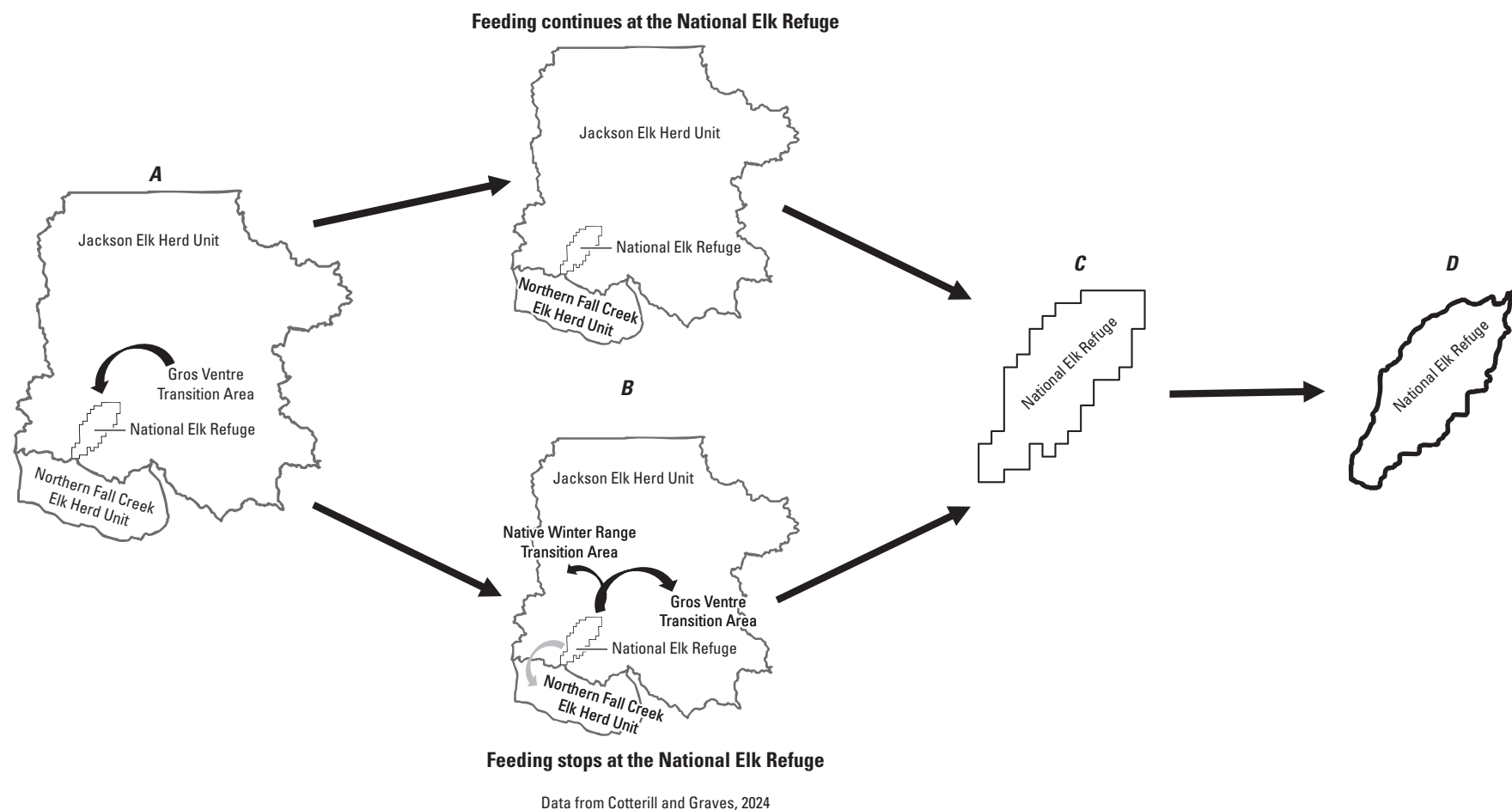


Figure C1. Flowcharts of the modifications to predicted fed-*Cervus elaphus canadensis* (Erxleben, 1777; elk) distributions during the winter months (December through April) and how winter elk space-use was projected across the National Elk Refuge (NER) in Jackson, Wyoming. *A*, a portion of fed elk was moved from the cells encompassing Gros Ventre Transition Area (GVTA) to the NER. *B*, under the continue feeding alternative, no further changes were made, but under other alternatives and years where the NER did not feed elk, fed elk predicted to be in the NER by the resource selection function (RSF) were relocated to the GVTA and non-feedground cells (Native Winter Range Transition Area, NWRTA). The elk chronic wasting disease model also moved a portion of those elk to the Northern Fall Creek Elk Herd Unit (NFCHU). *C*, the adjusted predictive maps from the broad-scale RSF in *B* estimated the number of elk in the NER in the winter months. *D*, the estimated numbers of elk in the NER from *C* were reprojected across a 30-meter resolution NER winter RSF to calculate the effects of elk on sensitive vegetation communities in the NER.

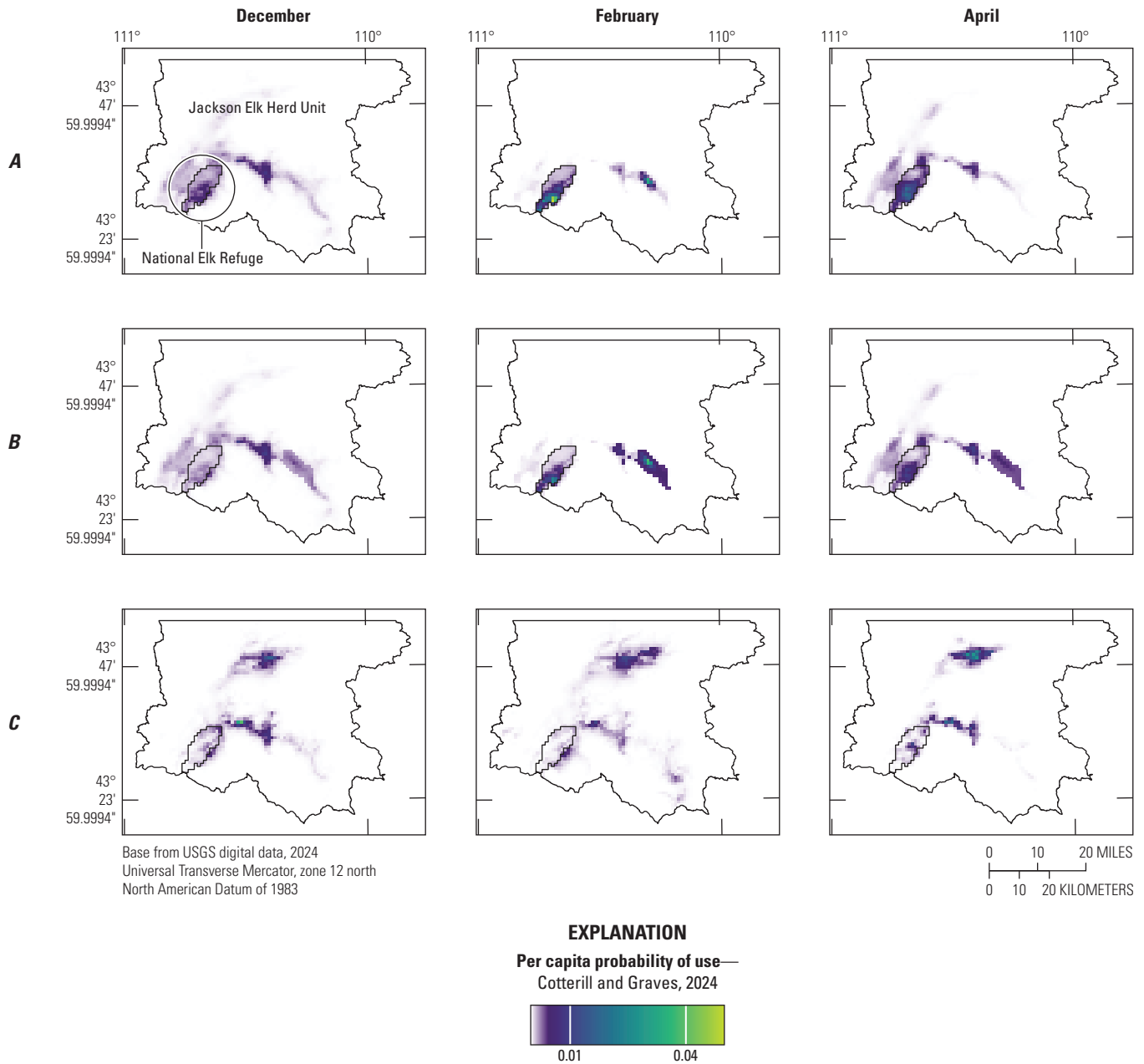


Figure C2. Maps showing the predicted monthly per capita probability of use within the Jackson Elk Herd Unit region of the study area for 3 months during average winter (December–April) conditions for, *A*, fed *Cervus elaphus canadensis* (Erxleben, 1777; elk) when feeding occurs on the National Elk Refuge (NER); *B*, fed elk when feeding on the NER is halted; and, *C*, unfed elk. The northern portion of the Jackson Elk Herd Unit had nearly zero predicted elk space-use during these months and is not shown.

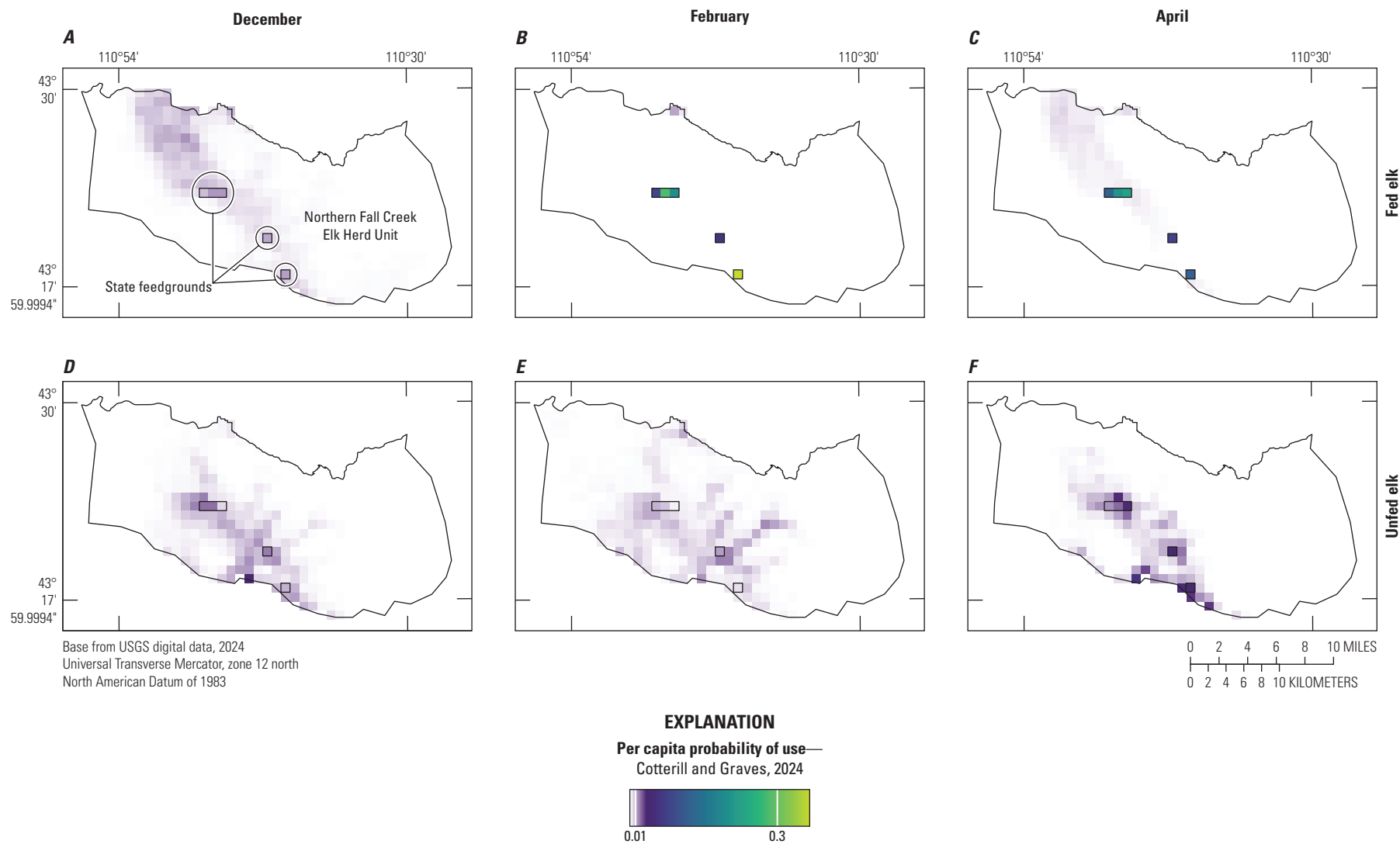


Figure C3. Maps showing the predicted monthly per capita probability of use for fed and unfed Northern Fall Creek Elk Herd Unit *Cervus elaphus canadensis* (Erxleben, 1777; elk) within the study area for 3 months during average winter conditions. *A*, fed elk in December. *B*, fed elk in February. *C*, fed elk in April. *D*, unfed elk in December. *E*, unfed elk in February. *F*, unfed elk in April.

C10 Evaluating Elk Distribution and Conflict Under Proposed Management Alternatives at the National Elk Refuge

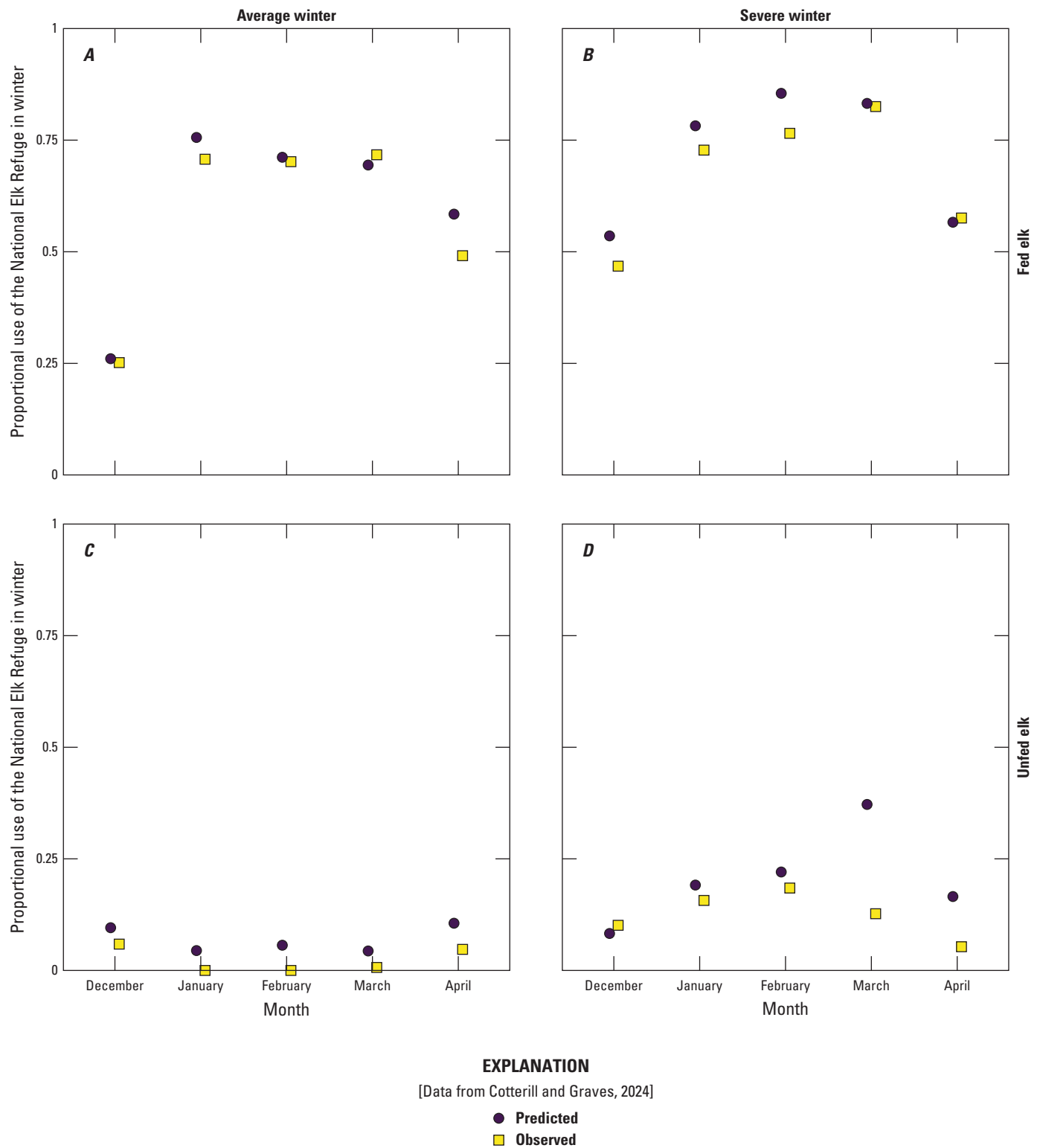


Figure C4. Symbol graphs showing the proportional use of the National Elk Refuge (NER) in Jackson, Wyoming, by Jackson Elk Herd Unit *Cervus elaphus canadensis* (Erxleben, 1777; elk) during winter months (December through April) under average winter conditions for, *A*, fed elk and, *C*, unfed elk, and under severe winter conditions for, *B*, fed elk and, *D*, unfed elk. The predicted use was calculated from the resource selection function (after reassignment of elk from the Gros Ventre Transition Area to the National Elk Refuge), and the observed use was calculated using global positioning system (GPS) collar data.

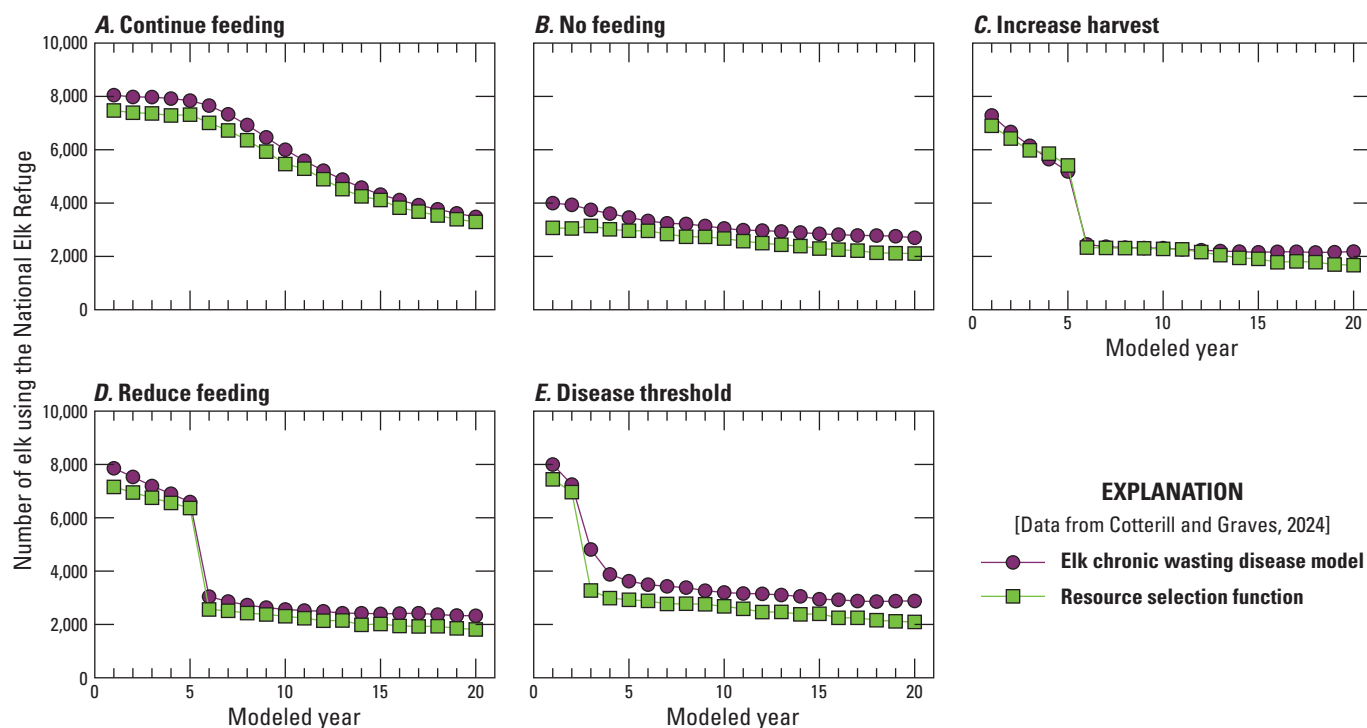


Figure C5. Line graphs comparing the predicted number of *Cervus elaphus canadensis* (Erxleben, 1777; elk) using the National Elk Refuge (NER) in Jackson, Wyoming, in February, during 20 modeled years under the following feedground management alternatives: *A*, continue feeding, *B*, no feeding, *C*, increase harvest, *D*, reduce feeding, and *E*, disease threshold. Elk chronic wasting disease model (Elk CWD model) values represent the mean values from 100 simulations. The resource selection function (RSF) predicts the average numbers of all elk in the NER.

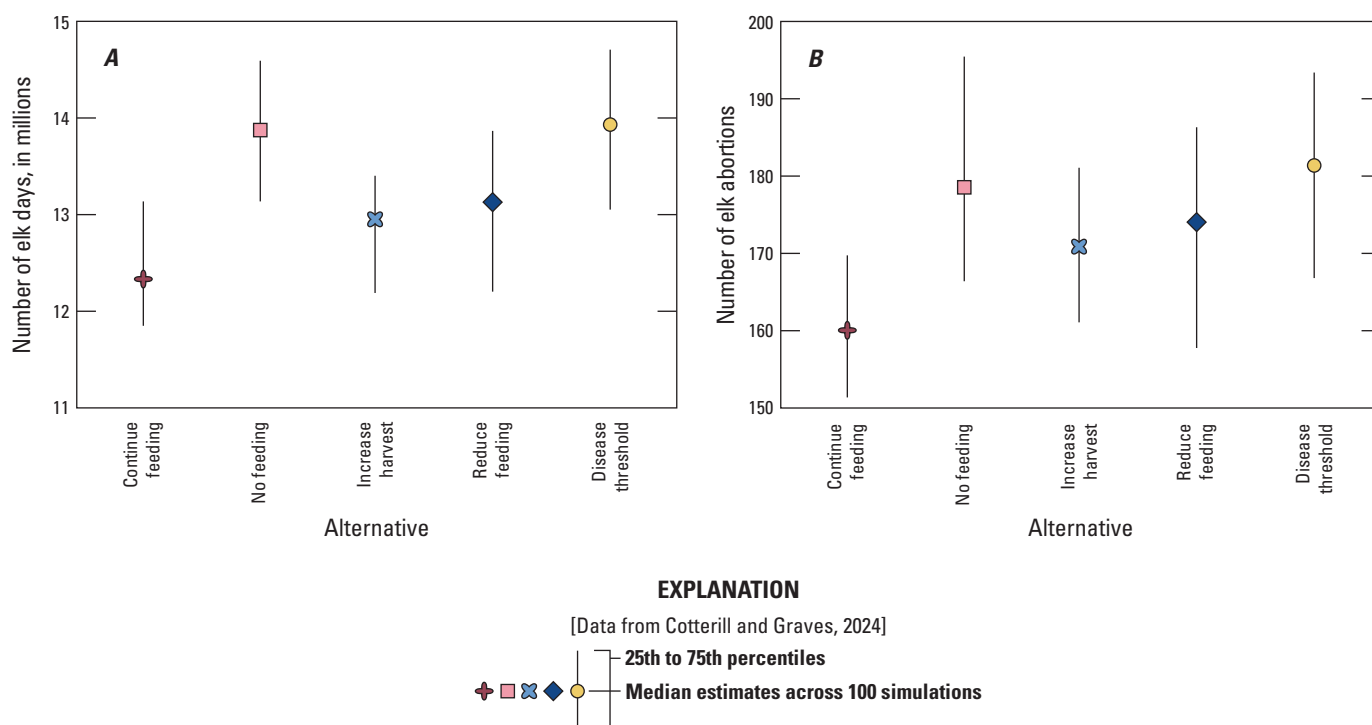


Figure C6. Error bar charts showing the cumulative sums for *A*, the predicted number of *Cervus elaphus canadensis* (Erxleben, 1777; elk) days on private properties, and *B*, the predicted number of abortions on winter cattle properties at the end of the 20-year simulations for five feedground management alternatives based on the broad-scale resource selection function (RSF).

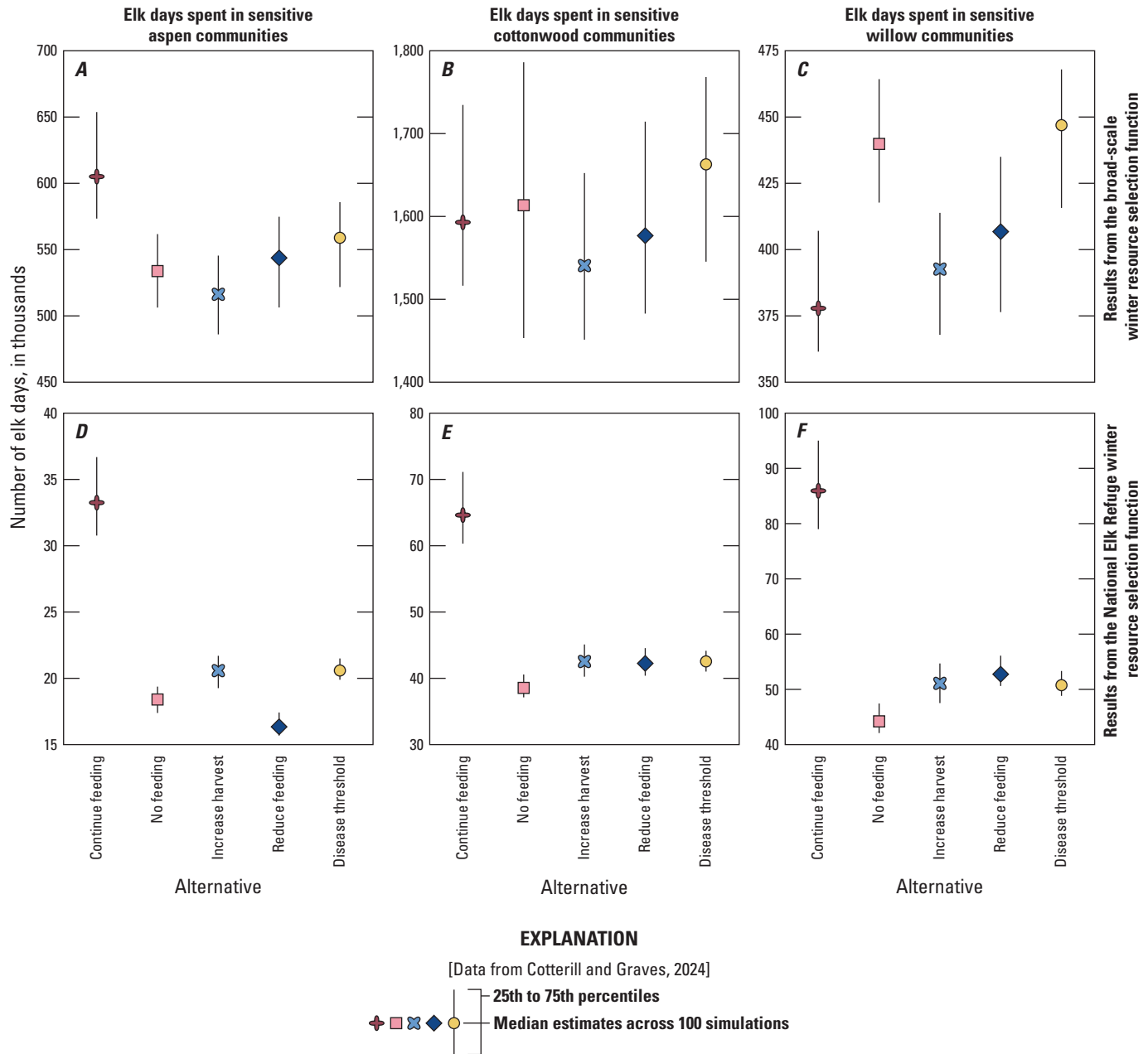


Figure C7. Error bar charts showing the cumulative sums for the number of *Cervus elaphus canadensis* (Erxleben, 1777; elk) days in sensitive vegetation communities at the end of the 20-year simulations for five feedground management alternatives for the winter (December–April) using the broad-scale resource selection functions (RSF) for the full study area (on communities of, *A*, *Populus tremuloides* Michx. [quaking aspen], *B*, *Populus angustifolia* E. James [narrowleaf cottonwood], and, *C*, *Salix* L. [willow]) and the fine-scale RSF for the National Elk Refuge (NER) in Jackson, Wyoming (on communities of, *D*, quaking aspen, *E*, narrowleaf cottonwood, and, *F*, willow). The reduce feeding alternative includes a provision for building additional elk exclosures in the NER, which would primarily benefit quaking aspen.

There was substantial variation in the projected measurable attributes throughout the 100 simulations of each alternative. In terms of limiting the cumulative year-round elk space-use of private property, the continue feeding alternative ranked highest in 64–83 percent of simulations across the other alternatives, although the increase harvest and reduce feeding alternatives outperformed the continue feeding alternative in 36 and 35 percent of simulations, respectively (fig. C8). Similarly, although the continue feeding

alternative ranked highest in limiting brucellosis transmission risk from elk to cattle (expressed as the number of *Brucella*-caused abortions on private properties used for overwintering cattle), some of the alternatives outperformed the continue feeding alternative in a substantial proportion of simulations, including the reduce feeding alternative (better in 39 percent of simulations), the increase harvest alternative (33 percent), and even the no feeding alternative (25 percent; fig. C8).

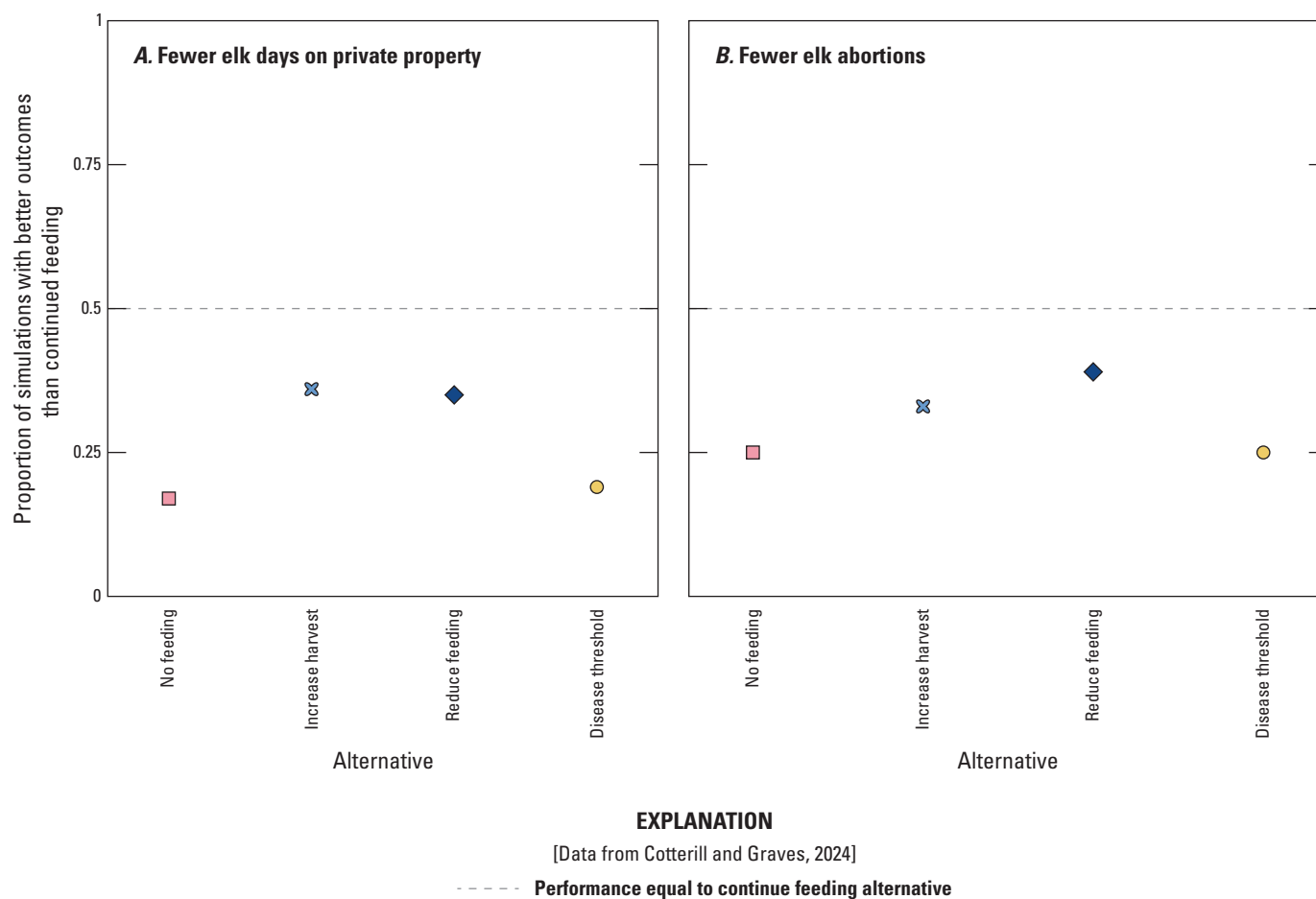


Figure C8. Plots showing the proportion of 100 simulations in which the other feedground management alternatives were projected to yield better outcomes than the continue feeding alternative in Jackson, Wyoming, for, *A*, the predicted number of *Cervus elaphus canadensis* (Erxleben, 1777; elk) days on private property, and, *B*, the predicted number of *Brucella*-caused elk abortions on winter cattle properties. Higher values indicate better outcomes.

When summed through the end of the first five years of implementation, the increase harvest and reduce feeding alternatives (the alternatives that reduce NER elk abundance) outperformed the continue feeding alternative in terms of private property use by elk and were similar to continue feeding in terms of brucellosis risk (refer to [app. C6](#) for more information).

In the matter of elk negatively affecting sensitive vegetation communities in winter, the continue feeding alternative frequently performed worst ([fig. C9](#)). Across core quaking aspen, narrowleaf cottonwood, and willow areas, the increase harvest alternative outperformed the continue feeding alternative in 98, 52, and 42 percent of simulations, respectively, across the full study area. Within the NER boundary, the continue feeding alternative performance was the worst in nearly all cases. The 5-year rankings of the sensitive area measurable attributes supported all other alternatives compared to continue feeding, particularly for the NER (refer to [fig. C6.2](#)).

Lastly, we summarized the mean annual sums of these measurable attributes in the first and last years of the simulations to provide some additional context ([table C2](#)).

There was substantial variation among the 100 simulations when viewed at any given timestep across each alternative. However, an overall pattern was clear: measurable attributes associated with elk space-use decreased in time across all alternatives because of the projected declines in elk abundance from Cross and others (this volume, chap. B, 2025).

Summary

Cervus elaphus canadensis (Erxleben, 1777; elk) abundance was projected to decline during the 20-year period across the alternatives, including the continue feeding alternative. Depending on the alternative, most abundance changes resulted from disease effects, management actions taken to reduce feeding or elk abundance directly, or a combination of those factors (this volume, chap. A, Cook and others, 2025). The measurable attributes reflected human-elk conflicts on private property, including prospective elk-to-cattle brucellosis spillover risk and effects on sensitive vegetation communities in winter (December–April). These effects

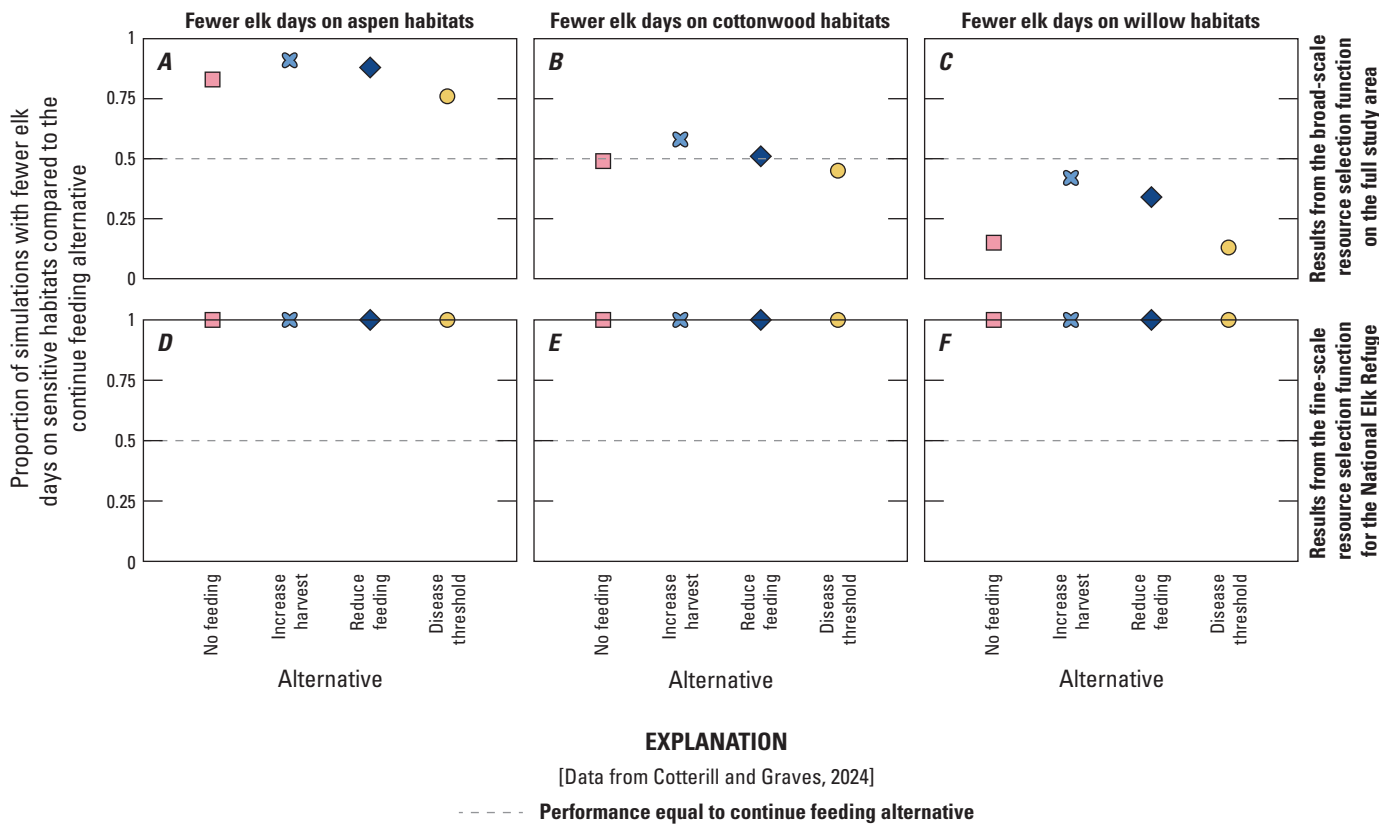


Figure C9. Plots showing the proportion of 100 simulations in which the other feedground management alternatives were projected to yield better outcomes than the continued feeding alternative for *Cervus elaphus canadensis* (Erxleben, 1777; elk) days on sensitive vegetation communities in winter (December–April) using the broad-scale resource selection function (RSF) for the full study area (elk days on communities of, *A*, *Populus tremuloides* Michx. [quaking aspen], *B*, *Populus angustifolia* E. James [narrowleaf cottonwood], and, *C*, *Salix* L. [willow]), and the fine-scale RSF for the National Elk Refuge (NER), Jackson, Wyoming, only (elk days on communities of, *D*, quaking aspen, *E*, narrowleaf cottonwood, and, *F*, willow). Higher values indicate better outcomes.

Table C2. The mean sums and standard deviations of the five measurable attributes throughout the full study area in Jackson, Wyoming, in the first (year 1) and last (year 20) years of 100 simulations across the five feedground management alternatives.

[“Number of abortions” are given in absolute values. All of the other metrics are reported in thousands of *Cervus elaphus canadensis* (Erxleben, 1777; elk) days. Sensitive vegetation communities consist of communities of *Populus tremuloides* Michx. (quaking aspen), *Populus angustifolia* E. James (narrowleaf cottonwood), and *Salix* L. (willow). The standard deviation is shown in parentheses after the mean sum for each metric. A higher standard deviation indicates greater variation across simulations, while a lower standard deviation indicates more similarity across simulations]

Feedground management alternative	Number of elk days on private property	Number of abortions	Number of elk days on sensitive aspen habitats	Number of elk days on sensitive cottonwood habitats	Number of elk days on sensitive willow habitats
Year 1					
Continue feeding	849 (43)	11 (1)	42 (4)	111 (11)	26 (2)
No feeding	963 (65)	13 (1)	35 (3)	122 (13)	29 (3)
Increase harvest	839 (48)	11 (1)	40 (4)	108 (11)	25 (2)
Reduce feeding	852 (49)	11 (1)	43 (5)	113 (11)	27 (3)
Disease threshold	846 (48)	11 (1)	42 (4)	110 (11)	26 (3)
Year 20					
Continue feeding	390 (82)	5 (1)	19 (6)	48 (15)	12 (3)
No feeding	491 (102)	7 (1)	20 (4)	52 (16)	16 (3)
Increase harvest	458 (108)	6 (2)	18 (5)	47 (14)	15 (4)
Reduce feeding	458 (104)	6 (1)	18 (5)	48 (14)	15 (4)
Disease threshold	506 (105)	7 (2)	21 (4)	54 (16)	17 (4)

were projected to decrease when abundance declined, and in general, the magnitude of these effects in year 20 was roughly half of what was estimated in year 1. However, the exact numbers depend on the alternative. On average, the continue feeding alternative predicted the smallest elk population at the end of year 20 because of the high chronic wasting disease (CWD) mortality (this volume, chap. B, Cross and others, 2025). Continue feeding is also predicted to concentrate more elk at the National Elk Refuge (NER) compared to other alternatives, and the NER contained a relatively large proportion of core *Populus tremuloides* Michx. (quaking aspen) areas. As a result, continue feeding is projected to result in fewer elk days on private property and reduced brucellosis spillover risk to cattle, but more elk days on quaking aspen areas across the full study area and more elk days on sensitive vegetation communities in the NER. Although the continue feeding alternative had the lowest projection for cumulative risk of brucellosis transmission from elk to cattle, fully contextualizing this risk is difficult without putting the risk into economic terms, which required information that was unavailable at the time of this study; estimates of the cost of brucellosis spillover events to cattle producers in the Jackson Elk Herd Unit have not been documented. We predict differences among the alternatives of about 19–20 elk abortions on cattle properties over the full 20-year simulation period. However, brucellosis risk decreased over time under all alternatives (by roughly half) because elk numbers decreased. A constant seroprevalence rate was assumed, but if elk densities decrease as elk abundance decreases, then brucellosis seroprevalence may also be expected to decline. The total number of predicted elk abortions on winter cattle properties across the alternatives may be less than or nearly equal to historical elk abortion numbers, which did not result in reported cattle *Brucella* infections in the Jackson Elk Herd Unit.

A fraction of the Jackson elk herd migrates beyond the extent of the study area as defined in this analysis, typically onto adjacent public lands including Yellowstone National Park. Between May and November, 7–12 percent of the global positioning system (GPS) locations in our dataset fell outside the study area. These areas are beyond the authority of the cooperating agencies that contributed to the structured decision-making process, and for the purposes of calculating the measurable attributes in this analysis, only the number of elk days on private properties was likely affected by this decision. Whereas the number of elk days on private property was calculated across all months of the year, other attributes were limited to winter months. Calculation of the sensitive vegetation community measurable attributes was also spatially constrained to core elk winter range. By restricting the summer range, the summer use of private property inside the Jackson Elk Herd Unit was potentially overestimated, although this effect could be similar across alternatives. Thus, although the absolute numbers would change if the study area expanded, this change should not affect the relative ranking of the alternatives against one another.

The GPS data used in this modeling effort were originally collected for a variety of purposes and included mostly female elk captured on feedgrounds. Thus, incorporating expert knowledge was important in developing an appropriate and useful resource selection function (RSF), wherein the numbers of elk predicted in important areas generally match expert knowledge. We

accommodated shifts in forage resources using monthly predictions, but forage may decline quickly in some areas where large numbers of elk transition, particularly in low forage years, potentially yielding subsequent movements. Although small areas in these monthly RSFs differ from known use patterns, these differences are consistent across alternatives and should minimally affect rankings across alternatives.

We incorporated as much model complexity as was allowable given our dataset. One limitation was the paucity of unfed-elk collar data, which is not surprising in a region where approximately 90 percent of the elk are fed during the winter (Wyoming Game and Fish Department [WGFD], 2022b) but also makes it challenging to predict what will happen without any feeding. Another limitation was the lack of feedback among models that approximated space-use and elk numbers. The elk CWD model informed our space-use models, but the results from the space-use models did not inform the elk CWD model. If the NER stops feeding elk and *Bison bison* (Linnaeus, 1758; bison) in winter, some redistribution of animals is expected. The details of that redistribution likely depend on factors not considered in the RSF, including the fidelity of individuals to seasonal ranges and shifting predator densities. For instance, an implicit assumption of habitat selection modeling is that future elk space-use will look like past elk space-use. Yet, the proportion of long-distance migrants in the Jackson elk herd decreased by approximately 40 percent over the 34-year period ending in 2012 (Cole and others, 2015). If this trend continues, we may be underestimating elk use of private properties across the 20-year simulations, and it is unclear how the feedground management alternatives may impact this declining trend in migration.

This chapter presents results based on all available GPS data from 287 female elk from 2006–23. From those GPS data, resource selection functions were estimated for fed and unfed elk across different management alternatives under severe and average winters at a 1,020-meter resolution on a monthly basis over 20 years (27 different predictive maps). We also did this on a 30-meter basis for NER-specific measurable attributes. Formal expert elicitation was used for those aspects that were not predictable given the available data and merged those with quantitative models while accounting for uncertainties. Finally, we summarized the results according to five measurable attributes representing the objectives of the NER. While there are areas for future improvement, these maps provide the best available information to decision-makers on this difficult management decision.

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Appendix C1. Core Elk Winter Areas Defined by the Expert Panel

We convened a panel of eight experts with specialized expertise in *Cervus elaphus canadensis* (Erxleben, 1777; elk) behavior and movement dynamics within the region. The panel included 5 staff members from the Wyoming Game and Fish Department, 1 staff member from the U.S. Fish and Wildlife Service, and 2 staff members from the National Park Service. The panel experts participated in a mapping exercise that defined core elk wintering habitats within the study area for National Elk Refuge (NER) elk when food was not provided. These core areas could include winter range on public lands and conflict private land areas (private lands where conflict could arise between owners and elk). Specifically, the experts responded to the following two verbatim questions about elk transitions to different areas immediately after feeding stops on the NER:

1. Of the elk that transition off [the] NER and onto a mix of conflict private land areas and winter range, we are interested to know what the “core area” of use is. We define core area as the area where 50 percent of the elk that transition off [the NER] will go (not to include State feedgrounds).
2. How confident are you that the polygon includes the core areas used by elk and excludes areas that are not used in years where feed is not provisioned?

We asked the panel to assume an average snowfall year with regard to the duration of the season and sustained snow depths. We also asked the panel to assume that elk may have learned behavioral responses to feeding from the normal feeding operations. Behaviors included the annual return of individuals to the NER with an expectation that supplemental food would be provisioned when forage becomes scarce. Question 1 was completed in Microsoft PowerPoint, and their raw estimates are shown in [figure C1.1](#).

Polygons provided by individuals were merged in ArcGIS Pro ([fig. C1.2](#)) to generate a minimum convex polygon that included all areas demarcated by each respondent. This polygon represents the maximum area where experts thought 50 percent of winter elk would be located after feed cessation, which reduced the spatial extent under consideration when calculating the sensitive area measurable attributes ([fig. C1.2](#)).

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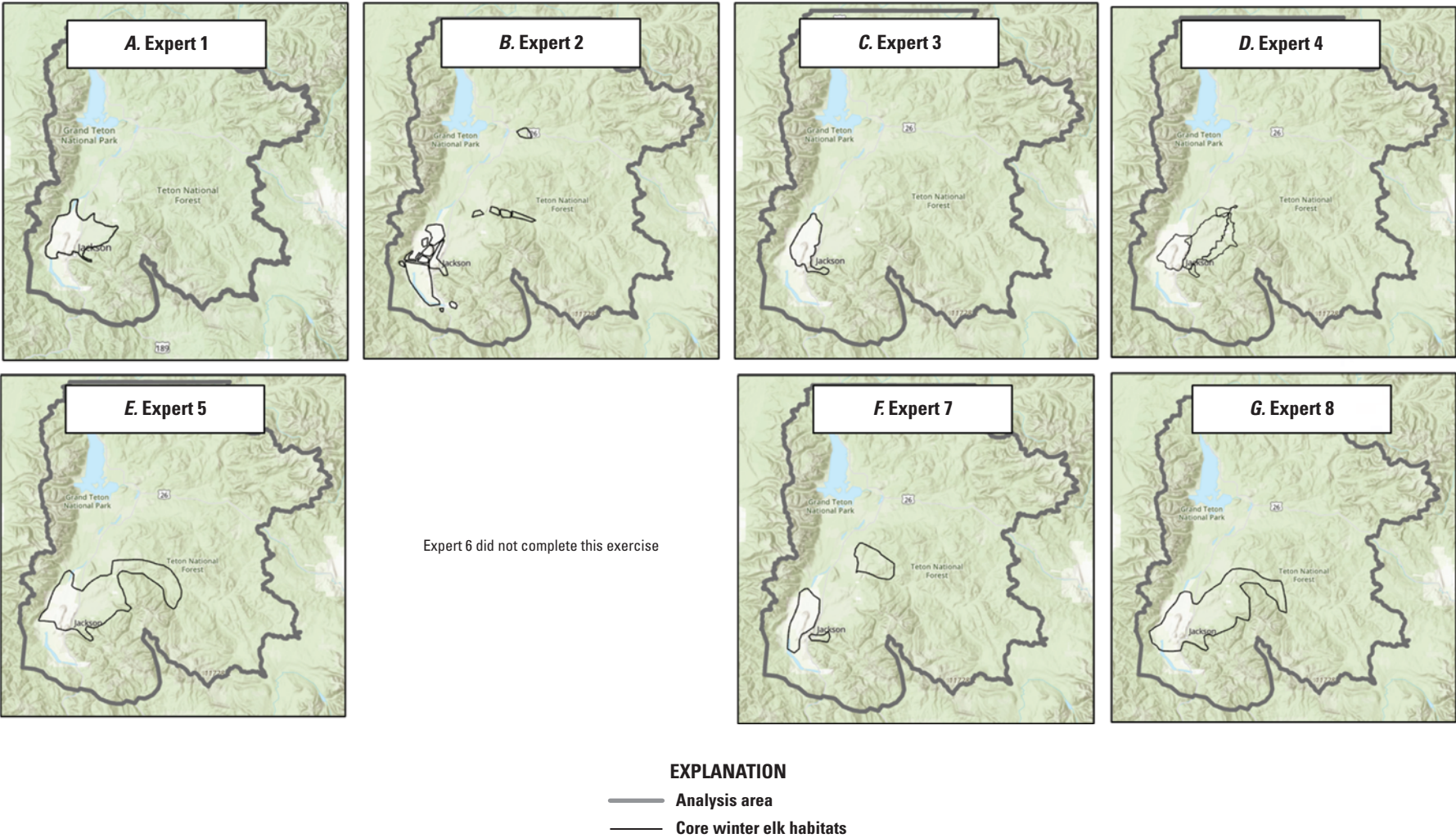


Figure C1.1. Maps showing the raw polygons drawn by experts depicting core winter *Cervus elaphus canadensis* (Erxleben, 1777; elk) habitats in the study area in Jackson, Wyoming, under no-feeding conditions (excluding a response from Expert 6, who did not complete the exercise).

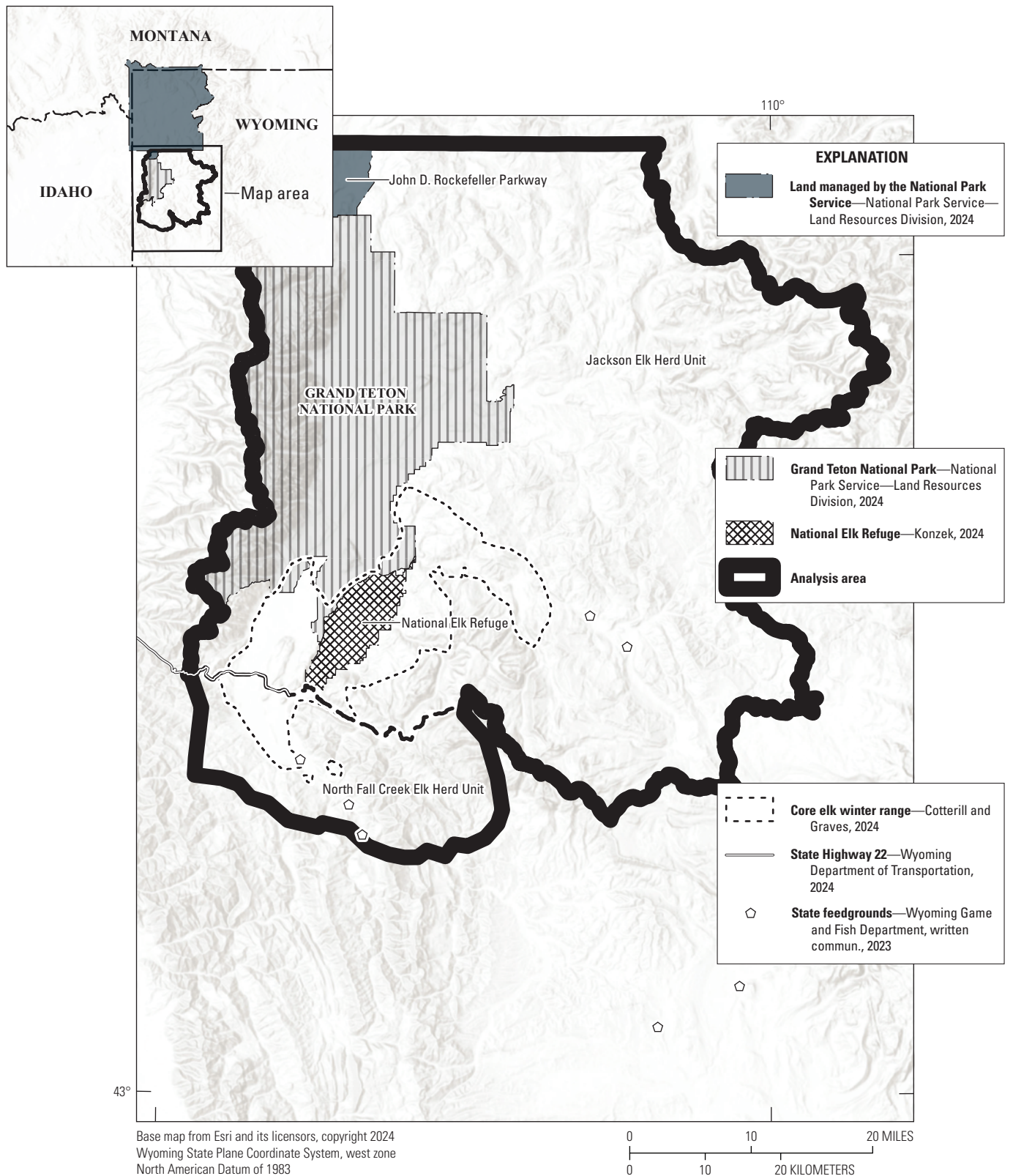


Figure C1.2. A map of the full study area that consists of two regions divided by State Highway 22: the Jackson Elk Herd Unit to the north and the Northern Fall Creek Elk Herd Unit to the south. The National Elk Refuge and State feedgrounds are shown in addition to the core *Cervus elaphus canadensis* (Erxleben, 1777; elk) winter range identified by experts as the core elk winter habitat.

Appendix C2. Predicted Elk Use of Winter Feedgrounds in the Northern Fall Creek Elk Herd Unit

A limited number of collars have been deployed for the Northern Fall Creek Elk Herd Unit (NFCHU), so location data from both the NFCHU and Jackson Elk Herd Units (JHU) were used to model habitat selection. Few *Cervus elaphus canadensis* (Erxleben, 1777; elk) crossed State Highway 22 (the boundary of the Jackson and Fall Creek Elk Herd Units) in the global positioning system (GPS) data spanning 2006–23, and the resource selection model does not account for this apparent barrier effect. To address this movement, we used expert elicitation to estimate how many elk would cross the highway to the NFCHU. These movements were incorporated as changes in abundance in the elk chronic wasting disease model described in Cross and others (this volume, chap. B, 2025). Thus, the population model resulted in separate abundance predictions for each herd unit. Although we estimated selection across the full study area using data from both JHU and NFCHU, we applied the abundance predictions to predict elk use for each region. The predicted probability of use map of each region was scaled to sum to 1. In doing so, we reasoned that State feedgrounds in the NFCHU were functionally similar to the National Elk Refuge (NER) in the Jackson Elk Herd Unit, and the selection coefficient for the NER in the Jackson Elk Herd Unit could be used to inform selection for the State feedgrounds. We then compared the predicted versus observed proportional winter elk space-use of the NFCHU feedgrounds (fig. C2.1).

Although some monthly predictions had larger differences (January in average winters, December and April in severe winters), the cumulative use by elk over the full winter (December–April) was similar.

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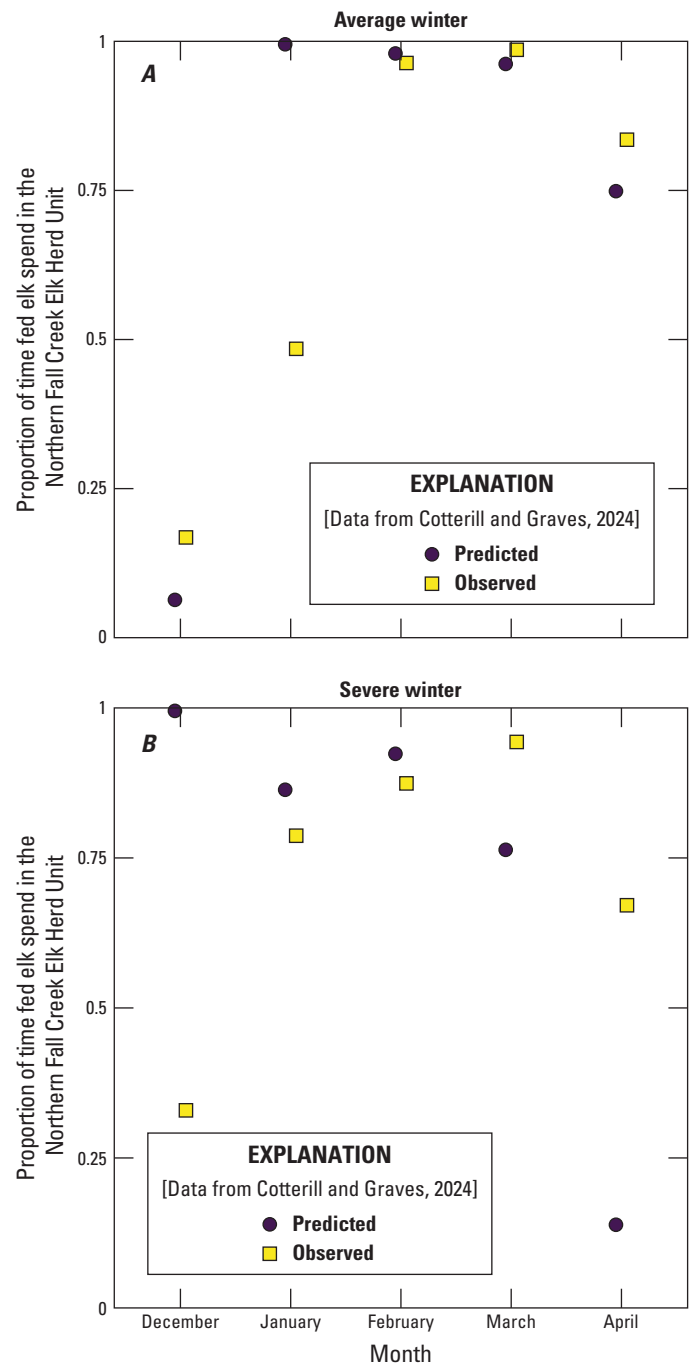


Figure C2.1. Symbol graphs showing the predicted and observed proportional use by fed *Cervus elaphus canadensis* (Erxleben, 1777; elk) for three State feedgrounds in the Northern Fall Creek Elk Herd Unit (NFCHU) during, *A*, average winters, and, *B*, severe winters. Winters are defined as December through April. Predicted values were the proportion of the NFCHU resource selection function probability of use occurring on feedgrounds, and observed values were the proportion of global positioning system (GPS) observations occurring on feedgrounds.

Appendix C3. Adjusted Use Predictions for Jackson Elk Attending State Feedgrounds in the Gros Ventre River Drainage or in the Native Winter Range

To align predictions of *Cervus elaphus canadensis* (Erxleben, 1777; elk) space-use under no-feeding winter conditions at the National Elk Refuge (NER) with expert opinion when no feeding occurs on NER, areas of important fed elk use were first identified from the resource selection function in the transition areas because these were not explicitly described by the experts initially. To identify the Gros Ventre Transition Area (GVTA; [fig. C3.1](#)), the February severe winter conditions map of predicted per capita elk use in the Gros Ventre River drainage was used because that map shows when and where elk are most spatially constrained while attending the State feedgrounds located in the Gros Ventre River drainage. The GVTA was classified as cells where predicted per capita use exceeded 0.0001 (equivalent to use by 1 elk in 10,000). This approach identified 79 cells, equal to 82.2 square kilometers, at the 1,020-meter resolution of the broad-scale resource selection function (RSF). Similarly, to identify the Native Winter Range Transition Area (NWRTA), we classified cells used by fed elk near, but outside of, the NER and the GVTA. The NWRTA cells also used average winter conditions, when elk use is less constrained spatially and includes a larger proportion of private property where conflict is possible. Using the same 0.0001 per capita predicted elk space-use threshold for classification, 126 cells (area=131.1 square kilometers) were identified as the NWRTA. Then, we adjusted the per capita probability of use maps such that RSF predictions matched the elk chronic wasting disease (CWD) model and (expert predictions) for the different population segments at monthly timesteps. The fed elk RSFs initially overpredicted GVTA use and underpredicted NER use. For each feedground management alternative, 30 percent of the total predicted use falling in the GVTA was transitioned to NER. Then, for alternatives where NER feeding ceased, portions of the predicted fed-elk use falling inside the NER were transitioned to the GVTA and NWRTA. Under the no feeding alternative, elk transitioned from the NER to the GVTA and NWRTA in the first winter of simulations. Under the reduce feeding and increase harvest alternatives, elk transitions started in the sixth year. Under the disease threshold alternative, elk transitions occurred in the third year, when most simulations predicted that 3 percent CWD prevalence would be met. To adjust the per capita use maps and thus transition elk, the per capita probability of use was proportionally subtracted across all cells in the NER and evenly added to all cells in the transition areas. Based on the best match to the expert opinion and results of those opinions embedded in the elk CWD model, 45 percent of NER elk use was assigned to the GVTA, and 5 percent of the remaining NER use was assigned to the NWRTA. These relative percentages are provided for clarity and reproducibility. However, they should not be directly interpreted as percentages of the herd transitioning away from NER. For that percentage, we refer to Cross and others (this volume, chap. B, 2025) and the expert predictions. Here, our adjustments to the map closely match the elk CWD model assumptions ([figs. C3.2 and C3.3](#)). Although the NWRTA was used to relocate fed NER elk to probable areas of use under the no-feeding

alternative, to compare our spatial predictions to elk CWD model predictions for the unfed segment of the Jackson elk herd, we summarized all elk in the study area outside of the NER and GVTA, not only elk within the NWRTA ([fig. C3.3](#)).

References Cited

- Cotterill, G.G., and Graves, T.A., 2024, Supporting code for—Evaluating elk distribution and conflict under proposed management alternatives at the National Elk Refuge in Jackson, Wyoming: U.S. Geological Survey software release, at <https://doi.org/10.5066/P14FF6E6>.
- Cross, P.C., Cook, J.D., and Cole, E.K., 2025, Predictions of elk and chronic wasting disease dynamics at the National Elk Refuge in Jackson, Wyoming, and surrounding areas, chap. B of Cook, J.D., and Cross, P.C., eds., Decision analysis in support of the National Elk Refuge bison and elk management plan: U.S. Geological Survey Scientific Investigations Report 2024–5119, 22 p., <https://doi.org/10.3133/sir20245119B>.

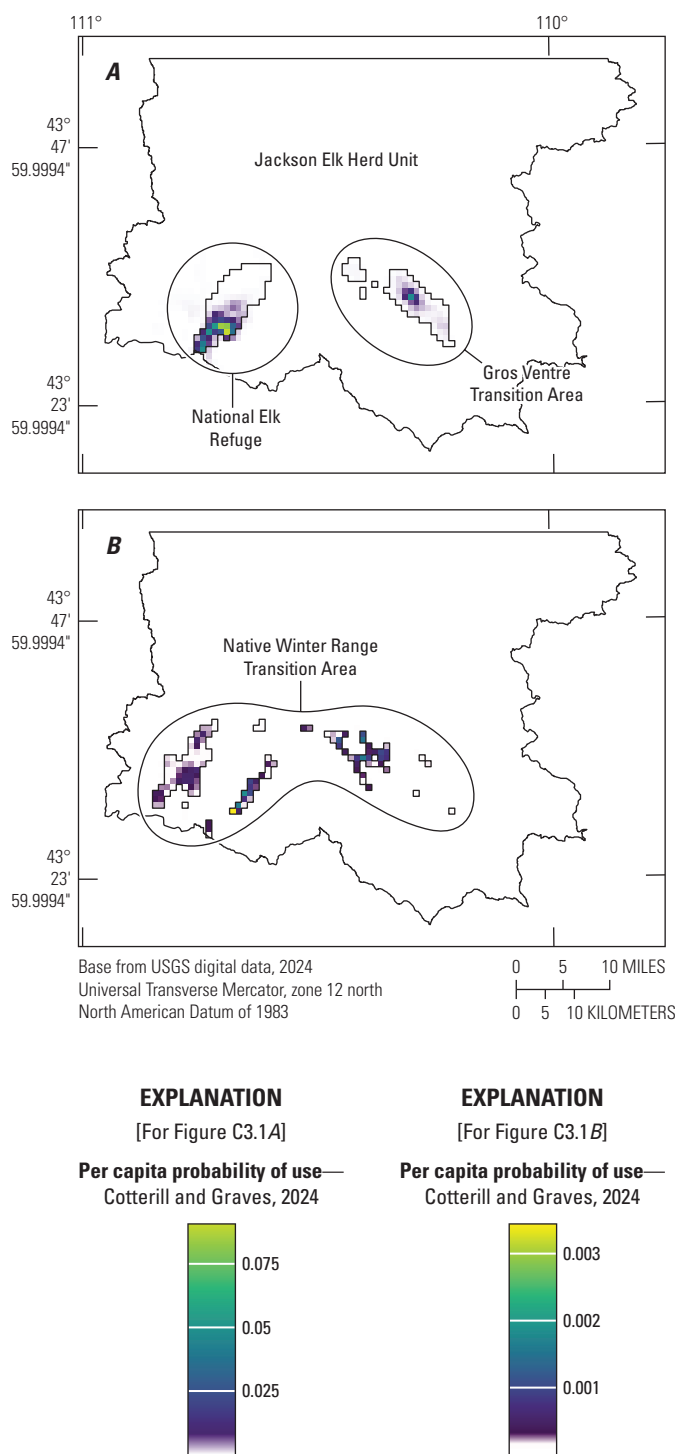


Figure C3.1. Maps showing areas of likely February *Cervus elaphus canadensis* (Erxleben, 1777; elk) space-use identified through the resource selection function for transitioning fed elk off the National Elk Refuge (NER) according to expert predictions under no-feeding conditions at the NER. Areas of likely elk space-use include, *A*, the NER and Gros Ventre Transition Area, or, *B*, the Native Winter Range Transition Area. Original values for the per capita probability of use from the resource selection function are shown.

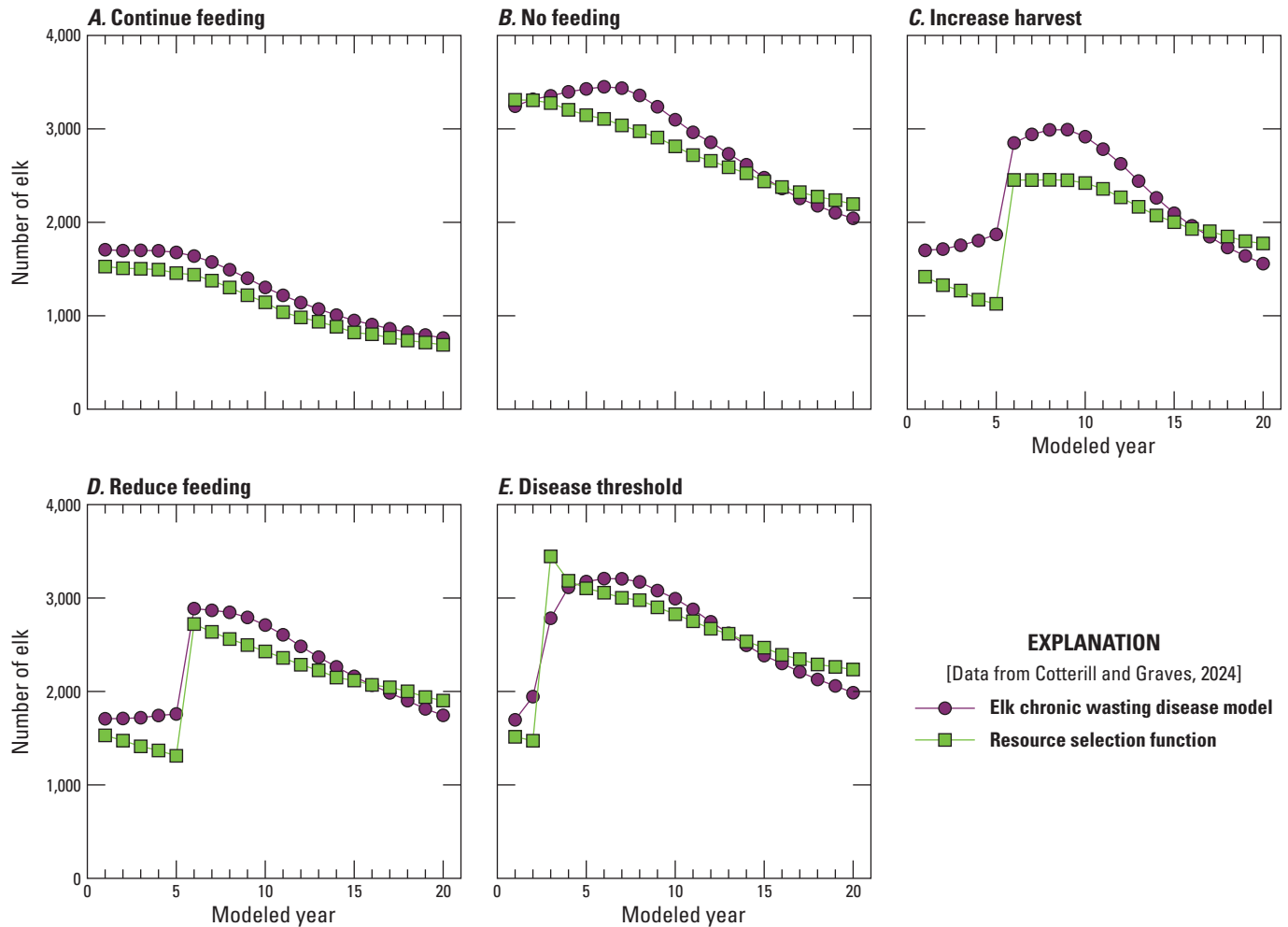


Figure C3.2. Line graphs comparing the numbers of *Cervus elaphus canadensis* (Erxleben, 1777; elk) using the State feedgrounds in the Gros Ventre River drainage in February during 20 modeled years under the following feedground management alternatives: *A*, continue feeding, *B*, no feeding, *C*, increase harvest, *D*, reduce feeding, and, *E*, disease threshold. The disease simulation model for elk chronic wasting disease (CWD) predicts the average February numbers for Gros Ventre elk (a population segment of the Jackson elk herd in Cross and others [this volume, chap. B, 2025]) across all simulations. The resource selection function (RSF) numbers predict the average February numbers of elk inside the Gros Ventre Transition Area. Average February numbers are calculated from 100 simulations for each year, but [figure C3.2](#) also shows 20 years of predictions for each alternative.

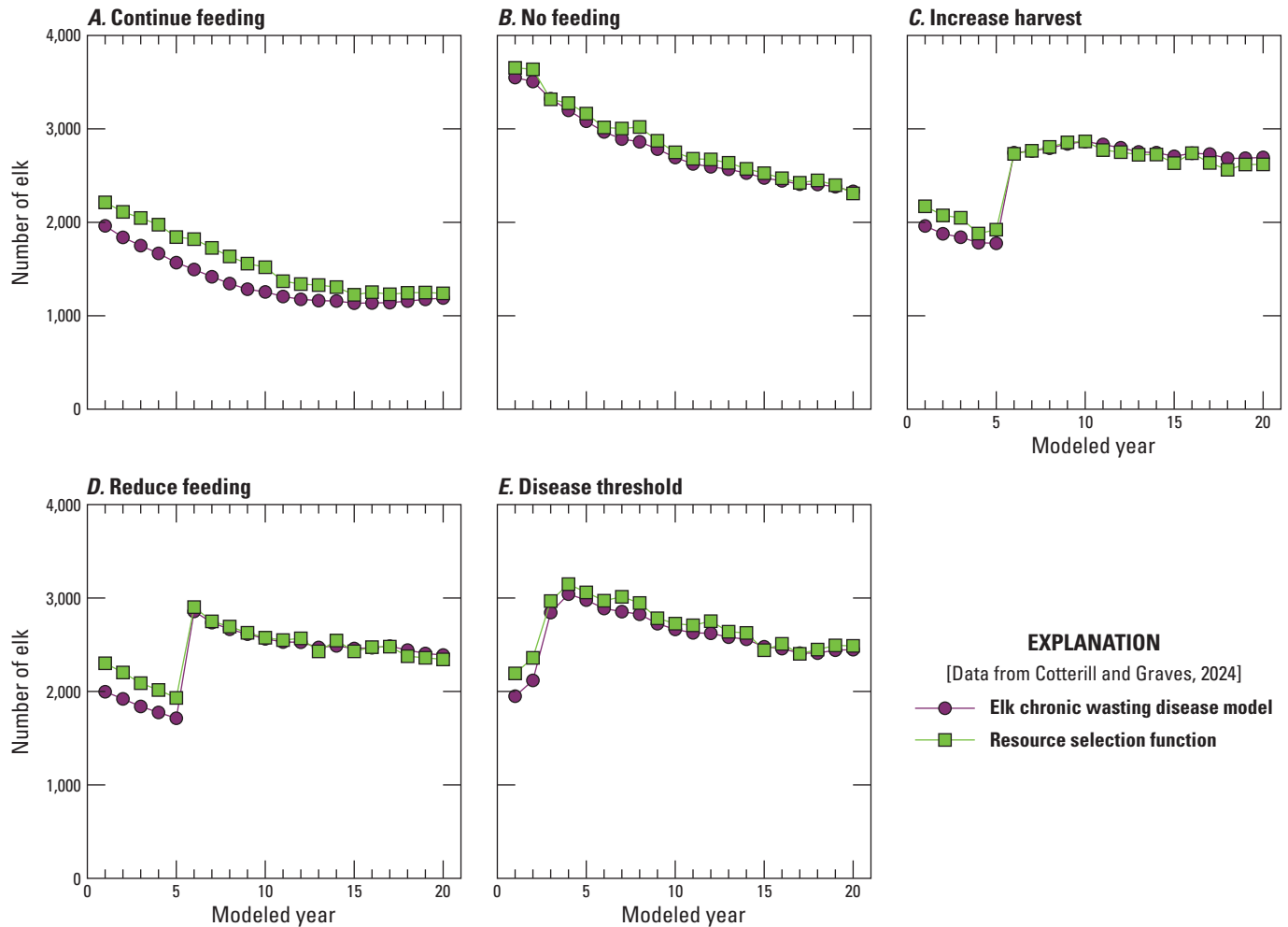


Figure C3.3. Line graphs comparing the predicted numbers of *Cervus elaphus canadensis* (Erxleben, 1777; elk) inside the Jackson Elk Herd Unit using all areas outside of the National Elk Refuge (NER) and the Gros Ventre Transition Area (GVTA) in February across 20 modeled years under the following feedground management alternatives: *A*, continue feeding, *B*, no feeding, *C*, increase harvest, *D*, reduce feeding, and, *E*, disease threshold. The disease simulation model for elk chronic wasting disease (CWD) predicts the average February numbers for the unfed portion of the Jackson elk herd across all simulations, and the resource selection function (RSF) numbers predict the average February numbers of Jackson Elk Herd Unit elk outside of the NER and the GVTA. Average February numbers are calculated from 100 simulations for each year, but [figure C3.3](#) also shows 20 years of predictions for each alternative.

Appendix C4. Elk Summer Predictive Maps from the Broad-Scale Resource Selection Function

Summer predictive *Cervus elaphus canadensis* (Erxleben, 1777; elk) use maps were modeled without any adjustments (fig. C4.1). We verified that the relative predicted versus observed elk use of high- and low-elevation areas was similar (fig. C4.2). We defined high-elevation areas as those at or above 2,400 meters (7,874 feet); anything below 2,400 meters (7,874 feet) was defined as low elevation. For reference, the town of Jackson, Wyoming, is at approximately 1,901 meters (6,237 feet).

Reference Cited

Cotterill, G.G., and Graves, T.A., 2024, Supporting code for—Evaluating elk distribution and conflict under proposed management alternatives at the National Elk Refuge in Jackson, Wyoming: U.S. Geological Survey software release, at <https://doi.org/10.5066/P14FF6E6>.

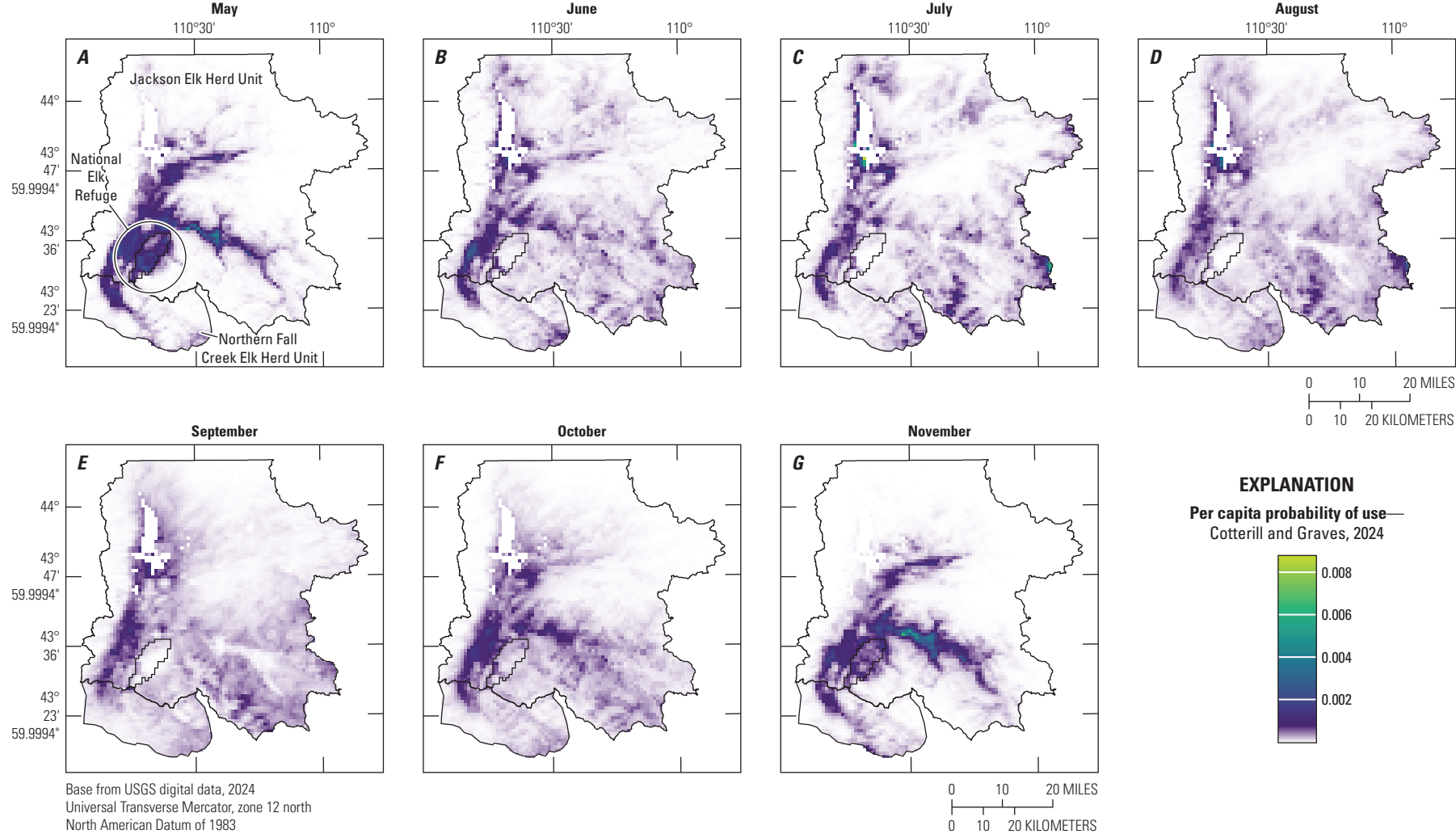


Figure C4.1. Maps showing the per capita probability of use by *Cervus elaphus canadensis* (Erxleben, 1777; elk) in the study area during summer months (May–November). The study area comprises two regions divided by State Highway 22. These regions are the Jackson Elk Herd Unit to the north and the Northern Fall Creek Elk Herd Unit to the south.

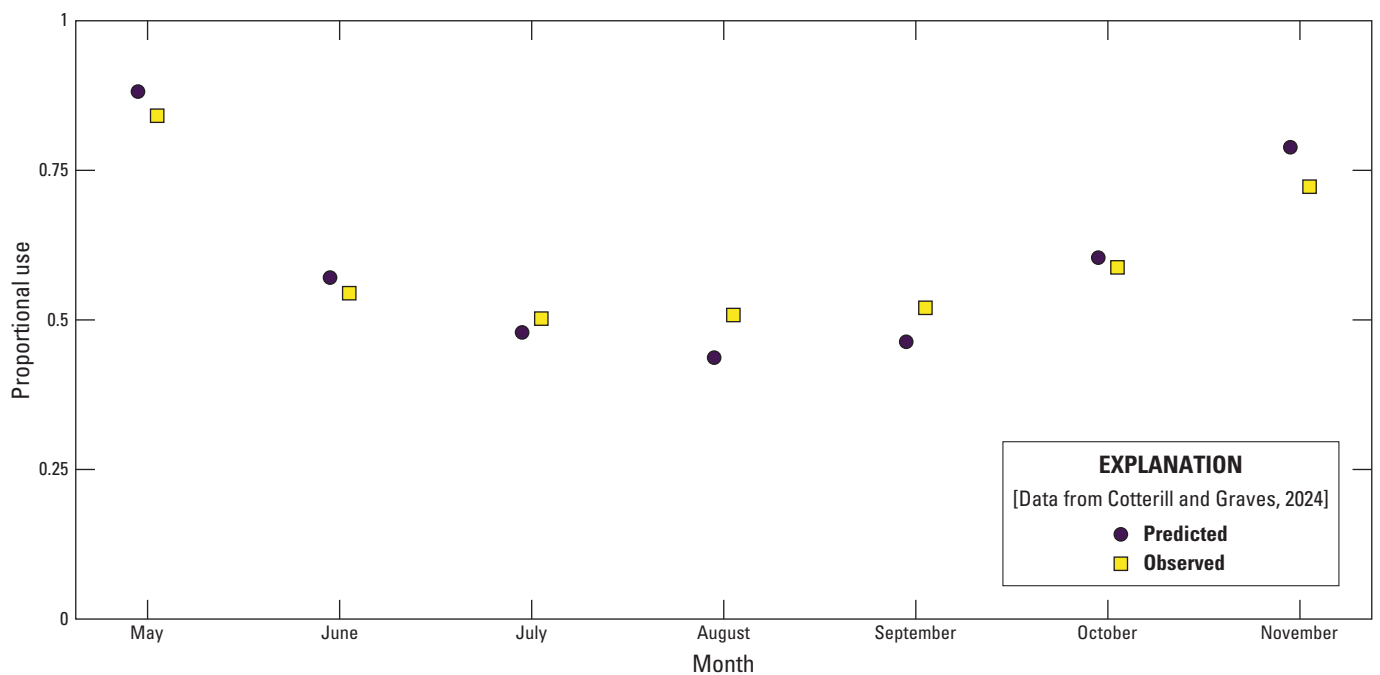


Figure C4.2. Symbol graph showing the proportions of *Cervus elaphus canadensis* (Erxleben, 1777; elk) using areas below 2,400 meters (7,874 feet) in elevation across the study area between May and November. The predicted proportions are calculated from the broad-scale resource selection function (RSF), and the observed proportions are calculated from the elk global positioning system collar data.

Appendix C5. Elk Predictive Maps from the National Elk Refuge Winter Resource Selection Function

The fine-scale winter resource selection function for the National Elk Refuge (NER) predicted lower *Cervus elaphus canadensis* (Erxleben, 1777; elk) densities on the NER following feed cessation under the other feedground management alternatives compared to the continue feeding alternative (fig C5.1).

Reference Cited

Cotterill, G.G., and Graves, T.A., 2024, Supporting code for—Evaluating elk distribution and conflict under proposed management alternatives at the National Elk Refuge in Jackson, Wyoming: U.S. Geological Survey software release, at <https://doi.org/10.5066/P14FF6E6>.

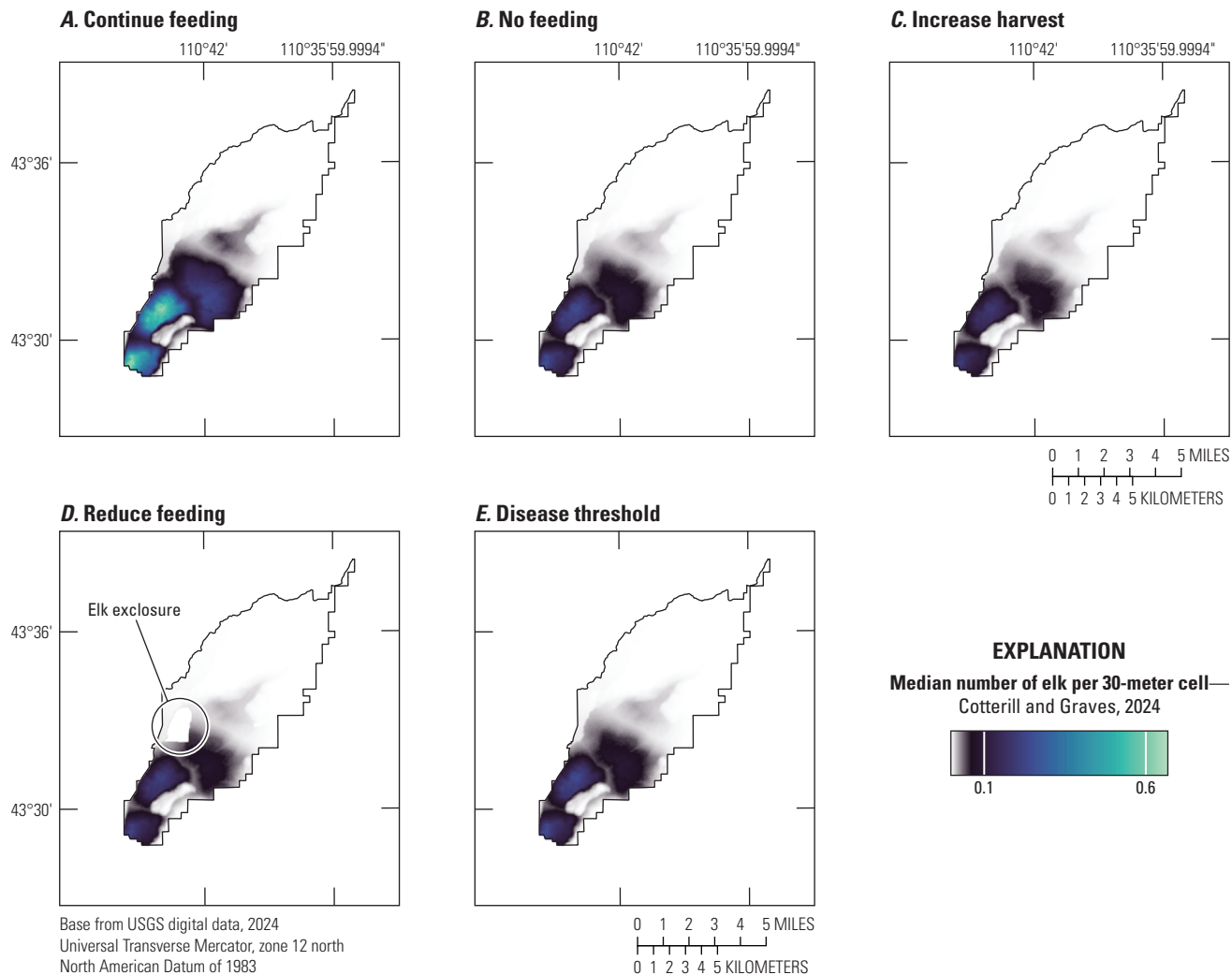


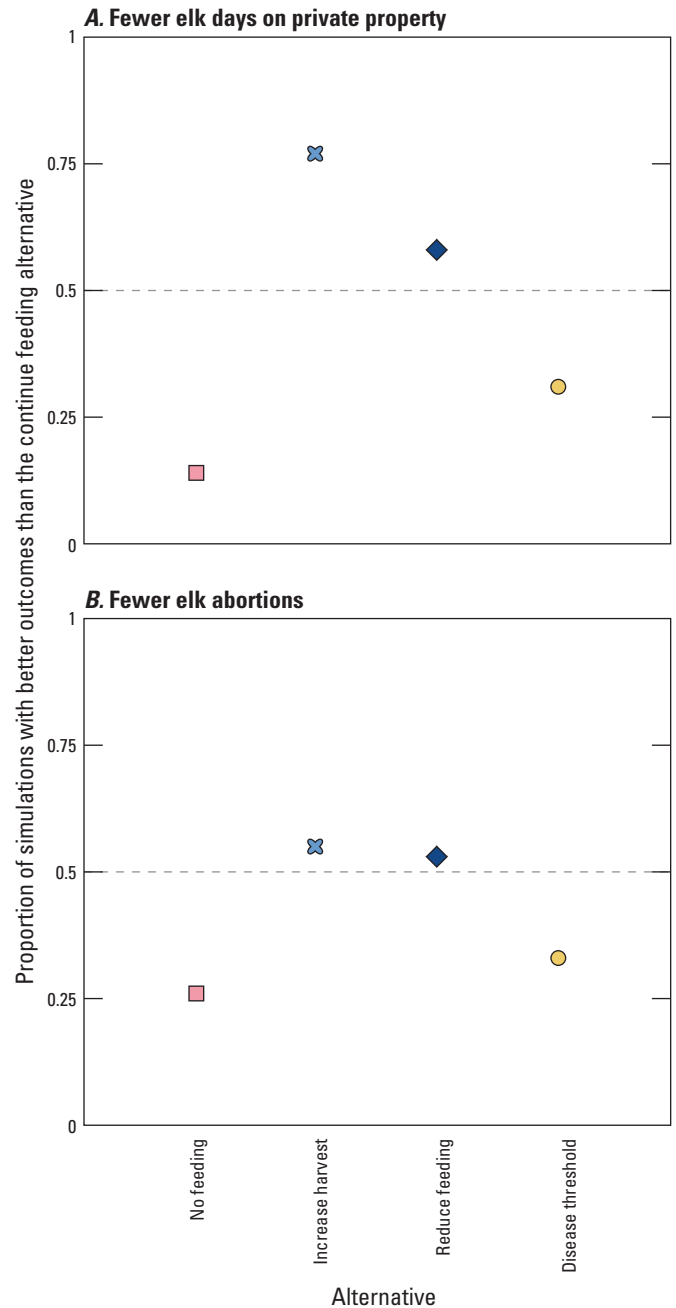
Figure C5.1. Maps showing the median number of *Cervus elaphus canadensis* (Erxleben, 1777; elk) predicted per 30-meter cell on the National Elk Refuge in February of the sixth simulation year (the first year after feed-cessation under the increase harvest and reduce feeding alternatives) for the following feedground management alternatives: *A*, continue feeding, *B*, no feeding, *C*, increase harvest, *D*, reduce feeding, and *E*, disease threshold. The reduce feeding alternative also included proposed elk exclosures.

Appendix C6. Near-Term Rankings (5 years) of Measurable Attributes

The 5-year rankings closely follow (1) the *Cervus elaphus canadensis* (Erxleben, 1777; elk) chronic wasting disease model's projections of Jackson Elk Herd Unit abundance in the first 5 years, (2) the assumptions made regarding elk transitioning to other areas after the National Elk Refuge feed cessation, and (3) the prediction under the disease threshold alternative that 3 percent chronic wasting disease prevalence is rapidly exceeded. As a result, the alternatives predict 1,000–2,000 fewer Jackson Elk Herd Unit elk per year in the first 5 years after implementing other feedground management alternatives compared to the continue feeding alternative (figs. C6.1, C6.2).

Reference Cited

Cotterill, G.G., and Graves, T.A., 2024, Supporting code for—Evaluating elk distribution and conflict under proposed management alternatives at the National Elk Refuge in Jackson, Wyoming: U.S. Geological Survey software release, at <https://doi.org/10.5066/P14FF6E6>.



EXPLANATION

[Data from Cotterill and Graves, 2024]

----- Performance equal to continue feeding alternative

Figure C6.1. Plots showing the proportion of 100 simulations in which the other feedground management alternatives were projected to yield better outcomes compared to the continue feeding alternative in terms of, *A*, the projected number of *Cervus elaphus canadensis* (Erxleben, 1777; elk) days on private property and, *B*, the brucellosis risk to cattle during the first 5 years following implementation of the feedground management alternatives. Higher values indicate better outcomes.

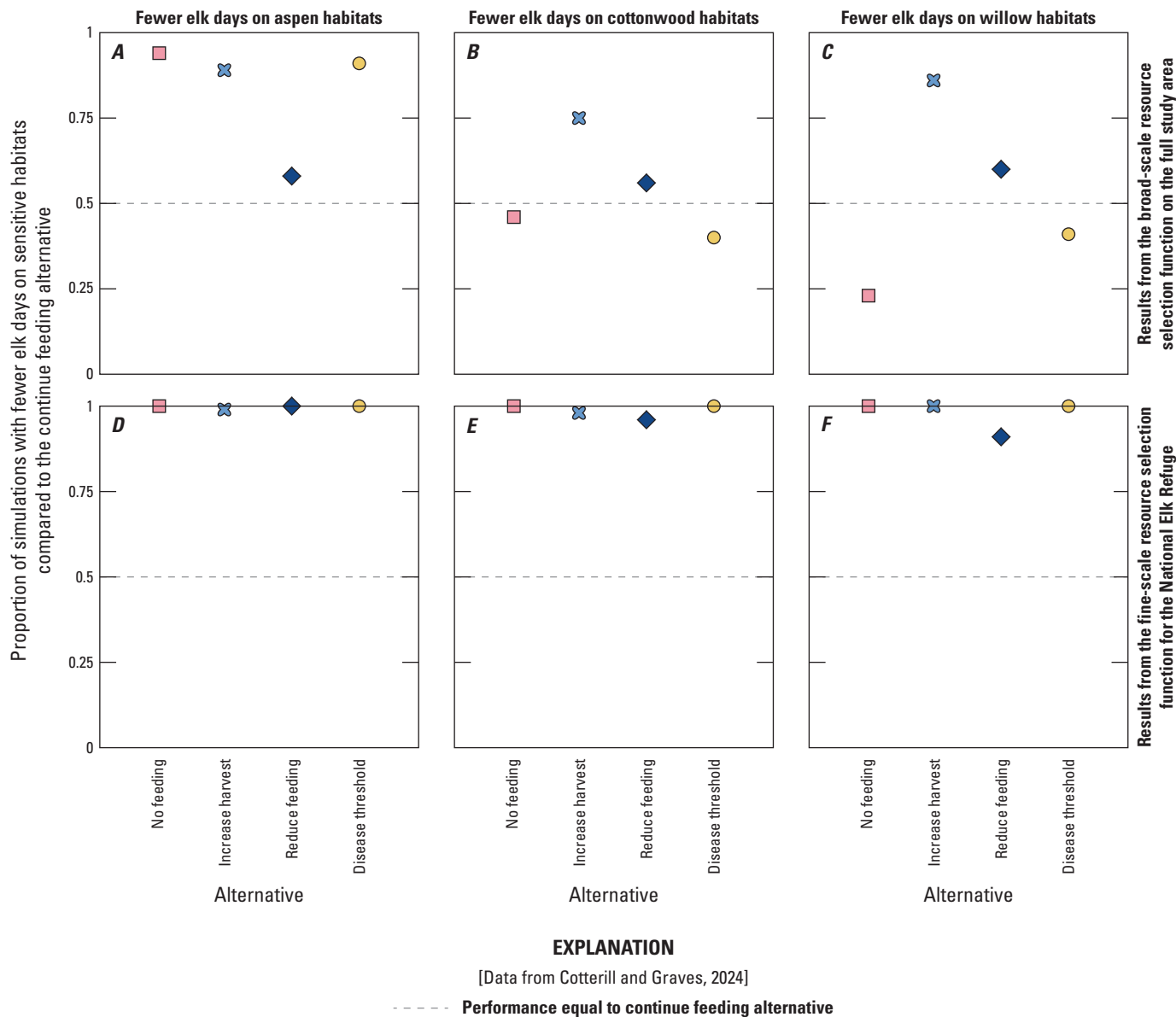


Figure C6.2. Plots showing the proportion of 100 simulations in which the other feedground management alternatives were projected to yield better outcomes compared to the continue feeding alternative in terms of *Cervus elaphus canadensis* (Erxleben, 1777; elk) affecting sensitive vegetation communities December–April using, *A*, the broad-scale resource selection function (RSF) for the full study area (elk days on communities of, *A*, *Populus tremuloides* Michx. [quaking aspen]; *B*, *Populus angustifolia* E. James [narrowleaf cottonwood]; and, *C*, *Salix* L. [willow]) and the fine-scale RSF for the National Elk Refuge (NER) in Jackson, Wyoming, only (elk days on communities of, *D*, quaking aspen, *E*, narrowleaf cottonwood, and, *F*, willow). These projections are for the first 5 years following implementation of the feedground management alternatives. Higher values indicate better outcomes.

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**APPENDIX E – U.S. Geological Survey, Chapter D of
Scientific Investigations Report 2024–5119:**

**Bison Population Dynamics, Harvest, and Human
Conflict Potential Under Feedground Management
Alternatives at the National Elk Refuge in Jackson,
Wyoming**

Ecosystems Mission Area—Biological Threats & Invasive Species Research Program

Prepared in cooperation with the National Park Service, U.S. Fish and Wildlife Service, and Wyoming Game and Fish Department

Bison Population Dynamics, Harvest, and Human Conflict Potential Under Feedground Management Alternatives at the National Elk Refuge in Jackson, Wyoming

Chapter D of

Decision Analysis in Support of the National Elk Refuge Bison and Elk Management Plan

Scientific Investigations Report 2024–5119

Cover. Bison move onto the McBride Feedground on the National Elk Refuge. The McBride Feedground is the northernmost feeding area on the Refuge and is the location where bison from the Jackson herd are fed alfalfa pellets in most winters. Photograph taken by Lori Iverson, U.S. Fish and Wildlife Service, February 2016.

Bison Population Dynamics, Harvest, and Human Conflict Potential Under Feedground Management Alternatives at the National Elk Refuge in Jackson, Wyoming

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Edited by Jonathan D. Cook and Paul C. Cross

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Scientific Investigations Report 2024–5119

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U.S. Geological Survey

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U.S. Geological Survey, Reston, Virginia: 2025

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Abbreviations

CWD	chronic wasting disease
FWS	U.S. Fish and Wildlife Service
GTNP	Grand Teton National Park
NPS	National Park Service
NER	National Elk Refuge
WGFD	Wyoming Game and Fish Department
WSMET	wildlife subject matter expert team

Bison Population Dynamics, Harvest, and Human Conflict Potential Under Feedground Management Alternatives at the National Elk Refuge in Jackson, Wyoming

By Jonathan D. Cook¹, Margaret C. McEachran¹, Gavin G. Cotterill¹, and Eric K. Cole²

Abstract

Bison bison (Linnaeus, 1758; American bison) were once abundant across North America but declined due to overharvesting in the late 1800s. The reintroduced population in and around Jackson, Wyoming has averaged 485 individuals between 2018–2023 and is the subject of a planning process to inform management strategies that will guide the U.S. Fish and Wildlife’s next “Bison and Elk Management Plan” for the National Elk Refuge. This small population may benefit from historical winter-feeding operations on the National Elk Refuge because those operations may increase overwinter survival and limit human-bison conflicts, which are the number of individual bison that engage in nuisance, damaging, or otherwise aggressive behaviors with humans and livestock, that may lead to culling and other sources of mortality (for example, vehicle collisions). To inform the next “Bison and Elk Management Plan,” the U.S. Geological Survey used a population model to evaluate five management alternatives for bison and *Cervus elaphus canadensis* (Erxleben, 1777; elk) feedground operations that included continuing the elk and bison feeding program, immediately stopping the feeding program, and three other alternatives that would phase out the feeding program after a period of time. The results indicate that the bison population would be expected to decline over the next 20 years under all alternatives that stop feeding bison on the refuge. Further, this decline would lead to an associated reduction in bison harvest opportunities for resident, nonresident, and Tribal hunters. Finally, human-bison conflicts would also be expected to increase under the no feeding alternatives because bison may venture onto private lands in greater numbers if feed is not provisioned during winter months. In combination, these results suggest that feeding may lead to better outcomes for bison over the next 20 years; however, these effects may be traded off against other downsides of the feedground program, such as increased rates of animal-to-animal contact on feedgrounds that can lead to disease transmission.

Introduction

Bison bison (Linnaeus, 1758; American bison) were once abundant and widespread across large extents of North America (Jones and others, 2020). The population that inhabited areas in and around Yellowstone National Park ([fig. D1](#)) was nearly extirpated by the mid-1880s and was lost from Jackson Hole, Wyoming. Bison were subsequently reintroduced into the Jackson region when 20 individuals were relocated from Yellowstone to an enclosure at Jackson Hole Wildlife Park in 1948 (U.S. Fish and Wildlife Service [FWS], 2019). The enclosed bison were supplemented with other bison from Theodore Roosevelt National Park after the discovery of brucellosis led to culling of the original herd. Then, in 1968 11 adults and 4–5 calves escaped and began ranging freely throughout the region, including seasonal movements to habitats on Grand Teton National Park (GTNP), the National Elk Refuge (NER), and other surrounding public and private lands. The escaped bison founded a free-ranging herd that initially remained at low abundance (less than 40 individuals). However, following the discovery of supplemental food provisioned to *Cervus elaphus canadensis* (Erxleben, 1777; elk) on the NER, the population grew by 10–14 percent annually starting in the 1980s (FWS and National Park Service [NPS], 2007). Winter counts in 2007 estimated a population high of 1,059 individuals; a more recent mid-winter count in 2023 estimated 514 individuals (WGFD, 2023).

While the larger population size has conveyed certain advantages to the Jackson bison herd, it has also led to some negative aspects related to human-bison conflicts and overgrazing on sensitive habitats. For example, larger bison populations are more resilient to random events and genetic effects, including bottlenecks (drastic population reduction) and drift (random gene variant fluctuations) that are a concern for bison in this population because of their low genetic diversity (Hartway and others, 2020). Larger populations likewise increase opportunities for wildlife viewing and photography, harvest by resident and nonresident Wyoming hunters, and Tribal ceremonial and subsistence take. However, this larger bison population has damaged native grasslands and other habitats from overgrazing, competed with elk for critical resources, elevated disease transmission risk from bison to domestic livestock, and increased costs to natural

¹U.S. Geological Survey.

²U.S. Fish and Wildlife Service.

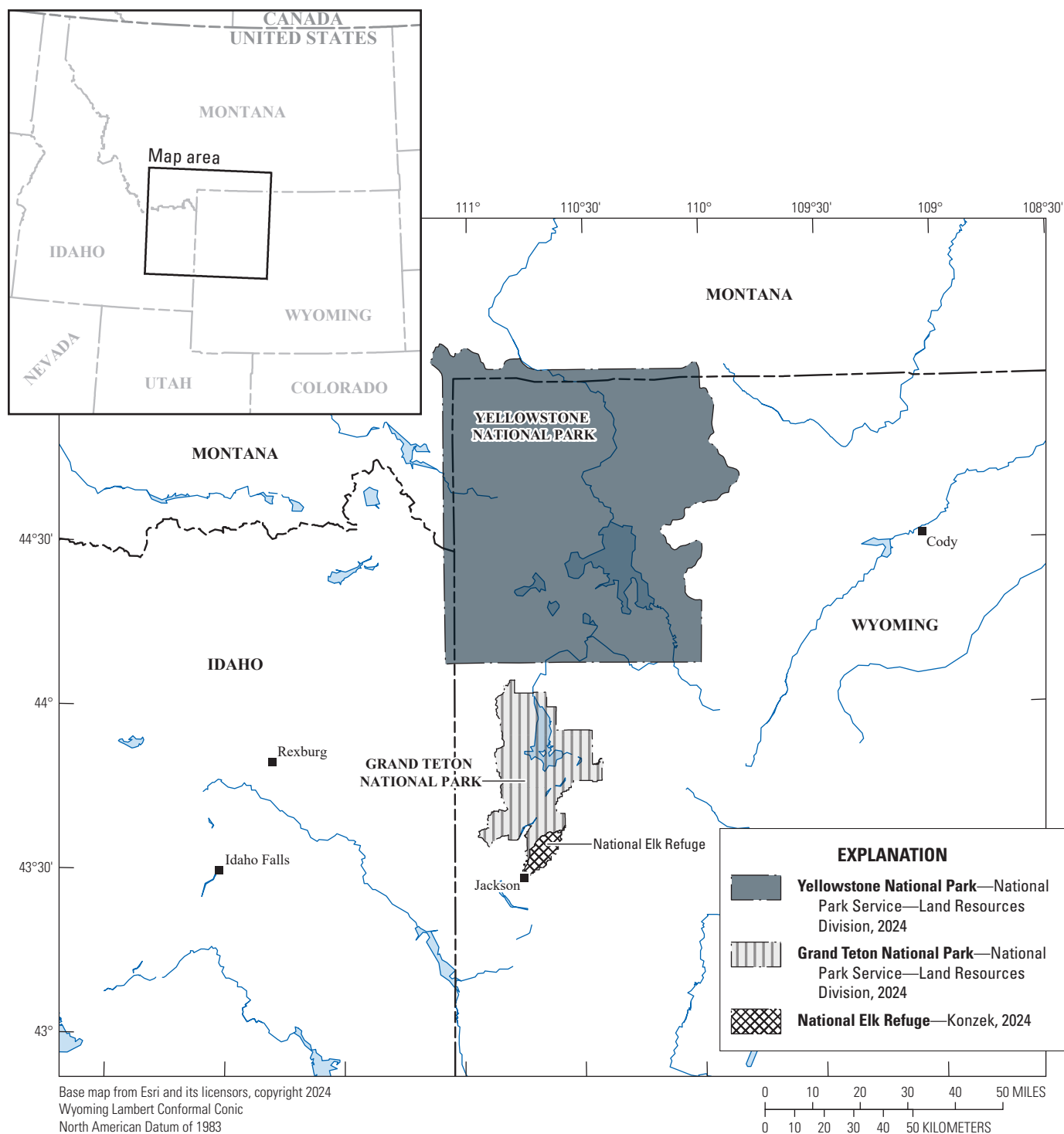


Figure D1. Map showing the boundaries of Yellowstone National Park, Grand Teton National Park, and the National Elk Refuge—the areas used by bison in the Greater Yellowstone Ecosystem, Wyoming.

resource agencies associated with bison management. Thus, successful bison management may require balancing the positive aspects of larger populations while limiting the effects of overabundance on sensitive habitats and human-bison conflicts.

Managing bison and associated conflicts falls under the authority of land management agencies, FWS, NPS, and state agencies tasked with managing wildlife and livestock, including the Wyoming Game and Fish Department (WGFD) and the Wyoming Livestock Board. Under their management authority, FWS is evaluating a range of management alternatives for bison and elk on the NER as part of their next “Bison and Elk Management Plan.” Currently, FWS provisions supplemental food to bison and elk during winter months to increase individual survival and reduce the potential for bison-elk and human-bison conflicts (FWS, 2019). The feeding program mainly operates between January and April of each year, depending on forage production and availability, and is guided by the “Step-Down Bison and Elk Management Plan” (FWS, 2019), which intends to reduce the reliance of bison and elk on winter feeding.

The alternatives under consideration for the next “Bison and Elk Management Plan” for the NER could alter feedground operations and replace the existing management (FWS and NPS, 2007) and step-down (FWS, 2019) plans. The alternatives were developed by FWS to evaluate changes to elk winter feeding in response to a recent detection of chronic wasting disease (CWD) in elk and concern that CWD could spread faster in elk in feedground settings (Cook and others, 2023). While bison are not susceptible to CWD, changes to winter feeding activities could change bison abundance, bison harvest, and the location and number of human-bison conflicts. This report details the development of a sex- and age-structured matrix model that uses empirical data and expert judgment to evaluate a set of proposed management alternatives and provide numeric estimates for objectives associated with bison abundance, bison harvest, and human-bison conflict potential over time and after 20 years of implementation (Cook and others, 2025b, this volume, chap. D). The results will inform an Environmental Impact Statement and assist managers in selecting an alternative that best meets management priorities and mandates on the NER.

Methods

We adapted an existing sex- and age-structured matrix model that was previously used to model other ungulate population dynamics and used it to evaluate alternatives in support of the NER “Bison and Elk Management Plan” (Cross and Almberg, 2019; Cook and others, 2023; Cross and others, 2023). The work to adapt the model proceeded in close collaboration with a wildlife subject matter expert team (WSMET) of 13 individuals with expertise in bison ecology and wildlife management principles. The team helped describe the expected changes to bison space use and population dynamics, the potential response of management agencies to bison populations, and also provided data that were

then developed into quantitative relationships. To inform parameter values, published literature and expert elicitation were used to estimate vital (population change) rates, harvest statistics, and other parameters. For expert elicitation, we used a modified Delphi and IDEA (“Investigate, Discuss, Estimate, Aggregate”) protocol with six science expert panelists who hold specialized knowledge about the parameters of interest (Hanea and others 2017); this group (herein referred to as ‘experts’, ‘expert panel’, or ‘expert panelist(s)’) was considered separate from the WSMET but did include five common members.

To initiate the model, historical bison herd counts and simulated bison population performance were incorporated with relevant sources of structural and parametric uncertainty identified by a scientific expert panel. For each alternative, we ran 1,000 projections while randomly sampling from the parametric uncertainty defined by the distribution for each parameter in each simulation. We then used the model to predict abundance, harvest, and winter movement dynamics of bison on and off the NER and under the management alternatives. In the following sections, we describe our methods, including the model structure, incorporation of alternatives, parameter estimation methods, and initial conditions.

Model Structure

The matrix model included five distinct sex and age classes chosen to represent demographic groupings that experience different vital and harvest rates within the Jackson bison herd. Those classes included (1) calves (0–1 years old) of both sexes, (2) male yearlings (1–2 years old), (3) female yearlings, (4) adult (more than 2 years old) males, and (5) adult females. The maximum age that an individual could reach was 15 years of age, and we assumed that reproduction began at age 2. The model transitioned those sex and age classes through monthly time steps and important life history events, including births in the spring, harvest in the fall, and monthly natural survival.

In addition to these monthly transitions, we included the following three dynamics that affect population performance: (1) calf mortality as a function of winter feeding and winter conditions, (2) mortality for all sex and age classes in human-bison conflict situations (for example, bison vehicle collisions, bison on cattle lands), and (3) an adaptive harvest rate-setting process as a function of the overall population size during February counts.

For calf mortality in severe winters and under unfed conditions, we allowed for increased mortality from January to April. The increased mortality was a result of a lack of available forage and increased expenditure of fat reserves during times of high snowpack. The reduction in survival was only applied to the calf class based on conversations with the WSMET and only in a proportion of modeled years (oral commun., 2024). We assumed that each year had a 0.25 probability of being severe enough to cause excess calf mortality.

The other source of mortality, human-bison conflict, also occurred in winter months. To determine how many bison would experience conflict and mortality in the winter, we randomly

assigned individual bison to one of the three following segments: (1) NER feedground, (2) native winter range, and (3) conflict bison population segments. The NER feedground bison were bison individuals that overwinter on NER, whereas the native winter range and conflict bison population segments overwinter off of NER either in areas with low conflict potential (native winter range segment), or in areas with high conflict potential (conflict segment). The conflict bison were expected to have increased use of private lands where negative interactions with local residents, livestock, and vehicles would occur, thus, we assumed that this segment was subjected to a higher monthly mortality rate. We determined the proportion of bison in each segment based on expert judgment and historical winter counts of bison on the NER and winter range. The feedground segment represented those individuals that overwinter on the NER (January–April in the model) in an average year and received most of their daily caloric intake by consuming provisioned food resources. The winter range segment consisted of individuals who did not overwinter on the NER feedgrounds but instead spent winter months on native winter ranges, including the northern and eastern areas of the GTNP (WSMET, oral commun., 2024). The final group, conflict bison, was assumed to either be at a low number when feedgrounds were operational or at a high number when feedground operations ceased (WSMET, oral commun., 2024). Under these unfed conditions, we assumed that the proportion of bison that used the NER (and expected to be fed) would split onto private lands if food were not provisioned. Further, we assumed that conflicts would be higher under severe winter conditions. Additional details on calf and conflict mortality are in the “Incorporating Alternatives” section.

For adaptive harvest, we allowed harvest rates of each sex and age class to be set annually according to the relationship between the February count and the Jackson bison herd objective of 500 total animals. The WGFD manages ungulates in Wyoming according to population objectives (± 20 percent), which consider available habitat, sustainable harvest opportunities, human-wildlife conflict, disease, and other factors. Population objectives are recommended by WGFD wildlife managers using biological and social considerations, undergo a public input process, and are decided by the Wyoming Game and Fish Commission (WGFD, 2024). The WGFD conducts population surveys annually and sets annual hunting seasons based on those surveys. The functional relationship of the adaptive harvest within the model, therefore, allowed for higher annual harvest rates in years when bison populations were large relative to the objective and lower rates when populations were small relative to the objective. If populations fell 20 percent below the objective (for example, February counts below 400 individuals), then the harvest rate was set to 0.01 to approximate only the continuation of Tribal harvests during those years. In the past, five bison per year have been harvested by the Shoshone-Bannock Tribes of Eastern Idaho, but recently, the Eastern Shoshone Tribe of the Wind River Reservation has also participated. We calibrated the relationship between the harvest and the objective based on historical data from the WGFD (unpub. data, 2024; calibrated data shown in [app. D1](#)).

Incorporating Alternatives

The specific set of management alternatives considered here was described by FWS and included these five options (for full details, including the connection with elk population size, please refer to Cook and others, 2025a, this volume, chap. A):

1. *Continue feeding.*—The NER will continue to provision food to bison and elk during winter months based on forage availability and number of conflicts.
2. *No feeding.*—The NER will immediately stop provisioning food to bison and elk during winter months.
3. *Increased elk harvest, then stop feeding.*—The NER will continue to provision food to bison and elk during winter months for the next 5 years, during which time the NER will work with the WGFD to increase elk harvest and attempt to reduce elk population size to 5,000.
4. *Reduce feeding, then stop feeding altogether.*—The NER will provision a reduced ration to elk during winter months for the next 5 years to reduce the elk population size to 5,000 prior to feedground closures. Exclosures will be designed to protect aspen stands in the south region of the NER and for willow and cottonwood north of the NER.
5. *Feeding phaseout after 3 percent chronic wasting disease (CWD) prevalence.*—The NER will continue to provision food to bison and elk during winter months until CWD sampling reveals 3 percent prevalence in the Jackson elk herd, at which point all feeding activities will cease on the NER. The timing of the 3 percent trigger (for example, years of feeding until this 3 percent disease threshold was reached) was informed based on estimates from Cross and others (2025, this volume, chap. B).

The performance metrics, or the measures that were used to evaluate the performance of each alternative on bison, were (1) the population size of bison in year 20, (2) the cumulative number of bison harvested across 20 years, and (3) the cumulative number of bison involved in human-bison conflict across 20 years. The FWS selected the 20-year projection period to match the typical plan implementation period before revisions are considered.

To project each of the alternatives, the model was altered to include the anticipated management strategy changes. For the continue feeding alternative, the basic structure of the population model was used, using historical data to split a single herd into two segments between the NER feedground and winter range segment during winter months. The adaptive harvest was also included to approximate the continue feeding harvest rate-setting process. The study assumed that under all alternatives the NER feedground and winter range segments experienced the same birth and natural mortality rates regardless of winter year type (that is, no excess mortality in severe winters during the years when feeding occurs on the NER). We expected that, under continue feeding, bison would locate supplemental food or other sources of forage even in severe winters because of the small

population size in the Jackson region. Further, while harvest rates are likely different between NER and winter range segments, we only allowed for a single adaptive harvest rate to affect the entire population because of data limitations and challenges in including additional model complexities.

The proportion of bison in each population segment for a given year was estimated by fitting a beta distribution to the proportion of the bison population observed on the NER feedground in February from 2014–23 ([table D1](#)). The proportion of winter range bison was taken as one minus the proportion of bison counted on the feedground ([table D1](#)). In addition to the NER feedground and winter range segments, a low probability (0.015) of bison from either segment coming into human conflict each year was included after being approximated from Wyoming Department of Transportation Highway Safety Crash data (Wyoming Department of Transportation, written commun., 2023). This estimate is likely higher in reality because it does not include data collected in the GTNP. Further, the GTNP works to reduce human-bison conflicts by actively moving bison off of roadways during winter months.

Table D1. Bison population counts, proportion fed, and harvest totals from 2014 through 2023 in the Jackson, Wyoming region.

[Counts include bison on and off the NER feedground, summed total of the raw counts conducted in February, adjusted counts that account for the imperfect sightability of bison in unfed settings, the percent of bison on feed, and total harvest. — data were not yet available]

Year	Fed counts	Unfed counts	Raw counts	Adjusted counts	Percent on feed	Total harvest
2014	778	8	786	786	96.9	299
2015	677	14	691	691	97.5	206
2016	618	48	666	668	92.9	274
2017	504	42	546	548	92.3	70
2018	0	567	567	567	0.0	91
2019	155	329	484	495	32.0	92
2020	306	182	488	494	62.7	109
2021	144	299	443	454	32.5	91
2022	382	84	466	469	82.0	130
2023	360	72	432	434	83.3	—

The four other alternatives that included variations on feed cessation on the NER were incorporated by adapting the model to include their respective mechanisms of change associated with winter habitat use changes of unfed elk and conflict potential. The adaptations were essentially the same across alternatives and primarily varied according to the timing of implementation. Under the no feeding alternative, model adaptations were triggered immediately (in other words, all modeled years), whereas under the increased harvest and reduced feeding alternatives, the changes occurred starting at the 5-year mark or after the disease threshold was met under the disease threshold alternative (in other words,

3 percent CWD prevalence detected in elk; Cross and others 2025, this volume, chap. B). Once feeding stopped (under no feeding, disease threshold, increased harvest, and reduced feeding alternatives), the changes to the model included the following conditions:

1. A larger proportion of the bison population transitioned to conflict situations during unfed winter months. This conflict population segment came from the proportion of bison that transitioned to the NER feedgrounds but were then not provisioned any food. On average, in the first year after the feedground program ended and in an average winter, 21 percent (95-percent prediction interval, 4 to 50 percent) of bison that returned to the NER for winter food provisions were expected to transition to conflict situations, whereas 79 percent of those bison would avoid conflict. The previously described winter range segment remained in place as part of the four no feeding alternatives.
2. We estimated that more previously fed bison would transition to conflict situations during severe winter conditions. In contrast to the percentage of conflict bison in the first year of no feeding in an average winter (21 percent, on average), the aggregate estimate for conflict bison in severe winters was 48 percent (95-percent prediction interval, 19 to 79 percent). We defined severe winters in a manner consistent with Cotterill and others (2025, this volume, chap. C) and thus treated it as a random variable with an annual probability of occurrence of 25 percent.
3. Conflict bison had lower overwinter survival compared to bison that stayed on the NER and winter range. We estimated the reduction in survival using expert judgment ([app. D2](#)) and expected mortality to occur from various sources, including bison vehicle collisions and culling on private lands.
4. In addition to increases in the proportion of bison that experienced conflict, the WSMET (oral commun., 2024) expressed uncertainty about how human-bison conflict may play out over time, especially under a prolonged lack of supplemental feeding on the NER and given any other changes that occur to mitigate acute bison conflicts (for example, private landowners erect fencing to protect haystacks). As a result, we worked with the WSMET to develop two competing hypotheses. The first was that the proportion of the bison population that ends up in conflict remains the same year after year, and the second was that the proportion of bison that end up in conflict changes over time. We used expert judgment to elicit weights on each hypothesis as well as the trend in the second. More details on the hypotheses and elicitation can be found in appendixes [D2](#) and [D3](#).

Parameter Estimation

Limited information is available for the Jackson bison herd to estimate vital and harvest rates under the management alternatives. For survival rates, we used data from Yellowstone

bison, including information published in annual bison status reports that estimate mean survival and year-to-year variation (Geremia and others, 2019). We used Geremia and others (2019) estimates from 2000–19 for adult female, adult male, and calf annual survival (table D2). Calf annual survival estimates were then applied to our yearling age class as well (ages 1–2 years old; table D2). We further reduced calf survival in severe winters by first performing a repeated and random Bernoulli draw {0,1} in each simulation year that functioned as an indicator of winter severity, where 0 indicated average winter survival and 1 indicated a severe winter. The annual probability of a severe winter was set to 0.25 based on the NER data and Cross and others (2025, this volume, chap. B). Then, based on whether it was a severe winter, either the baseline survival was applied as described above or monthly calf survival was 95 percent of baseline winter survival to approximate calf mortality during harsh winters. The reduced survival was derived by reviewing research on ungulate response to severe winter conditions (e.g., mule deer survival during the 2016–17 and 2018–19 severe winters was reduced from 0.9 to 0.65–0.7; LaSharr and others, 2023) and adjusting those effects relative to expectations about bison.

Table D2. Vital rates of bison in the Greater Yellowstone Ecosystem, including herds in Yellowstone National Park and the Jackson, Wyoming region.

[SD=standard deviation]

Demographic	Mean	Parametric SD
Survival rates ¹ , annual		
Calf	0.90	0.04
Yearling	0.90	0.04
Adult female	0.95	0.01
Adult male	0.95	0.03
Reproduction rates ² , annual		
Calf and yearling	0.00	0.00
Adult female	0.71	0.13
Harvest mortality rates ³ , annual		
Maximum calf	0.01	0.01
Maximum yearling male	0.18	0.07
Maximum yearling female	0.18	0.07
Maximum adult female	0.20	0.07
Maximum adult male	0.48	0.07

¹Approximated from Geremia and others, 2019.
²Approximated from Cain and others, 1997; 1998; 1999; 2000; 2001; 2002; 2004.
³Approximated from WGFD, unpub. data, 2024.

For birth rates, we used annual progress reports from a multi-year bison study (1997–2004) in the GTNP that focused on the reproduction and demography effects of brucellosis infection (Cain and others, 1997; 2004). The reports include annual data on collared and aged female bison, including pregnancy checks and

monitoring for births. In other herds, brucellosis seropositivity, a bacterial infection, has been shown to reduce bison birth rates (Fuller and others, 2007). In this study, all pregnancy and birth rate data, from both seropositive and seronegative bison, were used to estimate the overall adult female reproduction rate because of the uncertainty in how brucellosis trends might change over time under the alternatives (table D2). Finally, based on WGFD harvest data (WGFD, unpub. data, 2024), harvest rates were estimated, and then a sex and age class-specific maximum harvest rate was calculated by dividing the total annual harvest by the total February counts of the NER and native winter range bison (table D2). Maximum harvest rates informed our estimates for annual harvest as a function of population size (app. D1).

Winter bison distribution was informed by winter counts from 2018–23 (table D1). Bison have been counted at the NER and on the winter range since the 1940s. Prior to 2018, the majority overwintered on and around the NER. More recently, the proportion using feedgrounds has decreased (NPS, written commun., 2023). Therefore, we used 2018–23 data to assign bison to the NER feedgrounds and winter range. Under the no feeding alternatives, the individual four-point estimates (that is, low, high, central estimate, as well as a measure of uncertainty) from each science expert panel was used to generate random aggregate distributions that further split the NER bison into those that are expected to stay on the refuge and those that transition to conflict (app. D2). The aggregate distributions were generated by first fitting a distribution that matched the support of the parameter of interest (for example, beta distribution for vital rate parameters) to the quantiles provided by the experts. Then each distribution was aggregated using the Vincent average method (Howerton and others, 2023).

Initial Conditions

Starting values for the population size in models were randomly selected at the start of each simulation using data from 2018–23 and adjusted for imperfect detection of winter range bison (table D1). Our adjusted counts assumed that sightability was perfect on the NER but was biased low for counts of bison on winter ranges. Hess (2002) estimated bison count error during ground and aerial surveys in summer and winter. The probability of detection estimates ranged from 0.919 (95-percent confidence interval, 0.819 to 0.955) during winter aerial counts when bison were distributed in smaller groups in denser cover to a probability of detection of 0.975 (95-percent confidence interval, 0.959 to 0.983) during summer ground counts while bison were in larger groups but still distributed across the landscape in ways that challenged observation. Based on conversations with WSMET (oral commun., 2024) and given the landscape conditions in the region, we assumed that sightability was high and used the higher sightability estimate of 0.975. We further assumed that bison counts for fed bison occurred without error because of the smaller and denser population of the NER bison compared to Hess (2002). Thus, we fit the Hess (2002) sightability estimates to a beta distribution and assumed the true count of bison from the February counts to be given by equation D1:

$$p^{sight} \sim \text{beta}(180.35, 10.36),$$

$$N_t^{Total} = N_t^{FG} + \frac{N_t^{WR}}{p^{sight}}, \quad (D1)$$

where

- p^{sight} is the sightability estimate for animals on the winter range that may be observed imperfectly;
- N_t^{FG} is the February population count for bison on the NER feedground;
- N_t^{WR} is the February population count for winter range bison;
- N_t^{Total} is the sightability-adjusted estimate for the total bison population size.

In addition to accounting for observational error, we also treated the starting population size as a random variable to account for interannual variability in count data. Overall, bison counts have had a declining trend over recent years with 786 individuals counted in 2014 but 432 in 2023 (table D1). To avoid sampling from this declining trend, we used a subset of annual count data (2019–23) and randomly drew from these counts to initialize each model projection (modeled year, y , where $y=0$ for the initial population size).

Results

The Jackson bison herd was projected to remain stable under the continue feeding alternative with a final median population size of 541 individuals in year 20 (table D3). Under the no feeding, disease threshold, increased elk harvest, and reduced feeding alternatives, we projected smaller population sizes of 469, 470, 472, and 473 individuals, respectively. Thus, the difference between the continue feeding and alternatives that called for the cessation of feeding was 13 percent smaller population sizes at year 20 (table D3). In terms of population projections over

time for the no feeding, disease threshold, increased harvest, and reduced feeding alternatives, we projected a gradual decrease in populations starting in the years immediately following any change in feeding operations on the NER (fig. D2).

For harvest projections, the 20-year cumulative number of bison harvested was 1,879 under the continue feeding alternative and between 371 to 587 fewer animals than in the other four alternatives that stopped feeding. The no feeding alternative resulted in 1,292 bison harvested over the next 20 years, compared to 1,387 under the disease threshold, 1,496 under increased harvest, and 1,508 under reduced feeding alternatives. On an annual basis, these resulted in an average of 95 harvested bison in the first year and 93 harvested in year 20 under continue feeding management. For the rest of the alternatives that call for the cessation of feeding, there was a declining trend in average annual harvest. Under no feeding, the average annual harvest was 94 in year 1 and 56 in year 20; increased harvest alternative had an average harvest of 97 in year 1 and 59 in year 20; reduced feeding had averages of 97 in year 1 and 60 in year 20; and, finally, the disease threshold averaged 97 in year 1 and 57 in year 20 (fig. D3).

For the projections of the number of conflict bison, experts generally agreed that bison behavior would change over time in response to feed cessation. This study incorporated the two hypotheses about these temporal trends in conflict. The first hypothesis, that there was no trend in bison conflicts over time (for example, bison do not learn new behaviors that might lead to increased or decreased conflict), had an overall average belief weight of 0.19, whereas the other hypothesis, that bison conflict would either increase or decrease over time, had an overall average belief weight of 0.81. These results indicate that the expert panel believed it to be approximately 4 times more likely that bison conflict dynamics will change over time (app. D3). However, despite this general agreement, there was less agreement about the direction of that change (for example, whether conflicts would increase or decrease over time). One out of five experts believed that conflict would increase over time, but four out of five believed that conflict would decrease over time. As a result, we developed a mixed distribution that drew from either an increasing (one-fifth of the weight) or decreasing (four-fifths of the weight) proportion of the NER bison population as ending up in conflict situations.

Overall, after incorporating the structural uncertainty about future human-bison conflicts and parametric uncertainty about the proportion of bison that will redistribute into areas of conflict, we found that the continue feeding alternative had the lowest median number of conflict bison (143 cumulative across 20 years; fig. D4A; table D3) and the no feeding alternative had the highest number of conflict bison (1,077 cumulative across 20 years; fig. D4B; table D3). The other three alternatives had intermediate values of conflict bison with 756 increased harvest, 756 reduced feeding, and 905 disease threshold (fig. D4C, D, and E; table D3). In general, incorporating the two hypotheses surrounding changes in human-bison conflict over time led to a high degree of uncertainty around these median values, and a declining trend in conflict once feeding on the NER was stopped.

Table D3. Median population size in year 20, median cumulative harvest over 20 years, and median cumulative number of conflict bison over 20 years under the 5 alternatives in the Jackson, Wyoming region.

[SD, standard deviation]

Alternatives	Population size	SD	Harvest	SD	Conflict bison	SD
Continue feeding	541	57	1,879	198	143	16
No feeding	469	65	1,292	247	1,077	474
Disease threshold	470	67	1,387	248	905	482
Increased harvest	472	70	1,496	245	756	473
Reduced feeding	473	65	1,508	234	756	441

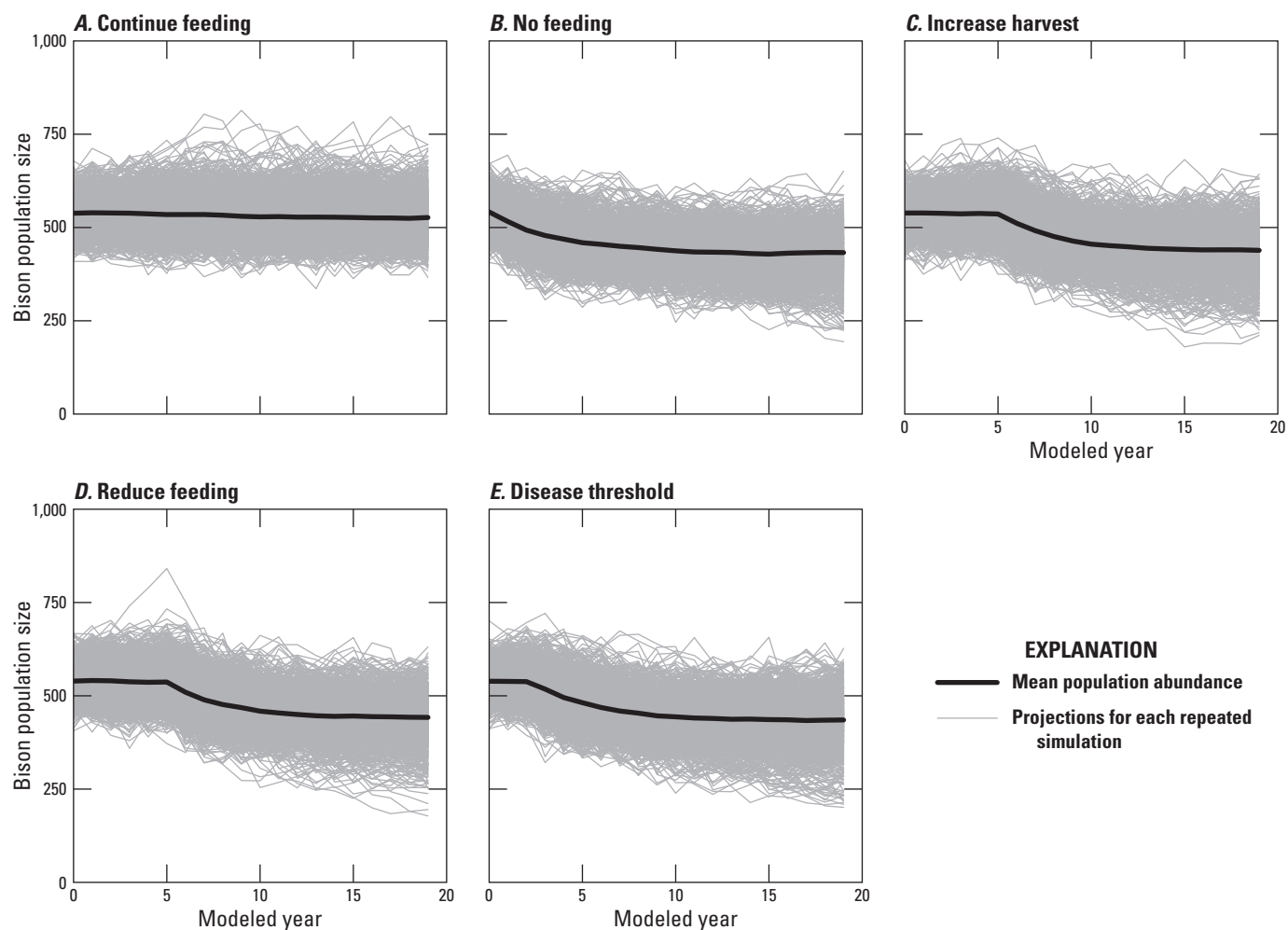


Figure D2. Graphs showing the projected bison population size in the Jackson, Wyoming region over time under the five alternatives: *A*, continue feeding, *B*, no feeding, *C*, increase harvest, *D*, reduce feeding, and, *E*, disease threshold.

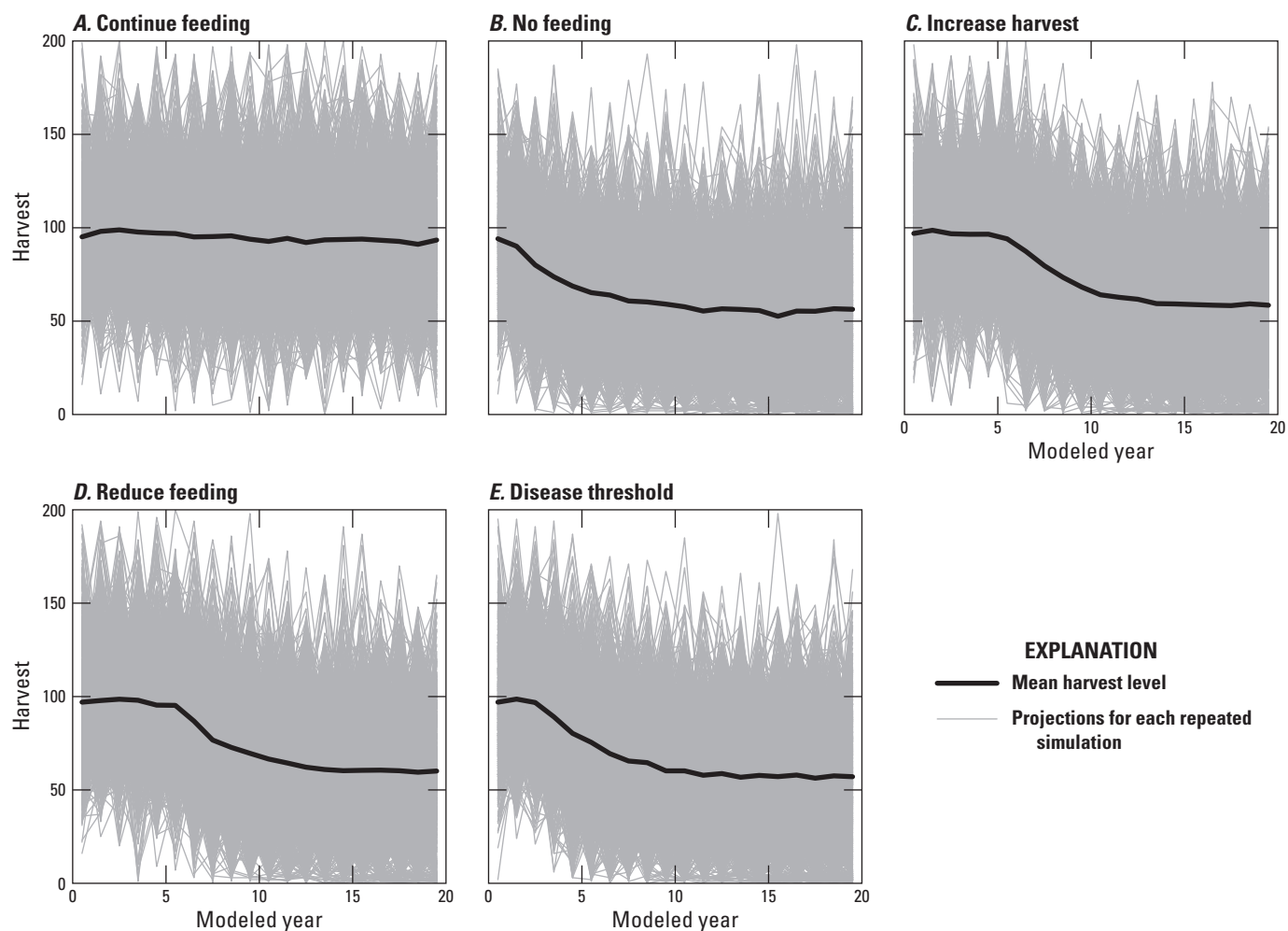


Figure D3. Graphs showing the projected bison harvest in the Jackson, Wyoming region over time under the five alternatives: *A*, continue feeding, *B*, no feeding, *C*, increase harvest, *D*, reduce feeding, and, *E*, disease threshold.

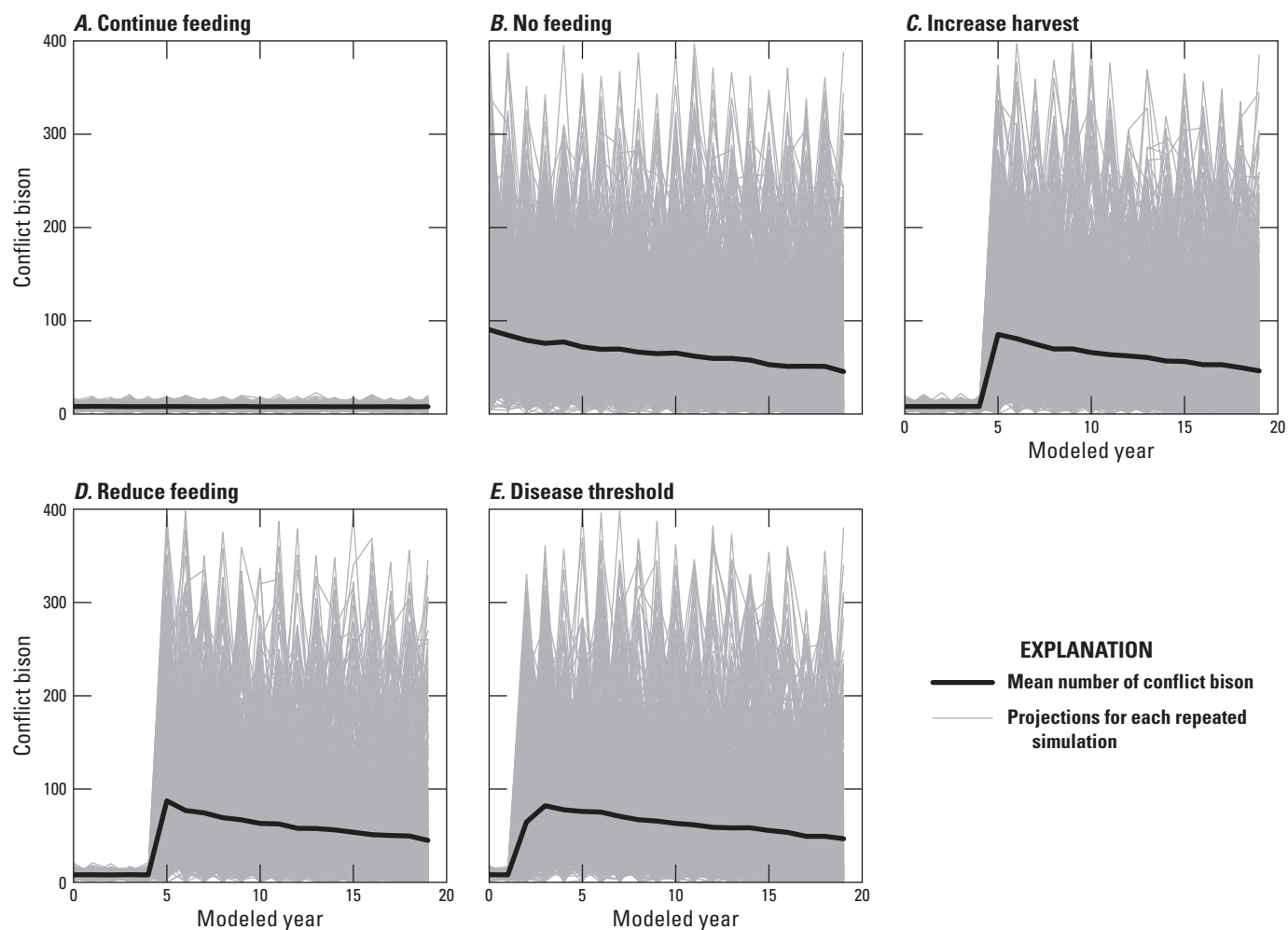


Figure D4. Graphs showing the projected human-bison conflicts in the Jackson, Wyoming region over time under the five alternatives: *A*, continue feeding, *B*, no feeding, *C*, increase harvest, *D*, reduce feeding, and, *E*, disease threshold.

Across the three metrics (bison abundance, harvest, and conflicts), the continue feeding alternative performed the best in the near-term (3–5 years) as well as in the long-term (20 years; [fig. D5](#)). However, the other four alternatives ranked comparably at year 20, with a reduced number of bison and harvest, as well as a higher but declining conflict potential compared to continue feeding. Nevertheless, how those changes occurred over time was slightly variable and depended on when feedground operations were ceased. For example, under the no feeding alternative, the decline in bison abundance and harvest and the increase in conflict started to happen in the first year, whereas, under the phaseout alternatives (reduced ration and aggressive harvest), this decline did not begin until year 5. The disease trigger alternative was intermediate in the performance of all metrics and depended on detecting CWD within elk before feeding is stopped.

Summary

This study projected the consequences of five potential management alternatives on three indicators for the Jackson, Wyoming, *Bison bison* (Linnaeus, 1758; American bison) herd over the next 20 years. The alternatives included one that maintained the National Elk Refuge feedground program and four others that stopped feeding over different time spans; the performance metrics used to evaluate the alternatives included bison abundance in year 20, as well as the cumulative harvest and number of conflict bison over that same period. In terms of performance, the continue feeding alternative was estimated to perform the best across all

three metrics. For abundance, continuing the feedground program resulted in a stable population over time; the 20-year estimate of 541 individuals was 68–72 individuals larger than the four alternatives that stop feeding activities on the National Elk Refuge. Similarly, this study found that continuing to feed bison led to higher harvest and fewer conflicts when compared against the alternatives that stop overwinter feeding.

Several assumptions were made in this modeling work that affected the overall results. First, we assumed that the Wyoming Game and Fish Department would continue to manage the Jackson bison herd in relation to the existing population objective of 500 individuals. This assumption had a strong effect on abundance and harvest projections. For example, under the continue feeding management alternative, the adaptive harvest rate setting process limited the potential growth of the bison herd by increasing harvest within years with higher population sizes and over the 20-year projections. On an annual basis, this led to an average of approximately 95 bison being harvested in each year in our continue feeding projections compared to an average of 97 harvested annually between 2018–23 (WGFD, unpub. data, 2024). While the comparisons between observed and simulated results match well for the continue feeding alternative, no comparable data are available to make these comparisons under the four alternatives that stop feeding on National Elk Refuge.

In contrast to the continue feeding alternative and the stable population of around 500 bison under this alternative, the four alternatives that stop feeding resulted in reductions in average population size and annual harvest. This was primarily a result of an increase in human-bison conflict and the associated reduction in survival that is expected by experts in conflict situations. The

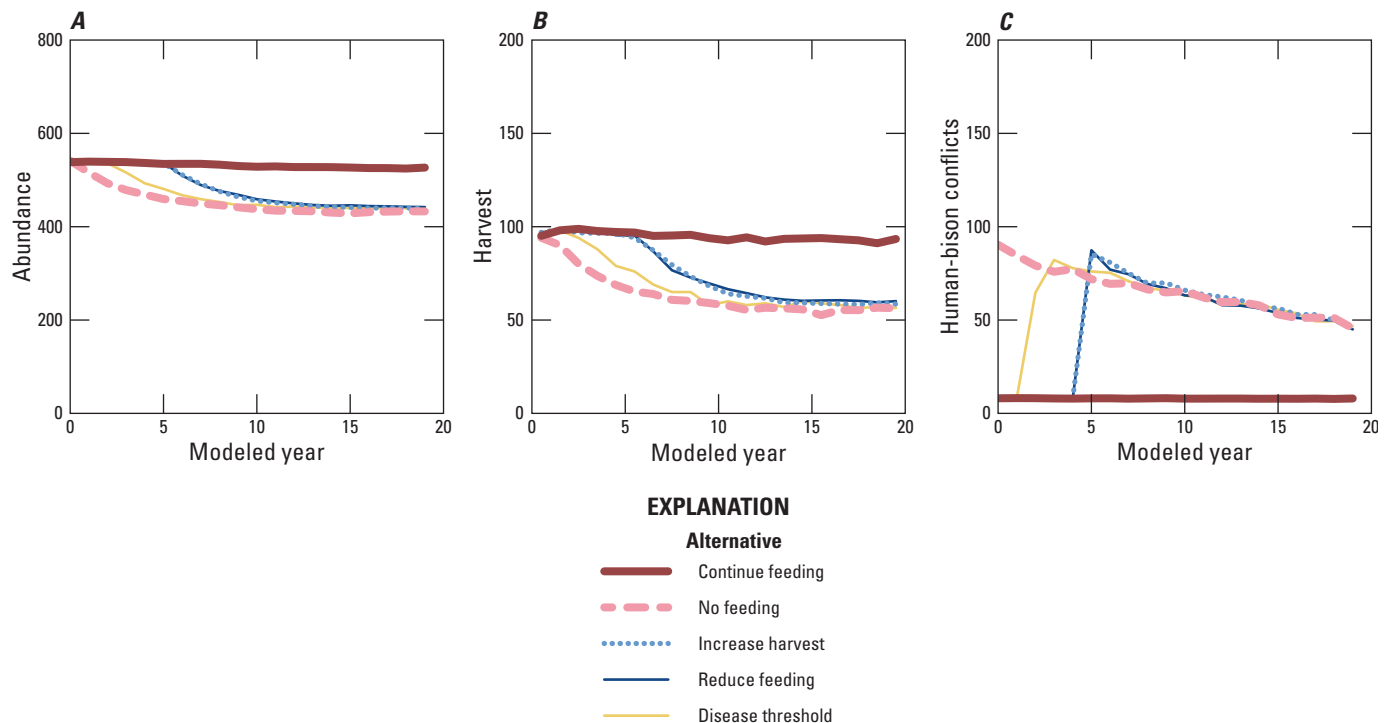


Figure D5. Graphs showing the projected effects of the alternative on the performance metrics over time under the five alternatives: *A*, abundance, *B*, harvest, and *C*, human-bison conflicts.

expert panel, which informed the transition of bison to conflict without feeding and the associated survival of conflict bison, estimated that survival would be reduced by between 3–25 percent, depending on the sex and age of the individual (table D1, app. D2). This reduction dramatically reduces the available bison harvest, particularly as the population approaches 400 individuals and the adaptive harvest relationship in the simulation model reduces the harvest rate closer to zero under these conditions.

This study assumed that fed and unfed bison have experienced, and will continue to experience, vital rates similar to the much larger bison population that inhabits Yellowstone National Park and surrounding areas. Most of the vital rate information, except for birth rates, drawn from the Yellowstone herd, was used to make assumptions about the productivity of the Jackson herd, should the National Elk Refuge select an alternative that required the cessation of feeding. Further, we assumed that there would be excess mortality in 25 percent of years that lowered the monthly survival of calves in severe winters. Lastly, we assumed the success rate of bison hunters to remain the same over time; however, if bison no longer return to areas where they are currently vulnerable to harvest, it is conceivable that bison harvest dynamics change over the next 20 years in ways that are unpredictable. In total, none of these assumptions can be tested prior to a management decision on the feedground program; however, the results for the continue feeding alternative tend to align well with observations of the Jackson herd over the past six February counts in terms of harvest and overall abundance.

We assumed that there is no relationship between bison density and brucellosis seropositivity. Brucellosis seropositivity affects the birth rates of bison (for example, higher rates of brucellosis result in lower birth rates) and thus, any changes to disease dynamics may affect the productivity of this herd and the resulting estimates of population size, harvest, and conflict potential. Furthermore, we assumed no relationship between elk and bison, and the potential for predators to switch prey in future scenarios in which elk numbers decline.

Finally, our projections indicate that the continuation of the feedground program has the potential to lead to more bison and harvest, as well as fewer conflicts when compared to the no feeding, disease threshold, reduced feeding, and increased elk harvest alternatives. However, the continue threat of elevated transmission of bison and elk diseases makes decisions on whether and how to feed these herds a difficult one.

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Appendix D1. Adaptive Harvest

Annual bison harvest is regulated to ensure a stable population size over time (table D1.1). Within our model, we incorporated a submodel that defined an adaptive relationship between annual harvest rate and February population size to ensure that the simulated population was not driven more than 20 percent below the population objective as a result of harvest. The submodel that we used to approximate this adaptive process was given by equation D1.1:

$$h_{a,y} = \left(hmax_{a,s} \left(1 - c \left(\frac{Objective}{N_y^{Total}} \right)^\delta \right) \right), \quad (D1.1)$$

where

$h_{a,y}$ is the harvest rate by age (a) and model year (y);

N_y^{Total} is the total February population size from the current simulation year (y);

Objective is the population objective (500) for the Jackson bison herd;

c is the proportion reduction when population was at carrying capacity;

δ controls the shape of the density-dependence; and,

$hmax_{a,s}$ is the maximum harvest rate by age class (a) and sex (s).

We assumed that the proportion reduction, c , and shape parameter, δ , were the same as values used in Cook and others (2023) and approximated the relationship between harvest and population size (fig. D1.1)

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Table D1.1. Number of active hunting licenses in Wyoming and total bison harvest for juveniles, males, and females from years 2013 through 2022. Data from Tribal harvest not included.

[Each hunter can only harvest one bison per license. Data are from the Wyoming Game and Fish Department (2022)]

Year	Total active licenses	Juvenile harvest	Male harvest	Female harvest	Total harvest
2014	321	32	111	156	299
2015	288	36	47	123	206
2016	281	37	69	168	274
2017	111	2	46	22	70
2018	182	2	73	16	91
2019	146	5	50	37	92
2020	161	7	72	30	109
2021	139	11	59	21	91
2022	141	16	68	46	130

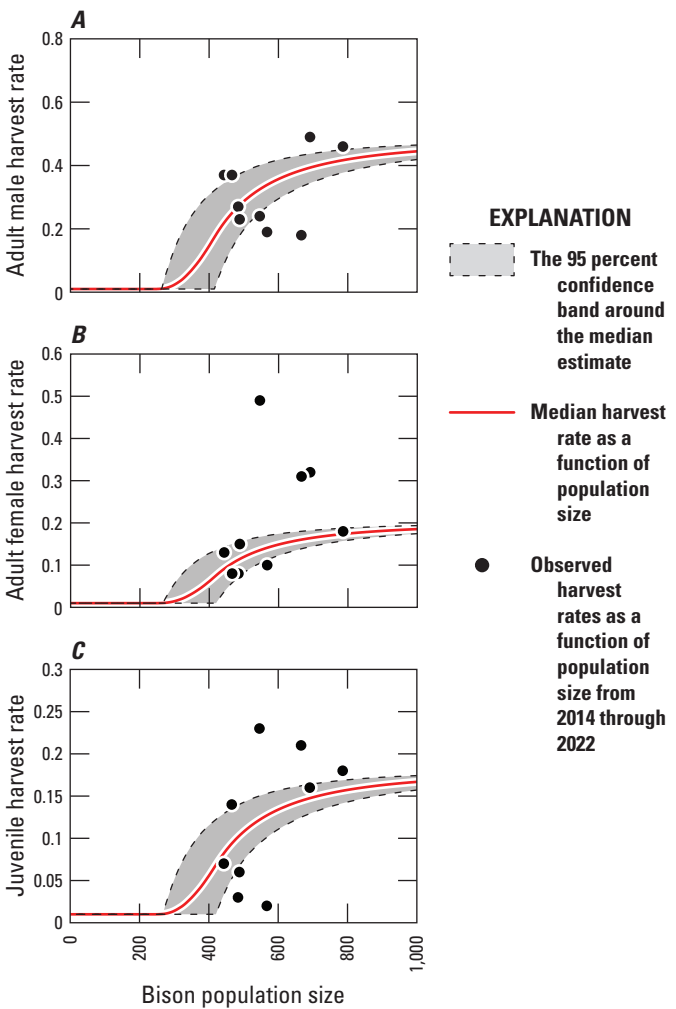


Figure D1.1. Graph showing the modeled relationship between bison herd population size and harvest rate: A, adult male data, B, adult female data, and, C, juvenile data.

Appendix D2. Expert Elicitation

We elicited experts on parameters using seven questions that were focused on unknown parameter values, relationships, or estimates, that were necessary to estimate bison population dynamics under different alternatives for the “Environmental Impact Statement” on bison and elk management on the National Elk Refuge (NER). These parameters and their uncertainty were elicited using a series of structured techniques that minimize bias and maximize the accuracy of estimates derived from the experts (Morgan, 2014; Sutherland and Burgman, 2015). Specifically, we used a four-point elicitation method to estimate a distribution that represented each expert’s knowledge (Speirs-Bridge and others, 2010) as well as a modified Delphi process that maximized the ability of the group to share privileged knowledge with one another in a way that might help improve individual and group-aggregate estimates (Hanea and others, 2017).

Uncertainty About Bison Vital Rates and Redistribution

The expert panel’s responses to Question 1—“Under current feeding operations, some bison spend at least part of the winter months overwintering on the NER in most years. In an average winter, what proportion of bison that overwinter on the NER would relocate to high conflict locations if the NER stopped provisioning supplemental feed?”—can be found in [figure D2.1](#).

The expert panel responses to Question 2—“Under current feeding operations, some bison spend at least part of the winter months overwintering on the NER in most years. In a severe winter, what proportion of bison that overwinter on the NER would relocate to high conflict locations if the NER stopped provisioning supplemental feed?”—can be found in [figure D2.2](#).

The expert panel responses to Question 3—“Assume that there were 100 human-bison conflicts in the first year after the NER stopped provisioning food, how many bison would you expect to be in conflict situations in year 20 after the NER stopped feeding (that is, no feeding for the past 20 years)?”—can be found in [figure D2.3](#). The panel was instructed to assume that years 1 and 20 were exactly the same in terms of winter conditions, habitat and landscape composition and configuration, and management response to bison movements. And to also assume that the overall population of bison remains the same, including the movements between the NER and other seasonal ranges ([fig. D2.3](#)).

The expert panel responses to Question 4—“For bison groups that overwinter on areas of high conflict potential, how many adult female bison would survive out of 100 annually?”—can be found in [figure D2.4](#). The panel was instructed to assume that, on average, 95 out of 100 adult female bison survive annually in feedground areas and other locations of low human-bison conflict potential.

The expert panel responses to Question 5—“For bison groups that overwinter on areas of high conflict potential, how many juvenile female bison would survive out of 100, annually?”—can be found

in [figure D2.5](#). The panel was instructed to assume that, on average, 95 out of 100 juvenile female bison survive annually in feedground areas and other locations of low human-bison conflict potential.

The expert panel responses to Question 6—“For bison groups that overwinter on areas of high conflict potential, how many adult male bison would survive out of 100, annually?”—can be found in [figure D2.6](#). The panel was instructed to assume that, on average, 95 out of 100 adult male bison survive annually in feedground areas and other locations of low human-bison conflict potential.

The expert panel responses to Question 7—“For bison groups that overwinter on areas of high conflict potential, how many juvenile male bison would survive out of 100, annually?”—can be found in [figure D2.7](#). The panel was instructed to assume that, on average, 95 out of 100 juvenile male bison survive annually in feedground areas and other locations of low human-bison conflict potential.

The expert panel responses to Question 8—For bison groups that overwinter on areas of high conflict potential, how many bison calves would survive out of 100, annually?—can be found in [figure D2.8](#). The panel was instructed to assume that, on average, 90 out of 100 bison calves survive annually in feedground areas and other locations of low human-bison conflict potential.

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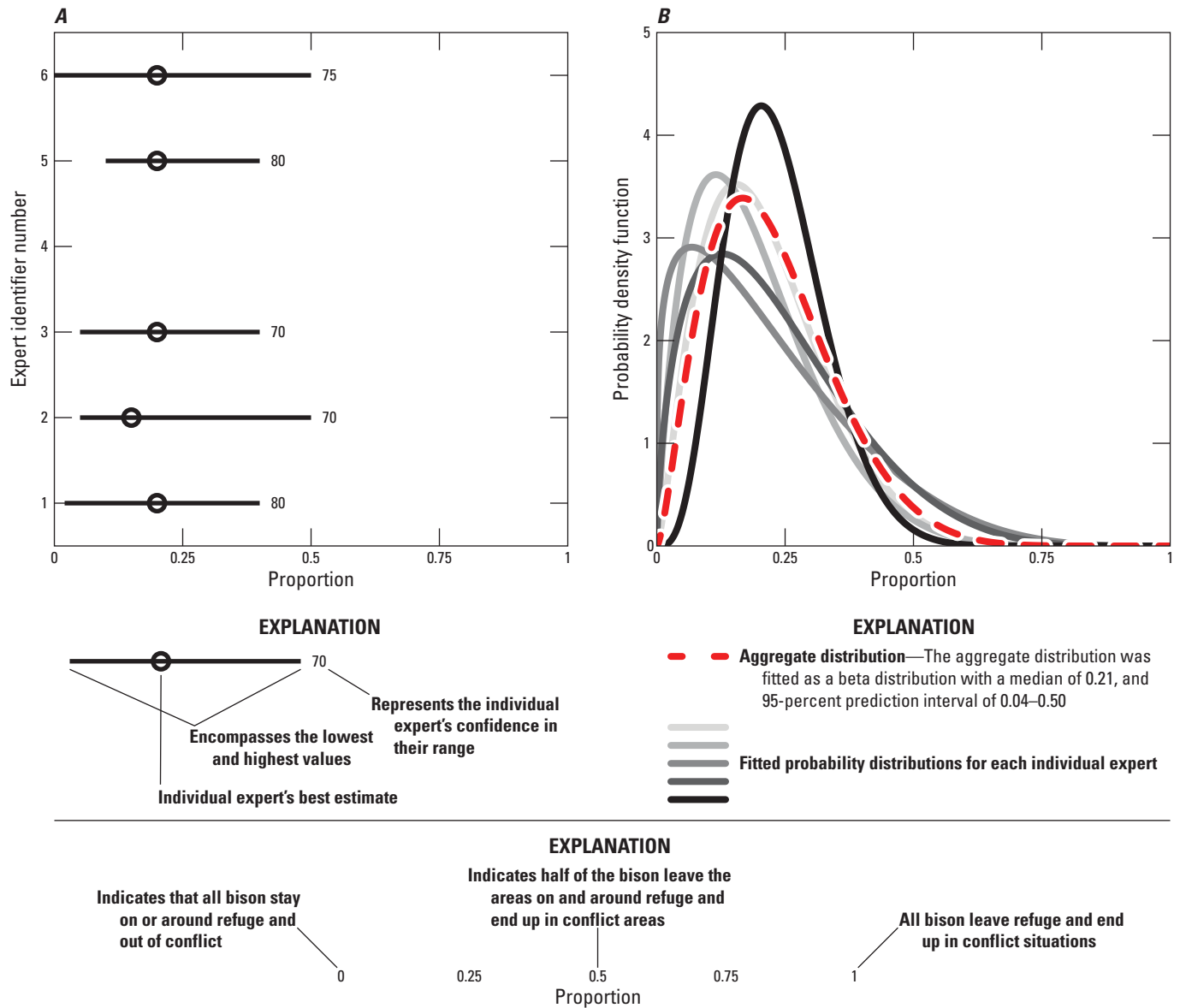


Figure D2.1. Graphs showing, *A*, the raw, four-point estimates of each of the five experts, and, *B*, the fitted probability distributions for each individual expert and the aggregate distribution for Question 1.

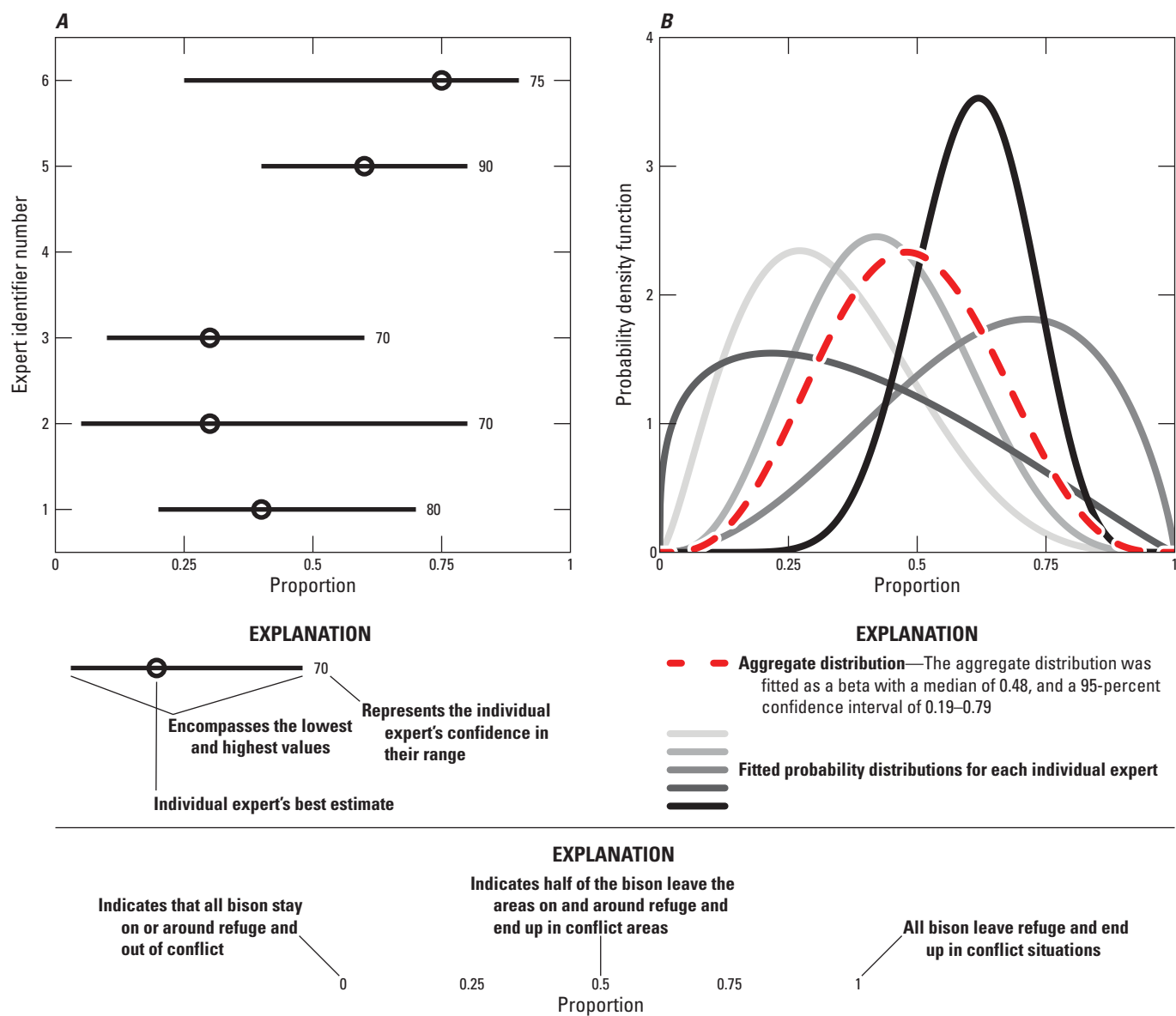


Figure D2.2. Graphs showing, *A*, the raw, four-point estimates of each of the five experts, and, *B*, the fitted probability distributions for each individual expert and the aggregate distribution for Question 2.

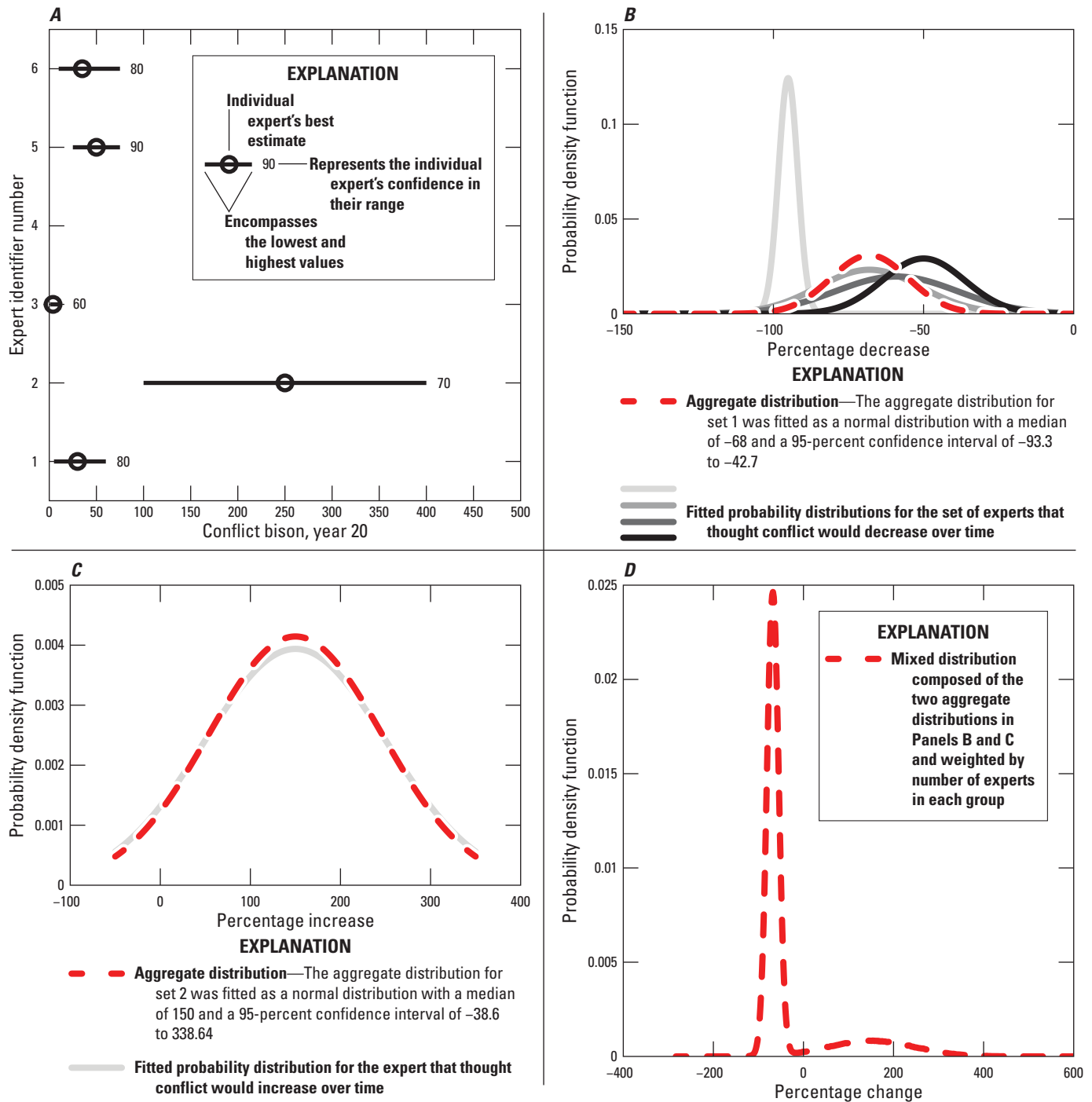


Figure D2.3. Graphs showing, *A*, the raw, four-point estimates of each of the five experts. One set of experts ($n=4$) estimated that conflict would decrease over time. Another expert ($n=1$) estimated that conflict would increase over time; *B*, the fitted probability distributions for the set of experts that thought conflict would decrease over time and their aggregate distribution; *C*, the fitted probability distributions for the expert that thought conflict would increase over time and their aggregate distribution; and, *D*, the mixed distribution that includes expert set 1 and set 2. Expert 4 participated in other questions about the distribution and survival of bison but did not complete the question about belief in the two hypotheses.

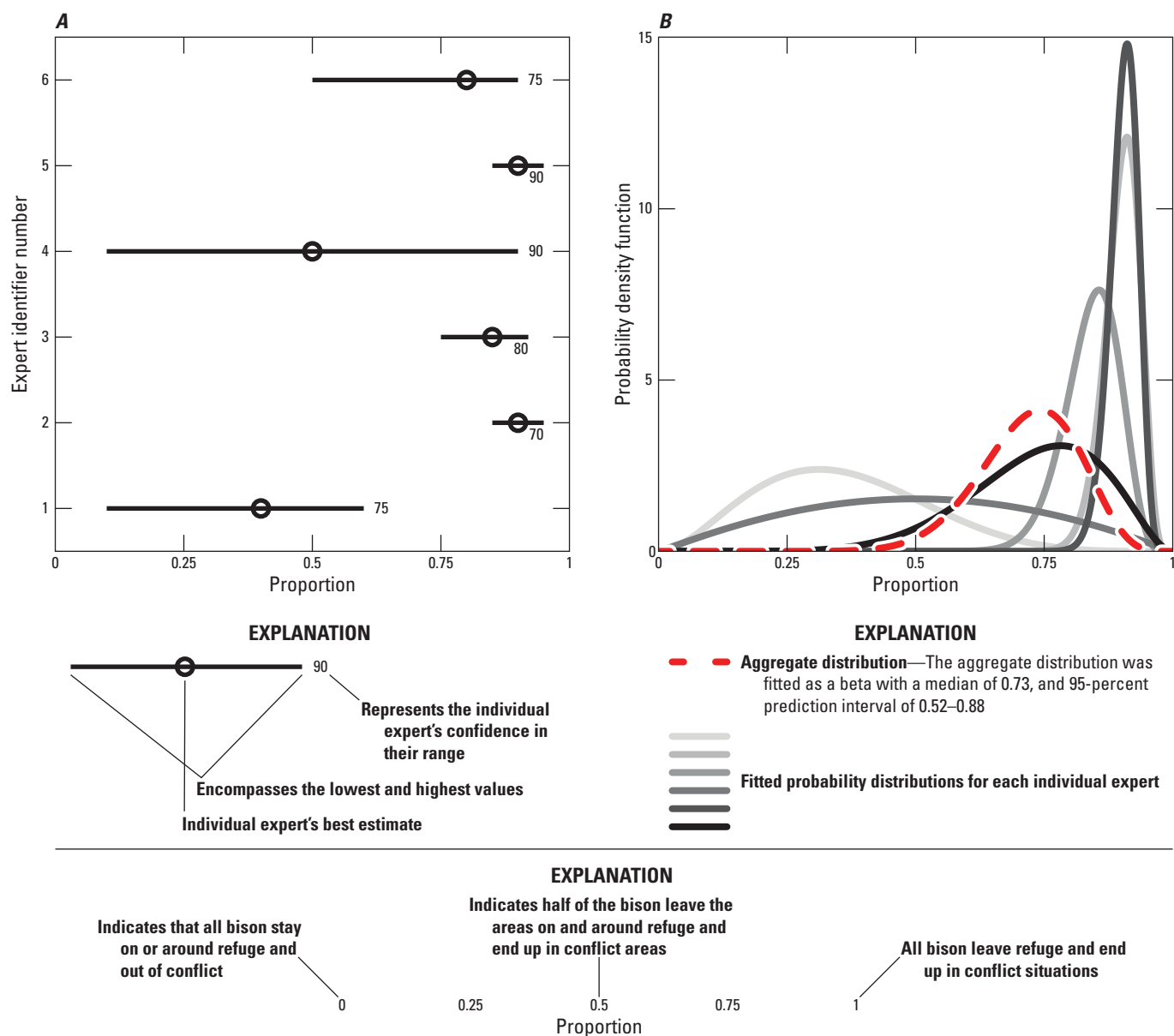


Figure D2.4. Graphs showing, *A*, the raw, four-point estimates of each of the six experts, and, *B*, the fitted probability distributions for each individual expert and the aggregate distribution for Question 4.

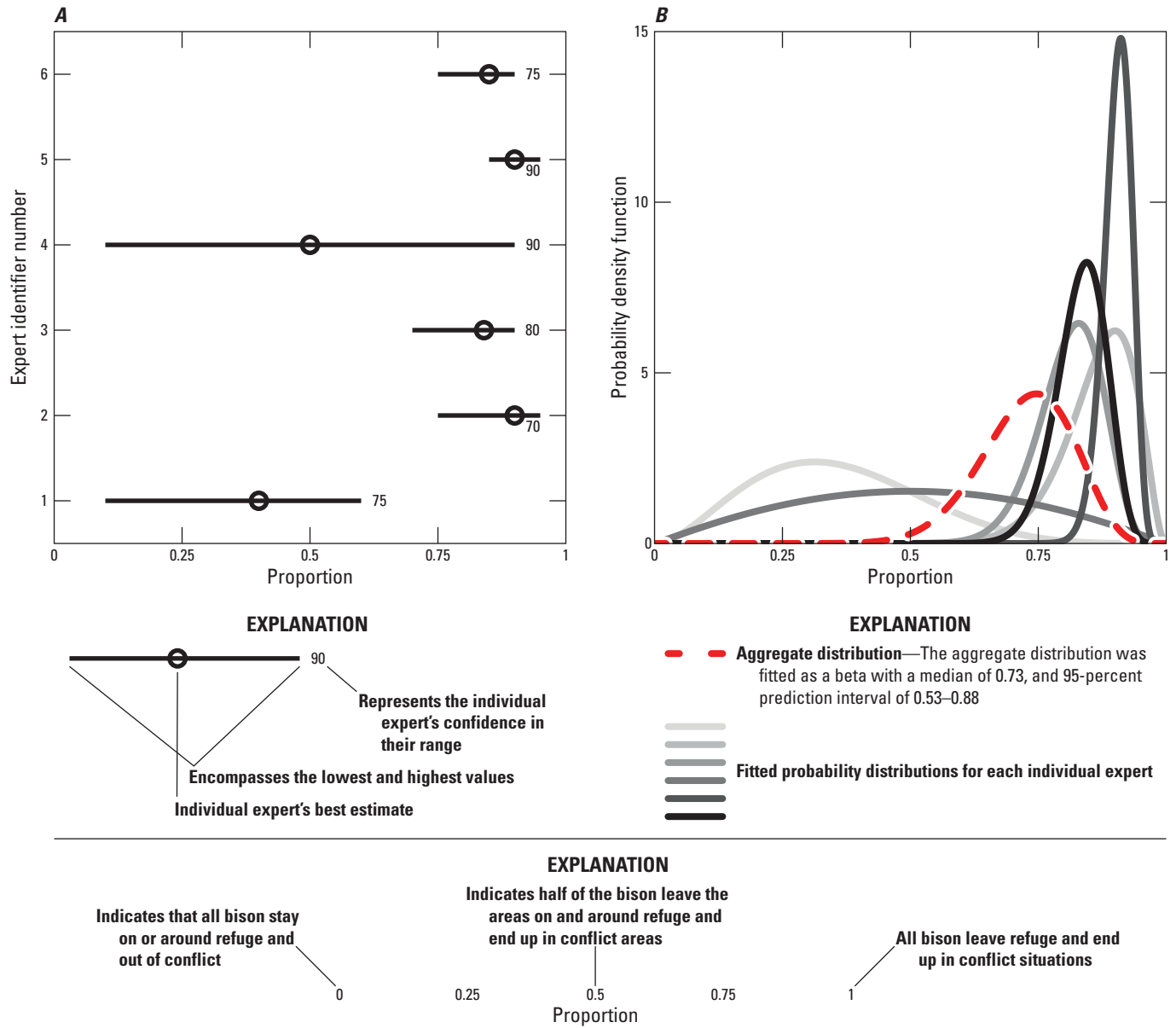


Figure D2.5. Graph showing, *A*, the raw, four-point estimates of each of the six experts, and, *B*, the fitted probability distributions for each individual expert and the aggregate distribution for Question 5.

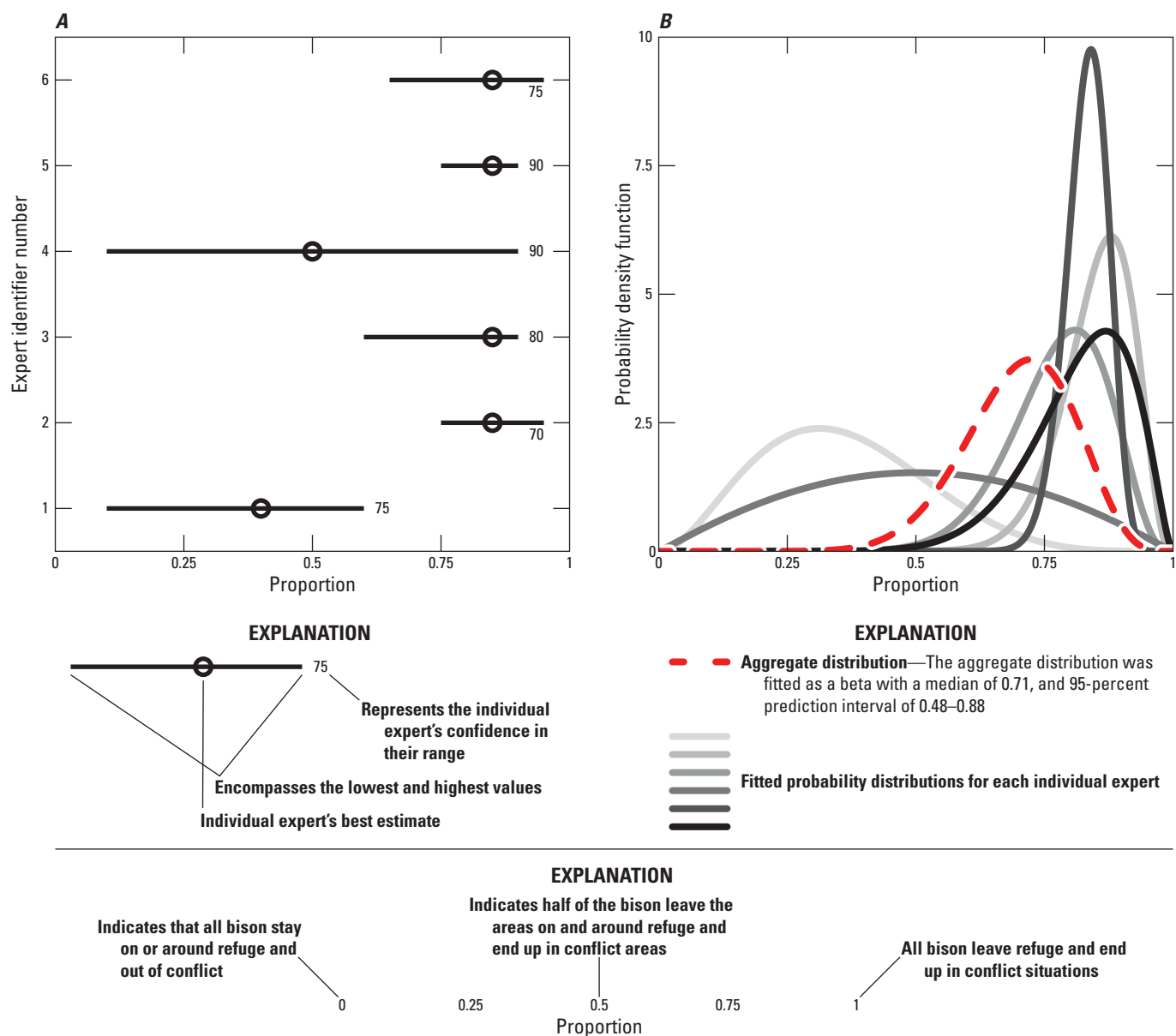


Figure D2.6. Graphs showing, *A*, the raw, four-point estimates of each of the six experts, and, *B*, the fitted probability distributions for each individual expert and the aggregate distribution for Question 6.

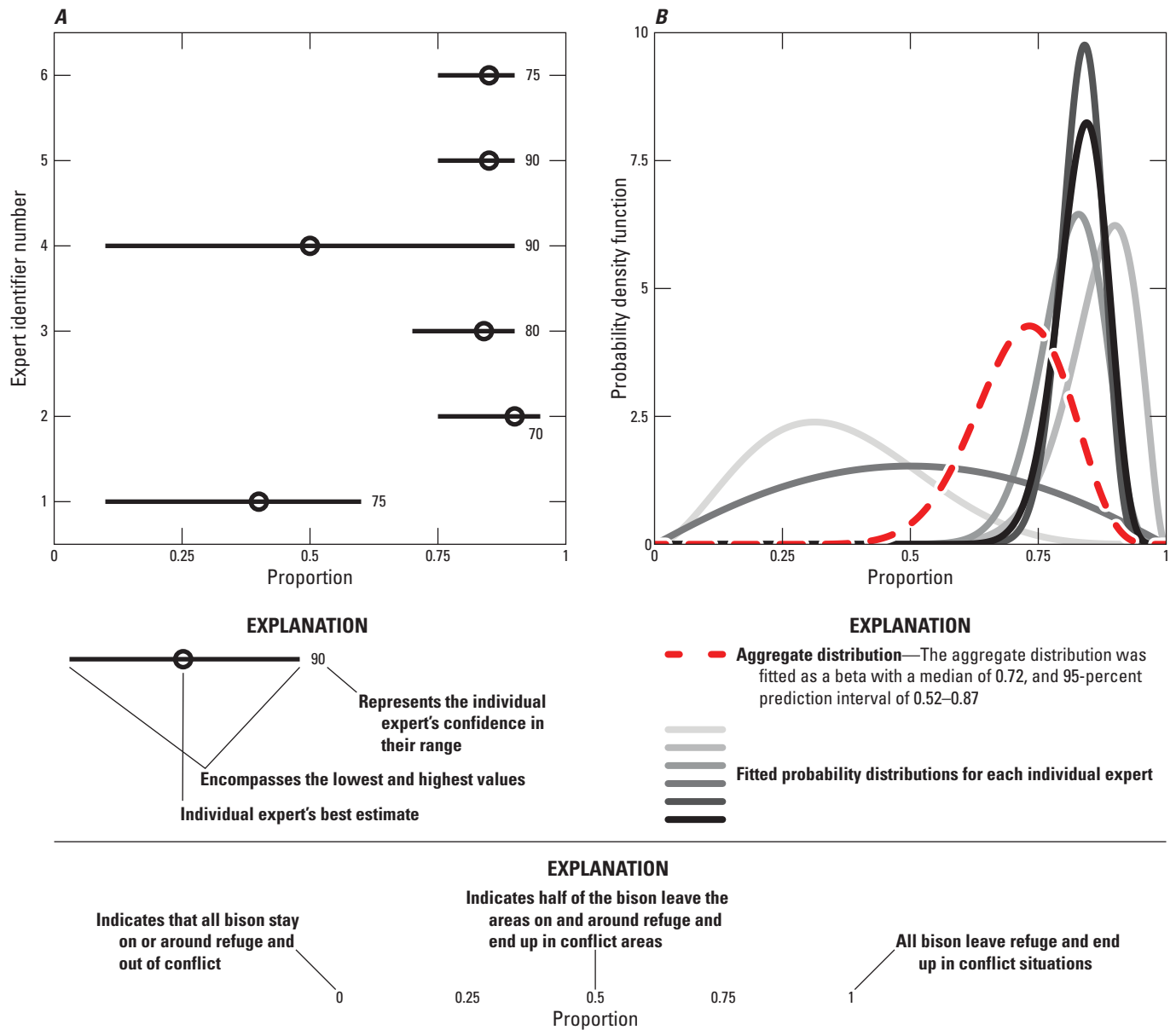


Figure D2.7. Graphs showing, *A*, the raw, four-point estimates of each of the six experts, and, *B*, the fitted probability distributions for each individual expert and the aggregate distribution for Question 7.

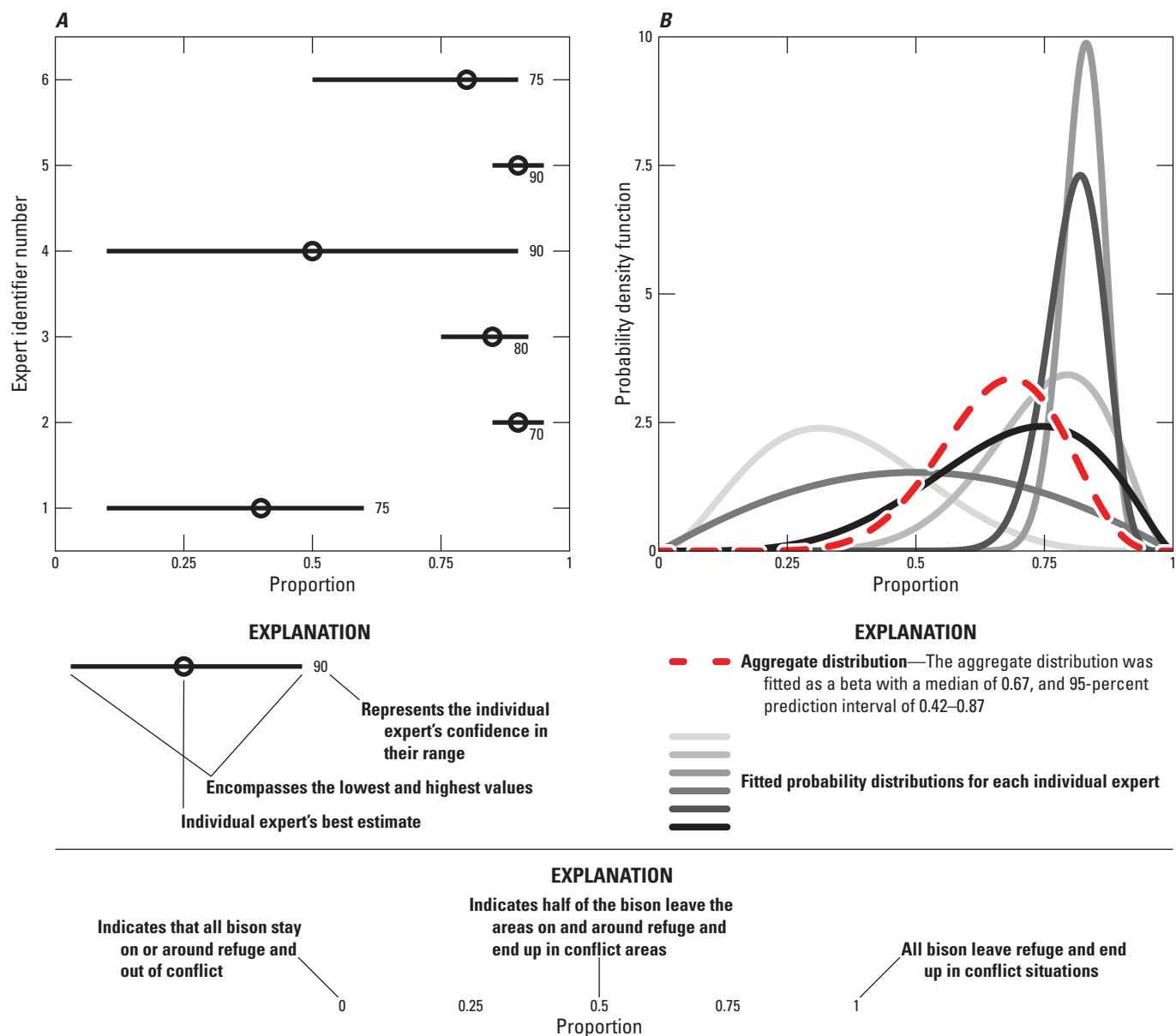


Figure D2.8. Graphs showing, *A*, the raw, four-point estimates of each of the six experts, and, *B*, the fitted probability distributions for each individual expert and the aggregate distribution for Question 8.

Appendix D3. Incorporating Structural Uncertainty in Human-bison Conflict Potential

Human-bison conflict as a result of changing feedground management, changes to landscape and environmental conditions (for example, winter severity patterns), and the potential response of wildlife management agencies to those conflicts is uncertain in the near- and long-term. Based on conversations with the expert panel and these sources of uncertainty, we considered the following two principal hypotheses in the number of human-bison conflicts over time (table D3.1):

Hypothesis 1. Human-bison conflict will remain relatively stable over time such that the proportion of bison that transition from winter range habitat on and around the National Elk Refuge to conflict situations will remain the same over time (fig. D3.1); and,

Hypothesis 2. Human-bison conflict will have an increasing or decreasing trend over time as a result of a multitude of potential mechanisms, including actions by agencies or the public that prevent conflict better over time, or from learned behaviors of bison that lead to avoidance of these areas (fig. D3.1).

We informed the weight on each of the two hypotheses (stable and increasing or decreasing conflict potential) using the expert panel. We asked each expert to provide their belief, on a 0–1 scale, that human-bison conflict would reduce or increase over time. We then took the mean of those estimates and used it for the weight

on hypothesis 2, and 1 minus the mean value as the weight for hypothesis 1. Table D3.1 includes the response of each expert panelist and the mean value used in the population projections.

Table D3.1. Expert belief in hypotheses 1 and 2.

[Hypothesis 1 is that human-bison conflict will remain relatively stable over time such that the proportion of bison that transition from winter range habitat on and around the National Elk Refuge to conflict situations will remain the same over time. Hypothesis 2 is that human-bison conflict will have an increasing or decreasing trend over time as a result of a multitude of potential mechanisms, including actions by agencies or the public that prevent conflict better over time or from learned behaviors of bison that lead to avoidance of these areas. Expert 4 participated in other questions about the distribution and survival of bison but did not complete the question about belief in the two hypotheses. —, no response]

Expert number	Belief in hypothesis 1	Belief in hypothesis 2
1	0.15	0.85
2	0.25	0.75
3	0.25	0.75
4	—	—
5	0.30	0.70
6	0.00	1.00

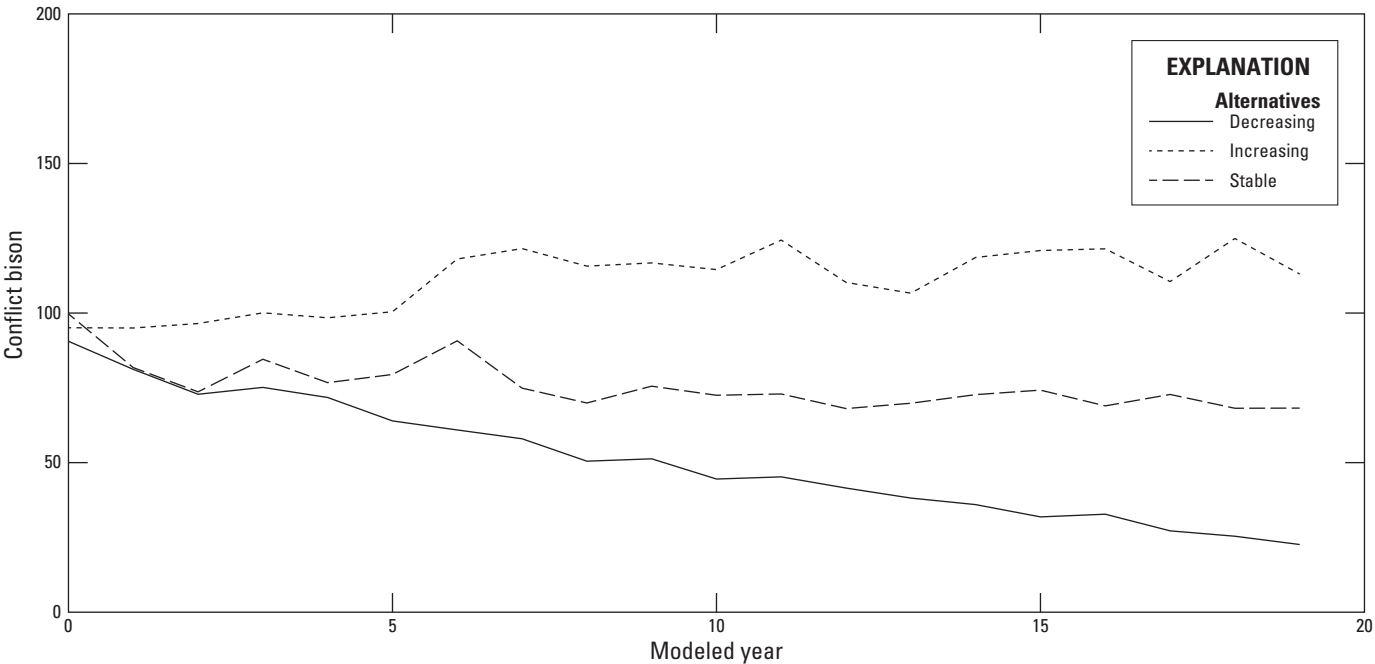


Figure D3.1. Plot representing the structural uncertainty in the relationship between human-bison conflicts in the Jackson, Wyoming region and the underlying hypotheses for how conflict might change over time.

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APPENDIX F – U.S. Geological Survey, Chapter E of Scientific Investigations Report 2024–5119:

Estimating the Social and Economic Consequences of
Proposed Management Alternatives at the National Elk
Refuge in Jackson, Wyoming

Ecosystems Mission Area—Biological Threats & Invasive Species Research Program

Prepared in cooperation with the National Park Service, U.S. Fish and Wildlife Service, and Wyoming Game and Fish Department

Estimating the Social and Economic Consequences of Proposed Management Alternatives at the National Elk Refuge in Jackson, Wyoming

Chapter E of
Decision Analysis in Support of the National Elk Refuge Bison and Elk Management Plan

Scientific Investigations Report 2024–5119

**U.S. Department of the Interior
U.S. Geological Survey**



Cover. Elk in the vicinity of the historic Miller Cabin on the National Elk Refuge. The Miller family sold their land to the federal government in the early 1900s, forming the first piece of what would eventually become the National Elk Refuge. Photograph taken by Gannon Castle, U.S. Fish and Wildlife Service, March 2020.

Estimating the Social and Economic Consequences of Proposed Management Alternatives at the National Elk Refuge in Jackson, Wyoming

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Abbreviations

>	greater than
<	less than
CWD	chronic wasting disease
FWS	U.S. Fish and Wildlife Service
JHU	Jackson Elk Herd Unit
NER	National Elk Refuge
WGFD	Wyoming Game and Fish Department

Estimating the Social and Economic Consequences of Proposed Management Alternatives at the National Elk Refuge in Jackson, Wyoming

By Margaret C. McEachran¹, Andrew Don Carlos², Gavin G. Cotterill¹, Eric K. Cole², Jonathan D. Cook¹

Abstract

The National Elk Refuge (Refuge) is managed by the U.S. Fish and Wildlife Service and includes habitats for bison and elk. Bison and elk provide opportunities for wildlife-related recreation and contribute to the tourism industry in and around Jackson, Wyoming. Over the last century, the Refuge has provisioned supplemental feed to elk and, more recently, bison during winter months to ensure adequate forage and prevent starvation and conflict with private landowners. However, supplemental feeding artificially aggregates animals and can increase rates of disease transmission and localized damage to sensitive habitats near the feeding areas. This report presents analyses and results to support two of the nine management objectives in the next “Bison and Elk Management Plan,” with a particular focus on the social and economic consequences of five management alternatives considered in this study. The alternatives are to continue feeding bison and elk during winter months on the Refuge, stop feeding after CWD is measured at 3 percent prevalence or above in the Jackson elk herd, stop feeding immediately, reduce feeding for five years and then stop feeding, and increase elk harvest for five years and then stop feeding. These alternatives are anticipated to alter bison and elk population and space-use dynamics, with corresponding effects on wildlife-related recreation and tourism, including the number of visitors and sleigh-ride participants on the Refuge, and hunters and outfitters within the Jackson Elk Herd Unit. The performance of each of this study’s alternatives was variable, resulting in overlap in the performance of alternatives on the select objectives over the next 20 years. Generally, visitation-related objectives performed better under the continue feeding alternative, whereas hunting-related objectives performed better under the increase harvest alternative. The results presented here may assist U.S. Fish and Wildlife Service decision makers in balancing social and economic benefits identified in the decision-making process for the “Bison and Elk Management Plan” with other objectives evaluated in this report.

Introduction

The National Elk Refuge (NER or Refuge) spans 24,700 acres in northwestern Wyoming and is a part of the larger Greater Yellowstone Ecosystem that includes the Yellowstone National Park, Grand Teton National Park, and several national forests across Wyoming, Montana, and Idaho ([fig. E1](#)). The Refuge provides important seasonal habitats for many species including *Cervus canadensis nelsoni* (Erxleben, 1777; Rocky Mountain elk), *bison bison* (Linnaeus, 1758; bison), *Canis lupus* (Linnaeus, 1758; grey wolves), and *Ovis canadensis* (Shaw, 1804; bighorn sheep). Drawn by opportunities to view wildlife and scenery, participate in outdoor recreation, and visit rich cultural and historical sites, the Refuge receives several hundred thousand visitors annually (Dietsch and others, 2020). In addition, the Refuge offers visitors a place to hunt, fish, and ride horse-drawn sleighs to view the elk herd during winter (Dietsch and others, 2020). The management of the NER is administered by the U.S. Fish and Wildlife Service (FWS), and its primary purpose is to protect habitat for elk and other big game species. However, the Refuge has sought to provide opportunities for wildlife-dependent recreation and environmental education for the public and to prevent human-wildlife conflict (National Wildlife Refuge System Improvement Act of 1997—Public Law 105–57, 111 Stat. 1252).

Lower elevation areas surrounding Jackson, Wyoming ([fig. E1](#)) have historically provided important overwintering habitat for many wildlife species, including elk. The NER was established in 1912 to ensure access to adequate elk winter range and reduce elk consuming feed or crops intended for domestic livestock when natural winter forage was insufficient. To supplement limited natural winter forage, the local citizens began feeding Jackson elk during winter months in 1910–1911, and, once established, the NER began conducting these efforts (FWS and NPS, 2007); the Refuge also began feeding bison in 1980 when a small free-ranging herd discovered the feedgrounds (Boyce, 1989). This supplemental feeding results in dense aggregations of elk and bison on the Refuge, providing opportunities to view higher numbers relative to unfed settings elsewhere in the Jackson region.

Across the country, over 500 Refuges in the National Wildlife Refuge System generate \$3 billion annually and support 40,000 jobs, illustrating the substantial economic and social contributions

¹U.S. Geological Survey.

²U.S. Fish and Wildlife Service.

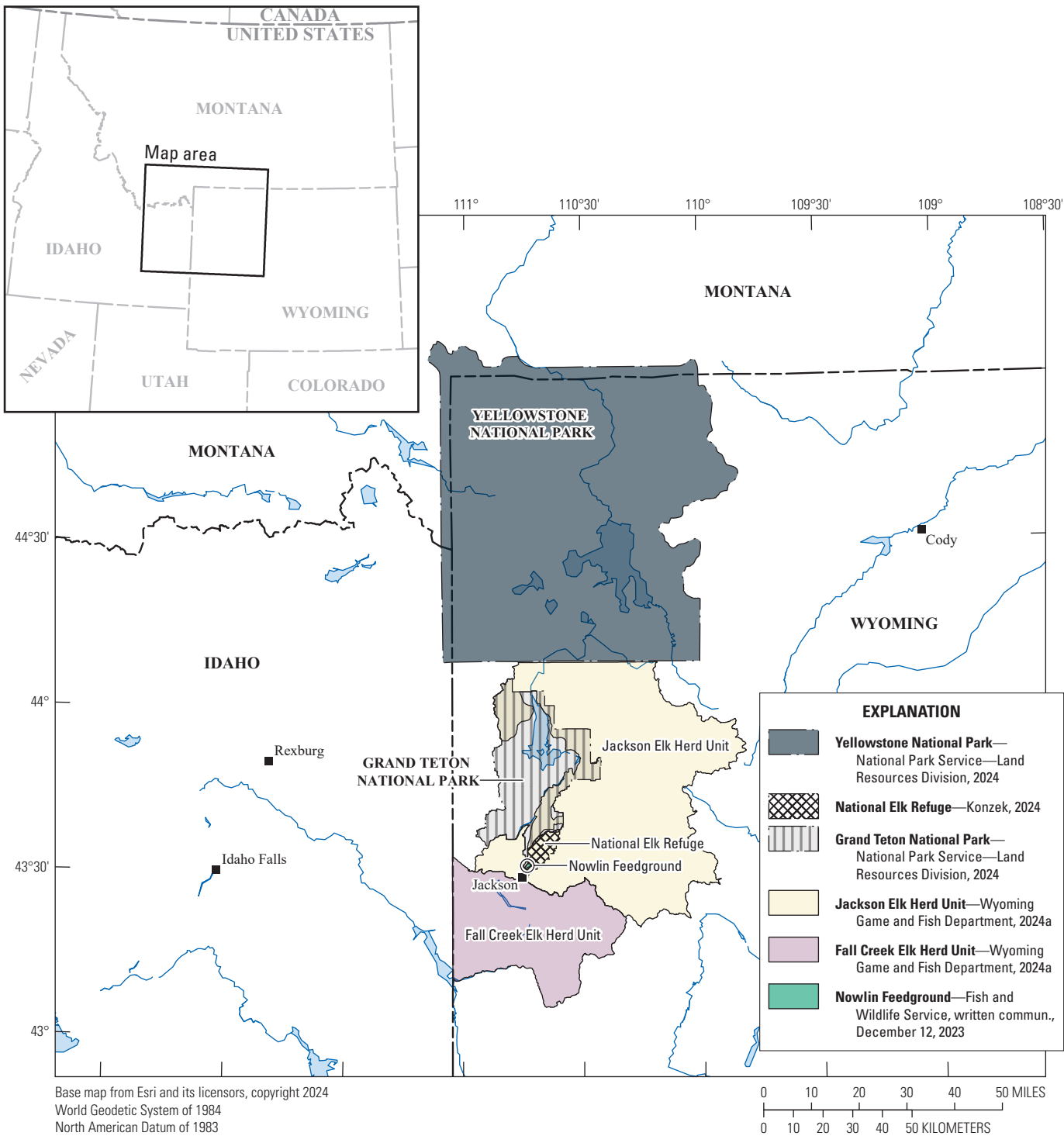


Figure E1. Map showing the location of the National Elk Refuge, Grand Teton National Park, Yellowstone National Park, Jackson Elk Herd Unit, Fall Creek Herd Unit, and Nowlin Feedground within the study area.

that Refuges make (Caudill and Carver, 2019). For the NER, wildlife-related recreation and tourism provide notable economic benefits to the Jackson region. The most recent systematic visitor survey found that many visitors come to the Refuge for unique opportunities to view large numbers of elk up close when elk are being fed during the winter months. This highlights the effect that feeding activities have on tourism in the area (Dietsch and others, 2020) and suggests that changes to bison and elk feeding may affect tourism.

Several thousand hunters also visit the region to purchase harvest tags and pursue elk in the Jackson Elk Herd Unit (JHU), bringing additional economic benefits (Koontz and Loomis, 2005). Finally, hunting outfitters operate businesses and receive economic revenue based on opportunities to guide clients in the pursuit and harvest of elk.

In addition to local recreational and economic benefits, supplemental feeding has been used to reduce elk and bison use of agricultural or other private properties when winter forage is scarce. Wintertime provisioning of supplemental feed is typically triggered when winter sampling of available forage biomass at index sites, selected to represent sites preferred by elk in the south end of NER, indicates that forage availability has fallen below 300 pounds per acre (U.S. Fish and Wildlife Service, 2019). Together with the Wyoming Game and Fish Department (WGFD) wildlife hazing actions designed to actively and non-lethally move elk away from problem areas (U.S. Fish and Wildlife Service, 2019), the provisioning of supplemental feed on the NER effectively minimizes elk and bison use of private lands, thereby minimizing the risk of human-wildlife conflict in the Jackson region. Human-wildlife conflicts include the depredation of agricultural products, damage to structures and livestock by wildlife, and transmission of infectious diseases from wildlife to livestock.

Supplemental feeding also has negative consequences for the social and economic aspects of the system. The dense aggregations of elk on the NER during winter months degrade vulnerable plant communities and increase the likelihood of transmission of several infectious diseases, including diseases with significant economic implications, such as brucellosis and chronic wasting disease (CWD). Brucellosis is a bacterial disease that affects elk, bison, and cattle and is transmitted when a susceptible individual contacts a fetus aborted from an infectious individual (National Academy of Sciences, Engineering, and Medicine, 2020). Brucellosis can lead to substantial costs for cattle producers because of requirements for testing, quarantine, and culling of infected herds if the disease is detected to prevent future spread and risk of human infection (Boroff and others, 2016). Chronic wasting disease is a progressive, neurodegenerative disease of cervids caused by an infectious prion, which persists in prion-contaminated environments and may cause population declines in densely aggregated winter populations using feedgrounds (Galloway and others, 2021; Cook and others, 2023). Chronic wasting disease was first detected in the Jackson elk herd in 2020. Although no further positive elk have been detected despite mandatory testing of all harvested elk on the Refuge, the disease is expected to increase in prevalence which could

have significant consequences for Jackson elk populations as well as the social and economic benefits associated with them (Cross and others, 2025, this volume, chap. B).

The FWS is currently creating an Environmental Impact Statement to revise its bison and elk management plan and to determine how to manage these populations in balance with the social, ecological, economic, and cultural features of the Greater Yellowstone Ecosystem landscape. The FWS is using a structured decision-making process to identify the fundamental objectives for this decision, including several related to the social and economic benefits that elk and bison provide to the area (Cook and others, 2025a, this volume, chap. A). A subset of those objectives is the focus of the analyses and reporting of this chapter, including Fundamental Objective 5—Maintain and enhance multiple use opportunities and public enjoyment; and Fundamental Objective 8—Maximize local economic benefits associated with bison and elk presence on the NER and surrounding lands.

To achieve their objectives, FWS is considering at least five alternatives that may affect the social and economic benefits associated with elk and bison in the NER and surrounding areas (Cook and others, 2025a, this volume, chap. A). Under a continue feeding alternative, the NER will continue to provision food to bison and elk during winter months based on forage availability and any human-wildlife conflicts. Under a no feeding alternative, the NER will immediately stop provisioning food to bison and elk during winter months. Under an increase harvest alternative, the NER will continue to provision food to bison and elk during winter months at current feeding rates for the next 5 years and then stop feeding. During this 5-year phaseout, the NER will work with the WGFD to increase elk harvest quotas for Hunt Area 77 (the NER, [fig. E1](#)) to reduce the elk population prior to feeding cessation. Under a reduce feeding alternative, the NER will continue to provision food to bison and elk consistently during winter months over the next 5 years but will reduce the daily amount of food that is provided to elk. The goal will be to reduce rations such that the total number of elk wintering on the NER will decline to 5,000 animals; then, after 5 years, feeding will stop completely. Finally, under a disease threshold alternative, the NER will continue feeding operations until CWD reaches 3 percent prevalence in the Jackson elk herd, at which point all feeding activities will cease on the NER.

The analyses presented herein provide decision makers with evidence for the potential effects of these management alternatives on the economic and social performance metrics, including visitation to the NER and visit- and hunting-related spending in the Jackson region. In this report, 20 model years marks the progress after implementation.

Methods

The U.S. Geological Survey developed three models to analyze the effects of the alternatives on visitation, visit- and hunting-related spending. The first model estimated the NER

visitation, which we used to project visitor spending and sleigh ride participation; the second model estimated revenue from elk harvest tag sales; and the third estimated other hunting-related revenue for outfitters under changing elk and bison populations.

Modeling Visitation to the NER

Tourism in the Jackson region was expected to fluctuate as a function of several factors including national-scale socioeconomic trends, weather conditions, and wildlife presence (Loomis and Caughlan, 2004). This study's analysis only considered winter visitation (December–April) because that is when elk are concentrated on the Refuge, when feeding occurs, and when most visitors come to the NER, historically.

To predict the changes in the NER visits under each alternative, we worked with technical experts from FWS, National Park Service, and WGFD to model historical visitation to the NER using 2005–23 data. At the time of publication, NER visitation data were not publicly available from FWS. We first developed a set of predictors that could affect visitation patterns at the NER based on expert guidance and a study by Loomis and Caughlan (2004). The predictors included: annual U.S. population estimate (U.S. Census Bureau, 2024), annual per capita income for U.S. residents (U.S. Census Bureau, 2024), monthly consumer price index (Federal Reserve Bank of St. Louis, 2024), monthly vehicle counts at the Moose, Wyoming entrance of Grand Teton National Park (National Park Service, written commun., 2024), monthly average temperature (degrees Fahrenheit), monthly precipitation total (inches) from the Jackson area weather station (Abatzoglou and Hegewisch, undated), and weekly counts of elk and bison on the NER that were summed into monthly counts (FWS, written commun., 2024). Indicator variables for month and year to account for any general short- and long-term trends in visitation that could not be explained by the variables previously listed were also considered.

Initial examination of the variables revealed strong correlations among consumer price index, Grand Teton National Park visitor counts, U.S. population, income per capita, and the variable for year. We retained only the year variable and considered it an index for all variables that trended positively with visitation over time. Further, monthly bison counts were excluded at this stage because of recent changes in bison herd dynamics that have resulted in a smaller population size and less wintertime use of the NER with no observable effect on the NER visitation. All predictor variables were centered and scaled to a mean of 0 and standard deviation of 1 using their historical mean and standard deviation prior to model fitting.

For model fitting and parameter estimation, we fit an initial model of monthly NER visitor center counts as a negative binomial response variable regressed on the remaining variables using a Bayesian approach (elk monthly counts, average monthly temperature, average monthly precipitation, year, and month variables). No evidence that average monthly temperature or precipitation affects the NER visitation was found and therefore these variables were excluded. We then fit a final model using monthly NER elk counts, year and month variables. This model was used to predict winter *visits* to the NER in each month, i , with a mean, μ , and dispersion parameter θ given by [equation 1](#):

$$visits_i \sim \text{NegBin}(\mu_i, \theta) \quad (1)$$

$$\log(\mu_i) = \beta_0 + \beta_1 \text{monthlyelk} + \beta_2 \text{monthDec} + \beta_3 \text{monthJan} + \beta_4 \text{monthFeb} + \beta_5 \text{monthMar} + \beta_6 \text{year}.$$

We used uninformative priors distributed as $\text{Normal}(0, 100)$ for the slope terms, and $\text{Normal}(10, 100)$ for the intercept. We ran 3 Markov chain Monte Carlo simulations (Gelman and Rubin, 1992) with 50,000 iterations, a thinning rate of 2, and a burn-in of 25,000 to generate posterior distributions for each model parameter, β . We assessed convergence using the Gelman-Rubin statistic (Gelman and Rubin, 1992) and model fit using a Bayesian posterior predictive check to estimate a Bayesian p -value (Gelman and Tuerlinckx, 2000). All statistical analyses were performed in R (version 4.3.1) and the r2jags package (R Core Team, 2018; Su and Yajima, 2024).

To predict future NER winter visitation under each alternative, we sampled from the posterior distribution for each variable of the fitted model and multiplied it by the corresponding simulated elk count, and temporal variable (month and year). The posteriors of the fitted coefficients were used to represent parametric uncertainty in the effect that each predictor had on future NER visitation. The results from chapters B and C provided 100 estimates of elk counts at monthly timesteps for 20 years under each alternative (Cotterill and others, 2025, this volume, chap. C; Cross and others, 2025, this volume, chap. B). The other predictors were time variables (month, year) that did not change across alternatives.

Predicting Visitor Spending

Changes in visitor spending were calculated using the projected number of visitors from the previous model in conjunction with NER visitor spending data collected during December 2018 and March 2019 (Dietsch and others, 2020). These data report differences in spending by residency status (local was defined as residing within 50 miles of the Refuge and nonlocal residents

defined as holding residence greater than 50 miles from the Refuge) and trip purpose (primary purpose, equal purpose to other local attractions, and incidental purpose includes trips to the NER that were unplanned). These data were also expected to be representative of winter season NER visitors and spending patterns that may be affected by the alternatives. For the visitor-related spending calculations, only data from nonlocal residents (respondents who lived >50 miles away from the Refuge) were included because of limited data for local residents (<50 miles from the Refuge). Local residents represented only 20 percent of survey respondents, were inconsistent in reporting their Refuge-related spending, and did not typically report a number of days associated with each trip. Additionally, local residents were assumed to continue spending money in the local area under all alternatives whereas nonlocal resident spending may be sensitive to any changes caused by the alternatives.

In accordance with guidance prescribed by the Office of Management and Budget (2023) and an assumption that benefits of consumer spending in the near term are more valuable than those that are received farther into the future, future spending values were adjusted using a nominal discount rate of 4.7 percent annually. This nominal discount rate adjusts for declining present value for monetary benefits that are received many years into the future.

Predicting Sleigh Ride Participation

Private concessionaires offer sleigh rides that provide winter NER visitors the opportunity to experience the Refuge and get close to large groups of elk (Loomis and Caughlan, 2004). Given the possibility that feeding changes could affect sleigh ride participation and operations, the historical relationship between sleigh ride participation and weekly elk counts on the Nowlin feeding area where sleigh rides occur were assessed. We used Pearson's correlation coefficient and a generalized linear model with a negative binomial response variable fit to historical sleigh ride data using the `glm.nb()` function from the MASS package (Venables and Ripley, 2002). At the time of publication, NER sleigh ride data were not publicly available from FWS.

Hunting and Hunter-associated Spending

The changes to future elk populations and associated effects to elk harvest tag sales and hunting-related spending were evaluated under each alternative. In chapter B, Cross and others (2025, this volume) predicted the number of harvested elk in each age and sex class and under each of the five alternatives. Those data were then used to estimate the total number of harvest tags that could be sold annually (n_{tags}) by WGFD under each alternative given by equation 2:

$$n_{tags} = \sum_{c=1}^4 \frac{n_{huntedc}}{1 - p_{notused} - p_{notfilled}} \quad (2)$$

where

n_{tags}	is the number of elk tags that WGFD could sell annually,
$n_{huntedc}$	is the number of harvested elk in each demographic class, c , (juveniles, females, yearling males or adult males) annually,
$p_{notused}$	is the mean proportion of tags that are purchased but not used by hunters, and
$p_{notfilled}$	is the mean proportion of tags that are purchased, the hunter went afield, but did not successfully harvest an animal.

The study assumed that hunters who purchased a tag but did not hunt (*notused*) contributed to WGFD tag sale revenue but not to local economic revenue, while hunters who went afield contributed to economic revenue regardless of whether they successfully filled the tag (harvested an animal). Average tag use and hunter success rates were derived using 2017–21 harvest data from the JHU (WGFD, 2024b). The total WGFD tag revenue was then calculated by multiplying the number of tags of each type by the corresponding cost per tag (WGFD, 2024b) to account for differences in cost of each tag type. A discount rate of 4.7 percent was applied to elk harvest tag sale revenue.

Hunting on the NER (WGFD Hunt Area 77) is unique in that hunters with unfilled tags for other hunt areas may use the tag on the NER. Given this uncertainty, our results are an approximation of future revenues because we assumed that a decrease in the number of elk that were available to harvest (estimated as total harvested elk in Cross and others, 2025, this volume, chap. B) resulted in an exact proportionate decrease in the number of elk tag sales, elk hunting trips, and elk hunting-related spending for each alternative and did not account for the possibility that hunters may still purchase tags and related goods elsewhere. We also only included elk harvest that occurs in the JHU under the alternatives and did not consider any elk that transitioned to the Fall Creek Herd Unit under the no feeding alternatives. For additional detail see Cross and others (2025, this volume, chap. B) for information regarding elk transition dynamics under the alternatives.

To estimate the total hunting trips and hunting-related spending, we used hunter-spending estimates from Koontz and Loomis (2005) and adjusted for an annual inflation of 2.8 percent between 2001 and 2024. Hunter characteristics were assumed to be consistent over time (for example, spending by residency) and used recent WGFD data to estimate the proportion of resident hunters and hunter success rates. We calculated annual hunting trip-related spending, *totalspend*, using average values from Koontz and Loomis (2005) and given by equation 3:

$$totalspend = \sum_{r=1}^2 n_{hunters_r} \times t_{spend_r} \times t_{year_r} \quad (3)$$

where

$n_{hunters_r}$ is number of hunters by residency status, r (Wyoming resident or non-Wyoming resident),

tspend is per-trip spending by hunter residency, and
tyear is number of trips per year by hunter residency.

Wyoming residents were further subdivided and a weighted average of local and nonlocal residency status was calculated based on data from Koontz and Loomis (2005). Finally, the total spending values were multiplied by a discount rate of 4.7 percent.

Outfitter Revenues

To estimate how changes in hunting could affect outfitter revenues, the proportion of hunted elk in JHU harvested by outfitter-guided clients was estimated using historical data (Wyoming State Board of Outfitters and Professional Guides, 2024). Predictions of future permitted outfitters and clients served were then estimated by applying these proportions to the predicted number of harvested elk under each alternative from Cross and others (2025, this volume, chap. B). McWhirter and others (2022) estimated the average cost of a guided elk hunt to be \$5,000, so we multiplied this value by the respective number of guided clients (regardless of whether they successfully harvested an elk) that were predicted under each alternative to predict future effects on outfitter revenue under each alternative and applied a discount rate of 4.7 percent.

Results

Predicted Changes in Nonhunting Visitors and Visitor-related Spending Under Each Alternative

The fitted model of historical NER winter visits as a function of monthly elk and temporal variables was consistent with observed data (posterior predictive check value=0.62) and each parameter successfully converged ($R_{hat}<1.1$; [table E1](#)). The effect of historical monthly elk counts on NER winter visitation was weakly positive (mean, 0.03; 95 percent credible interval, -0.05 to 0.10) and 74 percent of the posterior distribution was greater than zero. The median effect size corresponded to an average of 2.5 additional visitors for every 100 additional elk on the NER. When carrying the fitted model and its posteriors forward to project differences in predicted NER winter visits, minimal differences were found among the alternatives; although, a high degree of uncertainty was found within each alternative ([fig. E2](#)). Note that in the negative binomial model, where the predictors were centered and scaled prior to fitting, the parameter estimates represent one standard deviation change in the predictor variable as a result of a change in the log of NER visits.

The average 20-year cumulative estimate for NER winter visitors was slightly higher under the continue feeding alternative compared to the other alternatives ([table E2](#)); however, there

Table E1. Predictor variables of negative binomial model of historical winter visits to the National Elk Refuge in Jackson, Wyoming, parameter symbology, and fitted parameter estimates.

[The estimates were used to predict future visits under each of the proposed management alternatives and using predictions of future elk counts from Cross and others (2025, this volume, chap. B) and Cotterill and others (2025, this volume, chap. C). %, percent; CI, credible interval]

Variable	Parameter	Mean estimate (95% CI)
intercept	β_0	8.98 (8.80–9.15)
monthlyElk	β_1	0.03 (–0.05–0.10)
monthDec	β_2	0.83 (0.60–1.05)
monthJan	β_3	0.75 (0.51–0.98)
monthFeb	β_4	0.93 (0.67–1.20)
monthMar	β_5	0.90 (0.63–1.18)
year	β_6	0.15 (0.07–0.24)

Table E2. Cumulative predicted nonhunting winter season visitors and net present value-adjusted nonhunting visitor spending during winter months (December–April) on the National Elk Refuge in Jackson, Wyoming, predicted under each alternative.

[Note that these totals do not reflect the spending of local residents that live within 50 miles of the Refuge because of small sample size and inconsistencies in their reporting of local National Elk Refuge-related spending. \$, U.S. dollar; SD, standard deviation]

Alternative	Predicted cumulative winter visitors, in thousands		Predicted cumulative spending, in millions (\$)	
	Mean	SD	Mean	SD
Continue feeding	3,375	791.7	2,978	698.6
No feeding	3,271	774.4	2,886	683.3
Increase harvest	3,296	763.0	2,908	673.3
Reduce feeding	3,288	755.1	2,901	666.3
Disease threshold	3,286	752.9	2,889	664.3

was large within-alternative variation and substantial overlap of performance estimates for all alternatives. Predicted visitor spending under each alternative maintained this pattern, with nonhunting NER visitor spending predicted to be slightly higher on average under the continue feeding alternative compared the other alternatives, but with a large range of within-alternative variation ([table E2](#)).

Predicted Changes in Sleigh Ride Participants Under Each Alternative

A slight positive correlation was revealed between historical elk counts on the Nowlin feeding area and the number of sleigh ride participants (Pearson’s correlation coefficient=0.38). The elk-only model showed a small effect of Nowlin feedground

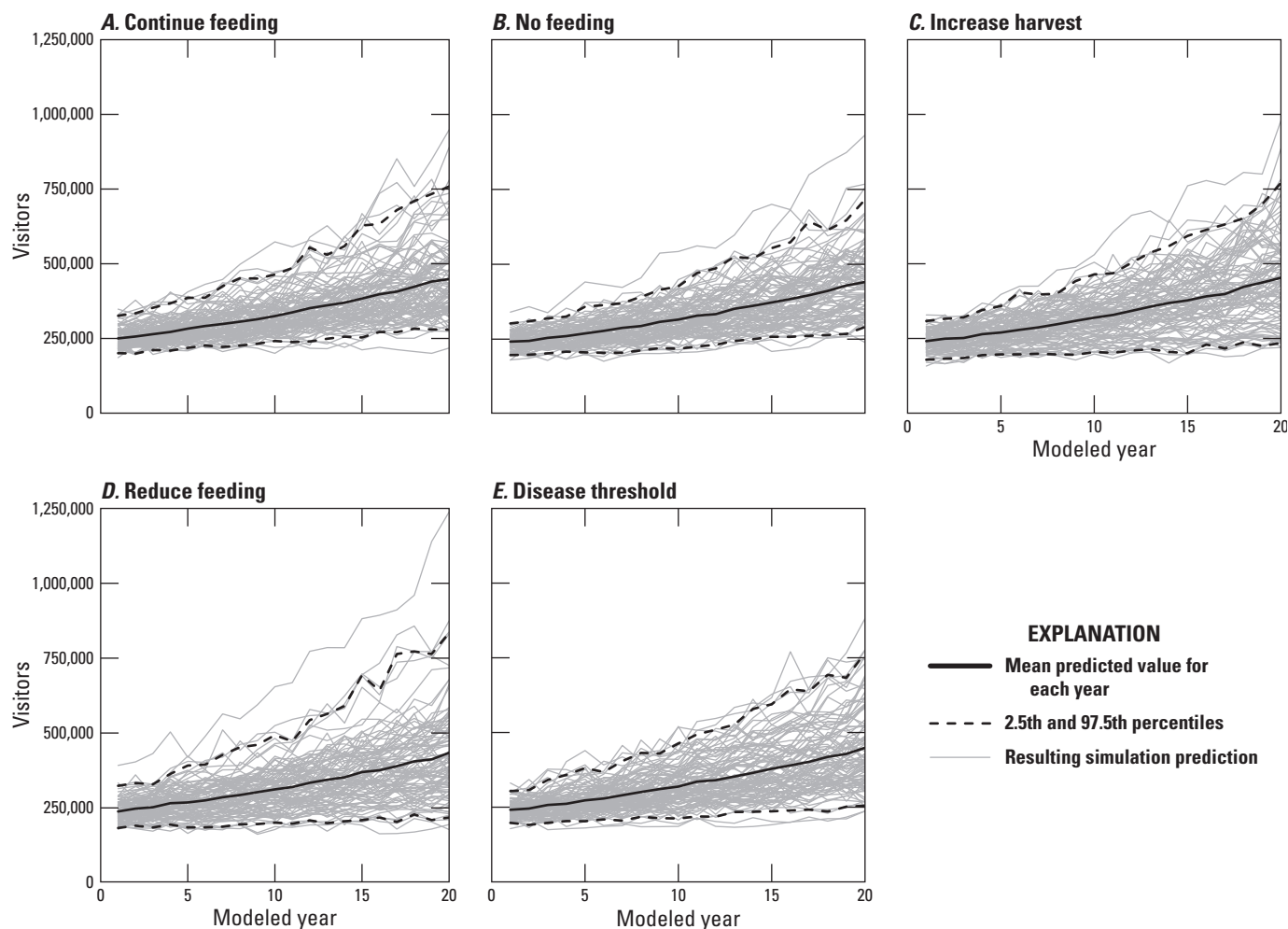


Figure E2. Graph showing annual predicted visitors to the National Elk Refuge in Jackson, Wyoming, during winter months under each alternative. *A*, continue feeding, *B*, no feeding, *C*, increase harvest, *D*, reduce feeding, and, *E*, disease threshold.

elk counts on sleigh ridership (4.23×10^{-05} , $p > 0.05$). This small effect corresponded to a one-unit change in elk counted on the feedground resulting in a 0.16-unit change in expected number of sleigh ride participants. As a result, based on an evaluation of historical data, we concluded that sleigh ride participation did not differ substantially across alternatives.

Predicted Changes in Hunting Visitors and Hunting-related Spending Under Each Alternative

The number of harvested elk varied through time and according to the alternative (Cross and others, 2025, this volume, chap. B). The harvest generally decreased as elk population projections fell below the JHU population objective of 11,000 elk (WGFD sets population objectives for each elk herd unit according to their estimates of a sustainable population); the decline in harvest was included in Cross and others (2025, this volume, chap. B) as an assumed response by WGFD to declining elk abundance under the alternatives.

Because we assumed proportionate spending by resident and nonresident Wyoming hunters remained the same as historical data, the increase harvest alternative resulted in hunting rates and hunting-related revenues that were initially much higher than the other alternatives but dropped rapidly after the initial period of intensive elk harvest. When considering these changes over time, the increase harvest alternative had higher predicted tag revenues (Mean=\$6.60 million, SD=\$574,000) and hunter-related spending (Mean=\$101.29 million, SD=\$9.56 million), but had substantial overlap in the estimated ranges of the alternatives (table E3; fig. E3).

Predicted Changes in Outfitter Revenues Under Each Alternative

In the last five years, an average of 19.5 outfitters (SD=3) guided an average of 17 clients (SD=17.5) each per year. Annually, elk harvested by outfitter-guided clients averaged 218 elk (SD=71 elk), which accounted for 21 percent of the annual total elk harvested in the JHU (SD=3.7 percent).

Table E3. Twenty-year predictions of the cumulative revenues from elk tag sales and the total predicted spending by elk hunters in the Jackson Elk Herd Unit of Wyoming under each alternative.

[\$, dollar; SD, standard deviation]

Alternative	Cumulative tag revenue, in thousands (\$)		Cumulative spending by hunters, in thousands (\$)	
	Mean	SD	Mean	SD
Continue feeding	5,472	640	88,539	12,214
No feeding	5,004	770	76,140	14,836
Increase harvest	6,604	574	101,294	9,558
Reduce feeding	4,765	758	73,023	14,145
Disease threshold	5,248	717	81,988	14,254

For every elk harvested in JHU annually, outfitters guided an average of 0.35 clients (including those who did not successfully harvest an elk).

Projecting these proportions over 20 modeled years, the increase hunting alternative had the highest predicted number of clients with an average estimate of 3,758 clients served over the next 20 years and a cumulative outfitter revenue of \$14.5 million. The next highest performing alternative was the continue feeding alternative with an average of 3,480 clients and \$12.6 million in revenue, followed by the disease threshold alternative with an average of 3,319 clients and \$11.7 million in revenue (fig. E4). The lowest cumulative number of clients and revenues were predicted under the reduce feeding alternative with 2,879 clients and \$10.4 million in revenue over the next 20 years.

Summary

After evaluating the effects of the five management alternatives under consideration for bison and elk management on National Elk Refuge (NER or Refuge) on social and economic dimensions of concern, this study found minor to moderate differences in the performance of the alternatives on the cumulative number of NER winter visitors, cumulative revenue from elk hunting license sales, cumulative local economic revenues resulting from hunting and nonhunting visitors, and revenues for outfitters guiding in the Jackson Elk Herd Unit. In general, large variation within predicted estimates of elk populations, harvested animals, and visitation resulted in substantial overlap in the estimates of performance of the alternatives for each performance metric. Although we predicted the highest number of NER visitors under the continue feeding alternative, we found that monthly elk counts explained less than 1 percent of the variation in historical NER winter visitation. However, the results of Cross and others (2025, this volume, chap. B), Cotterill and others (2025, this volume, chap. C), and

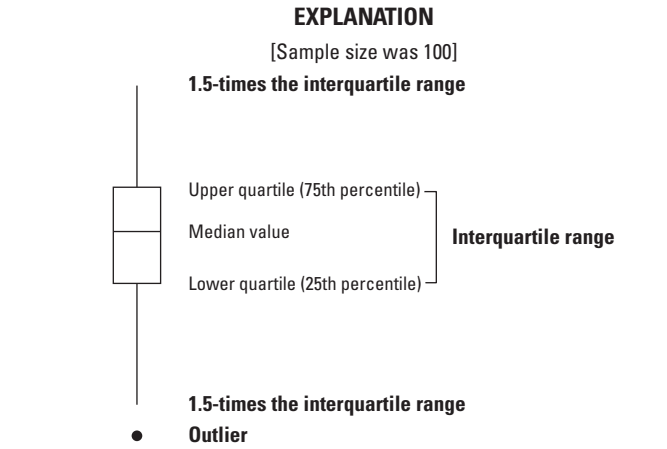
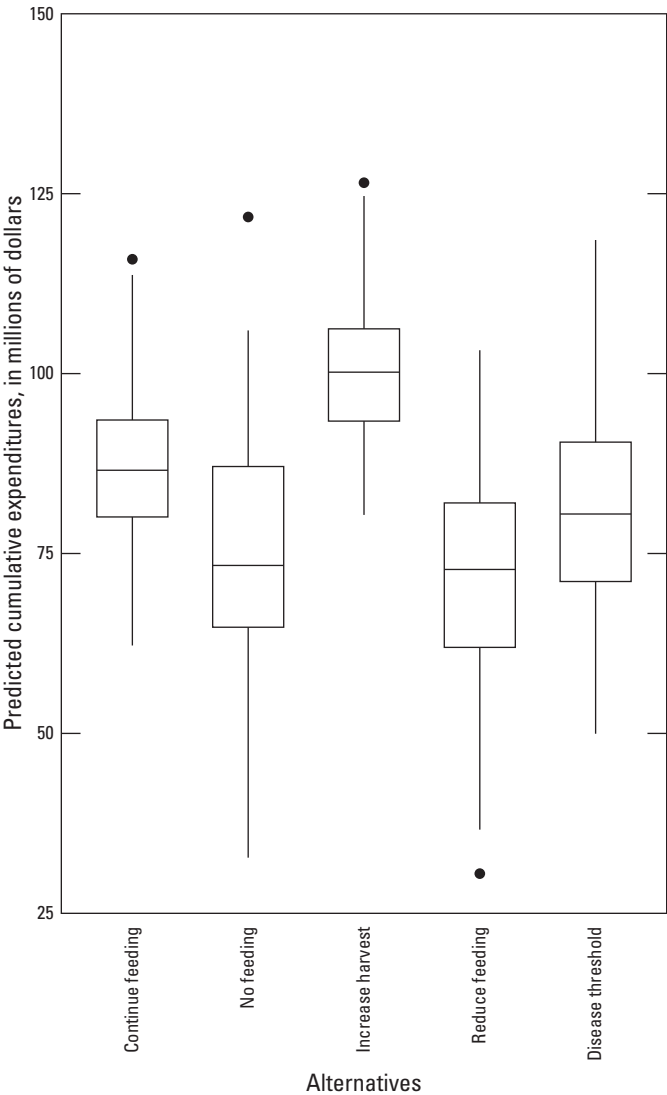


Figure E3. Boxplots showing cumulative predicted spending by elk hunters in the Jackson Elk Herd Unit in Wyoming over 20 model years. Values have been discounted through time using a rate of 4.7 percent.

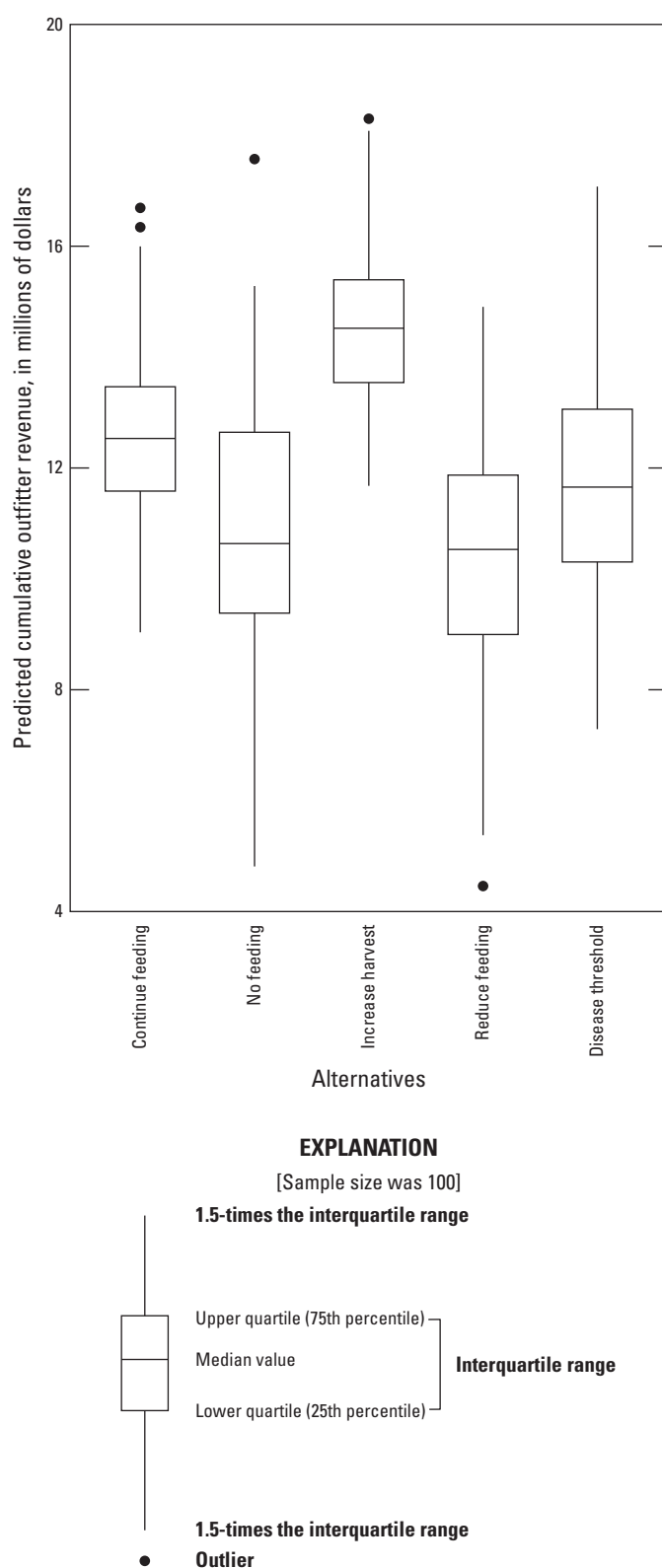


Figure E4. Boxplots showing cumulative predicted revenues from guided elk hunts in the Jackson Elk Herd Unit in Wyoming. Values have been discounted through time using a rate of 4.7 percent.

Cook and others (2025b, this volume, chap. D) predict substantial declines in elk and bison numbers on NER in winter months so the number of NER visitors and associated revenues could change in unexpected ways that are not fully captured by these analyses. The increase harvest alternative performed better on the hunting-related performance metrics on average, including Wyoming Game and Fish Department (WGFD) revenue from elk harvest tag sales, regional revenue from hunting-related spending, and outfitter-revenue, but there was large within-alternative variation.

Some of the estimates presented here are conditioned on strong assumptions about future outcomes. For example, we assumed that any changes in the number of Refuge visitors in winter months resulted in a direct and proportional change in non-hunting visitor spending; however, it is possible that this connection is not as direct. Instead, there is a possibility that non-hunting expenditures do not change in direct proportion to future trends in elk and Refuge visitation, especially given that 87% of Refuge visitors reported that the Refuge was not the only reason to visit the Jackson, Wyoming region (Dietsch and others, 2020). We further assume that future relationships between wildlife populations and visitation, hunting, and related spending can be approximated by relationships of the past. However, if management alternatives drive large changes in elk and bison numbers on the Refuge as indicated in Cross and others (2025, this volume, chap. B), Cotterill and others (2025, this volume, chap. C), and Cook and others (2025b, this volume, chap. D), the relationships might also change. Any effect of elk starvation and CWD-related mortalities that result from changes to NER feeding may negatively affect visitation and hunting in ways not predicted because of public reactions to seeing animals in poor condition.

We assumed that CWD would not affect hunter participation in the region. Previous studies of hunting patterns following CWD emergence have predicted hunting participation declines as CWD prevalence increases (for example, Needham and others, 2006). However, effects on participation vary by state, species pursued, and hunters' emotional response to CWD (Schroeder and others, 2021). Other studies have shown that these declines reverse and hunting returns to normal levels even as CWD prevalence increases (for example, Holland and others, 2020). Therefore, we assumed that hunter participation would remain constant despite predicted increases in CWD throughout the 20-year evaluation period.

Finally, the benefits predicted under the increase harvest alternative may be challenging to implement and thus may affect the revenues generated by outfitters in the region. The harvest regulation changes that would lead to the higher harvest that is predicted in the increase harvest alternative fall primarily under the authority of WGFD. As a result, actions that fall outside of the FWS decision process supported by these analyses would be required to implement this alternative.

Despite the limitations of this study, the findings remain informative for making decisions about elk and bison management of NER. The assumptions were guided by local and regional experts and apply equally across alternatives and thus could

be expected to affect each alternative in similar ways. As a result, differences among alternatives may represent good approximations of their relative performance. For this reason, the analyses presented here may assist decision makers in assessing the relative performance of each alternative concerning the anticipated effects on the social and economic benefits that elk and bison provide to the region.

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**APPENDIX G – U.S. Geological Survey, Chapter F of
Scientific Investigations Report 2024–5119:
Predictions of Elk, Chronic Wasting Disease Dynamics,
and Socioeconomics Under Alternative D at the National
Elk Refuge in Jackson, Wyoming, and Surrounding Areas**

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Prepared in cooperation with the U.S. Department of Agriculture, National Park Service, U.S. Fish and Wildlife Service, and Wyoming Game and Fish Department

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Cover. Elk and bison on the National Elk Refuge. Photograph taken by Gannon Castle, U.S. Fish and Wildlife Service, February 2022.

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Abbreviations

CWD	chronic wasting disease
FS	U.S. Department of Agriculture—Forest Service
FWS	U.S. Fish and Wildlife Service
JHU	Jackson Elk Herd Unit
NER	National Elk Refuge
NPS	National Park Service
PM	performance metric
SD	standard deviation
WGFD	Wyoming Game and Fish Department
USGS	U.S. Geological Survey

Predictions of Elk, Chronic Wasting Disease Dynamics, and Socioeconomics Under Alternative D at the National Elk Refuge in Jackson, Wyoming, and Surrounding Areas

By Jonathan D. Cook,¹ Gavin G. Cotterill,¹ Eric K. Cole,² and Paul C. Cross¹

Abstract

This chapter presents a description and quantitative evaluation of a collaborative alternative (alternative D) focused on near-term elk population reduction and chronic wasting disease (CWD) monitoring as part of winter elk and bison feedground operations on the National Elk Refuge adjacent to Jackson, Wyoming. Alternative D was developed by the U.S. Fish and Wildlife Service, the lead agency of an Environmental Impact Statement, in consultation with cooperating agencies, including the National Park Service, U.S. Forest Service, and Wyoming Game and Fish Department. In evaluating alternative D, the U.S. Geological Survey considered four distinct scenarios that incorporated whether the agencies were able to meet their elk population reduction goals, and the effects of the U.S. Fish and Wildlife Service stopping feeding after CWD prevalence was measured at or above 7 percent in the Jackson Elk Herd Unit. The modeled scenarios in which the U.S. Fish and Wildlife Service stopped feeding elk at 7 percent CWD prevalence had higher elk population sizes and generally lower CWD prevalence overall at the end of the 20-year simulation period. Further, three of the four alternative D scenarios resulted in fewer elk-use days on sensitive aspen, willow, and cottonwood habitat types compared to continuing to feed; the 7 percent CWD trigger scenario resulted in higher elk-use days on cottonwood and willow habitats compared to continued feeding, but fewer elk-use days on aspen habitats. When considering brucellosis risk, alternative D scenarios without the 7 percent CWD stop feeding trigger had lower risk than the alternative that stopped feeding elk immediately.

Introduction

The National Elk Refuge (NER, also referred to as “the Refuge”) is in northwestern Wyoming, adjacent to the town of Jackson, and is part of the Greater Yellowstone Ecosystem. Each winter, the NER provides supplemental food to *Bison bison* (Linnaeus, 1758; bison) and *Cervus elaphus canadensis*

(Erxleben, 1777; elk), as they have for at least the last century (16 U.S.C. §673, Wyoming Elk Reserve). In recent years, chronic wasting disease (CWD) in elk has been detected close to the Refuge; in 2020, elk tested positive in Grand Teton National Park, and, in 2024, at other nearby State-run feedgrounds, including Dell Creek and Horse Creek (WGFD, 2025). The spread of CWD has prompted the NER to re-evaluate its bison and elk feedground program to determine the best course of action that will minimize disease, maximize wildlife populations, and achieve other objectives important to the U.S. Fish and Wildlife Service (FWS). The U.S. Geological Survey worked closely to evaluate the range of management alternatives that were proposed by the FWS and other cooperating agencies as part of the drafting of a National Environmental Policy Act Environmental Impact Statement (FWS, 2023). The cooperating agencies included the National Park Service (NPS), the U.S. Forest Service (FS), and the Wyoming Game and Fish Department (WGFD).

Following the release of the first version of this report (Cook and Cross, 2025), discussions among FWS and cooperating agencies resulted in an additional management alternative that proposed new criteria by which to manage elk feeding operations and would attempt to minimize human-bison conflicts. The new alternative, hereafter referred to as “alternative D” to align with the FWS Environmental Impact Statement (FWS, 2023), includes a greater reliance on cooperative management among the agencies as well as modification of the conditions under which the feedground operations for elk would be stopped. This chapter evaluates the effects of alternative D on a subset of the 19 performance metrics first introduced in chapter A (Cook and others, 2025, this volume), and it considers a range of scenarios associated with the implementation of actions that are outside of the authorities of FWS and the NER.

Alternative D Description

If following alternative D, the FWS, along with the other cooperating agencies—NPS, FS, and WGFD, will work to reduce the number of elk that overwinter on the NER to about 5,000 animals, prior to stopping feeding, by increasing elk harvest opportunities. The goal is to reduce the population over 10 years under the new “Bison and Elk Management Plan,” having most of the herd reduced prior to year 8. Then, after 10 years of active elk herd reductions, the FWS will stop feeding elk on the Refuge. If,

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within those first 10 years, the prevalence of CWD is measured as 7 percent or higher in the Jackson Elk Herd Unit (JHU), the FWS will stop feeding elk immediately. Seven percent was selected as the threshold because previous work by Galloway and others (2021) indicated that the Jackson elk herd, mostly contained within the JHU, will decline at CWD prevalence equal to or greater than 7 percent. Regardless of the CWD prevalence, the FWS will end its supplemental feeding of elk after year 10. The NER will continue to feed bison over the next 20 years to minimize the potential of human-wildlife conflicts and maintain a minimum population of 500 bison.

Methods

General Approach

The evaluation of alternative D followed mostly the same process as the other five initial alternatives, whereby the actions described by the alternative were translated into quantitative relationships within a series of linked computer models. First, the alternative components associated with increasing harvest rates or stopping feeding in response to CWD were considered within the matrix elk population and CWD simulation model described in chapter B (herein CWD model; Cross and others, 2025, this volume). The CWD model allowed for repeat simulations of the elk population (fig. F1) and showed how the population changed over time in response to natural aging, reproduction, survival, and CWD processes, and also as a function of actions related to harvest and feedground management. The results of the simulations were used to summarize performance metrics that focused on elk population size, elk suffering, number of harvested elk, and changes in CWD prevalence (Performance metrics [PMs] 1a–c, 5a; table F4).

To model elk space-use patterns under alternative D, the raw elk counts of the number of elk with CWD were then projected onto a set of spatially explicit probabilistic maps that corresponded to monthly space use patterns for elk under conditions that matched seasonal variations in habitats and feeding operations at State and Federal feedgrounds (hereafter, spatial model; Cotterill and others, 2025, this volume, chap. C). The results from the spatial model produced metrics associated with elk use of sensitive habitats (PMs 2a–c, table F4) and private lands (PM 6a, table F4). A subset of the private lands where cattle overwinter were further used, in combination with counts of adult females, pregnancy rates, and brucellosis seroprevalences to derive a brucellosis abortion hazard for elk as a measure of risk to cattle producers (PM 6c, table F4; Cotterill and others, 2025, this volume, chap. C).

Finally, the outputs from the CWD and spatial models were used in three separate socioeconomic models to estimate metrics associated with either NER visitor counts (PM 5b, table F4) and their spending at local businesses (PM 8b, table F4), hunting revenues from elk tag sales (PM 8a, table F4) and hunting-related contributions to local economies (PM 8b, table F4), or outfitter revenues (PM 8c, table F4). Other metrics associated with FWS

management costs and invasive species risk were covered in chapter A (Cook and others, 2025). We assumed that the effects to bison populations (PM 1d, table F4), human-bison conflict (PM 6b, table F4), and bison harvest (PM 9a, table F4) under alternative D would be the same as under the continue feeding alternative because alternative D continues feeding bison over the entire 20 years of evaluation. The models are written in R (version 4.4.0; R Core Team, 2024) and are available online (Cook, 2024; Cotterill and Graves, 2025; Cross, 2025; McEachran and Cook, 2024).

Modeling alternative D differed from the other alternatives in that four distinct scenarios of alternative D were considered. The variables were whether the 7 percent CWD trigger and increased elk harvest were included or not, and in what combination with other management strategies. The first scenario did not include the 7 percent CWD trigger or increased elk harvesting and assumed that elk feeding was ended after year 10. The second scenario increased elk harvesting to achieve the goal of 5,000 elk using the NER by year 8 but did not include the 7 percent CWD trigger. The third scenario included the 7 percent CWD trigger to halt elk feeding, but did not increase elk harvesting. The fourth scenario included both the CWD trigger and increased elk harvesting options. These four scenarios helped to understand the range of outcomes that might happen given the inclusion and success of these different actions.

Results are presented across two spatial scales to facilitate broad-scale and fine-scale comparisons among the alternatives. The broader spatial scale (analysis area, fig. F1) included all areas where the Jackson elk herd currently inhabit, but also those areas where they are expected to relocate under management alternatives that stop feeding. This area included the JHU and the northern part of the Fall Creek Herd Unit. The finer spatial scale was defined as the JHU and is the scale at which most elk management decisions are typically made (fig. F1).

Modeling Details Under Alternative D

CWD and Elk Population Modeling

A few minor changes were required to implement alternative D in the elk and CWD model developed in chapter B (Cross and others, 2025, this volume). First, a trigger based on the CWD prevalence in the JHU was added. Similar to the 3 percent CWD prevalence trigger previously specified for the disease threshold alternative, we assumed that 400 elk were tested every November and if the CWD prevalence of that sample exceeded 7 percent, elk feeding was not conducted in subsequent years and elk redistributed themselves to other areas as modeled in Cross and others (2025, this volume, chap. B). To reduce the elk population on the NER to approximately 5,000 by year seven, the hunting rates of all sex and age classes were increased by 2.1 times from those reported in table A1 (Cook and others, 2025, this volume, chap. A). This resulted in a 14.7 percent increase in yearling and adult female elk harvested and a 16.8 percent increase of adult bulls harvested annually. Once the target number of 5,000 elk was achieved in the NER elk segment, hunting rates were reset back to baseline

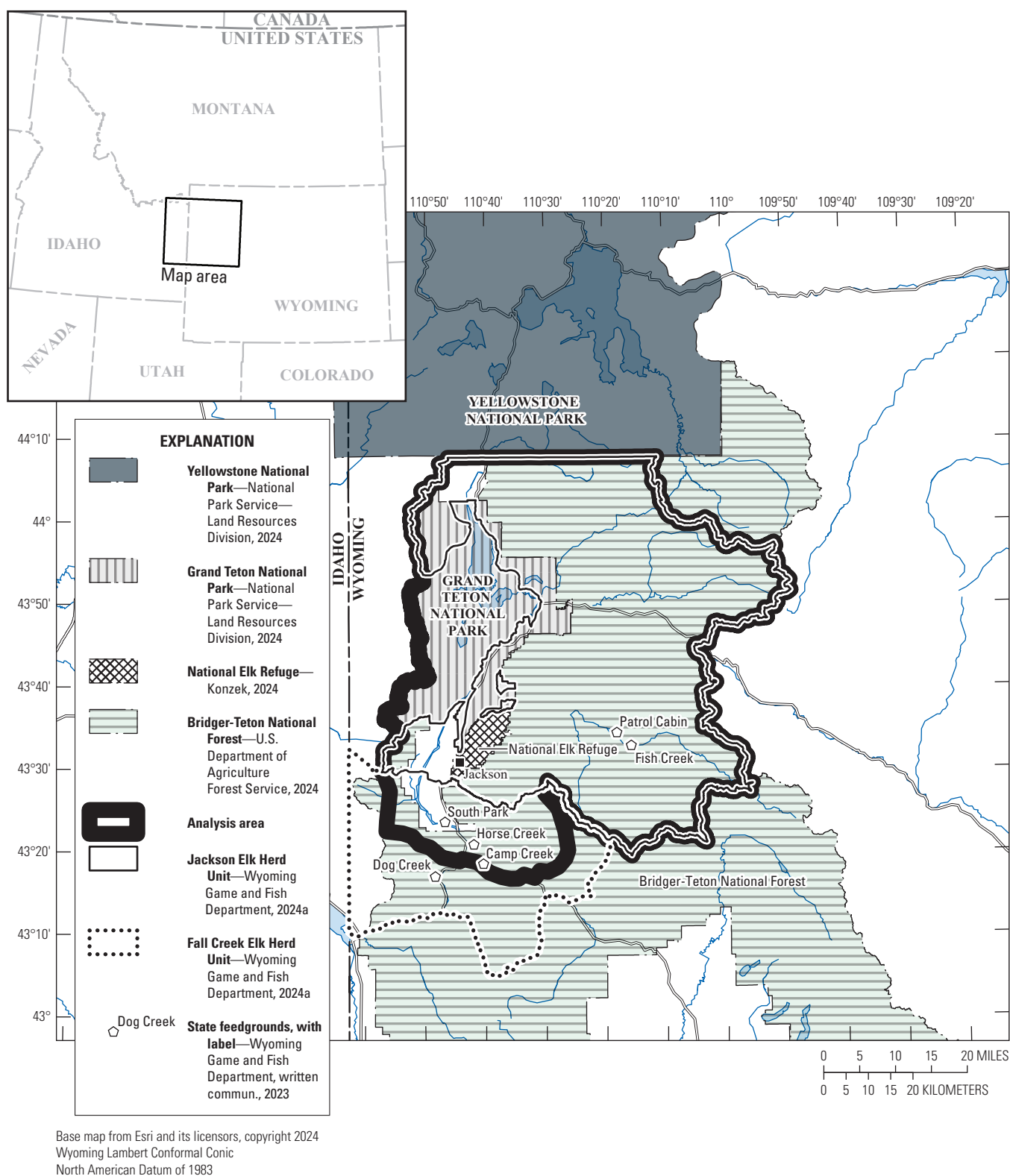


Figure F1. Map showing the study area. The analysis area is composed of the Jackson Elk Herd Unit, part of the Fall Herd Unit, the National Elk Refuge, and Grand Teton National Park. Also included are the locations of six State feedgrounds, Patrol Cabin, Fish Creek, South Park, Horse Creek, Camp Creek, and Dog Creek, that were considered in the analyses of this report. Modified from Cook and others, 2025, chap. A, fig. A1.

levels. Hunting rates declined linearly to zero when the JHU was 80 percent or less than the population objective of 11,000 elk. To evaluate the importance of the 7 percent CWD trigger and increased hunting, each scenario was evaluated with and without the 7 percent CWD trigger as well as the increased hunting, resulting in four different scenario combinations. If the CWD trigger was not reached by year 10, or if there was no 7 percent CWD trigger, supplemental feeding of elk ceased after year 10.

Elk Space-Use Modeling

The same spatial model as described in chapter C (Cotterill and others, 2025, this volume) was applied to the alternative D elk and CWD model results. As before, feed cessation at the NER triggered modifications to distributions in accordance with the same resource selection function fit to existing elk collaring data and adjusted by expert-elicited predictions. Under the 7 percent CWD trigger, temporal variations in seasonal landscape use by elk were accommodated across the full range of simulated outcomes from the CWD model. To determine when the switch between elk distribution under feedground operations and feedground closure happened, annual CWD prevalence estimates from Cross and others (2025, this volume, chap. B) were used.

Socioeconomics Modeling

The same three socioeconomics models were implemented to estimate NER visitation, non-hunting and hunting-related economic expenditures, elk harvest tag sales, and outfitter revenues

(McEachran and others, 2025, this volume, chap. E) under alternative D. As a result, findings presented for alternative D in this chapter reflect the same approaches as previously described in McEachran and others (2025, this volume, chap. E).

Results

CWD and Elk Population Size

The inclusion of the 7 percent CWD trigger resulted in a lower overall CWD prevalence over the 20 years (table F1). At year 10, if there were no increased hunting and no CWD trigger, the CWD prevalence in the JHU averaged 38 percent (standard deviation [SD]=9.7 percent) before declining back to 25 percent (SD=8.6 percent) by year 20 (fig. F2). In contrast, when there were both increased hunting and a CWD trigger, the CWD prevalence by year 10 in the JHU was, on average, 22 percent (SD=7.5 percent) and, by year 20, reached a CWD prevalence of 26 percent (SD=10 percent). Including the CWD trigger also resulted in fewer winter CWD mortalities over the 20 years compared with when a 7 percent CWD trigger was not included in the alternative. At the spatial extent defined by the full analysis area, we found similar trends as in the JHU with lower CWD prevalence under scenarios of alternative D that included the 7 percent CWD trigger (table F1). All scenarios of alternative D had lower CWD prevalence compared to the alternative that continued elk feeding for 20 years (table F1).

Table F1. Summary of elk and chronic wasting disease performance metrics as modeled for the Jackson Elk Herd Unit and analysis area in western Wyoming.

[CWD, chronic wasting disease; SD, standard deviation; JHU, Jackson Elk Herd Unit; Alt D, alternative D]

Alternative	Year 20 elk population size		Year 20 CWD prevalence		First 5 years of winter deaths		Cumulative elk harvest 20 years	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
JHU								
Continue feeding	5,166	1,494	0.35	0.06	5,910	532	9,877	1,604
Alt D no CWD trigger nor increased hunt	4,421	1,278	0.25	0.09	5,860	658	10,015	1,282
Alt D increased hunt	4,754	1,461	0.28	0.10	5,220	496	11,837	1,391
Alt D CWD trigger	6,452	1,650	0.23	0.09	5,834	654	9,845	2,068
Alt D CWD trigger and increased hunt	6,143	1,791	0.26	0.10	5,201	565	11,041	1,970
No feeding	6,724	1,574	0.24	0.08	5,667	600	8,916	1,835
Analysis area ¹								
Continue feeding	6,735	1,560	0.35	0.05	7,745	713	13,181	1,884
Alt D no CWD trigger nor increased hunt	5,867	1,471	0.28	0.07	7,702	859	13,419	1,709
Alt D increased hunt	6,144	1,557	0.31	0.08	7,048	673	15,161	1,781
Alt D CWD trigger	8,100	1,787	0.25	0.08	7,847	827	13,573	2,453
Alt D CWD trigger and increased hunt	7,829	1,967	0.28	0.08	7,144	753	14,752	2,260
No feeding	8,441	1,718	0.26	0.07	7,886	851	12,603	2,070

¹The analysis area includes elk from the JHU and elk within the analysis boundary in the Fall Creek Herd Unit in western Wyoming.

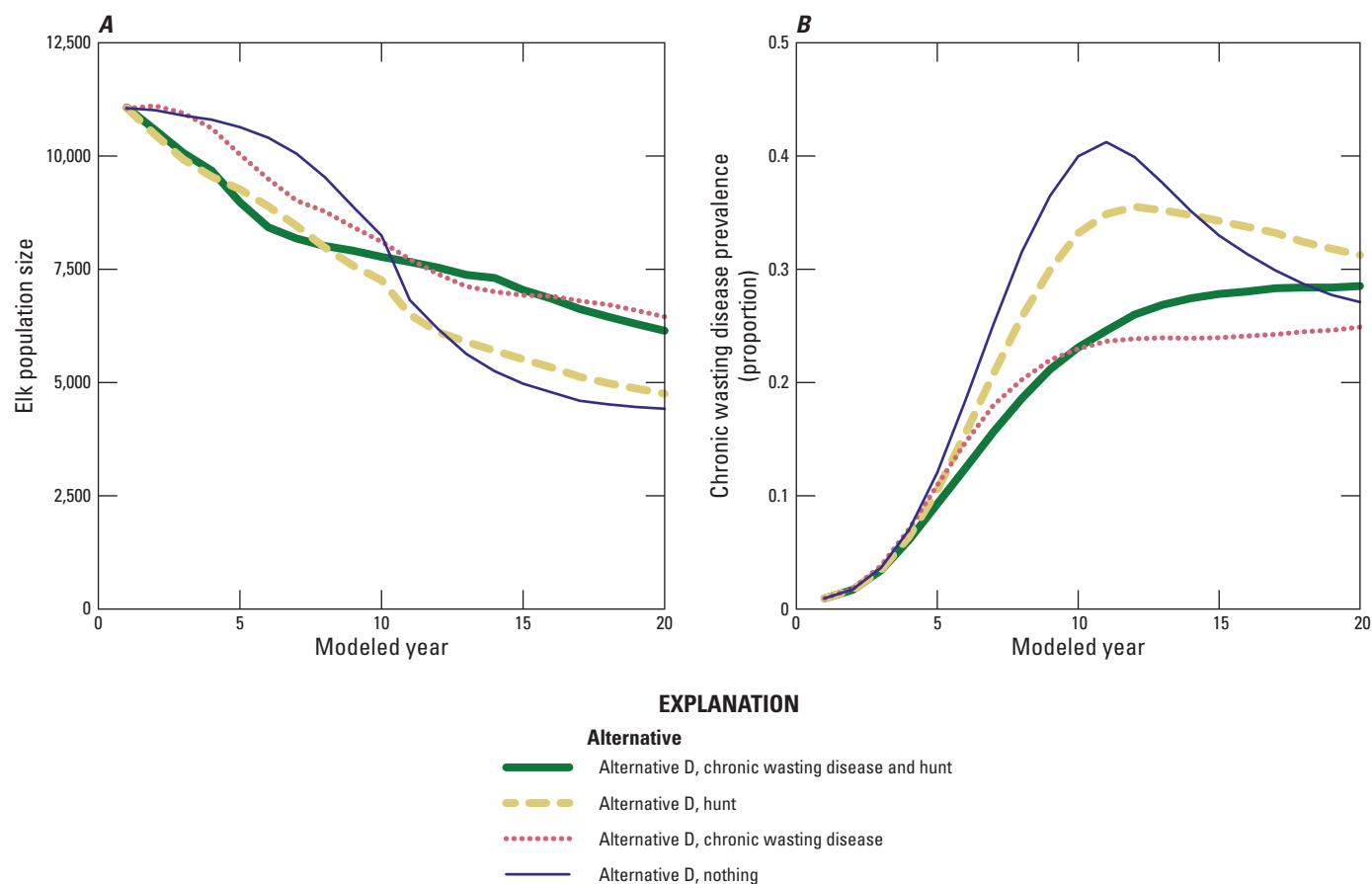


Figure F2. Graphs showing the performance of metrics for the Jackson elk population size and CWD prevalence under the four scenarios developed for alternative D, including the alternative with and without elk reductions caused by increased harvest and with and without a 7 percent CWD trigger. *A*, elk population size. *B*, CWD prevalence.

The alternative D scenario with the 7 percent CWD trigger resulted in a larger elk population size by year 20 compared with an alternative D with no 7 percent CWD trigger (table F1). Alternative D without the CWD trigger resulted in a Jackson elk herd population size at year 20 of 4,421 (SD=1,278) without an increase in hunting or 4,754 (SD=1,461) with an increase in hunting (table F1, fig. F1). In contrast, the inclusion of a CWD trigger and an increase in hunting resulted in a Jackson elk herd population size of 6,143 (SD=1,791) by year 20. An alternative D with a CWD trigger and an increase in hunting resulted in a higher elk population size by year 20 and a lower CWD prevalence than the continued feeding alternative (table F1). At the spatial extent defined by the full analysis area, we found similar trends as in the JHU with larger elk populations under scenarios that included the CWD trigger (table F1). The scenarios of alternative D that had no CWD trigger had lower elk population sizes compared to the alternative that continued feeding for 20 years, whereas alternative D scenarios with the CWD trigger had larger population sizes at year 20 (table F1).

The alternative D scenarios that focus on increasing initial hunting rates resulted in more cumulative elk harvested over the 20-year timeframe (11,041 [SD=1,970] elk harvested with CWD trigger and increased hunting compared to 9,845 [SD = 2,068] harvested with a CWD trigger but no increase in hunting). The

increased hunting rates led to more animals harvested at the full analysis area, having 14,752 (SD=2,260) elk hunted over 20 years with the CWD trigger and increased harvest compared to 13,573 (SD=2,453) with the trigger but without increased harvest (table F1).

Elk Use of Sensitive Habitats and Private Lands

In general, all four scenarios of alternative D resulted in fewer elk-use days on sensitive aspen, willow, and cottonwood habitat types on and adjacent to the Refuge compared to the continue feeding alternative (table F2). The exceptions for lower elk use were for cottonwood and willow under the alternative D scenario that included the 7 percent CWD trigger but not increased hunting, and willow under the alternative D scenario that included both the 7 percent trigger and had increased hunting (table F2). The scenario without the 7 percent CWD trigger, but with increased hunting, tended to perform the best across all metrics associated with elk use of sensitive habitats among the four scenarios of alternative D. Elk use of private lands and brucellosis risk to livestock was lower than the continue feeding alternative under alternative D scenarios without the 7 percent CWD trigger and higher under the two scenarios with the CWD trigger (table F2).

Table F2. Summary of elk use of sensitive habitats, private lands, and elk abortions on private lands for the analysis area in western Wyoming.

[SD, standard deviation; Alt D, alternative D; CWD, chronic wasting disease]

Alternative	Aspen ¹		Willow ¹		Cottonwood ¹		Private lands ²		Elk abortions on private lands	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Continue feeding	615	62	385	36	1,615	179	12.4	1.0	161	16
Alt D no CWD trigger nor increased hunt	546	45	375	39	1,560	185	12.3	1.2	160	20
Alt D increased hunt	510	45	357	34	1,486	162	11.9	1.0	158	16
Alt D CWD trigger	542	57	428	42	1,623	191	13.5	1.2	179	20
Alt D CWD trigger and increased hunt	525	55	411	43	1,585	171	13.2	1.2	173	21
No feeding	532	43	440	36	1,616	198	13.8	1.2	180	21

¹In thousands.

²In millions.

Socioeconomic Effects

The two alternative D scenarios without increased harvest showed similar cumulative revenues from elk harvest tags, hunting-related expenditures, and outfitter revenues compared to the continue feeding alternative over the 20-year period (table F3). These patterns result from the increased number of elk harvested under the alternative scenarios with increased harvest rates (table F1). In contrast, the alternative D scenarios with increased harvest had higher harvest-tag revenues, hunting-related expenditures, and outfitter revenues than the continue feeding alternative over the 20-year period (table F3).

Tradeoffs Among Alternatives

The full suite of nineteen performance metrics can be found in table F4. No single alternative or scenario among continued feeding, no feeding, and the four alternative D scenarios performed the best on all metrics simultaneously. Notably, there is a consistent tradeoff whereby stopping feeding earlier results in lower CWD prevalence and higher elk population sizes after 20 years but

produces higher elk use of private lands. The no feeding alternative results in one of the lowest estimates of CWD in elk and the largest elk population in year 20; however, that same alternative resulted in high elk use of private lands and sensitive habitats. Under the no feeding alternative, the bison population was lower, human-bison conflicts increased, and the estimated bison harvest was lower (table F4). In contrast, continuing to feed elk resulted in higher CWD prevalence in elk and lower elk population size in year 20, but less use of private lands, and some sensitive habitats, particularly willow. For bison, continued feeding resulted in more bison, fewer human-bison conflicts, and more estimated harvest (table F4).

Discussion

Scenarios with and without increased harvest and a 7 percent CWD trigger in alternative D resulted in predictions mostly consistent with other analyses in this report. These findings highlight the tradeoff between strategies that limit disease but maintain larger population sizes, and those that reduce human-wildlife conflicts but have higher CWD prevalence. For example, tradeoffs are apparent when

Table F3. Summary of 20-year cumulative revenues for elk harvest tag sales, hunting-related expenditures, and outfitters for the analysis area in western Wyoming.

[SD, standard deviation; Alt D, alternative D; CWD, chronic wasting disease]

Alternative	Elk harvest tag revenue ¹		Revenue for hunting-related expenditures ¹		Outfitter revenue ¹	
	Mean	SD	Mean	SD	Mean	SD
Continue feeding	5.5	0.6	88.6	12.2	12.6	1.7
Alt D no CWD trigger nor increased hunt	5.5	0.5	88.9	9.6	12.8	1.4
Alt D increased hunt	6.9	0.7	109.5	11.4	15.8	1.6
Alt D CWD trigger	5.3	0.8	84.6	15.5	12.2	2.2
Alt D CWD trigger and increased hunt	6.4	0.8	99.6	14.9	14.4	2.1
No feeding	5.0	0.8	76.1	14.8	10.9	2.1

¹In millions.

Table F4. Consequence table showing the performance metrics and alternatives. Modified from Cook and others, 2025, this volume, chap. A, Table A2.

[Refer to Cook and others, 2025, this volume, chap. A, Table A1 for full performance metric details. Measures for 1a–c were rounded to two significant figures. Fundamental objective four was raised as important by NER managers (in alignment with FWS and NPS, 2007); however, subject matter experts from the FWS, NPS, FS, and WGFD expected that the effects of bison and elk on the chemical, physical, and biological properties of water resources at the Refuge would be the same under all alternatives. Therefore, this objective was not considered further. Alt D, alternative D; CWD, chronic wasting disease; SD, standard deviation; min., minimum; max., maximum]

Performance metric, direction and unit	Continue feeding		Alt D no CWD trigger nor increased hunt		Alt D increased hunt		Alt D CWD trigger		Alt D CWD trigger and increased hunt		No feeding	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Objective 1—Maximize the health and well-being of wildlife												
1a, CWD prevalence, min. at year 20	0.35	0.05	0.31	0.08	0.28	0.07	0.28	0.08	0.25	0.08	0.26	0.07
1b, elk population size, max. at year 20	6,700	1,600	6,100	1,500	5,900	1,500	7,800	2,000	8,100	1,800	8,400	1,700
1c, minimize elk suffering, min. mortality in first 5 years	8,000	730	7,000	670	7,700	860	7,100	750	7,800	830	8,100	850
1d, bison population size, max. at year 20	550	60	550	60	550	60	550	60	550	60	462	65
Objective 2—Maintain ecosystem fluctuations and processes associated with bison and elk												
2a, elk use of aspen, min. cumulative elk days ^{1,2}	616	61	510	45	546	51	525	55	542	57	532	43
2b, elk use of cottonwood, min. cumulative elk days ^{1,2}	1,615	179	1,486	162	1,560	185	1,609	183	1,623	191	1,616	198
2c, elk use of willow, min. cumulative elk days ^{1,2}	385	36	357	34	375	39	411	43	428	42	440	36
Objective 3—Minimize risk of invasive species introduction associated with bison and elk management activities												
3, invasive species risk, min. cumulative feeding days ¹	1,243	100	680	74	680	74	344	87	319	78	0	0
Objective 5—Maintain and enhance multiple-use opportunities and public enjoyment												
5a, elk harvest, max. cumulative elk harvested ¹	13,181	1,885	15,162	1,782	13,419	1,710	14,753	2,261	13,574	2,453	12,603	2,071
5b, number of visitors, max. visitors ^{1,3}	3.4	0.8	3.3	0.8	3.3	0.8	3.3	0.8	3.3	0.8	3.3	0.8
Objective 6—Minimize human-wildlife conflicts												
6a, elk use of private lands, min. elk days ^{1,3}	12.4	1.0	11.9	1.0	12.3	1.2	13.2	1.2	13.5	1.2	13.8	1.2
6b, human-bison conflict, min. number of conflict bison	143	16	143	16	143	16	143	16	143	16	1,077	474
6c, Brucellosis risk, min. abortions on private lands ¹	161	16	158	16	160	20	173	21	179	20	180	21
Objective 7—Minimize costs of bison and elk management activities												
7, cost of management, min. dollars ^{1,3}	19.3	1.6	11.3	1.2	11.3	1.2	6.6	1.3	6.3	1.1	0	0
Objective 8—Maximize local economic benefits associated with bison and elk presence on the NER and surrounding lands												
8a, elk harvest tags, max. dollars ^{1,3}	5.5	0.6	6.9	0.7	5.5	0.5	6.4	0.8	5.3	0.8	5.0	0.8
8b, regional economic inputs for hunting activities, max. dollars ^{1,3}	88.6	12.2	109.5	11.4	88.9	9.6	99.6	14.9	84.6	15.5	76.1	14.8
8b, regional economic inputs for nonhunting, max. dollars ^{1,3}	3.0	0.7	3.0	0.7	3.0	0.7	3.0	0.7	3.0	0.7	2.9	0.7
8c, revenue of outfitters, max. dollars ^{1,3}	12.6	1.7	15.8	1.6	12.8	1.4	14.4	2.1	12.2	2.2	10.9	2.1
Objective 9—Maximize opportunities for Tribes to engage in activities related to their buffalo culture												
9, bison harvest, max. bison harvested	1,879	197	1,879	197	1,879	197	1,879	197	1,879	197	1,292	247

¹Cumulative across the 20-year simulation.

²Rounded, in thousands.

³Rounded, in millions.

considering continuing to feed elk for 20 years or stopping feeding immediately. Continuing to feed is predicted to lead to relatively high CWD prevalence and lower elk population size for the analysis area, but consistently performed better on metrics associated with elk use of private lands and sensitive habitats, compared to no feeding (table F4). The other alternatives or scenarios that stop feeding after several years, while elk populations are reduced by harvest (for example, alternative D with increased harvest), mitigate some of the negative effects on private lands associated with stopping feeding immediately, while also leading to increased harvest opportunities and economic revenues associated with hunting.

Under all scenarios for alternative D, the elk population in the JHU is predicted to decline by 42–60 percent, based on the lowest elk population size at year 20 of 4,400 individuals (alternative D without the 7 percent CWD trigger or increased harvest) and largest elk population size of 6,400 individuals under alternative D without hunting and the 7 percent CWD trigger (table F1). These declines result from the following two primary drivers: elevated disease-associated mortality and lowered elk survival without winter feeding. For disease, alternative D with the 7 percent CWD trigger performed similarly to stopping feeding immediately and the previously analyzed 3 percent CWD trigger alternative (25 percent CWD prevalence in year 20 under alternative D after stopping feeding at 7 percent as opposed to 26 percent CWD prevalence in year 20 under the no feeding and 3 percent disease threshold alternatives). In contrast, alternative D without the 7 percent CWD trigger and hunting led to a 38 percent spike of CWD around year 20 before declining to a level fairly comparable to the other alternative D scenarios.

Although there remains substantial uncertainty about the precise dynamics of CWD in supplementally fed and unfed elk in the JHU and whether disease transmission rates for fed elk might be as high as predicted in Cook and others (2023), CWD has a high prevalence in certain settings. Previous studies found CWD prevalence in excess of 60 percent in captive settings (Peters and others, 2000; Williams and others, 2014). Estimates in free-ranging elk have been generally lower; however, Wind Cave National Park is estimated to have the highest prevalence in elk at 29 percent (Sargeant and others, 2021).

Conclusion

The decision on whether and how to feed elk and bison on the NER is a complex one that has embedded tradeoffs when trying to maintain large populations of elk with limited human-elk conflict and abundant opportunities to hunt and view elk, while also minimizing the potential for disease to spread within animals in high-density feeding conditions. Increased harvest rates prior to closing feedgrounds may help alleviate some of the challenges associated with elk on private lands. Still, no alternative or scenario can maximize the achievement of all objectives simultaneously. This chapter provides updated analysis and estimates for alternative D compared to the previous set of five alternatives and further enhances the set of strategies available for FWS and cooperating agencies to navigate the difficult tradeoffs and develop the next Bison and Elk Management Plan.

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APPENDIX H – U.S. Fish and Wildlife Service: Scoping Summary Report

National Elk Refuge Bison and Elk Management Plan and Environmental Impact Statement

Scoping Summary Report

December 2023



U.S. Department of the Interior

Fish and Wildlife Service

Region 6 Mountain-Prairie Region

The Department of the Interior protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities.

Appendix I: National Elk Refuge Bison and Elk Management Plan and Environmental
Impact Statement
Scoping Summary Report

The mission of the U.S. Fish and Wildlife Service is working with others to conserve, protect, and enhance fish, wildlife, plants, and their habitats for the continuing benefit of the American people.

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Acronyms

BEMP Bison and Elk Management Plan

BTNF Bridger-Teton National Forest

CCP Comprehensive Conservation Plan

CDC U.S. Centers for Disease Control and Prevention

CIDRAP Center for Infectious Disease Research and Policy

CWD chronic wasting disease

EIS environmental impact statement

Service U.S. Fish and Wildlife Service

Grand Teton Grand Teton National Park

GYC Greater Yellowstone Coalition

NEPA National Environmental Policy Act

NGO non-governmental organization

NPS National Park Service

SCI Safari Club International

SEIS supplemental environmental impact statement

TSE transmissible spongiform encephalopathies

USFS U.S. Forest Service

WGFC Wyoming Game and Fish Commission

WGFD Wyoming Game and Fish Department

Section 1: Introduction

The U.S. Fish and Wildlife Service (Service), part of the U.S. Department of the Interior, is developing a Bison and Elk Management Plan (BEMP) and Environmental Impact Statement (EIS) to support healthy, sustainable bison and elk populations on the National Elk Refuge (the Refuge).

Public involvement is a key component of the National Environmental Policy Act (NEPA). As part of NEPA, scoping is an early and ongoing process required for an EIS. It engages federal, state, local, and tribal governments, as well as the public, to identify concerns, potential impacts and alternative actions. Scoping helps the Service develop a greater understanding of baseline conditions, emerging issues and new scientific information. It also informs development of alternatives and potentially affected resources to be analyzed in the EIS.

The Service published a Notice of Intent in the Federal Register on August 1, 2023, announcing a scoping period from August 1 to 31, 2023. This was also announced on the BEMP [project webpage](#), along with a project [fact sheet](#). The Service advertised the scoping period and project webpage through news media and social media. On August 1, 2023, the news release was distributed to Jackson Hole News & Guide; Buckrail; Mountain West News Bureau, Wyoming Public Media; and WYOFile. The Mountain-Prairie Twitter account, a Regional Twitter account for the Service, also announced the scoping period and project website on August 1, 2023.

During the 30-day scoping period, the Service held three public meetings: one each on August 21st, 22nd, and 23rd. Two were held in-person — one in Jackson, Wyoming, and the one in Pinedale, Wyoming. Attendance at the in-person meetings was lower than expected (fewer than 20 people). The last meeting was held virtually and was attended by 25 individuals.

Interested parties could provide input electronically via the Regulations.gov website or U.S. mail.

Following the 30-day public scoping period, the Service determined further engagement was needed to update the public on management objectives and alternatives being considered and to answer the public's questions. In March 2024, the Service announced additional opportunities to participate in developing the updated BEMP for the Refuge. These included information sessions on the alternatives being considered and feedback workshops to inform the public and highlight concerns, tradeoffs, and ways to reduce adverse consequences associated with management alternatives. The Service held two information sessions — one in-person session on May 1st in Jackson, Wyoming, and one virtually session on May 6th. Around 20 individuals attended each session. A recording of the virtual presentation was posted on the BEMP project webpage.

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Scoping Summary Report

The Service contracted the Langdon Group to facilitate workshops to elicit input from a wide range of interests and encourage deeper discussions on the management alternatives. Before the workshops, the Langdon Group conducted a situation assessment by interviewing 19 individual stakeholders identified by the Service. Situation assessment participants, as well as agency representatives from the Service, WGFD, National Park Service, and U.S. Forest Service participated in one of two three-hour workshops facilitated by the project team. The workshops were held in Jackson, Wyoming on May 21 and 22, 2024. In total, 20 people attended the workshops (excluding Service staff). The Stakeholder Engagement Summary Report (Appendix J) prepared by the Langdon Group outlines the feedback received from the situation assessment and workshop participants.

Section 2: Method of Comment Analysis

The comment analysis process included three main components:

- Developing a comment coding structure
- Reviewing, coding, and summarizing public comment submissions (see Section 7, Comment Submission Summary)
- Interpreting and analyzing substantive comments to identify issues and themes (see Section 8, Summary of Public Comments)

In this report, a comment submission refers to a unique comment received by letter or electronic means by the Service during the public scoping period. A comment refers to a substantive statement identified in the comment submission. The Service initially reviewed each submission as a whole to identify:

- Submissions that were out of scope as they did not pertain to the plan (for example, a submittal pertaining to another project or seeking relocation of a town)
- Submissions requiring immediate attention, such as those containing requests for maps, geographic information systems data, or other data; official Freedom of Information Act requests; requests for a scoping period extension; or other comments that needed to be brought to the attention of the Service immediately

Contact information was not gathered for out-of-scope submissions; those submissions were not processed further. Comments that merely supported or opposed a proposal or that only agreed or disagreed with Service policy were not considered substantive. All other submissions contained some level of substantive comment and were processed further. Once identified, each substantive comment was coded and compiled with other substantive comments. The Service considered all substantive comments and will use them to identify issues and values to be considered. Substantive comments received during the public scoping period did one or more of the following:

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- Raised issues the Service had not considered or reinforced issues the Service had already identified
- Presented new information the Service can use when developing the alternatives
- Raised reasonable concerns regarding public land resources in the planning area

All substantive comments are included in Table 1 below.

Section 3: Content Submission Summary

All submissions received on or before August 31, 2023, were evaluated and are considered in this scoping summary report. This report summarizes all the comments related to each issue.

The Service received 20 unique written submissions during the public scoping period. Of these, 18 unique written submissions were about the the Refuge BEMP. After reviewing each submission, we extracted 70 individual substantive comments. The number of substantive comments extracted from individual submissions varied from 1 to 20.

The Service categorized each submission by the commenter's affiliation. Letters written on business, agency, or organization letterhead or those signed using an official agency title were considered as representing that organization or agency. Unique submissions by affiliation break down as follows:

- Individual: 9 submissions
- Organization: 6 submissions
 - Defenders of Wildlife, National Wildlife Refuge Association, Sierra Club Wyoming Chapter
 - Friends of Animals
 - Gallatin Wildlife Association
 - Greater Yellowstone Coalition
 - Safari Club International
 - Wyoming Wildlife Advocates
- Government (federal, state, tribal, and local): 3 submissions
 - Coalition of Local Governments (County Commissions for Sweetwater, Lincoln, and Unita, and Conservation Districts for Lincoln, Little Snake, Sweetwater, Unita, and Sublette)
 - Montana Department of Fish, Wildlife and Parks
 - Wyoming Department of Environmental Quality — Water Quality Division

A total of 70 substantive comments were received and were grouped into broad issue categories of Wildlife, Other Natural Resources, Human Environment, and the NEPA, Process. See Table 1 for the list of substantive comments.

Section 3: Summary of Public Comments and Response

This section summarizes the issues and areas of concern identified in the scoping comments and provides the Service's response to those comments. Similar comments were grouped and summarized by issue category to highlight issues and information for the Service to consider during the planning process.

Wildlife

Disease

Comment Summary: Many commenters expressed concern about wildlife diseases such as chronic wasting disease (CWD), noting that disease management should be the highest priority for the Refuge, and suggested various management strategies to reduce disease risk and transmission such as reducing elk density, phasing out feeding, and vaccines.

Response: Responding to CWD and other disease threats to bison and elk is one of the main purposes and needs of the BEMP. The current draft BEMP and draft EIS include newly available scientific information and changed conditions since the original 2007 plan adoption, including the presence of CWD in the Jackson Elk Herd. The draft EIS analyzes the potential impacts of CWD and brucellosis not only on elk and bison, but also on other wildlife, livestock, and humans. As part of this planning process, the Service is considering a wide range of alternatives and management strategies to address these disease concerns and will continue to adaptively manage the bison and elk herds as new information and science arises surrounding new and emerging diseases.

Elk and Bison Population Objectives and Carrying Capacity

Comment Summary: Some commenters requested that the Service meet the State's population objective or aim for a higher target, while others requested that the Service only maintain populations of elk and bison that naturally available forage can support.

Response: For decades, the Service has worked closely with WGFD and NPS to cooperatively manage the Jackson bison and elk herds. As a result of this long-standing partnership, WGFD is participating as a Cooperating Agency on the Environmental Impact Statement (EIS). The Service remains committed to a cooperative approach to herd management, including supporting Wyoming's population objectives for these herds—as feasible—based on the Refuge's carrying capacity. One of the main goals of the Bison and Elk Management Plan is to ensure healthy and sustainable populations of bison, elk, and other wildlife on the Refuge. This issue is addressed throughout the draft EIS.

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Comment Summary: A commenter requested that the Service analyze how the bison population might grow naturally, without supplemental feeding, if they decide to reduce the elk population.

Response: In collaboration with USGS, the Refuge analyzed bison population dynamics under several management alternatives (Appendix E) using best available science, and that analysis suggested that the bison population would decline over the next 20 if the Refuge stopped supplemental feeding even with reductions in the elk population. This issue is discussed further in the draft EIS.

Habitat

Comment Summary: Commenters expressed that the planning processes consider restoration and enhancement of habitat not only for elk and bison but for all native species on the Refuge and in the greater ecosystem. Commenters encouraged coordination with adjacent public and private lands for habitat management along with securing financial resources for habitat restoration and irrigation improvements. Another commenter requested that the Service explore opportunities to expand tolerance for bison and elk on adjacent lands

Response: Alternatives B, C, and D in the draft EIS propose habitat restoration on former prairie/shrub feed ground locations and riparian areas along Flat and Nowlin Creeks. The Service is also proposing to continue forage production on the Refuge through irrigation based on availability of staff, resources, and funding.

We recognize that the conservation of bison and elk reaches far beyond the Refuge's boundary and successful conservation of these herds requires coordination, communication, and collaboration with not only the other Cooperating Agencies, but also private landowners, guides and outfitters, tribes, community members, and non-profit organizations. The Service plans to continue to strengthen these partnerships as we implement the BEMP and explore opportunities to enhance elk and bison winter range beyond the Refuge boundary. While the draft EIS considers the effects of bison and elk on adjacent lands (Chapter 4, Section 4.5 Private Lands and Other Public Lands), any strategies outside the boundaries and jurisdiction of the Refuge are beyond the scope of the Bison and Elk Management Plan and draft EIS.

Other Species

Comment Summary: A commenter requested that the Service prioritize balancing sustainable populations of elk and bison on the Refuge with the needs of other species, particularly migratory birds, which are included in the Refuge's purposes. Another commenter requested that the EIS address effects to threatened and endangered Species if elk or bison populations decrease.

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Response: As discussed above, one of the main needs of this Bison and Elk Management Plan is to ensure healthy and sustainable populations of not only bison and elk, but of the other wildlife on the Refuge. Conservation of wildlife and their habitats is the core management mission of the National Wildlife Refuge System. The Refuge protects critically important habitat for numerous iconic species, including elk, bison, wolves, trumpeter swans, bald eagles, bighorn sheep, and cutthroat trout. The effort to protect these species will continue under the BEMP. The draft EIS evaluates the impacts of all proposed alternatives on other wildlife, including threatened and endangered species in Chapter 4, Sections 4.1 Other Wildlife and Candidate and 4.1 Threatened, and Endangered Species).

Comment Summary: A commenter would like the Service to increase tolerance for wolves as a strategy to combat CWD.

Response: The Service allows wolves to roam freely, den, hunt, scavenge and otherwise behave as they naturally would on the Refuge. No hunting or hazing of wolves is permitted on the Refuge. While the draft EIS considers the effects of predation by wolves on bison and elk management, any strategies for managing wolves outside the boundaries and jurisdiction of the Refuge are beyond the scope of the Bison and Elk Management Plan and draft EIS.

Other Natural Resources

Climate Change

Comment Summary: A commenter emphasized the need to consider the effects of climate change on elk, bison, and their habitat. They call for implementing less harmful alternatives to manage these species under changing climate conditions.

Response: The potential effects of changing climate and ecological conditions in the future on the resources that would be potentially affected by the proposed action are discussed in the draft EIS where appropriate. In addition, Appendix L provides more detailed discussion of potential future climate and ecological conditions in the landscape and how these conditions may impact bison and elk on the Refuge and in the greater landscape.

Soil, Water, Plants

Comment Summary: A commenter expressed concern about the contamination of soil, water, and plants resulting from the proposed action, particularly potential contamination of these resources from CWD, and requested that adverse effects to these resource areas be analyzed.

Response: The potential adverse impacts on soils and vegetation resulting from the implementation of each alternative is discussed in detail in Chapter 4 (Section 4.1

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Vegetation/Habitat/Soils) of the draft EIS, including the potential for CWD soil contamination.

Water Quality

Comment Summary: Commenters also expressed concerns on how management of the bison and elk herds may impact water quality. Recommendations include identifying and evaluating potential impacts on surface and groundwater quality and implementing steps to minimize potential impacts from hazardous substances.

Response: Surface water and groundwater present in the potential area of effects and potential consequences of implementing the proposed action, including potential contamination of water resources with animal-born diseases, are evaluated in Chapter 4 (Section 4.1 Water Resources). The proposed action will not involve the use of chemicals, petroleum products, produced water, or any other hazardous substances.

Human Environment

Management Costs and Operations

Comment Summary: A commenter pointed out that ending feeding would save a considerable amount of Refuge's resources.

Response: The draft EIS provides an analysis of the costs of supplemental feeding. The Service acknowledges that the cessation of supplemental feeding would greatly reduce management costs (Chapter 4, Section 4.7 Management Costs and Operations).

Human Health and Safety

Comment Summary: A commenter expressed concern that Jackson residents could ingest prions through water, and that CWD has the potential to cross species barriers. The commenter also expressed concern over CWD in wild game entering the human food chain.

Response: While there is no evidence currently that CWD has the potential to be spread to humans, the EIS evaluates this cross-over possibility and other impacts of managing bison and elk on public health and safety (Chapter 4, Section 4.4 Public Health and Safety). The Service is committed to minimizing risks to human health and safety through its management of bison and elk on the Refuge.

Human-Wildlife Conflict

Comment Summary: There are concerns about potential conflicts with livestock and private lands if feedgrounds are reduced. A commenter would like the Service to continue feeding to reduce human-wildlife conflict and property damage. Another commenter

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requested that the Service consider alternative ways to reduce conflict, such as fencing to maintain separation between elk/bison and livestock.

Response: The Refuge is committed to a decision-making process for the BEMP that is appropriate for the landscape and minimizes the potential for human-wildlife conflicts. Minimizing human-wildlife conflict and property damage is one of the main considerations in this planning process and the draft EIS proposes several strategies for addressing human-wildlife conflict in the various alternatives considered (Chapter 3, Section 3.2 Alternatives). The draft EIS also analyzes the impacts of all management alternatives on both human-wildlife conflict and on property damage (Chapter 4, Section 4.4 Public Health and Safety, Section 4.5 Private Lands and Other Public Lands, and Section 4.6 Economics).

Wildlife-Dependent Recreation

Comment Summary: One commenter requested that the Service consider alternatives that do not include annual hunts to manage elk and bison populations. Another commenter requested that the Service preserve elk and bison hunting and viewing opportunities on the Refuge, particularly as they are compatible with State law and management goals.

Response: Hunting of resident wildlife on Service lands generally follows State regulations, including seasons and bag limits. However, station-specific regulations can be more restrictive to meet specific refuge objectives, such as managing wildlife populations and habitats, minimizing disturbance, maintaining high-quality recreational opportunities, reducing conflicts with other public uses, and ensuring public safety.

Although the term "refuge" implies a haven of safety, hunting is considered a legitimate and priority use of wildlife refuges if deemed compatible by the National Wildlife Refuge System Administration Act, as amended (16 U.S.C. 668dd(a)(3)(D)). Refuges are managed to support healthy wildlife populations, often producing harvestable surpluses. Hunting and fishing on refuges do not threaten wildlife populations and can replace other types of mortality. In some cases, hunting is used as a management tool to reduce populations, particularly for invasive species that threaten ecosystem stability. Facilitating hunting opportunities aligns with the Service's responsibilities under the NWRS legislation.

The Service has determined that bison and elk hunting, along with wildlife observation, photography, fishing, and environmental education, are compatible with the purposes of this Refuge. Therefore, eliminating hunting opportunities was not considered in this plan, and these priority public uses will continue to be provided.

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Socioeconomics

Comment Summary: The socioeconomic impact of changes in elk and bison management on local communities and businesses is a theme in several comments. Comments emphasize promoting wildlife-dependent recreation and non-hunting activities, considering the economic benefits of tourism and wildlife viewing. A commenter requested that the Service consider the impacts of diseased elk and bison on the economy.

Response: The draft EIS provides a detailed evaluation of the socioeconomic consequences of implementing the four proposed alternatives, including how disease may impact the economy, including tourism, hunting, residents, and landowners (Chapter 4, Section 4.6 Economics). The draft EIS also evaluates the potential impacts of both diseased and starving animals on visitor use and experience (Chapter 4, Section 4.3 Visitor Use and Experience).

Cultural and Historic Importance

Comment Summary: Commenter highlighted the value of increased bison populations for Tribes, including hunting opportunities and cultural significance. There is a call for developing a cooperative plan with interested Tribes to support treaty rights and tribal access to wildlife.

Response: The Service has been meeting with the Eastern Shoshone, Northern Arapaho, and Shoshone-Bannock Tribes throughout this planning process to hear and understand their interests in this planning process as well as cooperate beyond this planning process to support treaty rights and tribal access to wildlife on the Refuge. For more information on Tribal Coordination, see Chapter 2.3 of the draft EIS. A representative from the Shoshone-Bannock Tribe has joined the interdisciplinary team to assist in drafting and reviewing the BEMP and EIS, ensuring accuracy related to their interests.

The Service received a request from the Shoshone-Bannock tribe to consider an “bison tolerant alternative” that raises the population objective numbers of the Jackson bison herd to allow for a higher number of tribal harvests. While we appreciate this request from the Tribe and have left open the potential for the Service to manage a bison population that is higher than today, the State of Wyoming sets the overall Jackson bison herd population objective not the Service, and so setting the bison population objective is not part of the purpose and need of this plan. Therefore, we have dismissed this alternative from further consideration in this EIS. We will continue to have conversations with the Tribe and the State of Wyoming regarding the Tribe’s request. Additionally, the Service is further committed to continuing conversations and exploring opportunities to further honor treaty rights and tribal access to wildlife on the Refuge.

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NEPA Process

Adaptive Management

Comment Summary: Commenters recommended the Service use an adaptive management approach to managing bison and elk. One commenter called for setting specific, incremental implementation goals and metrics, along with conducting annual audits to assess progress and adjust plans accordingly.

Response: Alternatives B and D in the draft EIS include adaptive management strategies for elk and bison herd management, with clearly defined goals and measurable metrics. Under all alternatives, the Service—working in coordination with the WGFD and other Cooperating Agencies—will continue monitoring efforts to evaluate the effectiveness of these cooperative strategies. This monitoring will focus on overall population trends, herd segment sizes, and the prevalence of CWD and other diseases in the Jackson elk and bison herds. Based on the results, additional management actions will be taken as part of the BEMP implementation.

Scope of Analysis

Comment Summary: Commenter requested that the Service consider and address climate change, disease, supplemental feeding, habitat connectivity, cumulative impacts, the role of the Refuge, and the BEMP's relation with the Comprehensive Conservation Plan (CCP).

Response: The Service has considered, analyzed, and addressed all the above issues in the draft BEMP and EIS.

Cooperating and Participating Agencies

Comment Summary: Comments highlight the importance of coordination and cooperation with Cooperating Agencies and local agencies such as Lincoln County, Star Valley Conservation District, and Sublette County Conservation District in the planning and NEPA process.

Response: For decades, the Service has been working closely with WGFD, the National Park Service, and the U.S. Forest Service on managing the Jackson bison and elk herds. Due to these ongoing partnerships, these agencies are "Cooperating Agencies" on this EIS. A "Cooperating Agency" in a NEPA process are those Federal, State, Tribal, or local agencies that either have jurisdiction or "special expertise with respect to any environmental issue" (40 Code of Federal Regulations [CFR] 1501.8). As Cooperating Agencies, these agencies have participated in the planning process by helping develop the alternatives proposed in the draft EIS, providing technical data, expertise, comment, and review, and generally contributed their subject matter expertise to the development of this draft EIS.

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Furthermore, local entities were invited to and participated in the half-day workshops the Service held in May 2024 (Appendix I). Additionally, Sublette County Conservation District is a participating agency on the development of the EIS representing the interests of the above listed local entities and has been providing review and comments on the draft EIS to ensure local interests and impacts are properly represented in this planning effort.

Given the wide range of authorities and interests, the Service has used, and will continue to use, a cooperative approach with these entities in bison and elk management on the Refuge.

Comment Summary: A commenter requested that the Service ensure the BEMP is consistent with the State regarding disease management, winter-feeding programs, hunting regulations, and other relevant management issues. The commenter requested that the updated BEMP work with the State's Wyoming Elk Feedgrounds Plan.

Response: For decades, the Service has been working closely with WGFD on managing the Jackson bison and elk herds. In continuation of this partnership, WGFD is serving as a "Cooperating Agency" on the EIS and has collaborated on the development of the alternatives considered. The Service aims to be consistent with and in support of the State's Wyoming Elk Feedgrounds Plan where possible based on our varying missions, management and legal responsibilities with the ultimate goal of co-managing healthy and sustainable bison and elk herds.

Comment Summary: Commenters requested that the Service consider how other agencies' management plans that are under development may affect the bison and elk populations. These plans include BTNF's Forest Plan Revision, the WGFD's Elk Feedground Management Plan, the WGFD's annual hunting season setting and rulemaking, Teton County's update of Land Development Regulations, and the Grand Teton National Park's Visitor Use Plans.

Response: WGFD, U.S. Forest Service (Bridger-Teton National Forest), and NPS (Grand-Teton National Park) are all "Cooperating Agencies" and have collaborated on the development of the alternatives considered. The Service has considered these planning efforts by Cooperating Agencies, as well as Teton County and other local entities, and how they both impact and may be impacted by any potential management strategies the Service may implement as appropriate in the draft EIS in Chapter 4, Section 4.1 Elk: Other Reasonably Foreseeable Effects, Section 4.1 Bison: Other Reasonably Foreseeable Effects, and Section 4.5 Private Lands and Other Public Lands. The Service recognizes that a coordinated approach to bison and elk management is crucial to the long-term conservation of these species and will continue to cooperate with these entities on bison and elk management as we implement these management strategies based on our varying missions,

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management and legal responsibilities with the ultimate goal of co-managing healthy and sustainable bison and elk herds.

Public Engagement

Comment Summary: A commenter requested two public webinars.

Response: In March 2024, the Service announced additional opportunities to participate in developing the updated BEMP for the Refuge and held information sessions and workshops in April/May 2024.

Purpose and Need

Comment Summary: A commenter requested that a commitment to phase out winter feeding as expeditiously as practicable should be included in the purpose and need of the plan. The commenter also requested that the Service make no mention of the WGFD's herd objective in the purpose and need.

Response: Section 1.3 of the EIS states the purpose for the BEMP, which is to provide the Service with long-term management objectives and strategies for ensuring healthy and sustainable populations of bison and elk on the Refuge in compliance with the purposes of the Refuge, the mission of the National Wildlife Refuge System, other applicable laws and policies, and that meet the 11-listed supported needs of the BEMP, which do not specifically mention the WGFD's herd objective.

Range of Alternatives

Comment Summary: Commenters requested that the Service analyze a wide range of alternatives spanning from high to low levels of management. Commenters' recommendations ranged from phasing out supplemental feeding to continuing feeding. One commenter requested an alternative that would end supplemental feeding and summer irrigation. Yet another commenter requested that the no-action alternative be a continuation of current management, while all other alternatives be designed to phase out feeding as expeditiously as possible.

Response: The Service along with the USGS and other Cooperating Agencies, considered a wide range of alternatives both as part of the Structured Decision-Making Process (Appendix B) and the development of the draft EIS, in part based on these public comments. The draft EIS includes evaluation of a range of elk and bison management alternatives, which include continuing feeding elk and bison (Alternative A), stopping feeding elk based on a 3% CWD prevalence threshold (Alternative B), phasing out feeding of elk and bison over five years (Alternative C), and adaptatively managing the elk population to reduce the number of elk overwintering on the Refuge (Alternative D). See Chapter 3 of the draft EIS for more information.

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Reasonably Foreseeable Connected Actions

Comment Summary: Commenter emphasized the need to consider the cumulative impacts of reducing winter feedgrounds on all elk herd units and other related projects.

Response: The Service has analyzed how reducing winters feedgrounds on the Refuge will impact other elk herd units and other agencies' management of bison and elk in the State and Region throughout Chapter 4 of the draft EIS as appropriate, including in Section 4.1 Elk: Other Reasonably Foreseeable Impacts and Section 4.5 Private Lands and Other Public Lands.

**APPENDIX I – Stakeholder Engagement Summary
Report: National Elk Refuge, Bison & Elk
Management Plan (Prepared by the Langdon Group
for U.S. Fish and Wildlife Service)**

US FISH AND WILDLIFE SERVICE
NATIONAL ELK REFUGE, BISON & ELK
MANAGEMENT PLAN
LEADERS MEETING SUMMARY REPORT

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FWS, through the Department of the Interior’s Collaborative Action and Dispute Resolution office, contracted with Kearns & West to develop this report.¹

¹ Prepared by The Langdon Group under subcontract to Kearns & West, collectively referred to as the “Project Team.”

Background

The U.S. Fish and Wildlife Service (FWS), U.S. Department of the Interior, intends to prepare an updated Bison and Elk Management Plan (BEMP) and environmental impact statement (EIS) for the National Elk Refuge (NER). The BEMP describes FWS's proposal for the management of the Jackson bison and elk populations within their respective jurisdiction, with a goal of ensuring sustainable and healthy herds. An EIS will be prepared pursuant to the National Environmental Policy Act of 1969 to evaluate the potential environmental impacts of the updated BEMP.

The Jackson bison and elk herds make up one of the largest concentrations of free-ranging ungulates in North America. Currently, these herds number about 450 bison and 10,600 elk. More than 15 years have elapsed since the last BEMP was finalized in 2007. Conditions have changed, but elk management remains one of the most important management actions for the NER.

The BEMP will address changed conditions and newly available scientific information. The BEMP will also set new desired conditions, management goals, objectives, and strategies to guide management of bison and elk on the NER. The goal is a healthy, sustainable population of elk and bison on NER and the southern portion of the Greater Yellowstone Ecosystem.

Draft objectives of the updated BEMP include:

- Maintain sustainable populations of elk.
- Maintain sustainable populations of bison.
- Maintain sustainable populations of other wildlife affected by elk and bison management activities.
- Maintain physical habitats and environmental processes associated with bison and elk.
- Maximize health and human safety related to elk and bison.
- Maintain social and economic benefits associated with elk and bison.
- Minimize impacts on cultural, archaeological, and ethnographic resources.
- Minimize costs of bison and elk management activities.

In August 2023, FWS opened a 30-day scoping period for the development of an updated BEMP and an associated EIS for managing elk, bison and habitat on the National Elk Refuge. During this scoping period, FWS took public comments and held public scoping meetings to provide interested stakeholders and members of the public an opportunity to learn more about the process, ask questions, and provide feedback.

In March 2024, FWS announced additional opportunities to engage in the development of the updated BEMP for the National Elk Refuge. These included a series of public information meetings to introduce the alternatives, held in April and May 2024, and feedback workshops to inform the public and further understand concerns, tradeoffs, and potential ways to reduce adverse consequences associated with potential management alternatives. This work was summarized in a report (*APPENDIX A*).

On October 30, 2024, FWS held an in-person leaders meeting in Jackson, WY with leaders of key agencies associated with managing elk, bison and habitat near and surrounding the NER. The purpose of this meeting was to share data from USGS analysis and the Stakeholder Summary Report as well as review and discuss the most recent revisions to the proposed alternatives for the draft EIS.

Meeting Summary

This is a summary of the Leaders Meeting hosted by FWS in Jackson, WY on Wednesday, October 30, 2024, including topics, questions, points of discussion, and action items. This summary does not repeat content that was included in the presentation slides.

The Leaders Meeting was hosted by FWS on Wednesday, October 30, 2024, with no virtual component at the U.S. Forest Service (USFS) headquarters in Jackson, WY. In attendance were key representatives from Wyoming Game and Fish (WGF), the National Park Service (NPS), USFS, FWS, and U.S. Geological Survey (USGS). Two Project Team facilitators provided third-party, neutral facilitation services.

The purpose of the meeting was to review and discuss the most recent revisions to the draft EIS alternatives, as well as hear and ask questions about the report summaries from USGS on elk, bison, and socioeconomic modeling and CADR on the Stakeholder Assessment and Workshops.

Agencies were invited to participate five months in advance and the Project Team coordinated availability to set the meeting time, date, and location. Participants were sent the meeting agenda, Stakeholder Engagement Report Summary, and the draft EIS alternatives prior to the meeting.

LIST OF ATTENDEES

- USFWS: Matt Hogan
- USFWS: Ella Wagener
- USFWS: Frank Durbian
- USFWS: Eric Cole
- USFWS: Andrew DonCarlos
- WGF: Angela Bruce
- WGF: Doug Brimeyer
- WGF: Brad Hovinga
- WGF: Justin Binfet
- USFS: Chad Hudson
- USFS: Randy Griebel
- NPS: Chip Jenkins
- NPS: Yvette Converse
- USGS: Paul Cross
- USGS: Jonathan Cook
- Langdon Group: Bryant Kuechle
- Langdon Group: Kelsea MacIlroy

CALL TO ORDER

The meeting was called to order at 10:00 am by the lead Project Team facilitator. The facilitator reviewed the agenda, basic housekeeping, and reviewed the goals and intent for the day's meeting. No questions were asked.

MEETING GOAL SETTING: AROUND THE HORN

The facilitators moved to an "around the horn" asking one or two representatives from each agency to respond to the question: What are your agency's goals for this meeting? The support Project Team Facilitator

took notes at the front of the room on one of two flipcharts. Responses are listed in the table below by agency and in the order in which they were shared.

AGENCY	RESPONSE TO QUESTION
FWS	• All agencies move forward together and are on the same page. • Here to listen for understanding different perspectives. • Finding common ground.
NPS	• Primarily concerned with long-term ecosystem health. • Hear risks and pressures from other agencies. • Discuss the strengths and weaknesses of the science.
WGF	• Make forward progress in this process. • Hear response to comments that were previously submitted.
USFS	• Recognize similar efforts. • Identify how it all fits together. • Think through the messaging.

Next, the lead facilitator asked again for one or two representatives from each agency to respond to a second question: Where is your agency at with elk and bison management plans as of today?

AGENCY	RESPONSE TO QUESTION
FWS	• Draft EIS by end of year. • Publish EIS in February or March of 2025. • Finish by end of 2015.
NPS	• Was the co-lead of 2007 BEMP, but because this plan is more focused on feeding on the refuge itself, not as involved. • Wish to be arm-in-arm with state and federal agencies. • Will have a management response and take actions based on response or alignment with what FWS decides to do.
WGF	• Just finished their Elk Management Plan and now working on individual site plans. • Timelines are similar with FWS.
USFS	• Ahead of other agencies. • Currently waiting on data to refine the FEIS. • Meeting with WGF for sequencing and details to work out in FEIS.

Matt Hogan, FWS Mountain-Prairie Regional Director, welcomed and thanked everyone for attending the meeting. He stated that the agencies present in the room can sometimes be indistinguishable from each other in the eyes of the public. Thus, it can help all agencies in the room to be as “synced as we can be” to not confuse the public with engagement and public communications.

USGS STUDY – Jonathan Cook and Paul Cross, USGS

Representatives of the USGS presented their work to date on elk, bison, and socioeconomic modeling.

First, they explained the scope of the models:

- Decision context: Whether and how to provide supplemental feed to bison and elk on NER.
- Temporal scope: 20 years.
- Spatial scope: Depends on specific metric and expected extent of effect, but included parts of Jackson elk herd unit, Fall Creek herd unit.

- Poles of spectrum: Feeding and not feeding.
- Panel of experts providing input, advising, and guidance on models and assumptions.

Then, the USGS representatives discussed the various findings, assumptions, and output of the elk and bison models. After reviewing the elk and bison models, they reviewed the findings from the socioeconomic models looking at various consequences of the proposed alternatives. They clarified that this modeling was run prior to the most recent revisions of the alternatives. They provided an overview of the USGS studies with a summary table in the slides showing that continued feeding outperformed not feeding on nine metrics, no feeding outperformed on five metrics (most critically on chronic wasting disease and elk numbers), and the models were roughly the same on five metrics. Limitations include the fact that there is a high degree of uncertainty in the future because they are attempting to model conditions that have not been observed in the region. They concluded that there is likely room for better outcomes for the agencies if they can work together in-between the two extremes of feeding/not feeding. See attached presentation.

Finally, USGS reviewed the timeline for the release of the study report. The technical report is in its final review stages. It's expected release is late November or early December 2024, but they may be able to share smaller sections of the report prior to its release, if requested.

The USGS took questions from participants. Questions are listed in the table below in the order they were asked.

QUESTION	RESPONSE
What does 2-4x increase in elk contact mean?	USGS explained how they defined and gathered the data.
Have you done this with other herds?	USGS explained further about how the data selections and assumptions were made.
Did you use a standard starting date for visitor sleigh rides?	USGS were not able to answer this question at this time and would have to go back and look.
Did you look at other high-density rates for elk? The contact rates may be different or similar to here. Concern with using 4x higher during fall, when probably different with Eastern WY and Estes Park.	USGS did not use contact rates itself. It came from an expert panel. USGS can circle back to that and ask the panel "have you considered all of this?"
Did you look at the average age of mortality among captive elk contrasted with wolf predation. How did that inform the model?	Post infection, elk will survive an average of 3 years. Captive animals are born negative and then die in 4-7 years. In Rocky Mountain National Park they survive 2 years. There is limited information on this.
In the metrics, is there an ability to play with these and look at different options?	Yes, but metrics would need re-analysis.

EXTERNAL STAKEHOLDER FEEDBACK – The Project Team

This presentation focused on key takeaways from the stakeholder assessment and stakeholder workshops. The presenter touched on each of the major themes that emerged from interviews with stakeholders then shared key points of discussion on the previous draft alternatives from the workshops.

The presenter took questions and comments from participants. Questions and responses are listed below in the order in which they were received.

QUESTION/COMMENT	RESPONSE
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There was anxiety and perception at workshops that because agencies (such as NPS) were not co-leads, they were not as invested.	
Were comments about agency coordination more prevailing among a specific interest group?	No, it was widespread among all interest groups. <i>NOTE:</i> Discussion was around whether it was more NGOs or not, but looking back at the interviews and workshop interactions, it was widespread among all groups.
Were interviews one-on-one or group?	Almost all were one-on-one, only one had two people.
How was “natural” and “unnatural” environment defined?	TLG did not define these terms, but let participants define them.
There are many opinions in the area about this elk herd, from free ranging to zoo animals. There is an opportunity here to message this and manage what is possible.	FWS is working on a communication plan that engages all agencies.
Was any value given to population decreases from disease spread vs winter die off?	Value was given to the impact (negative optics) a die off would have on the community and refuge.
Any differentiations between concerns about private landowners and ranchers?	Yes, concerns were differentiated for the two groups separately. A lot of concern was expressed for expensive landscaping and ranches, namely potential contact between cattle and elk.
There is less agriculture in the area than what there used to be, but it is not less significant.	The area is seeing more “Hobby Horse” agriculture in the area than what it used to be.
How do we handle impact to agriculture producers in the area outside of Jackson Hole?	This was not part of the Project Team’s process but FWS commented that they will circle back with partners (Star Valley Conservation District) to gather input on this topic.
Did anyone distinguish between short distance and long distance migrants?	Yes, this came up in the alternatives discussion and was categorized under “new alternatives.”
Useful feedback heard at workshop included adaptive alternatives and longer-term stakeholder interface.	There is an interagency elk management working group in existence that has been dormant.
There is interest in more agency coordination, the EIS will focus on what FWS can control on the ground and BEMP will focus on greater landscape management/coordination. Navigating different jurisdictions and involving the public in that work is important. How do we set up a dynamic where management of animals is a continual conversation with all interest agencies (local, state, federal) and homeowners? Agencies need to come up with a collective way to meet the public’s expectation.	There is an interagency elk management working group in existence that has been dormant.
Be clearer in the BEMP about how the agencies are working together, roles, and responsibilities. There is a never-ending need to educate the public that management actions look different on private properties vs national parks.	FWS is developing this language for the BEMP.

After the presentation and discussion, the group agreed to take a break and would resume with the Draft Alternatives Presentation during a working lunch.

DRAFT ALTERNATIVES OVERVIEW & DISCUSSION – Ella Wagener and Frank Durbian, FWS

The FWS presented an updated version of the draft alternatives from the EIS and posed the question: Did they hit or miss the mark with the revisions to the alternatives based on the comments from each agency? If they missed the mark, how can they meet the mark by editing one or more of the proposed alternatives? The presentation started with an overview of why the NER is re-evaluating the supplemental feeding of elk. The three key reasons are the potential for disease, the cost of feeding elk, and the impacts to wildlife and habitat on the refuge. Then, they presented the revised alternatives and options:

Three Alternatives (Revised):

Alternative 1: Status Quo (prior to reduced feeding)

Alternative 2: Slow Reduction over 7 years or until chronic wasting disease prevalence reaches 3%

Alternative 3: 5-Year Supplement feeding for 5,000 elk, then stop feeding

Each option below could be added to the above:

Option 1: Increase harvest/focus on short-distance migrant elk (nuisance elk)

Option 2: Periodic supplemental feeding of bison

Option 3: Severe winter management

Discussion and questions on the presentation occurred and was facilitated by Project Team facilitators with notetaking on the flipcharts. Comments, questions, and key discussion topics are captured in the table below in the order they occurred.

QUESTION/COMMENT/DISCUSSION TOPIC	RESPONSE
Are you analyzing each alternative with each option added for a total of 12 unique alternatives?	The options provided a better description of what was happening. The analysis will be based on what option makes sense and capture impacts of all alternatives and all options, then discuss what combinations make sense. Agencies can discuss impacts once it's determined which options make sense to include.
Will the draft EIS be narrowed down? Are you going to do an analysis of all 12 options?	FWS will do an analysis of 6 separate items (3 alternatives and 3 options) that can be combined. The higher-level goal is to analyze everything that might be considered.
The discussion primarily centered around building an alternative that all agencies could live with and WGFD desired to have another alternative beyond the ones listed that aligned with their State plan.	

The group achieved consensus on working cooperatively to build an additional alternative, referred to as "Alternative D" where FWS and WGF will attempt to work through conflicts regarding adaptive management and clear management thresholds as well as potential conflicts between agency policy and legal mandates.

DECISION	FWS will, cooperatively with the field staff from other agencies – WGF, NPS, and USFS – attempt to craft an Alternative D that includes agency cooperation to end the need for
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	feeding. This alternative includes aspects of options 1, 2, and 3, clear management actions, and thresholds for ending feeding, such as a 10-year timeline.
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NEXT STEPS & REVIEW MEETING GOALS

The project team facilitators reviewed the key decision.

ACTION ITEM: FWS will set up a meeting with appropriate agency partner field staff to attempt to craft an Alternative D based on the parameters set in the decision.

The project team then revisited the goals shared by each agency for the meeting and asked one or two representatives from each agency to respond to the questions: Were your goals for the day met? What are your takeaways from this meeting? Responses are listed in the order they were shared for each agency.

Agency	Response to question
USFS	- Looking forward to discussions with WGF and how feed grounds in National Forest interact. - Need to talk about sequencing with all the agencies. - Enjoyed getting insight for feeding program.
NPS	- Received more information about the science. - Now have a better understanding of coordination among agencies and what we are looking at.
WGF	- Our comments were addressed. - The candid conversation was appreciated. - When talking about different objectives, really appreciated this comment: “cooperate to reduce need to feed rather than stop feeding and then cooperate.”
FWS	- Thank you to project team facilitators and USGS. - Appreciated the stakeholder request for all agencies to work together. We can do a better job telling the story if we tell it together rather than separately. There is a desire to tell the story collectively rather than confuse the public.

The meeting concluded at 2:03 pm.

US FISH AND WILDLIFE SERVICE
NATIONAL ELK REFUGE, BISON & ELK
MANAGEMENT PLAN
STAKEHOLDER ENGAGEMENT SUMMARY REPORT

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FWS, through the Department of the Interior’s Collaborative Action and Dispute Resolution office, contracted with Kearns & West to develop this report.²

² Prepared by The Langdon Group under subcontract to Kearns & West, collectively referred to as the “Project Team.”

Executive Summary

The U.S. Fish and Wildlife Service (FWS), U.S. Department of the Interior, intends to prepare an updated Bison and Elk Management Plan (BEMP) and environmental impact statement (EIS) for the National Elk Refuge (NER). The BEMP describes FWS's proposal for the management of the Jackson, Wyoming bison and elk populations within their respective jurisdictions with the goal of ensuring sustainable and healthy herds. An EIS will be prepared pursuant to the National Environmental Policy Act of 1969 to evaluate the potential environmental impacts of the BEMP.

The BEMP will address changed conditions and newly available scientific information. The BEMP will also set new desired conditions, management goals, objectives, and strategies to guide the management of bison and elk on the NER. The ultimate goal is for a healthy sustainable population of elk and bison on NER and the southern portion of the Greater Yellowstone Ecosystem.

The FWS contracted with the project team to elicit input from a wide range of interests and evaluate prospects for collaboration among partner agencies as well as collaboration with other potentially affected interests. This input was obtained and recorded through a situational assessment, which this report summarizes. Potential assessment participants were identified in coordination with FWS, and 19 interviews were conducted online or over the phone in April and May 2024.

Situation assessment participants, as well as agency representatives from FWS, Wyoming Department of Fish and Game (WGF); National Park Service (NPS), and US Forest Service (FS), attended and participated in one of two, three-hour workshops facilitated by the project team. The workshops were held in Jackson, Wyoming on May 21 and 22, 2024. In total, 20 people signed-in to the workshops (excluding FWS staff).

The following terms are associated with broad percentages to indicate the number of participants who shared a particular view, as determined by the project team. "A few" refers to more than one person, but less than 10% of interviewees; "some," "several," and "other" refers to between 11-50% of interviewees; "many" refers to 51-75% of interviewees, and "most" or "almost all" interviewees refer to greater than 75%.

Coordination among state and federal agencies was discussed in all conversations as a key to a successful management plan for the NER. Elk do not know boundaries and move between FWS-, FS-, and NPS-managed lands, and feeding operations and species management are managed and shared by FWS and the WGF.

The NER feeding program is the crux of the BEMP and the primary differentiator between potential alternatives. Most alternatives eliminate feeding from future management of the NER. Participants are divided about the level of impact that feeding plays in disease spread, and whether herd numbers should or should not be reduced through changes in the feeding program.

One perspective is that feeding creates an artificial, unnatural elk population that fosters increased likelihood of disease spread; under this perspective feeding should be stopped or significantly reduced. The other perspective acknowledges that feeding the elk population is unnatural and human-caused, that this cannot be undone, and that an entire ecosystem has been built around these elk herd numbers. Feeding is a critical component to maintaining the current ecosystem and is not a significant contributor to spreading disease.

Some participants suggested that either option will reduce elk herds: Continuing to feed elk will reduce herds because of disease spread. Ending the feeding will reduce herds due to winter die off.

The increased potential for disease spread, predominantly Chronic Wasting Disease (CWD) and, to a lesser degree, brucellosis, among animals in close proximity through the NER feeding program is the primary driver for alternatives that reduce feeding. Most participants agree that disease spread increases as a result of feeding; however, disagreement exists over whether elk are severely impacted by these diseases. Most participants believe disease will create a die off and significantly impact the elk populations, while some believe elk can carry disease but will not experience death or significant health impacts as a result. Few believe the introduction of disease will have a positive effect by reducing elk numbers to a manageable number.

Many participants spoke to the role the elk herds and the NER play in the Greater Yellowstone Ecosystem, primarily as a “keystone species” and “protein source” in the food chain. Reductions in the NER elk herd population will likely impact the populations of predators that rely on them as a food source. Opinions are split, however, as to whether a reduction in numbers on the NER will have a negative impact on predator numbers or behavior. One perspective is that reduced elk numbers will have lasting impacts to multiple species and subsequently the ecosystem and tourism. Another perspective is that other species will adjust and lower numbers of elk and predators are acceptable: the ecosystem is resilient and will recover. Most participants agree the NER and the animals that winter there are in an unnatural state as a result of human intervention, and that returning to a completely natural state is no longer a viable option.

All participants acknowledge that changes to the elk population will impact the surrounding infrastructure and private landowners. Wildlife crossings and fencing are seen by many as a successful effort to safely move elk from the NER to other public lands and away from roads and private properties.

The NER is a key component to the economy of the Jackson area. The popularity of winter sleigh rides and wildlife viewing, and the role a significant elk population plays in maintaining the ecosystem, drives tourism to Yellowstone and Grant Teton National Parks, where visitors want to see a diversity of wildlife. The most commonly cited role the elk population plays in the economy is through hunting and outfitting.

Some argue that if feeding is eliminated, there will still be elk and other wildlife. Tourism, hunting and the overall economy will adjust.

During the workshops, participants provided specific input to each alternative and suggested new or adjusted alternatives, and considerations relevant to all alternatives, specific to elk management through supplemental feeding.

Background

The U.S. Fish and Wildlife Service (FWS), U.S. Department of the Interior, intends to prepare an updated Bison and Elk Management Plan (BEMP) and environmental impact statement (EIS) for the National Elk Refuge (NER). The BEMP describes FWS's proposal for the management of the Jackson bison and elk populations within their respective jurisdictions, with a goal of ensuring sustainable and healthy herds. An EIS will be prepared pursuant to the National Environmental Policy Act of 1969 to evaluate the potential environmental impacts of the updated BEMP.

The Jackson bison and elk herds make up one of the largest concentrations of free-ranging ungulates in North America. Currently, these herds number about 450 bison and 10,600 elk. More than 15 years have elapsed since the last BEMP was finalized in 2007. Conditions have changed, but elk management remains one of the most important management actions for the NER.

The BEMP will address changed conditions and newly available scientific information. The BEMP will also set new desired conditions, management goals, objectives, and strategies to guide management of bison and elk on the NER. The goal is a healthy, sustainable population of elk and bison on NER and the southern portion of the Greater Yellowstone Ecosystem.

Draft objectives of the updated BEMP include:

- Maintain sustainable populations of elk.
- Maintain sustainable populations of bison.
- Maintain sustainable populations of other wildlife affected by elk and bison management activities.
- Maintain physical habitats and environmental processes associated with bison and elk.
- Maximize health and human safety related to elk and bison.
- Maintain social and economic benefits associated with elk and bison.
- Minimize impacts on cultural, archaeological, and ethnographic resources.
- Minimize costs of bison and elk management activities.

In August 2023, FWS opened a 30-day scoping period for the development of an updated BEMP and an associated EIS for managing elk, bison and habitat on the National Elk Refuge. During this scoping period, FWS took public comments and held public scoping meetings to provide interested stakeholders and members of the public an opportunity to learn more about the process, ask questions, and provide feedback.

In March 2024, FWS announced additional opportunities to engage in the development of the updated BEMP for the National Elk Refuge. These included a series of public information meetings to introduce the alternatives, held in May 2024, and feedback workshops to inform the public and further understand concerns, tradeoffs, and potential ways to reduce adverse consequences associated with potential management alternatives.

Process and Methodology

The FWS contracted with the project team to elicit input from a wide range of interests. The purpose was to gather thoughts and interest about bison and elk management on the NER, capture the diverse perspectives around the issues, and help build working relationships among cooperating agencies and other impacted stakeholders. This process sought to achieve the following goals:

- Improve communication and understanding of the BEMP with the public.
- Build trust with the public through transparent communication and engagement.
- Understand thoughts and interests surrounding bison and elk management on the refuge.
- Identify potential outcomes of the draft alternatives.
- Identify additional alternatives that are not being considered and should.

It was important to provide the opportunity to receive all input, while establishing agency sideboards for the type of input that can be used for potential improvements and changes in the BEMP. The following guidelines were established to help define the side boards for this process:

- Keep the BEMP as the main issue of discussion.
- Focus on topics associated with bison and elk management and future opportunities/challenges.
- Share appropriate and relevant timeframes for implementation of strategies discussed.
- Understand the issues around all alternatives. The goal is not consensus around an alternative,
- The EIS has not been drafted. This input will help FWS develop the foundation of the plan.
- Future engagement will provide the opportunity to provide feedback about the preferred alternative.

Engagement occurred in two phases: Situation Assessment (SA) and facilitated workshops.

Situation Assessment

The project team interviewed 19 individual stakeholders as identified by FWS. Interviews occurred by phone or video conference. These interviews included representatives from the following organizations:

Swift Creek Outfitters
Ecotour Adventures
Teton County Commission
City of Jackson - Town Council
Lockhart Ranch
Jackson Hole Wildlife Foundation
Jackson Hole Conservation Alliance
Moore Films
Jackson Chamber of Commerce
Sierra Club
Safari Club
Teton County
Greater Yellowstone Coalition

Shoshone-Bannock Tribe
Jackson Hole Travel and Tourism Board
Taylor Ranch
WY Guides and Outfitters

Interviewees received an introduction to the project and overview of the situation assessment process from FWS, followed by a request from the project team to schedule a conversation in advance of interviews.

The interview format was designed to solicit valuable and constructive input. The approach was conversational with active listening, allowing participants to steer the discussions. Conversations were predictably varied, reflecting different interests and priorities. Participants were informed their input would not be attributed to them individually or to their organizations.

Discussion group questions were designed to be customized and generate valuable insights through open dialogue ([APPENDIX A](#)).

Workshops

Situation assessment participants, as well as agency representatives from FWS, Wyoming Department of Game and Fish (WGF); National Park Service (NPS), and US Forest Service (FS) attended and participated in one of two, three-hour workshops facilitated by the project team. The workshops were held in Jackson, Wyoming on May 21 and 22, 2024. Workshop formats were identical. Two opportunities were provided to match schedules and maintain small group settings. In total, 20 people signed-in to the workshops (excluding FWS staff).

Each workshop began with an introduction presentation by the project team and FWS to share the meeting process and provide background about the BEMP update, followed by two facilitated small group conversations, each focused on soliciting input on these specific questions:

1. What are the potential outcomes (positive, negative, unexpected, and tradeoffs) of the alternatives presented?
 - a. To elk?
 - b. To bison?
 - c. To predator animals and other wildlife?
 - d. Other ecosystem impacts?
 - e. To the economy?
 - f. To private properties?
 - g. To the habitat?
 - h. How can agencies and non-government partners work together to mitigate these outcomes?
2. What are other alternatives that are not being considered and should?
 - a. Are there components of alternatives that FWS is not pairing that should be considered?
 - b. What is missing from an existing alternative that should be added or considered?

After each small group conversation, facilitators reported out the findings of each group to the larger group. After Group 1 was finished, during the break, the project team moved some participants between groups to help diversify the perspectives and conversations.

Findings

The following sections capture the opinions, beliefs, and perceptions expressed by the SA and workshop participants as recorded by the project team. ***This report is not intended to verify the accuracy of participant statements.***

Input is summarized in two broad categories, each with their own subcategories. “Themes” are categories of input received primarily through the SA. The SA provides a snapshot in time of a cross section of interested parties and their communities. However, it is not a representative sample or a “vote” and should not be interpreted as such. The report uses terms associated with broad percentages to indicate the number of participants who shared a particular view, as determined by the project team. “A few” refers to more than one person, but less than 10% of interviewees; “some,” “several,” and “other” refers to between 11-50% of interviewees; “many” refers to 51-75% of interviewees, and “most” or “almost all” interviewees refer to greater than 75%.

The “alternatives” section captures comments provided during the workshops that specifically relates to an alternative, multiple alternatives, and new or modified alternatives to elk management through supplemental feeding. The structure of the facilitated process encouraged constructive dialogue, perspective sharing, and equal opportunity among participants. Due to the group discussion format, it is not possible to identify a clear preference or level of support for one alternative over another, and no conclusions should be drawn about the strength of one alternative or comment over another based solely on the discussions. The section is organized with relevant comments listed under each alternative subheading. Comments are the opinion of one or more workshop participants.

Themes

Additional Stakeholders

The following stakeholders were suggested as important to include in the process:

- Elk Creek and Flat Creek Inns
- Jackson Hole Golf and Tennis
- Jackson Hole Guides and Outfitters
- Lockart Family
- Lucas Family
- Lloyd Dorsey
- Mead Family
- Photography groups
- Spring Creek Ranch
- Sy Gilliland, Outfitter
- Tribes with historical connection (Wind River, Northern Arapaho, Shoshone-Bannock, Sheep Eaters)
- Wildlife disease experts, specifically Paul Cross, Montana State University Wind River Indian Reservation
- Wolf advocacy organizations
- Wyoming Department of Transportation
- Wyoming Wildlife Advocates

Agency Coordination

Coordination among state and federal agencies was discussed in all conversations as a key to a successful management plan for the NER. The elk do not know boundaries and move between FWS, FS, and NPS lands, and feeding operations and species management are managed and shared by FWS and the WGF. One participant mentioned that the success of the NER and the BEMP are contingent on the other agencies' ability to cooperatively mitigate impacts and share common goals.

The WGF goal of maintaining a Jackson Hole elk herd of 11,000 elk is perceived by most as an appropriate target. Predators like wolves and grizzly bears can keep this number in check. Participants are split as to whether a 5,000 elk target on the NER is appropriate or not significant enough and whether this level is attainable while also maintaining an 11,000 elk target for the larger herd.

Most participants believe that agreement among agencies is necessary to avoid litigation, and all agencies need to collaborate on the development of EIS alternatives. One participant commented that the previous BEMP was a joint plan and questioned why this plan is specific to FWS and focused on the NER. There is concern expressed by some that the actions of this BEMP don't consider the planning efforts of the other agencies and may create redundant efforts.

Participants recommended the following specific coordination efforts:

- Engage with the Governor's office early and often.
- Work with the FS management plan to ensure the FS know how elk movement patterns impact trail management.
- Major openings (treatments) of forest are needed.

- Consider the migration of the southern Grand Teton National Park elk herd in management decisions.
- Ensure that alternatives bring all agencies to the table to have a conversation about animal migration, specifically the numbers of animals projected to leave the NER and impact other agency lands.
- The NER is one piece of a larger feeding ground network managed by multiple agencies. When feeding is reduced in one location, it will create increased demand on the others.
- Collectively, agencies should promote greater biodiversity.
- Ensure coordination is occurring with Native American tribes. Visitors want to know how tribes used this land..
- Agencies should coordinate with private landowners to open up more land for forage through short term leases and long-term conservation easements.
- FS and Bureau of Land Management (BLM)-administered land could be used for wintering if land were set aside, specifically in the Bridger Teton National Forest Management Plan revision. This may require moving grazing out of areas for periods of time and coordinating changes to the hunting regulations with WGF.
- Agencies should work together to pool and increase funding.
- Coordinate with County Commissioners to mitigate impacts. Counties need to understand whether they need to apply resources, particularly for scenarios in which feeding ends.

Bison

Bison management was not a major concern among most participants. Most indicated that the NER is managing bison well, that their role is minimal, and that if bison numbers increase it will be important to build awareness of the potential for spreading brucellosis.

Specific comments regarding Bison were:

- They are not native to winter range in the NER and only learned there was feed there in the last 20 years. If numbers increase significantly this could have an impact on the elk population.
- Bison can be destructive to private property.
- The objective of 500 feels high.
- Bison management could be achieved by expanding the Shoshone-Bannock Tribe hunting season on the NER.

Community Outreach/Engagement

Some participants mentioned specific community outreach and engagement efforts that they would like to see incorporated into the BEMP:

- Education and outreach will be important, particularly if elk numbers decrease. Share information about how this will impact the Jackson Hole community, both positively and negatively, and what it means to live in an elk environment. Prepare the public for hard years where many elk may not survive.
- Create an “Annual Elk Summit” that brings stakeholders together to monitor and discuss adaptability to changes and their diverse impacts (economic, social, political).
- Be clear about how the BEMP impacts specific interest groups.

- Showcase the NER to the community by providing opportunities to get people out in parts of the refuge they may not have visited.
- Solicit volunteer help with weed management and other projects. This will help the NER inform the community about management challenges.
- Increase awareness with outfitters about mutual sharing of NER hunting grounds with other hunters.
- Public outreach and education (youth programs, adult programs) are vital to the success of and support for the refuge.

Ecosystem and Landscape

Many participants spoke to the role the elk herds and the NER play in the Greater Yellowstone Ecosystem, primarily as a “keystone species” in the food chain. Changes to the NER elk herd population will subsequently impact the populations of predators that rely on them as a food source. Opinions are split about whether a reduction in numbers on the NER would have a negative impact. One perspective is that reduced elk numbers will have lasting impacts to multiple species and subsequently the ecosystem and tourism. Another perspective is that other species will adjust, and lower numbers of elk and predators are acceptable: the ecosystem is resilient and will recover. Most participants agree that the NER and the animals that winter there are unnatural and a result of human intervention. Most also agree that returning to a completely natural state is no longer a viable option.

Many participants shared that the NER plays a broad role in the ecosystem, beyond elk and bison management. Fish in Flat Creek, deer, pronghorn, and bighorn sheep all rely on the NER for habitat.

Specific comments about the NER role in the broader ecosystem include:

- Consider climate data and how a changing climate will impact populations and management decisions long term.
- The current number of elk is appropriate to hold the wolf population to about 150..
- Elk are not in the same areas they used to be. They are spending more time in river bottoms and private land to avoid the wolves, or they are going into the high alpine.
- Feeding elk has produced a monoculture that does not promote the greatest biodiversity.
- Heavy elk concentration has pushed out cottonwoods and willow stands.
- There are fewer songbirds, moose, and other species on the NER because elk do not allow for those habitats to grow.
- Consider opening Spring Gulch for additional winter habitat.
- Pastures south of town could support forage and native vegetation, but there is a question whether elk populations there would be welcome by residents.

Feeding

The NER feeding program is the crux of the BEMP and the primary differentiator between alternatives: most alternatives include a reduced feeding component. Participants are split about the level of impact feeding plays in disease spread and whether herd numbers should or should not be reduced through changes in the feeding program.

One perspective is that feeding creates an artificial, unnatural elk population that fosters an environment for increased likelihood of disease spread. According to this perspective, feeding should be stopped or significantly reduced. The other perspective acknowledges that the elk population is unnatural and human

caused, but this cannot be undone: an entire ecosystem has been built around these elk herd numbers. Feeding is a critical component to maintaining the current ecosystem and it is not a significant contributor to spreading disease.

Some participants opined that either option will reduce elk herds: continued feeding will reduce elk through disease spread, and ending elk feeding will reduce elk through winter die off.

Alternatives presented by some participants were:

- Implement an emergency feeding program similar to what is being done in Montana and Idaho to replace the current feeding program. This creates a new threshold for when feeding is implemented.
- FWS has done a good job adding irrigation and water systems to grow more natural forage. Building on these efforts will create forage that can replace winter feeding.
- WGF has a plan to look at other feed grounds and reduce or eliminate feed at those locations. These efforts need to be coordinated with FWS to manage the broader overall Jackson Hole elk herd.
- Introducing a later hunting season will help reduce numbers, allowing feeding to continue.
- If feeding is eliminated, this significant cost could shift to habitat restoration, private land acquisition, or cost-sharing programs that help move cattle out of ranches seasonally, opening more ground for winter feeding.

Specific comments provided are:

- The ecosystem may thrive after feeding is eliminated or reduced, however when a large winter storm occurs or spring rainstorm that crusts up the snow, the die off reduces the herd significantly, then predators and the broader ecosystem will be more severely impacted.
- 70-80 days of feeding is necessary, beyond that the elk can survive any winter.
- Feeding is necessary but could be dispersed out to northern areas to diversify the herd.
- Weak and young elk are getting pushed out of the feed lines and not getting the forage they need.
- Feeding elk reduces pressure on surrounding landowners. Without feeding, they will move to private landowners and damage property.
- Feeding helps keep elk off roadways, which reduces the potential for wildlife-vehicle collisions.
- With wildlife crossings and public/private land opened up for winter range, there is space for animals to exist outside of the NER.
- The primary driver for continuing to feed is political pressure from the hunting and outfitting community. Large elk numbers from the feeding program sustains the outfitting economy, which is important to the state of Wyoming.
- The current elk population embodies the culture in Jackson Hole. Individuals and advocacy groups want to ensure there are robust numbers to maintain the “valley of the elk” reputation.
- There were good reasons to start feeding in 1910 because of the impact elk were having on ranches. Ranching in the area is no longer significant and therefore feeding is now unnecessary. Ranching has changed, but the elk management has not.
- Decisions must consider the body condition of the elk entering the winter. Healthy elk will survive with reduced or eliminated feeding.

Habitat Restoration/Water Quality

Participants provided input about additional measures to help promote a healthy ecosystem on the NER. The following ideas were offered by participants:

- Manage the amount of sediment in the waterways to improve water quality and fish rearing habitat.
- Reduce noxious weeds, specifically cheat grass on the buttes.
- Consider how water management impacts downstream users and work closely with irrigators to create solutions.
- Reconstruct the wetlands and riparian areas. These get overlooked and should have greater effort applied to them. This will support a stronger bird population.
- Rehabilitate the riparian areas.
- Install exclusionary fencing to help riparian recovery.

Health and Disease

The increased potential for disease spread, predominantly Chronic Wasting Disease (CWD) and to a lesser degree brucellosis, among animals in close proximity due to the NER feeding program is the primary driver for alternatives that reduce feeding. Most agree that disease spread increases in these circumstances, however disagreement exists as to whether elk are severely impacted by these diseases. Most believe disease will create a die off and significantly impact the elk populations, while some believe that while elk can carry the disease, it will not result in death or significant health impacts. Few believe the introduction of disease will have a positive effect by reducing elk numbers to a manageable number.

Specific comments provided include:

- It is unclear what level of CWD is tolerable or natural.
- CWD is harmful to deer but does not seem to be as harmful to elk. This should not be the driver behind decisions made at the NER.
- Keeping cattle and elk separate will reduce the potential of disease spread from animals to livestock. This is mostly relevant for brucellosis. CWD does not spread from elk to cattle.
- The process requires a large-scale scientific analysis by collecting data through collaring and monitoring elk health.
- Dispersed feeding will reduce the potential for disease spread.
- There is a financial incentive for outfitters and guides to downplay CWD. This is a threat to their ability to sell hunts out of state.
- There is no scientific rationale offered for claims that CWD does not spread among elk.

Landowner and Human Infrastructure Interactions

All participants acknowledge that changes to the elk population will have some impact on human infrastructure and private landowners. Wildlife crossings and fencing are seen by many as a successful effort to move elk from the NER to other public lands and away from roads and private properties. Specific ideas were offered on how private land can adapt to support a healthy elk population:

- Increase hunting opportunities on private land. This will provide an option for different populations to hunt, such as youth, seniors, veterans, and the disabled.

- Increasing elk populations on private lands will result in “zoo ranches” with less conflict for the wildlife and greater human interaction.
- Private landowner landscaping should attempt to mimic the natural environment rather than unnatural landscaping (ornamental shrubs) that causes frustration when it is impacted by elk.
- Seek to reduce development in elk movement corridors.
- Fence hay or seasonally remove cows. This will allow for the removal of fences designed to keep cattle in and elk out. It is recognized that moving cows may not be financially feasible for all ranches, however cost-sharing and incentive programs could make this more viable.
- Ranchers should consider shifting operations to non-brucellosis cows, instead of cow-calf operations, to allow elk and cattle to feed the same ground.
- Explore leases with private landowners that would open more winter ground.

Local Economy

The NER is a key component to the economy of the Jackson Hole area. Winter sleigh rides and wildlife viewing are popular, and a significant elk population plays a role in maintaining an ecosystem that drives tourism to Yellowstone and Grand Teton National Parks, where visitors expect to see a diversity of wildlife. The most commonly cited role the elk population plays in the economy is through hunting and outfitting.

Some argue that if feeding is eliminated there will still be elk and other wildlife. Tourism, hunting, and the overall economy will adjust.

Alternatives

Alternative 1: Keep supplemental feeding (status-quo)

- This ignores existing conflicts involving highways, private landowners, summer elk, and public versus private lands.
- This increases disease conditions.
- This maintains the high elk herd, which is good for the economy.
- This introduces many legal challenges.
- This would cause a devastating prion infestation. It is essential to stave off CWD now.
- This will not affect the tourism economy if there is a harsh winter that would result in a significant die off without feeding.
- Bears and wolves are here to stay. The predatory base has learned to survive on the elk protein base. If that base is tampered with, in year one, there will be major impacts with displacement of predators.
- This is the only viable alternative. The 5,000-target population is too low. At one point the NER wintered 11,000. That was too high. The target needs to be between these numbers, but it is hard to keep that at a consistent level because of the predators and intrusion of private lands.
- If you drop below the status quo, the calf recruitment level changes. Currently, the predators keep the calf ratio in check.
- With a herd of 7,000-8,000 there is no impact to the Yellowstone migrants.
- The current system provides the protein needed for the broader animal population.
- Adjust hunting regulations to increase annual harvest.

- Feeding is a learned behavior that cannot be unlearned, therefore this is the only viable alternative.

Alternative 2: Immediate stop to supplemental feeding

- There needs to be discussion of who shares the burden of conflict. A portion of the elk herd has shifted into residential areas. How do we address that in this alternative and alternatives 3-5?
- This will shift the elk to the Gros Ventre where the habitat is not desirable.
- This will result in significant impact to private landowners and ranches that absorb the elk. Consider including compensation for impacted landowners.
- This will bring negative worldwide media attention when elk die off occurs.
- Consider the FWS' vulnerability to lawsuits and how this will hamper progress and impact the agency's capacity and funding.
- Consider the impact on human safety with increased elk numbers on roadways.

Alternative 3: Reduce supplemental feeding over five-year period, then end supplemental feeding

- This may cause more private land conflicts with elk getting into livestock hay, back yards, and on roadways.
- This will allow the community to collaborate and adapt the landscape.
- Public perception problem is still a challenge if the result is visible dead elk.
- This provides five more years to adapt to change than alternative two.
- CWD is still a concern.
- Five years is not long enough.
- Alternatives 3 and 5 would produce the desired outcome of healthier "wild" elk.
- The five-year phase out is arbitrary and based on feedback. This needs flexibility to accommodate economic concerns.

Alternative 4: End supplemental feeding once CWD prevalence threshold is reached

- Questions remain regarding the ability to detect CWD. There is a lot of subjectivity in an environment with a high prevalence of predators. How objective are the testing methods?
- Based on the sample size, there is reasonable confidence in the prevalence estimates, enough to develop a threshold.
- There are a lot of unknowns about the trigger for when the community needs to pivot. More data on what habitat exists would be helpful.
- This is a reactive model, which is harder to mitigate and manage.

Alternative 5: Aggressive elk harvest first, then end supplemental feeding

- This will produce more balance with the habitat.
- With aggressive phase out there will be a negative public perception.
- This requires considering difficult winter hunts.

- Ensure the “right” elk are harvested.
- Smaller increments help the public perception optics.
- This challenges the ability to adapt and implement change management strategies. Are we able to adapt mid-season? Can the management strategy be adapted to the best available science?
- Consider separating bison and elk to provide more flexibility, availability of forage, and reduced conflict.

New Alternatives/Modifications and Considerations to Alternatives

- Alternative 4 from the 2007 BEMP EIS featured a 5,000 head objective target and aggressive harvest of short distance migration elk.
 - Outfitters supported this.
 - Short migrants are considered a nuisance to some landowners, however not all property owners think they are a nuisance. Values are likely to continue to shift this way.
 - Predator base stays the same if the harvest focus is on short distance migrants.
- Combine alternatives 3,4 and 5 with a more flexible tiered response.
- Consider hybridizing several alternatives.
- Modify Alternative 3 to a 10-year phase out.

Shared Recommendations

During the workshops, participants provided recommendations for inclusion in all alternatives:

- Incorporate USGS, peer-reviewed models for the Jackson Elk Herd, expected to be released at the same time as the EIS. The report is expected to show that current CWD prevalence is below 1%. CWD grows slowly at low prevalence, then increases drastically. It is difficult to predict how quickly numbers will reach 3%, but the curve would be steeper in fed animals.
- Less elk will result in invasive weeds that need to be addressed in the BEMP.
- Identify how the health and condition of elk will be measured.
- There is concern that any alternative could result in elk numbers below the target and the resulting impacts to the elk, predators, and the economy. This potential outcome necessitates the need for adaptability and contingencies.
- None of the alternatives address the impacts outside the NER
 - It is very difficult to capture all that could happen outside of the NER.
 - FWS does not have jurisdiction but may be able to talk more about mitigation measures outside of the NEPA process.
- Change “Feed Ground” to “Elk Management Area.”
- Stage feeding in different areas of the NER.
- Accept variances (swings) in elk population.
- Include commitment to winter closures from recreation and public access to help build resilient habitat.
- Implement controlled burns to regenerate forage growth.
- Additional items to consider adding to all alternatives:
 - Adaptive management procedures
 - Emergency feeding provisions
 - Fencing
 - Habitat manipulation to increase forage
 - County land development regulations and ordinances

- Low density feeding programs the FS has implemented
- Incentive based landowner agreements to open private lands
- Impact to other wildlife from new elk migration patterns

APPENDIX A: Situation Assessment Discussion Questions

The following are grouped into categories based on the Triangle of Satisfaction model, that argues for anyone to find satisfaction, three needs must be met.

Psychological

- Tell me about you and your story: How are you connected to the elk refuge and bison and elk management?
- What is your connection to this conversation? Why is it important? Or not important?
- What is your involvement in the future of the elk refuge, related to bison and elk management?
- Are you being appropriately engaged or involved? Explain.
- Are there religious or cultural connections to bison and elk management that need to be considered in a planning effort?

Substantive

- What do you consider a “healthy” bison and elk population? -- What do you know about current and proposed elk and bison population objectives? Are these numbers sustainable? Is the data understandable? Do they warrant discussion?
- What is your position on supplemental feeding of elk or bison?
- How familiar are you with current elk and bison management actions on the refuge?
- What do you know about Chronic Wasting Disease (CWD)? Who is responsible for managing CWD transmission among elk? What don’t you understand? Is the NER handling or managing it appropriately? What role does supplemental feeding play? Explain.
- What is your position on the status of brucellosis transmission from elk to domestic livestock? Is the NER addressing this issue appropriately or is greater action needed?
- What is the status of bison and elk impacts to adjacent landowners? Does more or less need to be done to address any issues?
- Explain the refuge’s relationship with the local economy (recreation, outfitting, viewing, guiding). Is this being appropriately addressed? If not, how can this better be addressed.
- How are bison and elk from the refuge positively or negatively impacting local agriculture interest? How is this being addressed and is there room for improvement?
- Are human-wildlife conflicts being appropriately addressed? Explain.
- How are changes on the landscape (weather, land ownership, development) impacting the bison and elk herds and how should this be considered?
- How much consideration should other species be given on the refuge? Are their needs being appropriately considered? Are they being impacted?
- What is your opinion about refuge habitat restoration efforts?
- Are soil quality and water health being appropriately considered? Explain.
- Are invasive species being managed appropriately? Explain.
- Is there new information or alternatives FWS should be considering when making management decisions?

Procedural

- What challenges might we encounter in trying to bring the public and interest groups together for discussion?
- What is your past and current relationship with the FWS?

- Have you participated in a workshop in the past? How did it go?
- Describe a workshop you have participated in or are aware of that was successful.
 - Do you have an unsuccessful example?
 - How have people felt let down by this process and what were their expectations for it?
 - What were they hoping to see come out of it?
- Are there processes that you think will be effective in capturing valuable input for this process, such as World Café small group discussions? In this format, what discussion topics would be appropriate for small group discussion?
- Are there interests or voices you are aware of that may be difficult to reach? ...or haven't had the opportunity to participate in these types of processes, but should have?
 - How have efforts to reach/connect with them in the past been successful?
 - Are there specific interest groups or local resource agencies that may have their finger on the pulse of reaching underserved members of the community?

APPENDIX J – Requests and Comment from the Shoshone-Bannock Tribes:

Shoshone-Bannock Requests for Directive from Assistant Secretaries Regarding Update to National Elk Refuge, Bison and Elk Management Plan (letter dated November 25, 2024);

Shoshone-Bannock Tribes' Comment Regarding DEIS Bison Elk Management Plan on National Elk Refuge (letter dated December 9, 2025)

The SHOSHONE-BANNOCK TRIBES

FORT HALL INDIAN RESERVATION
PHONE (208) 478-3700
FAX # (208) 237-0797



FORT HALL BUSINESS COUNCIL
P.O. BOX 306
FORT HALL, IDAHO 83203

RE: Shoshone-Bannock Requests for Directive from Assistant Secretaries Regarding Update to National Elk Refuge, Bison and Elk Management Plan.

Greetings Assistant Secretaries Estenoz and Newland,

The Shoshone-Bannock Tribes (Tribes) have a reserved off-reservation hunting right under Article 4 of the 1868 Fort Bridger Treaty (15 Stat., 673). For purposes of maintaining our cultural hunting lifeways we want to address our requests regarding updates to the Bison and Elk Management Plan (Management Plan) on the National Elk Refuge (NER) in Jackson Hole, Wyoming.

We are sending these requests to your offices for the commitment that they be directed for integration into the updated Bison and Elk Management Plan. Our requests are as follows:

First Request: That there be a section within the Management Plan that recognizes the NER and surrounding areas as the traditional homelands of the Shoshone-Bannock Tribes.

This cannot be disputed, as the archeological artifacts found on the NER have been identified as Shoshone-Bannock. This area, including the NER, Grand Teton National Park, Yellowstone National Park, and surrounding areas have been our homelands from time-immemorial, and remain our homelands today.

This section should expand on the fact that artifacts found thereon are Shoshone-Bannock. Additionally, this should recognize our traditional practices such as hunting and gathering, which continues today both on and off-reservation. This section should specifically reference our reserved right to hunt off-reservation under Article 4 of the 1868 Fort Bridger Treaty.

The fact that we've hunted bison on the refuge since 2007/2008 should be mentioned and detail the importance of the hunt to our people and the recognition of our culture and lifeways. Our origin stories center on Yellowstone National Park affirmed by

artifacts found within and amongst the area to include the NER dating our inhabitation and use thousands of years before.

The historical importance of tribal bison harvest was recognized in the original 2007 Management Plan and Record of Decision. However, it was only mentioned under a subheading titled "ethnographic resources." Specifically, it was limited to the following statement:

Ethnographic Resources. Hunting was a tradition practiced by American Indian tribes, who are believed to have traditionally used the lands within Grand Teton National Park and the National Elk Refuge. (emphasis added)

The referenced belief above and fact of artifacts are at odds with one another and is not acceptable, we inhabited/used this area for thousands of years, it is our homelands. The relationship between the Shoshone-Bannock Tribes and the NER should be expressly incorporated into the Management Plan with its own section and give recognition to our occupation and use of the area, traditionally and contemporarily.

Second Request: The Shoshone-Bannock Tribes are requesting that the objective numbers set for elk and bison in the Management Plan draft alternatives be restructured to raise the objective number of bison – specifically to allow for a higher number of tribal harvest; Request bison tolerant alternative.

In the 2007 Management Plan chosen alternative, as well as the draft updated proposed alternative, the wintering elk objective is 5,000 animals and the bison objective is 500 animals. This draft alternative also proposes to phase-out of supplemental feeding altogether at 3% CWD prevalence or after 7 years.

We want to know what the biological reasoning is for keeping bison at 500, and attempting to keep elk at 5,000? Why not allow the bison herd to grow to 1,000-1,200 animals and reduce elk to 3,800-4,000 animals? This number of bison would allow the Shoshone-Bannock Tribes a more sufficient number for Tribal take and honor the important cultural relationship between the bison and our Tribal members.

If we can raise the number of bison harvest on the NER to fulfill the trust responsibility to the Tribes and meet Tribal objectives, this would both benefit our Tribes and align with "recogni[zing] ... the cultural significance of bison to various tribes."¹

¹ 2007 Final Bison and Elk Management Plan.

As it stands, the Compatibility Determination is the only document that limits the tribal take to 5 bison/tribe. Neither the 2007 FEIS nor the ROD expressly limit tribal take. Based on this, we are making several requests below.

Tribal Preferred - Bison Tolerant Alternative/Request

The Shoshone-Bannock Tribes are requesting that the bison objective be raised to 1000-1,200 bison within the FEIS and ROD, and that the CD be amended to eliminate the arbitrary cap of 5 bison/tribe for a higher tribal take from the overall number of bison on the refuge.² The NER has sustained this number of bison in previous years, though it may take scaling back the elk objective. This supports the objective in the draft alternatives and prior Management Plan of sustaining a genetically viable bison herd. A larger bison herd would facilitate genetic diversity to withstand future adversity such as climate change and disease. Following, supplemental feeding would need to continue. We can co-manage the population of bison, and elk for that matter, by periodic hunting on the refuge. This would equate to multiple hunts throughout the year, not just one. These are our homelands, if anyone has a right to harvest these animals, it is the Shoshone-Bannock Tribes.

Tribal take should be prioritized over recreational take by the USFWS, as our Trustee. Further, the NER has allowed for instances of exclusive use on the refuge, such as the boy scout antler harvest which nets thousands of dollars for their benefit. Given the USFWS' trust responsibility, and documents such as Secretarial Order No. 3403 "Joint Secretarial Order on Fulfilling the Trust Responsibility to Indian Tribes in Stewardship of Federal Lands and Waters," we believe our requests are fully justifiable and valid.

Finally, option 1 (potentially applicable, to Alternatives B & C) proposes expanding harvest opportunities of short distance migrant elk that winter on the NER. The Tribes can help facilitate this option and co-manage the herd given our treaty right to hunt the unoccupied lands of the United States. According to the draft option, roughly 30-40% of the elk that winter on the NER migrate a short distance from the Snake River Corridor. There are unoccupied lands within this corridor and surrounding areas. Given the repudiation of Race Horse by Herrera and the vacatur of Reppis, our Treaty right to hunt is alive and well – as we have invariably posited. In good faith, we've attempted to meet with the Wyoming Governor to discuss our intent to hunt in Wyoming, however he declined.

Your agencies and the USFWS should facilitate this discussion around our Treaty right to hunt unoccupied lands of the United States within Wyoming. This would benefit the USFWS given the proposal to target the short distance migratory elk that our Tribal members would harvest and uphold the trust responsibility between the

² The Tribes also request to continue gathering on the refuge. This has not been an issue of contention.

Shoshone-Bannock Tribes and the United States. This follows, as the U.S. and the Shoshone-Bannock Tribes are signatories to the Treaty.

Third Request: The Shoshone-Bannock Tribes are requesting ongoing, scheduled Government-to-Government consultation throughout the process of developing the Final EIS and ROD for the updated Management Plan.

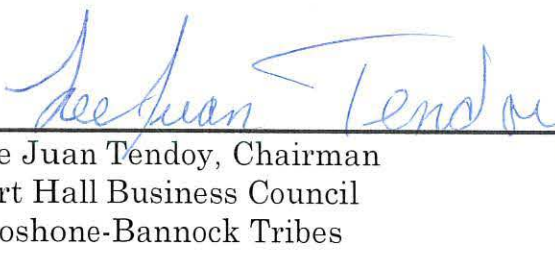
At the time of this meeting the USFWS is still in the drafting process. We're requesting that as our Trustee, both Assistant Secretary Estenoz and Assistant Secretary Newland issue directive to integrate our requests on this matter.

Further, we're appreciative that the USFWS accepted our Government-to-Government consultation request and has made good on its promise to travel and meet when necessary.

We're requesting to schedule Government-to-Government consultation at the following times: 1) prior to publication of the DEIS and 2) when the FEIS is completed, prior to a ROD being issued.

In closing, these requests are both a treaty and trust responsibility to maintain the cultural lifeways of the Shoshone-Bannock people, to continue our connection to our homelands. The reasoning herein is a significant change in the right direction to provide a meaningful harvest for our people to feed their families. We pray for your commitment to uphold treaty and trust obligations.

Respectfully submitted,



Lee Juan Tendoy, Chairman
Fort Hall Business Council
Shoshone-Bannock Tribes

The SHOSHONE-BANNOCK TRIBES

FORT HALL INDIAN RESERVATION
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FORT HALL BUSINESS COUNCIL
P.O. BOX 306
FORT HALL, IDAHO 83203

TO: Frank Durbian, Project Lead at National Elk Refuge, Jackson, Wyo.

FROM: Donna Thompson, Chairwoman, Shoshone-Bannock Tribes

DATE: 12/9/2025

RE: **Shoshone-Bannock Tribes' Comment Regarding DEIS Bison Elk Management Plan on the National Elk Refuge.**

Mr. Durbian,

The intent of this document is to convey the Shoshone-Bannock Tribes' (hereinafter Tribes) formal comment regarding updating the NER's Bison Elk Management Plan (BEMP hereinafter) Draft Environmental Impact Statement (DEIS).

The Tribes reserved our paramount right to hunt on the unoccupied lands of the United States in the 1868 Fort Bridger Treaty (15 Stat. 673), a right which exists on the NER, today. For your information and review, and to support the Tribes' long held position of existing rights to hunt on the Refuge, which has never been diminished in any form (in fact recent significant changes in federal court precedent have only supported our position), the Tribes are attaching a DOI Solicitor's Office memo confirming our right to hunt on the Refuge, expressly, dated January 6th 1993.

Jackson Hole, Wyoming is well within the homelands of the Shoshone-Bannock Tribes and remains an area intimately tied to our Tribes, our membership, Treaty rights, ceremonies, and cultural uses. Since time-immemorial our people have lived upon and utilized these lands and resources to provide for our people and our lifeways. We appreciate the open and candid communication, discussion, and consultation from you and your staff and intend on continuing this working relationship long into the future. We also appreciate inclusion of the Tribes' specific section as previously requested, as written by our Fish and Wildlife staff.

Specific Feedback and Requests to be Integrated into the Updated Bison and Elk Management Plan.

I. Executive Orders, Memorandum, Treaty, and other laws to be cited.

The executive summary of the DEIS on pg. ii begins with citations to Executive Order 14154 (“Unleashing American Energy,” 2025) and Presidential memo titled, “Ending Illegal Discrimination and Restoring Merit-Based Opportunity (2025) while simultaneously citing rescinded CEQ regulations implementing NEPA as guidance to the “extent appropriate” as they align with E.O. 14154. The Tribes request that this section be expanded to include which rescinded provisions specifically were followed in developing this document so we can gauge processing of USFWS documents moving forward.

Additionally, the Tribes find that if these Executive Orders and Memorandum are appropriate to cite within this document, that it is essential to also cite E.O. Executive Order 13175 of November 6, 2000, “Consultation and Coordination With Indian Tribal Governments,” the purpose of which is to, “[E]stablish regular and meaningful consultation and collaboration with tribal officials in the development of Federal policies that have tribal implications, to strengthen the United States government-to-government relationships with Indian tribes, and to reduce the imposition of unfunded mandates upon Indian tribes[.]” This executive order defines policies that have tribal implications as, “regulations, legislative comments or proposed legislation, and other policy statements or actions that have substantial direct effects on one or more Indian tribes, on the relationship between the Federal Government and Indian tribes, or on the distribution of power and responsibilities between the Federal Government and Indian tribes.” The intent of this E.O. ensures that the Tribes are afforded consultation and ongoing coordination with the USFWS regarding this plan. Therefore, this executive order should also be cited as binding agency directive as others cited and referenced in the document. It is important to identify that this E.O. has been reaffirmed by Presidents Bush, Obama, Biden and Trump throughout the last 25 years. In that same vein, Presidential Memorandum on Tribal Consultation and Strengthening Nation-to-Nation Relationships (January 26, 2021), Joint Secretarial Order 3403 on Fulfilling the Trust Responsibility to Indian Tribes in the Stewardship of Federal Lands and Waters (November 2021), Interior's 2021 Detailed Plan for Improving Interior's Implementation of E.O. 13175, our codified 1868 Treaty (15 Stat. 673), and attached DOI Solicitor's memo dated January 6, 1993, should also be cited given the context of wildlife and land management on the NER by the USFWS, an agency Trustee as recognized within the mandates cited herein.

The United States is a signatory to the Treaty agreement and acts as a trustee to the Tribes, to ensure the rights we hold are not infringed upon. As stipulated in this Country's founding documents, "This Constitution, and the Laws of the United States which shall be made in Pursuance thereof; and all Treaties made, or which shall be made, under the Authority of the United States, shall be the supreme Law of the Land; and the Judges in every State shall be bound thereby, any Thing in the Constitution or Laws of any State to the Contrary notwithstanding." U.S. Const. art. VI, cl. 2 (emphasis added). This citation is significant for many reasons including the recognition of federal supremacy in law (our Treaty) and management of wildlife and federal lands. Wording within the draft BEMP alternatives and discussion possesses a tenor of state-forward or state-focused benefit and management decision making, with tribes sparsely mentioned as somewhat of a fallback. The alternatives drafted are flawed for this reasoning, as harvest under the Draft BEMP does not require Tribal consultation or coordination in decision making on the Refuge. The Tribes' involvement in these management and harvest decision needs to be captured in the document. Otherwise, it does not align with upholding the Tribes' Treaty reserved rights, our sovereignty, nor trust responsibility as bestowed. This is expressly found in the alternatives wherein state wildlife management on the refuge is considered throughout, specific to state sportsman opportunity, before the Tribes are considered for the same. This is not correct, and given our priority and express Treaty reserved right to hunt on the unoccupied lands of the United States, must be remedied within the BEMP.

Importantly and necessarily, given recent statements made by officials such as WGFD officers not authorized to speak on behalf of the Tribes, the Tribes have never consented in any form nor asserted or conveyed in any form, that the lands within the exterior boundaries of the NER are categorically, "occupied."¹ In fact, the continuation of hunting by the Tribes today (as we have from time-immemorial), the Eastern Shoshone Tribe, and state sportsman on the Refuge strongly dictate that lands within the NER are certainly unoccupied lands of the United States, owned and managed by the United States, subject to the Tribes' Treaty reserved right to hunt. The Tribes' Treaty right to hunt is a Federal reserve right. It is a primary right recognized in the US Constitution and other Federal law including binding precedent, not a secondary right subject to state priority. The language identified above by the Tribes needs to be amended throughout this document to reflect the points made herein and the Tribes' long held position that our federal reserve Treaty right to hunt

¹ See https://www.gillettenewsrecord.com/news/wyoming/article_55a65dbd-d8b4-5983-bdf6-ef9eab3a6978.html

exists on the Refuge today, in alignment with and supported by the attached DOI Solicitor's memo. To be absolutely clear, the Tribes' position is that we hunt on the Refuge pursuant to our Treaty right to hunt. A hunt is a hunt, and we request that the document be amended to capture our Treaty right to hunt throughout and not be so attenuated as to reference it merely as a "ceremonial hunt" – context requires us to specify our position, which is that ceremonial hunts as identified by the Tribes are encapsulated under our Treaty right to hunt, which is the case here on the Refuge. The USFWS has internal policy in addition to law recognizing its duty to uphold and facilitate these rights.

Additionally, due to the Treaty-reserved right to hunt, Wyoming does not have unilateral management over game and natural resources within its borders nor within the NER, rather, "Although States have important interests in regulating wildlife and natural resources within their borders, this authority is shared with the Federal Government when the Federal Government exercises one of its enumerated constitutional powers, such as treaty making." *Minnesota v. Mille Lacs Band of Chippewa Indians*, 526 U.S. 172, 204, 119 S. Ct. 1187, 1204, 143 L. Ed. 2d 270 (1999) (such as the Shoshone-Bannock Tribes' federal reserved Treaty right to hunt, codified in the 1868 Fort Bridger Treaty) (emphasis added). This general matter has been litigated and adjudicated within the 10th Circuit Federal Court of Appeals, specifically the NER as cited below:

Although the Property Clause does not authorize an exercise of a general control over public policy in a State, it does permit an exercise of the complete power which Congress has over particular public property entrusted to it. In our view, the "complete power" that Congress has over public lands necessarily includes the power to regulate and protect the wildlife living there.

Kleppe, 426 U.S. at 540–41, 96 S.Ct. 2285 (emphasis added).

In view of the foregoing, we believe the point painfully apparent that the Tenth Amendment does not reserve to the State of Wyoming the right to manage wildlife, or more specifically vaccinate elk, on the NER, regardless of the circumstances.

...

In the end, the proposition that the FWS lacks the power to make a decision regarding the health of wildlife on the NER when a State, for whatever reason, disagrees with that decision

proves too much. To be sure, Congress in enacting the NWRSIA recognized that “National Wildlife Refuges are often important components of the ecosystems in which they are located and contribute significantly to the conservation of those ecosystems. Nonetheless, they cannot fulfill the mission set forth in [the NWRSIA] unless they are consistently directed and managed as a national system.” H.R.Rep. No. 105–106, at 8. By establishing a system “to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration” of wildlife, 16 U.S.C. § 668dd(a)(2), Congress undoubtedly intended a preeminent federal role for the FWS in the care and management of the NWRs.

Wyoming v. United States, 279 F.3d 1214, 1227–34 (10th Cir. 2002) (cited in relevant part) (this preeminent role inherently includes recognition of the Tribes’ Treaty right).

The Tribes possesses thousands of years of successful wildlife management, extending from time-immemorial to present-day. We exclusively manage wildlife and natural resources within the exterior boundaries of our Reservation and co-manage the same off-Reservation pursuant to our Treaty, navigating complex jurisdictional issues and federal laws such as the ESA. Therefore, the Tribes request to be included in wildlife management functions and decisions on the NER as discussed within the draft BEMP as it directly affects Treaty assets of the Tribes, and request that this be formalized within the document.

As it is, after review of the DEIS all the action alternatives will require significant cooperation from Cooperating Agencies such as the Wyoming Game and Fish Commission and Department to meet the purpose and need identified in this document. The cessation of the elk feeding program at the Refuge will require Wyoming to act quickly to set appropriate sportsman harvest rates, but these processes and approvals are outside of the authorities of the Service. The success and failure of the resulting management document from all the action alternatives is dependent upon actions of other Cooperators, in particular Wyoming.

To ensure the Service can meet its purpose and need for this management document the Tribes recommend that all the action alternatives provide clear measurable objectives for review and assessment. Alternative B – 7 Year Adaptive Population Management with 3% Chronic Wasting Disease Threshold possesses some measurable objectives that may assist the Service to achieve sustainable bison and

elk numbers (~500 bison and 5,000 elk) by reducing over-wintering elk and limiting disease spread by directly addressing disease-risk reduction thresholds. Alternative B supports ecosystem process by moving elk back onto natural forage and restoring natural migration patterns. Alternative B provides economic and harvest opportunities and reduces long-term management costs and human-wildlife conflict. Again, even the implementation of Alternative B would require significant support from Cooperating Agencies to fully implement.

Additionally, we're also attaching our letter sent last year regarding Tribal allocation of bison on the Refuge as a reminder that our position regarding the Tribes' allocation of bison needs to be raised. Finally, we are also requesting that our staff meet with you at in the near future to discuss elk harvest on the Refuge as discussed with the FHBC and staff on previous occasions.

If you should have any additional questions or for further discussion and ongoing coordination, please contact Gaylen Edmo, SBT Fish and Wildlife Policy Analyst at 208-851-3225 - gaylen.edmo@sbtribes.com and Claude Broncho, SBT Fish and Wildlife Policy Representative at 208-221-2044 - claudio.broncho@sbtribes.com.

Respectfully Submitted,



Donna Thompson, Chairwoman
Fort Hall Business Council
Shoshone-Bannock Tribes

ATTACHMENT 1

9104
United States Department of the Interior

OFFICE OF THE SOLICITOR

Washington, D.C. 20240



FWS.RM.0797

JAN 6 1993

In reply, please address to
Main Interior, Room 6456

Memorandum

To: Regional Solicitor, Rocky Mountain Region

From: Associate Solicitor, Division of Indian Affairs

Subject: Shoshone-Bannock Hunting Rights

This is in response to your memorandum dated December 15, 1992, addressed to the Regional Director, Fish and Wildlife Service, Region 6.

We wish to make one significant correction and/or clarification of the discussion contained in your memorandum. Please provide a copy of this memorandum to the Fish and Wildlife Service in conjunction with your December 15 memorandum.

Your memorandum correctly asserts that the Shoshone-Bannock Tribes still have the right to hunt in the National Elk Refuge, but that tribal hunting may be regulated if necessary for resource conservation. The memorandum then states that "[a]s long as the regulations are applied to the Tribes in a non-discriminatory manner, reasonable and necessary conservation regulation can be applied to the Tribes. See Puyallup Tribe v. Washington Game Dep't, 391 U.S. 392 (1968)." Three paragraphs later, the memorandum concludes that "tribal members should be allowed to participate in any hunting allowed on the Refuge, but may be subject to the same regulations mandated by Congress that govern other hunters on the refuge."

We agree that Puyallup is the correct standard to apply in determining the appropriateness of regulating the tribal exercise of reserved hunting rights.¹ See also State v. Tinno, 94 Idaho 759, 497 P.2d 1386, 1392-93 (1972) (state regulation of Shoshone-Bannock fishing struck down). Although the standards developed in Puyallup and its progeny were developed in the context of

¹ The Billings Field Office also has referred recently to Puyallup and its progeny as stating the appropriate standard for evaluating the regulation of Indian treaty rights.

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tribe's exercise of its reserved hunting and fishing rights. Cf. Tinno, 497 P.2d at 1397 (McQuade, C.J., concurring specially) (treaty affords tribal members first priority to fish). When a treaty right is implicated, the specific impact of Indian use/activity must be examined separately from that of non-Indians. It is not appropriate to lump Indians and non-Indians together in a general assessment. Cf. id. at 1396 ("if the State were permitted to impose upon Indians the same regulations applicable to other citizens, then the treaty in reality would provide 'no right at all'").

The following discussion may be useful in understanding the proper standards and the precision required in regulating the exercise of Indian reserved rights, and the distinction between the "non-discriminatory" element and the "necessity" requirement.

Federal and treaty reserved Indian hunting and fishing rights are not immune from regulation. Although the rights, once vested, may not be limited or qualified, except by express congressional action, the states and the Executive Branch of the Federal Government may impose nondiscriminatory, necessary conservation measures on the tribes' exercise of their rights. In the context of state regulation, the Supreme Court has held

that although, these rights "may .t.t. not be qualified by the State, . . . the manner of fishing [and hunting], the size of the take, the restriction of commercial fishing [and hunting], and the like may be regulated by the State in the interest of conservation, provided the regulation meets appropriate standards and does not discriminate against the Indians." The "appropriate standards" requirement means that the State must demonstrate that its regulation is a reasonable and necessary conservation measure, . . . and

that its application to the Indians is necessary in the interest of conservation.

Antoine v. Washington, 420 U.S. 194, 207 (1975) (emphasis added) (citing Puyallup Tribe v. Department of Game of Washington, 391 U.S. 392, 398 (1968)); see also United States v. Washington, 384 F. Supp. 312, 342 (W.D. Wash. 1974), aff'd and remanded 520 F.2d 676 (9th Cir. 1975), cert. denied, 423 U.S. 1086 (1976); United States v. Washington, 520 F.2d at 686 & n.3.

In United States v. Michigan, the district court reviewed and restated the legal standards applicable to state regulation of Indian fishing rights:

The "appropriate standards" required of non-discriminatory regulations must meet two criteria: (1) the regulation must be a reasonable and necessary conservation measure, and (2) its application to the Indians must be necessary in the interest of conservation. Antoine v. Washington, 420 U.S. 194.

The meaning of the first of these criteria is set out in United States v. Washington, 384 F. Supp. at 342.

"Reasonable" means that a specifically identified conservation measure is appropriate to its purpose; and "necessary" means that such purpose, in addition to being reasonable, must be essential to conservation.

Even more significant is the second of the above criteria: it must be necessary to regulate the Indians. United States v. Washington, supra, says of this standard:

If alternative means and methods of regulation and necessary conservation are available, the state cannot lawfully restrict the exercise of off-reservation treaty right fishing, even if the only alternatives are restriction of fishing by non-treaty fishermen, either commercially or otherwise, to the full extent necessary for conservation of fish.

384 F. Supp. at 342. The Ninth Circuit commented in the following language:

Direct regulation of treaty Indian fishing in the interests of conservation is permissible only after the state has proved unable to preserve a run by forbidding the catching of fish by other citizens under its ordinary police power jurisdiction. Antoine v. Washington, 420 U.S. 194 (1975).

520 F.2d at 686. To regulate Indian fishermen first, to apply the same regulations to them as to non-treaty fishermen, is to render the treaty rights nugatory. (citations omitted).

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505 F. Supp. 467, 474-75 (W.D. Mich. 1980).

Unless the above standards are adhered to in agency decisions affecting Indian reserved hunting and fishing rights, the Department will unnecessarily be at risk, should conflicts with a tribe arise.

We appreciate the fact that your memorandum recognizes that it is subject to review by the Washington office, given the national scope of this issue. In the future, for matters such as these involving general principles of Indian law, please consult with this Division before issuing formal opinions to client agencies.

If you have any questions, please feel free to contact me or Steve Linscheid, 202-208-5134, who is on my staff.

Catherine E. Wilson
Catherine E. Wilson

cc: Associate Solicitor, Division of Conservation and Wildlife
Regional Solicitor, Pacific Northwest Region
Field Solicitor, Twin Cities, Pacific Northwest Region
Field Solicitor, Billings, Pacific Northwest Region

ATTACHMENT 2

The SHOSHONE-BANNOCK TRIBES

FORT HALL INDIAN RESERVATION
PHONE (208) 478-3700
FAX # (208) 237-0797



FORT HALL BUSINESS COUNCIL
P.O. BOX 306
FORT HALL, IDAHO 83203

RE: Shoshone-Bannock Requests for Directive from Assistant Secretaries Regarding Update to National Elk Refuge, Bison and Elk Management Plan.

Greetings Assistant Secretaries Estenoz and Newland,

The Shoshone-Bannock Tribes (Tribes) have a reserved off-reservation hunting right under Article 4 of the 1868 Fort Bridger Treaty (15 Stat., 673). For purposes of maintaining our cultural hunting lifeways we want to address our requests regarding updates to the Bison and Elk Management Plan (Management Plan) on the National Elk Refuge (NER) in Jackson Hole, Wyoming.

We are sending these requests to your offices for the commitment that they be directed for integration into the updated Bison and Elk Management Plan. Our requests are as follows:

First Request: That there be a section within the Management Plan that recognizes the NER and surrounding areas as the traditional homelands of the Shoshone-Bannock Tribes.

This cannot be disputed, as the archeological artifacts found on the NER have been identified as Shoshone-Bannock. This area, including the NER, Grand Teton National Park, Yellowstone National Park, and surrounding areas have been our homelands from time-immemorial, and remain our homelands today.

This section should expand on the fact that artifacts found thereon are Shoshone-Bannock. Additionally, this should recognize our traditional practices such as hunting and gathering, which continues today both on and off-reservation. This section should specifically reference our reserved right to hunt off-reservation under Article 4 of the 1868 Fort Bridger Treaty.

The fact that we've hunted bison on the refuge since 2007/2008 should be mentioned and detail the importance of the hunt to our people and the recognition of our culture and lifeways. Our origin stories center on Yellowstone National Park affirmed by

artifacts found within and amongst the area to include the NER dating our inhabitation and use thousands of years before.

The historical importance of tribal bison harvest was recognized in the original 2007 Management Plan and Record of Decision. However, it was only mentioned under a subheading titled "ethnographic resources." Specifically, it was limited to the following statement:

Ethnographic Resources. Hunting was a tradition practiced by American Indian tribes, who are believed to have traditionally used the lands within Grand Teton National Park and the National Elk Refuge. (emphasis added)

The referenced belief above and fact of artifacts are at odds with one another and is not acceptable, we inhabited/used this area for thousands of years, it is our homelands. The relationship between the Shoshone-Bannock Tribes and the NER should be expressly incorporated into the Management Plan with its own section and give recognition to our occupation and use of the area, traditionally and contemporarily.

Second Request: The Shoshone-Bannock Tribes are requesting that the objective numbers set for elk and bison in the Management Plan draft alternatives be restructured to raise the objective number of bison – specifically to allow for a higher number of tribal harvest; Request bison tolerant alternative.

In the 2007 Management Plan chosen alternative, as well as the draft updated proposed alternative, the wintering elk objective is 5,000 animals and the bison objective is 500 animals. This draft alternative also proposes to phase-out of supplemental feeding altogether at 3% CWD prevalence or after 7 years.

We want to know what the biological reasoning is for keeping bison at 500, and attempting to keep elk at 5,000? Why not allow the bison herd to grow to 1,000-1,200 animals and reduce elk to 3,800-4,000 animals? This number of bison would allow the Shoshone-Bannock Tribes a more sufficient number for Tribal take and honor the important cultural relationship between the bison and our Tribal members.

If we can raise the number of bison harvest on the NER to fulfill the trust responsibility to the Tribes and meet Tribal objectives, this would both benefit our Tribes and align with "recogni[z]ing ... the cultural significance of bison to various tribes."¹

¹ 2007 Final Bison and Elk Management Plan.

As it stands, the Compatibility Determination is the only document that limits the tribal take to 5 bison/tribe. Neither the 2007 FEIS nor the ROD expressly limit tribal take. Based on this, we are making several requests below.

Tribal Preferred - Bison Tolerant Alternative/Request

The Shoshone-Bannock Tribes are requesting that the bison objective be raised to 1000-1,200 bison within the FEIS and ROD, and that the CD be amended to eliminate the arbitrary cap of 5 bison/tribe for a higher tribal take from the overall number of bison on the refuge.² The NER has sustained this number of bison in previous years, though it may take scaling back the elk objective. This supports the objective in the draft alternatives and prior Management Plan of sustaining a genetically viable bison herd. A larger bison herd would facilitate genetic diversity to withstand future adversity such as climate change and disease. Following, supplemental feeding would need to continue. We can co-manage the population of bison, and elk for that matter, by periodic hunting on the refuge. This would equate to multiple hunts throughout the year, not just one. These are our homelands, if anyone has a right to harvest these animals, it is the Shoshone-Bannock Tribes.

Tribal take should be prioritized over recreational take by the USFWS, as our Trustee. Further, the NER has allowed for instances of exclusive use on the refuge, such as the boy scout antler harvest which nets thousands of dollars for their benefit. Given the USFWS' trust responsibility, and documents such as Secretarial Order No. 3403 "Joint Secretarial Order on Fulfilling the Trust Responsibility to Indian Tribes in Stewardship of Federal Lands and Waters." we believe our requests are fully justifiable and valid.

Finally, option 1 (potentially applicable, to Alternatives B & C) proposes expanding harvest opportunities of short distance migrant elk that winter on the NER. The Tribes can help facilitate this option and co-manage the herd given our treaty right to hunt the unoccupied lands of the United States. According to the draft option, roughly 30-40% of the elk that winter on the NER migrate a short distance from the Snake River Corridor. There are unoccupied lands within this corridor and surrounding areas. Given the repudiation of Race Horse by Herrera and the vacatur of Repsis, our Treaty right to hunt is alive and well – as we have invariably posited. In good faith, we've attempted to meet with the Wyoming Governor to discuss our intent to hunt in Wyoming, however he declined.

Your agencies and the USFWS should facilitate this discussion around our Treaty right to hunt unoccupied lands of the United States within Wyoming. This would benefit the USFWS given the proposal to target the short distance migratory elk that our Tribal members would harvest and uphold the trust responsibility between the

² The Tribes also request to continue gathering on the refuge. This has not been an issue of contention.

Shoshone-Bannock Tribes and the United States. The Shoshone and the United States have a long history of cooperation in this country.

Lee Juan Tendoy The Shoshone-Bannock Tribes, you represent a strong, proud, and resilient community. We are proud to have you here, and we look forward to working with you on this project.

As the first of its kind, the SHSFB is a great example of the Shoshone-Bannock Tribes' commitment to the future. We are proud to have you here, and we look forward to working with you on this project.

Further, we appreciate that the SHSFB project will demonstrate the Shoshone-Bannock Tribes' commitment to the future. We are proud to have you here, and we look forward to working with you on this project.

We are proud to have you here, and we look forward to working with you on this project. We are proud to have you here, and we look forward to working with you on this project.

In addition, we appreciate that the SHSFB project will demonstrate the Shoshone-Bannock Tribes' commitment to the future. We are proud to have you here, and we look forward to working with you on this project.

Sincerely,
Lee Juan Tendoy

Lee Juan Tendoy, Chairman
Fort Hall Business Council
Shoshone-Bannock Tribes

APPENDIX K – Future Climate and Ecological Conditions for the National Elk Refuge Bison and Elk Management Plan

Future Climate and Ecological Conditions for the National Elk Refuge Bison and Elk Management Plan

The National Elk Refuge (Refuge) and surrounding landscape is projected to experience changes in climate and ecological conditions by the middle of the 21st century. Potential effects to the Refuge and surrounding areas include declining snowpack, intensifying drought, shifting vegetation communities, more severe wildland fires and increasing erosion (Martinuzzi et al., 2016, Hostetler et al. 2021). To support an update of the National Elk Refuge Bison and Elk Management Plan (USFWS 2019) and associated Environmental Impacts Statement, projections of how changing climate conditions may impact annual, seasonal and elevational snowpack and vegetation growing conditions at the Refuge and surrounding areas for the middle of the 21st century are summarized and reported below.

Source Climate Models

Divergent climate projections that describe a broad range of potential future conditions are an important tool to support information needs of decision makers and help to outline the spectrum of potential resource responses to climate change, develop strategies robust to that range, and avoid unexpected conditions (Lawrence et al., 2021). Future climate projection metrics including air temperature, precipitation and a suite of derived climate variables (e.g., growing degree days) were gathered and summarized from 20+ fifth generation (Pachauri et al., 2014) Global Climate Models (GCMs) of the Coupled Model Intercomparison Project (CMIP5) sanctioned by the Intergovernmental Panel on Climate Change (IPCC). GCMs are based on historical trends combined with varying greenhouse gas emission rates to produce a range of climate futures (Kim et al., 2022; Runyon et al., 2024). The coarse-scale GCMs were statistically downscaled to ecologically relevant resolutions (generally, 4 km x 4 km cells) using the Multivariate Adaptive Constructed Analogs (MACA) method version 2 and the gridMET training dataset (Abatzoglou and Brown 2012). MACA removes biases and increases the resolution of model outputs while capturing observed patterns of daily near-surface meteorology and simulated changes in GCMs. This method has been shown to be slightly preferable to direct daily interpolated bias correction in regions of complex terrain due to its use of a historical library of observations and multivariate approach (Abatzoglou and Brown 2012). The downscaled GCMs project future climate condition based on plausible greenhouse gas emissions

scenarios through the end of the 21st century (Kim et al., 2022; Runyon et al., 2024). These scenarios, called Representative Concentration Pathways (RCP), range from a future where emissions are substantially reduced from current emission levels (RCP 2.6), remain relatively constant (RCP 4.5) or increase substantially (RCP 8.5) due to human industrial and conservation activities (van Vuuren et al., 2011).

Baseline (approximately 1971–2010 but varies slightly based on available data) and mid-century projections (2040–2069) were reported because the Bison and Elk Management Plan is intended to guide refuge management over a 20-year timeframe.

We identified two plausible, divergent climate futures (“Warm Wet” and “Hot Dry”) to capture relevant variation across climate models and greenhouse gas emission scenarios (see Lawrence et al., 2021; Runyon et al., 2024). These two climate futures represent different ways the climate might develop at the Refuge through 2050 and both are plausible. It is important to note the naming of these futures is relative to one another, not the past. In other words, the Warm Wet climate future might be more arid than what the unit has experienced historically but the name denotes that it projects wetter conditions than the Hot Dry climate future. We also identify the mean predicted future of all 20 GCMs.

Future Snowpack Based on Predicted Fall and Winter Conditions

Future Fall and Winter Conditions – Low Elevation

Modeling of mid-century snow depth and snow-water content suggest the Refuge will experience reduced snow depth and fewer days with snow cover by mid-century. Models also predict milder winter (December, January, February) temperatures, including warmer cold snaps, which suggests more favorable conditions for bison and elk on winter ranges. See Table 1.

Most downscaled GCMs project an increase in the total amount of winter precipitation by mid-century, whereas all models suggest a reduction in winter snow water equivalent (SWE), our best estimator of on-the-ground snow volume. This may seem counterintuitive: more winter precipitation might be expected to result in increased snow volumes. However, SWE is influenced by air temperature and its effects on both rain/snow proportions and melting rates. Due to increased minimum daily temperatures (5-8°F by mid-century, Table 2), precipitation is projected to increasingly come in the form of rain by mid-century. Also, snowpack

at all elevations is expected to be reduced, compared to baseline conditions, due to higher melt rates and rain-on-snow events.

Cold season snow duration was characterized in and around the analysis area using the SnowClim model (Figure 1). SnowClim (Lute et al., 2022) is a physics-based snow model for the western United States derived from thousands of snow depth and air temperature measurements at more than 900 Snowpack Telemetry (SNOTEL) sites across the mountain west. Spatially explicit models estimating duration of snow cover during 2000-2013 and *at the end of the century* under RCP 8.5 suggests the number of days with measurable snow cover on the Refuge will decline by about 50 days. Projected data is only available for end of century. SnowClim does not report mid-century conditions, but a visual estimate based on Figure 1 and SWE projections (Table 2) suggest approximately 20-30 additional snow-free days by mid-century.

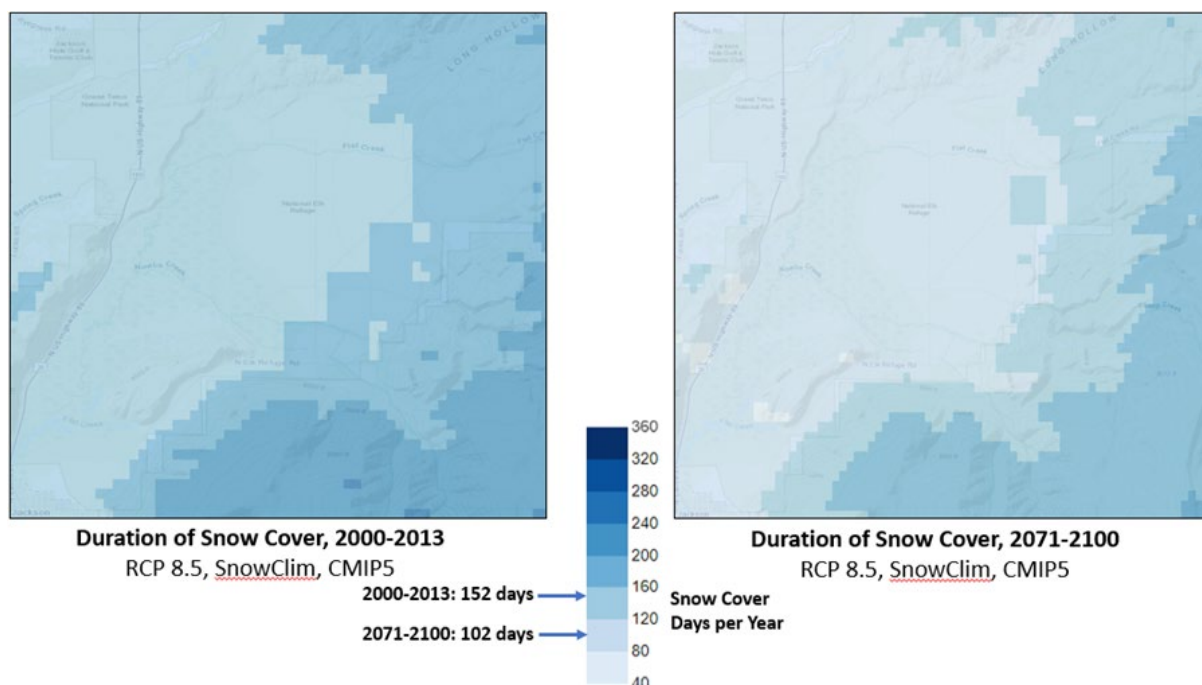


Figure 1. Average duration of snow coverage in the analysis area projected by SnowClim (Lute et al. 2022). The baseline period (2000-2013) is on the left and end of century on the right. The SnowClim model estimate about 50 snow-free days in the valley by the end of the century. SnowClim is a physics-based snow model parameterized by and calibrated at Snowpack Telemetry (SNOTEL) sites across the western United States (US).

Model	Fall Precipitation (in)		Winter Precipitation (in)		Mean Daily Winter Minimum Temperature (F)		Coldest Winter Day (F)		Winter SWE (in)	
	Value	Change	Value	Change	Value	Change	Value	Change	Value	Change
Baseline	8.6		12.6		6		-20		11.0	
Dry HadGEM2-ES365	9.0	+0.4	12.4	-0.2	13	+7	-11	+9	6.7	-4.3
Dry IPSL-CM5B-LR	8.4	-0.2	12.3	-0.3	13	+7	-9	+11	6.5	-4.5
Wet MRI-CGCM3	8.4	-0.2	15.4	+2.8	11	+5	-13	+7	10.3	-0.7
Wet CanESM2	11.5	+2.9	15.6	+3.0	14	+8	-9	+11	8.6	-2.4
20 GCM Mean	8.9	+0.3	13.9	+1.3	13	+7	-10	+10	8.1	-2.9

Table 1: Projected values and changes from baseline (1971-2010), below 7,000', for total mid- 21st century fall (September, October, November) and winter (December, January, February) precipitation, mean daily minimum winter temperature, coldest winter day and mean snow-water equivalent as estimated by four downscaled GCMs and a 20-GCM ensemble. Models disagree on change in winter precipitation (from a 0.3" decline to 3.0" increase) but only the 'wettest' model (MRI-CGCM3) suggests winter snowpack (SWE) will be reduced by less than 2.3" by mid-century.

Future Winter Conditions – High Elevation

Although perhaps least relevant to elk and bison of the four season-elevation breakdowns presented in this appendix, individual and averaged GCMs project substantial change in winter conditions at high elevations. Expect minimum daily temperatures and the first fall frost to completely depart from the baseline condition. These conditions may delay elk herd movement to lower elevations in the fall. Although the area might experience increased fall and winter precipitation, the countering effects of increasing air temperature indicate reduced snowpack in most years.

Consistent with lower elevation fall and winter projections (Table 1), warmer temperatures are expected to drive a reduction in snowpack by mid-century. This condition is more likely to drive ecological conditions than any changes in cold season precipitation amounts. Although managers should expect increasing variability among years, that might include winters with substantially reduced snowpack which would likely result in substantial and inter-annual variation in the

hydrographs in and around the Refuge and ripple effects on soil moisture and fire risk at all elevations and seasons.

Model	Winter Precipitation (in)		Mean Daily Winter Minimum Temp (F)		Mean Daily Winter Maximum Temp (F)		Coldest Winter Temperature (F)		Winter SWE (in)	
	Value	Change	Value	Change	Value	Change	Value	Change	Value	Change
Baseline	9.6		4.2		27.0		-22.0		8.4	
Dry (ISPL-CM5B-LR)	9.4	-0.2	11.3	+7.1	31.3	+4.3	-10.5	+11.5	4.8	-3.6
Dry (HadGEM2-ES365)	9.6	0.0	11.3	+7.1	33.6	+6.6	-13.6	+8.4	4.8	-3.6
Wet (MRI-CGCM3)	11.7	+2.1	8.7	+4.5	29.6	+2.6	-14.7	+7.3	7.9	-0.5
Wet (CanESM2)	12.2	+2.6	12.1	+7.9	32.7	+5.7	-11.1	+10.9	6.4	-2.0
20 GCM Mean	10.7	+1.1	10.9	+6.7	31.7	+4.7	-12.6	+9.4	6.1	-2.3

Table 2: Projected values and changes from baseline (1971-2010), 7,000'-8,500', for total mid- 21st century winter (December, January, February) precipitation Inches, mean daily minimum temperature (F), mean daily maximum temperature (F), coldest winter day (F) and winter SWE (inches) as estimated by four downscaled GCMs and a 20-GCM ensemble.

Vegetation Growing Conditions Based on Future Spring and Summer Conditions

To characterize growing season precipitation and estimate growing season duration change by mid-century relative to elevation, we evaluated spring (March, April, May) precipitation and spring onset (Table 3) as well as summer (June, July, August) precipitation and projected length of the growing season (Table 4). For these analyses, growing season is defined as the cumulative consecutive days in which minimum daily temperatures are above freezing (32°F).

Future Spring and Summer Conditions – Low Elevation

All but the 'driest' Global Climate Models (GCMs) (IPSL-CM5A-LR) project substantially wetter springs by mid-century, and each of these four GCMs suggest spring (March, April, May) green up will occur 2-3 week earlier. Air temperature increases are expected to be most pronounced in March (Hostetler et al. 2021). Therefore, the Refuge should expect an early spring more often by mid-century.

Coupled with reduced snow duration and warmer overnight temperatures, it is likely that more bare ground will be exposed in valley bottoms as winter changes to spring, mid-century.

Model	Spring Precipitation (in)		Spring Minimum Daily Temperature (in)		Spring Snow Water Equivalent (in)		Spring Potential Evapo-transpiration (F)		Last Day of Spring Freeze (day)	
	Value	Change	Value	Change	Value	Change	Value	Change	Value	Change
Baseline	10.4		21.2		13.1		1.5		June 20	
Dry IPSL-CM5A-LR	10.4	0	28.1	+6.9	6.6	-6.5	3.6	+2.1	June 7	-13
Dry IPSL-CM5A-MR	10.8	+0.4	28.0	+6.8	6.5	-6.6	3.9	+2.4	June 3	-17
Wet MIROC5	13.5	+3.1	31.8	+10.6	7.4	-5.7	5.3	+3.8	June 7	-13
Wet CanESM2	13.8	+3.4	29.7	+8.5	6.5	-6.6	4.2	+2.7	June 4	-16
20 GCM Mean	12.1	+1.7	27.6	+6.4	7.2	-5.9	3.5	+2.0	June 6	-14

Table 3: Projected values and changes from baseline (1971-2010), below 7,000', for mid- 21st century total spring (March, April, May) precipitation, spring daily minimum temperature, spring potential evapotranspiration, spring SWE and the last day of spring freeze below 7,000' elevation as estimated by four downscaled GCMs and a 20-GCM ensemble. Only the IPSL-CM5A-LR model projects springs precipitation to decline – all others, including the next 'driest' model project an increase of > 1" spring precipitation. However, all models agree that spring weather will generally arrive earlier by mid-century.

Summer (June, July, August) precipitation amounts and growing season length are expected to change notably on the Refuge according to a majority of the 20 GCMs, with every model indicating the growing season (defined as the cumulative consecutive days in which minimum daily temperatures are above freezing (32°F)) below 7,000' will expand significantly – perhaps doubling in duration (Table 4).

Model	Summer Precipitation (in)		Daily Maximum Temperature (F)		Hottest Day Temperature (F)		Days w/ Max Temperature above 86°F (days)		Potential Evapo-transpiration (in)		Length of Growing Season (days)	
	Value	Change	Value	Change	Value	Change	Value	Change	Value	Change	Value	Change
Baseline	5.3		70.0		82.3		1.4		18.5		33.3	
Dry (Inmcm4)	4.2	-1.1	77.4	+7.4	89.2	+6.9	17.5	+16.1	21.5	+3.0	67.9	+34.6
Dry (Bcc-csm1-1)	4.3	-1.0	78.0	+8.0	89.3	+7.0	18.6	+17.2	21.5	+3.0	98.2	+64.9
Wet (GFDL-ESM2G)	6.6	+1.3	74.7	+4.7	86.9	+4.6	9.2	+7.8	19.7	+1.2	77.2	+43.9
Wet (CanESM2)	6.4	+1.4	78.0	+8.0	90.2	+7.9	16.7	+15.3	20.6	+2.1	112.2	+78.9
20 GCM Mean	5.3	0.0	77.1	+7.1	89.3	+7.0	15.6	+14.2	21.0	+2.5	97.7	+64.4

Table 4: Projected values and changes from baseline (1971-2010), below 7,000', for total mid-21st century summer precipitation (inches) mean summer daily maximum temperature (F), hottest summer day (F), number of days when air temperature exceeds 86°F (days), length of growing season (days) and mean potential evapotranspiration (in) as estimated by four downscaled GCMs and a 20-GCM ensemble.

The significant extension of the growing season coupled with relatively small change in summer precipitation suggests a profound change in range condition may be expected by mid-century. This may especially be true if dryer, longer summers follow wetter, warmer spring conditions. This combination has the potential to influence plant species composition, alter overall range productivity and heighten fire risk on the Refuge.

Future Spring and Summer Conditions – High Elevation

Modeling projects spring conditions may arrive 2-3 weeks sooner in the high country by mid-century with substantial increases in spring precipitation at least in some years. As the season progresses, expect a 40+ day increase in growing season with minimal changes in summer precipitation.

All GCMs, except the driest model (IPSL-CM5A-LP), project an increase in spring precipitation in the high country by mid-century. Coupled with warmer than baseline spring temperatures (Hostetler et al. 2021; Table 5) and earlier onset of spring, managers should expect wetter springs on average. Warm, wet and early springs suggest more favorable soil moisture, earlier green-up and a cumulative increase in primary productivity. This set of conditions are also likely to result in higher stream flows and potential flood conditions in low-lying, flat terrain. This may not impact elk and bison behavior; however, it may reduce the available foraging area in some years.

Model	Spring Precipitation (in)		Spring Daily Min Temperature (F)		Spring SWE (in)		Potential Evapo-transpiration (in)		Day of Last Spring Freeze (days)	
	Value	Change	Value	Change	Value	Change	Value	Change	Value	Change
Baseline	8.7		19.4		9.5		1.0		June 22	
Dry (IPSL-CM5A-LR)	8.6	-0.1	26.4	+7.0	4.0	-5.5	3.0	+2.0	June 10	-12
Dry (CSIRO-Mk3-6-0)	9.0	+0.3	23.0	+3.6	6.3	-3.2	2.3	+1.30	June 12	-10
Wet (MIROC5)	11.4	+2.7	29.9	+10.5	4.6	-4.9	4.8	+3.8	June 12	-10
Wet (CanESM2)	11.4	+2.7	27.8	+8.4	3.6	-5.9	3.6	+2.6	June 8	-14
20 GCM Mean	10.1	+1.4	25.7	+5.3	4.5	-5.0	3.0	+2.0	June 10	-12

Table 5: Projected values and changes from baseline (1971-2010), 7,000'-8,500', for total mid- 21st century spring precipitation, mean daily spring minimum temperature, spring potential evapotranspiration, spring SWE and the last day of spring freeze as estimated by four downscaled GCMs and a 20-GCM ensemble. Wet and dry models suggest markedly different precipitation scenarios whereas the 20-model mean estimates a slight precipitation increase in the high country by mid-century. Most models agree that spring weather will generally be warmer and arrive earlier by mid-century.

All downscaled GCMs suggest negligible changes in summer precipitation (Table 6) in the high country by mid-century, although even small changes in precipitation during this critical, dryer season may result in profound ecological changes. Reduced summer precipitation following a wet, productive spring may exacerbate fuel conditions conducive to fire, leading to less predictable, more severe wildfires. Projected extension of the growing season with only marginal precipitation changes suggest more droughty summers are likely in average years.

Model	Summer Precipitation (in)		Mean Daily Max Temperature (F)		Hottest Day Temperature (F)		Days w/ Max Temperature above 86°F		Length of Growing Season (days)		Potential Evapo-transpiration (in)	
	Value	Change	Value	Change	Value	Change	Value	Change	Value	Change	Value	Change
Baseline	4.8		68.2		80.1		0.1		18.7		17.8	
Dry (inmcm4)	3.8	-1.0	75.5	+7.3	87.1	+7.0	7.7	+7.6	59.9	+41.2	20.8	+3.0
Dry (Bcc-csm1-1)	3.9	-0.9	76.2	+8.0	87.2	+7.1	7.7	+7.6	94.6	+75.9	20.9	+3.1
Wet (GFDL-ESM2G)	6.0	+1.2	72.9	+4.7	84.8	+4.7	3.1	+3.0	67.4	+48.7	19.0	+1.2
Wet (CanEsm2)	5.6	0.8	76.1	+7.9	88.1	+8.0	7.2	+7.1	105.7	+87.0	20.0	+2.2
20 GCM Mean	4.8	0	75.3	+7.1	87.1	+7.0	6.7	+6.6	88.8	+70.1	20.4	+2.6

Table 6: Projected values and changes from baseline (1971-2010), 7,000'-8,500', for total mid-21st century summer precipitation (inches) , mean summer daily maximum temperature (F), hottest summer day temperature (F), number of days when air temperature exceeds 86°F, length of growing season (days) and mean potential evapotranspiration (inches),as estimated by four downscaled GCMs and a 20-GCM ensemble. Models disagree on change in summer precipitation (from a 1.0" decline to 1.2" increase) but all agree that the growing season will expand by more than one month (41 – 87 days) by mid-century.

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