Wilderness, Wildlife, and Ecological Values of the Hyalite-Porcupine-Buffalo Horn Wilderness Study Area

A Report for the Lee and Donna Metcalf Foundation

By The Craighead Institute

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Heather Lake in the Hyalite-Porcupine-Buffalo Horn Wilderness Study Area.
Photo Credit: Lance Craighead

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Acknowledgements

This document is a synthesis of the work and knowledge of many people: I have just attempted to pull it all together into a somewhat cohesive whole that paints a picture of the ecological and conservation values of the Hyalite-Porcupine-Buffalo Horn Wilderness Study Area (HPBH WSA). I would like to acknowledge all the scientists and professionals whose work I have cited in this report. In particularly I acknowledge those with whom I corresponded or talked as this report took shape: in alphabetical order I would like to thank Brent Brock, Jeff Burrell, Jodie Canfield, April Craighead, Molly Cross, Julie Cunningham, Jesse DeVoe, Shana Dunkley, Robert Garrott, Steve Gehman, Jon Haber, Mark Haroldson, Robert Inman, Joe Josephson, Kristin Legg, Karen Loveless, Peter Nelson, Kelly Proffitt, Chris Ray, Brad Shepard, David Thoma, Rick Tingey, Darcie Warden, and John Weaver. I am deeply indebted to Rick Reese, Frank Culver, Don Bachman and Mike Meloy for their encouragement and support, and to the Lee and Donna Metcalf and RMR Foundations for providing funding.

Executive Summary

This report is a review of existing data and literature that were available in 2015 pertaining to the Hyalite Porcupine Buffalo Horn Wilderness Study Area (HPBH WSA) which is located in the Gallatin National Forest in the Gallatin Mountains of southcentral Montana. It was commissioned by trustees of the Lee and Donna Metcalf Foundation to address a perceived need to gather all the relevant science and data into one document, to facilitate planning, as the fate of the HPBH WSA is decided.

Wilderness Study Areas are areas that were set aside by the U.S. Congress so that they could be studied in more detail to determine their “suitability for preservation as wilderness”. At the time the Wilderness Act was passed in 1964 the goals of wilderness preservation were to retain “…its primeval character and influence, without permanent improvements or human habitation” and to “preserve its natural conditions”, primarily to provide “outstanding opportunities for solitude or a primitive and unconfined type of recreation". Other attributes of wilderness were listed as: "…ecological, geological, or other features of scientific, education, scenic, or historical value." In 1977 The Montana Wilderness Study Act was passed: about 155,000 acres of land on the Gallatin National Forest, formally known as the Hyalite Porcupine Buffalo Horn (HPBH) Wilderness Study Area (WSA) are included in the Act, which requires Congress to evaluate and decide whether the area merits inclusion in the national Wilderness system.

Although solitude and primitive types of recreation are still important wilderness values, we have learned much more about the ecological importance of wilderness areas in the decades since the Wilderness Act, and the Montana Wilderness Study Act, were passed. We now know that intact, roadless areas of secure habitat are critical for maintaining healthy ecosystems, particularly in the face of our rapidly changing climate. Intact, functioning ecosystems are our best hope for removing carbon dioxide from the atmosphere and sequestering it, and for buffering the impacts of climate change. Intact areas with wilderness characteristics are essential for maintaining the fish and wildlife populations that provide Montanans with a quality of life that has disappeared from most other states. This report summarizes the current state of knowledge of the ecology of the Hyalite-Porcupine-Buffalo Horn Wilderness Study Area (HPBH WSA) in an effort to provide a solid scientific foundation to determine its "suitability for preservation as wilderness" as mandated by the Montana Wilderness Study Act. This report also discusses other possible actions that can be taken by the U.S. Forest Service, the U.S. Congress, and the Executive Branch of government to manage these lands without fulfilling the requirements of the Montana Wilderness Study Act.

This report examines the ecology of seven key 'focal species': Bighorn Sheep, Mountain Goat, Cutthroat Trout, Elk, Grizzly Bear, Wolverine, and Pika. Other species mentioned in the report include: Columbia Spotted Frog, Boreal Toad, Bison, Wolf, Lynx, and Fisher. These species were chosen because of their documented value as focal species in nearby landscapes, their sensitivity to climate change and land use change, and the existence of sufficient data to evaluate their status in the HPBH WSA. These focal species are used as an index to represent the total biodiversity of the area. More rigorous approaches to choosing focal species are outlined in the report that could be taken by the Forest Service to assess current conditions for the Custer-Gallatin National Forest Plan Revision which begins in 2016.

The Gallatin Elk Herd represents the heart and soul of the HPBH WSA. One of the last elk herds in Montana in 1910 survived in parts of the HPBH WSA and has since recovered; there are now 5,000-6,000 elk that summer in the high country of the HPBH WSA and winter in lower elevations. A critical component of habitat, particularly during hunting seasons and winter, is adequate security. Elk habitat has been managed generally to provide security from predators and humans so that they can survive and reproduce under conditions that are natural and are free of the stress provided by human disturbance. The elk herd is currently healthy and well-managed by the Montana Department of Fish, Wildlife, and Parks. Some winter ranges have been steadily decreasing in size, particularly near Bozeman, as more and more development removes habitat.

Bighorn sheep have also persisted in the HPBH WSA during the years that market hunting and other factors decimated wildlife populations in Montana; there are now about 219 sheep comprising 4 herds living in the HPBH WSA. Their habitat is increasingly shared by mountain goats but the degree of competition between them remains unclear.

Mountain goats are not native to the HPBH WSA but have migrated in from neighboring ranges where they were introduced. About 179 mountain goats now reside along the Gallatin Crest within the HPBH WSA.

Grizzly bears were probably extirpated from the HPBH WSA by 1975 when they were listed as Threatened under the Endangered Species Act. They have since increased in numbers and expanded in distribution so that grizzlies are considered to occupy almost all of the HPBH WSA which is considered primary grizzly bear habitat by the Interagency Grizzly Bear Study Team. Ongoing studies should provide more information on how many grizzlies are currently using the HPBH WSA.

Wolverines have probably used the HPBH WSA continuously. Because they travel so extensively they could have been extirpated briefly but then recolonized the area. Wolverines that were radio-collared in the Madison Range were found to often visit the HPBH WSA and at least one den site has been recorded there. All of the HPBH WSA is considered either primary or maternal wolverine habitat and it is critical for connectivity.

Pikas are found throughout the HPBH WSA, primarily at higher elevations (above 8,500 feet) but extending to lower areas wherever there is suitable habitat. Pika populations have probably remained stable throughout the HPBH WSA since 1992 when studies were initiated, but will likely decline as the climate warms.

Two subspecies of cutthroat trout inhabit streams in the HPBH WSA; Yellowstone Cutthroat Trout, which are found east of the Gallatin Crest in the Yellowstone River drainage, and Westslope Cutthroat Trout, which are found west of the Gallatin Crest in the Gallatin River drainage. Cutthroat trout require cold water source streams that will become even more important in the future for refugia as the climate changes and downstream waters become increasingly warmer.

Recent Climate Change Assessments have concluded that the GYE and Gallatin NF will experience continued warming temperatures, decreasing springtime snowpack, and decreasing late season soil moisture. The climate will probably become hotter and drier at lower elevations and hotter with similar precipitation at higher elevations. This dryness at lower elevations will probably be due to changes in water balance, and is an average across the entire GYE; since precipitation is predicted to slightly increase at least in Gallatin County. Headwater streams in the HPBH WSA are predicted to maintain cold water conditions under most scenarios. Compared to other areas in Montana and the Gallatin NF, the HPBH WSA will become critically important as a refuge from climate change in the future.

The existing information on the seven focal species indicates clearly that the HPBH WSA is an ecologically intact landscape that still contains about 99% or more of the vertebrate species that historically used the area (bison are still missing but could recolonize the area if they were not prevented from doing so by state agencies). For many species the HPBH WSA can be considered a complete ‘ecosystem’ that meets all requirements for sustainable populations; for other more wide-ranging species such as elk, grizzly bear, and wolverine the HPBH WSA is a critical component of the Greater Yellowstone Ecosystem (GYE) which supports sustainable populations of those species and comprises a key part of the larger metapopulation of wolverines. The GYE may eventually comprise part of a larger grizzly bear metapopulation if connectivity is maintained or restored and animals are allowed to move freely.

The HPBH WSA, along with the NW corner of Yellowstone National Park, to which it is connected physically and ecologically, has long been a refuge for beleaguered wildlife populations. At the turn of the last century (1900) this region was one of the few places in the northern Rocky Mountains that still supported elk, bighorn sheep, grizzly bears, and other species that had been decimated by market hunting, fur trapping, and an expanding human population. Hunting restrictions and other regulations have allowed wildlife populations to recover until they are near carrying capacity in the HPBH WSA. Today however, these populations are again threatened by developments and activities of the increasing human population as well as the warming climate which it has created. As in the past, the key to maintaining the wildlife and the ecosystem is to maintain a low human footprint and restrict activities which are damaging to the environment.

Most wildlife species, particularly those prized for hunting, viewing, and photographing, are sensitive to human-caused disturbance and habitat alteration. A review of the relevant scientific literature in this report documents the vulnerability of the seven focal species. Currently, the only human activities occurring on the WSA occur on the trail network and off-trail hiking and climbing. The amount of disturbance to wildlife caused by trail users is greatest from all-terrain vehicles (ATVs) or off-road vehicles (ORVs) followed by mountain bikes, horseback riders, and hikers according to most existing studies. Motorized use of trails in the HPBH WSA is limited to seasonal use on some trails by motorcycles and snowmobiles. Bicycle use is also limited to the same trails as motorcycles. Disturbance due to human activities reduces the amount of habitat available for use by wildlife, increases stress, and depletes energy reserves, thus reducing the carrying capacity of the habitat: the best habitat for wildlife is found in areas with the least human disturbance. Habitat effectiveness models can predict the value of habitat for individual species under different disturbance scenarios and can be used by the Forest Service and other parties to assess the effects of recreation use on the trails in the HPBH WSA.

Intact ecosystems which are not fragmented by human developments or degraded by human activities are important for many reasons. These include the provision of ecosystems services such as clean air and clean water, climate regulation, soil formation, nutrient cycling, and harvesting of food, fuel, fibers, and pharmaceuticals. Ecosystems also provide spiritual and psychological benefits whose values are not yet well understood. These benefits, like many others derived from wild places, cannot be exactly measured in traditional economic terms. Based on the data and information contained in this report, the HPBH WSA can be considered an intact ‘ecosystem’ or critical component of a larger ecosystem, the GYE, and as such should be protected from further human alteration and disturbance. This protection should be as restrictive of human uses as possible and should be as permanent as possible.

To ensure that wildlife have sufficient habitat for population persistence into the future, and to confer resilience in the face of climate change and land use change, there must be an adequate amount of protected habitat available among the spectrum of lands that are accessible to those wildlife. The more permanent that protected habitat is, and the larger the area is, the more certainty there is that wildlife populations can persist. Fragmenting the HPBH WSA into smaller pieces of protected habitat would greatly diminish its value for wildlife habitat and the provision of ecosystems services, and could nullify its ability to function as a refuge from climate change.

Introduction

This document is intended to provide a fairly comprehensive summary of the current ecological conditions of the Hyalite-Porcupine-Buffalo Horn Wilderness Study Area (HPBH WSA) and a discussion of how those conditions may change in the future. It was commissioned by trustees of the Lee and Donna Metcalf Foundation to address a perceived need to gather all the relevant science and data into one document, to facilitate planning, as the fate of the HPBH WSA is decided. Some of the decisions about the future of the HPBH WSA may be made during the Gallatin National Forest Plan Revision which will be a 4-year process beginning in early 2016. This document is not a part of this planning process – it is an independent look at some of the species and issues involved in forest plan revision – but it is hoped that much of the information provided herein will be useful to the Gallatin National Forest, and can save time and money, as that much more comprehensive planning revision proceeds.

The HPBH WSA is a unique resource for the people of Montana and the nation. It encompasses about 155,000 acres of land on the Gallatin National Forest which were designated by the Montana Wilderness Study Act of 1977. Many documents have been written about its wildlife, ecological importance, and recreational opportunities. New information is periodically available about the HPBH WSA and about its relationship to the broader landscapes and ecosystems in which it is embedded. This document attempts to build upon earlier efforts by incorporating much new information and data that has been completed since those documents were finalized. There is also other data that is still being collected and analyzed by a variety of researchers that was unavailable at the time this document was written. Whenever possible those efforts are mentioned and hopefully they will provide additional insights as the Forest Plan Revision unfolds. The overall goal is to help guide decisions so that the HPBH WSA will provide the greatest benefits – the highest and best use – not only to the people of Montana, but to all the other species that face the same challenges that we do as the future unfolds.

This document can be viewed as a first step towards a systematic conservation assessment to aid in the design and implementation of a protected area network that can meet sustainability and conservation goals; considered as the best management practice worldwide (Margules and Pressey 2000, Groves et al. 2002, Groves 2003, Leslie 2005).

There are many terms used in this document that also have specific meaning in the context of Forest Plan Revisions and other governmental processes: terms such as ‘vulnerability’ and ‘focal species’. This document does not propose to contain equivalent analyses to full-blown agency efforts, which in many cases are beyond the scope of this single effort; these possible areas of confusion are pointed out throughout the document. Any confusion with other terms not specifically explained in the document is inadvertent; this is an independent look at the ecology of the HPBH WSA, not a formal agency analysis. It is hoped, however, that the approaches used in this document may be of some use and possible guidance for formal agency analyses; many of which are still in the process of being formulated and standardized.

The HPBH WSA is shown in Figure 1 in the context of adjacent roads and roadless areas. Major trails are shown in gray with motorized access trails in orange as of spring of 2015. Bozeman, Montana is at the top center of the map.

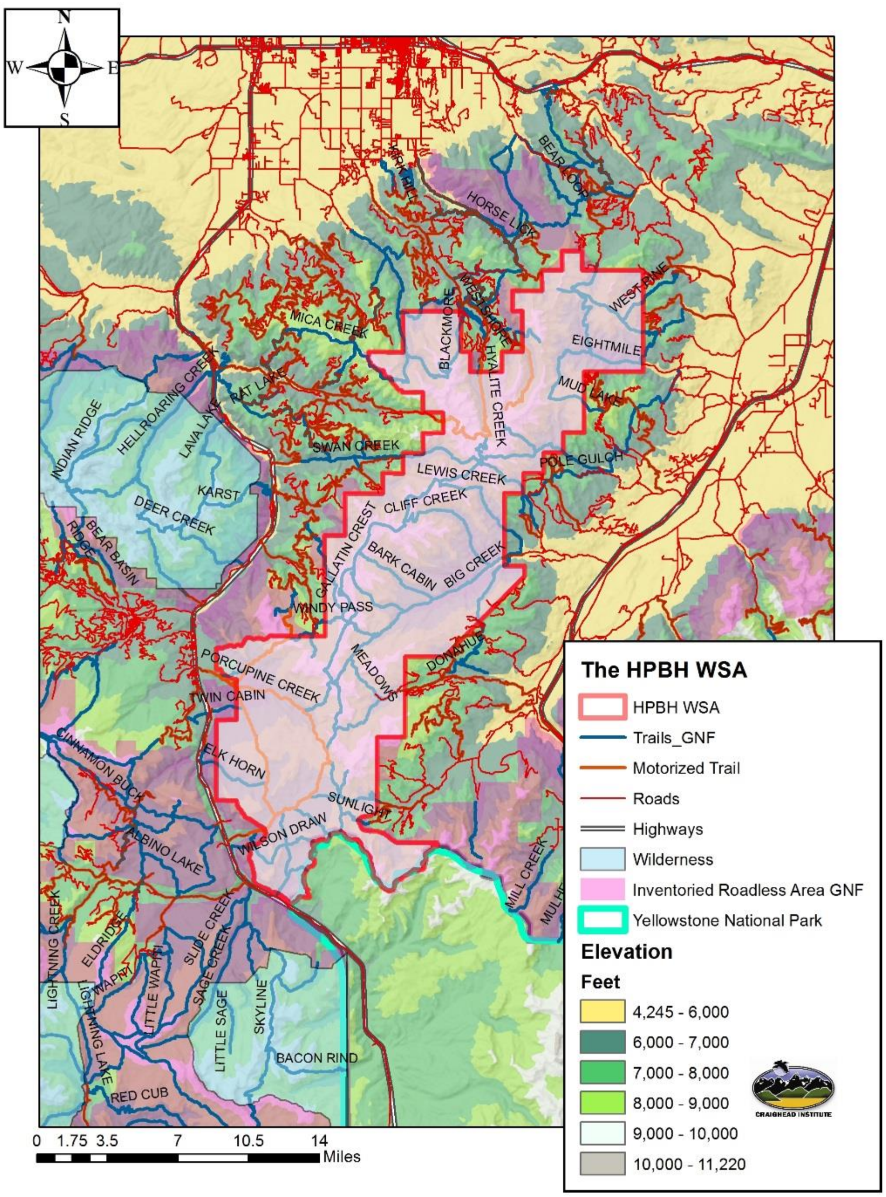

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Figure 1. The Hyalite Porcupine Buffalo Horn Wilderness Study Area.

The HPBH WSA is located in the core of the Gallatin Mountain Range along the Gallatin Crest which is also the boundary line between Gallatin and Park Counties. Drainages on either side of the crest flow east into the Yellowstone River or west into the Gallatin River (Figure 2). The highest peaks of the WSA are about 10,300 feet in elevation. Hyalite Peak is listed at 10,303 ft (3141 m) while Ramshorn Peak is listed at 10,301 ft (3140 m) according to the North America Vertical Datum of 1988 (NAVD88). The lowest elevations in the HPBH WSA are at about 5,800 feet where the boundary crosses Big Creek and Eightmile Creek. The WSA is about 36 miles in length and ranges from 4 to 12 miles in width.

In order to assess the biodiversity of the area a suite of focal species were chosen that should provide an 'umbrella' for most of the native terrestrial species in the HPBH WSA. These species are discussed in the following sections. Seven species were chosen: Bighorn sheep (*Ovis Canadensis*), Mountain Goat (*Oreamnos americanus*), Cutthroat Trout (*Oncorhyncus clarkii*) , Elk (*Cervus canadensis* or *Cervus elaphus*), Grizzly Bear (*Ursus arctos*), Wolverine (*Gulo gulo*), and Pika (*Ochotona princeps*). Other species of interest are briefly discussed: Bison (*Bos bison*), Wolf (*Canis lupus*), Lynx (*Lynx Canadensis*), Fisher (*Pekania pennanti*), Moose (*Alces americanus*), Beaver (*Castor Canadensis*), Columbia Spotted Frog (*Rana luteiventris*), Boreal or Western Toad (*Anaxyrus boreas*) and Western Tiger Salamander (*Abystoma mavortium*).

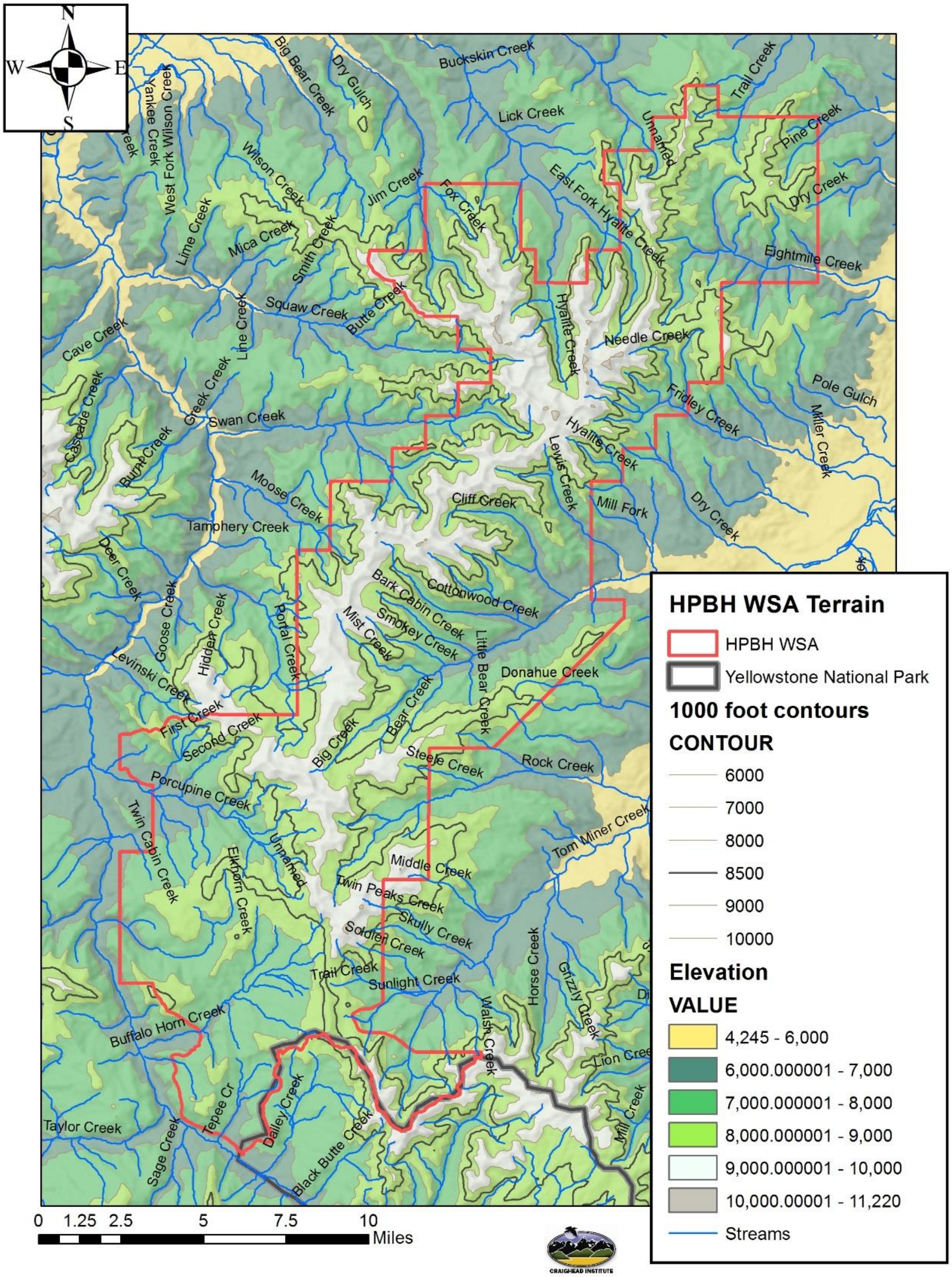

Figure 2. Elevation, Terrain, and Streams of the HPBH WSA.

Over half of the HPBH WSA is above 8,000 feet in elevation. The most common forest type in the Gallatin National Forest is Douglas fir at 27 % of the total forest land area, followed by lodgepole pine (25%), spruce-fir (25%), Whitebark pine (13%) Engelmann spruce (8%), limber pine (1%) and ponderosa pine (1%). The Forest has more than 60 Forest Habitat Types (DeBlander 2001).

The GAP landcover program has mapped and classified vegetation and landcover in Montana (Figure 3). The predominant forest type in the HPBH WSA is Mixed Subalpine Forest which is interspersed with Montane Parkland and Subalpine Meadows. At higher elevations, above 9,000 feet, there are extensive Alpine Meadows interspersed with Mixed Whitebark Pine Forest which give way to Rock on the higher peaks. At lower elevations there are scattered stands of Lodgepole Pine and Douglas fir. Using a similar approach as GAP analysis, but at a finer scale, Debinski et al. (2010) classified three forest classes (Douglas-fir; Whitebark pine; and three densities of a Mixed Conifer class composed of lodgepole pine, Engelmann spruce, and Douglas fir) and six non-forest meadow classes (representing a distinct xeric-to-hydric gradient from sedge meadow to dry grassland with sagebrush) using remotely sensed data and GIS in a study area that overlapped most of the HPBH WSA. Butterflies and birds showed clear preferences for certain habitats (Debinski et al. 2010).

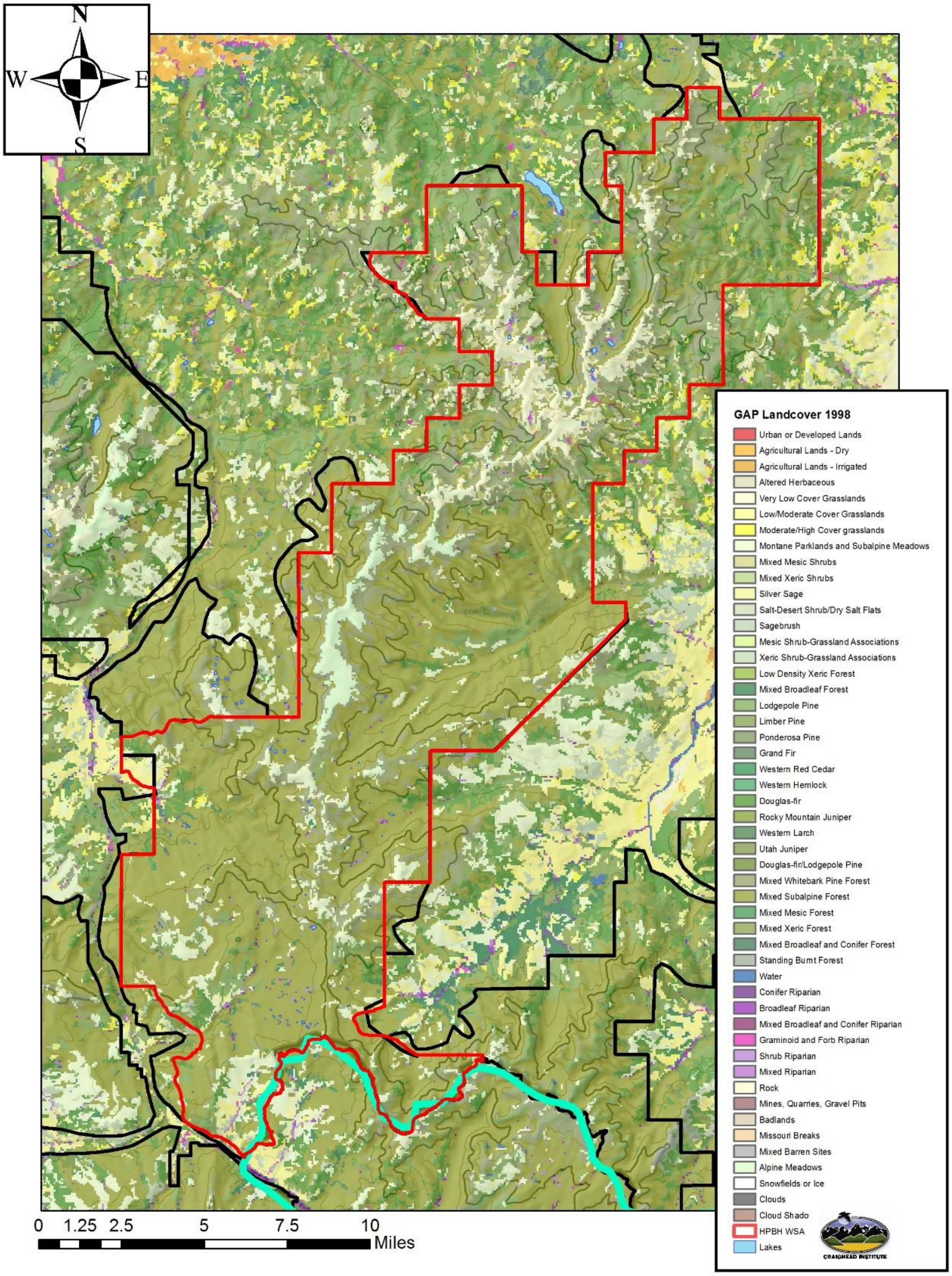

Figure 3. GAP landcover classes for the HPBH WSA 1998.

Background

Wilderness and Wilderness Study Areas

The Wilderness Act (78 Stat. 890; 16 U.S.S. 1132), co-sponsored by Senator Lee Metcalf of Montana, was passed by the US Congress in 1964. It mandates the preservation of wilderness character in congressionally designated wilderness. The Congressional Record (United States Congress 1983) reinforces this mandate, stating, "The overriding principle guiding management of all wilderness areas, regardless of which agency administers them, is the Wilderness Act (section 4(b)) mandate to preserve their wilderness character." Wilderness character is not explicitly defined in The Wilderness Act of 1964, but congressional intent is expressed in the Definition of Wilderness, Section 2c of the Wilderness Act:

> "A wilderness, in contrast with those areas where man and his works dominate the landscape, is hereby recognized as an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain. An area of wilderness is further defined to mean in this Act an area of undeveloped Federal land retaining its primeval character and influence, without permanent improvements or human habitation, which is protected and managed so as to preserve its natural conditions and which (1) generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable; (2) has outstanding opportunities for solitude or a primitive and unconfined type of recreation; (3) has at least five thousand acres of land or is of sufficient size as to make practicable its preservation and use in an unimpaired condition; and (4) may also contain ecological, geological, or other features of scientific, education, scenic, or historical value."

The primary definitions of the act (1 and 2) have been characterized as the 'anthropocentric' wilderness concept while the other attributes listed (3 and 4) represent the 'biocentric' concept (Leslie and Taylor 1985); both are important components of wilderness. Leslie and Taylor (1985) argue that "anthropocentric wilderness inventories can only establish a wilderness threshold by an essentially arbitrary decision because the perception of wilderness quality by recreationists differs widely among individuals and is influenced by such a variety of personal factors as to defy logical analysis (lttelson et al., 1974)". This appears to be the approach being taken currently by the community collaborative techniques being used to evaluate uses of roadless areas and Wilderness Study Areas. In contrast, Leslie and Taylor (19850 assert that "biocentric wilderness inventories can establish an objective wilderness threshold by reference to ecological principles, particularly those embodied in island biogeography theory (Diamond, 1975)." In that regard, this report can be considered a biocentric approach to evaluate wilderness values (of the HPBH WSA) from an ecological, wildlife-centered, perspective.

Other definitions of wilderness include The World Conservation Union (IUCN) Framework for Protected Areas definition as "a large area of unmodified or slightly modified land and/or sea, retaining its natural character and influence, which is protected and managed so as to preserve its natural condition”. Mittermeier et al. (2011) defined 24 globally important wilderness areas as those that were <70% intact with human densities of less than or equal to 5 people per square kilometer. They considered only those areas greater than 1 million hectares, one of which is the Rocky Mountains. Wilderness is a global concept.

The 1977 Montana Wilderness Study Act (MWSA: P.L. 95-150) was passed by the U.S. Congress in November and set aside the Hyalite-Porcupine-Buffalo Horn Wilderness Study Area (often called the Gallatin Crest WSA), along with eight other wilderness study areas. The Act stated that “In furtherance of the purposes of the Wilderness Act, the Secretary of Agriculture shall, within five years after the date of enactment of this Act, review certain lands designated by this section, as to their suitability for preservation as wilderness, and report his findings to the President….. and that “certain lands in the Gallatin National Forest, Montana, which are generally depicted on a map entitled ‘Hyalite-Porcupine-Buffalo Horn Wilderness Study Area’ and dated April 1976, comprising approximately one hundred and fifty-one thousand acres, which shall be known as the Hyalite-Porcupine-Buffalo Horn Wilderness Study Area.”

The Act further stated that these WSAs shall be administered by the Secretary of Agriculture to maintain their presently existing wilderness character and potential for inclusion in the National Wilderness Preservation System until Congress determines otherwise. The term “maintain their presently existing wilderness character” has been interpreted by some to mean that the managing agency, the U.S. Forest Service, was obligated to administer the area as de facto wilderness (ie. closing the area to all mechanized and motorized uses) until such time as a determination could be made.

The Hyalite-Porcupine-Buffalo Horn area was also included in the RARE II study process which was initiated in June of 1977. All of the nine Montana Wilderness Study Act (MWSA) areas were included in the RARE II inventory. The purpose of RARE II was to study all roadless and undeveloped areas in the National Forest System and recommend them as either wilderness or nonwilderness. The RARE II process did not meet all the requirements of the MWSA legislation. For instance, RARE II did not provide for public notice and hearings and the incorporation of the hearing record in the report to Congress. Even so, the Forest Service decided to begin the evaluation of the MWSA areas by including them in the RARE II process to the extent possible. Through the RARE II process, all MWSA areas were placed in a "further planning" category until the remaining requirements of the MWSA legislation were completed.

The Lee Metcalf Wilderness was not one of the 54 original wilderness areas set aside by the Wilderness Act. This wilderness was designated in 1983 by its own act; the Lee Metcalf Wilderness and Management Act of 1983 (P.L. 98-140). In its original form it would have included what is now the Hyalite-Porcupine-Buffalo Horn Wilderness Study Area in a contiguous 600,000 acre Wilderness. By the time the Lee Metcalf Wilderness and Management Act was passed however, Senator John Melcher and others had split this larger area into 4 separate wilderness areas totaling 259,000 acres. This removed protection from the area which was subsequently developed around the Big Sky Resort.

History of the Hyalite-Porcupine-Buffalo Horn Wilderness Study Area

The HPBH WSA, along with the NW corner of Yellowstone National Park, to which it is connected physically and ecologically, has long been a refuge for beleaguered wildlife populations. At the turn of the last century (1900) this region was one of the few places in the northern Rocky Mountains that still supported elk, bighorn sheep, grizzly bears, and other species that had been decimated by market hunting, fur trapping, and an expanding human population. For example, 12,000 antelope hides were shipped out of Bozeman in 1874; 250,000 bison hides were shipped out of the Yellowstone and Missouri drainages in 1881-1882; the Yellowstone bison herd was reduced to 25-50 total animals by 1905; only 5,000-6,000 elk were left in the entire state of Montana by 1910; and the Audubon/badlands bighorn sheep in eastern Montana and western North Dakota were extirpated by 1916. The only bison left in Montana in 1883 consisted of 12-13 in the Pablo/Allard herd on the Flathead reservation which had grown to 700 by 1896 (Picton and Lonner 2008).

Hunting restrictions and other regulations have allowed wildlife populations to recover until they are near carrying capacity in the HPBH WSA. Today however, these populations are again threatened by developments and activities of the increasing human population as well as the warming climate which we have created. As in the past, the key to maintaining the wildlife and the ecosystem is to maintain a low human footprint and restrict activities which are damaging to the environment.

In 1977, approximately 50,000 - 56,000 acres within the HPBH WSA were privately owned (The 1985 Hyalite Porcupine Buffalo Horn Wilderness Study Report identified approximately 49,300 acres of private land but the 1977 Gallatin NF Forest Travel Plan Map identified over 56,000 acres of private land). These private lands were arranged in a checkerboard pattern across the WSA because private lands were allotted to the Burlington Northern Railroad by the Pacific Railway Act of 1862 during construction of the transcontinental railroad. Ten square miles of land were granted for each mile of railroad laid. Since 1977 the Forest Service has worked to consolidate all lands within the WSA boundary into Forest Service ownership.

A series of reports have been prepared relating to the HPBH WSA. Ten public workshops were conducted in Montana in September 1979 to identify issues relating to the MWSA areas. A separate effort was made to identify public issues and management concerns for the Gallatin National Forest as part of the Forest planning process. This resulted in the Hyalite Porcupine Buffalo Horn Wilderness Study Report EIS prepared by the Forest Service for the Gallatin National Forest Plan in 1958 (USDA 1985). The initial Wilderness Study Report (USDA 1985) was a legislative environmental impact statement required by Congress. Much of the early documentation in this report and in Schlenker (2003) is found in that Study Report.

The purpose of the 1985 Study Report was to evaluate the area for its wilderness suitability and make a recommendation for its future management following the requirements of the National Environmental Policy Act (NEPA) and the National Forest Management Act (NFMA). The Study Report analyzed seven different alternatives. Alternative 5 allocated the entire study area, which had not been encumbered by roads and timber harvest, to wilderness. Alternative 7, the Proposed Action, included designation of a special scenic area in the Hyalite Peaks area (23,102 acres) to be reserved for public recreation. A national recreation trail along the Gallatin Crest was also proposed. No wilderness was recommended in alternative 7, with 42,803 acres allocated for 'Wildlife and Recreation', 23,102 acres allocated as 'Scenic Area', 13,103 acres as 'Dispersed Recreation (nonroaded), 12,785 acres as 'Timber Management', 8,503 acres as 'Near Natural' and 1,774 acres as 'Big Game with Timber Management'. No Record of Decision (ROD) was completed from this report; normally this would have been done by the Forest Supervisor and the ROD would form the basis of a Bill before Congress to pass an Act that would determine the status of the lands in the HPBH WSA. It is at this point in the process that the science-based NEPA and NFMA processes have created recommendations that can be acted upon by Congress. Depending upon the political climate in Congress, such a Bill could either be supported or opposed and perhaps alternative Bills could be written: science gives way to politics and there are no guarantees about the outcome. Such Bills can also be attached as riders to other 'must pass' legislation, such as defense funding, to ensure their passage; in general all legislators from the state in question need to support such strategies for them to be successful.

The conclusion of the 1985 Study Report was to adopt Alternative 7 and not recommend the HPBH study area for inclusion in the natural wilderness preservation system despite the finding within the report that: "Most of the area is suitable for wilderness consideration. Impacts to the area's natural integrity and appearance tend to be on the area's periphery. Natural appearance of the area will be affected in a few places by sight or sounds from outside the boundaries, but these disturbances would probably affect less than 5 percent of the area.".

Wilderness was not included in the Proposed Action primarily because of fragmented land ownership: "The chief impediment to [Wilderness] manageability of the area is the private checkerboard inholdings." (USDA 1985, p III-8). However, since 1985 the privately owned inholding lands have been largely consolidated through land exchanges and purchases, thus removing this 'impediment' to wilderness consideration. The HPBH WSA lands currently make up about 40% of all NF lands within the Gallatin Range, and about 73% of the total inventoried NF roadless lands within the Gallatin Range.

In 1996, the Montana Wilderness Association initiated legislation over Forest Service Management of WSA's across Montana, citing loss of historic wilderness character due to increased motorized recreation and lack of appropriate management actions by the Agency. This lawsuit specifically cited the HPBH WSA and concerns about Gallatin National Forest management actions. The litigation was settled in 2001 and resulted in the Forest Service's agreement to conduct travel management planning for all WSAs. Travel Planning and Forest Planning decisions have subsequently superseded the mandate for Wilderness consideration in determining the status of the lands within the HPBH WSA.

In 2003, the Gallatin National Forest completed the "Hyalite Porcupine Buffalo Horn Wilderness Study Area Character Assessment" authored by Kimberly Schlenker (Schlenker 2003). This report summarized the current physical and social conditions of the HPBH study area in 2003 as compared to existing wilderness characteristics in 1977. Changes since 1977 were documented, and their effects on four principal characteristics of wilderness: natural integrity, remoteness, opportunities for solitude, and apparent naturalness were described. By 2003, the Forest Service had acquired over 37,000 acres of the private land checkerboarded with Forest lands, most of these previously owned by Burlington Northern Railroad and its timber subsidiary, Plum Creek Timber, Inc. (Clark et. al 2012). However, many activities took place on these lands from road construction and timber harvest to camp improvements on private lands leased by outfitters. By the time of the 2003 report the Forest Service did not have complete data on all the activities that may have had an effect on wilderness characteristics. The acquisition of these lands increased the number of public access points from 9 to 16 trailheads (Schlenker 2003).

In 2012 The Gallatin National Forest, in cooperation with the University of Montana, completed the “Wilderness Character Monitoring Report Hyalite Porcupine Buffalo Horn Wilderness Study Area” authored by Erin Clark, Kimberly Schlenker, and Catherine Filardi (Clark et al. 2012). The report draws heavily from the University of Montana Wilderness Institute's 2011 efforts collecting field data relevant to wilderness character. This effort stemmed from a 2009 collaboration between the Wilderness Institute, the Aldo Leopold Wilderness Research Institute, the Forest Service, and several local, non-governmental organizations to develop measurable field Indicators for the four qualities of wilderness character Identified in the Wilderness Act of 1964. In 2009 and 2010. These indicators were 1) untrammeled quality, 2) natural quality, 3) undeveloped quality, and 4) Opportunities for solitude or a primitive and unconfined type of recreation. Wilderness Institute crews implemented these field protocols across four of Montana's congressionally designated Wilderness Study Areas. During summer 2011, Wilderness Institute crews and community volunteers hiked every trail in the HPBH WSA and made detailed observations along 218 miles of system trails and 44 miles of non-system trails (Clark et al. 2012). This report was designed to establish a baseline for each of these measures of wilderness so that trends could be evaluated over time. At this time the total area of the WSA was estimated at approximately of about 155,000 acres of land.

Forest Plans

Our system of forest reserves was established by the Forest Service Organic Administration Act of 1897 (16 U.S.C.). The intention of the forest reservations was "to improve and protect the forest within the reservation,... securing favorable conditions of water flows, and to furnish a continuous supply of timber for the use and necessities of citizens of the United States” (US Govt 1897). The Transfer Act of 1905 transferred the forest reserves of the United States from the Department of the Interior, General Land Office to the Department of Agriculture, Bureau of Forestry (US Govt 1905). The National Forest Management Act (NFMA: (P.L. 94-588) was enacted in 1976. It requires each National Forest to develop a Forest Plan and to revise the plans every 15 years. It provides guiding principles for forest management with strategies to protect habitat and balance multiple uses to ensure the persistence of wildlife, including at-risk and federally protected species. In effect it elevated the value of ecosystems, habitat and wildlife on our national forests to the same level as timber harvest and other uses. NFMA put into law and regulations an important national priority: forest plans must provide for the diversity of habitat and animals found on national forests (Haber and Nelson 2015a).

The New 2012 Forest Planning Rule

In 2012 the Forest Service promulgated the National Forest System Land Management Planning Rule, 36 CFR Part 219 (USFS 2012), which is usually referred to as the 2012 Planning Rule. These regulations established a process for developing and updating forest plans and set conservation requirements that forest plans must meet to sustain and restore the diversity of ecosystems, plant and animal communities and at-risk species found on these public lands (36 C.F.R. §§ 219.1-219.19). This planning rule applies to new Forest Plan Revisions and amendments. It presents ecosystem and species conservation planning processes and has many specific requirements. Some of the changes in Forest Planning which apply to the HPBH WSA are discussed below. In January 2015, the Forest Service published Final Agency Directives for Implementation of the 2012 Planning Rule (FSM 1900 Planning, FSH 1909.12). This report on the HPBH WSA is designed to provide analyses and recommendations consistent with the NFMA planning regulations, the 2012 Planning Rule, and the Final Agency Directives for Implementation of the 2012 Planning Rule which hopefully can be used by the Custer-Gallatin NF for their Forest Plan Revision. For a clearer understanding of the concepts discussed below see Haber and Nelson (2015a).

The 2012 Planning Rule provides a process for developing, revising, or amending plans that is adaptive and science-based, engages the public and is designed to be efficient, effective and within the agency's ability to implement (77 Fed. Reg. 21162). The rule establishes a three-phase planning process (Haber and Nelson 2015a):

1. Assessment. The assessment identifies and evaluates information relevant to the development of a forest plan. The assessment is used during plan revision to evaluate what needs to change in the current plan, including what is needed to meet the requirements of the planning rule. During the assessment phase, the planning rule requires the Forest Service to identify and evaluate 15 categories of existing information relevant to the plan area. The categories that relate most directly to diversity include:

1. Terrestrial ecosystems, aquatic ecosystems and watersheds.
2. System drivers, including dominant ecological processes and stressors and the ability of ecosystems to adapt to change.
3. Threatened, endangered, proposed and candidate species and potential Species of Conservation Concern.

The assessment process must identify relevant information on attributes of ecosystem diversity, ecological integrity and species persistence. Human structures and uses are important attributes of ecological conditions. Identification of these ecological conditions during the assessment is necessary to provide a basis for plan components that manage human structures and uses. In the Gallatin NF it is very important that the assessment carefully consider roads and recreation uses as these are likely to be the predominant direct human influence on diversity in the HPBH WSA plan area, so information concerning the impact of roads, trails, and other recreation on species persistence should be incorporated into the assessment.

2. Development. During the Forest Plan development stage, the Forest Service develops and finalizes the Forest Plan and plan monitoring program. It should focus on the need to change the existing plan based on the assessment, and the development of plan components that satisfy the diversity requirements of the 2012 Planning Rule. A draft proposal is developed and management alternatives are evaluated through the National Environmental Policy Act (NEPA, 42 U.S.C.) process. The combination of ecosystem and species-specific plan components must provide ecological conditions necessary for at-risk species.

3. Implementation/monitoring. After finalizing the forest plan, the agency begins to implement the plan, including the development and implementation of management projects. Projects must be consistent with the forest plan and implementation of the plan must be evaluated through a monitoring program. Monitoring information is then evaluated to determine if aspects of the forest plan should be changed. In addition, the Forest Service must use the best available scientific information to inform the planning process (219.3) throughout all three phases.

The planning rule describes these phases as iterative, complementary and sometimes overlapping. The intent is to provide a planning framework that is responsive to new information and changing conditions (Haber and Nelson 2015a). Forest plans are required to have direction, including standards and guidelines, in order to meet ecosystem and species conservation requirements. Forest Plans have guidelines for Diversity, Species, Ecosystems, and Connectivity.

Diversity in Forest Planning

Diversity is defined in the 1982 Planning Rule as: “The distribution and abundance of different plant and animal communities and species within the area covered by a land and resource management plan.”, and guidance includes: “Forest planning shall provide for diversity of plant and animal communities. ...Inventories shall include quantitative data making possible the evaluation of diversity in terms of its prior and present condition.”. Ecosystem Diversity is defined in the 2012 Planning rule (219.9) as “the variety and relative extent of ecosystems” (USFS 2012). Although forests are mandated to be managed for diversity of plant and animal communities and to conduct quantitative inventories; the forest planning process determines what this required ‘diversity’ means on each national forest (constrained by the requirements of NFMA and the planning regulations). Maintaining viable populations of native species is the scientifically accepted method of achieving the goal of maintaining species diversity: “diversity is sustained only when individual species persist; the goals of ensuring species viability and providing for diversity are inseparable” (Committee of Scientists 1999). Rather than inventorying and monitoring all native species, the current best management practice is to use a subset of all species – a suite of focal species – to serve as indicators of ecological integrity (see Focal Species section below).

Diversity requirements of the Planning Rule are focused on two spatial scales: landscape components, and project components. Landscape components are broad-scaled and relate to the vision and priorities of the plan area; in the case of the HPBH WSA, landscape components would relate to the entire Gallatin National Forest and perhaps neighboring areas of which the HPBH WSA is an integral part. ‘Ecosystem’ components are generally those that describe biological conditions at the scale of the selected ecosystems. It is often appropriate to include them as landscape plan components.

Project components are finer-scaled and include standards, guidelines, and 'suitability' determinations that can prohibit specific uses and preclude or regulate particular management options (Haber and Nelson 2015a). 'Species-specific' components may tend to be project components (standards and guidelines that provide mitigation for certain activities known to cause adverse effects on the species or its habitat). They may also be desired conditions for species populations or for conditions at a finer scale relevant to a species' conservation needs. 'Plan' components to address ecological conditions related to human uses and structures may also tend to be directed at the needs of specific species. A travel plan for the HPBH WSA is a project that could have project components that provide guidance and criteria for travel planning. Designating suitable uses within parts of the HPBH WSA could also be project components.

Species in Forest Planning

Previous to 2012, National Forests were charged to maintain "Management Indicator Species" (MIS) which were used to make inferences about other species in the Forest and the condition of 'Old Growth' habitat among other things. These were: "The species selected because their population changes are believed to indicate the effects of management activities. [219.19 (a)(1)]". Guidance included; "Identify and select MIS" [219.19 (a)(1)] and "Establish objectives for the maintenance and improvement of habitat for MIS" [219.19 (a)] and "Planning alternatives shall be evaluated in terms of both amount and quality of habitat and of animal population trends of the MIS" [219.19 (a)(2)]. In the Gallatin NF the Old Growth MIS are pine marten (for moist spruce sites) and northern goshawk (for dry Douglas-Fir sites).

Each Forest manages "Sensitive Species". These are defined by Forest Service Manual (FSM) 2670 as: "Those plant and animal species identified by a Regional Forester for which population viability is a concern, as evidenced by:

> a. Significant current or predicted downward trends in population numbers or density.
> b. Significant current or predicted downward trends in habitat capability that would reduce a species' existing distribution."

Species considered for Sensitive Species status included US Fish and Wildlife Service (FWS) candidates for Federal listing, and State lists of endangered, threatened, rare, endemic, unique, or vanishing species, especially those listed as threatened under State law. It is unclear at this point what transition will be made from the Sensitive Species Program as Forests implement the 2012 Planning Rule.

Forests are also required to contribute to the recovery of species listed under the Endangered Species Act (ESA). Rather than just ensure that there is no further decline in listed species, the Forest must proactively manage species with affirmative acts that contribute to recovery. In 1982 the requirement called for the maintenance of 'viable populations' of native species of concern which applied to other species in addition to those listed under the ESA. These were defined as: "Having the estimated numbers and distribution of reproductive individuals to insure its continued existence is well distributed in the planning area. (219.19)". To maintain them Forests were directed to “Provide for adequate fish and wildlife habitat to maintain viable populations of existing native vertebrate species. [219.27(a) (6)]”.

With the 2012 Planning Rule ‘viable population’ was changed to a requirement to maintain species with a “sufficient distribution to be resilient and adaptable” to future stressors; including climate change. Because species are addressed at several levels in both the old and new planning rules conservation planners have recommended that a set of ‘target species’ be selected under the 2012 Planning Rule that encompasses Federally listed, proposed and candidate species, and species of conservation concern; focal species; and public interest species, as an initial step in the assessment phase of a Forest Plan (Haber and Nelson 2015a). Once a set of species is selected, land units, ecosystem characteristics, ecological conditions, and key areas for those species, need to be identified.

The 2012 Planning Rule requires that an Environmental Impact Statement (EIS) be prepared for Forest Plan Revisions. The Record of Decision (ROD) for the Forest Plan Revision documents that the plan complies with the Rule’s diversity requirements.

Focal Species in Forest Planning

The 2012 Planning Rule now calls for selecting “Focal Species” which are used to make inferences about the integrity of the forest Ecosystems. Focal Species are defined as “A small subset of species whose status permits inference to the integrity of the larger ecological system to which it belongs and provides meaningful information regarding the effectiveness of the plan in maintaining or restoring the ecological conditions to maintain the diversity of plant and animal communities in the plan area. Focal species would be commonly selected on the basis of their functional role in ecosystems”. This requires a transition to a new monitoring system in the future, but the old MIS and Sensitive Species are probably not to be lost; some may be designated as focal species while others may continue to be managed as they were previously.

A recent overview of the focal species concept and a framework for choosing focal species can be found in Brock and Atkinson (2013). For a wildlife assessment of the Madison Valley, the Wildlife Conservation Society selected 15 focal species from a pool of 63 candidate species using a ‘landscape species approach’. These focal species were not necessarily defined in the same way that the Forest Service may define them: this suite of species was selected as surrogates to conserve all habitat types within the assessment area and encompass all major threats to maintaining functional wildlife populations. Each candidate species was scored for each of five criteria: area, heterogeneity, ecological functionality, socio-economic importance, and complementarity (Brock et al. 2006).

The 15 focal species selected for the Madison Valley study (Brock et al. 2006) were: Grizzly Bear, Moose, Elk, Boreal Toad, Wolverine, Red-naped Sap Sucker, Warbling Vireo, Yellow Warbler, Columbia Spotted Frog, Fluvial Arctic Grayling, Greater Sage Grouse, BighornSheep, Pronghorn, Westslope Cutthroat trout, and Black-backed Woodpecker. Grizzly bear had the highest aggregate focal species score, followed by wolf, elk, mountain lion, and wolverine. ‘Umbrella’ scores were derived for each species to estimate the number of other species that are protected if enough habitat is protected for a population of the ‘umbrella’ species. Boreal toad had the highest score with 401 other species under its umbrella. The rest of the top 5 umbrella species were Columbia Spotted Frog (359 spp), Elk (321 spp), Grizzly bear (300 spp), and Westslope Cutthroat trout (288 spp).

A Forest Service focal species analysis for the HPBH WSA would likely find many of the same species important, but may follow a somewhat different approach. A streamlined expert-based method for selecting focal species is found in Brock and Atkinson (2013). This approach can be completed in a 3-4 day workshop with a few days for preparation and follow-up. These methods are beyond the scope of this HPBH WSA report but this approach could be used for the Forest Plan Revision process. The focal species used in this report were not rigorously selected, but were chosen because of their high value in the Madison Valley Assessment, for their importance in the habitat types making up the majority of the HPBH WSA, and because there was enough data and information available to evaluate their status.

Ecosystems in Forest Planning

The 2012 Planning Rule defines an ecosystem as: “**A spatially explicit, relatively homogeneous unit of the Earth that includes all interacting organisms and elements of the abiotic environment within its boundaries. An ecosystem is commonly described in terms of its composition, structure, function and connectivity.**” Forest Plans must include “plan components, including standards or guidelines, to maintain or restore the diversity of ecosystems and habitat types throughout the plan area” (USFS 2012). In doing so, the plan must include plan components to maintain or restore key characteristics associated with terrestrial and aquatic ecosystem types, rare aquatic and terrestrial plant and animal communities, and the diversity of native tree species similar to that existing in the plan area.

According to Haber and Nelson (2015a) “although ecosystem components may tend to focus on natural resource conditions and management, the plan must also address infrastructure and human uses if they affect necessary conditions for at-risk species”. These are included in the definition of “ecological conditions” that can affect diversity (“Ecological conditions include habitat and other influences on species and the environment, e.g., the abundance and distribution of aquatic and terrestrial habitats, connectivity, roads and other structural developments, human uses and invasive species).

Connectivity in Forest Planning

Landscape connectivity is the relative degree with which one landscape component (such as an ecosystem) is ecologically connected to other components. It can be thought of as having both structural and functional components. Structural connectivity is the physical relationship between patches of habitat or other ecological units; functional connectivity is the degree to which landscapes actually facilitate or impede the movement of organisms and processes of ecosystems (Brooks 2003, Baguette et al. 2013). A third category of potential connectivity represents the landscape structure adjusted to take into account the dispersal ability of a given organism (Calabrese and Fagan 2004)

The 2012 Planning Rule requires consideration, planning and management for ecological connectivity. It includes explicit requirements for maintaining or restoring ecological connectivity on national forest lands and for facilitating connectivity planning across land ownerships. These may be the first such requirements in the history of U. S. public land management (Haber and Nelson 2015b.

The 2012 Planning Rule defines connectivity as: "**Ecological conditions that exist at several spatial and temporal scales that provide landscape linkages that permit the exchange of flow, sediments, and nutrients; the daily and seasonal movements of animals within home ranges; the dispersal and genetic interchange between populations; and the long distance range shifts of species, such as in response to climate change.** " (219.19). This definition reflects both structural and functional aspects of connectivity. The rule's reference to spatial scales and "landscape linkages" suggests a spatial structure of connected patches and ecosystems. References to water flows, sediment exchange, nutrient cycling, animal movement/dispersal, species climate adaptation and genetic interchange are functional characteristics - ecological processes - that are sustained by connectivity (Haber and Nelson 2015b).

The HPBH WSA is a critical landscape for wildlife connectivity both locally and regionally between Yellowstone National Park and protected areas to the north and northwest. Connectivity for wildlife is an increasingly important concept to be addressed in management decisions for maintaining long term persistence of wildlife populations by helping ensure the resilience (ability to adapt to change) of those populations. As discussed in the previous section, a connectivity strategy is a key element in Forest Plan Revisions mandated by the 2012 Planning Rule. Connectivity planning is also identified as a key element in other government processes (Haber and Nelson 2015b). Some of these processes are:

The Presidential 'America's Great Outdoors Initiative' was established by Secretary's Order 3323 (www.doi.gov/americasgreatoutdoors/index.cfm). It lists the goal of "conservation of land, water, wildlife, historic, and cultural resources, creating corridors and connectivity across these outdoor spaces, and for enhancing neighborhood parks."

The Grizzly Bear Recovery Plan described linkage zones between recovery areas (www.igbconline.org/index.php/population-recovery/grizzly-bearlinkage-zones) and states that "linkage zone identification and the maintenance of existing linkage opportunities for wildlife between large blocks of public lands in the range of the grizzly bear are fundamental to healthy wildlife."

The Western Governors' Association (WGA) Wildlife Corridors and Crucial Habitat Initiative (www.westgov.org/wildlife-corridors-and-crucial-habitat) mandates each western state to develop plans for maintaining crucial habitat and wildlife corridors. Because connectivity crosses many jurisdictions the WGA policy states that federal land management agencies should identify key wildlife migration corridors in land management plans. The US Forest Service in participating with this directive (Haber and Nelson 2015b).

The Forest Service Strategic Framework for Responding to Climate Change (The Roadmap), introduced in 2008 in response to the USDA 2010-2015 Strategic Plan, is another program that includes “development of wildlife corridors to facilitate migration” as a strategy to address climate change effects. This framework is described in the ‘National Roadmap for Responding to Climate Change’ (USDA Forest Service 2011: www.fs.fed.us/climatechange/pdf/Roadmapfinal.pdf). One of the ‘immediate initiatives’ in the roadmap is **connecting habitats to improve adaptive capacity by:**

- Collaborating with partners to develop strategies that identify priority locations for maintaining and restoring habitat connectivity.
- Seeking partnerships with private landowners to provide migration corridors across private lands.
- Removing or modifying physical impediments to species movement most likely to be affected by climate change.
- Managing forest and grassland ecosystems to reduce habitat fragmentation.
- Continuing to develop and restore important habitat corridors for fish and wildlife.

Secretarial Order 3330 of the Department of Interior, “Improving Mitigation Policies and Practices of the Department of the Interior” states that: “Through the development of a comprehensive mitigation strategy, we can ensure that our national wildlife refuges, national parks, and other Federal lands and waters are managed for conservation purposes with sound stewardship and a commitment to conserve habitat and fish and wildlife migration corridors”.

In 2009, Secretarial Order 3289 was signed: Addressing the Impacts of Climate Change on America’s Water, Land, and Other Natural and Cultural Resources. The U.S. Department of the Interior committed to conserve and manage fish and wildlife in the face of climate change, including more than 800 species of migratory birds. This order established 8 regional Climate Science Centers, and a network of Landscape Conservation Cooperatives (LCCs). These new agencies in part are a response to the fact that shifting habitat may require management changes: “Shifting wildlife and habitat populations may require investment in new wildlife corridors”.

The National Park Service strategy, Climate Change Response Strategy, calls for plans to “develop cross-jurisdictional conservation plans to protect and restore connectivity and other landscape-scale components of resilience.”

The US Fish and Wildlife Service (FWS) developed a new policy in 2010: “Rising to the Urgent Challenge: Strategic Plan for Responding to Accelerating Climate Change” to promote habitat connectivity and integrity. This lead to an interagency effort: The “National Fish, Wildlife and Plants Climate Adaptation Strategy” that outlines strategies and actions to increase connectivity and protect wildlife corridors.

In 2012 the new Transportation Act, “Moving Ahead for Progress in the 21st Century” (MAP-21) was passed by Congress and signed into law by President Obama. It calls for environmental mitigation to reduce vehicle-caused wildlife mortality or to restore and maintain connectivity among terrestrial or aquatic habitats. It also makes funds available to highway departments and Native American Tribes to improve public safety and reduce vehicle caused wildlife mortality while maintaining habitat connectivity. This document makes specific reference to ‘ecosystem connectivity’. It is relevant to the HPBH WSA in that it addresses connectivity adjacent to federal lands (“environmental mitigation in or adjacent to Federal land to improve public safety and reduce vehicle-caused wildlife mortality while maintaining habitat connectivity”). Thus it helps ensure that efforts to maintain and restore connectivity within the Gallatin National Forest can be connected to adjacent jurisdictions across highways, by funding mitigation measures such as overpasses or underpasses for wildlife.

The Montana Department of Fish, Wildlife & Parks (MFWP) has developed large landscape block (LLB) and connectivity layers generated as part of the Crucial Areas Planning System (CAPS) for All Native Habitat, Alpine, Grass/Shrub, Forest Generalist, and Forest Specialist ecotype models. The Connectivity Project of MFWP’s Assessment was intended to provide the greatest habitat conservation benefit to support the greatest number of species. The goal was to identify priority geographic areas in order to maintain wildlife connectivity between important habitats in Montana.

Connectivity for Alpine Habitats is shown in Figure 4 based on the FWP connectivity layers. Large Landscape Blocks (LLB) represent contiguous areas of the target ecotype with relatively low levels of human influence. The term ‘ecotype’ indicates general ecological groupings based upon primary habitat associations. In Figure 4, portions of the area of the HPBH WSA appear as Large Landscape Blocks surrounded by high value connectivity habitat. LLB connectivity depicts likely pathways of animal movement and connectivity between LLBs of the target ecotype and are based on least cost corridor analyses. This map and other ecotype connectivity maps are available on DataBasin.org by searching for ‘Montana Connectivity’.

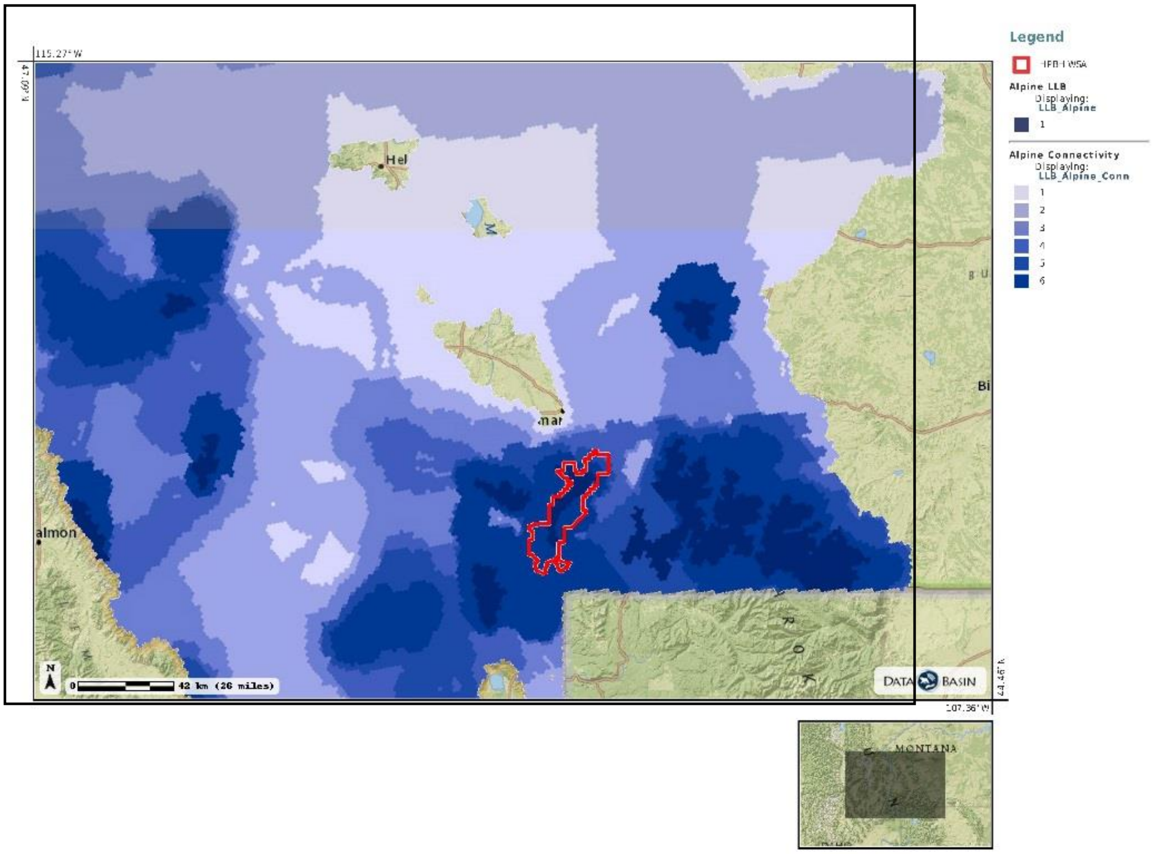

Figure 4. Montana Alpine Large Landscape Blocks and Connectivity: HPBH WSA in red.

This map does not include Wyoming or Idaho, but demonstrates that the HPBH WSA is an integral part of the alpine network connecting Yellowstone National Park to alpine areas further north, and west. This can be more clearly seen in Figure 5: the white areas are all above 8,000 feet and demonstrate that the HPBH WSA is a direct extension of the higher elevation landscapes of Yellowstone Park. It is connected across short distances of lower elevation to the other high elevation landscapes to the east and west. These areas are crucial to many species such as Bighorn sheep, Mountain goats, Wolverines, Pika, and Grizzly Bears as described in the following sections.

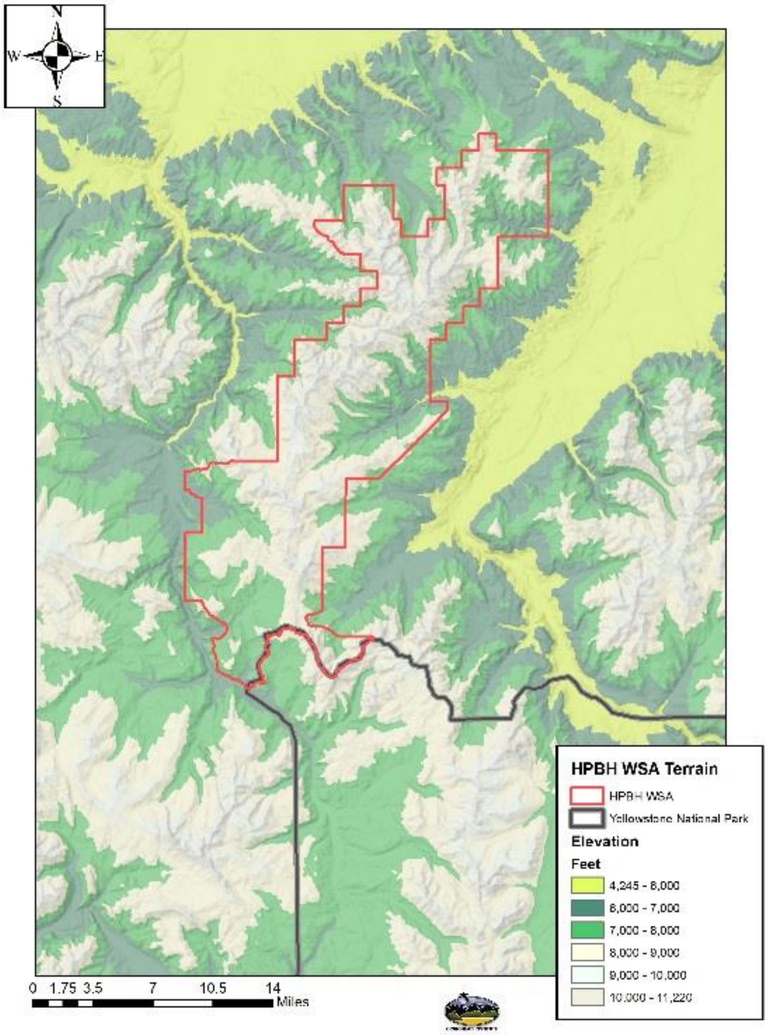

Figure 5. High Elevation Connectivity in the GYE.

A more generalized map depicting all ecotypes, described as natural habitats, with relatively low levels of human influence, based on the FWP connectivity layers, is shown in Figure 6.

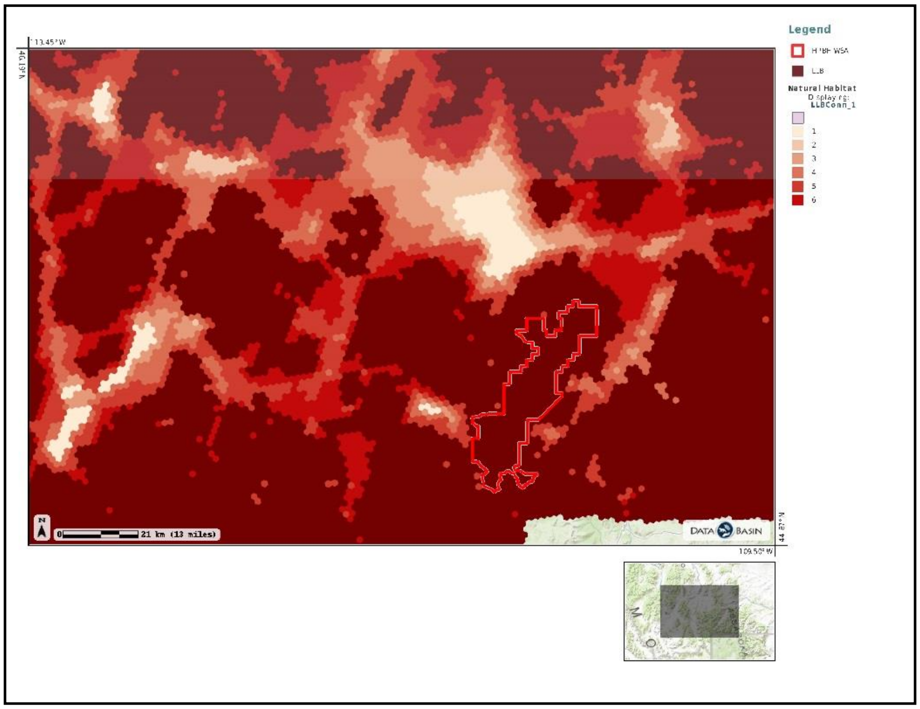

Figure 6. Montana Natural Habitat Large Landscape Blocks and Connectivity

Figure 6 shows clearly that the HPBH WSA is a major component of the Large Landscape Blocks of Natural Habitat connected to Yellowstone Park. Taken together, figures 4, 5, and 6 show that the HPBH WSA is an integral part of the high elevation landscape of the GYE. This is a landscape that is becoming a critical refuge for wildlife as the climate warms and changes (see Climate Change section below).

Recreation and Effects on Fish and Wildlife

There is a large body of scientific research on the effects of various forms of recreation on wildlife, habitat, and other environmental components. Most of the literature has focused on the effects of paved roads, but there is a growing body of research on the effects of different types of trails and different activities on those trails. A 1975 survey of land managers reported substantial erosion on mountain trails during the previous decade that was attributed to dramatic increases in horse and foot travel on trails not designed to accommodate higher volumes of traffic (Godin and Leonard, 1979). Since 1975, the use of mountain bikes, motorcycles, all-terrain vehicles ATV's), off-road vehicles (ORVs), and snowmobiles has also increased dramatically.

The first review of the recreation impacts literature was done in 1985 by Boyle and Samson (1985) who found 536 references concerning effects of nonconsumptive outdoor recreation on wildlife (Boyle and Samson 1985). The variety and magnitude of recreational impacts has increased greatly since then. In 1997 a review of scientific literature on effects of linear developments on wildlife included thousands of documents (Jalkotzy et al. 1997). A subsequent review by the Montana Chapter of the Wildlife Society in 1999 summarized 403 papers related to effects on carnivores alone (Claar et al. 1999). A bibliography compiled for the Bridger-Teton National Forest in 2002 included 607 scientific papers, reports, articles and documents written with respect to the effects of roads on wildlife and the montane ecosystem (Nietvelt 2002).

All forms of recreation contribute to trail erosion and cause disturbance to non-habituated wildlife. These impacts are discussed relative to individual species in the wildlife sections below. In a literature review for Mount Spokane State Park by Pacific Biodiversity Institute (Snetsinger and White 2009) impacts were summarized: outdoor recreation was found to be the 2nd leading cause of decline of U.S. threatened and endangered species on public lands (Losos et al. 1995) and 4th leading cause across all ownerships (Czech et al. 2000). As recreational use of public lands continues to grow, there is increasing concern over the trade-offs that may exist between recreation and protection of wildlife (Reed and Merenlender 2008).

A "Synthesis of the Literature and State of the Practice" about conflicts on multiple-use trails was compiled by the Federal Highway Administration at the request of The National Recreational Trails Advisory Committee (FHWA 1994). This document looked at the challenges faced by trail managers to protect natural resources while maintaining user safety and providing high-quality user experiences. As might be expected from a highway agency, the document focuses primarily on trail construction types, and users, and avoiding conflicts among users. It does however state that: "All trail use, regardless of travel mode, impacts natural resources". Resource damage depends on many factors including the type of ecosystem, type of wildlife, elevation, type of vehicle, and level of use among others (FHWA 1994).

Another thorough review of relevant research was done by Kuss, et al. (1990). They concluded that generally hiking and backpacking cause greater changes to trails than walking; backpacking causes more damage to trails than hiking without a pack; horses and packstock cause greater damage than hiking; trail biking causes more damage than hiking; and track-driven vehicles cause more damage than wheel-driven vehicles. Impacts on wildlife and the environment were not well addressed. Cole and Knight (1990) did an assessment of recreational impacts on biodiversity in wilderness areas. Their review did not include wheeled vehicles and found that fishing, hunting, and associated management practices had the greatest impact on diversity at a regional scale.

The effects of recreation on the environment and on other recreationists vary greatly even among members of the same user-group. It can be summed up in one sense by Sprung (1990) who noted that people who view the environment as an integral part of the experience are more susceptible to feeling conflict than those who see the environment as just a setting for their activity. (Low Impact Mountain Bicyclists of Missoula (LIMB), for example, encourages riders "to use mountain bikes to enjoy the environment, rather than use the environment to enjoy mountain bikes". Since the FHWA review in 1994 the type of vehicles (ATV's, ORV's, mountain bikes, and snowmobiles) have changed greatly and the demand for areas of use has intensified. This same author conducted a review comparing mountain biking to other forms of travel (Sprung 2004) and concluded that studies did not show that mountain bikes cause more natural resource impact. Sprung based his conclusion on several studies that did not show any significant difference in soil erosion or wildlife displacement between hikers and mountain bikers; including

Taylor and Knight (1993), Wisdom et al. (2004), Thurston and Reader (2001), and Wilson and Seney (1994). Aside from some poor study designs, the factor that is ignored in reaching this conclusion is the fact that mountain bikers travel a lot farther than hikers in the same time period and thus create a disturbance over a much larger area; even if the disturbance is equivalent to hiking at any given point. This point is made by Vandeman (Vandeman 2004) who represents the opposite side of the mountain bike spectrum from Sprung; each has a website promoting their views. In one study by Wisdom et al. (2004) the same 20 mile (32 km) study area was covered by one pair of users on ATV's, 2 pairs of mountain bikers, and 3 pairs of hikers to traverse the distance in the time allotted.

In 2000 a review focusing on ATV's and ORV's and snowmobiles was published (Stokowski and LaPointe 2000). Their key findings were that the impacts were similar for all types of motorized vehicles; the main differences were due to more intensity of use or the level of fragility of the affected environment. In western habitats wildlife are negatively impacted by the presence and noise of ATVs, ORVs, and snowmobiles, although some mammals (deer, for example) may become, over time, habituated to these vehicles. Snowmobiles compact insulating layers of snow and thus compromise the habitat of mammals living below the snow layer. Since snowmobiles share the same noise characteristics as ATVs and ORVs, they may put undue stress on large ungulates, including moose and deer. ATV use has been found to widen and rut forest roads, and to increase the sediment load to streams which may threaten fisheries (Stokowski and LaPointe 2000). The U.S. Forest Service published a review of recreation impacts and their management in wilderness (Leung and Marion 2000) based upon Leung's Doctoral dissertation in the Great Smoky Mountains and Marion's research as Unit Leader and Scientist at the USGS Patuxent Wildlife Research Center. This paper summarizes the impacts of direct effects of recreation on soil, vegetation, wildlife, and water, as well as indirect/derivative effects. Direct effects on wildlife include habitat alteration; loss of habitats; introduction of exotic species, wildlife harassment; modification of wildlife behavior; and displacement from food, water and shelter. Indirect effects include reduced health and fitness; reduced reproduction rates; increased mortality; and community composition changes (Leung and Marion 2000).

A literature review in 2009 reviewed impacts on 21 wildlife species in Mount Spokane State Park in Washington and documented studies that found impacts on elk and wolverine among other species. (Snetsinger and White 2009). The mere presence of trails negatively impacts 14 of the 21 species, and areas of concentrated recreation/recreational development negatively impacted an additional 7 species. Just human presence/wildlife observation was documented to impact 9 of the 21 focal species. Snowmobiles were the only motorized form of recreation included in the review; they ranked highest of recreation types in terms of the number of focal species impacted (7 of 21 species). Noise, speed, and ability of snowmobiles to go off-trail likely contribute to their relatively high level of impact. Horseback riding and biking were documented to affect notably fewer of the focal species (1 and 2, respectively), but very few studies in this review included these forms of recreation (Snetsinger and White 2009).

Another review in 2009 compared impacts of hiking, mountain biking, and horse riding on vegetation and soils (Pickering et al. 2009). Overall they found that there had been little research at that time related to horses and biking compared with hiking. They did conclude that there are specific impacts of horses such as those associated with manure and urine, grazing and the construction and use of tethering yards and fences. Mountain bike specific impacts include soil and vegetation damage from skidding and the construction of unauthorised trails, jumps, bridges and other trail technical features (Pickering et al. 2009).

A review in 2010 by the Miistakis Institute in Canada (Quinn and Chernoff 2010) found that all trail use has environmental effects. The most detrimental environmental effects (especially to soils and vegetation) occur when a trail is first constructed. Effects on soil and vegetation are difficult to evaluate regarding hiking versus horseback versus wheels. Effects on wildlife are generally more pronounced with mountain bikes than with either hiking or horseback, generally due to the 'sudden encounter' effect (Quinn and Chernoff 2010).

Travel Plans

Up until 2005 a Travel Plan was required as a part of each Forest Plan. At that point the Forest Service determined that Forest Plans are strategic documents, they do not make final agency action decisions, whereas Travel Plans are decision documents. This thinking culminated in the revision, in January of 2005, of the regulations for implementing the National Forest Management Act (NFMA) at 36 CFR 219.

After 2005, the Forest Service no longer proposed to incorporate the route designation decisions and programmatic direction of the Travel Management Plan as part of the Forest Plan. Instead, the Travel Management Plan would be a stand-alone document. In summary, the revised regulations at 36 CFR 219 direct that Forest Plans no longer make final agency decisions. The proposed Travel Management Plan would make final agency decisions (e.g. appropriate uses of roads and trails) and therefore would not be consistent with the principles of a revised Forest Plan.

The Gallatin Forest published the first Travel Plan in 1977 as part of the Gallatin Forest Plan. It was revised in 1978, 1980, 1982, 1983, 1987, 1991, 1996, 1999, 2003 and 2006. In 1977 there were 27 miles of road in the WSA; 8.4 miles of National Forest, and 18.6 miles on private land. There were 175.5 miles of Forest System trails. In 1977, essentially all of the trails on the west side of the HPBH study area, the Gallatin Crest trail, and the Tom Miner trail on the east side, were only open to motorcycles or trail vehicles <40" wide in the summer. Summer motorized use was totally restricted on 3 trails: the Skyline Ridge trail along the Yellowstone National Park boundary, the South Cottonwood trails, and the Big Creek trail.

All the remaining trails on the east side of the Gallatin Divide were open to all types of summer motorized use, including jeeps and three-wheeled trikes. In reality though, only the South Rock, Blackmore, Middle Fork of Hyalite, and East Fork of Hyalite Creek trails had legal public access. Further, they were essentially only used by motorcycles because they are too steep and narrow for larger vehicles.

In the winter of 1977, most of the HPBH study area was unrestricted to snowmobiles, with two exceptions. Snowmobiles were restricted to the Big Sky snowmobile trail in the entire Porcupine drainage and a portion of the Bozeman Creek drainage was closed to snowmobiles. In spite of the fact that most of the study area was technically open to snowmobile use, they actually only used a small portion of it. Snowmobiling on the entire east side of the study area was extremely limited or non-existent in 1977 (Schlenker 2003).

In 1991 the definition of trail vehicles was changed from "motorized vehicles of less than 40" total width" to "a motorized vehicle less than 50 inches wide, such as a trial bike, scooter, motorcycle, moped or all-terrain vehicle."

The Bozeman Ranger District issued a special closure order in 1997 that restricts all-terrain vehicles (ATVs) and four-wheeled vehicles from the Porcupine and Buffalo Horn drainages, an area totaling around 49,000 acres. This special order was enacted under emergency closure order authority, in response to soil and vegetation damage from ATV use in fragile wet areas and on single-track trails. This order was reissued every year since the original order expired on May 1, 2003.

In August, 1999, the West Pine, North Dry, and Eightmile trails on the Livingston Ranger District were closed to motorized vehicles by special order.

In January 2001, the Regional Forester issued a decision that prohibits cross-country motorized wheeled vehicle travel on all National Forest lands in a three-state area (Montana, North Dakota, and parts of South Dakota). This decision (known as the 2001 OHV (off-highway vehicle) decision restricts motorized wheeled vehicles to existing roads and trails on National Forest lands, and requires that vehicles fit entirely within the road or trail tread for legal travel. The only exception would be if that route was designated open to ATVs on that Forest's 2001 travel plan map.

In the fall of 2002, a "benchmark" travel plan was presented to the public as a starting point to generate feedback on travel management issues and initiate conversations and collaboration on travel management with other agencies and interested parties.

The benchmark includes road and trail-specific suggestions for one possible way to manage travel in the future. Within the HPBH study area, it proposes to eliminate ATV use and reduce snowmobile use to a smaller area. It also proposes to reduce motorcycle use on existing routes, and restrict summer motorized use to designated routes only. The benchmark is an attempt to model a travel scheme that more closely resembles 1977 actual use within the study area.

In 2006, the Gallatin National Forest published its Record of Decision for the Final Travel Management Plan. The Decision established summer and winter travel management direction across the entire Gallatin Forest, including the HPBH WSA. This Decision received 113 appeals in 2007 and was subsequently upheld by the Regional Forester, in response. Citizens for Balanced Use (OBU) filed suit on the Travel Plan in its entirety, and the Montana Wilderness Association, Greater Yellowstone Coalition, and The Wilderness Society challenged the WSA's management direction. All complaints were joined and addressed in District Court. The court ruled on these complaints in September 2009, upholding the Travel Plan Decision in all areas other than the HPBH WSA. Within the WSA, the travel decision was enjoined, and in its place the Gallatin National Forest implemented interim summer and winter travel orders further restricting mechanized and motorized travel within the HPBH WSA. This winter interim order was promptly challenged in District Court by OBU. Shortly after the 2009 District Court ruling, the Forest Service and OBU appealed the District Court Decision to the 9th Circuit Court, in December 2011, the 9th Circuit Court ruled that the 2006 Travel Plan Decision within the HPBH WSA did not adequately protect wilderness character. On June 25, 2012, District Court Judge Hadden found that OBU's subsequent suit had been "squarely resolved" by the 9th decision in the case of Russell Country Sportsmen v. United States Forest Service and granted the defendants motion for summary judgment. Thus the 9th Circuit Court has affirmed that the HPBH WSA has important characteristics of wilderness that should be protected, at least until Congress decides otherwise.

Changes in travel management were summarized by Clark et al. (2012) in Table 1, below:

Table 1. Summary of travel management, 1977 to 2011

	1977 Mileage	Pre-2006 Travel Plan Decision Mileage	2006 Travel Plan Decision Mileage	Interim Travel Plan Orders Mileage – 2011/2012
All trails	205	205	208	208
Open to motorcycles, mountain bikes, foot, and stock	188 *	136	68	39
Open to mountain bikes, foot, and stock (not motorcycles)	205	205	100	21
Foot and stock use only	17	0	37	148
Timeshare trails	0	0	±15	±15
*Miles of snowmobile trail ** *	12	12	12	12
Approximate open snowmobile area	136,000 acres	112,000 acres	11,000 acres	2,666 acres

* While trails were legally open to mountain bikes in 1977, they were not likely present.
** This mileage represents the Big Sky Snowmobile Trail running north to south from Portal Creek exiting at Buffalo Horn Creek, the only official sanctioned snowmobile trail in the WSA since 1977.

Table 1. Summary of travel management in the HPBH WSA (from Clark et al. 2012).

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Key Habitat Areas for Key Species

Background

an·i·mal (àn[1]e-mel) *noun* [Lat.< *animalis*, living < *anima*, soul.]
A multicellular organism of the kingdom Animalia, characterized by the capacity for locomotion, fixed bodily structure, restricted growth, nonphotosynthetic metabolism, and an ability to recognize and respond to stimuli. (Webster's II. New College Dictionary)

The very definition of an animal implies movement. Animals move across landscapes to meet daily, seasonal, and lifetime needs. Such movements are necessary for survival of individuals and the persistence of the population and species. Movements occur across a wide range of scales from daily movements (meters to kilometers) to seasonal migrations (tens to hundreds of kilometers) to lifetime movements (thousands of kilometers in sum). A male grizzly bear in Yellowstone, for example, requires about 900 km^2 of habitat during his lifetime and will disperse, on average, about 200 km when he is weaned and leaves his natal area. The longest recorded dispersal of a brown/grizzly bear is 800 km. To allow dispersal of wide-ranging species such as grizzlies and wolverines, and to allow seasonal migrations for species such as elk and deer, connectivity (or habitat connection) is needed between secure habitat like the HPBH WSA and other habitat cores within the region.

Climate Change

Climate change in the west will generally bring rising temperatures, declines in snowpack, earlier spring snowmelt and reduced late summer flows (McWethy et al. 2010). The effects of these changes on ecosystems will be complex and difficult to predict or manage. They have been summarized as:

> “Investigations of the past suggest that we should expect dynamic and rapid ecosystem response to changing climate conditions, but in ways that may be difficult to predict. Paleoenvironmental records illustrate that while existing biomes have experienced distribution shifts, they have been resilient to climatic change across multiple time scales (e.g., decadal to millennial). They also suggest, however, that we should anticipate increased extreme and unforeseen disturbance synergisms; increased tree mortality, shifts in treeline position, and non-native plant invasions; and ultimately changes in plant community composition, structure, and function that may constitute novel vegetation assemblages. This poses significant challenges for developing management plans, but should not deter an adaptive management approach that allows for reassessment and modification of management strategies in the coming decades. By using scenario planning, managers can consider a wide range of possible future conditions to examine potential trajectories of ecological change. Managing for future conditions will, at the least, involve a continuation of well-established resource management and conservation practices.” (McWethy et al. 2010)

In one of the earliest papers on climate change in the GYE, Romme and Turner (1992) reported climate change predictions that were made before climate science became as rigorous and quantitative as it is today. The early predictions were much less confident than they are today and did not address the ecological consequences of change, a feature that is now better understood. Their predictions however are still applicable today, but current predictions are more specific and more refined (Romme and Turner 2015). These are discussed later in this section.

Another early analysis of the GYE (Bartlein et al. 1997), suggested that management agencies were ill-equipped to deal with these changes:

“The projected climate changes within the Yellowstone region and the individualism displayed by species in their potential range adjustments are equal or greater than the changes seen in the paleoecologic record during previous warming intervals. Although the results support conservation strategies that include habitat connectivity, the magnitude of the changes may exceed the ability of species to adjust their ranges. The predicted patterns call into question the adequacy of current management objectives to cope with the scope of future changes.”

Since that time (1997) many agencies have revised their planning approaches to try to cope better with climate change. The USFS has established a Climate Change Resource Center (http://www.fs.usda.gov/ccrc/) to connect land managers and decision makers with useable science to address climate change in planning and application. Additional climate change initiatives are discussed earlier in the Forest Plans section. One of the FS directives, The FS ‘National Roadmap for Responding to Climate Change’ (USDA Forest Service 2011) (www.fs.fed.us/climatechange/pdf/Roadmapfinal.pdf). states:

> “To address the risks and vulnerabilities associated with climate change, land managers will need science-based assessments of the relative vulnerability of key ecosystem components and their ability to adapt to increased stress. These assessments will help managers set priorities in maintaining healthy, resilient ecosystems and protecting communities and infrastructure. Basing their decisions on such assessments, land

> managers can avoid fragmented, piecemeal approaches and make cost-effective investments. Vulnerability assessments will need to span the range of ecosystem elements and values at risk. Designated wilderness areas and wild and scenic rivers will need to be studied to help determine the potential impacts of climate change on these unique resources and determine their important role in adaptation and mitigation. Vulnerability assessments are needed for communities, their institutions, and their capacity to adapt to disturbances associated with climate change. Vulnerability assessments are the basis for defining the social, economic, and ecological costs of inaction as a reference point against which to compare proactive adaptation measures. Understanding climate change effects and the systems involved requires integration across agencies, disciplines, and programs. Numerous efforts to assess the vulnerability of species, ecosystems, and communities are already underway, and additional efforts are planned. Various methods have been applied and new methods are in development to provide a reliable suite of tools for assessing various aspects of vulnerability. Existing vulnerability assessments will need to be synthesized and interpreted, using the results to guide more targeted appraisals for forest and grassland ecosystems. Useful assessments will require strong partnerships among science, management, and communities."

A review to vulnerability analyses and approaches relating to environmental change was published in 2005 by W. Neil Adger (Adger 2005). A guide to vulnerability assessments was produced in 2011 by the National Wildlife Federation in collaboration with the US Fish and Wildlife Service as a product of an expert workgroup which included scientists from the US Forest Service (Glick, Stein, and Edelson 2011). A workshop on climate change effects on the Yellowstone River and sagebrush steppe ecosystems was held in Bozeman in 2008; reports and a bibliography of related publications can be found online at http://www.nwf-wcr.org/ClimateChangeFWP-12-08.htm. Workshop results included management objectives to maintain native sagebrush habitat and species, maintain water flows and native fisheries, and maintain hunting and other recreational opportunities. Reflecting the seriousness of climate change impacts, the workshop also found that:

> "The next revision of the Montana Comprehensive Fish and Wildlife Conservation Strategy needs to incorporate risks from climate change, including a reframing of management objectives and significant consequences to wildlife from climate change. Other management plans like the elk plan and the North American Waterfowl Management Plan also need to be revised to incorporate climate change. The state's ongoing planning effort on critical areas and corridors, which includes impacts of climate change as well as other factors such as developments and roads, already are starting to incorporate some needed new thinking".

In 2008 The Wildlife Society published a special issue on climate change with a bibliography on articles related to wildlife management and climate change (Ansu and McCarney 2008. available online at http://online.nwf.org/site/DocServer/NRNRC-GW-FWP-TWSClimateChangeBibliography.pdf?docID=6281). Additional information on climate change impacts can be found in the sections of this report addressing individual species, below.

Recent Climate Change Assessments have concluded that the GYE and Gallatin NF will experience continued warming temperatures, decreasing springtime snowpack, and decreasing late season soil moisture. The predictions are based upon the best Global Climate Models downscaled to local topography using current climate trends from SNOTEL data (see Chang and Hansen 2015). The climate will probably become hotter and drier at lower elevations and hotter with similar precipitation at higher elevations (Romme and Turner 1992, 2015). This dryness at lower elevations predicted by Romme and Turner will probably be due to changes in water balance, and is an average across the entire GYE; since precipitation is predicted to increase at least in Gallatin County (see Appendix for more localized Gallatin County predictions). These changes will result in a longer, warmer, and drier growing season than present which some research (Hansen et al. 2015) suggests is likely to lead to a change in species composition and possible replacement by sagebrush-dominated communities. The patterns of change in temperature and precipitation are not uniform across the landscape but vary according to local topography, soils, and weather patterns.

These changes are already occurring. Current long-term snowpack declines are found across the western U.S. and are being caused by temperature increases. (Tercek et al. 2015). Temperatures at all elevations have warmed significantly since 1985; elevations below 6,500 feet have also become significantly drier (Chang and Hansen 2015). Higher elevations have shown no significant change in precipitation yet, but as they continue to warm there should be earlier snow melt leading to more prolonged drought stress later in the growing season. This warming is associated with earlier spring snowmelt, warmer summer conditions, and a longer growing season and fire season (Romme and Turner 2015). By 2040, conditions like those in 1988, when the big Yellowstone fires occurred, will be fairly common (David Thoma, pers. comm.)

As climate change progresses there will be significant changes in the forests of the Gallatin Mountains and some shifts in the distribution of the wildlife species using them. Whitebark pine is the most vulnerable of the tree species and has already suffered severe losses due to outbreaks of mountain pine beetle fueled by warming temperatures (Logan et al. 2010). Estimates of the extent of losses within the GYE vary from a 20-30% infection rate (Shanahan and Chambers 2014) to 46% severe mortality and 82% moderate-to-severe mortality (Logan et al. 2013). In addition the amount of area with the climatic conditions suitable Whitebark pine growth is predicted to decrease in the future (Chang et al. 2014). Suitable area may decrease from 21% of the GYE to 11% or less. Remaining suitable climate area for limber pine, aspen, douglas-fir, lodgepole pine, Engelmann spruce, and subalpine fir will also decrease greatly, while conditions and suitable areas for sagebrush and juniper will increase (Hansen et al. 2015). Climate conditions will change enough that other species such as ponderosa pine will have favorable conditions in the GYE.

The USGS has established the National Climate Change Viewer (NCCV, http://www.usgs.gov/climate_landuse/clu_rd/nex-dcp30.asp and http://www.usgs.gov/climate_landuse/clu_rd/apps/nccv_documentation_v1.pdf) that includes the historical (past 56 years) and future climate projections from 30 of the downscaled models for two of the RCP emissions scenarios; RCP 4.5 and RCP 8.5. RCP 4.5 is one of the possible emissions scenarios in which atmospheric greenhouse gas (GHG) concentrations are stabilized so as not to exceed about 650 ppm CO^2 equivalent (as of this report the atmospheric CO^2 equivalent was 403.7). RCP8.5 is the most aggressive emissions scenario in which GHGs continue to rise unchecked through the end of the century leading to about 1370 ppm CO2 equivalent. The NCCV allows users to see projected changes in climate (maximum and minimum air temperature and precipitation) and the water balance (snow water equivalent, runoff, soil water storage and evaporative deficit) for any state, county and USGS Hydrologic Units (HUC). It uses the same water balance models used by Tercek et al (2013) reported above to predict changes in snowpack for the GYE and by Thoma et al. (2015). Localized predictions for Gallatin County indicate that conditions may differ somewhat than the GYE average. Some relevant results for the HPBH WSA are shown in the APPENDIX. Results for prediction of temperature changes in the HPBH WSA show a steady increase in maximum average temperature and minimum average temperature even with the most optimistic scenario for the shortest time frame (APPENDIX Figure 27). This increase is fairly uniform throughout the year and will increase by 6 – 10 degrees Fahrenheit by 2100 (Westerling et al. 2011).

For Gallatin County as a whole, overall precipitation may increase slightly (APPENDIX Figures 28-30). Precipitation will fall fairly uniformly across the county APPENDIX Figure 31).

If the model looks farther into the future, the trend of increased precipitation will continue (APPENDIX Figure 32) with greater increases south of the HPBWSA in SW Yellowstone and Grand Teton Parks.

Average annual mean precipitation will increase slightly into the future with relatively modest increases by 2100 (APPENDIX Figure 33).

The biggest change in precipitation in Gallatin County will come in snowfall amounts and patterns, and snow water equivalences (APPENDIX Figures 34 through 36). The higher elevation areas like the HPBH WSA and Bridger Range will experience lower average snow in the future while lower elevations in the NW part of the county should have just slightly lower snow. As these predictions look farther into the future, the snowfall will continue to diminish. Combined with the precipitation forecasts, these models predict less snow and more rain over time with some localized differences in amounts. By 2100, under scenario 8.5 there will be an average change of about 1-2 inches in snowfall.

Runoff in the future will follow a similar pattern to precipitation with increases in late winter and spring, and decreasing after June (APPENDIX Figure 37). The higher elevation areas like the HPBH WSA will experience lower total runoff in the future while lower elevations in the NW part of the county should have higher runoff.

An average change of 2-4 inches doesn't seem like much of a change in precipitation, but the timing of events will have significant effects on plants and animals in the HPBH WSA. Runoff will start earlier in the year and drop off during the summer months. A comparison of the various model outputs shows broad agreement in this respect with differences in magnitude depending on the model (APPENDIX Figure 38).

The website for the National Climate Change Viewer (NCCV, http://www.usgs.gov/climate_landuse/clu_rd/nex-dcp30.asp) allows a wide variety of simulations to be run for all regions of the country. Regardless of the models used, there is a consensus that total runoff in Gallatin County will not change greatly in the future (APPENDIX Figure 39), but the timing of runoff will.

Another way to look at the effects of climate change is to analyze what changes in plant and animal communities these differences in temperature and precipitation will have. The Conservation Biology Institute and the Klamath Center for Conservation Research have developed a climate change toolkit (AdaptWest) to help planning for climate adaption. As the climate warms, most regions will shift from their current climates by 2050. This toolkit was developed in response to Executive Order 13653: "Preparing the United States for the Impacts of Climate Change" was issued in November 2013. To implement actions, the Executive Order established an interagency Council on Climate Preparedness and Resilience, chaired by the White House and composed of more than 25 agencies. Actions include developing actionable climate science, launching a climate data initiative, and providing a toolkit for climate resilience.

To enhance the role of science in helping manage climate impacts, strengthen the climate resilience of watersheds, natural resources and ecosystems, and enhance adaptive capacity (the ability of a system to adjust to climate change, moderated potential damages, and/or cope with the consequences), AdaptWest is designed to provide spatial data on the location of potential refugia (areas with a high contribution to a landscape's adaptive capacity), and estimates on the relative intensity of climate-related threats to ecosystem services.

AdaptWest can be used to help land management agencies and other organizations implement strategies that promote resilience, protect biodiversity, and conserve natural resources in the face of a changing climate. It uses a wide range of spatial data to provide regional analyses and provides a bridge between climate and ecological data. The datasets used are open, well-documented, and reliable.

It is especially useful in identifying future refugia which are key to promoting climate change resilience. A method of accomplishing this is to calculate the climate velocity of a given area: velocity is the rate at which species must move to shift to areas of similar climate as their current area changes. Climate velocity analyses can highlight areas with high adaptive capacity that may serve as refugia, and also areas with high levels of threat to ecosystem services. In areas with low velocity of climate change, species can adapt if they can disperse faster than the velocity of climate change.

Climate velocity data for all of North America at 1km resolution are available at: http://adaptwest.databasin.org/pages/adaptwest-velocitywna. Among other results, it can identify areas where current climates will disappear: be pushed off mountaintops and continents. Analyses can be done in two directions. Future climate velocity predicts where current species will go to (how fast will they need to move); Backward climate velocity predicts where species will come from (how distant are source populations). Climate velocity analyses can inform questions about the 1) Ability of resident species to persist locally or regionally, 2) Which areas can best facilitate such persistence, and 3) Likely degree of community turnover.

Analyses of climate velocity were run for the HPBH WSA and the neighboring region. These show the predicted climate velocity for two time frames, 1995-2055 and 1995-2085, under two climate change scenarios: RCP 4.5 and RCP 8.5 (APPENDIX Figures 40-43). These two scenarios represent the extremes of most climate predictions; from the most optimistic (4.5) to the most unfavorable (8.5). Given the slow response of most nations to reduce CO2 emissions, the more unfavorable scenarios may in fact be the most realistic. Under any scenario, in general, many refugia are mid-slope montane areas, especially on north-south trending mountain ranges such as the HPBH WSA. These are areas where the species present are able to move or down slope to find suitable conditions.

The most optimistic predictions are those made for a shorter time frame (up until 2055) and assuming great efforts are made right now in reducing greenhouse gas emissions (RCP 4.5). In this scenario the HPBH WSA fares quite well and most of the current species do not have to move fast or far to find a similar climatic niche (plant and animal communities will not change precipitously). Predictions for a longer time frame (until 2085) and using the same RCP 4.5 model predicts similar results (APPENDIX Figures 44-45).

Even predictions assuming few efforts are made right now in reducing greenhouse gas emissions (RCP 8.5) for a shorter time frame (until 2055) estimate that HPBH WSA will fare moderately well and species will have to move moderately fast or far to find a similar climatic niche. Plant and animal communities will change less than regions to the south, but more than regions to the north (APPENDIX Figure 46).

Under a worst-case scenario with predictions for a longer time frame (until 2055) and using RCP 8.5 (which assumes little reduction in CO^2 emmissions) the HPBH WSA fares poorly and species will have to move very fast or far to find a similar climatic niche. Plant and animal communities throughout the region will change greatly. The climate niche on south-facing slopes north of Gardiner, Montana, will disappear as they become even drier and hotter. Potential refugia will move north from the HPBH WSA and may be found in the Bridger and Bangtail mountain ranges. This highlights the need for maintaining intact habitat for connectivity northward from the HPBH WSA so that many species can adapt by moving north. (APPENDIX Figure 47).

Human Shifts in Distribution Due to Climate Change

Another important effect of a warming climate that has not received much attention to date will be large shifts in human populations as people migrate to areas with more favorable climates. It is estimated that millions of people will leave their homes in coming decades in search of viable livelihoods and safety (Warner et al. 2009). In poorer countries and communities, people will probably stay until conditions become unbearable before moving. Poor people are often exposed to the impacts of climate change more than others because economic and political forces confine them to living in high-risk landscapes. Thus poor people, especially those in marginalised social groups, are much more vulnerable to the impacts of climate change (Warner et al. 2009). Estimates of the current numbers of migrants and projections of future range from 25 to 50 million by the year 2010 (Myers 2001) to almost 700 million by 2050 (Christian Aid 2007). A middle of the road estimate is 200 million environmentally-induced migrants by 2050 (Brown 2008). At the same time the human population is projected to grow from 6.8 billion today, to 9 billion by 2050 (Warner et al. 2009).

However, relatively wealthier people have the option of leaving as soon as conditions become uncomfortable and relocating in other areas where temperatures are not going to increase as quickly or as greatly. In the United States there is already evidence of migrations from crowded, hot, and dry landscapes to relatively cool, uncrowded regions with ample water such as Montana. Gallatin County is one of the fastest growing counties in Montana with an estimated 100,000 inhabitants by 2017 (Bacaj 2013). Most new arrivals are retirees or young professionals; people over 65 will increase by 72% to 12,446 by 2017 (Montana.gov 2013). Growth in Gallatin County is 29% natural change (births minus deaths) and 71% due to migration (Headwaters 2014). This trend has continued since at least 2003 when most newcomers were relatively wealthy compared to the state average per capita income (Schlenker et al. 2003) and were older retirees attracted by scenery, quality of living, and outdoor recreation activities like skiing and fishing (USDA 2002).

Gallatin County's growing population is increasingly supported by non-labor income, such as dividends, interest, and rent (Headwaters Economics 2014), reflecting a population that has more leisure time for recreation and other pursuits. Headwaters Economics has developed an interactive website for the Great Northern Landscape Conservation Cooperative (at http://headwaterseconomics.org/dataviz/atlas-gnlcc) to track economic, land use, and climate changes by county in Montana and other NW states. Average temperature in Gallatin County increased about 1 degree F versus 19970-1979 and precipitation was relatively stable from 1970-2011, but snow water equivalent dropped about 20% while growing degree days and evapotransporation increased. Gallatin County saw over 15% growth in jobs from 2001-2011 while the population grew by over 20,000 people. Services and Non-labor were the greatest sources of income growth with services contributing over 65% of jobs. This report on the WSA is not intended as an economic analysis, but the implications of demographic changes in Gallatin County are that pristine natural areas like the HPBH WSA will see accelerating pressure from recreationists as more people move into the area.

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Bighorn Sheep

Bighorn sheep (*Ovis Canadensis)* graze and browse in a variety of habitats generally adjacent to cliffs or other steep escape terrain. They often share those habitats (sympatry) with Mountain goats (*Oreamnos americanus*). In the Madison Valley Wildlife Assessment conducted by the Wildlife Conservation Society, protection of Bighorn sheep habitat also protected 108 out of 411 other species (Brock et al. 2006).They are a focal species for alpine and subalpine habitats in particular. Information on Bighorn ecology can be found on the Montana Field Guides at: http://fieldguide.mt.gov/speciesDetail.aspx?elcode=AMALE04010

Bighorn sheep are native to the Gallatin Range, unlike Mountain goats which were introduced elsewhere in the GYE and have expanded into the Gallatin Range. There are 28 recognized bighorn herds in the state of Montana. Herds are named according to the location of their winter ranges. Gehman (2010) reported that four of these herds or subpopulations utilized portions of the Gallatin Range in the HPBH WSA. Surveys by Wild Things Unlimited in Tom Miner Basin indicated that Bighorn sheep numbers declined from the 1984-1988 period to the 2006-2008 period, including the Ramshorn Peak/Trail Creek area of the HPBH WSA which declined from 47 to 14 maximum number observed (Gehman 2010).

FWP has conducted Bighorn sheep aerial surveys in collaboration with the Northern Yellowstone Cooperative Wildlife Working Group in the upper Yellowstone area since 1991. The portion of the HPBH WSA south of Big Creek was included in this effort. These surveys were expanded into the Gardiner Basin and Yellowstone National Park (YNP) in 1995. Gehman (2010) surveyed the Gallatin Mountains including the HPBH WSA and documented additional Bighorn sheep north of Big Creek near Hyalite Peak and Fridley Creek.

GYE Bighorn Sheep
Photo Credit: Lance Craighead

Kristin Legg studied the movement patterns and habitat use of the Tom Miner and Point of Rocks bighorn herds during 1994 and 1995 for a Master's degree at Montana State University (Legg, 1996). Ten radio-collared ewes were tracked from their winter ranges. The Point of Rocks ewes utilized summer range in Hyalite Basin around Hyalite Peak, and moved to the Cinnabar winter range during the rut before returning to Point of Rocks for the winter. The Point of Rocks, and other herds wintered at lower elevations of 1500-2000 m (1,500-6,560 ft) in drier grass and sage-steppe communities. Wintering sites in Tom Miner were generally on southwest-facing slopes between 1800-2500 m (5,900-8,200 ft) within 100 m of escape terrain (cliffs). Wintering areas included whitebark pine, subalpine fir, bunchgrass, and subalpine vegetation types. All herds used summer range above 2000 m on ridge tops and alpine meadows.

In 2010, The Mountain Ungulate Research Initiative was begun by Dr. Robert Garrott and Dr. Jay Rotella at Montana State University (MSU), with Dr. Patrick White at Yellowstone National Park (YNP) with the National Park Service (Garrott et al. 2010). This is a long term collaborative effort to advance understanding of Bighorn sheep and Mountain goat ecology. The focus is on spatial and population ecology. Investigations have begun in the GYE and Gallatin Mountains including the HPPBH WSA and NW Yellowstone Park. Primary objectives of the studies include 1) understanding the ecological interactions between sympatric populations, 2) developing and refining habitat suitability models, 3) documenting spatial dynamics within and among populations and identifying important movement corridors, 4) collecting vital rate data to better understand population dynamics, and 5) investigating potential responses of bighorn sheep and mountain goats to gradual changes in the regional climate (Garrott 2011). This effort has also been referred to as "Comparative studies of sympatric bighorn sheep and mountain goats in the Greater Yellowstone Ecosystem" (Gehman 2010).

In 2014, The Mountain Ungulate Research Initiative began a 6-year collaboration with a larger group of agencies, institutions and foundations. Information on research and results is available at the Montana State University Mountain Ungulate Research website (http://www.mtbighorninitiative.com/home.html). This ongoing work includes two projects: the Greater Yellowstone Area Mountain Ungulate Project (http://www.mtbighorninitiative.com/gyamup-home.html) and the Montana State-wide Bighorn Sheep Initiative (http://www.mtbighorninitiative.com/mtbi-home2.html) which is a collaboration between MSU and FWP. The Bighorn Sheep Initiative is funded with $1.2 million from hunting permit sales and federal taxes on the sale of sporting arms and ammunition (Pittman-Robertson funds).

As a part of the Mountain Ungulate Research Project (Garrott et al. 2010, 2011), beginning in 2010, Mike Sawaya developed databases for storing point, polygon, and demography data for bighorn sheep and mountain goats (Sawaya 2010). Elizabeth Flesch analyzed historic bighorn sheep and mountain goat population counts to estimate herd growth rates. A total of 538 bighorn sheep counts since 1971 showed variable growth rates among the 26 herd units in the Greater Yellowstone Area (GYA). There was no evidence that mountain goats sharing habitat with bighorn sheep adversely affected the bighorn populations, although detecting and counting these species is difficult, and is also a factor in the variability of counts (Flesch and Garrott 2012). Carson Butler examined climatic variation and age ratios in bighorn sheep and mountain goats in the Greater Yellowstone Area (Butler and Garrott 2012). Megan O'Reilly assessed resource selection of bighorn sheep and mountain goats in northern Yellowstone to examine the potential for competition and to develop enhanced habitat models (O'Reilly et al. 2012). Jesse DeVoe began investigating the possibility of competition between Bighorn sheep and Mountain Goats by evaluating potential niche overlap of the two species, but was unable to collect enough data on Bighorn sheep during the study period (DeVoe 2015, and Pers Comm). A current student, Blake Lowrey is investigating overlap and competition using GPS data from both species.

Results of the 2014 aerial surveys by the Northern Yellowstone Cooperative Wildlife Working Group, conducted by Karen Loveless with FWP, recorded that the Point of Rocks subpopulation consisted of 42 sheep (26 ewes, 4 lambs, and 12 rams). The Tom Miner herd consisted of 56 sheep (29 ewes, 15 lambs, and 12 rams). The Yankee Jim – Corwin herd numbered 32 sheep (9 ewes, 4 lambs, and 6 rams). The Beattie Gulch – Cinnabar herd numbered 89 sheep (47 ewes, 12 lambs, and 30 rams). All of these subpopulations have increased since the surveys began in 1991; the Tom Miner and Beattie-Cinnabar herds declined from 2013 to 2014 by 23 and 7 animals respectively, but were still above earlier numbers These herds comprised a total of 219 bighorn sheep in 2014 (Loveless, 2014).

The Point of Rocks herd moves north about 16 km to summer range in the Hyalite Basin. The Tom Miner herd winters on the south side of Tom Miner basin and moves about 6 km northwest to summer on Fortress Mountain (Legg 1996) and Ramshorn Peak (Loveless 2014). The Cinnabar-Beattie bighorn herd spends the summer months in the high country along the border of Yellowstone Park near the aptly named Bighorn Peak (Loveless, 2014, DeVoe, 2015: Figure 7).

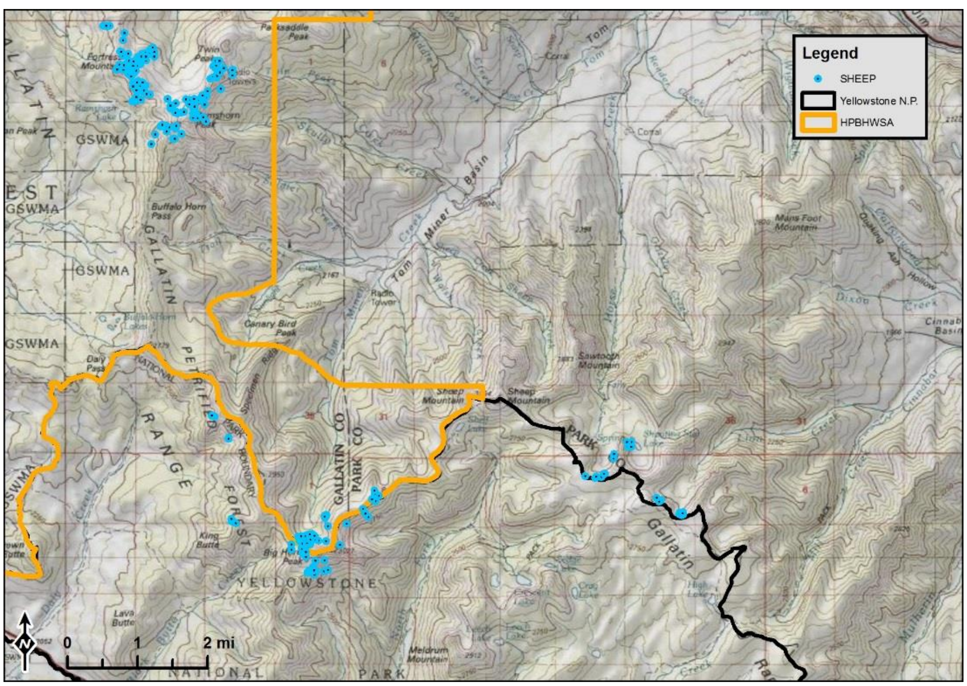

Figure 7. Bighorn Sheep GPS locations in the southern HPBH WSA.
Credit – Jesse DeVoe.

The Mountain Ungulate Research Project currently includes the thesis research of Jesse DeVoe at Montana State University. Figures 7, 9 and 10 were provided by Jesse DeVoe.

Winter ranges of these herds are located primarily along the Yellowstone River and Tom Miner Creek (Figure 8).

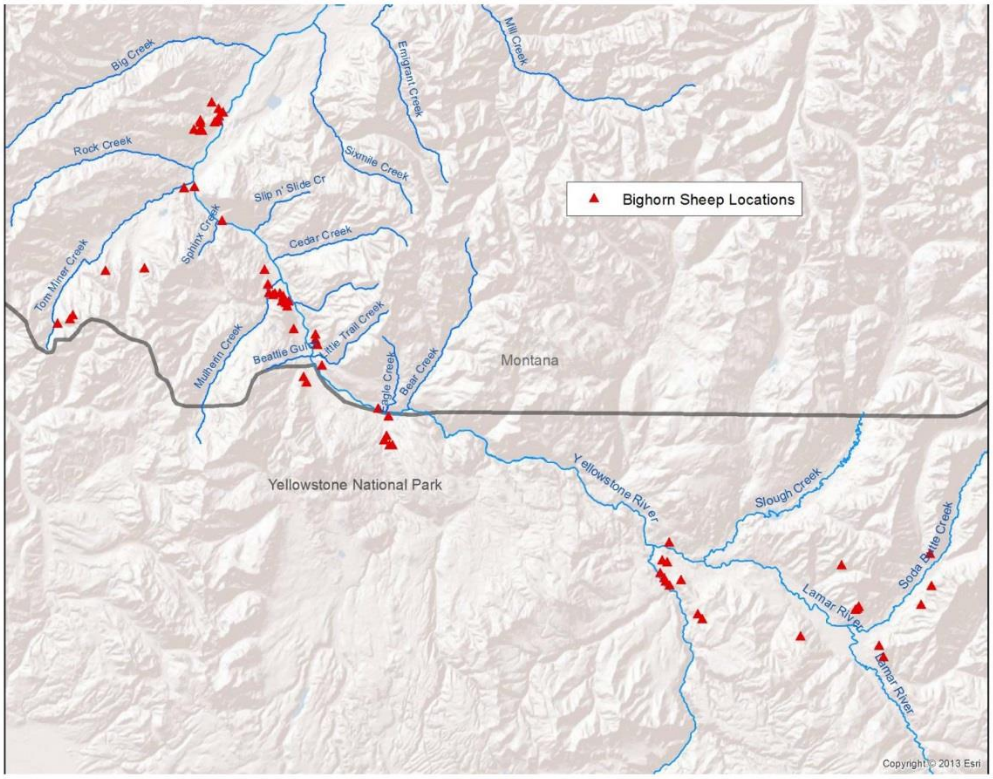

Figure 8. Locations of Bighorn sheep during 2014 spring aerial surveys.
Credit Karen Loveless, Fish, Wildlife, and Parks (Loveless 2014).

Vulnerability

Bighorn sheep populations were formerly abundant throughout western North America but many declined or were eliminated by the early 1900s due to over-hunting, disease, competition with domestic livestock for forage, and competition with humans for space (Beuchner 1960). Although the GYE can be considered a stronghold for Bighorn sheep in general, some herds have declined in recent decades. Current threats to Bighorns include disease, habitat loss, competition, and climate change. It is likely that all Bighorn sheep populations in Montana are carrying some level of disease and parasites contracted in part by contact with domestic sheep in the past (Garrott pers. comm. 2015). Climate change will affect plant communities and timing of events (phenology) and may reduce habitat for Bighorns in the future; however, changes in the HPBH WSA should be less than in other parts of the GYE (see APPENDIX). In general, bighorn sheep are forced to lower elevations by weather conditions during winter where they are closer to roads and human disturbance. Many individuals become habituated to human activities in this manner. In spring and summer, they can move to more remote areas with less disturbance.

Lambing areas, in particular, are areas with little human disturbance and are near escape terrain. Except for hunting, most human activities are tolerated by most bighorn sheep except when approached too closely. Domestic sheep grazing in areas inhabited by bighorn sheep can introduce pathogens that the wild sheep are much less resistant to than the domestic hosts (Clifford et al. 2009).

Mountain Sheep and Roads

Miller and Smith (1985) examined 1150 behavioral responses of desert bighorns to potential disturbances in Arizona and found that sheep exhibited stronger reactions to 1 or 2 humans on the ground than to parked vehicles or aircraft. Interactions with moving vehicles were not analyzed. In some cases, stress from human disturbances can be serious for individuals and eventually for populations, and was considered to be a factor in the loss of two California populations (DeForge 1981). In general, the closer the disturbance occurs, the farther sheep will move to get away (Hicks and Elder, 1979; MacArthur et. al. 1979, 1982) but there is a great amount of variability in sheep reactions (Miller and Smith 1985). Also, in addition to overt behavioral responses to human activities, bighorn sheep have been shown to respond at a physiological level, with elevated heart rates and blood cortisol levels, without showing outward signs of stress (Harlow et. al., 1987; MacArthur et. al., 1982).

Other studies have indicated that in some cases bighorn sheep may not be disturbed by the presence of people (Russo, 1956; Geist, 1971), although these observations were not as quantitative as those of Miller and Smith (1985). In some cases, sheep appear to be able to avoid disturbances caused by most recreational activities (excluding hunting) and such uses were not considered to affect populations (Hicks and Elder, 1979; Purdy and Shaw; 1980, Purdy 1981; Hamilton et. al., 1982). Bighorn sheep have become habituated to people and vehicular traffic around gas well sites in Alberta where sheep have abandoned traditional mineral licks in order to lick pipes and equipment containing sodium and other chemicals. Sheep were also found to eat soil containing minerals used in drilling and testing and mitigation measures were proposed to prevent access of sheep to potentially toxic compounds (Morgantini and Bruns, 1988; Morgantini and Worbets, 1988). These studies indicate the possibility of impacts from above ground facilities and accidental spills or leaks.

Important Habitat Areas

Important habitat currently occupied within the HPBH WSA includes the Hyalite Basin around Hyalite Peak; the high country around Ramshorn Peak and Fortress Mountain; and the area around Bighorn Peak along the border of Yellowstone National Park. Migration routes between these summer ranges and the winter ranges at lower elevations are also crucial to maintaining these subpopulations.

Bighorn Sheep and Connectivity

Bighorn sheep are a classic K-selected species. In other words they have evolved a life history strategy that depends upon long lifespans and low reproductive rates (MacArthur and Wilson 1967). They tend to develop populations that live at fairly high densities close to the carrying capacity (K) of their environment (Geist 1971). Their offspring develop slowly and they have a complex social structure based upon family groups. They do not colonize new areas easily due to the fact that female animals tend to disperse much shorter distances than males (Krausmann et al. 1999, Epps et al. 2007), particularly into unoccupied habitat. Like grizzly bears, they tend to expand their occupied area gradually with female offspring staying with or near to their mothers. Because their habitat is not continuous, this lack of dispersal means that herds of sheep tend to stay in one place and grow until they are densely packed. As this happens, disease or other causes of mortality may reduce the herd size. However, even when stressed by hunger due to overcrowding, the females do not disperse and colonize new habitats.

Connectivity for bighorn sheep primarily requires habitat that males can move through from one female population center (herd) to another. For this to happen, the herds need to be fairly close to one another with steep topography connecting them. For desert bighorn, Creech et al. (2014) estimated a dispersal distance of 16.4 km in terrain with less than a 15% slope, or 164 km in steeper terrain (greater than 15% slope). Thus desert bighorn sheep are 10 times as likely to disperse through mountainous habitat as they are across valley bottoms. As the climate warms, sheep herds will increasingly occupy habitat at higher elevations (Epps et al. 2006) and those with suitable connectivity habitat between them will be more resilient. Translocation of bighorn sheep to new areas as 'critical nodes of connectivity' promises to link existing populations by active dispersal corridors that restore connectivity (Epps et al. 2007). Recent experimental translocations of bighorn sheep in the Madison drainage by FWP and MSU (Garrott pers. comm. 2015) may establish new populations close to existing ones. This approach may be useful along the HPBH WSA to improve connectivity and provide resilience to climate change.

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Mountain Goat

Mountain Goats (*Oreamnos americanus*) graze and browse in a variety of habitats, often sharing those habitats with Bighorn sheep (sympatry). They are opportunistic foragers and will eat grasses, shrubs, sedges, lichens, herbs, and even conifer needles (Chadwick 1983). They are generally found on or close to cliffs and other precipitous terrain; within 250-400 feet of cliffs - usually steeper than 40^o (Gross et al. 2002, Poole and Heard 2003). Although mountain goats are not native to the HPBH WSA, they are a species of interest to many people who use the area for recreation. They may be considered a 'focal species' or 'target species' under the 2012 Planning Rule because of their public interest. They are a socially popular and "charismatic" species with high watchable-wildlife values, but are viewed with concern by Yellowstone National Park because of their potential to damage alpine and subalpine plant communities (Lemke 2004) and compete with bighorn sheep. Additional information on ecology can be found on the Montana Field Guide website at:
http://fieldguide.mt.gov/speciesDetail.aspx?elcode=AMALE02010

Mountain goats were never introduced into the Gallatin Range but FWP successfully introduced them into the Crazy, Bridger, Madison, Absaroka, and Beartooth Ranges between 1941 and 1969 (Lemke, 2004; Picton and Lonner 2008). These populations are all within 80 km of the HPBH WSA and Yellowstone. Translocations that occurred closest to the HPBH WSA were: the West Fork of the Gallatin River and the Spanish Peaks in the Madison Range, Pine Creek and Deep Creek in the Absarokas, and the Bridger Mountains (Gehman, 2010). The time and source of their colonization of the Gallatin Mountains is not known; the earliest record was on Bighorn

Peak along the Gallatin Crest in 1965 (Varley 1996; Gehman 2010). By 2015 there were an estimated 2,104 mountain goats in the Greater Yellowstone Area (GYA). It may have the potential to support almost 9,000 if all suitable habitat is occupied (DeVoe 2015).

The Mountain Ungulate Research Initiative is a long term collaborative effort to advance understanding of Bighorn sheep and Mountain Goat ecology (Garrott 2011; Garrott et al. 2010, 2011. see discussion in previous Bighorn sheep section). As a part of the Mountain Ungulate Research Project, several graduate students at Montana State University have conducted research on both bighorn sheep and mountain goats as discussed in the previous Bighorn sheep section). In addition, Jesse DeVoe focused on understanding and modeling the habitat selection of mountain goats based upon sloped terrain, ruggedness, forage availability, and heat load/solar radiation. Habitat selection was closely associated with terrain at one scale (500 X 500m) and was associated with canopy cover, heat load, and vegetation at a finer scale (DeVoe 2015). A little over half (57%) of the suitable habitat in the GYA appears to be already occupied so the regional population may be able to increase in the future. However, most of the habitat in the HPBH WSA is already occupied. Recent locations of GPS-tagged mountain goats are shown in Figure 9, and locations of both mountain goats and bighorn sheep are shown in Figure 10 demonstrating the overlap in habitat use (sympatry) of these two species.

Mountain goats do not migrate to lower, gentler terrain in winter as much as Bighorn sheep, but either stay on high windswept ridges near cliffs, or move to bands of cliffs at lower elevations (Chadwick 1983, Rice 2008, Poole et al. 2009). They have very low reproductive rates; young goats grow more slowly than Bighorn sheep and females may not begin breeding until age 4 or older (Côté and Festa-Bianchet 2003, Festa-Bianchet and Côté 2008).

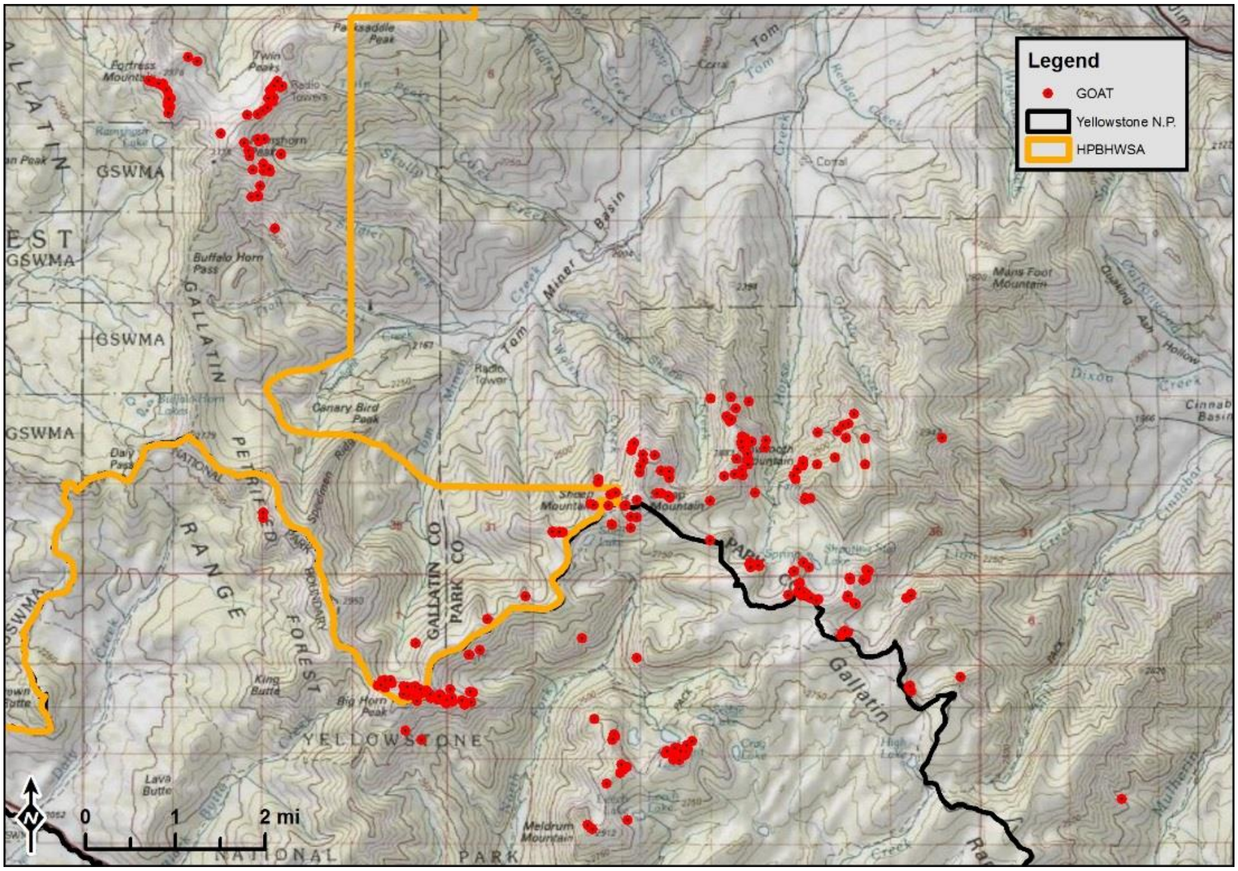

Figure 9. Mountain Goat GPS locations in the southern HPBH WSA.
Credit: Jesse DeVoe

FWS_LIT_020988

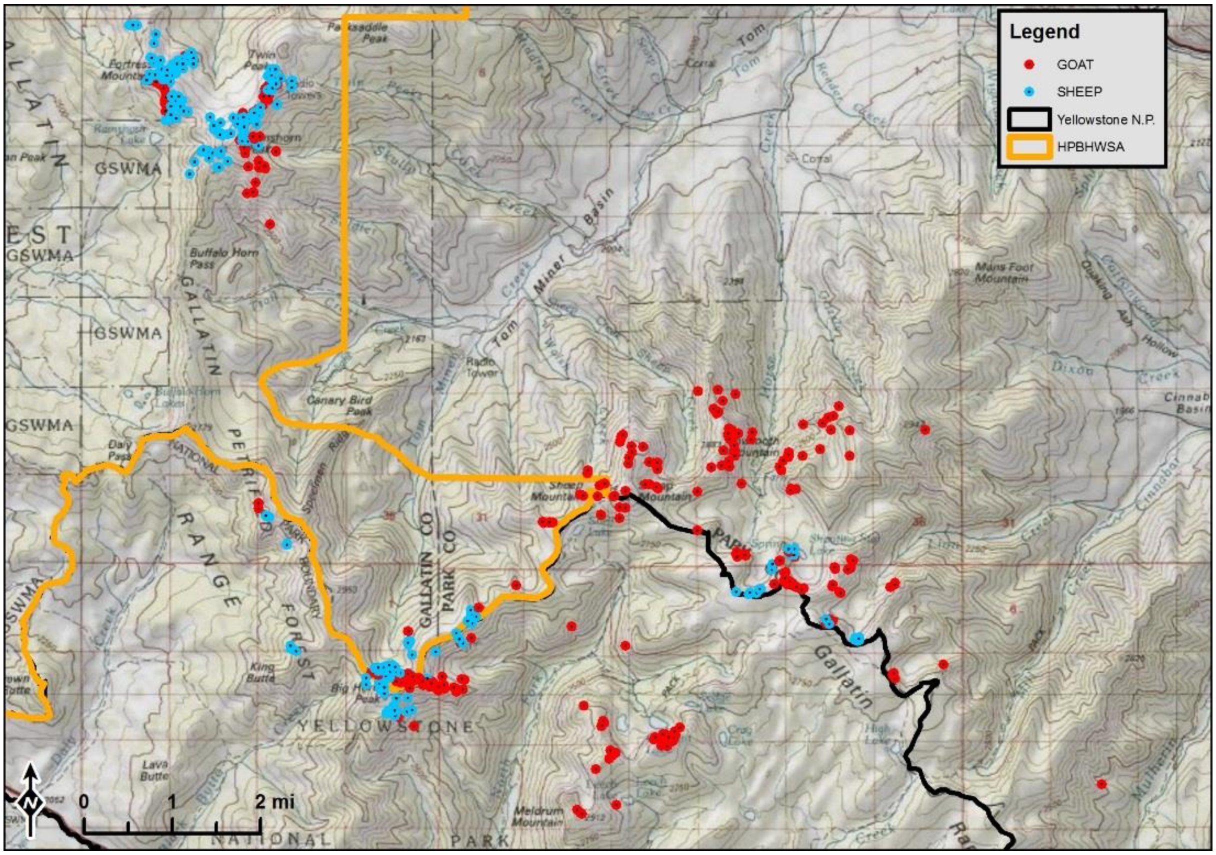

Figure 10. Bighorn Sheep and Mountain Goat GPS locations in the southern HPBH WSA.
Credit: Jesse DeVoe

The 2014 Mountain Goat survey of Hunting District (HD) 314 covered all of the Gallatin Crest and counted 180 mountain goats; the previous survey in 2011 counted 179. 42 groups of goats were observed. The population has been stable since 2011 but the kid:goat ratio indicates that the population is likely to increase (Loveless 2014). The population has been expanding since 1990 when they were only found along the boundary of Yellowstone Park and near Ramshorn Peak. Few goats were seen in the Sentinel and Hyalite areas in 1999 when the survey first included that area, but now over 50% of the population resides there (Figure 11).

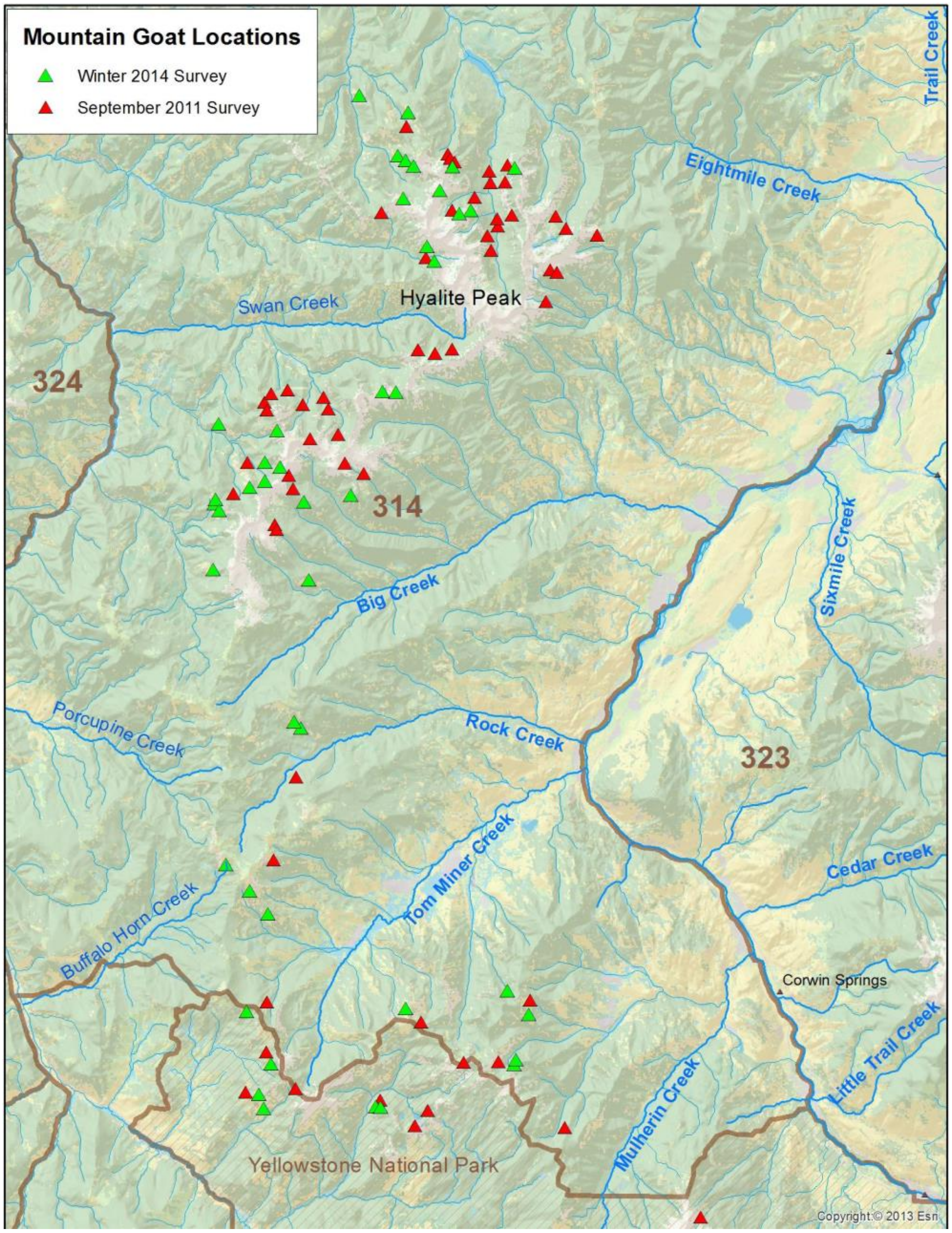

Figure 11. Locations of Mountain goats from aerial surveys of HD314 during 2011 and 2014.
Credit: Karen Loveless, Fish Wildlife, and Parks (Loveless 2014).

Vulnerability

Mountain goats rarely conflict or compete with humans (Foss and Rognrud 1971). Their high-elevation habitat keeps them at a distance from most human activities. However, they are highly prized for hunting (Gilchrest 1991) and mountain goat hunting licenses for HD314 are difficult to obtain. Since 1996, hunter success has been 80%. The number of licenses in HD314 was increased from 14 to 30 in 2012, and up to 31 in 2013, based upon higher numbers observed during the 2011 survey (Loveless 2014).

Mountain goats are most at risk during winter because of the difficulty in moving and foraging through deep snow (Côté and Festa-Bianchet 2003). They are especially sensitive to disturbance at this time of year. They can be displaced by helicopters (Côté 1996, Goldstein et al. 2005) and do not learn to habituate to them. They would likely be disturbed by helicopter supported activities such as recreation or exploration (Weaver 2014). In Alberta, researchers found that they were disturbed by ATVs, and recommended that ATV use should be regulated in areas with Mountain Goats (St. Louis et al. 2013).

Threats to mountain goats include disease, habitat loss, competition, and climate change. Climate change will affect plant communities and timing of events (phenology) and may reduce habitat for mountain goats in the future; however, changes in the HPBH WSA should be less than in other parts of the GYE (see APPENDIX).

Important Habitat Areas

Important habitat currently occupied within the HPBH WSA includes the Hyalite Basin around Hyalite Peak; the high country around Ramshorn Peak and Fortress Mountain; and the area around Bighorn Peak along the border of Yellowstone National Park. It is likely that mountain goats may continue to expand into all suitable habitat within the HPBH WSA although most habitat appears to be already occupied (DeVoe 2015 and DeVoe pers. comm. 2015).

Mountain Goats and Connectivity

Mountain goats are better dispersers than Bighorn sheep (Festa-Bianchet and Côté 2008) and can colonize new habitat more readily as seen by their success in expanding their range in the GYE and the Gallatin Mountains. They are rarely found at lower elevations however, and require mountainous terrain to connect populations or to disperse to new areas. Both males and females may disperse, but more likely males, and have been recorded travelling an average of 25 miles in Olympic National Park with a maximum of about 55 miles (Stevens 1983). The HPBH WSA is important for connectivity north-south for existing mountain goat populations and as a refuge as the climate warms.

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Cutthroat Trout

Both Yellowstone Cutthroat Trout (*Oncorhynchus clarkia bouvieri*; YCT)) and Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*; WCT) subspecies currently inhabit streams in the HPBH WSA (Figure 12). The YCT were indigenous to the Yellowstone River drainage and WCT were indigenous to the Gallatin River drainage. Most streams also contain non-indigenous Brown, Brook, and Rainbow Trout. Both species of trout are common in headwaters, lake, and stream environments. They feed primarily on aquatic insect life and zooplankton. Cutthroat trout prefer cold water in streams with more pool habitat and cover than uniform, simple habitat (Shepard et al. 1984). Juvenile cutthroat trout overwinter in spaces between large stream substrate (rocks and boulders). Adult cutthroat trout need deep, slow moving pools that do not fill with bottomfast ice in order to survive the winter (Brown and Mackay 1995).

Westslope cutthroat trout are native to the northwestern United States and southwestern Canada. Their historic range was the largest of any interior cutthroat trout subspecies and included the Missouri, Columbia, and Saskatchewan River basins (Behnke 1992). Populations have declined rangewide (Liknes and Graham 1988; Shepard et al. 1997, 2005) and were estimated to inhabit only 59% of their historical range by 2009 (May 2009). Of their current distribution, only 43% of the total stream length occupied is believed to be inhabited by genetically pure populations of Westslope cutthroat trout, or about 25% of the species' historical range (May 2009) but not all of these have been tested. Additional ecological information can be found in the Montana Field Guide: http://fieldguide.mt.gov/speciesDetail.aspx?elcode=AFCHA02088

Yellowstone cutthroat trout occurred historically in the Yellowstone River drainage in Montana and Wyoming and in the Snake River drainage in Wyoming, Idaho, Utah, Nevada, and probably Washington (Gresswell 2009). About 99 percent of the historically occupied stream habitats were in Wyoming, Idaho, and Montana (May et al. 2007). YCT appear to feed on fishes more so than do the Westslope cutthroat (Behnke 1992). Additional ecological information can be found in the Montana Field Guide: http://fieldguide.mt.gov/speciesDetail.aspx?elcode=AFCHA02087

Of those cutthroat trout populations that have actually been genetically tested, the proportion of genetically pure populations is only about 10% for Westslope and about 17% for Yellowstone cutthroats (Shepard. Pers. comm. 2015). Regardless of their genetic purity, either species of cutthroat trout are an important umbrella species. In the Madison Valley Wildlife Assessment conducted by the Wildlife Conservation Society, protection of WCT habitat also protected 288 other species (Brock et al. 2006). Protection of these high elevation headwaters will be increasingly important as refugia for native trout and other species as the climate warms.

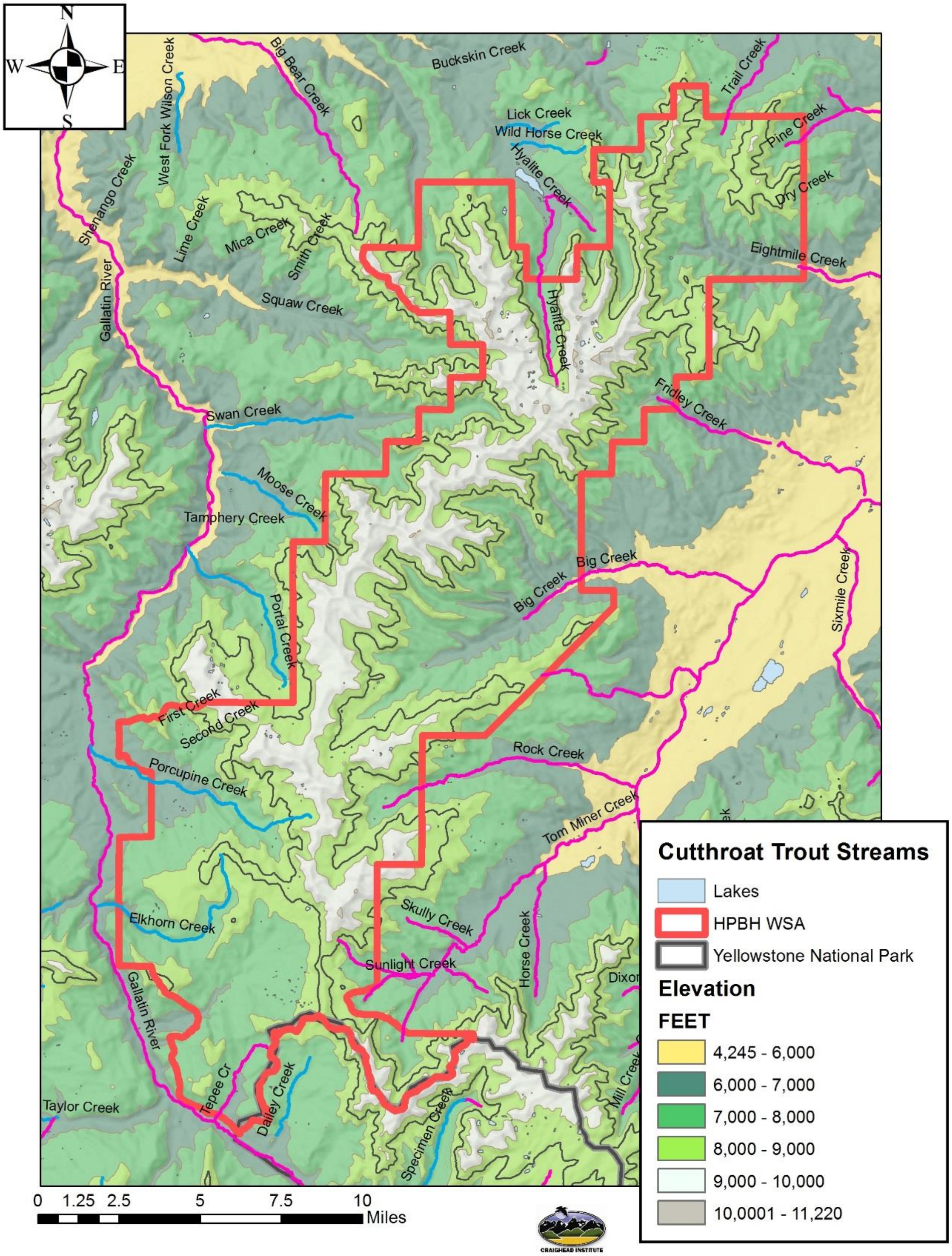

Figure 12. Cutthroat Trout Streams in the HPBH WSA. Data from FWP.

Pink colored streams in Figure 12 have Yellowstone Cutthroat Trout and Blue colored streams have Westslope Cutthroat Trout. Many streams in the HPBH WSA have hybridized trout crosses. It is difficult to ascertain exactly which streams may still have genetically pure strains of either species, but according to surveys done in the early 2000's it is likely that Rock Creek, Tom Miner Creek (and tributaries), and Fridley Creek had pure strains of YCT at that time. Big Creek historically had pure strains but was not tested (MCTSC 2007). No pure strains of WCT were identified and tested in the HPBH WSA at that time.

As a recreational resource, the value of the cutthroat trout fishery in the Gallatin and Yellowstone Rivers is significant to the economies of Gallatin and Park counties. A study by Gresswell and Liss found that the value of the Yellowstone Cutthroat Trout fishery in Yellowstone Park ranked above that of all other species of fish (Gresswell and Liss 1995). This fishery in Gallatin and Park counties, as in Yellowstone Park, depends upon management that reduces resource extraction and protects natural systems (Gresswell and Liss 1995) throughout the HPBH WSA.

Vulnerability

In 1997 the U.S. Fish and Wildlife Service (FWS) received a formal petition to list WCT as ''threatened throughout its range'' under the ESA (U.S. Office of the Federal Register 1998). After conducting a status review the FWS concluded that a ''threatened'' listing was ''not warranted'' for WCT because of the currently wide distribution of this subspecies and ongoing conservation measures (U.S. Fish and Wildlife Service 1999; U.S. Office of the Federal Register 2000).

Shepard et al (2005) assessed the status of Westslope Cutthroat Trout within the Western United States. Of the nearly 54,600 km of stream length currently occupied by WCT, 2% was in national parks, 19% was in designated Forest Service wilderness areas, 21% was in Forest Service designated roadless areas (excluding wilderness areas), and 30% was in other federally managed lands. They found that wilderness and roadless areas provide important strongholds for WCT. This was similar to findings from other assessments (Liknes and Graham 1988; Marnell 1988; Rieman and Apperson 1989; Thurow et al. 1997).

The US Forest Service Rocky Mountain Research Station has developed an interactive web site with stream temperature data and predicted stream temperature scenarios (NorWeST) to improve management and conservation of aquatic resources (http://www.fs.fed.us/rm/boise/AWAE/projects/NorWeST.html). The interactive map has predictions for all the streams in the HPBH WSA with historic mean August temperatures from 1993-2011 and predicted temperatures under two global climate model ensemble scenarios. Additional modeled scenarios and years are available for download as GIS shapefiles.

WCT are thermally adapted to their source streams which provide cold water with low mean summer temperatures; streams studied ranged from 6.7 to 11.2 degrees C (Drinan et al. 2012).

Data from the NorWeST models show that historic August means in the HPBH WSA have been about 5-7 degrees Celsius at upper elevations in the HPBH WSA warming to 8-9 degrees at mid-elevations and reaching 10 degrees and higher as streams leave the WSA. At lower elevations the Yellowstone River near Big Creek averages about 16-17 degrees while the Gallatin River near Storm Castle Creek is about 12-13 degrees. Under the A1B future scenario for example, the streams in the HPBH WSA will warm only slightly while the Yellowstone River is predicted to increase 1-2 degrees near Big Creek and rise above 18 degrees below Emigrant. The Gallatin River will rise about 1 degree in 40 years. By 2080, stream headwaters on the west side of the Gallatin Crest may have risen to 8-9 degrees Celsius but headwaters on the east side will still be in the 5-7 degree range. By 2080 the Yellowstone River near Big Creek may be over 18 degrees while the Gallatin River near Storm Castle should still be around 12-14 degrees. When viewed in the context of the entire Missouri Headwaters Unit, the HPBH WSA contains the largest extent of cold water streams in the unit (APPENDIX Figure 16) and will serve as an important area for aquatic refugia in the future. Currently these streams are the hatching and rearing areas for the cutthroat trout that live as adults in the larger rivers.

Important Habitat Areas

All streams in the HPBH WSA currently inhabited by either species of Cutthroat Trout are important habitat areas. They will become even more important in the future for refugia as the climate changes and downstream waters become increasingly warmer. Even if the trout are currently only found in lower stream reaches outside the HPBH WSA boundary, the headwaters of those streams are critical to maintaining conditions suitable for trout downstream. Westslope Cutthroat currently inhabit reaches of Swan Creek, Moose Creek, Portal Creek, Porcupine Creek, Elkhorn Creek, the West Fork of Wilson Creek, Lick Creek, Teepee Creek, Wildhorse Creek, Big Bear Creek and the Gallatin River, according to FWP GIS data (Figure 12).

Yellowstone Cutthroat currently inhabit reaches of Tom Miner Creek, Sunlight Creek, Soldier Creek, Trail Creek (off Tom Miner Creek), Dry Creek (off Tom Miner Creek), Sheep Creek, Skully Creek, Rock Creek, Donahue Creek, Big Creek, Fridley Creek, Pine Creek, North Fork Pine Creek, Trail Creek, Big Bear Creek, Hyalite Creek, East Fork Hyalite Creek, and the Yellowstone River according to FWP GIS data (Figure 12).

Cutthroat Trout and Connectivity

Connectivity for aquatic species such as fish occurs in waterbodies; for trout in the HPBH WSA all connectivity is downstream through the Yellowstone and Gallatin Rivers. Therefore it is not meaningful to think of connectivity within the HPBH WSA except in the few places where tributary streams might join. There is connectivity, for example, between Porcupine Creek and Elkhorn Creek but it occurs outside the WSA. However, for trout to be able to travel between streams in the HPBH WSA they require suitable stream conditions within the rivers, which is dependent upon cold, clear waters from the headwater streams. Therefore, although there is negligible connectivity within the HPBH WSA for trout, connectivity for all trout streams depends upon maintaining pristine conditions in the headwaters.

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Elk

Elk are highly migratory with distinct summer and winter ranges. They spend the summer at higher elevations where growing plants have higher nutritional content (Constan 1967, 1972, Chapman and Feldhammer 1982, Hall 1981, Foresman 2001). Elk forage selectively for grasses (Houston 1982, Irwin and Peek 1983, McCorquodale 1993, Unsworth et al. 1998). Very few if any elk remain in the higher elevations during winter. Movements in the Gallatin Range are primarily east-west. As winter snow accumulates, elk are forced to move to lower elevations such as the Gallatin and Paradise Valleys where they forage on mostly dead plant material in areas of light snow cover. These movements are altered by disturbance, particularly by humans in fall during hunting season, and by predators such as wolves. Many elk travel as far as Yellowstone Park to reach summer range.

In the Madison Valley Wildlife Assessment conducted by the Wildlife Conservation Society, protection of elk habitat also protected 322 other species (Brock et al. 2006). Additional information on elk ecology is available on line with the Montana Field Guides http://fieldguide.mt.gov/speciesDetail.aspx?elcode=AMALC01010

GYE Elk
Photo Credit: Lance Craighead

Elk have historically used the Gallatin Range as far back as there are records. In 1910 the Gallatin herd was one of the last elk herds in Montana; only about 5,000-6,000 elk remained in two areas at that time, Yellowstone Park and what is now the Bob Marshall Wilderness. The elk from Yellowstone Park in 1910 wintered in the West Gallatin and Yellowstone River drainages (Picton and Lonner 2008, Gehman 2010) so the elk using the HPBH WSA are among the oldest lineages in Montana. Allan Lovaas (1963,1970) studied the Gallatin elk herd for the Montana Fish and Game Department (now Fish, Wildlife, and Parks) and concluded that the main Gallatin elk herd has probably always dwelled year-long within the mountains. Areas like the Porcupine Creek drainage generally had less snow and milder conditions than other areas. Elk from Yellowstone Park would move to lower elevations in the Gallatin Range during winter, especially in years of heavy snow (Lovaas 1970). A study of migration routes completed by Regan Lyons in 2006 documented that the Gallatin Crest is a dividing line for most elk herds using the HPBHWSA (Figure 13): elk that summer east of the Crest migrate down to wintering areas on the east side along the Paradise Valley, while elk that summer west of the Crest move westward in winter although some often remain within the WSA in the Porcupine and Swan Creek drainages.

There are many more elk utilizing the east side of the Gallatins because there is more open grassland habitat there (Gehman 2010). Elk summering at the north end generally migrated northward from the Gallatin Face into the Gallatin Valley south of Bozeman. Some elk from Yellowstone National Park migrate into the Buffalo Horn drainage in winter and sometimes pass through into the Taylors Fork (Lyons 2006). Steven Gehman (2010) summarized elk distribution data for the Gallatin Mountains; FWP recognizes nine elk herd units that utilize the HPBH WSA based upon their wintering areas. About 5,000-6,000 elk were in those wintering areas in early 2010. Some winter ranges have been steadily decreasing in size, particularly near Bozeman, as more and more development removes habitat. However, there has been a recent trend of increasing numbers of elk north of Big Creek up to 2010 and on to 2014 (Gehman 2010, Loveless 2014).

The Gallatin elk herd is distributed through several Hunting Districts (HD): primarily HD 301, HD 309, HD 310, HD 312, and HD 314. Some elk at the southern tip of HD 393 use the Gallatin range, but that district is centered around the Bridger Mountains. The elk management plan objective range for HD 314 on the east side of the Gallatin Range is 2400-3600 elk: 3,908 were estimated in 2013; 3,654 in 2014 and 4,226 in 2015.. Elk have been increasing in the north end of the district but decreasing in the south. The largest group observed in aerial surveys (754) in March 2014 were just north of Big Creek (Loveless 2014). Elk in the northern portion of HD 314 (north of Big Creek) tend to remain there year-round primarily on private lands and high quality public lands in the HPBH WSA. Elk in the southern portion of HD 314 may migrate south to Yellowstone Park into the Upper Gallatin and Upper Gardiner River drainages during summer and mix with elk from the Yellowstone northern range (FWP 2011).

Overall, elk numbers have remained fairly constant since at least 2010 in all HDs comprising the Gallatin elk herd. Elk harvest has remained fairly constant in all HDs except HD 314 which reported lower numbers in 2011 (344), 2012 (282), and 2013 (269) from a high in 2010 (728). Harvest is managed by FWP to reach population objectives for each district. Elk status and distribution information can be downloaded at http://fwp.mt.gov/fishAndWildlife/management/elk/ . Elk harvest information can be downloaded at http://fwp.mt.gov/hunting/planahunt/harvestReports.html

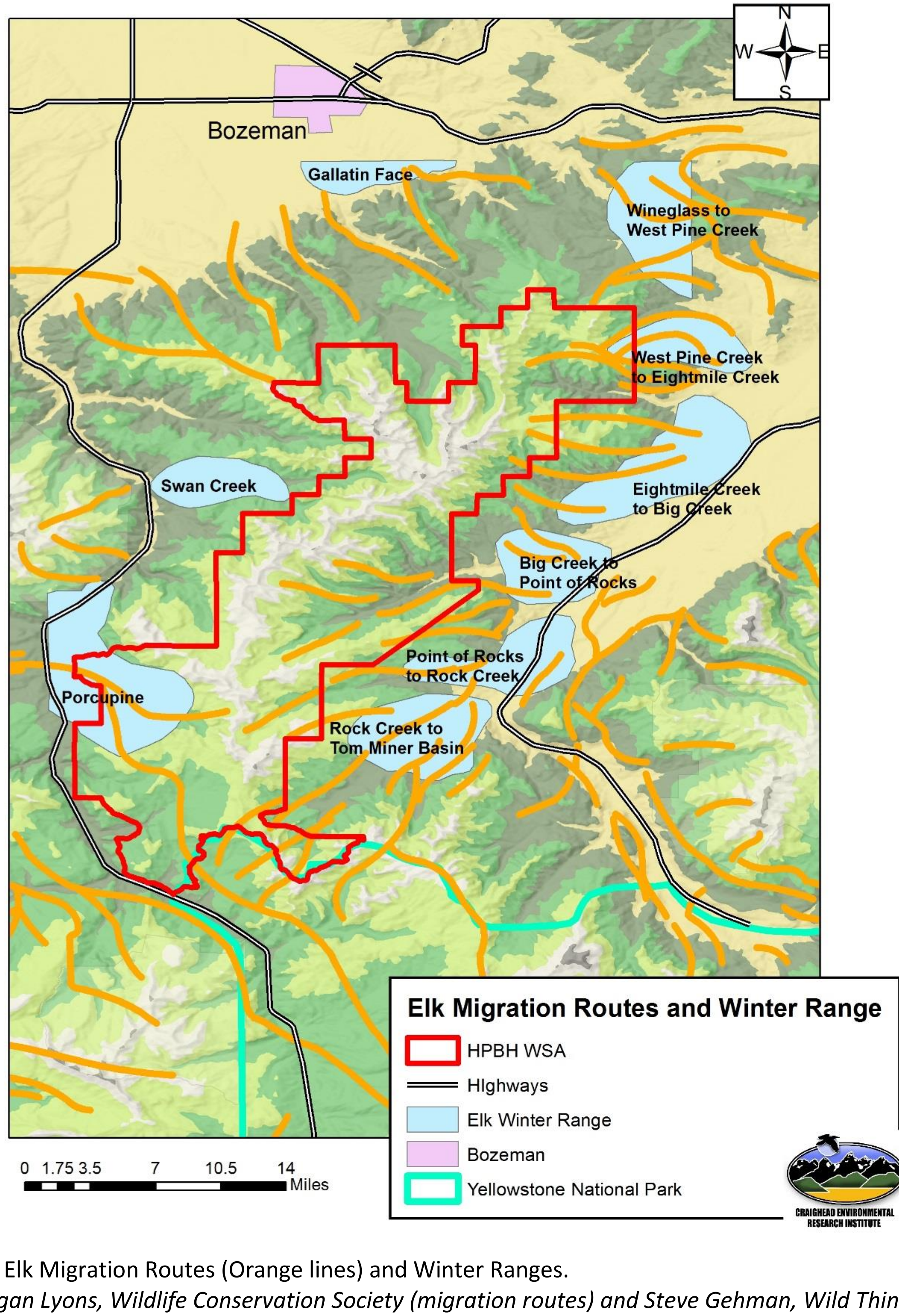

Figure 13. Elk Migration Routes (Orange lines) and Winter Ranges.
Credit: Regan Lyons, Wildlife Conservation Society (migration routes) and Steve Gehman, Wild Things Unlimited (winter ranges).

Vulnerability

Historically elk were probably the most widespread member of the deer family in North America. They were extirpated from most of their range by 1900 (Boyd and Cooperrider 1986). In Montana they survived in remote, isolated refugia until protection and reintroductions early in this century allowed recovery through much of their former range (Mussehl and Howell 1971).

Declines in elk use of habitat adjacent to forest roads have been documented in most of the North American range (Hershey and Leege 1976, Lyon 1979, Marcum 1976, Perry and Overly 1976, 1977, Rost and Bailey 1974, Rost 1979, Thomas et al. 1979, Ward 1976). Lyon (1983) found that: "evidence was consistent and overwhelming that vehicular traffic on forest roads evokes an avoidance response by elk. Even though habitat near roads is not denied to elk, it is not fully used". As a result of Lyon's analyses U.S. Forest Service guidelines were developed which restricted activities on big game winter range from December 1 through May 15 and elk habitat effectiveness (security areas for elk) required an open road density standard of 0.75 miles/sq. mile or less. Components of elk security include vegetation density, road density, distance from roads, extent of area and size of vegetation blocks, hunter density, timing and length of hunting season and land ownership (MDFWP 1992).

A critical component of habitat, particularly during hunting seasons and winter, is adequate security. Elk habitat has been managed generally to provide security from predators and humans so that they can survive and reproduce under conditions that are natural and are free of the stress provided by human disturbance (Rowland et al. 2005, Thomas 1991). Secure habitat for reproduction is essential for ensuring population growth, while secure habitat at other times of the year is important for ensuring survival and health. Elk security has been defined by Lyon and Christiansen (1990) and others. Further definition and guidelines for retaining elk security west of the Continental Divide in Montana were developed by Hillis et al. (1991). These guidelines were based upon the facts that 1) elk behavior changes in response to the hunting season, 2) elk avoid areas adjacent to roads with vehicular traffic, especially during the hunting season, 3) elk spend more time in dense cover during hunting season than they do before the hunting season, 4) elk movements generally are confined to habitats within a traditionally used home range, and 5) road closures may either increase or decrease elk vulnerability depending upon the influences of cover, topography and hunting pressure, both within and adjacent to a security area (see Hillis et al. 1991 for citations). These guidelines are considered outdated and recommended that security area minimums should be equal to or greater than 250 acres in size, equal to or greater than one half mile (0.8 km) from an open road, and should comprise at least 30% of a valid analysis unit (Hillis et al. 1991).

These guidelines have been used by the Forest Service across all western forests even though habitat components in many forests are different from the areas where the data were collected to develop the guidelines (Lolo NF): those have been the best data available. Currently however there is a project underway in the Gallatin NF to develop new guidelines based upon data from GPS collars on elk that promises to provide a more accurate and refined picture of elk security requirements (Garrott, pers. comm. 2015). The collars were placed on elk in the Gallatin NF as part of a study of brucellosis and the detailed location data that they reveal is being analyzed in the context of roads, trails, and habitat in a joint project with the US Forest Service (Custer Gallatin NF) and the Montana Department of Fish, Wildlife, and Parks (FWP). The results should add greatly to our understanding of the effects of recreation in the HPBH WSA, as well as in similar forests. Recent amendments to the Helena NF Forest Plan use 1,000 roadless acres as the size for elk security (Canfield, pers comm. 2015).

Elk, roads, and trails.

There have been a number of studies on the effects of recreation activities on elk. A recent literature review by McCorquodale (2013) with the Washington Department of Fish and Wildlife summarizes research on ways roads (and motorized trails) may potentially affect elk: 1) physiologic and energetic effects, 2) effects on distribution and habitat use, and 3) effects on vulnerability to mortality and, potentially, population dynamics. Naylor (2006, Naylor et al. 2009) found that off-road recreation produces a change in elk behavior. Results of studies in a 3,590 acre section of the study area demonstrated that activity budgets of elk were altered during exposure to off-road recreation disturbance in a 25,000 acre elk summer range in Oregon at the Starkey Experimental Forest and Range. Elk increased their travel time during most disturbance, which reduced time spent feeding or resting. Elk travel time was highest during ATV exposure, followed by exposure to mountain biking, hiking, and horseback riding. Elk reacted negatively to ATV traffic at distances up to 1,000 meters and had a high probability of fleeing if they were near an ATV trail when ATVs were detected. It appeared that elk would habituate to horseback riding, but not to mountain biking.

In one well-designed study, Wisdom et al. (2004) observed increases in elk flight response and movement rates related to human recreational use in the same 3,590 acre section of the Starkey Experimental Forest and Range in Oregon. Elk flight response was greatest for ORV use, followed by mountain biking, and finally human hikers and horseback riders. "Higher probabilities of flight response occurred during ATV and mountain bike activity, in contrast to lower probabilities observed during hiking and horseback riding. Probability of a flight response declined most rapidly during hiking, with little effect when hikers were beyond 500 meters from an elk. …Higher probabilities of elk flight continued beyond 750 meters from horseback riders, and 1,500 meters from mountain bike and ATV riders." Significantly, an increase in movement rates at sunrise and sunset following daytime ORV and mountain-biking use was observed, suggesting the elk are displaced from preferred security and foraging activities following human use. Only one pair of ATV users were needed to cover the 20-mile study area, but two pairs of mountain bikers and three pairs of hikers were needed to cover the distance in the time allotted, underscoring the different relative distances that the three groups are capable of covering.

Recreational opportunities associated with elk are economically important and can generate revenues from hunters, wildlife watchers, and photographers. Disturbance from these types of recreation users can induce stress in elk particularly during hunting season, in winter when they are restricted to lower elevations, and in spring when they seek forage in areas free of snow that are also sought by recreationists (Canfield et al. 1999). Elk response to humans can be similar to predator avoidance behavior. When wolves were present, elk in portions of the HPBH WSA stayed in areas that were closer to conifers, and used open grasslands more heavily when wolves were absent (Creel et al. 2005).

Vieira (2000) studied the effects of both pedestrian and ATV (four wheeler) effects on movement patterns of elk in a White River, Colorado, study area. The mean distance moved by the elk in response to the ATV was more than twice the pedestrian mean. Vieira was able to measure the distance traveled by each elk in response by using radio collared elk tracked by airplane. ATV use by hunters on public lands was considered responsible for greater flight distances and greater chances of elk entering private land. A study comparing responses of elk to ATV's, mountain biking, hiking, and horseback riding (Naylor et al. 2009) found that elk spent less time resting and more time travelling in response to the disturbance. ATV use caused the greatest disturbance (increase in travel and reduced resting time) followed by mountain biking, hiking, and horseback riding.

A study of the response of elk to ATV use along a 32 km (20 mi) trail demonstrated that elk respond with flight or avoidance behavior up to 1 km from humans on ATV's. Elk displayed avoidance of the trail even when no ATV's or other users were present (Wisdom et al. 2004, 2005). Snowmobiles have been shown to cause less disturbance then skiers or people on foot (Parker et al. 1984). However, this may not be important in the HPBH WSA since elk winter range is at lower elevations, often on private lands, which is not as heavily used by either skiers or snowmobiles. Aune (1981) documented some displacement of wildlife by winter recreation in Yellowstone Park by inhibiting movement across roads to preferred foraging areas and displacing them from areas adjacent to roads.

A literature review by Snetsinger and White (2009) found documentation of negative impacts on elk from snowmobiles, skiing, hiking, biking, horseback riding, human presence, trails, and developed recreation sites. Flight responses have been recorded for elk up to 650 m from skiers (Cassirer et al. 1992); 500 m from hikers and horseback riders; and 1500 m from bikers (Wisdom et al. 2004). Elk were observed fleeing further distances from bikers than from hikers or horseback riders (Wisdom et al. 2004, 2005). As any Montana elk hunter knows, elk can be approached more closely on horseback than on foot even during hunting season; and either method is much more effective than using a motorized vehicle except in unusual cases where elk are habituated or cornered. Wisdom et al. (2004, 2005) also found that elk were slightly less sensitive to horseback riders than to hikers or bikers.

Rowland et al. (2005) summarized the benefits or road closures for elk:

- Decreased energy expenditure by elk, a result of less frequent disturbance by motorized vehicles, with potential improvements in animal performance.
- Increases in total amount of effective habitat for elk in the area affected by the closures.
- Increased hunting opportunities on public lands, when roads are closed on public lands adjacent

to comparatively less-roaded private lands, thereby enticing elk to remain on public lands rather than moving to private lands where hunting may not be allowed or is prohibitively expensive (Wertz et al. 2004).

• Decreased damage to crops and haystacks from elk on private lands, due to decreased disturbance from traffic on public land, which in turn causes elk to remain on public land longer during the fall and winter seasons.

• Improvements in diet quality when elk are able to forage undisturbed in areas previously avoided due to excessive motorized traffic; these changes may translate into improvements in animal fitness and population performance.

• Increased hunter satisfaction from the opportunity to hunt in a roadless area or the use of all terrain vehicles on closed roads or other "off-highway" sites (Gratson and Whitman 2000).

• Decreased vulnerability of elk during hunting seasons, due to fewer hunters willing to hunt without a vehicle or able to access the area.

Important Habitat Areas

Figure 13 demonstrates that most of the HPBH WSA is important spring and summer range for elk. In fall elk generally stay at the higher elevations as long as possible until forced down by deepening snow. Most elk also stay in the high country because there is less pressure from elk hunters. In other areas, where there is easier access to the high country by hunters, elk appear to have learned to descend quickly through the mid-elevations and stay on their winter ranges if they are on private lands where there is also less hunting pressure. At this time of year elk can sometimes be observed bouncing back and forth from private lands to public lands as they are displaced by hunters or occasionally wolves. Wolves prefer flatter terrain than most of the HPBH WSA and therefore impact elk primarily during late fall and winter.

Elk and Connectivity

Elk tend to use the HPBH WSA for spring and summer range and to move through other parts of the Gallatin National Forest when migrating to and from winter range. Therefore, most connectivity habitat is located on the edges of the HPBH WSA and adjacent to it. One exception to this pattern however is the importance of the southern end of the HPBH WSA as a migration corridor for elk from Yellowstone Park moving to and from the Madison Valley and areas in Gallatin Canyon. The Buffalo Horn drainage in particular is very important for regional connectivity for elk

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Grizzly Bear

Grizzly bears are one of the most well studied species in North America; they are also considered one of the best examples of an 'umbrella' or 'focal' species for conservation (Merrill et. al. 1999, Brock et al. 2006, Brock and Atkinson 2013). Weaver (2014) used grizzly bears as a key focal species for use in planning on the Flathead National Forest (Weaver 2014). They are omnivorous animals with low reproductive rates and prefer habitat that is remote from roads and other disturbance. Information on grizzly ecology can be found in the Montana Field Guide: http://fieldguide.mt.gov/speciesDetail.aspx?elcode=AMAJB01020
Grizzlies have re-colonized the HPBH WSA beginning in the 1970's after being mostly extirpated from the area (see discussion below). They were listed as threatened under the Endangered Species Act in 1975. The Yellowstone Population was designated as a Distinct Population Segment and was removed from Threatened status in 2007 (USFWS 2007) but then re-listed by court order in 2009. This re-listing was upheld under appeal by a 9th Circuit Court Order in 2011. Their Threatened status is currently under review and the U.S. Fish and Wildlife Service should make a decision sometime in 2015.

Female grizzly with cubs
Photo Credit: Lance Craighead

Grizzly bears in the Greater Yellowstone Ecosystem displayed stable or increasing populations from 2002-2011 (IGBST 2012) and continue to expand (IGBST 2014). As the population grows and expands, primarily younger bears are dispersing out of the core protected areas into additional areas of good habitat. The Interagency Grizzly Bear Study Team (IGBST) has mapped the distribution of the Yellowstone population over time. These data, available at the IBST website (http://www.nrmsc.usgs.gov/research/igbst-home.htm) document a gradual expansion of the population out from the Yellowstone Park core area. By 2014, all inventoried roadless areas south of Interstate 90 in the region were inhabited by grizzly bears (Figure14). These areas, including the HPBH WSA are critical to maintaining the Yellowstone population, regardless of their status as threatened under the ESA or not. The HPBH WSA and other high elevation areas will become even more important for grizzly bear population persistence as the climate warms. Areas with little human disturbance are critically important for living and denning habitat, and will be even more so if grizzlies are delisted and a hunting season is opened.

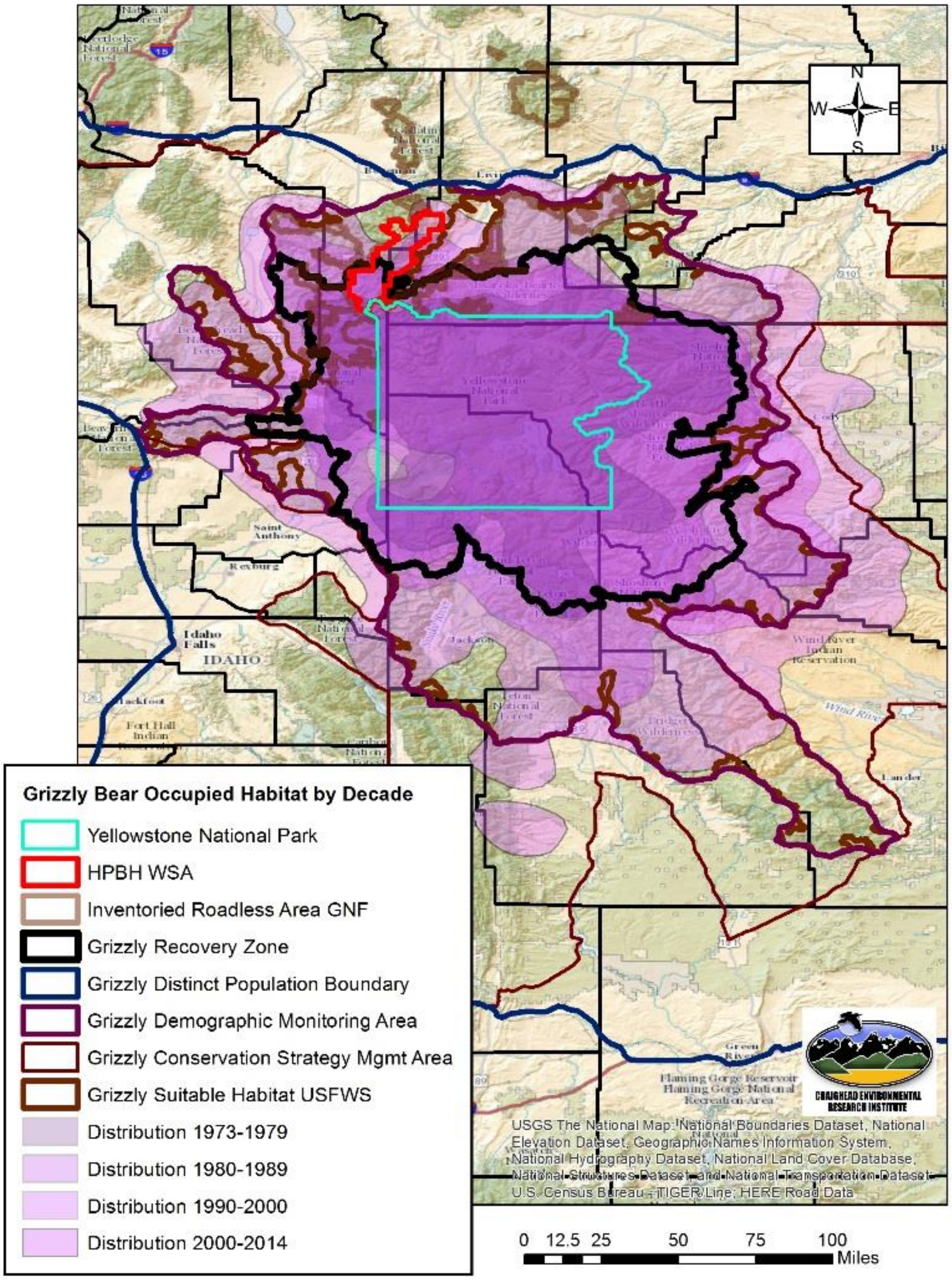

Figure 14. Regional Distribution of Grizzly Bears by Decade in the Greater Yellowstone Ecosystem.
Credit: Interagency Grizzly Bear Study Team.
https://www.sciencebase.gov/catalog/item/554ceb27e4b082ec54129da3

From 1973-1979 grizzlies only occupied the southern tip of the HPBH WSA. From 1980-1989 the population expanded to include the Porcupine Creek and Rock Creek drainages and the headwaters of Big Creek. From 1990-2000 the population expanded primarily on the eastern half of the HPBH WSA to include the Big Creek, Dry Creek, and Fridley Creek drainages. By 2014, grizzly bears had been documented as using almost all of the HPBH WSA except for a small block of land at the headwaters of Fox Creek (Figure 15). The distribution of the grizzly bear population has continued to expand since 2014.

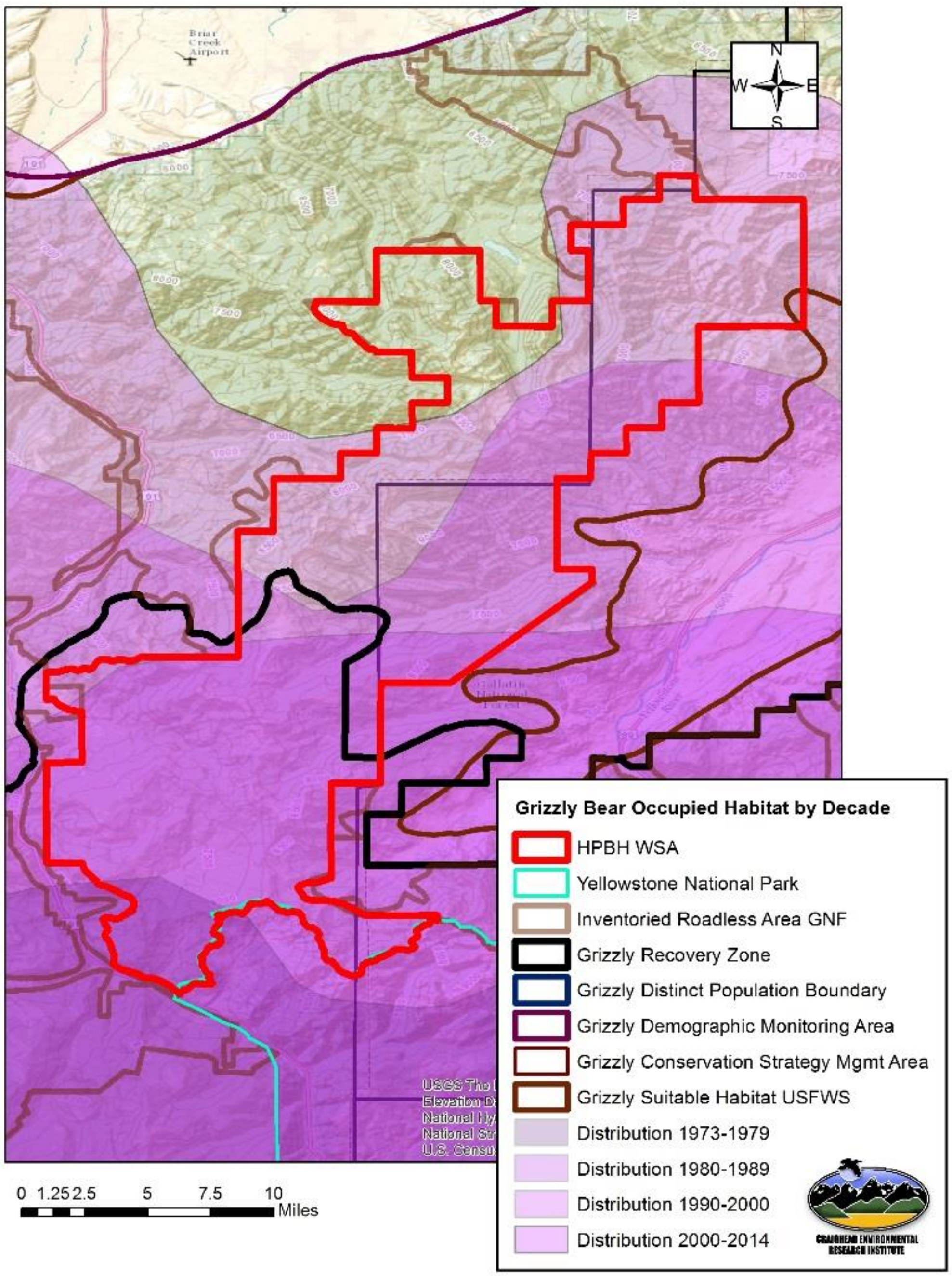

Figure 15. Grizzly Bear Population Expansion by Decade in the HPBH WSA.
Credit: Interagency Grizzly Bear Study Team.
https://www.sciencebase.gov/catalog/item/554ceb27e4b082ec54129da3

The southern portion of the HPBH WSA, south of the headwaters of Big Creek and Portal Creek, is within the Gallatin 3 bear management subunit, and is within the Grizzly Bear Recovery Zone.

The entire HPBH WSA, (except for a tiny corner where the HPBH WSA border crosses Eightmile Creek), is considered suitable grizzly bear habitat by the USFWS. The entire HPBH WSA is within the boundaries of the USFWS Distinct Population Boundary, Demographic Monitoring Area, and Conservation Strategy Management Area.

Gehman (2010) summarized information on grizzly bear distribution in the HPBH WSA and updated his report in 2012. On the basis of observations, track counts, and DNA from hair snares over 32 drainages in the Gallatins he documented 57 grizzly hair samples representing 10 different male grizzlies outside of Tom Miner basin. A total of 28 genetically identified grizzly bears were sampled in the Gallatin Range outside of Yellowstone National Park. It is likely that all of these bears utilized some portion of the HPBH WSA. By 2011 Gehman had documented grizzly bear tracks and/or DNA from hair samples as far north as Big Creek and the headwaters of Trail Creek.

As the grizzly bear population has continued to expand, the management focus for the Interagency Grizzly Bear Committee (which includes Montana FWP, the USFWS and the USFS) has shifted from reducing mortality of grizzlies within the Grizzly Bear Primary Conservation Area (PCA or Recovery Zone) towards providing security and protection for grizzlies in areas outside the current Grizzly Bear PCA wherever appropriate. The southern end of the HPBH WSA (Buffalo Horn) is within the Primary Conservation Area. The rest of the HPBH WSA falls within the Bozeman Bear Analysis Unit (BAU). BAUs are areas determined by the state to be biologically suitable and socially acceptable for grizzly bear occupancy; they were established by the 2006 Forest Plan Amendment to be comparable in size to Bear Management Unit (BMU) subunits inside the PCA. The Montana State Grizzly Bear Management Plan recommends and encourages federal land management agencies to maintain habitat in BAUs, and the 2006 Forest Plan Amendment requires the monitoring of changes in percent secure habitat every 2 years in National Forests in the GYE. These changes are measured against the 2008 transportation layer developed by Gallatin National Forest.

Since many of the areas being colonized are not contiguous with protected areas, and the intervening landscape is often fragmented by roads, trails, and developments, it is increasingly important to identify key linkage zones between the secure core areas, and protect habitat in those zones, so that outlying areas can become effective cores in the greater metapopulation of grizzly bears. For mammals such as the grizzly bear, habitat connectivity is important for individual bears to meet their requirements for feeding, mating, denning and movement within and between habitat areas. At a metapopulation level, dispersal between population centers is important for population persistence (Boyce et al. 2001, Levins 1970, Hanski and Gilpin 1997). Maintaining a Discrete Population Segment (DPS) such as the Yellowstone population, or an ecosystem with grizzly bears is thus an ecoregional conservation problem and in some cases may involve multiple ecoregions (Craighead and Vyse 1996).

Grizzly bears are an important umbrella species. In the Madison Valley Wildlife Assessment conducted by the Wildlife Conservation Society, protection of WCT habitat also protected 300 other species out of 411 (Brock et al. 2006). In the HPBH WSA they utilize all habitats, with the exception of rock and the highest elevation alpine areas, at some time of year.

Vulnerability

Although grizzly bears have widely varied diets, in the GYE they feed heavily on four key foods: whitebark pine, Yellowstone cutthroat trout, Army cutworm moths, and ungulates. Whitebark pine is declining in many portions of the Yellowstone area due to mountain pine beetles, white pine blister rust, and global warming. Yellowstone cutthroat trout have been reduced due to the introduction of lake trout in Yellowstone Lake. Army cutworm moths may suffer declines due to climate change or control of the larvae by pesticides in alfalfa and wheat fields. No studies have yet been done to determine what their main foods are in the HPBH WSA, but it is unlikely that cutthroat trout are a significant food source since there are no concentrated areas of trout spawning such as there are in Yellowstone Park.

In 2015 the Wildlife Conservation Society completed a survey of a small group of experts to examine their perspectives on the effects of climate change on grizzly bears and connectivity for bears (Cross 2015. in preparation). Three aspects relating to grizzly bears were addressed: climate change effects on security cover, climate change effects on grizzly food resources, and climate change effects on human land use and other threats to grizzly bears. While the experts indicated several ways in which changes in climate may influence the location and quality of grizzly bear connectivity linkages, overall they felt the most important factors influencing grizzly bear linkages in the foreseeable future are factors related to human tolerance for bears, the risk of mortality or conflict for bears, and increased development on private lands. These findings were similar to a similar workshop held in 2009 (Cross and Servheen 2009). Increased activity and/or development on public lands was not addressed in the survey but it will very likely be a relevant factor determining where grizzly bears can live and travel in the future; especially as human populations increase. Indirect effects of climate change will include migration of human populations from unfavorable climates such as coastal areas and dry areas to higher elevations with better living conditions (Warner et al. 2009) where they will put increasing pressure on natural resources including wildlife.

Grizzly bears, roads, and trails

Effects of human activities on grizzly bears are complicated by the relationship between the habitat type, the spatial distribution of habitat and disturbance, and the type of disturbance or mortality. Despite the variation in habitat and disturbance factors, there are consistent effects of human activities on bears at the local level. Although bears in Yellowstone and Montana were fully protected, human caused mortality comprised 86-91% of adult bear mortality up to 1995 (Weaver et al. 1996). Female mortality is particularly critical to population viability so that even small incremental increases in mortality risk or disturbance are a threat within occupied habitat (Mattson and Reid 1991, Mattson and Craighead 1994).

Roads have been shown to be the most important variable correlating human influence on grizzly habitat. Trails with motorized traffic have effects on wildlife that are similar to roads. Almost all studies have shown negative impacts (Elgmork 1978, Zager 1980; Zager et al. 1983, Archibald et al. 1987, Mattson et al. 1987, McLellan and Shackleton 1988, Kasworm and Manley 1990). Illegal killing and management control (removal of habituated bears) are the two main sources of adult bear mortality in the Greater Yellowstone Ecosystem or GYE (Mattson et al. 1987, Weaver et al. 1996), and both are associated with roads. Road use by humans may also disrupt bear behavior and social structure, reduce the availability of adjacent foraging habitats, and create barriers to movement (Archibald et al. 1987, McLellan and Shackleton 1988, McLellan 1990). These effects may extend up to three kilometers from primary roads and one to 1.5 km from secondary roads (Kasworm and Manley, 1990; Mattson and Knight, 1991). In the GYE roads with buffer areas represented 32.9% of the area, but accounted for 70.3% of bear mortalities (Mattson and Knight 1991), therefore the mortality risk is almost five times higher near roads (Doak 1995). Craighead et al. (1995) concluded that road densities higher than 1 km/6.4 km^2 (one third the threshold set by agencies at that time) are suboptimal for bears.

Waller and Servheen (2005) used GPS collars to record grizzly movement data every hour in Glacier Park for 4 years. They found that the barrier effect of Highway 2, along the southern boundary of Glacier National Park, depended upon traffic volume; particularly at night when most bears tried to cross. Roads were complete barriers to grizzly movement when traffic volume exceeded 100 vehicles per hour. They found that the only reason grizzlies could cross highways at all was due to very low traffic volume during evening and night hours (Waller and Servheen 2005). A follow-up study from 2012-2013 found that traffic volumes had increased to the point where bears were unable to cross at least 12 hours out of the day, but even lower traffic volumes caused strong avoidance of the highway by bears (Waller and Miller 2015).

Recreational development increases bear mortality risk and alienates bears from preferred habitats such as riparian areas. The effect of developments on mortality extends up to 6 km from the recreational site (Mattson and Knight 1991). Even non-motorized trails may be avoided to a distance of 300 m (Kasworm and Manley 1990, Mace et al. 1996). Mace and Waller (1998) found that in the Jewel Basin hiking area east of Kalispell, Montana, bear use increased with greater distance from trails and lakes with campsites. Grizzlies and other animals can be displaced from needed resources by human activities on trails, often without the knowledge of recreationists. Cole and Knight (1990) referred to this as "unintentional harassment of animals" and noted that "entry into grizzly bear habitat can displace bears, or, where bears habituate to humans, lead to encounters that eventually result in destruction of the bear". As with all animals living in habitat that is near the carrying capacity for the species, displacement generally means death. If a bear is displaced from an area needed for its survival it is forced to move into other, already occupied habitat. If it encounters a more dominant bear in the new place it may be killed or displaced further into areas occupied by other bears. If the new bear kills or displaces the bear that was occupying the habitat, the result is the same: one less bear in the population.

In a review of mountain biking impacts (Quinn and Chernoff 2010) noted that:

> " 'The sudden encounter is the most common situation associated with grizzly bear inflicted injury' (Herrero 1989). Mountain bikers are at particular risk of this type of

encounter because the potential speed and relative silence of a biker may facilitate closer proximity to bears before being detected. Schmor (1999) interviewed 41 mountain bikers in the Calgary region who cycled in the Rocky Mountains. The responses indicated that 84% of survey participants had come within 50 m of a bear while mountain biking and 66% of the encounters clearly startled the bear. Herrero & Herrero (2000) studied incidence of conflict/interaction between humans and grizzly bears (Ursus arctos horribilis) along the Moraine Lake Highline Trail in Banff National Park. They found that, though intensity of use was much lower for mountain bikers than for hikers along this trail, mountain bikers accounted for a disproportionately high incidence of conflict with bears. Herrero and Herrero (2000) suggest that grizzly bears are more likely to attack if a human is closer than 50 m before being detected. The speed and relative silence of mountain bikes, especially when combined with environmental factors (e.g., dense vegetation, hilly terrain, sound of running water), likely contributed to mountain bikers approaching bears closer than 50m before being detected by the bear. Parks Canada instituted a requirement to travel in tight groups of at least six, which has reduced human-bear conflict in the area (Simic 2007)."

Yellowstone National Park contains 867 km of roads and sees more than three million visitors a year (Craighead et al. 1995) yet most of its 600-700 grizzly bears are never seen near the road s. The impact of recreational development and associated roads reduces the ability of national parks to function as core security areas for grizzly bears (Gibeau et al. 1996). Bears inhabiting "multiple-use" lands surrounding parks face additional threats. Habitat outside the parks can be managed by the use of road density standards to provide security for grizzly bears (Mattson 1993). The historical decline of the grizzly was associated with the expansion of livestock grazing, especially of sheep, and associated predator control (Peek et al. 1987, Mattson 1990). Livestock depredation-associated killing remains the second most important mortality source for bears in Canada (McLellan 1990) where grizzly bears and cattle ranching overlap. Mineral and gas exploration forms another important disturbance source, primarily through associated road development (McLellan and Shackleton 1988, McLellan 1990). One exception to the rule that motorized use is more disruptive than foot traffic appears to be when the motorized use is predictable and routine and traffic does not stop but continues moving. McLellan and Shackleton (1988), indicated that grizzly bears reacted more strongly to people on foot in remote areas than to motorized equipment in more developed areas. Grizzly bears that encountered people on foot in remote areas left the creek drainage, while those grizzly bears that encountered logging equipment and motor vehicles in roaded areas moved to cover but remained in the area. Weilgus et al. (2002) found that grizzly bears did not select against (avoid) restricted roads with only logging traffic.

Extensive road networks can act as population sinks with high rates of human-caused bear mortality due to legal and illegal hunting and defence-of-life shooting (Ciarniello et al. 2007). Ciarniello et al. (2007) compared two study areas (SA) in central British Columbia: The plateau study area (Parsnip) had resource development (12% logged) with an extensive road network, while the mountain study area (Hart Mountains) was relatively pristine (2% logged). Six of nine bears shot by hunters were within 100 m of a secondary or decommissioned logging road. Five grizzly bears were killed illegally in the more roaded plateau area (four not reported to authorities), while there were no illegal kills detected in the less developed mountain study area.

Grizzly bears have been extirpated from the lowlands throughout Montana that once supported much of their population and they are now generally confined to higher-elevation regions in the Rocky Mountains. Within these regions, human development often converges with the critical lower elevations in spring habitat (Mattson et al. 1987, Mace et al. 1996, Gibeau et al. 1996). Grizzly bear dispersal across human dominated landscapes is often associated with an elevated mortality risk because they can be vulnerable to being attracted to human associated food sources (Mace and Waller 1998). Subadult females establish home ranges near their natal home ranges; either overlapping with, or adjacent to, their mother's home range (Craighead et. al. 1999). Thus, range expansion or re-colonization of empty habitat requires contiguous habitat within which females can establish home ranges, breed, and their female offspring can do likewise. Population expansion occurs incrementally; one female home range at a time.

The only effective barriers to grizzly dispersal (other than very large bodies of water) are caused by human activities (Craighead and Vyse 1996). Although grizzlies are capable of long distance dispersal, none of 460 radio-tagged grizzlies have traveled between the large core reserves in the Northern Rockies up through 1996 (Servheen, personal communication reported in Weaver et al. 1996) and none have been tracked there since. It is likely that barriers caused by human activities have impeded these longer movements since grizzlies in contiguous habitat unaltered by humans often travel this far.

In 1996 The Gallatin NF plan added Amendment #19, the Grizzly Bear Recovery Amendment. This was in response to a 1995 amended biological opinion provided by the US Fish and Wildlife Service for national forests in the Greater Yellowstone Area. This amendment modified previous Forest Plan management direction for recovery of the "threatened" grizzly bear, as it relates to open motorized route density, with the following guidelines for the grizzly bear recovery zone:

1. Allow no increase open motorized access route density.
2. Allow no increase in total motorized access route density.
3. Allow no decrease in the amount of core area from the current levels.

This amendment was nullified due to the delisting of the grizzly bear in April 2007 and the amendment of Forest Plans to adopt the Grizzly Bear Conservation Strategy. See Amendment #27. However, it has been reinstated following re-listing of the grizzly.

Important Habitat Areas

All of the HPBH WSA is important habitat for the grizzly bear; it is within the state conservation strategy management area and is suitable habitat according to the FWS; it is also occupied habitat according to the IGBST. Grizzlies primarily use mid-slope and subalpine habitats, but also make use of lower elevations and alpine areas. They also travel across alpine areas to get from one drainage to another.

Grizzly Bears and Connectivity

Grizzly bears, like wolverines, require large areas of habitat to persist. Male grizzlies also disperse long distances and can genetically maintain a metapopulation structure if there is sufficient habitat for connectivity between core populations. Female grizzlies, unlike wolverines, do not disperse long distances; female offspring invariably establish home ranges adjacent to, or overlapping with, their mother's home range.

In general, a metapopulation can have a greater probability of persistence than isolated single populations. At a metapopulation level, dispersal between population centers is important for population persistence (Levins 1970, Hanski and Gilpin 1997). Providing for dispersal between local populations helps ensure genetic exchange, as well as allowing for immigration and emigration in response to epidemic disease, insect outbreaks, climate change or large scale fire that might extirpate one or several local populations (Breitenmoser et al. 2001, Hedrick 1996, Hedrick and Gilpin 1996). Historic evidence supports the existence of a true metapopulation structure for grizzly bears in the contiguous United States and habitat modeling indicates that the potential remains for a metapopulation structure to be re-established (Craighead and Vyse 1996).

The first connectivity model for grizzly bears was published by Walker and Craighead in the Proceedings of the ESRI Users Conference (Walker and Craighead 1997). The primary movement route, using a least-cost-path, between the GYE and the NCDE includes the HPBH WSA (Figure 16). Red denotes the highest value corridor habitat followed by green and then blue. This model has been refined, and other modeling approaches have been developed since 1997, but all of them include this corridor.

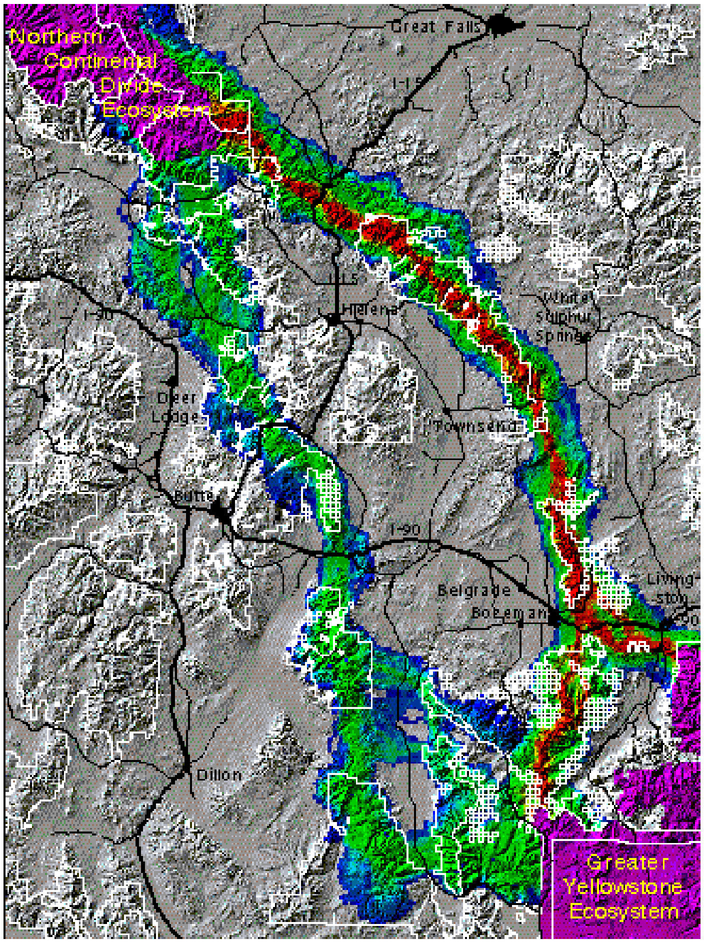

Figure 16. Least Cost Path Corridors for Grizzlies Between GYE and NCDE.
Credit: American Wildlands, Richard Walker and Lance Craighead

Connectivity for grizzly bear metapopulations can occur at two levels; 1) Genetic connectivity can be established over fairly long distances (average dispersal distance 200 km) by male bears moving between population centers. Habitat between populations needs only to be adequate for travel and survival of a male bear over a period of weeks. 2) Demographic connectivity can be established in nature only by female bears gradually occupying habitat between larger, more secure, habitat blocks. For female movement to colonize uninhabited areas such as the central Idaho wilderness from the GYE, this could take decades or centuries but will only happen if there is sufficient habitat in between for females with families to live and persist. However, besides natural dispersal, female and male bears can be transplanted by wildlife management agencies into empty habitat.

Evidence for historic grizzly bear connectivity suggests that the GYE population was connected to the west and north through the Centennial Mountains to the Selway-Bitterroot ecosystem, to the Cabinet-Yaak ecosystem, and ultimately to Canadian populations (Mattson and Merrill 2002, Merrill et al. 2005). Other evidence indicates historic connectivity to the Northern Continental Divide Ecosystem (NCDE) through the Tobacco Root, Highland, Champion-Thunderbolt and/or Elkhorn mountains (Picton 1986, Merriam 1922). It is also likely that grizzlies had connectivity to the NCDE through the HPBH WSA area, the Bridger and Little Belt Mountains. Grizzlies inhabited the Little Belts as recently as the 1960's (Aune, Pers. Comm. 1996)

Maintaining all options for grizzly bear connectivity to other population centers such as the NCDE is critical for the long-term persistence of the GYE grizzly bear population. Even large and protected reserves such as the GYE are too small to maintain viable populations of large mammals if they are isolated (Soule 1980; Belovsky, 1987; Allendorf et al. 1990). An isolated population of 600-800 bears requires gene flow from other populations to maintain and increase genetic variability. Current estimates of the genetic Effective Population Size (Ne) of the Yellowstone population range from only 13-65 (Paetkau et al. 1997) to slightly over 100 (Miller and Waits 2003), well below the level of 500-5000 recommended for preventing genetic impoverishment. The retained genetic heterozygosity has been estimated at from 55% (Paetkau et al. 1997, Craighead et al. 1999) to 75% which is less than zoos manage for, and the inbreeding coefficient of grizzly bears in the Yellowstone population is estimated at 0.125: this is what one would get from a marriage of first cousins (Gilpin, pers. comm. 2006). The main factor affecting levels of genetic diversity appears to be connectedness to larger populations (Paetkau et al. 1997)

From a genetic standpoint, maintaining a corridor for connectivity through the HPBH WSA to the NCDE, will be very important for the persistence of grizzly bears in the GYE, particularly as climate change and land use change alter current grizzly bear habitat. In 2007 grizzly bear habitat and connectivity was modeled by the Craighead Institute for the entire northern Rockies region of the U.S. (Figures 17 and 18). The study found that the HPBH WSA is important living habitat as well as part of a key movement corridor for grizzlies.

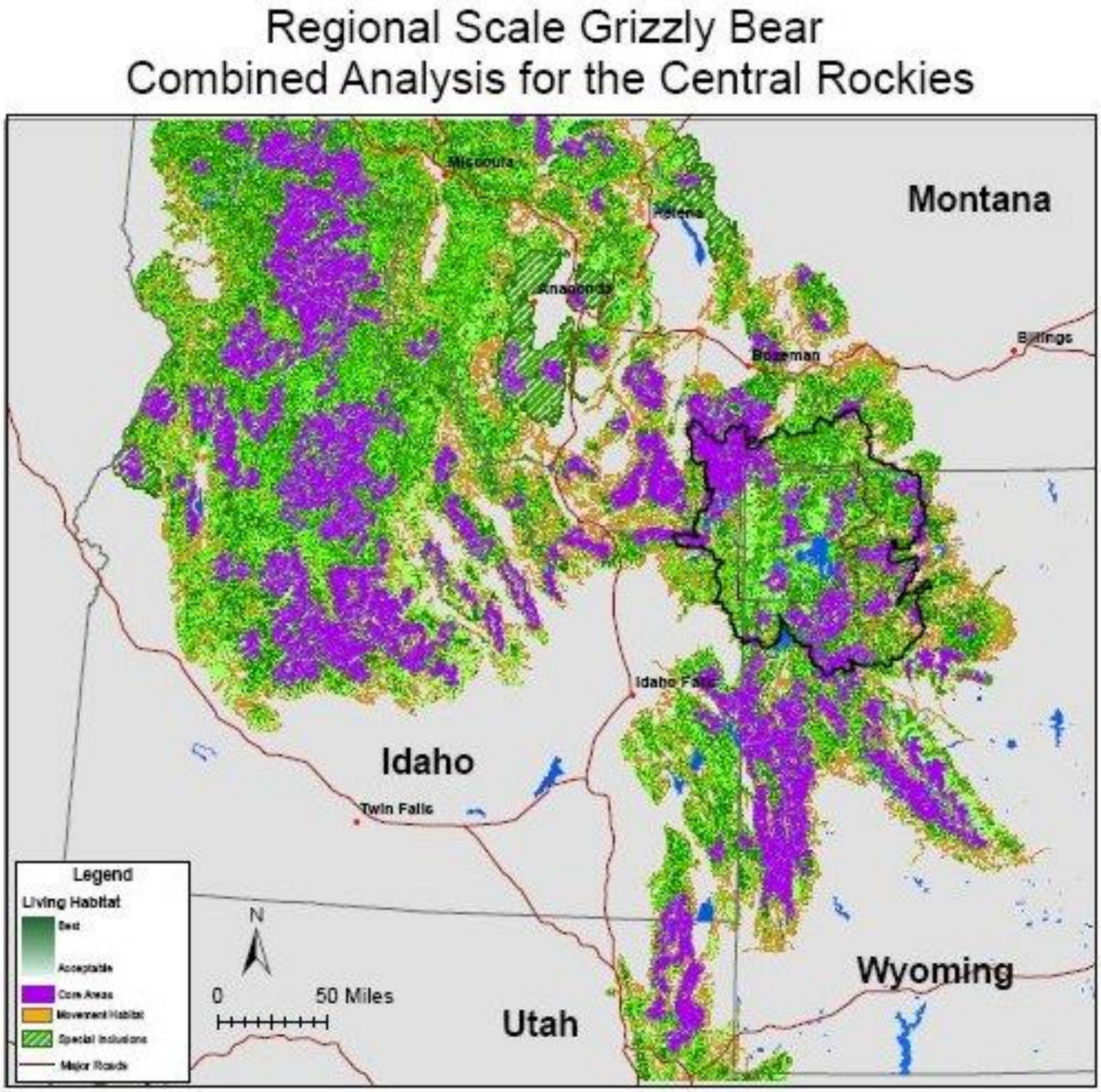

Figure 17. Combined grizzly living and connectivity habitat.
Credit: Craighead Institute, Thomas Olenicki

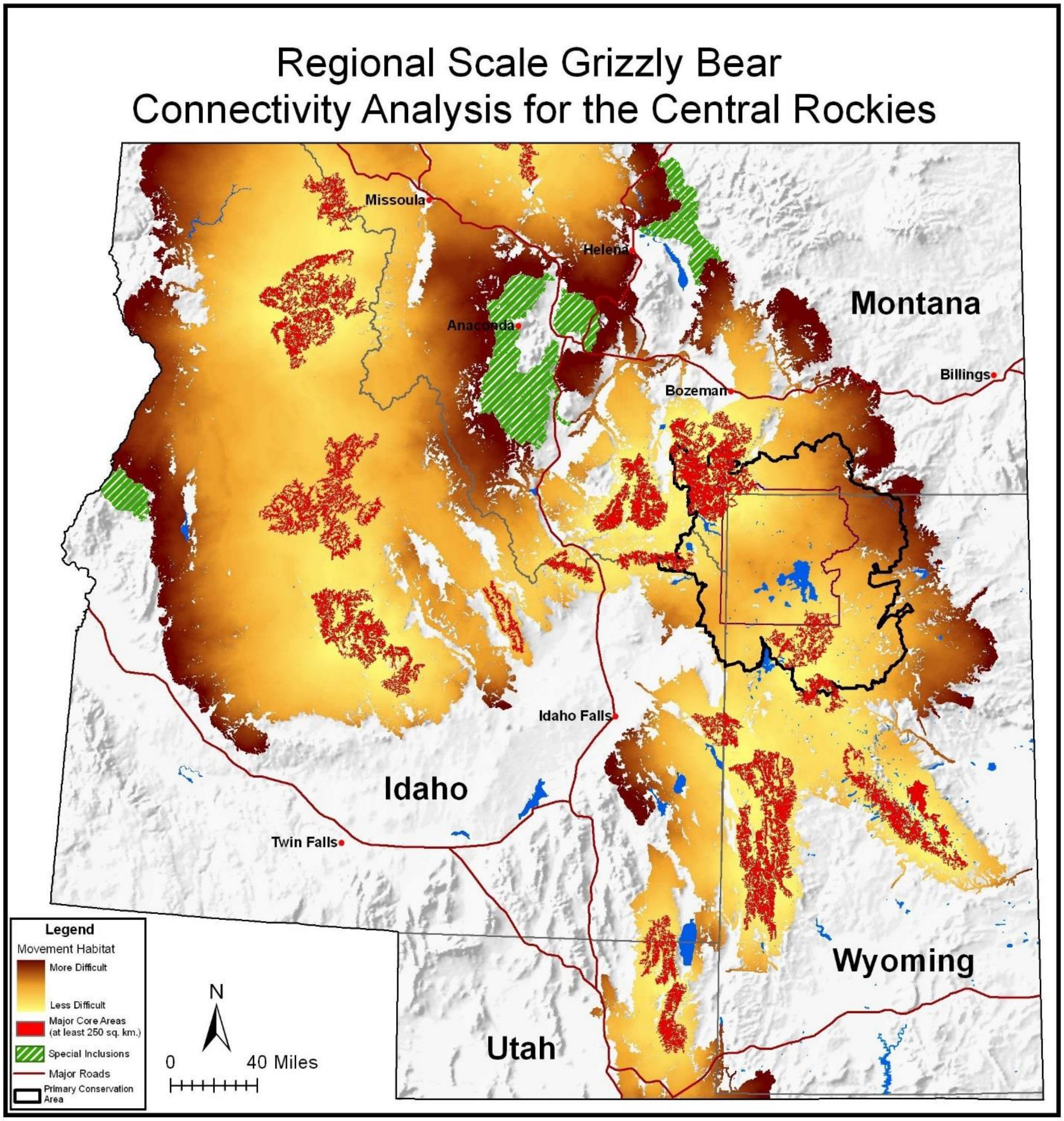

Figure 18. Regional Connectivity for Grizzly Bears.
Credit: Craighead Institute, Thomas Olenicki

Weaver (2014) used a quantitative approach to assign conservation values to lands in the Flathead National Forest. He assigned a 'Very High' conservation value for grizzly bears to lands that contained primary habitat components in a secure setting (more than 500 m from an open road. These same criteria can be found in about 99% of the HPBH WSA (the sole exception being in the SW end of the WSA along Highway 89 near Teepee Creek where the WSA boundary is about 300m from the highway for a distance of about 3 km).

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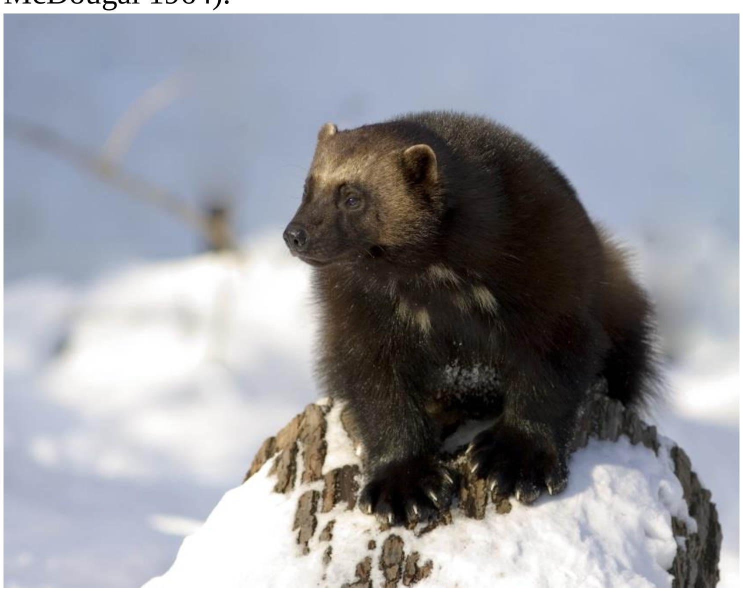
Wolverine

There are an estimated 250 to 300 wolverines in the contiguous U.S. Wolverine are a Species of Concern in the state of Montana. They range year-round across the western part of the state. Adult females have territories that are about 100 square miles in size (Inman 2013). Wolverines were nearly exterminated in Montana by 1920 (Newby and Wright 1955). Numbers began increasing in the western part of the state from 1950 to 1980 primarily due to dispersal from Canada and then later from Glacier National Park (Newby and Wright 1955, Newby and McDougal 1964).



Wolverine
Photo Credit: Anna Yu, istock.com.

The wolverine is more of a generalist than other mustellids like the marten and fisher, it makes more use of open areas and a wider variety of vegetation types (Banci 1994, Copeland 1996).

Wolverine distribution and abundance are directly related to food abundance and security. In general they need large undisturbed areas with an abundance of small and large animals. Carrion is an important part of their diet, especially in late winter and spring. Dependence on carrion may link the viability of wolverine to other carnivore populations such as wolves, and wolf poisoning campaigns in some areas have eradicated wolverine (Banci 1994). Wolverines also rely on carrion from hunting in some areas such as the HPBH WSA (Gehman 2010).

In the Madison Valley Wildlife Assessment conducted by the Wildlife Conservation Society, protection of wolverine habitat also protected 151 other species (Brock et al. 2006). Additional information on wolverine ecology and distribution can be found in the Montana Field Guide at http://fieldguide.mt.gov/speciesDetail.aspx?elcode=AMAJF03010

Montana was the last of the Lower-48 states to have a wolverine trapping season; FWP considered the wolverine trapping season to present only 'recreational harvest opportunities'. It was not designed to prevent wolverine depredation on other species, domestic livestock or humans. Currently there is no open trapping season for wolverine in Montana due to a court restraining order that blocked the opening of the 2012-2013 trapping season. At that time, November 2012, the wolverine had been petitioned for listing as threatened under the Endangered Species Act and the FWS was reconsidering its status. A state court judge blocked the trapping season while the review took place.

The wolverine had twice been petitioned for listing under the Bush Administration, but was denied; and a subsequent petition in 2010 under the Obama Administration found wolverine to be "warranted, but precluded" meaning that other imperiled species had priority for the limited funds available. The most recent petition, in 2012, cited climate change as one of the primary reasons for its vulnerability. Eventually, the FWS extended the review period for 6 months to complete a more thorough review of the issue. In 2014 the FWS Rocky Mountain Regional Director Noreen Walsh recommended that the wolverine not be listed, an action that was counter to FWS field scientists' recommendations. Finally, in August 2014 the FWS withdrew the petition for listing, citing uncertainty in the effects of climate change on snowpack and uncertainty whether less snow cover would put wolverines in danger of extinction.

Vulnerability

Wolverines in Montana have persisted despite a past history of unlimited trapping and hunting solely because of the presence of designated wilderness and remote inaccessible habitat (Hornocker and Hash 1981). In Alberta they were extirpated from most of the province except in the refugia offered by the national parks (Banci 1994). The fossil record shows that pre-settlement distribution included lowland environments (Copeland 1996), and extended as far south as Arizona and New Mexico (Banci 1994). Present distribution of the wolverine, like that of the grizzly bear, may therefore be primarily related to which regions escaped human settlement and activity.

Wolverines, roads, and trails

Wolverine populations probably cannot sustain rates of human caused mortality greater than 7-8% which is lower than in most studies of trapping mortality. Road access thus can increase trapping injury or mortality including incidental trapping (Squires et al. 2007). Although there is no trapping season currently in the HPBH WSA, there is trapping for other species (wolves and marten) and road and trail access will be a factor to consider if the wolverine season is re-opened in the future.

Wolverine have been reported to avoid areas of human activity (Copeland 1996; Copeland and Harris 1993, 1994; Krebs et al. 2007) and habitat requirements may show more parallels with those of the grizzly bear than with those of more closely related carnivores. They require large areas of habitat with little or no human disturbance (Hash 1987), although it may be their preference for higher elevations, not avoidance, that keeps them away from humans to some extent (Copeland et al. 2007). Snowmobile traffic in high mountain cirques has been hypothesized to disrupt denning and negatively affect reproductive success. In the Lolo Forest along the Idaho-Montana border south of Superior, the only known active wolverine den in the entire alpine region in the 1990's was found in a single basin that was inaccessible to snowmobiles (O'Connor pers. comm. 1998). Similar areas may be at risk from disturbance by winter recreation such as heli-skiing (Copeland 1996).

More recent research indicates that "wolverines tolerate overlap of (winter) recreation within their home ranges, but that they also exhibit potential behavioral and energetic effects linked to recreation disturbance including increased wolverine movement rates and reduced resting periods in higher recreation areas and on high recreation days (e.g., Saturday, Sunday)." (Heinemeyer and Squires 2013). Six denning females were monitored, and 2 of 6 denning attempts failed (Heinemeyer and Squires 2012). Of these failures, one occurred in a highly recreated landscape and the other was probably due to old age and poor health (Heinemeyer and Squires 2013). As is always the case with wolverine studies, sample sizes are necessarily small. This study by Round River Conservation Studies and the US Forest Service Rocky Mountain Research Station is planned to continue for several more years to gather additional data.

It is possible that U.S. populations are dependent on immigration from Canada, and the low or declining populations in southern B.C. and Alberta are thus of regional importance (Banci, pers. comm. reported in Butts 1992). These trends are occurring despite a decline in trapping, and could also be related to logging, oil and gas exploration, and other human development. The southern interior of B.C. is the fastest growing area in the province, with large increases in human settlement, recreational facilities, and backcountry use. Loss of ungulate winter range to development has affected wolverine food resources in some regions. Landscape level diversity, such as between dry and wet forest types, allows the wolverine to survive on temporally variable food resources. However, as with the grizzly bear, seasonal movements to use variable resources make wolverine vulnerable to human-caused landscape fragmentation.

Spatial refugia (large areas that are not trapped and are free from land-use impacts) are important for sustaining wolverine populations throughout their range; very large refugia may be the best means of ensuring their persistence. (Banci 1994); this is particularly true in southern Alberta, and in Yellowstone National Park (Buskirk 1995). Connectivity between the GYE and remnant Colorado wolverine populations, as well as between the Canadian Rockies and U.S. populations in Idaho and the Cascades may be lost if current trends continue. Although male wolverine may successfully cross developed habitat, dispersal requirements for females with young are more habitat-specific. Like grizzly bears, subadult females rarely disperse because, unlike male offspring, they are tolerated near their natal home ranges (Banci 1994). Thus, range expansion or re-colonization of empty habitat requires contiguous habitat within which females can establish home ranges, breed, and their female offspring can do likewise. Population expansion occurs incrementally; one female home range at a time.

Important Habitat Areas

Wolverine are year-long residents of the HPBH WSA and it is considered to be a major block of wolverine habitat (Figure 19) according to modeled data from all recent wolverine studies (Inman et al. 2013). Dr. Robert Inman conducted a 10-year study of wolverine in the Madison Range with the Wildlife Conservation Society, but only visited the Gallatin Range a few times. During his visits he found one active wolverine den. Several GPS locations (n=26) of wolverines from the Madison Range were recorded in the HPBH WSA showing that there is movement between these core areas (Inman, pers. comm. 2015).

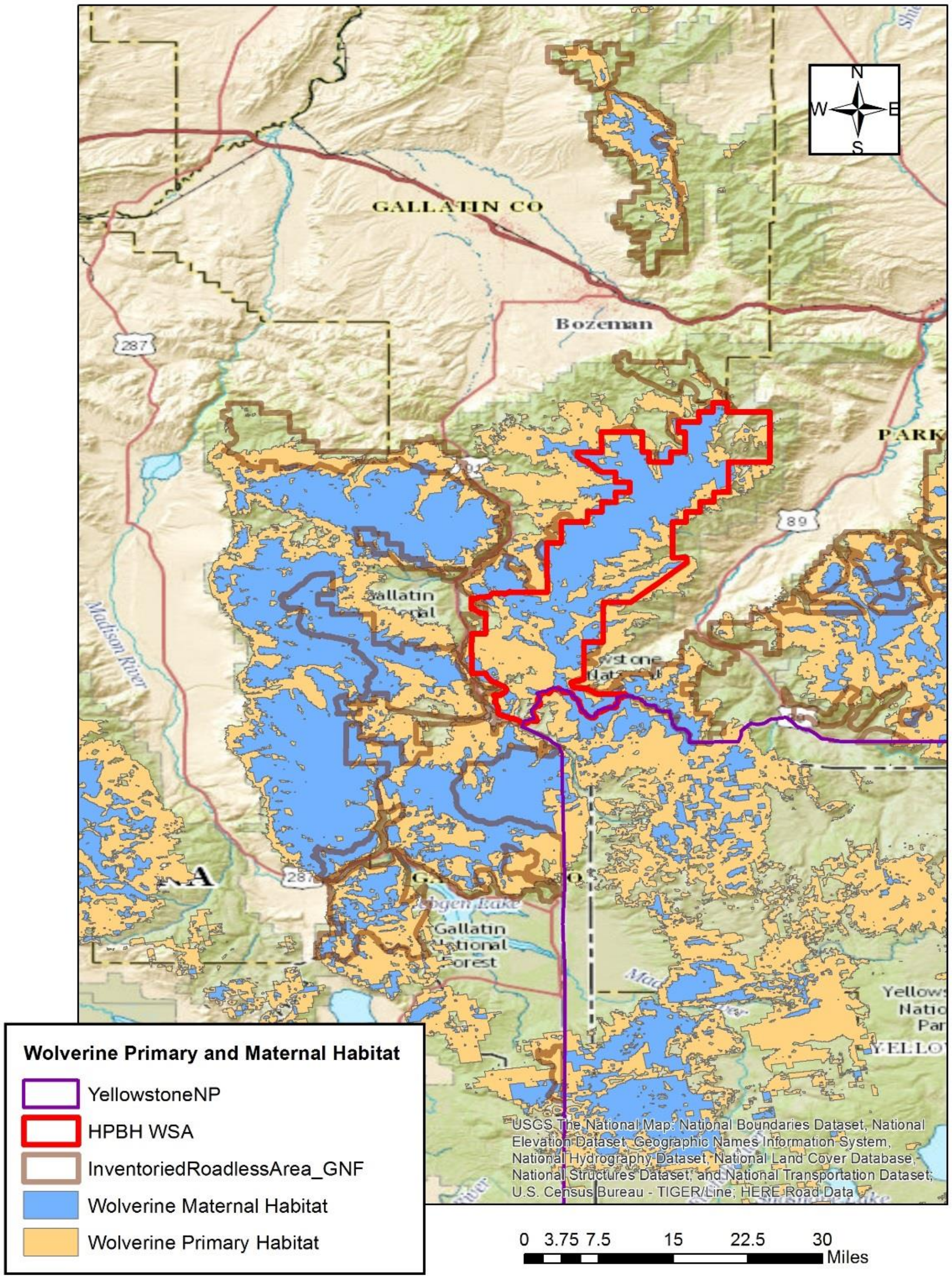


Figure 19. Wolverine Primary and Maternal Habitat.

All of the HPBH WSA (except the low-elevation NW tip at the headwaters of the North Fork of Trail Creek and Pine Creek; north of Eightmile Creek), and most of the Inventoried Roadless Areas in the GNF are primary wolverine habitat. Primary habitat is defined as areas suitable for survival and use by resident adults. It also probably represents the historical distribution of wolverines. Maternal habitat is a subset of primary habitat at higher elevations modeled from 31 known den and rendezvous site locations (Inman et al. 2013). Wolverines den generally in high mountain cirques where there is sufficient snow cover until May to insulate the den and provide cover (Copeland et al. 2010).

Steve Gehman and Wild Things Unlimited conducted snow tracking surveys during 9 winters and documented wolverine presence each winter in all areas of the HPBH WSA (Gehman 2010). Data from the snow tracking surveys indicated that wolverine may have been avoiding roads, snowmobile trails, logged habitat and areas of high human use in areas mostly below 2,280 m of elevation (Gehman and Robinson 2000). In each winter wolverines utilized hunter-killed big game carcasses which suggests that the high quality habitat for game animals (Elk, moose, bighorn sheep, and deer) helps create high quality habitat for wolverines (Gehman 2010).

A review of wolverines and recreation recommended that managers should avoid placing new recreational trails and roads through previously unfragmented habitats, and they also should be located away from potential denning areas. Negative impacts on wolverines were found from snowmobiles, skiing, hiking, and human presence (Snetsinger and White 2009). No data were found on effects of biking and horseback riding.

Wolverines and Connectivity

The Wolverine is the 'poster child' of connectivity: both males and females travel extensively throughout the year to find food and mates; they also disperse long distances when they are subadults. Male wolverines tend to disperse more frequently and farther than females (Flagstad et al.,2004; Inman et al. 2012, 2013; Vangen et al. 2001). Data from research in the Madison and Teton Mountain ranges indicate that both males and females are capable of dispersing to areas at least 170 km from their mother's home range. Other data suggest that this may underestimate the distances wolverines disperse. GPS collar data, documented an exploratory movement by a male who travelled 112 km from its mother's center of activity and covered over 200 km in less than 6 days (Inman et al. 2012). One wolverine that was collared in the Madison Range dispersed as far as northern Colorado and returned; crossing the Wyoming Red Desert and Interstate 80 on both legs of the 900 km journey (Inman et al. 2009).

The HPBH WSA is an integral part of an important wolverine movement corridor going north-south connecting the GYE with the Bridger and Big Belt mountains and the NCDE. Wolverine connectivity was modeled by Robert Inman and Scott Bergan as part of a PhD Dissertation (Inman 2013: Figure 20). Connectivity was modeled using Circuitscape™ which identifies a least-cost-path based upon habitat 'resistance' between habitat cores (primary habitat patches > 241 km^2). Primary habitat was modeled using latitude-adjusted elevation, terrain ruggedness index, snow depth on April 1, road density, interpolated human density, distance to high-elevation talus, distance to tree cover, and distance to April 1 snow >2.5 cm, along with a quadratic term for snow depth (Inman et al. 2013). Connectivity was modeled using a resistance surface between core areas defined as the inverse of the scaled habitat suitability score with the values squared (Inman 2013). The resultant map identifies the best habitat for movement.

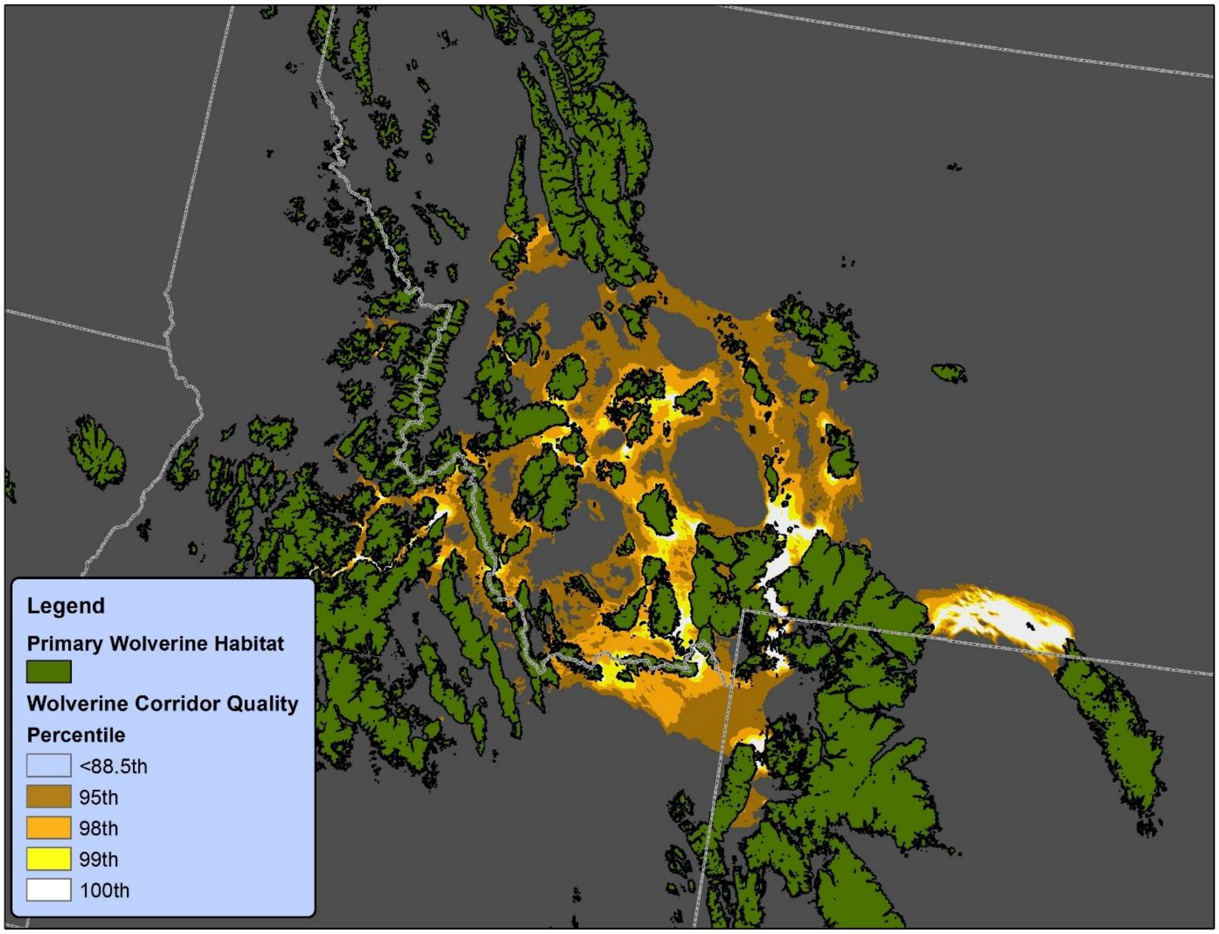


Figure 20. Regional Wolverine Connectivity Corridors. Brighter colors indicate less resistance to movement. *Credit: Robert Inman, WCS.*

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Pika

Pikas are the smallest member in the rabbit family (about the size of a hamster) that includes rabbits and hares. Pikas live in mountainous regions typically near treeline throughout the western United States and are found mainly in moist subalpine and alpine habitats that are dominated by talus slopes. They can be found at elevations between 5,000 to 13,000 feet. They live in areas of talus that contain both large and small rocks. In some areas they utilize rock slides. Pikas are herbivorous eating a variety of flowers, grasses, shrubs and trees: they primarily inhabit talus fields fringed by suitable vegetation in alpine or subalpine areas (Smith and Weston 1990). By mid to late summer (July-September) they begin storing food under rocks, creating "haypiles". These haypiles can be large relative to pika size - measuring 3 feet in diameter. Pikas are territorial and these haypiles tend to be built in the same location year after year. Pikas will defend their territories with high-pitched whistles and physical chases. They are diurnal, feeding primarily in the morning and late afternoons depending on the weather. Pikas are typically found in rocky talus areas throughout the western part of Montana and range between 5,500-10,500 feet in elevation. Pikas serve as indicators of adequate snow cover and healthy plant communities.

GYE Pika
Photo Credit: Lance Craighead

Pika distribution is already limited by a warming climate. The geographic distribution of American pika may have encompassed not only the western United States and Canada during the last glacial maximum (30,000 years ago or later), but also parts of the eastern United States (Grayson 2005). Archaeological and paleontological records for pika demonstrate that approximately 12,000 years ago, pikas were living at relatively low elevations (less than 2,000 m (6,560 ft)) in areas devoid of talus (Mead 1987, Grayson 2005). By the Wisconsinan glacial period (approximately 40,000 to 10,000 years ago), American pikas were restricted to the intermontane region of the western United States and Canada. Low-elevation populations of American pikas became extinct in the northern half of the Great Basin between 7,000 and 5,000 years ago (Grayson 1987). Fossil records indicate that the species inhabited sites farther south and at lower elevations than the current distribution during the late Wisconsinan and early Holocene periods (approximately 40,000 to 7,500 years ago), but warming and drying climatic trends in the middle Holocene period (approximately 7,500 to 4,500 years ago) forced populations into the current distribution of montane refugia (Grayson 2005, Smith and Weston 1990).

Pikas have been little studied in Montana until recently. The Montana state field guide states only that "Information on this species is incomplete…" with a range map covering the western portion of the state http://fieldguide.mt.gov/displaySpecies.aspx?family=Ochotonidae. In Montana, there is little historical information to assess whether habitat loss has occurred or if populations are stable. Limited available data does not indicate a decline. Approximately 90 percent of available habitat in Glacier National Park is occupied (National Park Service NPS 2009). American pikas are believed to occur in all locations where they were observed historically within the Grand Teton National Park (NPS 2009).

Although pikas are common in Montana, few colonies have been recorded. To document pika distribution, Craighead Institute (ChI) biologists survey areas where occupancy is unknown. In 2009 ChI began training sessions for biologists with state and federal agencies. In 2010 ChI included citizen scientists as well as agency personnel to record pika locations and started a series of public lectures and training sessions to engage more volunteers: 5 volunteers recorded 6 new sites. Data collecting in 2011 involved over 20 volunteers recording 70 new Montana pika locations. These data more than tripled the size of the Montana Natural Heritage Program database which continues to grow every year.

Pikas are considered to be a nongame animal under Montana Code (MC 2009 87-5-102), as they are not a nuisance animal (MC 2009 80-7-1101) or expressly otherwise named in Montana's hunting regulations. It is illegal to take, possess, transport, export, sell, or offer them for sale (MC 2009 87-5-106). This designation protects pikas from direct harm, but does not offer protection to pika habitat. Montana Fish, Wildlife and Parks (FWP) has identified pika as a species with greatest inventory need in the Montana Comprehensive Fish and Wildlife Conservation Strategy (FWP 2005). They are not on the Montana Natural Heritage Program Animal Species of Concern list, which is the list FWP refers to when implementing the MCFWCS. Pikas are designated as a Tier 3 species in Montana, meaning they have a lower conservation need because they are either abundant and widespread or they have adequate conservation already in place (FWP 2005).

Pikas in the HPBH WSA have been studied since 1992 by researchers at the University of Colorado (Ray and Beever 2013, Wilkening et al. 2013). Pikas at the study sites around Emerald and Heather Lakes have remained fairly constant in number (Ray, pers. comm.). Citizen science observations directed by the Craighead Institute have documented pika presence in suitable habitat throughout the HPBH WSA (Figure 21, and Craighead, pers. comm. 2015). The Craighead Institute is developing a baseline dataset of known pika locations which increases every year as more locations are recorded; the goal is to develop a clear understanding of pika distribution in order to track changes as the climate changes.

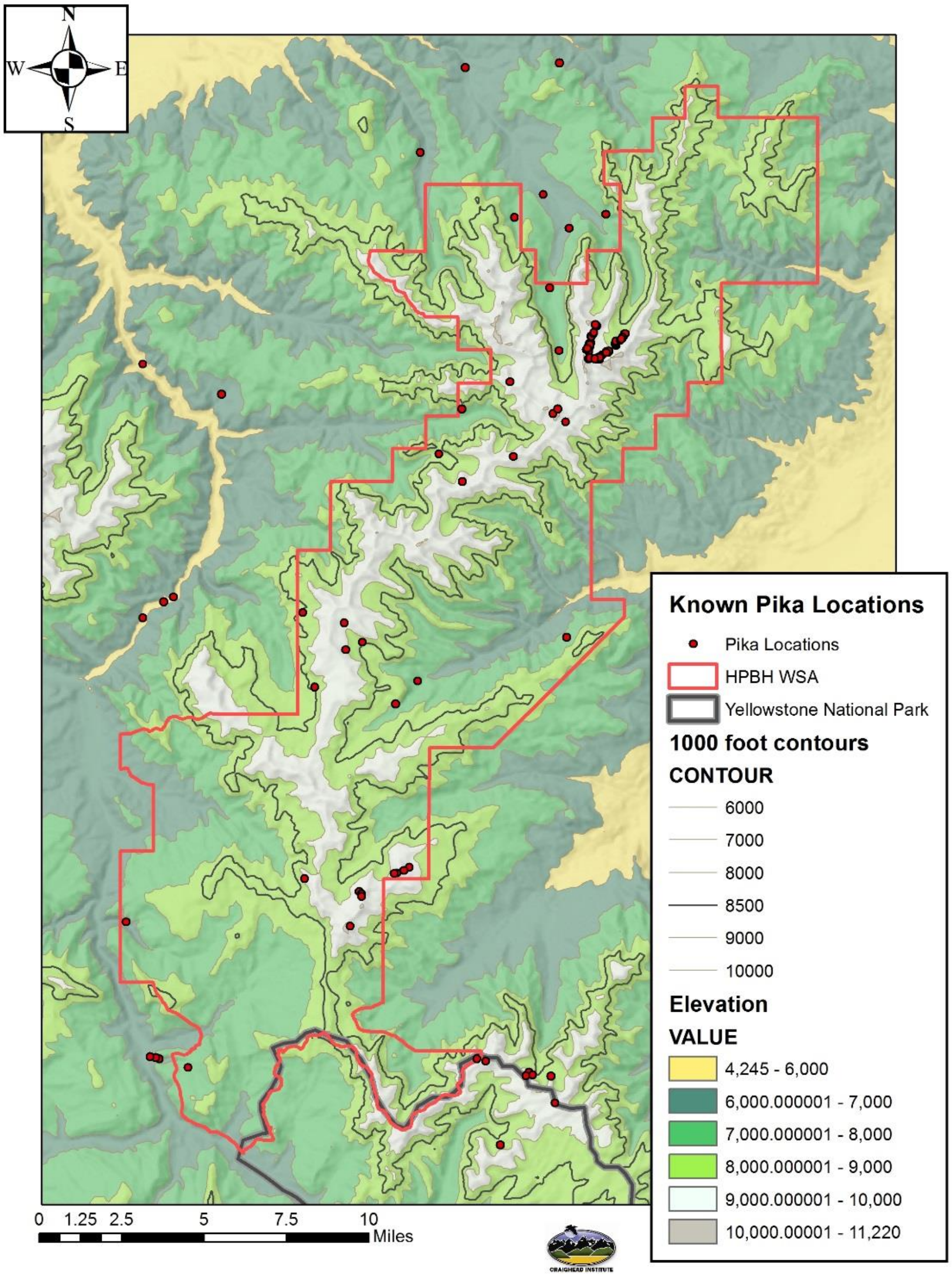

Figure 21. Known Pika Locations 2015.
Credit: Craighead Institute, April Craighead

The horseshoe-shaped cluster of pika locations on the map (Figure 21) are the talus slopes above Emerald and Heather Lakes which have been intensively studied. Most pika colonies are found above about 8,500 feet in the HPBH WSA; it is likely that almost all talus slopes with suitable boulder sizes near alpine vegetation are inhabited by pikas. There are also many other known locations at lower elevations in the Gallatin and Hyalite Canyons; the lowest of these is at about 5600 feet.

Vulnerability

Pikas are extremely well adapted to montane environments, but are sensitive to climatic extremes: temperatures above 80° F which can be lethal to pikas in as little as six to eight hours (Smith 1974). To stay cool, pikas will stay in rock crevices or under large boulders until the temperature cools. Pikas do not hibernate and remain active all winter long. They store large "haypiles" or stores of vegetation in the late summer and fall that they cache and will utilize all winter long. The alpine environment in which pikas reside contains currently some of the most threatened habitats due to climate change. Recent research in the Great Basin region has indicated that climate change is having a significant effect with 7 out of 25 pika populations having been extirpated recently and in the past century (Beever et al. 2010a, 2010b). Two likely direct causes of pika declines are increasing warm temperatures in summer and decreased snow depth in winter which reduces insulation leading to prolonged exposure to cold in pika habitat.

In 2009, the American pika was petitioned to be listed as threatened by the U.S. Fish and Wildlife Service under the Endangered Species Act. The petition was prompted by the declining populations in the Great Basin area within the past few decades. Pika populations are also moving up in elevation as seen in the Great Basin and in California which is an indication that climate change is having an effect on pika behavior and distribution. Although that listing was denied in 2010, the Fish and Wildlife Service highlighted the need for additional scientific data on species distribution and under-talus temperature modeling. Since that ruling there has been an increase in research in the Western United States related to pika distribution and habitat modeling, as well as efforts to identify areas where pikas may persist in the future. When climate-related stressors change a species' habitat so quickly that migration is impossible, those species may benefit from the availability of uniquely situated areas within a specific habitat that offer relatively stable environmental conditions. It is important to identify these safe havens—also known as "refugia."

Pikas are vulnerable to high ambient temperatures during summer and need insulation from snowpack to survive subzero temperatures in winter (MacArthur & Wang 1973, Smith 1974, Beever et al. 2003, MacDonald and Brown 1992). Temperature restrictions influence the species' distribution because hyperthermia or death can occur after brief exposures (as little as 6 hours) to ambient temperatures greater than 25.5 °C (77.9 °F), if individuals cannot seek refuge from heat stress (Smith 1974). Therefore, American pika habitat progressively increases in elevation in the southern extent of the distribution (Smith and Weston 1990). They need adequate alpine vegetation that they forage during summer and cache in 'haypiles' that they consume during winter.

The FWS decision not to list pikas was based solely upon surface temperature predictions due to climate change because there were virtually no data available for other risks due to climate change such as decreased snow depth. It is predicted that climate change will result in increased surface temperatures but additionally climate warming corresponds with a reduced mountain snowpack (Mote et al. 2005 and Regonda et al. 2005) and a trend toward earlier snowmelt in western North America (Stewart et al. 2005).The International Panel on Climate Change (IPCC) concluded that snow-season length and depth of snowpack are very likely to decrease in most of North America (Christenson et al. 2007). More localized climate predictions are found in this report in the Climate Change section in the APPENDIX.

Important Habitat Areas

Pikas are likely to be found in any large talus slopes above 8,500 ft in the HPBH WSA. In addition there are known colonies as low as 6,000 feet in Gallatin Canyon so they are likely to occur at all elevations within the HPBH WSA on the west side of the Gallatin Crest. Pikas at the lower elevations have likely adapted behaviorally to warmer temperatures, and perhaps genetically as well. As the climate warms, high elevation pikas may be replaced by better adapted pikas from lower elevations.

Pikas and Connectivity

Pikas are generally found above 8,500 feet in this region. Connectivity most often occurs north-south along the Gallatin Crest with perhaps some genetic interchange among pika colonies. However, the presence of lower elevation colonies in Gallatin Canyon is evidence that there is also connectivity east-west along the drainages and ridges leading down to the Gallatin River. As the climate warms, this type of connectivity may become essential to maintaining pika populations in the PHBH WSA if more heat-tolerant pikas are able to migrate upwards in elevation to occupy habitat that may be available if less heat tolerant individuals are extirpated. At a regional scale, pikas currently occupy a large block of high-elevation habitat in the GYE with the best connectivity found to the north (Figure 22). Areas of suitable habitat occur in the Bridger and Big Belt Mountains but pika have not been positively identified in these ranges at present. There is anecdotal evidence of pikas in the Bridger in the late 1900’s so it is likely that this population has gone locally extinct in recent times (Craighead, Pers. Comm. 2015).

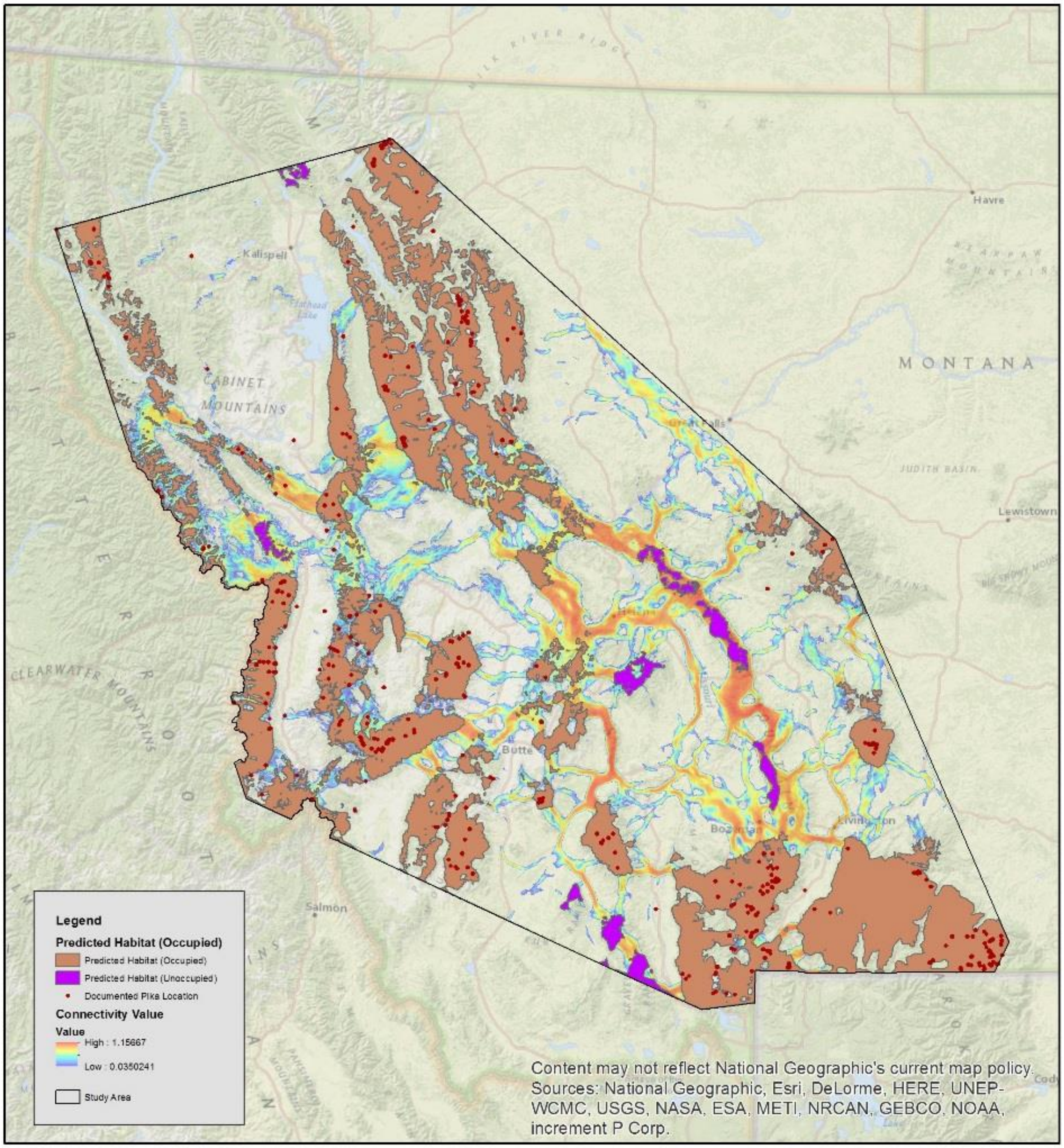

Figure 22. Pika Predicted Habitat and Connectivity in Montana.
Credit: Craighead Institute, Brent Brock, April Craighead

A predictive model based on the data in Figure 22 (Brock and Craighead, Pers. Comm. 2015) suggests that pika populations in habitat patches below a certain size threshold and beyond a certain distance from a source population have gone extinct due to stochastic (random) demographic, genetic, and environmental variation and not from loss of habitat or other deterministic causes. This fits well with classic island biogeographic theory (MacArthur and Wilson 1967). It also suggests that connectivity to the north from the GYE will not be possible for pikas attempting to move to higher latitudes to adapt to climate change due to both the inhospitable low elevation areas between suitable habitat and the fact that the size of the habitat patches will decrease as the climate warms.

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Other Species of Interest

Bison

Bison are the largest land mammals in North America. They are grazers and feed on grasses, forbs, and sedges (which are their most important food in all seasons). Bison represent a key species because their grazing and wallowing activities strongly influence plant community composition and habitat structure. Bison move continuously as they forage with females leading family groups. Bulls remain solitary or in small groups for most of the year, but rejoin the females during mating season in June to September. Peak mating is in July and August.More information on bison ecology can be found on the Montana Field Guide website: http://fieldguide.mt.gov/speciesDetail.aspx?elcode=AMALE01010

Bison historically occupied portions of the HPBH WSA but were extirpated by about 1889 when the North American population had been decimated from about 30 million to just 1,091 by unregulated shooting and conversion of habitat. One of the few remnant populations persisted in Yellowstone National Park and had dropped to just 25-50 animals by 1901 (Picton and Lonner

2008). These animals were augmented from other pure genetic strains and have now grown to a population of 2,300 to 5,000 animals in two herds which breed in and around the Lamar Valley (northern herd) and Hayden Valley (central herd). Bison move from their summer ranges to lower winter ranges as snow accumulates and dense snowpack develops. The central herd moves both west and north toward park boundaries in winter and may remain along the west boundary well into birthing season (Newsletter 2015). The majority of potential habitat for bison (grasslands and shrub-steppe) within the HPBH WSA as mapped by the Montana Department of Fish, Wildlife, and Parks, is in the SW corner in the Buffalo Horn drainage along the NW border of YNP (FWP 2012).

The National Park Service and the State of Montana are jointly preparing a Yellowstone-area Bison Management Plan and Environmental Impact Statement (plan/EIS). The purpose of the plan/EIS is to conserve a wild and migratory population of Yellowstone-area bison, while minimizing the risk of brucellosis transmission between these wild bison and livestock to the extent practicable. The public scoping period closed on June 15, 2015. Currently, Yellowstone National Park, the State of Montana, the U.S. Forest Service and others manage bison under the Interagency Bison Management Plan (IBMP) that was adopted in 2000 which directs the National Park Service, U.S. Forest Service, and Animal and Plant Health Inspection Service to cooperate with the State of Montana to jointly implement the IBMP. More information on the IBMP is available at http://ibmp.info/index.php.

The original Plan was adjusted several times and a formal Adaptive Management Plan was created in 2008. (IBMP 2014). Agencies now involved with the IBMP include the Animal and Plant Health Inspection Service (APHIS), Confederated Salish and Kootenai Tribes (CSKT), InterTribal Buffalo Council (ITBC), Montana Fish, Wildlife, and Parks (MFWP), Montana Department of Livestock (MDOL), National Park Service (NPS),Nez Perce Tribe (NPT), and U.S. Forest Service (USFS).

Objectives of the new Plan which will need to be addressed in the Gallatin National Forest Plan Revision, and other management processes that include the HPBH WSA, include:

- Maintain a viable, wild bison population and allow for ecological processes to occur.
- Accommodate and manage for the natural migration of bison to and from winter range, to the extent practicable.
- Contribute to the conservation of bison in North America.
- Increase hunting opportunities outside the park.
- Clarify the public participation process as well as agency perspectives, jurisdictions, and management objectives.

Additional information is available about the bison management planning process at the National Park Service's Planning, Environment and Public Comment (PEPC) site: http://parkplanning.nps.gov/YELLBisonPlan.

As bison are allowed to migrate to new ranges outside the Park it is very probable that some animals will occupy portions of the HPBH WSA where they will come under the jurisdiction of the Gallatin National Forest and FWP.

Wolf

Figure 23. Wolves in the GYE
Credit: Thomas Mangelsen

Because of their preference for terrain conducive to capturing prey on the run, wolves will probably not use much of the HPBH WSA. Wolves prefer more gentle terrain with little slope (Paquet et al. 1997) and do not often use slopes more than 45^o (Paquet et al. 1999). Home range selection as well as travel routes are influenced by topographic position (Paquet et al. 1996). Wolves use valley bottoms and lower slopes especially during the winter months because of the presence of ungulate prey (Paquet et al. 1996, Boyd 1997).

Gehman (2010) observed resident wolves in the Tom Miner Basin which reportedly denned along Horse Creek and reported on the 8-mile pack which ranged from Eightmile Creek to Rock Creek on the eastern side of the Gallatin Range. Wolves tend to den in areas that have good canopy cover, hiding cover, herbaceous ground cover, and woody debris, and are close to water (Trapp 2004). The 2014 Annual Reports list a wolf pack along Fridley Creek (USFWS 2015, Bradley et al. 2015). Wolves from this pack may use the lower elevation areas of the HPBH WSA. Creel et al. (2005) studied elk responses to wolf presence in the Porcupine, Daly, and Teepee drainages of the HPBH WSA and found that wolf presence increased the probability that elk would stay close to conifers; when wolves were absent they used grassland areas (Creel et al. 2005)

Wolves are very adaptable and are great dispersers; they can fill in the blank spots on the map where suitable wolf habitat remains empty. Both males and females can disperse long distances: averages from 40-95 miles (65-154 km) for males, and 40-76 miles (65-123 km) for females (Fritts and Mech 1981, Boyd and Pletscher 1999). The longest known dispersal distance is 520 miles (840 km) reported by Boyd et al. 1996).

Wolves were established as a Nonessential Experimental Population in the GYE in 1994 and Designated as a Distinct Population Segment in 2009. Wolves were delisted in Idaho, Montana, and parts of Oregon, Washington and Utah in 2011. In August 2012 they were delisted in Wyoming, but in September 2014 this was vacated; wolves are currently listed as a Nonessential Experimental Population in Wyoming which prohibits hunting. As of December 31, 2014, there were at least 1,657 wolves in 282 packs (including 85 breeding pairs) in Montana, Idaho and Wyoming. The FWS expects the population to maintain a long-term average of around 1,000 wolves.

In 2014 the GYA population of gray wolves was estimated at a minimum of 122 wolves in 23 verified packs, 11 of which qualified as a breeding pair within the GYA. This was an increase in 5 breeding pairs from 2013 (Bradley et al. 2015).

Lynx and Fisher

There is historic evidence of Lynx and Fisher in the Gallatin Range, and Gehman observed tracks of fisher during winter surveys in 1998-99 and 2004-2005 in the west-central portion of the Gallatin Range. He observed lynx tracks in 2004-2005 in the southern part of the range (Gehman 2010). The HPBH WSA appears to be used by these species for connectivity although there does not appear to be a resident population of either species.

Moose

Moose were not chosen as a focal species in this report because there was little data available for the HPBH WSA. Moose were used as a focal species in the Madison Valley Wildlife Assessment (Brock et al. 2006) and had an Umbrella score of about 209/411. Moose are managed as a big game species in the HPBH WSA and have been relatively common in suitable habitat, especially riparian shrub habitat near early successional shrublands, forest, and meadows although in recent years there has been a decline in moose populations throughout Montana (DeCesare et al. 2014). This decline prompted a 10-year study by FWP which began in 2013. Montana reported a 40 percent drop in available hunting tags from 769 to 463 between 1995 and 2010. Winter ticks, brain worm, and habitat changes (perhaps exacerbated by climate change) may be contributing to the decline according to the Wildlife Management Institute: (https://www.wildlifemanagementinstitute.org/index.php?option=com_content&view=article&id=643:states-initiating-research-on-moose-declines&catid=34:ONB%2520Articles&Itemid=54).

Beaver

Beaver were not chosen as a focal species in this report, or in the Madison Valley Wildlife Assessment (Brock et al. 2006) because beaver habitat was sufficiently covered by using grizzly, elk, and westslope cutthroat and because there is very little data on beaver status in the HPBH WSA. Beaver are an important species in riparian habitat and can provide habitat for many other species when populations are stable. Beaver were also provided a complete umbrella by Boreal toad, which were not used either in this report because of lack of data.

Amphibians

Amphibians are very sensitive to the effects of climate change, and they are excellent focal species to serve as indicators of ecosystem health. In the Madison Valley Wildlife Assessment, Boreal (or Western) toad had the highest Umbrella score with 401 other species under its umbrella (Brock et al. 2006). Columbia Spotted Frog was second highest with 359 other species dependent upon the same habitat for some, or all, of their life histories. Both Boreal Toads and Columbia Spotted Frogs are found in the HPBH WSA, but there is not enough data available to determine their current status or to monitor changes in their populations. Spotted frogs require water with no fish Anecdotal information on Spotted Frog observations near pika study sites indicate that population sizes fluctuate greatly and that there may be a relationship between harsh winters with little snow cover and high over-winter mortality of frogs and tadpoles (Craighead, pers. comm. 2015).

Western Tiger Salamanders (*Abystoma mavortium*) are also native to the HPBH WSA.

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Wildlife and Habitat in the Hyalite-Porcupine-Buffalo Horn Wilderness Study Area

The HPBH WSA is an island of intact, natural, higher-elevation habitat, mostly surrounded by development on three sides, but remaining connected to other intact habitat in Yellowstone National Park (Figure 24). There are only two permanent buildings within the WSA: a Forest Service Cabin at the headwaters of Portal Creek, near Windy Pass and the Buffalo Horn administrative cabin. A small cabin on Eightmile Creek where sheepherders stored salt was burned in the Fridley fire in 2001 (Schlenker et al. 2003).

The WSA is within dispersal distance for many species to other islands of habitat in the Lee Metcalf Wilderness and the Absaroka-Beartooth wilderness as well as other Inventoried Roadless Areas. Grizzly bears, wolverine, elk, mountain goats, and other species have made such movements in the past and can be expected to continue to do so in the future as long as there is sufficient, high-quality habitat in the HPBH WSA.

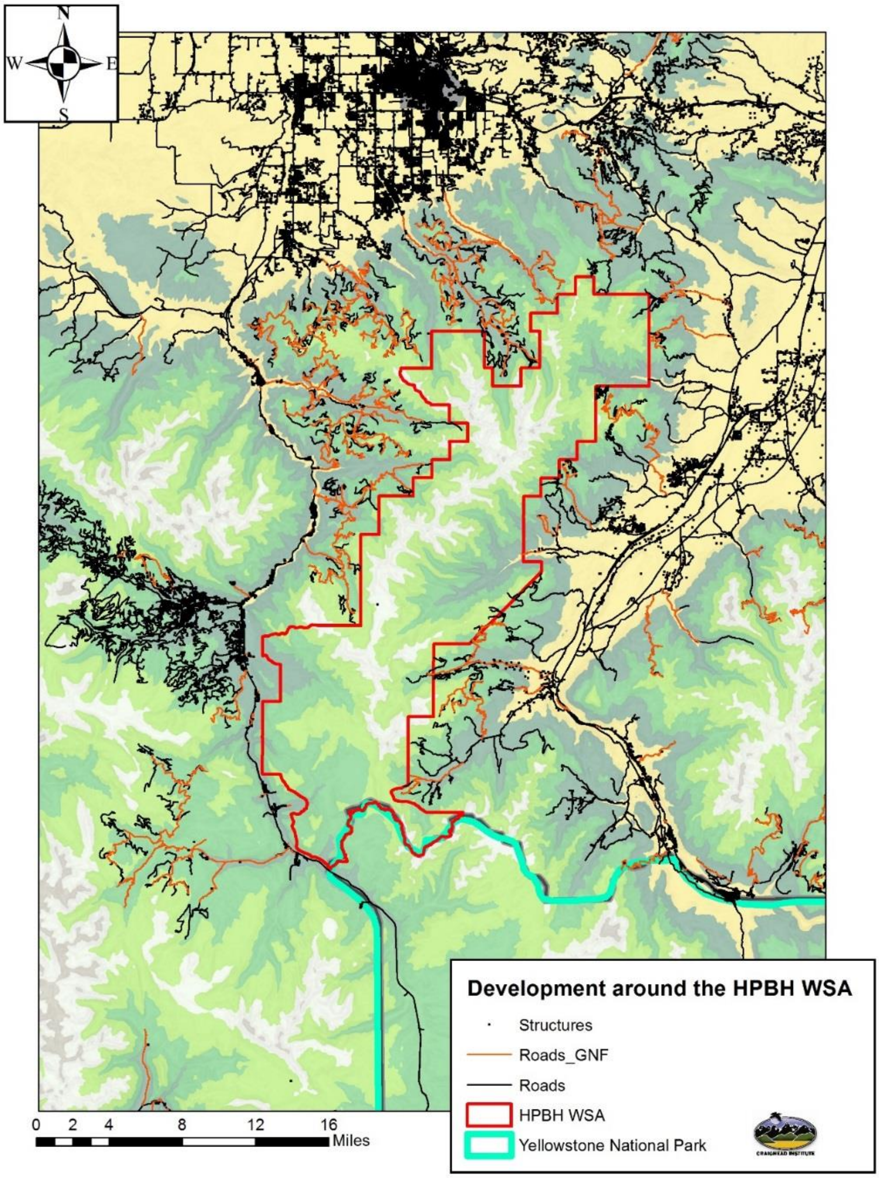

Figure 24. Development around the HPBH WSA.

Habitat Capability, Suitability, and Effectiveness

To examine the relationship between habitat and wildlife populations, Fuhr and Demarchi (1990) developed a method comparing the current condition of habitat to its ideal state. They used the term *capability* to represent the potential carrying capacity of a given area if all habitat conditions are ideal. The definition of capability has broadened somewhat since then to mean the highest potential value of a particular habitat for a particular species: what the ecosystem would be like in an undisturbed and unmanaged state at optimal seral stages of vegetation.

This ideal state rarely if ever occurs. To describe actual habitat conditions the terms *suitability* and *effectiveness* were later developed as described by Hamilton and Austin (2004) and these terms are used with slightly different shades of meaning in different contexts. Habitat Suitability represents the carrying capacity of an area in its present condition, not including habitat alienation and fragmentation such as roads and trails. "Suitability is defined as the ability of the habitat in its current condition to provide the life requisites of a species" (BC Wildlife Branch 1999). Habitat Effectiveness represents the carrying capacity of an area including human-caused habitat displacement and fragmentation. In its original sense, Habitat Effectiveness is the density of animals that would result when all human influences on habitat are factored in (Hamilton and Austin 2004). In another sense it means the relative use of vegetation communities relative to the optimum local conditions that provide food and cover (Benkobi et al. 2004). This is a similar approach to the Cumulative Effects Model (CEM) developed to describe grizzly bear habitat in the Greater Yellowstone Ecosystem (Weaver et al. 1986). This model was developed using hundreds of variables and functions and incorporating results from 20 years of bear data (1977-1996). Sub-models were merged to define a Habitat Value (HV) model (using the CEM term equivalent to habitat suitability) and a Habitat Effectiveness (HE) model that incorporates human effects. The key concept in all of these modeling approaches is that habitat suitability (or quality) depends upon the unaltered aspects of the environment and that human activities degrade that habitat suitability for almost all species.

One Forest Service Model (Habcap) predicts habitat effectiveness based upon calculations of forage, cover, and cover-forage proximity, modified by effects of roads. In a study in the Custer Forest in South Dakota, the size of the area considered ineffective habitat due to roads depended upon road classes which were determined from estimates of vehicle traffic. Primary roads may have 30-35 vehicles/week, secondary roads had 10-35 vehicles/week, and primitive roads had <7 vehicles per week. In this study the disturbance distance was estimated at 180m from primary roads, 60m from secondary roads, and 30m from primitive roads (Benkobi et al. 2004). These road classes have much lower traffic volumes than most areas and disturbance distances from roads in other areas are consequently much greater; but this model approach is based upon the same understanding: habitat effectiveness is decreased by road traffic.

These concepts of effectiveness are the basis for modern-day understanding and modeling of wildlife-habitat relationships. It is well understood that human activities and developments have a deleterious effect on most wildlife species and their habitat. Briefly, the optimal conditions for wildlife and native plant communities exist where there is no disturbance, alteration, or fragmentation caused by humans. As human-caused changes occur to habitat, such as trails, roads, structures, resource extraction, and other activities, the 'effectiveness' of the habitat for wildlife decreases. The greater the cumulative impacts, the less effective the habitat becomes for supporting wildlife populations.

In the HPBH WSA, at the time it was designated as a Wilderness Study Area in 1977, the only human impacts were the system of trails that existed; there have been few changes in the number and location of trails since that time (Figure 25). Currently, the only significant human disturbance in the HPBH WSA remains in the form of trails and the activities that those trails permit: camping, hunting, fishing, hiking, climbing, running, horseback riding, mountain biking, ORVs, and ATVs and others. The trail network in the region is fairly dispersed and mostly low impact with more concentrated use near Bozeman, Hyalite reservoir, and Big Sky. There are approximately 200 miles of Forest Service system trails within the HPBH WSA. No new trails have been constructed since 1977. The Big Sky snowmobile trail #900 is the only designated snowmobile trail in the area; 12 miles cross through the WSA (Schlenker et al. 2003).

The disturbance caused by the trail network and activities on those trails reduces the quality of the habitat for wildlife. In other words, all suitable habitat in the WSA is not available for use by wildlife, and the effective habitat is what remains and is what determines the carrying capacity of the area and ultimately the number of each species that can survive and persist there.

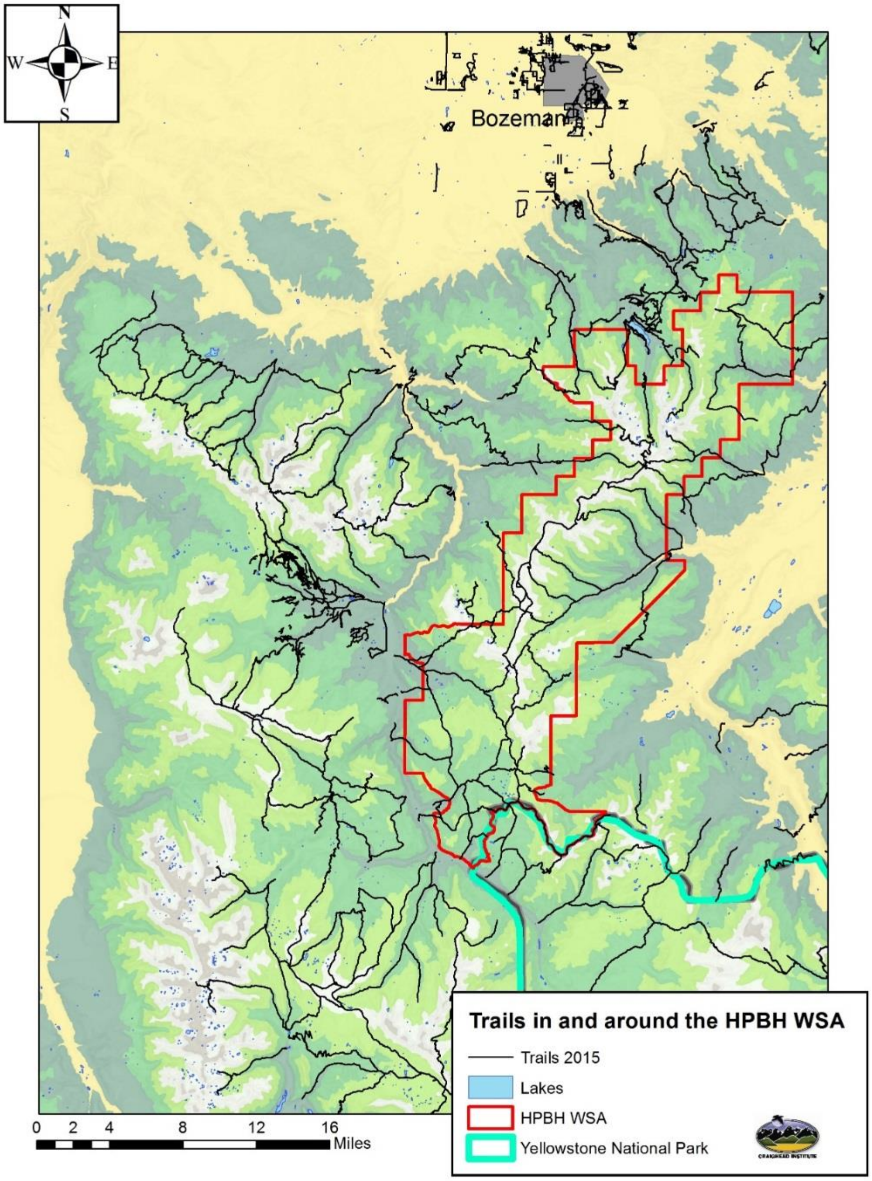

Figure 25. Trails in and around the PHBH WSA.

Although the trails are fairly dispersed, the impact of the trails in the HPBH WSA is not dispersed because of the differing impacts of motorized recreation versus other forms of travel. The distance at which animals are disturbed or displaced depends upon many factors such as the species involved, the terrain, whether or not the animals are currently being hunted, the volume of traffic, the decibel level of the vehicle, the wind direction, and even the individual response of the animal. Distances of the disturbance effects are varied from one wildlife study to another, but follow the same general pattern: hiking and horseback riding cause the least disturbance, followed by mountain biking, followed by motorized travel. One of the most rigorous and well-designed studies found that displacement of elk (avoidance of habitat near trails) can extend up to 500 meters (550 yards) from a hiker, beyond 750 meters (820 yards) from horseback riders, and beyond 1500 meters (1,640 yards) from mountain bike and ATV riders (Wisdom et al. 2004, 2005). In addition, as the volume of traffic increases, the disturbance also increases. Of course, the actual disturbance effects will vary from one area to another as discussed above but the relative severity of impacts should be roughly equivalent. To illustrate the magnified effect of motorized use, Figure 26 shows all trails buffered by a distance corresponding to their use and a generalized rating of Habitat Quality/Effectiveness for elk in the HPBH WSA. This rating is based upon expert opinion and is not the result of a habitat effectiveness model. The first parallel set of lines represents a 500m buffer (546 yards) or the zone of disturbance caused by a hiker, the second set of parallel lines represents a 1000m buffer (1094 yards) and the third set of parallel lines encompasses a 1500m buffer (1640 yards) or the zone of disturbance caused by a motorized ATV or ORV: the motorized-use trails in the HPBH WSA currently allow use by mountain bikes and motorcycles.

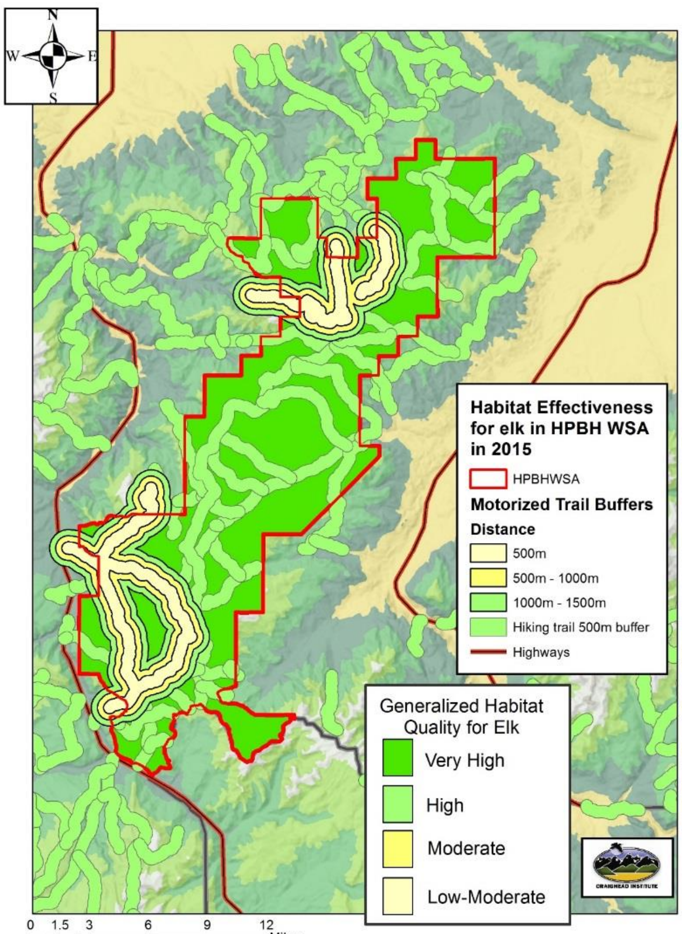

Figure 26. All trails showing disturbance buffers corresponding to current use.

These buffered areas illustrate the relative amount of wildlife habitat that is under-utilized by species such as elk and grizzly bears. This map also illustrates the partial barrier effect that motorized trail use can cause that may hinder some animals from moving north from Yellowstone Park into the HPBH WSA or perhaps moving northward from within the HPBH WSA. Effects on elk have been well studied. These effects are summarized by Rowland et al. (2005) as: 1) Elk avoid areas near open roads, 2) Elk vulnerability to mortality from hunter harvest, both legal and illegal, increases as open road density increases, and 3) In areas of higher road density, elk exhibit higher levels of stress and increased movement rates. Additional information on the impacts on elk can be found in the section of this report on elk vulnerability (page 69-80).

As mentioned in the previous species accounts, John Weaver with the Wildlife Conservation Society developed a methodology to rate the conservation value of areas of habitat in the Flathead National Forest for different species (Weaver 2014). The quantitative methods used in that study are beyond the scope of this report, but a more qualitative assessment of the values of the HPBH WSA is possible. Table 2 presents a qualitative assessment of the Conservation Value (or Habitat Effectiveness value) for each species for the HPBH WSA. To compare existing and future conditions the WSA has been broken into three sections based on topography and current use (Figure 27: North: Hyalite region to about Lewis Creek in the Big Creek drainage. Central: Lewis Creek to near Windy Pass at the head of Portal, Big, and Rock Creeks. South: Windy Pass to Yellowstone Park boundary). A simple rating of Very High, High, Moderate, or Low was used. These ratings are meant to be similar in concept, but not equivalent to, the rating system used by Weaver which was much more rigorous and quantitative. These ratings should provide a sense of comparison to Weaver's work however since the HPBH WSA habitats for these species are very similar in intactness to the high quality roadless habitats of the Flathead National Forest. They are roughly equivalent to the 'Habitat Effectiveness' of the area. They can be used as a measure of value in relation to landscapes anywhere within the National Forest system in Montana.

Species	**Conservation Value of the northern HPBH WSA**	**Conservation Value of the central HPBH WSA**	**Conservation Value of the southern HPBH WSA**
Bighorn Sheep	Very High	Very High	Very High
Mountain Goat	Very High	Very High	Very High
Cutthroat Trout	Very High	Very High	Very High
Elk	Very High-Moderate	Very High	Very High-Moderate
Grizzly Bear	Very High-Moderate	Very High	Very High-Moderate
Wolverine	Very High	Very High	Very High
Pika	Very High	Very High	Very High
Composite	**High-Very High**	**Very High**	**High-Very High**

Table 2. Qualitative Conservation Values of the HPBH WSA.

This table demonstrates the importance of habitat (conservation value) throughout the HPBH WSA for all the species that use these areas (as well as the rest of the species that are protected under their ‘umbrella’). Cutthroat Trout habitats are ranked very high because they may be pure genetic strains, but primarily because the headwaters of trout streams in the HPBH WSA are very important to maintain all fish species downstream as well as providing an umbrella for all other riparian species. Grizzly Bear and Elk habitats are ranked Very High-Moderate in the northern and southern sections, instead of Very High, because the presence of motorized trails in those sections results in lower Habitat Effectiveness. Lower Habitat Effectiveness and Conservation Values occur only in the vicinity of trails, and the reduction in value depends greatly upon the type and intensity of use; overall the HPBH WSA contains High to Very High Conservation Values for all wildlife species considered in this report. As the number of trail users, and the frequency of use increases in the future, the quality of habitat can be expected to decrease.

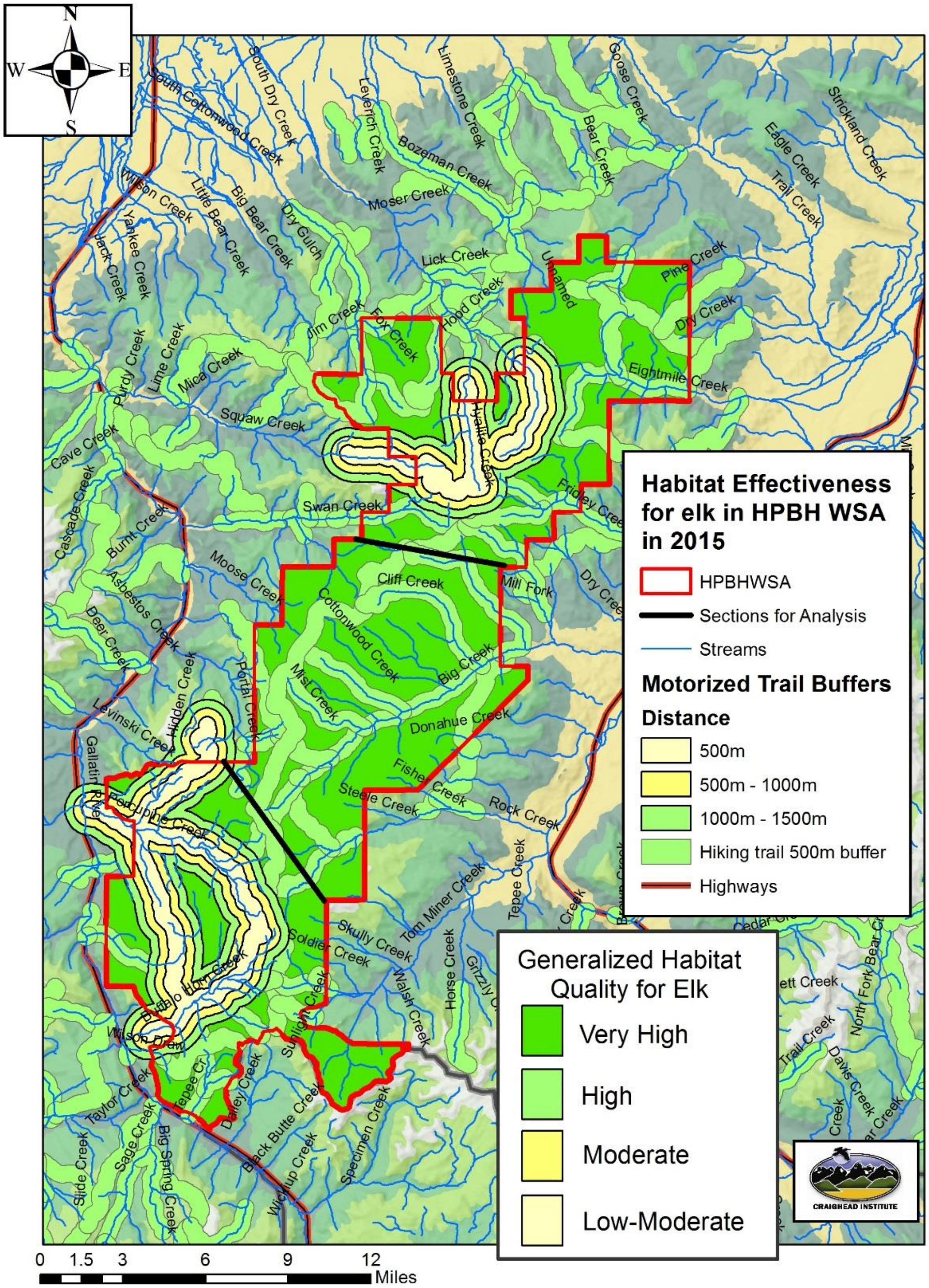

Figure 27. Three sections of the HPBH WSA for Analysis. Conservation values can be low to moderate in the vicinity of motorized trails depending upon the amount of use.

Connectivity values (Table 3) are similarly very high in the southern portion of the HPBH WSA because of its direct connection to Yellowstone Park. Connectivity values are slightly lower in the northern portion, although still very important for most species because it is a longer distance across lower elevation habitat to reach other high elevation areas to the north (Bridger Mountains) and moderate distances to the east and west. These distances can easily be travelled by grizzly bears and wolverines if they do not become totally blocked by development. Connectivity for trout occurs through downstream connections and is not applicable across the high elevations of the HPBH WSA.

Species	Connectivity Value of the northern HPBH WSA	Connectivity Value of the central HPBH WSA	Connectivity Value of the southern HPBH WSA
Bighorn Sheep	High	High	Very High
Mountain Goat	High	High	Very High
Cutthroat Trout	NA	NA	NA
Elk	High	High	Very High
Grizzly Bear	High	Very High	Very High
Wolverine	Very High	Very High	Very High
Pika	High	High	Very High
Composite	**High- Very High**	**High- Very High**	**Very High**

Table 3. Qualitative Connectivity Values of the HPBH WSA.

Weaver (2014) recommended that all areas in the Flathead National Forest that had 'High' composite scores or better for all focal species be designated as Wilderness. In a similar manner, considering the importance of the HPBH WSA for the focal species discussed in this report, its importance for maintaining diversity, and its importance for connectivity, the results of this analysis leads to a recommendation that all of the HPBH WSA be designated for low-impact recreation (Table 4). Considering the impacts of motorized recreation and mountain bikes, particularly as these uses will increase greatly in the future, it is recommended that from a wildlife perspective, trails within the HPBH WSA that are currently open to motorized recreation and mountain bikes be closed in the future. Trails in less intact habitat in the Custer-Gallatin NF would be more appropriate for these uses without compromising the ability of wildlife species to survive and persist.

The role of Protected Areas in Biodiversity Conservation

The Hyalite-Porcupine-Buffalo Horn Wilderness Study Area (HPBH WSA) was set aside, along with eight other wilderness study areas, by the 1977 Montana Wilderness Study Act (P.L. 95-150). The purpose was to leave the area undeveloped until the Secretary of Agriculture could review the lands, as to their suitability for preservation as wilderness, and report to the President.

According to the Wilderness Act, a wilderness is an "area of undeveloped Federal land retaining its primeval character and influence, without permanent improvements or human habitation, which is protected and managed so as to preserve its natural conditions and which (1) generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable; (2) has outstanding opportunities for solitude or a primitive and unconfined type of recreation; (3) has at least five thousand acres of land or is of sufficient size as to make practicable its preservation and use in an unimpaired condition; and (4) may also contain ecological, geological, or other features of scientific, education, scenic, or historical value."

By all these criteria, the HPBH WSA certainly qualifies for wilderness designation. In particular, its ecological features, as discussed in this report, highlight its importance for maintaining native plant and animal populations, and the ecosystem services they provide, into the future. Wilderness areas were originally valued for the "opportunities for solitude or a primitive and unconfined type of recreation". The sponsors of the Wilderness Act realized that all of our federal lands were being developed for resource extraction and other uses, and that there would be no wild places left to enjoy the solitude and wildness if they weren't protected. At that time there was no clear understanding of the great ecological importance of these wild places.

We now understand that many wildlife species require areas free of human disturbance in order to survive and reproduce; and that most wildlife require some degree of isolation and protection in order to thrive. Wildlife are called "wildlife" because of that unwritten understanding that they need to live separately from human activities; unlike domestic animals which have been bred to tolerate, and accept, constant interaction with human beings. The response of wild animals to human disturbance, like all behaviors, varies among individuals in the shape of the typical bell-shaped curve that all students of biology learn (Figure 28). In the case of tolerance of humans, there are always some individual animals who can greatly tolerate human activities; shown by the yellow 'tail' of the bell-shaped curve. They may have learned not to be afraid because their mothers were tolerant of people; they may be willing to accept some level of discomfort because there is something they need, like high-quality forage, that is close to people, they may even use the presence of people to avoid predation for themselves or their offspring.

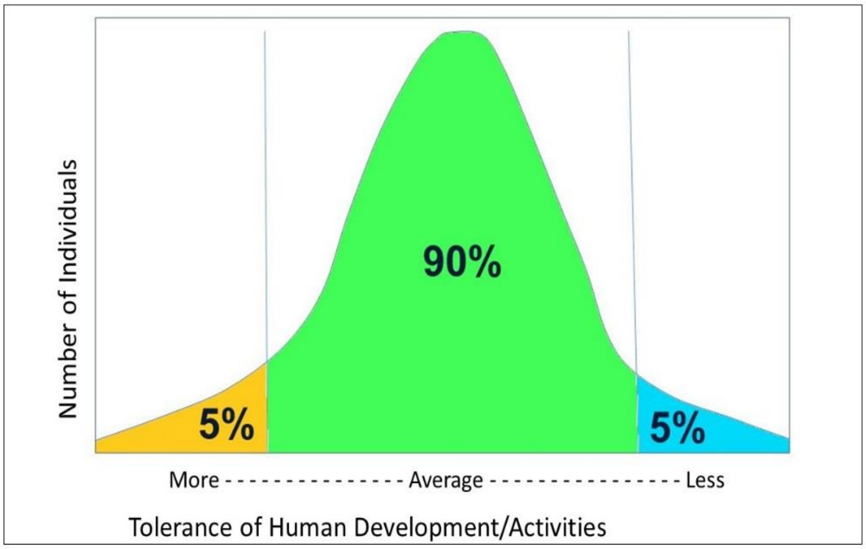

Figure 28. A bell-shaped curve of wildlife response to human disturbance

Similarly, there are always some individual animals who cannot tolerate human activities in the slightest degree, represented by the blue-colored tail on the right of the graph. These may be animals who have been hunted heavily or had intensely negative experiences (e.g. mother being killed) when young, or who need great security at crucial times such as when giving birth. The vast majority of individual animals fall in the middle of the curve; these percentages are not intended to be exact, but to give a sense of the proportions. Avoidance of human disturbance is similar to avoidance of predation, especially during hunting seasons.

Wildlife like elk require security from human disturbance at all times during the year. Some elk may hang out on the lawns at Mammoth Hot Springs all year; but the vast majority are living in the high country during spring and summer. Elk that are unhunted, as in Yellowstone Park, are more tolerant and many spend time near roads; but elk that are hunted every year, like the elk that live in and around the HPBH WSA spend their time as far from people and their activities as they can manage. The closest they get to humans is during winter when the snow drives them into the lower elevations on their winter ranges. Without the security of the HPBH WSA they would spend more time and energy avoiding human disturbance, as they do to avoid wolves (Creel et al. 2005, Creel and Winnie 2005, Abramsky et al. 2002, Hughes and Ward 1993) and this can lower their fitness.

As with all animals living in habitat that is near the carrying capacity for the species, displacement generally means death for some individuals in the population. If an elk, wolverine, or bear is displaced from an area needed for its survival it is forced to move into other, already occupied habitat. If it encounters a more dominant animal or unwelcoming herd in the new place it may be killed or displaced further into areas occupied by still other animals. Conversely, if the new arrival kills or displaces an animal that was previously occupying the habitat, the result is the same: one less animal in the population. Thus, if the level of disturbance from humans forces an animal to move away from the disturbance, it doesn't just 'go somewhere else' where it finds 'the same type of habitat'. Displacement of animals causes ripple effects throughout the population with the result that there is less habitat overall and the population declines accordingly.

Public lands can be classified by their managing agencies, by acts of Congress, and by Presidential actions. Some of the more common classifications are presented in Table 4. This is not an exhaustive list, and there may be some inaccuracies or incomplete information, but this is just intended to show the complex nature of land use management in the United States.

Classification	Protection	Allowed Uses	Time frame of Protection
Research Natural Area	Highest	Scientific research	Permanent* Established by managing agency
National Park	High	Hiking, Skiing, Horseback, no mechanized use, no hunting	Permanent* by Act of Congress
National Monument	High	Existing rights, most recreation uses	Permanent* by Presidential Decree or Act of Congress
Wilderness Area	High	Hiking, Skiing, Horseback, hunting, no mechanized use	Permanent* by Act of Congress
National Conservation Area	High	On BLM lands, non-motorized use	Permanent* by Act of Congress
Primitive Dispersed Recreation Area	High	Non-motorized use only	Temporary: until Travel Plans or Forest Plans are revised
National Scenic Area	Medium	Varies from area to area	Permanent*
Special Interest Area	Varies	Varies from area to area: mechanized use, livestock grazing, and visitor sites.	Temporary:
Special Recreation Area	Varies	Varies from area to area	Temporary:
Motorized Dispersed Recreation Area	Low	Motorized use	Temporary:
Motorized Route	Low	Motorized use	Temporary:
Range Allottment	Low	Livestock grazing	Temporary: requires permit renewal
Timber Harvest Units	Low	Roads and Timber Harvest	Temporary:

Table 4. Alternative Classifications for Wildlife Habitat of the HPBH WSA.
* Congressional and Presidential actions can generally be revoked by other Congresses or Presidents

As mentioned, public lands can be classified by different means. Some of the more common actions for classifying Forest Lands are listed in Table 5. Again, this is not an exhaustive list, and there may be some inaccuracies or incomplete information.

Methods of Changing Land Designation	Time frame of Designation
Forest Plan Revision	Temporary
Forest Travel Plan Revision	Temporary
Act of Congress based on NEPA	Permanent*
Act of Congress based on Congressional Bill	Permanent*
Presidential Decree	Permanent*
Agency Administrative Action	Temporary or Permanent*

Table 5. Methods of Changing Land Designation
* Congressional and Presidential actions can generally be revoked by other Congresses or Presidents

Conclusions

Intact ecosystems which are not fragmented by human developments or degraded by human activities are important for many reasons. These include the provision of ecosystems services such as clean air and clean water, climate regulation, soil formation, nutrient cycling, and harvesting of food, fuel, fibers, and pharmaceuticals. Ecosystems also provide spiritual and psychological benefits whose values are not yet well understood. In a recent analysis of the economic benefits accrued from wild nature (Balmford et al. 2002), benefits from intact ecosystems were estimated to greatly exceed those from continued habitat conversion with an overall cost:benefit ratio of 100:1. Protected areas are now seen as a means to conserve ecosystem services which support society (McNeely 2015) and they are highly cost-effective in protecting biodiversity (Balmford et al. 2002, Rodrigues et al. 2015).

Because of the negative effects of human-related activities and developments on many wildlife populations and individuals there is a critical need for secure areas of refuge where animals are able to meet their life history needs of survival and reproduction with a minimum of disturbance. Such areas need to contain high quality habitats and need to be as permanent as possible so that wildlife have a certainty that they can find what they need at the same location over time. Climate change can gradually affect that certainty as habitats change, but those changes are beyond our control to a large degree; management of public lands and human use restrictions can also affect that certainty, and those changes can be controlled, but are also unpredictable to a degree. Land use on unprotected public lands in the future may depend upon upper-level agency decision-making and often political and economic pressures. Land use on private lands can change at any time; areas with little hunting pressure can become heavily hunted in the future causing wildlife such as elk to try to find new areas of refuge.

One of the current trends in conservation efforts considers that we are now in a human-dominated era, the Anthropocene (Crutzean and Stormer 2000, Kareiva et al. 2007), where "eco-pragmatism" approaches are used to determine land uses that are compatible to both wildlife species and human demands. This view has some validity on lands that are already heavily compromised by human alteration and use, but should not be applied to intact ecosystems that are currently roadless. Caro et al. (2011) have succinctly summarized the need for intact ecosystems:

> "There are still ecosystems that are sufficiently intact to retain key ecological functions and species, and it is vital to identify and protect them now. We define intact ecosystems as those in which the majority of native species are still present in abundances at which they play the same functional roles as they did before extensive human settlement or use, where pollution has not affected nutrient flows to any great degree, and where human density is low".

Altering the last remaining roadless areas to accommodate human uses that are not essential to our survival is actually not "pragmatic": those intact ecosystems may in fact be essential to our survival in the future as climate change progresses. Based on the data and information contained in this report, the HPBH WSA can be considered an intact 'ecosystem' or critical component of a larger ecosystem, the GYE, and as such should be protected from further human alteration and disturbance. This protection should be as restrictive of human uses as possible and should be as permanent as possible.

To ensure that wildlife have sufficient habitat for population persistence into the future, and to confer resilience in the face of climate change and land use change, there must be an adequate amount of protected habitat available among the spectrum of lands that are accessible to those wildlife. The more permanent that protected habitat is, and the larger the area is, the more certainty there is that wildlife populations can persist. Fragmenting the HPBH WSA into smaller pieces of protected habitat would greatly diminish its value for wildlife habitat and the provision of ecosystems services, and could nullify its ability to function as a refuge from climate change.

Additional Data Needs, Analysis Possibilities, and Stakeholder Approaches for application to wilderness study and other planning processes.

Focal Species Data Needs

The focal species used for this report serve as umbrella species for most of the other species in the HPBH WSA with the exception of obligate forest dwellers. Additional focal species such as marten, fisher, lynx, flying squirrel, or goshawk would be useful for planning purposes to cover the habitats not completely covered by the focal species in this report. The US Forest Service is contracting with Wild Things Unlimited to collect additional data on lynx and fisher which may provide enough data to include them as focal species. Amphibians would also be useful as focal species and for monitoring to track the effects of climate change; surveys to establish baseline data on amphibian species distribution and status would be extremely useful for Forest Planning.

Habitat Effectiveness Modeling

Habitat Effectiveness Models are extremely useful tools for assessing the capacity of the HPBH WSA for key species. The Forest Plan Revision should include habitat models for all focal species addressed. In addition to traditional habitat modeling approaches, newer technologies such as the use of LIDAR(see below) to determine vegetation structure in conjunction with vegetation classes derived from spectral data offer greater accuracy and definition for habitat modeling.

LIDAR Data

LIDAR (Light Detection and Ranging), an optical remote sensing tool that measures and maps physical features on the earth with vertical resolution down to 5 cm., is one of the most significant new data technologies for resource management. Pulses from an aircraft-borne laser beam reflect from various surfaces and are recorded as precise images of the ground surface, vegetation (including trees, understory shrubs and herbs), and built environment. Originally developed by NASA, LIDAR is now 'flown' by commercial vendors, and libraries are maintained by NOAA, USGS, and other large organizations. The use of unmanned drones to acquire LIDAR data promises to reduce the price greatly in the future. The emergence and growth of LIDAR technology is creating a new wave of sophisticated and accurate environmental tools to help scientists and resource managers cope with changing land use, changing climate, changes in biodiversity, risk management, extreme weather events, resource inventory, facilities siting, and other issues. Time-series LIDAR data can provide precise estimates of snow pack, increase in wildfire fuels, spread of exotic plants, geological changes such as fault expansion or soil movement, vegetation changes, etc.

In addition to current resource management needs, Lidar offers a significant increase in the ability to monitor, predict, and manage climate change adaptation. The acquisition of LIDAR data for the Gallatin National Forest would greatly facilitate Forest Planning. In addition to habitat modelling, LIDAR data would also improve

- Fire prevention and management
- Flood prevention and management
- Water Quality Monitoring
- Drought preparedness
- Forestry uses and management
- Minerals/Oil and Gas development and management
- Other energy development (wind, solar)
- Invasive plants
- Carbon sequestration/biomass of forest, grassland
- Geological Risk Detection
- Wildlife habitat management and protection
- Climate change adaptation
- Endangered species management

Although Lidar data are currently very expensive, the costs can be greatly reduced by cost-sharing consortiums with other users. Costs over large contiguous areas can range as high as \$1,000 per mi^2 (for 50-100 mi^2 areas). Cost sharing approaches that acquire larger areas of data coverage can reduce the price to about \$500 per mi^2 (for areas greater than 250 mi^2) while shortening acquisition and distribution times. Costs for LIDAR data that include the Gallatin NF could also be shared by the US NPS, BLM, USFWS, FEMA, and state agencies such as the Montana Dept. of Agriculture, Dept. of Natural Resources and Conservation (Water Resources Div, Conservation and Resource Development Div), Dept. of Environmental Quality, Dept. of Fish, Wildlife and Parks, Dept. of Livestock, Dept. of Public Health and Human Services, Montana Bureau of Mines and Geology (State Survey), Dept. of Transportation, Montana Bureau of Mines and Geology (State Survey) and the Judicial Branch (Montana Water Court, Natural Resource Damage Program).

Multi-Stakeholder Decision Support

There are a number of newer approaches to balancing the value of biodiversity and ecosystems services with the needs or wants of multiple stakeholders. One such tool is the Nature Conservancy's InVEST, Natural Capital Project http://www.naturalcapitalproject.org/invest/. According to the InVEST website: "InVEST is a suite of free, open-source software models used to map and value the goods and services from nature that sustain and fulfill human life. If properly managed, ecosystems yield a flow of services that are vital to humanity, including the production of goods (e.g., food), life-support processes (e.g., water purification), and life-fulfilling conditions (e.g., beauty, opportunities for recreation), and the conservation of options (e.g., genetic diversity for future use). Despite its importance, this natural capital is poorly understood, scarcely monitored, and, in many cases, undergoing rapid degradation and depletion. Governments, non-profits, international lending institutions, and corporations all manage natural resources for multiple uses and inevitably must evaluate tradeoffs among them. The multi-service, modular design of InVEST provides an effective tool for balancing the environmental and economic goals of these diverse entities."

There are also custom approaches for multi-stakeholder analyses that are transparent and easy to update. Using spreadsheets such as Excel in combination with GIS, these approaches divide the planning area into units and attribute those units with values to reflect the priorities of given stakeholders and other information such as whether one use is compatible or incompatible with other uses. Wildlife species can be treated as stakeholders using this approach. This facilitates the identification of areas of overlap of stakeholder preferences and areas of conflict between stakeholders. The use of such tools, or partnering with NGOs such as the Nature Conservancy would greatly facilitate and improve Forest Planning.

Wealth Accounting

Multi-stakeholder collaboration and decision making systems can also be based upon Wealth Accounting, a methodology that measures the stocks and flows of social, environmental, economic, and human variables; rather than the traditional approach that considers only economic values. A new policy tool called Wealth of Montana, http://www.scigaia.com/projects/wealth-of-montana/ which is based at the University of Montana Foundation, promises to improve our understanding of the true value of wildlife, biodiversity, and intact ecosystems such as the HPBH WSA. According to its SciGaia website, The Wealth of Montana "is an online multi-stakeholder decision support system that will utilize a smart information grid to analyze, in a multi-stakeholder fashion, how changes in (Montana's) physical, social and economic environment can best inform state and regional policies to maximize the sustainable well-being of its citizens and environment". As this approach is fine-tuned it could provide valuable insights into the best management practices for the HPBH WSA.

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