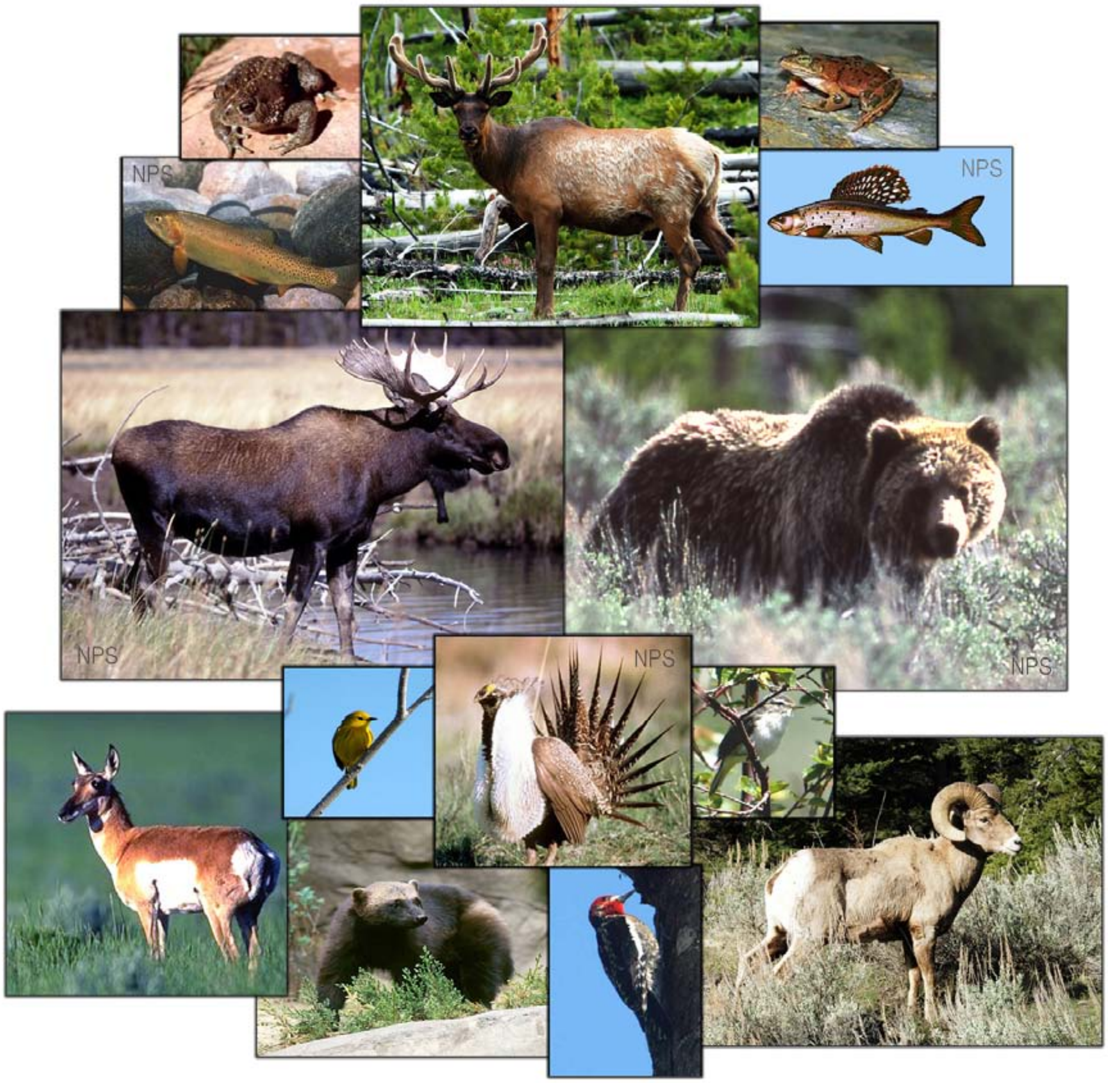
A WILDLIFE CONSERVATION ASSESSMENT OF THE MADISON VALLEY, MONTANA.



CRAIGHEAD ENVIRONMENTAL RESEARCH INSTITUTE

WILDLIFE CONSERVATION SOCIETY

MADISON VALLEY RANCHLANDS GROUP

A Wildlife Conservation Assessment of the Madison Valley, Montana.

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Introduction

It's an early autumn morning as you gaze southeastward, just to the right of the rising sun, across the Madison Range. Sunlight colors the golden riparian ribbons following streams, large and small alike. A dozen warblers in fall migration settle among the aspens bordering the alpine lake below you, chipping and gorging on small insects having been forced landward by a nocturnal rain. Your view from a peak in the Tobacco Roots takes in the Madison Valley bounded by its synonymous range and the Gravelly Range to the west. A clear view of the Teton's presents itself as they shoot skyward from south of the Yellowstone Plateau, while the Centennials and the Snowcrest Range anchor the south and southwest horizons freshly draped in snow. You actually anchor the northwest horizon of the Greater Yellowstone Ecosystem where below you, running south to north, the Madison River threads its way from its birth in Yellowstone National Park at the union of the Gibbon and Firehole rivers. The upper reaches rush and run while its lower sections, following a roily tumult through the Beartrap Canyon, laze to the river's confluence with the Jefferson and Gallatin rivers at Three Forks. Hence, the birth of the Missouri River; "Big Muddy" of the Plains Indians.

This watershed is a special place, an understanding that is obvious from your clear and unobstructed vantage point. The Madison Valley (Figure 1) bordered by its conterminous and defining mountain ranges is an integral piece of the area known as the Greater Yellowstone Ecosystem (GYE) while providing a pivotal link on an ecological, as well as socioeconomic, chain reaching from the Wyoming's Wind River Range to northwestern Canada. Like many ecologically and culturally important places in the world, embarking on a young millennium we are at risk of loving this beautiful valley to death. As local human populations swell with in-migration, coupled with ecological, social, and economic impacts even greater than mere numbers belie, the very nature of local areas can change. Cultures change, economies change, hydrologies change, ecologies change, and even climate can change with changes in human landuse and population. That is the way of it. However, with knowledge grounded in a local, but not merely provincial, perspective we can act to minimize negative impacts of population growth and development, working to wisely shepherd change in ways that help retain the wonders of the place in which we live. It is with this in mind, that the Wildlife Conservation Society, with the collaboration of many persons and organizations, notably the Madison Valley Ranchlands Group, the Craighead Environmental Research Institute, Montana Department of Fish, Wildlife & Parks, the US Forest Service, and the Bureau of Land Management, embarked on a project to lay the groundwork for a conservation assessment of the Madison Valley. Moreover, we have attempted to robustly, objectively, and succinctly determine best avenues for implementing on-the-ground conservation measures based upon autecological as well as community ecological information on natural history, stresses to long-term viability of species, and restorative processes.

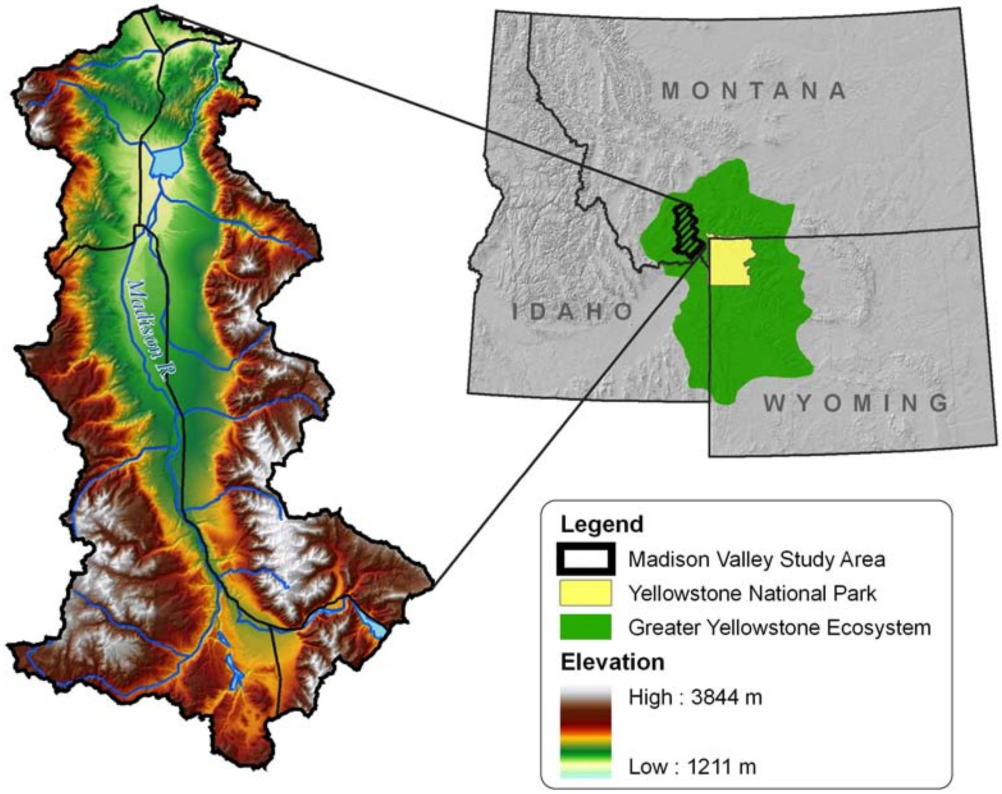


Figure 1. The Madison Valley study area, defined as the Madison River drainage from Hebgen Lake north to Harrison and from the top of the Madison Range Divide on the east to the top of the Gravelly and Tobacco Root Mountains on the west.

Toward that end, we have embarked on what really amounts to an early step in the process of ecological and intentional land use planning for the Madison Valley; nearly a million acres extending from Hebgen Reservoir in the south to Harrison in the north. We have followed what we hope is a transparent methodology in identifying areas for conservation action spatially, temporally, and realistically. To increase transparency, and to that end, both internal and external validity, as well as allowing for modifications by others with conservation planning in mind, some of the processes that we have followed are a reliance on public and/or published data sources including Montana GAP vegetation data, TIGER roads data, county-level plat GIS data, and MT Natural Heritage Element Occurrence and Point Observation Data, among others. The vast majority of data used for this project are to be found in the public domain. Additionally, our methodologies for identifying species important to conservation action, threats to those species, and natural history information have relied upon peer-reviewed publications, expert opinion, and reiterative processes such as the development conceptual models that outline the stresses, sources of threats, and interventions for each species.

Following Groves (2003) we employed a "Four-R Framework" to identify areas within the Madison Valley that may be important to wildlife conservation. Specifically, we want these areas to be *Representative* in that they represent the biological features and the range of conditions under which they occur. An integral part of ensuring that conservation targets are representative is through an information-based species selection process. The Landscape Species Approach (LSA; Wildlife Conservation Society 2001) outlined below is based upon using natural history parameters, as well as species vulnerabilities and cultural significance, in order to build a representative suite of species capturing all habitats and threats operating in the project area, in this case, the Madison Valley.

Second, these areas must be *Resilient* to natural and human-caused disturbances. As such, populations of species, and/or their habitats should be of high qualities that can buffer stochastic and deterministic disturbances. This in fact entails that the pinpointing of important conservation areas includes areas of adequately functioning ecological processes. When ecological processes are protected we can reasonably expect that the majority of dependent species will be conserved as well.

Third, to avoid extinction or endangerment to threats (natural and human-induced), conservation targets (those biological features we seek to conserve) and areas should be represented multiple times within the area of inquiry. That is to say, there is an importance associated with *Redundancy*. The selection of areas most desirable for conservation was directed from a wildlife-centered perspective as above, and as such, multiple areas of adequate habitat effectiveness were generally determined independently. In other words, we placed no limit on area or numbers of patches prioritized for each species. In the case of distinct and isolated populations making up a metapopulation of a certain species, adequate numbers of populations with a suitable distribution of these populations should be a central component of conservation planning.

Fourth, conservationists should evaluate where, when, and how conservation targets or areas that are stressed, not viable, or lack ecological integrity may be *Restored*. It is of little value to identify areas for conservation measures that in fact are impossible to restore to qualities necessary for use by the species suite of interest. This comes naturally as a product of threats analysis and through modeling the human landscape. For example, to the chagrin of an idealist, we must understand that conservation planning based upon today's habitat use by wildlife species is based upon a benchmark. Whether that benchmark is at the beginning of the 19th Century (Lewis & Clark) or what we see today, there are certainly habitats that cannot support species that were historically supported. Grizzly bears once haunted the river bottoms of the intermountain valleys where they gorged on winter killed bison. At this point in the history of the West, a pragmatic conservationist would not concentrate resources on the restoration of that specific relationship.

In this report, we hope to both describe the ecological framework of the Madison Valley and reasons that we, and others of the conservation community, and by definition, all those who work and live here, should devote ourselves to the conservation of this watershed. As such, below we describe the process followed in this conservation assessment as well as the results produced:

- what is unique about the Madison Valley and why conserve habitat here
- the method in which species were selected for driving the conservation prioritization process
- the assumptions and limitations of the methods and data
- assessing complementarity of the species suite
- inclusion of special elements to represent habitats not represented by other species
- analysis and description of threats for each species
- modeling the human landscape
- modeling the habitat of each selected species
- results for each selected species
- analysis of wildlife habitat connectivity
- overlaying the results to give a composite picture of conservation priorities in the Madison Valley
- the results of summary analyses

We describe each species selected to develop the conservation prioritization with the following outline followed:

- Current status
- Current threats – including the conceptual model followed (see below)
- Habitat analysis
- Conservation strategies

Furthermore, ecology is the science of relationships. Hence, we desire conservation programs that maintain interspecies, and by extension, interhabitat and abiotic relationships. So, with that in mind, vertebrate diversity summaries (potential, current, and potential vertebrate diversity loss), overlay analyses, and connectivity analyses were investigated to produce maps of the Madison Valley that are robust and in essence multivariate. With this information in-hand, we hope that conservation practitioners can readily move to advance on-the-ground conservation projects and plans. But, first, let's explore the reasons for concentrating on conservation in the Madison Valley.

The Place

The Greater Yellowstone Ecosystem (GYE) is one of the most ecologically intact natural systems at temperate latitudes the world-over. At least seven major (depending upon one's definition, of course) rivers are born in the GYE. El Dorado of flyfishing culture they comprise the "Golden Ring" with names like the Henry's Fork, Snake, Yellowstone, Gallatin, and Madison. Small mountain freshettes coalescing into larger streams carry winter's snowmelt well into-if not through- the summer nourishing riparian spruce glens, beaver meadows, cottonwood gallery forests, willow thickets, lower elevation oxbow sloughs and side channels, irrigated hay and row-crops, and the region's cities themselves. The streams not only transport life-sustaining water from the winter snowpack and montane summer showers down to the valleys, but, these creeks form a miraculous network, a *rete' mirabele'*, if you will, carrying nutrients downward suspended in the sediments of spring's runoff and autumn's leaves, nutrients upward in the bodies and eggs of spawning trout and altitudinally migrating aquatic insects, and nurture ribbons of riparian vegetation providing both habitat and movement corridors for a majority of wildlife.

Large elevation gradients from valley bottoms to mountain summits, rugged topography, a temperate continental climate, a highly varied geology, historical large-scale disturbances, and historical linkages to other mountainous areas have all contributed to what we see as today's ecological value exemplified by the GYE. Altitude within the ecosystem ranges from below 1000 m along the Yellowstone River as it departs to over 4100 m in the Wind River Range and Teton's (Figure 2). Coupled with the great topographical relief from the plains and river bottoms to alpine tundra, a rugged alpine glaciated topography replete with hanging valleys, lofty cascades, and terminal moraines has made early long-lasting exploitation of higher altitudes difficult. Moreover, the highlands of the GYE have historically provided not only refugia for large mammals such as bison and grizzlies, but have also provided part of the intact habitat matrix necessary for species that depend upon structurally and vegetatively diverse habitats. The mountains of the GYE have experienced less development than the broad and productive valley bottoms in effect providing space and isolation for many of these species.

Due to the latitude and associated continental climate (with a Pacific influence in its western areas) of the GYE, habitat diversity in these mountains is relatively high with soils, climate, and aspect all interacting to provide a varied matrix of plant communities. For example, on warmer and well-drained southfacing slopes late spring brings to bloom a community of arrowleaf balsamroot among native bunchgrasses while nearby, perhaps only feet away but oriented north, Douglas-fir and subalpine fir dominate a sparse understory of huckleberry or buckbrush.

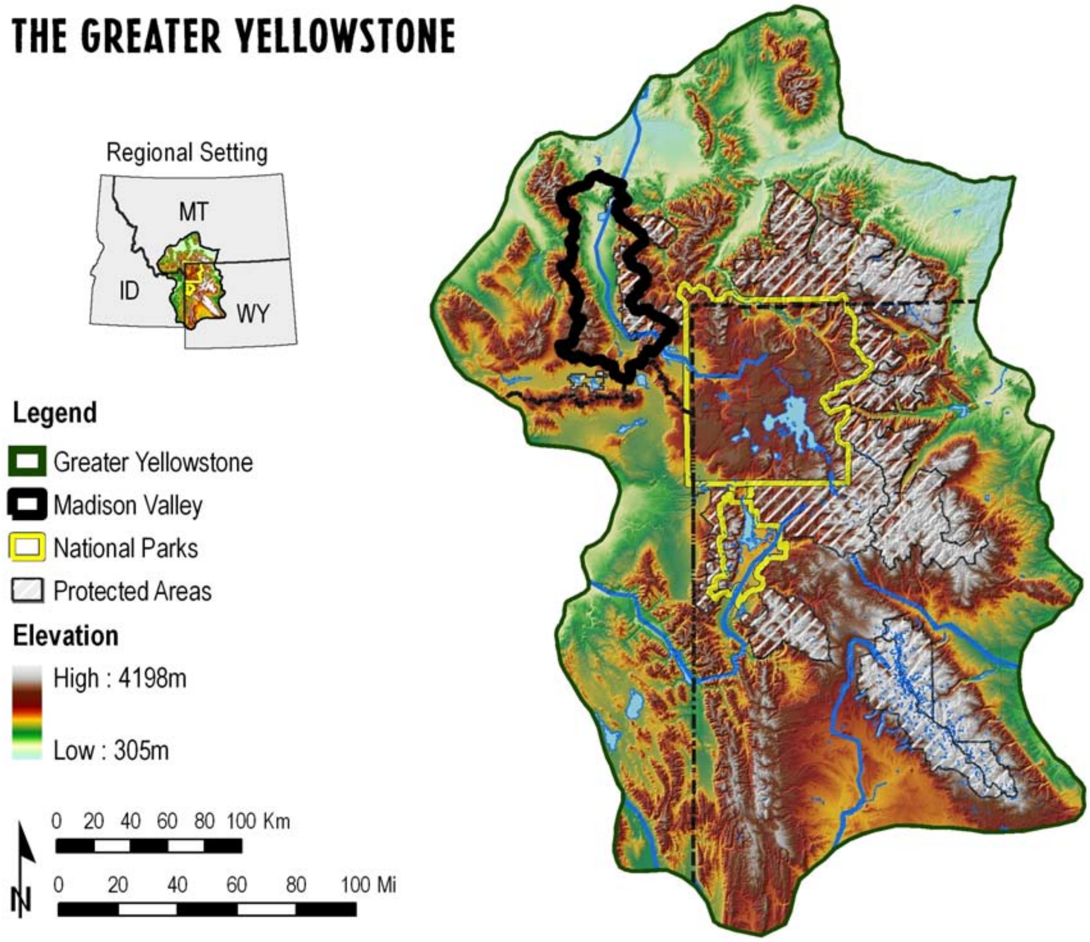


Figure 2. Physiognomic map of the Greater Yellowstone Ecosystem (area boundary as delineated by Noss *et al*. 2002)

As Don Despain (1990) noted, the distribution and diversity of plant communities in the GYE is highly influenced by both climate and parent material of the soils. Where well-drained rhyolitic soils dominate, fire adapted and ecologically simple lodgepole pine/grouse whortleberry communities predominate whereas where sedimentary parent materials and volcanic debris have deposited more productive natural communities are found. In many areas alpine glaciers of the Pleistocene redistributed these soils into complex distributions influenced to this day by ever migrating stream courses. Overlay these geologic patterns with local climatic and disturbance regimes and one observes a great diversity of plant communities with their representative suites of wildlife.

Today, the GYE hosts populations of all the large mammals that inhabited the area at European-American exploration and settlement including predators such as grizzly, American black bear, cougar, gray wolf (reintroduced), and ungulates including bison, elk (wapiti), moose, pronghorn, bighorn sheep, mule deer, and white-tailed deer. Smaller species have not faired so well, however. Black-footed ferrets, whooping cranes, Rocky Mountain locusts, and passenger pigeons were likely found ringing the GYE, if not inhabiting it specifically, and wild viable populations of these species are no longer found here. Furthermore, questions also remain regarding the population viability of lynx, fishers, and northern leopard frogs living in and around Yellowstone National Park.

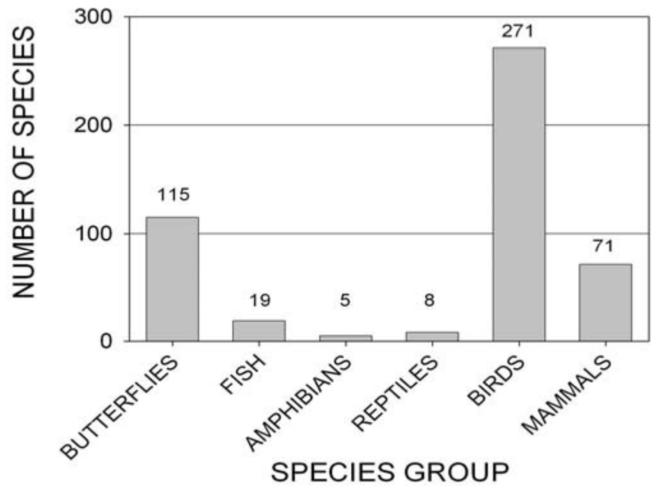


Figure 3. Known number of species of selected animal groups inhabiting the Madison drainage.

Today, the Madison is one of the most ecologically intact valleys of the Greater Yellowstone Ecosystem, a reflection of a healthy land stewardship ethic maintained by the valley's residents and land managers. Along with large carnivores such as the grizzly bear, gray wolf, and wolverine, the citizens of the Madison Valley share this 900,000 acre watershed with a migratory and non-migratory population of pronghorn, nearly 300 species of birds, a remnant of southwest Montana's ancient, geological connection to Hudson Bay—the fluvial arctic grayling–and a host of other wildlife species. Actually, it is assumed that westslope cutthroat trout also can trace their phylogeny back to the Pleistocene, specifically, glacial Lake Missoula.

The Madison River watershed harbors over 2,100 miles of streams from narrow mountain torrents to slow, lazy sloughs and spring-fed creeks. These streams are the lifeblood upon which communities, economies, and wildlife depend. Even though they occupy less than 5% of the area of the drainage, the streamside habitats (riparian) support over half of all wildlife species that are native to this region including many species of songbirds such as the familiar Yellow Warbler, a variety of amphibians, and numerous species of mammals from small (bats) to large (moose). The riparian habitats of these streams are what first brought Euro-Americans to southwestern Montana as men such as John Work and Osborne Russell plied the streams falling off the Madison and Gravelly Ranges for beaver. They were, in turn, using the same trails that Native Americans had used for centuries. The Shoshone Indians long hunted and grazed their large herds of horses here and even they followed precursors like the Kiowa to the valley. Even today, hikers in the highest mountain meadows can find evidence of their presence by searching the ground at their feet for flakes of obsidian.

The Madison Valley, although not central geographically to the GYE, plays a central role in the GYE's relationship to other ecologically intact areas of the Central Rocky Mountains, specifically, the Northern Continental Divide Ecosystem (Glacier and Banff national parks) and the wildlands of central Idaho (Salmon-Selway Ecosystem or Selway-Bitterroot) (Figure 4). At its northwest position, let's say on the face of a clock centered at West Thumb of Yellowstone Lake between 9:30 and 11 o'clock, the Madison Valley and its associated mountains links Yellowstone to the central Idaho wildlands at Raynold's Pass and Papoose Creek while linking the GYE to Glacier National Park and the Bob Marshall Wilderness Area via the Norris and Virginia City hills.

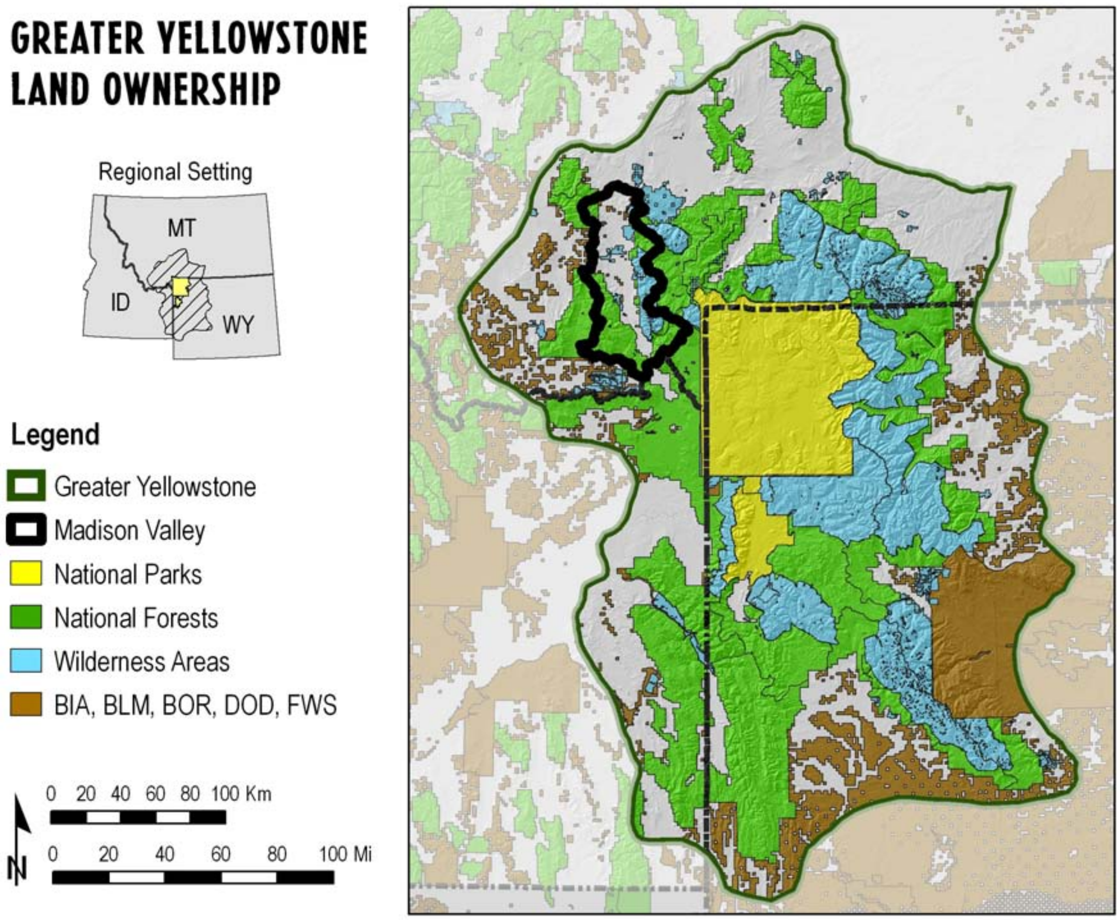


Figure 4. Land ownership map of the GYE showing public and protected lands adjacent to and within the Madison Valley.

The Why

Of course, the ecological values that we've already outlined above, to a large extent define *The Why* behind conservation of the Madison Valley. However, portions of this ecological tapestry are threatened by development, changes in economics, and recreation while simultaneously at risk from regional climate change. These currently occurring and potentially occurring stresses furthermore define reasons to explain *The Why* of applied conservation in the Madison as well as the reasons for this project.

Madison County, like the other 19 counties comprising the GYE, is no stranger to the rapid regional population growth that really got going in the 1990s. From 1990 to 2000, county population increased 14% (38% from 1970-2002) while per capita income increased by 12%. Forty-two percent of this income was derived from non-labor sources and it is important to note that, adjusted for cost of living increase, the average earnings per job in Madison County have decreased nearly 16% from 1970-2000 ($19,075 and $16,053, respectively). These statistics describe a change in economy from more "primary" sources such as timber, mining, and agriculture to sources such as investments, retirement income, and service sector income. With these economic changes come cultural changes that interact strongly and often drive ecological changes through development pressure. These changes have led the American Farmland Trust to rank Madison County as the third most at risk Rocky Mountain county with respect to loss of strategic ranchlands (American Farmland Trust, 2006).

In a study of ranchland dynamics over 10 counties in Greater Yellowstone, Madison County ranked in the top tier of counties (along with Sublette Co, WY and Park County, MT) in terms of ranchland acquisition by both amenity buyers and developers (Haggerty *et al*. 2004). Madison County was the only county studied in which two of the twenty largest landowners are developers. Developers remained active buyers of ranchland property over 400 acres throughout the 1990s in Madison County. At the same time, there have been a considerable number of conservation easements secured on several large ranches in the valley and some landowners are pioneering conservation ranching approaches. In fact, the Madison Valley has the largest concentration of conservation easements in all of Montana.

The fast pace of development in other valleys in the GYE (Teton, Jackson Hole, Gallatin, Paradise) is strongly suggestive that a similar fate may await the private lands of the Madison Valley unless conservation actions are taken soon. The socioeconomic trends, ranchland dynamics, contentious wolf-livestock conflicts, the relatively intact ecological nature of the valley, and the recent surge in conservation interest by a number of organizations suggests that the time to develop a strong conservation plan and launch a broad conservation initiative is at hand.

As local economic facets change in and around the Madison Valley, not only do wildlife communities change as human communities change, but, the functions and relationships within and among these wildlife communities change. Several ways in which change occurs is through the loss of connectivity, loss of natural disturbance mechanisms like wildfire, loss and conversion of habitat from a state in which certain native species can be supported to situations where these species can no longer exist (a decrease in habitat quality), or do so at a vulnerable level, to the complete loss of habitats for native species (a decrease in habitat quantity). All of these changes impact more than just the local valley due to the geographical and functional position the Madison Valley holds to the whole of the Greater Yellowstone Ecosystem.

Recently, Montana Audubon identified the Madison River Valley as an Important Bird Area (IBA) of national significance based upon its importance for breeding and migrating songbirds and waterfowl (Marks *et al*. 2006). The cottonwood gallery forests along the Madison River are prime nesting grounds for such songbirds (neotropical migrants, of course) as Willow Flycatchers, Warbling Vireos, Gray Catbirds, American Redstarts, Yellow-breasted Chats, and many others. Additionally, Bald Eagles nest at four sites between Ennis Lake and Varney Bridge. The Madison IBA is one of 26 sites identified across the state for research and conservation.

Van Kirk (1999) identified the Madison drainage as exhibiting poor aquatic habitat quality, average watershed integrity, and of medium priority for watershed conservation and restoration in comparison with all the drainages of the GYE. Biotic integrity for native trout and grayling was identified as poor due to the preponderance of nonnative fish and small presence of natives. Even though the Madison River is dammed at Hebgen and Ennis Reservoirs and naturally at Quake Lake with flows regulated, Van Kirk *et al*. (2000)

and Van Kirk and Benjamin (2001) graded the hydrologic function of the Madison River as good, while identifying watershed riparian conditions as poor. These authors felt that riparian information availability was good when comparing to other watersheds, and perhaps so at the scale of the total GYE (but, see below, as riparian information is severely limited in the Madison Valley). These authors felt that in relation to all 41 river basins in the GYE, the Madison River basin should be preserved and protected. Moreover, contained in the operating license held by PPL Montana for Hebgen Dam, is an allowance for flushing flows to mimic more natural hydrology. An experimental pulse was released in Spring 2006 with analyses continuing (Pat Clancey, MFWP; pers. comm. 7 Sept. 2006).

Additionally, *Montana's Comprehensive Fish and Wildlife Conservation Strategy (*Montana Fish, Wildlife & Parks, 2005) identified the Madison River as a "Tier 2" 4th Code Hydrological Unit (HUC) indicating importance as an aquatic area whereas the Madison Valley comprises a portion of a "Tier 1" focus area ranking denoted as Southwest Montana Intermontane Basins and Valleys. The surrounding mountains all have been designated by this strategy as belonging to "Tier 2". What this pragmatically means is that they have been identified as conservation focus areas that provide some of the greatest opportunities to conserve the community types and species in greatest need of conservation. We direct you to the aforementioned publication for greater detail.

Unique to the Madison Valley is a local non-government organization, the Madison Valley Ranchlands Group (MVRG), formed by local ranchers "to keep the ranching way of life viable by protecting open space for productive agriculture, wildlife habitat, recreation, and watershed management." With encouragement from the Montana Department of Fish, Wildlife and Parks (MT FWP), WCS formed a partnership with MVRG in 2003 to assist them in identifying the most important remaining wildlife habitats in the valley. (MVRG is a small organization with only two full-time staff.) Noss *et al*. (2002) identified portions of our project area as important and in need of conservation, namely, the Gravelly-Snowcrest, the Red Rock/Centennial, Tobacco Roots, and West Yellowstone megasites. The Henry's Fork megasite lies directly south and contiguous to this project area and is integral to the migratory population of pronghorn inhabiting both the Madison and the Henry's Lake drainages, whereas the Gallatin River site lies just to the east and is integral ecologically through movements of large ungulates and predators.

Although the Noss' GYE biodiversity assessment identified small portions of the upper Madison Valley as a conservation priority, this assessment was conducted at a sufficiently broad geographic scale (the entire GYE) to preclude specific recommendations for on-the-ground actions. The 43 megasites identified in this assessment ranged in size from 28,000 acres to 780,000 acres with an average of 270,000 acres. Portions of the upper Madison Valley were included in the 510,000 acre Gravelly-Snowcrest megasite, but the lack of information on threats and the scale at which the site was identified and delineated provide no information detailed enough to take conservation action. However, these sorts of regional or ecoregional analyses were never intended to do more than highlight generalized areas for conservation attention, which, in turn, require more detailed follow-up analyses at the site or landscape scale. The Nature Conservancy and other GYE-regional land trusts have been conducting several such landscape or site analyses in the Greater Yellowstone Ecosystem. To date, no such analyses have been conducted in the Madison Valley watershed. In fact, in a study conducted by the Resources Law Group in 2003 on behalf of the Duke, Moore, and Packard Foundations that focused on private land conservation priorities in the Greater Yellowstone Ecosystem, the Madison Valley was identified as one of two high priority focal areas in need of more detailed site conservation planning.

Finally, a collaborative group of agency, private, and non-governmental entities referred to as the Wildlife Committee has been organized in order to better understand wildlife issues of the Madison Valley and to resolve issues by developing strategies that benefit both wildlife and Madison Valley residents. Subcommittees have been formed to more strategically address issues such as elk management, wolves, education, county planning and/or zoning, and how to most efficiently and successfully put this Conservation Assessment to good use. We urge the reader to become familiar with the workings of this gathering in concert with the reading and implementation of the recommendations contained within this document.

At the Wildlife Conservation Society, we are applying the Living Landscapes Program to take wildlife conservation beyond traditional borders. Namely, we are developing wildlife-based strategies for the conservation of large, wild ecosystems that are integrated in wider landscapes of human influences. This process sets conservation priorities by looking through the eyes of wildlife so that we can arrive at practical site-based methods to conserving wildlife, wildlands, and the local human communities that depend upon intact ecological communities. Herein, we describe our methods and results of conservation assessment at a watershed scale. We hope that you find this document useful within the Madison Valley and also hope that such a process can serve as a template for conservation design in other valleys of the Greater Yellowstone Ecosystem.

Methods

The Landscape Species Approach

Umbrella species and focal species are useful tools for wildlife conservation. Umbrella species are species whose conservation serves to conserve many co-occurring species (Fleishman *et al.* 2000). Focal species are suites of species that can be used to form specific guidelines to meet conservation goals but a precise definition of the term is difficult (Caro and O'Doherty 1999, Caro 2000, Armstrong 2002, Lambeck 2002, Lindenmayer and Fischer 2003). Sanderson *et al.* (2002) proposed a conceptual model for conservation planning based upon a narrowly defined suite of focal species known as the landscape species approach (LSA). We used the LSA with some modification to conduct a conservation assessment of the Madison Valley.

The LSA provides a spatially explicit method for identifying conservation priorities and formulating conservation strategies (Figure 5). LSA uses a suite of focal species designed to provide a comprehensive and robust umbrella for the conservation planning area. The methods for selection of focal species for the Madison Valley are detailed under 'Species Selection' below. Once a suite of focal species is selected, a 'biological landscape' is developed for each species. Biological landscapes are habitat models that provide spatially explicit maps of an area's potential to provide habitat for a species without regard to current or future human activities or conservation threats. In other words, the biological landscape provides a best guess of the habitat quality that could occur for a species in the absence of any habitat loss or degradation. 'Human landscapes' are also created to map the human activities most likely to impact the ability to achieve conservation targets for the focal suite. Human landscapes are then intersected with biological landscapes to document changes in habitat potential due to human activities, identify areas where human activities may conflict with species biological needs, and identify areas where the biological needs of species continue to be met without significant conflicts with human activities. It should be noted that human activities do not always affect wildlife in negative manners, as certain activities may actually benefit various species or groups of species. Through this type of overlay analysis process, LSA provides a useful tool for evaluating the extent and severity of threats to achieving conservation targets, determining priority areas for conservation action, and for developing strategies to implement the type of conservation action most likely to produce a positive outcome.

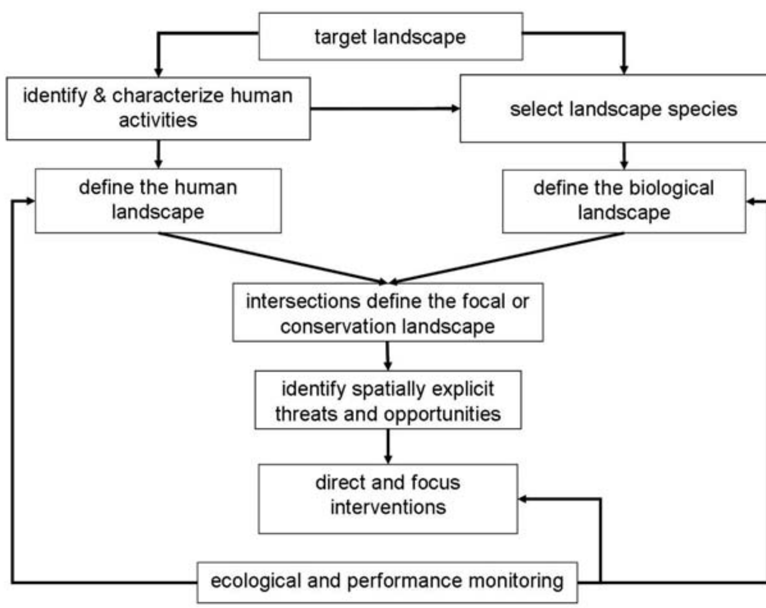


Figure 5. Process model for the Landscape Species Approach modified from Sanderson *et al*., (2002).

Assumptions and Limitations

As with any analysis, this conservation assessment was conducted with a number of important assumptions and limitations. The major assumptions and limitations are as follows:

Assumptions:

- *Focal species provide a conservation umbrella for other species and habitat.* The focal species for this assessment have been chosen to represent all major habitat types within the Madison Valley assessment area. Therefore we assume the majority of habitat needs of all native species in the Madison Valley will be met if all of the conservation needs of the focal species are met.
- *Habitat models and maps are predictions of reality.* Models by definition are simulations of reality. Models are based upon assumptions and data limitations of their own and cannot be expected to perfectly match reality. Every attempt has been made to use the best available data and expert opinion to develop models that provide a reasonable representation of actual conditions on the ground. In some cases, the models have been validated statistically but in most cases limitations of data availability and time precluded statistical validation. However, each model has been subject to expert review.

Limitations:

- *Biological data are limited for most species.* Unlike some protected areas, comprehensive biotic inventories do not exist for private, and often public, lands in the Madison Valley. In general, adequate location data for focal species within the Madison Valley assessment area were unavailable for model development or validation. Only one species, wolverine, had sufficient data available to allow for the development of an empirically based model from field data. In a few cases, available data provided an opportunity for rough assessment of model accuracy but for all species except grizzly bear and wolverine, the data available at the time of analysis were inappropriate for empirical model validation because of insufficient quantity or spatial resolution. Therefore, we relied mostly on natural history and habitat use data published in peer-reviewed publications and expert opinion to parameterize and validate models.
- *Some landcover types are not adequately mapped.* The Montana GAP and SILC datasets provide perhaps some of the highest quality landcover maps available for any state. However, even with such high quality data, there are still deficiencies in mapping some landcover and habitat types. For example, National Wetlands Inventory data were not available for the entire assessment area at the time of this study. The existing landcover datasets do a poor job of detecting some important landcover types. Most notable are mesic shrub riparian communities (willow), aspen, and sagebrush. These landcover types tend to be significantly underrepresented in available landcover data. In some cases, improved landcover classifications are available for only a portion of the assessment area. For example, SILC2 provides an improved sagebrush classification that includes structural information important for mapping sagebrush dependent species such as sage-grouse. However, SILC2 only covers the southern portion of the assessment area. Because this assessment includes a landscape analysis of the entire assessment area, it is not appropriate to use higher quality data for only a portion of the assessment area. In the case of riparian willow, The Wildlife Conservation Society developed a willow classification for the Madison Valley. However, limited available resources precluded developing special landcover maps for all deficient landcover types. Finally, in some cases the spatial resolutions of available data are insufficient for accurate habitat mapping of some species. The finest resolution for available landcover data is 30m but some species such as Yellow Warbler and Warbling Vireo select habitat based on features not detectable at that resolution.
- *Potential habitat models do not predict species occurrence.* It is important to realize that the LSA does not produce predictive habitat models in the traditional sense. Rather, LSA models the

potential habitat by eliminating human-caused factors from model inputs. It is well documented that human activities have a significant influence on species distributions. Therefore, potential habitat models presented in this document predict areas where suitable habitat might occur if the area is not influenced by human activities. Likewise, habitat effectiveness maps incorporate relevant human influences and predict the current distribution of habitat quality. However, the presence of suitable habitat does not guarantee occupancy of a species at that location. For example, some habitat patches may be too small or too remote from other patches to be permanently occupied. However, these unoccupied patches may serve as important stepping-stones for species to move across the broader landscape and maintain habitat connectivity. Whenever possible, models incorporate species habitat patch size requirements and dispersal potentials to differentiate habitat patches likely to be used only to maintain habitat connectivity from those likely to be occupied to maintain species populations.

- *Not all threats are mapped or available.* An attempt was made to map all threats identified for the entire suite of focal species. However, data are not available to map some threats. For example, chytrid fungus is a potential threat to amphibians but its status in southwest Montana is unknown so no attempt has been made to map the spatial extent of this disease. Other threats are non-spatial in nature and therefore unmappable. For instance, introduced non-native species are considered to be a major reason for the decline of west-slope cutthroat trout and fluvial arctic grayling. However, these exotic species are now nearly ubiquitous throughout the Madison River drainage so mapping their occurrence would provide little toward prioritizing conservation for these two focal species.
- *Not all focal species habitats were modeled.* Due to limitations listed above and other considerations, habitats for some focal species were not modeled. Details regarding why a certain species was not modeled are included in the results section of this document.

Species Selection

The LSA uses a quantitative approach for selecting a suite of focal species that are designed to conserve all habitat types within the assessment area and encompass all major threats to maintaining functional wildlife populations within that area. Following the methodologies outlined in Sanderson *et al.* (2002) and Coppolillo *et al.* (2004), we populated a species-specific database with information pertaining to five categories: area, heterogeneity, ecological functionality, vulnerability, and socio-economic significance. Each characteristic subsequently was subdivided into divisions that are more precise or underlying processes and probabilities, which are described later in this section.

Identification of Candidate Species Pool

Through a meeting of biologists and managers convened in December 2001, an initial pool of 38 candidate species (three amphibian species, 15 birds, and 20 mammals) was identified (Table 1). This pool provided the basis for building a more complete pool of candidate species in the fall of 2002. Reviewing the enumerated 410 vertebrate species known to inhabit the Madison Valley during some portion of the year, or extremely likely to based upon nearby records and habitat affinities, led us to the following: five species were removed from the initial pool with the northwestern GYE occurring at the edge of their distribution while we added species to the original pool that we believed were biologically relevant to planning efforts and/or were significant in their population numbers or viability, significant in their ecological use of fine-grained habitats within the GYE, or significant due to their ecological function. Sixty-three species comprised the final pool of candidate species encompassing three fish, five amphibians, three reptiles, 25 birds, and 27 mammals (Table 1).

Ideally, we would have entered the selection process initially including all 410 vertebrate species. Moreover, as land managers and agencies are beginning to understand the importance of land use decisions on invertebrates, endemic plants, and other organisms and systems, as well as their ecological import (Johnson *et al*. 1999, Noon *et al*. 2005) an inclusion of representative invertebrates, especially known endemics, would have been prudent. Such efforts were beyond the resources available. Moreover, even for vertebrates in one of the most investigated regions in North America (the GYE), region-specific natural history data are largely lacking while distribution data are extremely sparse.

Table 1. Pools of candidate species providing the basis for the selection of Landscape Species for the Madison Valley & Centennial Valley Project Area, Greater Yellowstone Ecosystem.

Initial Candidate Pool		Candidate Pool Entering Species Selection	
Common name	Latin binomial	Common name	Latin binomial
Fish		Fish	
NONE		Westslope Cutthroat Trout	*Oncorynchus clarki lewisi*
Amphibians		Yellowstone Cutthroat Trout	*Oncorynchus clarki bouvieri*
Northern Leopard Frog	*Rana pipiens*	Arctic Grayling (fluvial)	*Thymallus arcticus*
Boreal Chorus Frog	*Pseudacris maculata*	Amphibians	
Boreal Toad	*Bufo boreas boreas*	Tiger Salamander	*Ambystoma tigrinum*
Reptiles		Northern Leopard Frog	*Rana pipiens*
NONE		Columbia Spotted Frog	*Rana luteiventris*
Birds		Boreal Chorus Frog	*Pseudacris maculata*
Trumpeter Swan	*Cygnus buccinator*	Boreal Toad	*Bufo boreas boreas*
Harlequin Duck	*Histrionicus histionicus*	Reptiles	
Whooping Crane	*Grus americana*	Rubber Boa	*Charina bottae*
Bald Eagle	*Haliaeetus leucocephalus*	Western Terrestrial Garter Snake	*Thamnophis elegans*
Northern Goshawk	*Accipiter gentilis*	Western Rattlesnake	*Crotalus viridis*
Red-tailed Hawk	*Buteo jamaicensis*	Birds	
Mountain Plover	*Charadrius montanus*	American White Pelican	*Pelecanus erythrorhynchos*
Greater Sage-Grouse	*Centrocercus urophasianus*	Trumpeter Swan	*Cygnus buccinator*
Great Gray Owl	*Strix nebulosa*	Harlequin Duck	*Histrionicus histionicus*
Red-naped Sapsucker	*Sphyrapicus nuchalis*	Barrow's Goldeneye	*Bucephala islandica*
Three-toed Woodpecker	*Picoides tridactylus*	Bald Eagle	*Haliaeetus leucocephalus*
Black-backed Woodpecker	*Picoides arcticus*	Northern Goshawk	*Accipiter gentilis*
American Dipper	*Cinclus mexicanus*	Red-tailed Hawk	*Buteo jamaicensis*
Yellow Warbler	*Dendroica petechia*	Ferruginous Hawk	*Buteo regalis*
Sage Sparrow	*Amphispiza belli*	Golden Eagle	*Aquila chrysaetos*
Mammals		Peregrine Falcon	*Falco peregrinus*
Black-tailed Jackrabbit	*Lepus californicus*	Blue Grouse	*Dendragapus obscurus*
Beaver	*Castor canadensis*	Greater Sage-Grouse	*Centrocercus urophasianus*
Black-tailed Prairie Dog	*Cynomys ludovicianus*	Long-billed Curlew	*Numenius americanus*
Coyote	*Canis latrans*	Great Gray Owl	*Strix nebulosa*
Gray Wolf	*Canis lupus*	Red-naped Sapsucker	*Sphyrapicus nuchalis*
Mountain Lion	*Felis (Puma) concolor*	Three-toed Woodpecker	*Picoides tridactylus*
Canada Lynx	*Lynx canadensis*	Black-backed Woodpecker	*Picoides arcticus*
Black-footed Ferret	*Mustela nigripes*	Olive-sided Flycatcher	*Contopus cooperii*
Wolverine	*Gulo gulo*	Brown Creeper	*Certhia americana*
River Otter	*Lontra canadensis*	Warbling Vireo	*Vireo gilvus*
American Marten	*Martes americana*	American Pipit	*Anthus rebescens*
Fisher	*Martes pennanti*	American Dipper	*Cinclus mexicanus*
Black Bear	*Ursus americanus*	Yellow Warbler	*Dendroica petechia*
Grizzly Bear	*Ursus arctos*	Lincoln's Sparrow	*Melospiza lincolnii*
Pronghorn	*Antilocapra americana*	Black Rosy-Finch	*Leucosticte atrata*

Initial Candidate Pool		Candidate Pool Entering Species Selection	
Common name	Latin binomial	Common name	Latin binomial
Bison	*Bison (Bos) bison*	Mammals	
Bighorn Sheep	*Ovis canadensis*	Masked Shrew	*Sorex cinereus*
Wapiti (Elk)	*Cervus elaphus*	Townsend's Big-eared Bat	*Corynorhinus townsendii*
Moose	*Alces alces*	Black-tailed Jackrabbit	*Lepus californicus*
Mule Deer	*Odocoileus hemionus*	Snowshoe Hare	*Lepus townsendii*
		Beaver	*Castor canadensis*
		Pine Squirrel	*Tamiasciurus hudsonicus*
		Northern Flying Squirrel	*Glaucomys sabrinus*
		Northern Pocket Gopher	*Thomomys talpoides*
		Southern Red-backed Vole	*Clethrionomys gapperi*
		Heather Vole	*Phenacomys intermedius*
		Sagebrush Vole	*Lemmiscus curtatus*
		Coyote	*Canis latrans*
		Gray Wolf	*Canis lupus*
		Mountain Lion	*Felis (Puma) concolor*
		Canada Lynx	*Lynx canadensis*
		Wolverine	*Gulo gulo*
		River Otter	*Lontra canadensis*
		American Marten	*Martes americana*
		Fisher	*Martes pennanti*
		Black Bear	*Ursus americanus*
		Grizzly Bear	*Ursus arctos*
		Pronghorn	*Antilocapra americana*
		Bison	*Bison (Bos) bison*
		Bighorn Sheep	*Ovis canadensis*
		Wapiti (Elk)	*Cervus elaphus*
		Moose	*Alces alces*
		Mule Deer	*Odocoileus hemionus*

Selection Criteria

Each candidate species was scored for each of the five criteria: area, heterogeneity, ecological functionality, socio-economic importance, and complementarity. These scores were assigned as described below.

Area:

Each candidate species' area requirements were scored based upon four factors: home range size of an individual, dispersal distance, proportion of project area occupied by the species, and whether habitat connectivity is necessary for the maintenance of an ecologically functional population. When gender differences were known for area characteristics, a metric for females was applied.

Heterogeneity:

A heterogeneity value was developed for each species through an interaction of three facets measuring landscape heterogeneity and its relevance to the species. These factors were jurisdictional heterogeneity (proportion of jurisdictional types or land management entity occupied by the species), habitat heterogeneity (proportion of habitat types occupied by the species), and necessary habitat types (proportion of habitat types the survival of the species depends upon). Within the Madison Valley assessment area the landscape falls under ten (including water bodies) jurisdictional types (Table 2) whereas 40 landcover types (Table 3) were identified through the Montana GAP Project (Fisher *et al.* 1998).

Table 2. Jurisdictional information used for the selection of Landscape Species in the GYE.

Manager	Area (ha)	Percent of Landscape
Bureau of Land Management	257924	12.26
Bureau of Reclamation	752	0.04
US Fish & Wildlife Service	15116	0.72
National Park Service	31462	1.50
US Forest Service	639645	30.40
US Dept. of Agriculture (non FS)	6429	0.31
State of Montana	194452	9.24
Local Municipalities	410	0.02
Private	939974	44.68
Water Bodies	17715	0.84

Table 3. Land cover types from MT GAP analysis used for the selection of Landscape Species in the GYE.

Montana Gap Land Cover Type	Area (ha)	Proportion of Area	Montana Gap Land Cover Type	Area (ha)	Proportion of Area
URBAN OR DEVELOPED LANDS	4254.93	0.0017	LOW DENSITY XERIC FOREST	1308.15	0.0005
AGRICULTURAL LANDS - DRY	71511.66	0.0286	MIXED BROADLEAF FOREST	21899.97	0.0088
AGRICULTURAL LANDS - IRRIGATED	109581.66	0.0438	LODGEPOLE PINE	95095.62	0.0380
ALTERED HERBACEOUS	3896.91	0.0016	LIMBER PINE	29414.34	0.0118
VERY LOW COVER GRASSLANDS	79785.81	0.0319	PONDEROSA PINE	1090.26	0.0004
LOW/ MODERATE COVER GRASSLANDS	525586.32	0.2100	DOUGLAS-FIR	176614.83	0.0706
MODERATE/ HIGH COVER GRASSLANDS	14770.35	0.0059	ROCKY MOUNTAIN JUNIPER	5084.37	0.0020
MONTANE PARKLAND & SUBALP MEADOW	199737.90	0.0798	DOUGLAS-FIR/ LODGEPOLE PINE	21054.33	0.0084
MIXED MESIC SHRUBS	13126.86	0.0052	MIXED WHITEBARK PINE FOREST	67903.11	0.0271
MIXED XERIC SHRUBS	7900.74	0.0032	MIXED SUBALPINE FOREST	254463.93	0.1017
SALT-DESERT SHRUB/ DRY SALT FLATS	45.36	0.0000	MIXED XERIC FOREST	47583.45	0.0190
SAGEBRUSH	393043.59	0.1571	MIXED BROADLEAF/CONIFER FOREST	1701.00	0.0007
MESIC SHRUB-GRASSLAND ASSOCIATIONS	1371.33	0.0005	STANDING BURNT FOREST	44799.48	0.0179
XERIC SHRUB-GRASSLAND ASSOCIATIONS	451.98	0.0002	WATER	15834.69	0.0063
ROCK	33333.93	0.0133	CONIFER RIPARIAN	8243.37	0.0033
MINES, QUARRIES, GRAVEL PITS	2417.04	0.0010	BROADLEAF RIPARIAN	7196.04	0.0029
BADLANDS	2.43	0.0000	MIXED BROADLEAF/CONIFER RIPARIAN	2999.43	0.0012
MIXED BARREN SITES	10001.88	0.0040	GRAMINOID & FORB RIPARIAN	14176.62	0.0057
ALPINE MEADOWS	11863.26	0.0047	SHRUB RIPARIAN	24002.73	0.0096
SNOWFIELDS OR ICE	164.43	0.0001	MIXED RIPARIAN	10255.41	0.0041

Ecological Functionality:

We identified nine aspects of ecological functionality that may be used to characterize species inhabiting the GYE (Table 4). The ecological function for each species was rated on a 0-3 scale, with 3 being the highest impact or importance on ecological communities. *Relative* strength of community impact across species was rated in impact of predation (i.e., gray wolf high), herbivory impact (i.e., elk high), importance as a seed disperser (i.e., Clark's Nutcracker high), seed predation (i.e., pine squirrel high), importance as pollinator (i.e., none were high in this species pool), mechanical impacts to soil or vegetation (i.e., northern pocket gopher high), influence as a strong competitor (i.e., elk high), amount of biomass contributed to communities (i.e., amphibians high), and the strength of the species' habitat engineering (i.e., beaver high).

Table 4. Classes of ecological functionality used to characterize species in the GYE.

Number Species Exhibiting				
Function	Negligible	Low	Moderate	High
Predation	28	18	10	7
Herbivory	47	8	5	3
Seed Dispersal	49	4	7	2
Seed Predation	52	7	1	2
Pollination	62	0	0	0
Mechanical	52	4	4	2
Strong Competition	50	9	1	3
Biomass	49	13	0	1
Habitat Engineer	55	3	2	3

Socio-economic Significance:

Animal species bear heavily within human economies and cultures worldwide with the GYE being no exception. To incorporate the socio-economic importance of species into our selection process we characterized each species as to whether it can be seen as a potential flagship species, exhibits a positive economic value, exhibits a negative economic value, exhibits a positive local cultural value, and exhibits a negative local cultural value. Each metric was scored as a "0", "+1", or "-1." It should be noted that some species (notably grizzly bear and gray wolf) could show both negative and positive economic and cultural values, albeit likely not symmetrical in reality. We entered socioeconomic scores into the selection algorithm separately among the above 4 categories so as not to erroneously cancel out positive values with negative values. Binary scores for each of the 4 characteristics were added to form the socio-economic category score. Scoring positive and negative cultural values independently effectively separates species with both positive and negative value from those with one or the other.

Vulnerability:

It is generally recognized that species exposed to a greater number of land uses are more likely to conflict with human activities and be deleteriously affected by them (Newmark et al. 1994, Woodroffe and Ginsberg 2000). Hence, we characterized land use within the project area into 26 activities that potentially influence the viability of species in the GYE (Table 5). Some of these activities, such as removal of animals for the pet trade for instance, were more directly related to the species than to the landscape itself. The threat or potential threat of each landuse was identified and characterized on a species specific basis through a matrix accounting for severity, urgency, area affected, time for species recovery, and probability of occurrence (Nature Conservancy 2000, Table 6).

Table 5. Types of anthropogenic activities identified in the GYE potentially impacting the persistence of animal species.

	Number Species Affected			
Land Use	None	Measurable	Substantial	Eradication
Timber Harvest	17	14	19	13
Fences	54	6	2	1
Fire Suppression	45	9	5	4
Fire	34	1	10	18
Powerlines	59	1	1	2
Roads	33	10	15	5
Vehicular Traffic	38	16	8	1

Land Use	None	Number Species Affected Measurable	Substantial	Eradication
Roadway Chemical/Sediment Pollution	46	6	10	1
Motorized Recreation	40	9	10	4
Non-motorized Recreation	43	4	11	5
Grazing	34	16	9	4
Weed/Pest Control	42	7	11	3
Hunting	32	6	20	5
Fishing	52	8	0	3
Pollution	44	5	8	6
Oil/Gas/CBM	49	2	4	8
Mineral Mining	45	2	4	12
Homesite Development	38	6	11	8
Farming	51	6	0	6
Dewatering	42	6	5	10
Severing Migration	46	1	4	12
Nonnative Introductions	50	3	2	8
Invasive Aliens	44	9	9	1
Exotic Disease	17	4	31	11
Management Activities	58	1	3	1
Pet Trade/Falconry	49	10	1	3

We listed and scored each of the 26 land use actions (as a potential threat) with regard to their effect on each of the candidate species. Each land use was scored according to the severity (S) of its effect on the species, urgency (i.e. the timescale over which it would occur; U), the time it would take the species to recover from the threat (R), the proportion of the candidate species' local distribution affected (Pa), and its probability of occurrence (Po) using the criteria in Table 6.

Subsequently, we summed across all potential threats combining these measures into a project area-specific "vulnerability index" for each candidate species:

$$\sum \{(U + R) \times S \times Pa \times Po\}$$

This index aggregates the threats to each species scaled according to their overall importance. The same is true for threats affecting only a small proportion of the landscape. Severity (S), probability of occurrence (Po), and proportion of local extent affected (Pa), are included as multipliers so that insignificant human activities (i.e. those that have no effect, affect a tiny area, or are exceedingly unlikely) do not contribute to a species' threat index.

Data Confidence

Basic and site-specific natural history information is lacking for most vertebrate species and that was no exception for the candidate species, even within the well-studied GYE. Hence, for many species we relied upon information not gathered within the project area and in some instances relied upon estimates for congeneric species mediated through comparative information and/or consultation with biological experts. We developed a rating of uncertainty for all parameters entered into the selection regime following a six-point scheme (Table 7). Higher values indicate less confidence in the validity of the information and hence, the inclusion of such a species in the final species suite was specifically evaluated. Not only is natural history information lacking, but, documented information on threats to species long-term viability is lacking for most species (grizzlies are generally a notable exception) and again we relied upon comparisons to congenors, data from elsewhere, and/or expert opinion. Hence, from a practical and pragmatic viewpoint, we strongly support efforts to describe the distribution and natural history of regional plants and animals such as the efforts of the Montana Natural Heritage Program through their "Species of Concern" list (Montana Natural Heritage 2006) and those of Montana Fish, Wildlife & Parks in their maiden effort resulting in "Montana's Comprehensive Fish and Wildlife Conservation Strategy" (Montana Fish, Wildlife & Parks. 2005).

Furthermore, information directly related to the ecology and conservation of birds in Montana is eloquently outlined in Partners in Flight Draft Conservation Plan (Casey 2000). We urge managers and others to consult this document for information especially when programs and projects have the potential to impact riparian habitats as most of Montana's birds use these productive areas during some portion of their residence. We also urge readers to consult the forthcoming Bat Conservation Plan and Strategy for Montana (Schwab and DuBois 2006) that will be produced by MFWP shortly. This plan will assist the planner in including information on the ecological needs of bats in decision making.

Table 6. Criteria used by the Living Landscapes Program to assess threats.

Factor	Rank Rating	Factor	Rank Rating
Severity		Proportion of Local Area Affected	
None or positive	0	0	0
Measurable effect on density or distribution	1	1-10%	1
Substantial effect but local eradication unlikely	2	11-25%	2
Local eradication possible	3	26-50%	3
Urgency		>50%	4
Will not happen in >10 years	0	Recovery Time	
Could happen between 3-10 years	1	Immediate	0
Could (or will) happen within 1-3 years	2	1-10 years	1
Threat occurring presently	3	11-100 years	2
		100+ years or never	3
		Probability	0-1

Table 7. Uncertainty rating scheme applied to species characteristics.

Rating	Characteristics of information
1	Peer-reviewed published literature within GYE
2	Peer-reviewed published literature outside GYE
3	Non-published reports, theses, dissertations, or unpublished data/personal communication from recognized authority within GYE
4	Non-published reports, theses, dissertations, or unpublished data/personal communication from recognized authority outside GYE
5	Professional judgment based upon local knowledge/experience or comparison with other species within GYE
6	Professional judgment based upon local knowledge/experience or comparison with other species within GYE

Aggregate Scores

Scores within each of the five categories were aggregated in a stepped fashion (Figure 6). Since values within the area category showed extreme variation within and, especially, between subcategories, we first normalized within subcategory with subsequent summation and normalization on the area category level. We applied this same methodology to the heterogeneity category. Vulnerability, functionality, and socioeconomic values were normalized at the category level (Table 8). Hence, species scores ranged from 0-1.0 within each category summing to a maximum potential of 5.0 (maximum value of 1.0 on each of the five categories: area, heterogeneity, ecological function, vulnerability, socioeconomic). Total aggregate scores for the 63 candidate species ranged from the brown creeper at 0.24 to 4.50 for grizzly (Figure 7). Mean score equaled 1.462 (SE = 0.109) with a median value equal to 1.240.

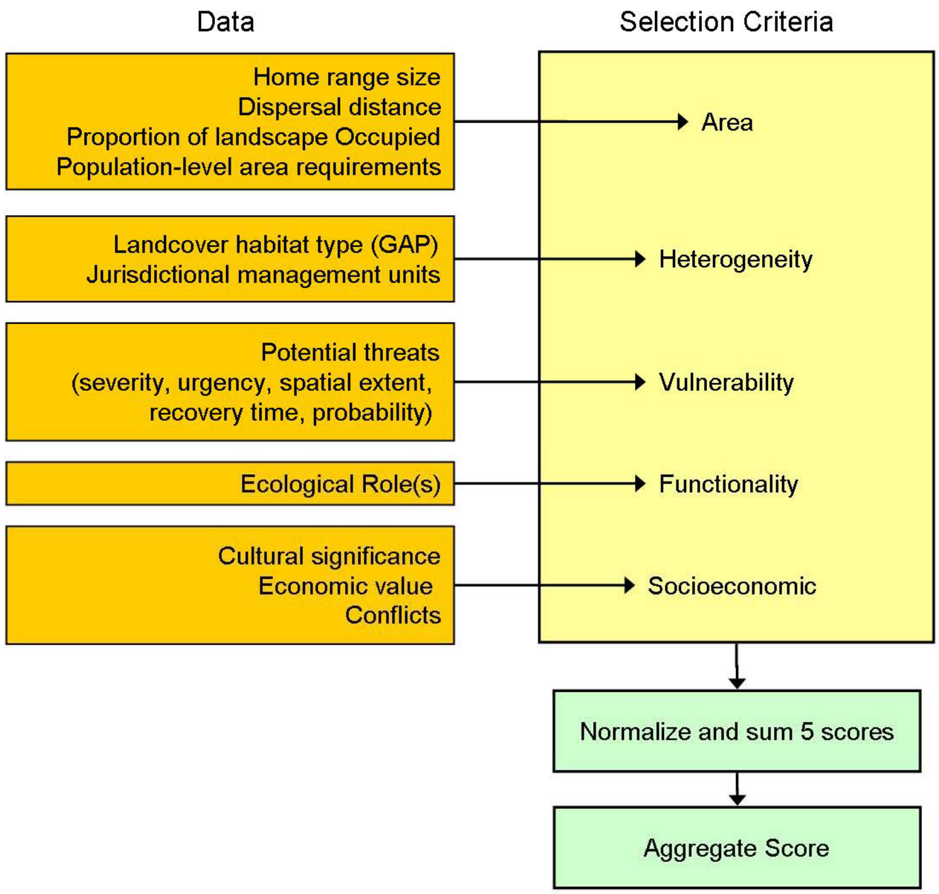


Figure 6. Development of species aggregate scores in the Madison Valley (from Coppolillo *et al*. 2004).

Table 8. Normalized metrics and total aggregate scores for species.

Species	Area	Heterogeneity	Functionality	Vulnerability	Socioeconomic	Total
Grizzly Bear	0.75	0.75	1.00	1.00	1.00	4.50
Gray Wolf	0.62	1.00	0.46	0.19	1.00	3.27
Wapiti (Elk)	0.39	0.69	0.77	0.54	0.80	3.19
Mountain Lion	0.58	0.86	0.23	0.47	1.00	3.14
Wolverine	1.00	0.62	0.08	0.62	0.60	2.91
Mule Deer	0.66	0.58	0.23	0.72	0.60	2.80
Canada Lynx	0.88	0.55	0.08	0.65	0.60	2.76
Black Bear	0.70	0.37	0.62	0.19	0.60	2.47
Beaver	0.48	0.33	0.77	0.04	0.80	2.42
Coyote	0.46	0.60	0.46	0.09	0.80	2.41
Greater Sage-Grouse	0.45	0.40	0.23	0.66	0.60	2.35
Northern Pocket Gopher	0.58	0.29	0.85	0.08	0.40	2.19
Moose	0.49	0.29	0.23	0.54	0.60	2.16
River Otter	0.61	0.32	0.15	0.15	0.80	2.03
Bighorn Sheep	0.40	0.28	0.15	0.31	0.80	1.96
Boreal Toad	0.71	0.52	0.23	0.22	0.20	1.88
Westslope Cutthroat Trout	0.38	0.15	0.15	0.57	0.60	1.86
Pronghorn	0.31	0.45	0.08	0.41	0.60	1.85
Bison	0.19	0.18	0.54	0.08	0.80	1.79
Yellowstone Cutthroat Trout	0.38	0.15	0.15	0.45	0.60	1.73
Arctic Grayling	0.39	0.00	0.15	0.50	0.60	1.64
Pine Squirrel	0.45	0.23	0.85	0.08	0.00	1.61
Golden Eagle	0.34	0.60	0.15	0.06	0.40	1.55
Western Rattlesnake	0.57	0.39	0.08	0.03	0.40	1.47
Fisher	0.47	0.42	0.08	0.28	0.20	1.46
Ferruginous Hawk	0.47	0.46	0.15	0.16	0.20	1.45
Boreal Chorus Frog	0.71	0.49	0.15	0.05	0.00	1.40
Northern Leopard Frog	0.42	0.45	0.15	0.15	0.20	1.38
Bald Eagle	0.25	0.36	0.15	0.18	0.40	1.34
Great Gray Owl	0.18	0.29	0.15	0.09	0.60	1.32
Northern Flying Squirrel	0.45	0.26	0.46	0.08	0.00	1.25
Peregrine Falcon	0.49	0.32	0.00	0.03	0.40	1.24
American Marten	0.49	0.25	0.08	0.20	0.20	1.22
Black-backed Woodpecker	0.08	0.16	0.38	0.18	0.40	1.21
Columbia Spotted Frog	0.45	0.46	0.15	0.14	0.00	1.21
Blue Grouse	0.41	0.23	0.31	0.04	0.20	1.18
Harlequin Duck	0.10	0.32	0.08	0.29	0.40	1.18
Tiger Salamander	0.08	0.41	0.08	0.21	0.40	1.18
Rubber Boa	0.23	0.49	0.38	0.07	0.00	1.17
Trumpeter Swan	0.62	0.42	0.08	0.04	0.00	1.16
Southern Red-backed Vole	0.47	0.26	0.38	0.03	0.00	1.14
Masked Shrew	0.60	0.32	0.08	0.08	0.00	1.08
Heather Vole	0.46	0.26	0.31	0.03	0.00	1.06
Western Terrestrial Garter Snake	0.36	0.51	0.15	0.02	0.00	1.04

Species	Area	Heterogeneity	Functionality	Vulnerability	Socioeconomic	Total
American White Pelican	0.00	0.35	0.15	0.08	0.40	0.99
Three-toed Woodpecker	0.32	0.40	0.15	0.07	0.00	0.94
Red-tailed Hawk	0.15	0.22	0.38	0.18	0.00	0.93
Sagebrush Vole	0.16	0.22	0.23	0.26	0.00	0.87
Snowshoe Hare	0.14	0.25	0.38	0.06	0.00	0.84
Northern Goshawk	0.11	0.22	0.15	0.09	0.20	0.78
Townsend's Big-eared Bat	0.15	0.45	0.08	0.08	0.00	0.76
Red-naped Sapsucker	0.14	0.24	0.23	0.06	0.00	0.67
Black-tailed Jackrabbit	0.14	0.34	0.15	0.03	0.00	0.66
Barrow's Goldeneye	0.08	0.39	0.08	0.06	0.00	0.60
American Dipper	0.04	0.27	0.23	0.05	0.00	0.59
Olive-sided Flycatcher	0.03	0.24	0.00	0.04	0.20	0.51
Lincoln's Sparrow	0.03	0.27	0.15	0.03	0.00	0.49
Long-billed Curlew	0.09	0.18	0.00	0.11	0.00	0.38
Black Rosy-Finch	0.04	0.16	0.15	0.02	0.00	0.38
Warbling Vireo	0.04	0.26	0.00	0.03	0.00	0.33
Yellow Warbler	0.01	0.22	0.00	0.03	0.00	0.26
American Pipit	0.07	0.17	0.00	0.02	0.00	0.25
Brown Creeper	0.04	0.19	0.00	0.02	0.00	0.24

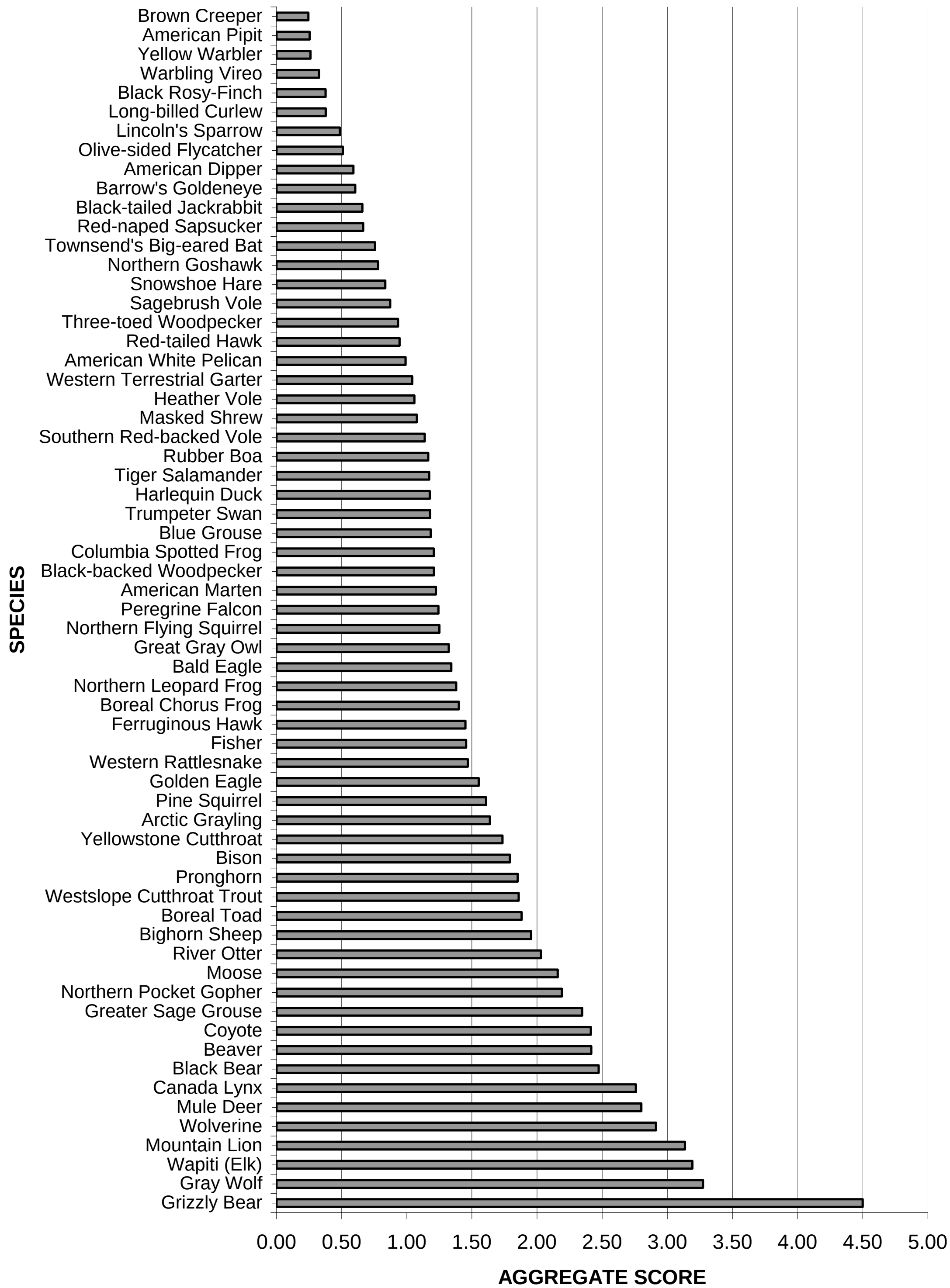


Figure 7. Distribution of aggregate scores for 63 species considered.

Complementarity

Complementarity analysis optimizes the focal species suite by evaluating the contribution that each species makes to conserving habitat (Figure 8). Complementarity is defined as minimum overlap in habitat requirements, distributions across jurisdictional units and distinctiveness of threats encountered (Coppolillo *et al.* 2004). Following the scoring of all 63 candidate species, we began building a complementary suite. As grizzly bear showed the highest aggregate score, this species providing the basis for the suite by encompassing 29 of 40 habitats and 17 of 26 identified threats. Following grizzly bear, the next 15 highest aggregate scores were chosen and the species most complimentary to grizzly bear was chosen. This process was repeated for the entire candidate list until all habitat types were covered by one or more species. This resulted in the selection of 9 landscape species for the core focal suite (Table 9).

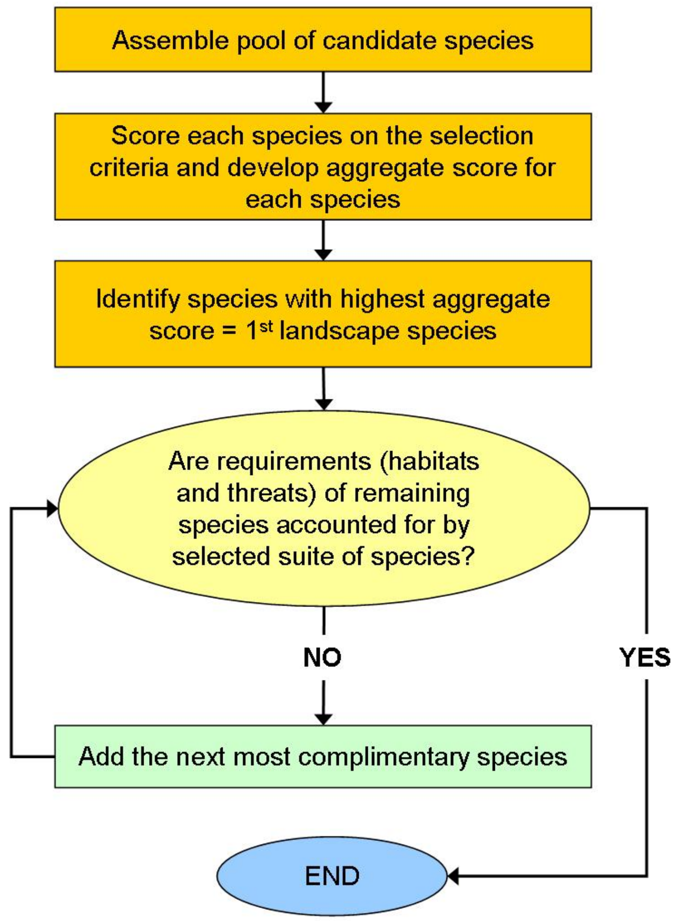


Figure 8. Framework used to build the Landscape Species Suite in the Madison Valley (from Coppolillo *et al*. 2004).

Special Elements

The suite of focal species was reviewed to determine whether it left significant gaps for conservation in the valley. The review resulted in the inclusion of six additional species for assessment. We refer to these species as Special Elements because they do not necessarily conform to the definition of a landscape species. The cold water salmonid, westslope cutthroat trout was added because it is a species of special concern that has been petitioned for protection under the Endangered Species Act, was once widespread throughout the Madison River drainage but has experienced serious decline, and inhabits high quality headwater stream habitats not covered by any of the landscape species.

Additionally, the suite of landscape species under represented riparian tree and shrub habitats. Grizzly bear, elk, and other species utilize riparian habitats but do not depend on these habitats for their long-term survival. Moose depend on woody browse in general, and riparian browse in particular, as a major food source but are not sensitive to the structural form of these habitat types for nesting habitat and cover like many other species are. To address this deficiency, we added a suite of three birds (Yellow Warbler, Warbling Vireo, and Red-naped Sapsucker) to serve as an umbrella for species dependent upon aspen, cottonwood, and willow habitats in a variety of structural forms. Other riparian passerines may also serve as appropriate special elements, specifically in their dependence upon various types of riparian habitats. Species that could be used include Willow Flycatcher, Veery, Lincoln's Sparrow, Gray Catbird, and American Redstart among others. Ideally, perhaps, a composite riparian passerine guild could be included within the suite of landscape species to account for subtle habitat differences among riparian passerines as well as differences in response to local threats (for instance, some passerines appear more sensitive to grazing and/or cowbird parasitism; Casey 2000). We added Columbia spotted frogs since this species functionally links riparian habitats and aquatic communities to adjacent uplands. Moreover, populations of Columbia spotted frogs can be monitored to gauge conservation success and amphibians often comprise a significant portion of a community's biomass.

Finally, the review revealed the focal species suite did not adequately umbrella for natural fire processes. Although many of the focal species benefit from natural fire disturbances, none of them depend on fire for long-term population viability. Therefore, a highly fire-dependent species, black-backed woodpecker, was added as an indicator for this very important ecological process. The addition of these six special element species brought the total number of species in the focal suite to 15 (Table 9). For this assessment, special elements are treated the same as landscape species and only the methods for their selection differed.

This 15-species suite contained 7 of Montana's Animal Species of Concern (Montana Natural Heritage Program and Montana Fish, Wildlife and Parks 2006); overall, if contained species that occupy all Montana Natural Heritage Program's habitat associations except caves. Furthermore, six of the selected species are contained in Montana Fish, Wildlife & Parks' (2005) Tier 1 list of Species of Greatest Conservation Need.

Table 9. Species selected for inclusion in the Landscape Species Suite for the GYE.

Species	Type
Grizzly Bear	Landscape Species
Elk	Landscape Species
Wolverine	Landscape Species
Moose	Landscape Species
Pronghorn	Landscape Species
Westslope Cutthroat Trout	Special Element
Greater Sage-Grouse	Landscape Species
Boreal Toad	Landscape Species
Arctic Grayling	Landscape Species
Bighorn Sheep	Landscape Species
Black-backed Woodpecker	Special Element
Columbia Spotted Frog	Special Element
Red-naped Sapsucker	Special Element
Yellow Warbler	Special Element
Warbling Vireo	Special Element

Species Threats Analysis

Conservation targets or goals were established for each focal species with targets chosen to support the overall project goal "to conserve and restore all major wildlife habitat types and their component species with emphasis on native shrub-steppe, riparian ecosystems, and linkages between mountain chains and mountain valleys." At least two experts were interviewed to determine existing and potential threats to achieve the conservation targets for each focal species. Experts interviewed include biologists from federal, state, university, and NGO biologists with significant professional experience studying or managing the species in question. Interview questions were formatted to determine the stress, source, severity, and scope of threats following The Nature Conservancy's "5-S" principles (Nature Conservancy 2000). Following expert interviews, conceptual models were developed linking threats and their sources with potential intervention activities (See Results). At least one intervention is proposed to address every threat identified for each species. The scope and severity of threats were considered when determining a suggested intervention action. However, the conceptual models do not attempt to prioritize threats or suggest a particular course of action. Threats identified in conceptual models were included in Geographic Information Systems (GIS) based analysis for each species to prioritize conservation actions. We include a conceptual model within each species description outlining the thought process followed for analysis, or conservation profiling, of each species. Simply put, a conceptual model is a graphical representation of an overarching goal for the conservation work that can be attained through identifying species-specific goals or targets, assessing direct and indirect threats to those targets and the sources of those threats, followed by interventions to abate and mitigate these threats. We fitted each species-specific conceptual model into an overarching conceptual model helping to define the entire conservation assessment process for the Madison Valley.

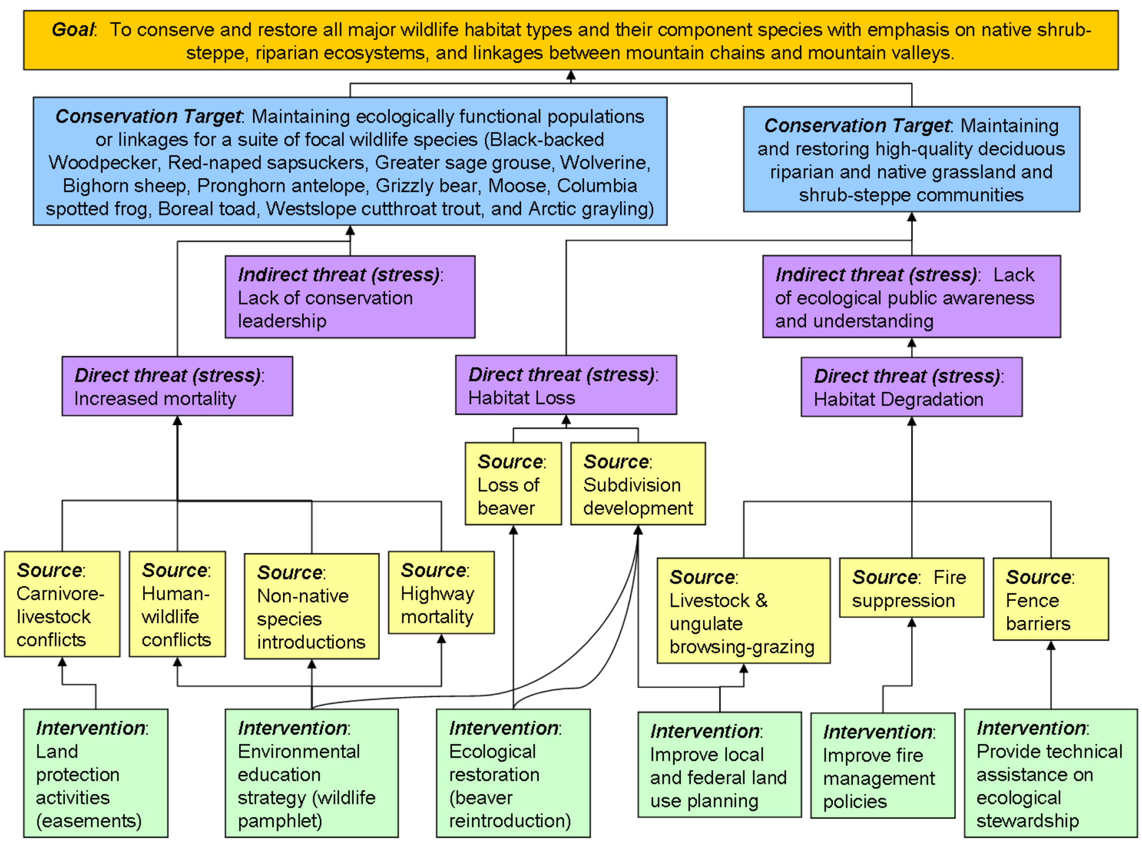


Figure 9. Overarching conceptual model for assessment of conservation priorities in the Madison Valley.

Human Landscape Mapping

Human activities that were identified in the conceptual models as factors important for the conservation of one or more focal species were mapped in a GIS. For each activity, we attempted to obtain the most accurate and current data available to describe the activity and transform the data into a map depicting the potential influence of the activity on wildlife populations or their habitat. For example, GIS layers of roads were combined from several state and federal sources. Roads within the combined layer were weighted according to their relative influence on wildlife habitat quality (e.g. major highways have a higher negative weight than infrequently traveled dirt roads) and a grid of weighted road density was calculated from the weighted roads. A similar process was repeated for each relevant human activity identified in the conceptual models. A workshop was held to obtain feedback from experts and gain suggestions for ways to improve the human landscape maps. Many helpful comments were received and maps were revised to incorporate the suggestions of experts (Figure 10). Once human landscape mapping was complete, the maps were incorporated into priority overlay and connectivity analyses on a species-specific basis.

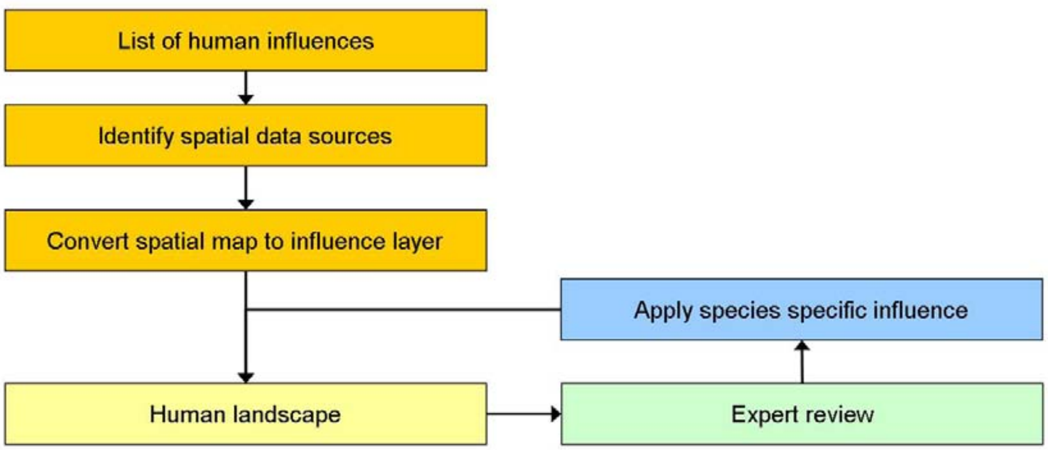
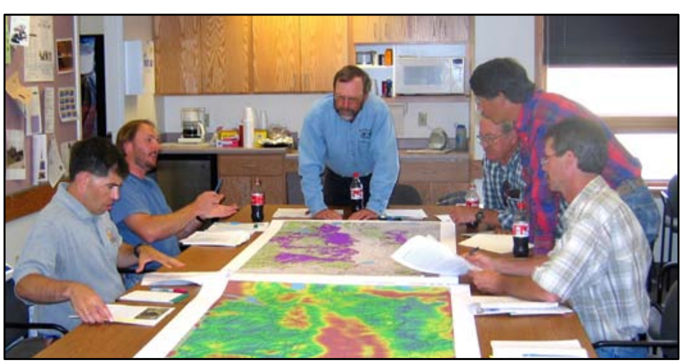


Figure 10. Iterative process for mapping each species' relative human landscape

Species Habitat Modeling

We developed species habitat models by incorporating information from a variety of sources into a GIS to produce spatially explicit habitat maps. Sources of habitat information include existing habitat suitability models, published habitat studies, expert opinions, and field data. These species habitat models are intended to map *potential* habitat because they do not include human activities or land uses as parameters. Therefore, the models are not intended to predict species occurrence or abundance but rather, serve to indicate where a species might find suitable habitat in the absence of human influences. Models were developed using ArcGIS 9.1 Model Builder. As with the human landscape mapping, a workshop was held to obtain expert review of the habitat models. Habitat models were revised to incorporate expert comments and suggest to the extent practical. Detailed methods for each species are described under the Results in this report.



Wildlife Habitat Connectivity Analysis

Wildlife habitat connectivity analysis was conducted on focal species where connectivity was important for meeting conservation targets. Least-cost corridor analysis was run in a GIS using methods modified from Singleton (2002). Cost-distance, or weighted-distance, estimates the relative effect of habitat quality on the costs associated with travel across a particular location. Animals traveling through poor quality habitat incur higher costs than when traveling through high quality habitat. Cost-distance produces a metric that weights the distance traveled by habitat quality such that traveling through poor quality habitat is the equivalent of traveling a farther distance through better quality habitat. Corridor analysis calculates the sum of the cost distances for two cost surfaces representing the cost of movement from an associated habitat core. The surface of accumulated costs can be used to determine the least-cost corridor by setting threshold values for the maximum cost an animal can tolerate.

For each species, we defined habitat cores as the areas of adequate quality potential habitat that were large enough to support breeding individuals or populations. Cost-distance surfaces were calculated for each habitat core. Least-cost path values were calculated for each possible pair-wise combination of habitat cores and a composite least-cost corridor surface was obtained by extracting the minimum least-cost corridor value at each cell location. In other words, the composite least-cost corridor surface represents the minimum cost accrued for traveling at a particular location among all possible pair-wise habitat core combinations. The composite least-cost corridor values were converted to probability surfaces using the best method available. When possible, field data of animal locations were used to estimate probability of use by assigning cost-distance values to each observed location and then assigning the ranked percentile values of observed frequencies of use for each cost-distance value. When field location data were not available, a maximum cost-distance threshold was set based upon expert opinion. See 'Results' in this report for detailed connectivity analysis methods for each species.

Overlay Analysis

Overlay analysis was conducted in a GIS as an aid for setting conservation priorities. For all species modeled, habitat effectiveness was estimated using weighted overlays of combined threats and potential habitat. Habitat effectiveness represents the quality of habitat available for a species currently. Habitat effectiveness was modeled by converting human landscape maps into threats layers on a species-specific basis. Only the human landscape layers associated with a threat identified in the threats analysis for a given species were used to calculate habitat effectiveness. Each human landscape was converted to a threats layer using the best available information for that species. For example, if residential development was identified as a significant threat for a species, then housing density was calculated from the human structures layer. The resulting density was then converted into coefficients of degradation using the best available information for that species. Individual threats were weighted according to their relative importance for the species and summed to produce scores that estimate the total reduction in habitat quality from all threats combined for each cell on the map. These combined threats scores were subtracted from potential habitat quality to produce maps of habitat effectiveness for each species.

A second overlay procedure was used to estimate the extent and degree of habitat degradation that has occurred for a species. Habitat degradation was calculated by subtracting potential habitat quality from habitat effectiveness and removing cells with a value of zero (no change in habitat quality) from the output.

For those species sensitive to loss of habitat connectivity, a similar overlay method was used to evaluate effective connectivity and connectivity degradation. Connectivity was estimated using the methods described previously. Potential connectivity was estimated using the inverse of potential habitat value as the cost surface and effective connectivity was calculated using the inverse of habitat effectiveness as the cost surface. Where appropriate, habitat cores were defined separately for potential and effective connectivity and are described in more detail in the results section for individual species. Connectivity degradation was calculated by subtracting potential connectivity from effective connectivity and removing cells with value = 0.

Summary Analysis

To identify priority 'hot spots' and conservation issues for maintaining wildlife diversity in the Madison Valley data were summarized by compiling the GIS based analysis results for all species. These analyses were conducted to determine the highest priority private and public lands for maintaining species diversity and habitat connectivity in the valley as well as determining what human activities are affecting the most wildlife species.

Umbrella Scores

Summary analysis was based on the assumption that each focal species provides an "umbrella" for several other wildlife species not included in the focal species suite. In other words, we assumed that by managing to conserve those species with the most demanding requirements or that are the most sensitive to human-caused change, other less demanding or less sensitive species ought to be adequately conserved to maintain wildlife diversity. However, focal species differ considerably regarding the umbrella they provide. For example, a landscape species such as the grizzly is a habitat generalist that requires large, relatively undisturbed areas for survival. Due to these requirements, in addition to its trophic position, grizzly needs conflict with a number of human activities. Therefore, grizzly bears provide an umbrella for a large number of species due to the diversity of habitat types required to support grizzlies in combination with a large number of human activities that can threaten grizzly survival. In contrast, a special element such as the black-backed woodpecker is a habitat specialist largely requiring recently burned patches of forest. Therefore, black-backed woodpeckers provide an umbrella for fewer species than grizzly bears but the species they represent tend to be highly vulnerable to a single pervasive human activity - fire suppression and salvage logging of burned areas.

To account for differences among focal species with respect to the umbrellas they provide, we weighted each focal species according to the number and vulnerability of species that obtain "shelter" under each focal species. To weight focal species, we compiled a list of all 411 vertebrate species believed to be native to the Madison Valley. A habitat use matrix was created for all 411 species using Montana GAP land cover classes (Table A1-1 in Appendix A for complete species matrix score list). An umbrella coefficient was calculated for each species combination by calculating the proportion of habitat types used by both species (Table A1-2 in Appendix A for complete species umbrella score list). For example, bighorn sheep use a total of 12 GAP habitat types and 3 of those are also used by moose. Therefore, the umbrella coefficient that moose provide for bighorn sheep = 3/12 = 0.25. A total umbrella score was calculated for each of our focal species by summing its coefficients for all species. After focal species and proportional scores were assigned, the proportional scores were summed by focal species to provide the total number of species under the umbrella of each focal species (Table 10). This provides an estimate of the relative importance of each focal species for acting as an umbrella to conserve other species. A vulnerability-weighted umbrella score was calculated by first multiplying the proportional coefficients described earlier by the vulnerability score for each focal species that was calculated during the landscape species selection process (See Results). These weighted proportions were summed by focal species to yield vulnerability-weighted umbrella scores for each focal species. This produces an umbrella score that considers both the number of species conserved and the vulnerability of species conserved to balance the need for conserving the greatest number of species versus those species that are most threatened.

Table 10. Total umbrella scores for each focal species (sum of the species umbrella score for all species).

Species	Grizzly Bear Umbrella	Moose Umbrella	Elk Umbrella	Boreal Toad Umbrella	Wolverine Umbrella	Red-naped Sap Sucker Umbrella	Warbling Vireo Umbrella	Yellow Warbler Umbrella	Columbia Spotted Frog Umbrella	Fluvial Arctic Grayling Umbrella	Greater Sage Grouse Umbrella	Bighorn Sheep Umbrella	Pronghorn Umbrella	West slope Cutthroat trout Umbrella	Black-backed Woodpecker Umbrella
Total Species Umbrella (of 411)	300.27	208.64	321.93	401.51	150.61	154.88	171.13	136.89	359.00	168.74	54.91	107.94	176.62	287.79	25.17
Proportion of Species	73.24	50.89	78.52	97.93	36.74	37.78	41.74	33.39	87.56	41.16	13.39	26.33	43.08	70.19	6.14

Hotspot Mapping

Composite overlay maps were created in a GIS using all mapped focal species to create conservation 'hot spots'. Hot spots can be defined a number of ways but for this report we define hot spots as those areas where conservation actions are likely to provide the greatest benefits. In general, these are areas that either support the largest number of wildlife species, or are areas particularly threatened by human activity and where lack of action is likely to result in significant loss of wildlife resources or ecosystem function. Similar methods were used to produce composite maps for habitat and habitat connectivity. Individual species habitat scores were reclassified into habitat vs. non-habitat by classifying the best 50% of habitat scores as 1 and eliminating the rest. Habitat grids were multiplied by the vulnerability-weighted umbrella score of each focal species and summed to produce a map of the total umbrella scores for all species. Composite maps were generated for both potential habitat and habitat effectiveness using the same methods. We mapped composite habitat degradation by subtracting the composite effective umbrella scores from composite potential umbrella scores. These methods were repeated using least-cost path scores for all focal species to determine connectivity hotspots and degradation.

Threat Scores

We calculated threat scores to estimate the number of candidate species and the vulnerability-weighted number of candidate species affected by human activities. The number of species affected by each human activity was estimated by summing the umbrella scores of all focal species affected by each human activity. Vulnerability-weighted threat scores were calculated similarly by summing the vulnerability-weighted umbrella scores for all species affected by each threat.

Results

Bighorn Sheep (Ovis canadensis)

Current Status:

Bighorn sheep currently occur in three areas within the Madison Valley assessment area (Figure 11A). The largest herd (approximately 85) occurs in the Spanish Peaks area in the northern Madison Range. A second herd (approximately 30) occurs in the Taylor/Hilgard Mountains. And a third herd has been recently reintroduced to the Greenhorn Mountains at the extreme western edge of the assessment area. The two eastern herds are within Montana hunting districts 301 and 302, which are currently closed to sheep hunting (Figure 11B).

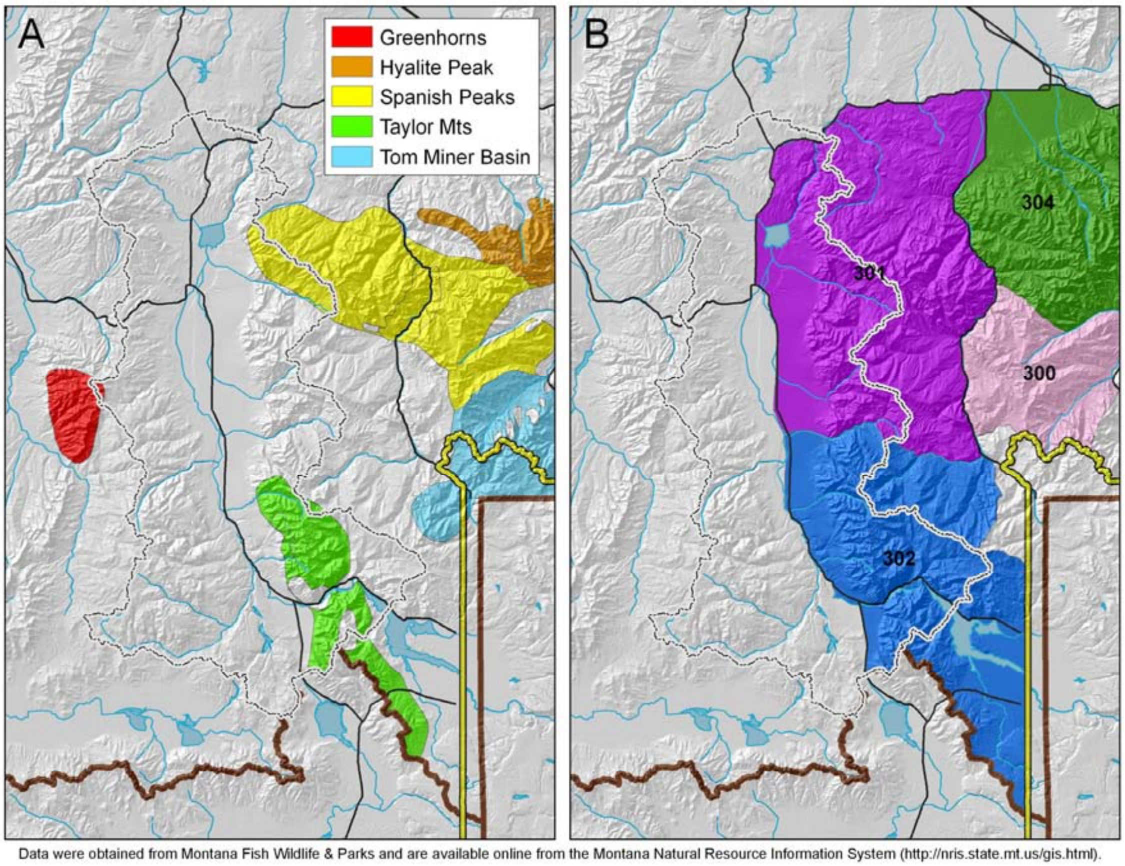
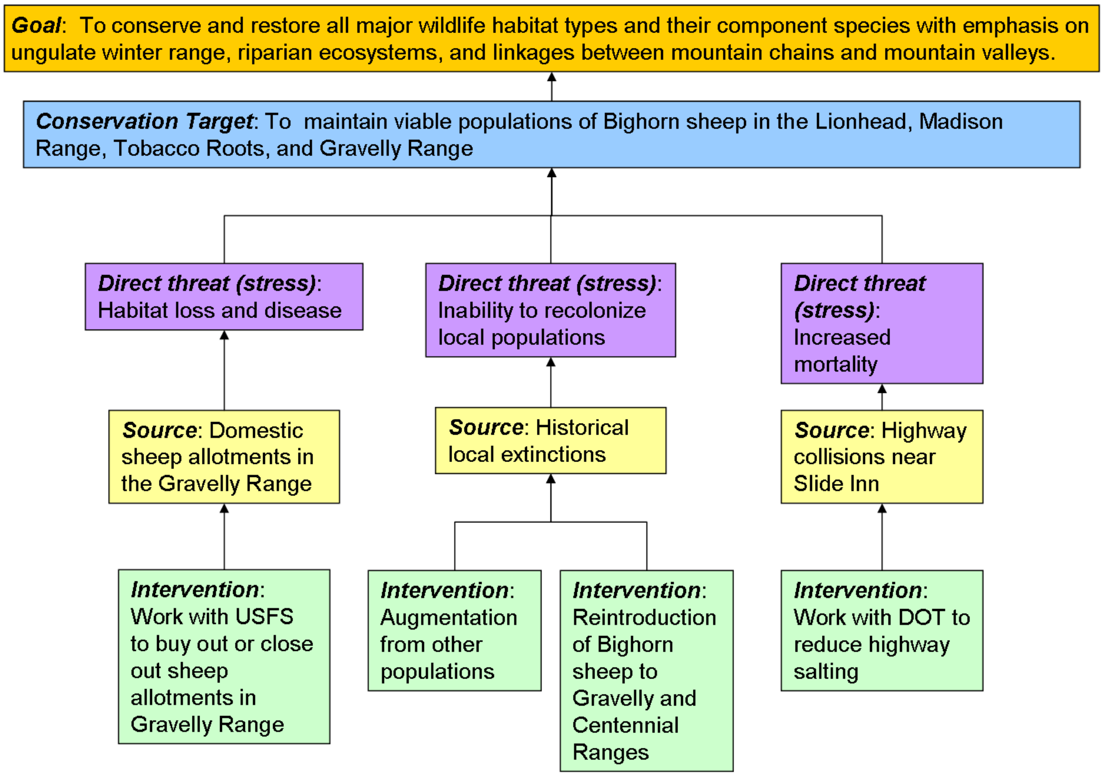


Figure 11. A) Bighorn sheep herds and B) Bighorn sheep hunting districts in the Madison Valley.

Current Threats:



There are three major threats influencing the ability to reoccupy their historic range within the Madison Valley. Bighorn sheep are highly susceptible to disease transmitted by livestock, particularly by domestic sheep. Therefore, bighorn sheep cannot persist where domestic sheep grazing occurs. Due to the isolated nature of bighorn sheep habitat characterized by steep rocky slopes for escape terrain, historic bighorn populations occurred as a meta-population among isolated habitat patches. Long-term population viability of meta-populations depends on the ability of animals to disperse between isolated habitat patches. Therefore, maintaining connectivity between isolated patches of bighorn habitat is important for maintaining natural long-term population viability in the region. Finally, like many wildlife species, bighorn sheep are attracted to mineral licks and suffer increased mortality from vehicle collisions when they are attracted to roadsides by salt applications for winter snow abatement. The Spanish Peak herd regularly congregates along the road near the junction if U.S. Hwy 191 and MT Hwy 64 in winter to lick salt from the roadside making them vulnerable to vehicle mortality.

Habitat Analysis:

In addition to currently occupied habitat in the northern Madison Range, the Taylor/Hilgards, and the Greenhorn Mountains, the habitat model indicates additional potential habitat in the Madison range surrounding Fan Mountain, the Gravelly Range, and the Tobacco Roots (Figure 12). In addition, the Centennial Mountains, outside the assessment area, contain potential habitat that may have sufficient connectivity with the Madison Valley to help sustain meta-populations in the area. Most habitat of the potential habitat remains intact (Figure 13). The only significant habitat degradation is in the Gravelly and Centennial Mountains where domestic sheep grazing occurs on public land (Figure 14).

Conservation Strategies:

There are several opportunities to improve the long-term viability of bighorn sheep in the Madison Valley. There remain three significant blocks of habitat that are currently unoccupied and may support reintroduced populations of sheep. The Tobacco Roots appear to offer extensive areas of high quality habitat and do not contain sheep allotments. The Gravelly and Centennial Mountains contain significant amounts of potential habitat which historically were occupied. However, domestic sheep grazing in those areas would need to be mitigated before their value for bighorn sheep could be realized.

Connectivity between isolated patches of habitat needs to be maintained to allow bighorn to naturally re-colonize patches where sheep have disappeared. Fragmented populations typically experience periodic local extinctions within isolated habitat patches. Restoring bighorn to as many suitable patches as possible and maintaining connectivity between patches will help to maintain a robust meta-population without the expense and uncertainty associated with artificial relocation programs. A priority of immediate concern should be to maintain connectivity across Jack Creek to allow expansion of the Spanish Peaks herd into the Fan Mountain area. A long-term priority should be to restore bighorn to the Gravelly and Centennial Mountains, which could provide complete meta-population connectivity among all bighorn herds within the Madison assessment area.

Mitigating the use of salt for winter snow maintenance should reduce mortality caused by vehicles. Bighorn frequently congregate along the roadside in the vicinity of the confluence of US Hwy 191 and MT Hwy 64. Where practical, efforts should be made to discouraging sheep from congregating near the road where they are likely to be involved in an accident. Alternative methods of snow abatement should be explored to reduce this threat. In addition, the stretch of US Hwy 287 in the vicinity of Quake Lake runs in proximity to moderately good bighorn habitat. Potential impacts of road salting on bighorn sheep in this area should be considered.

BIGHORN SHEEP POTENTIAL HABITAT

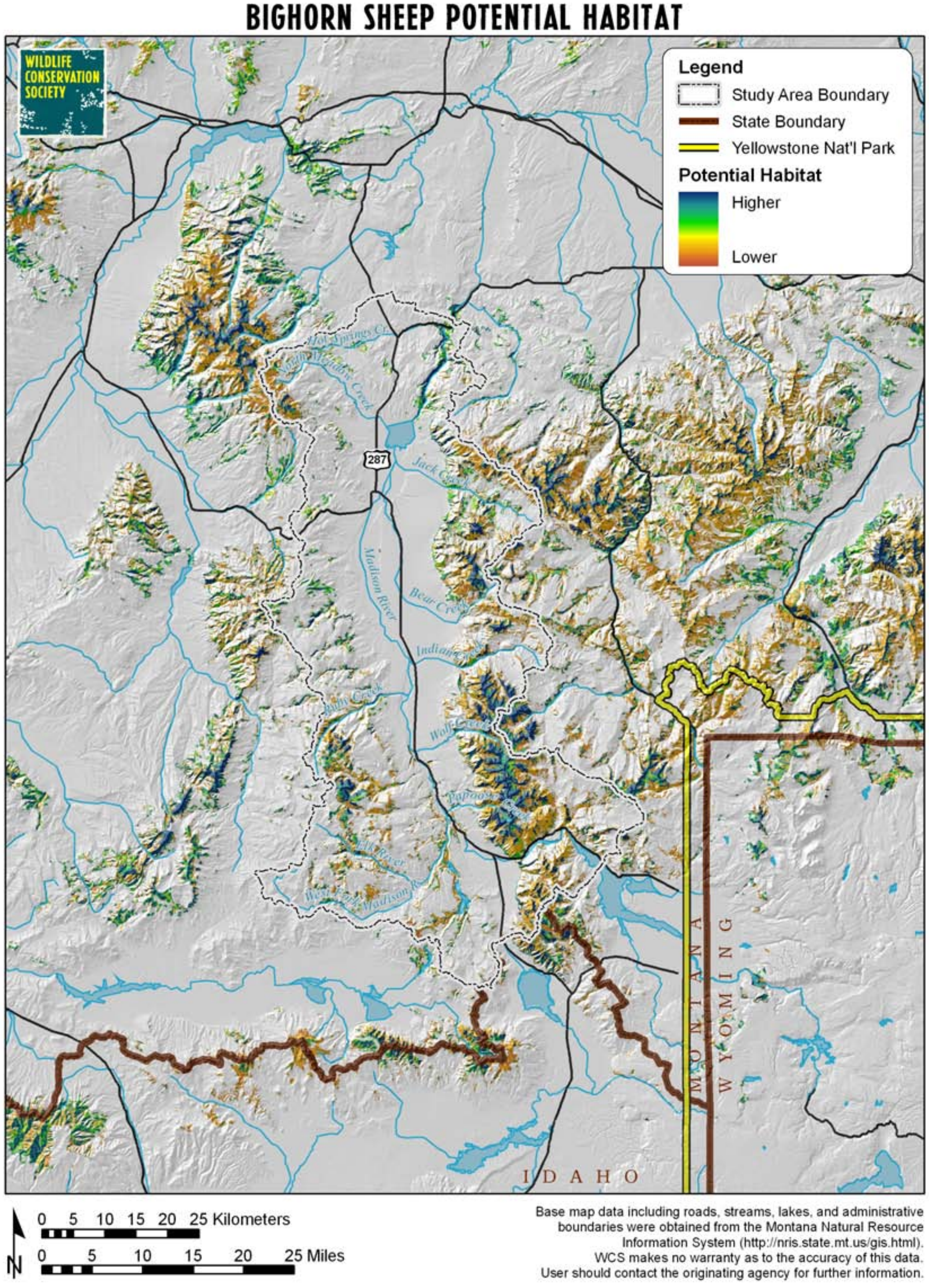


Figure 12. Bighorn Sheep potential habitat in the Madison Valley.

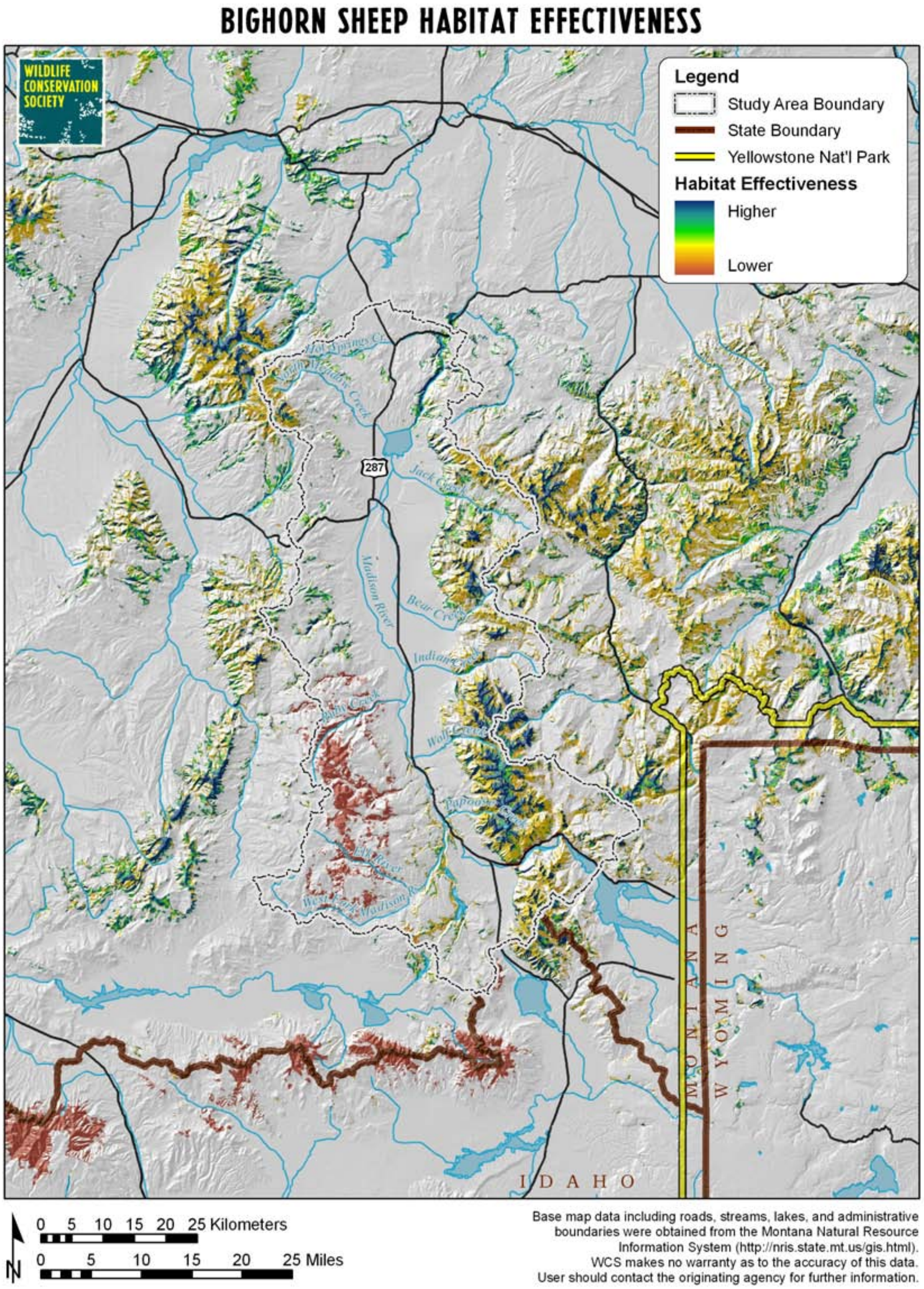


Figure 13. Bighorn Sheep habitat effectiveness in the Madison Valley.

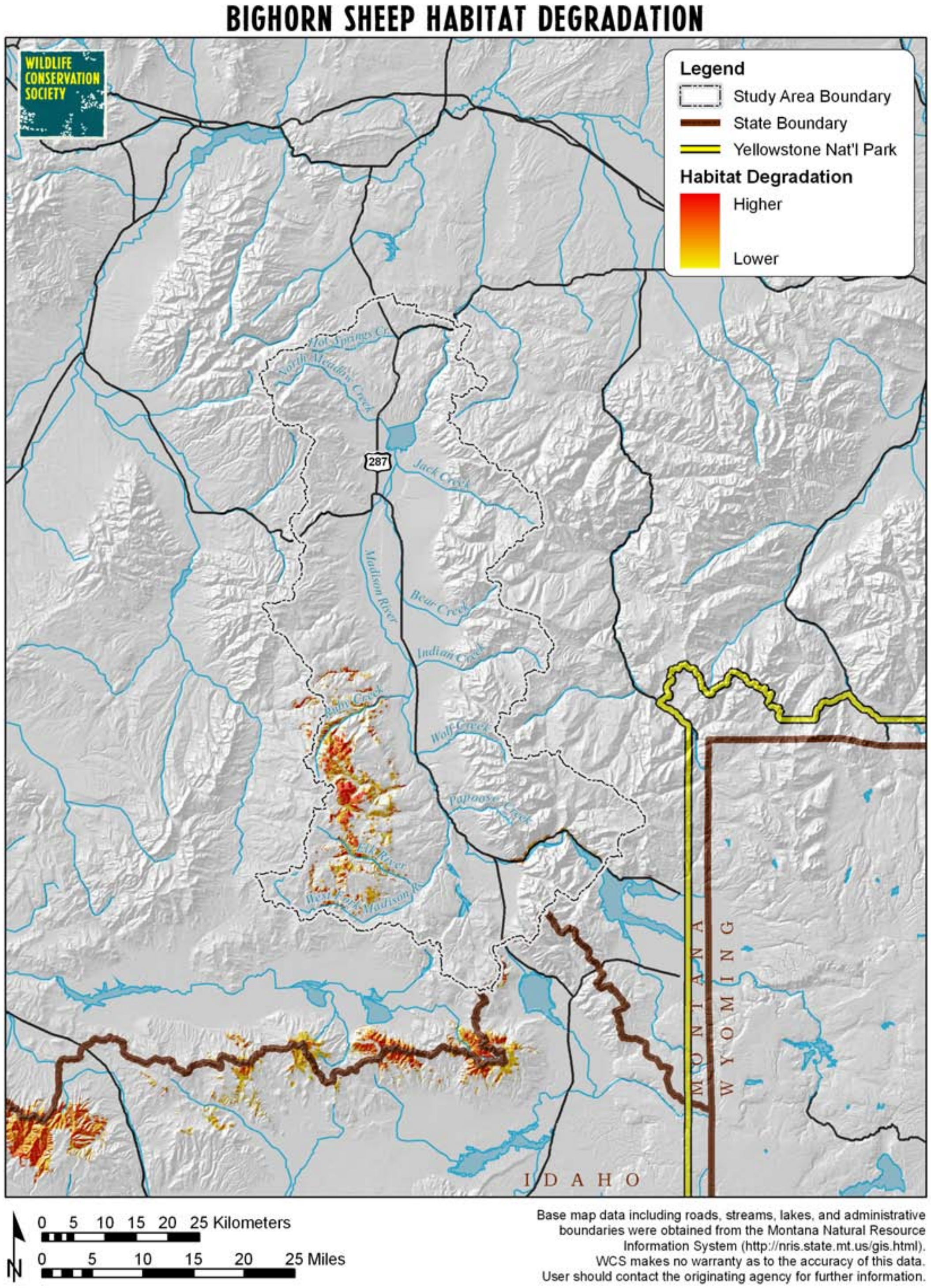


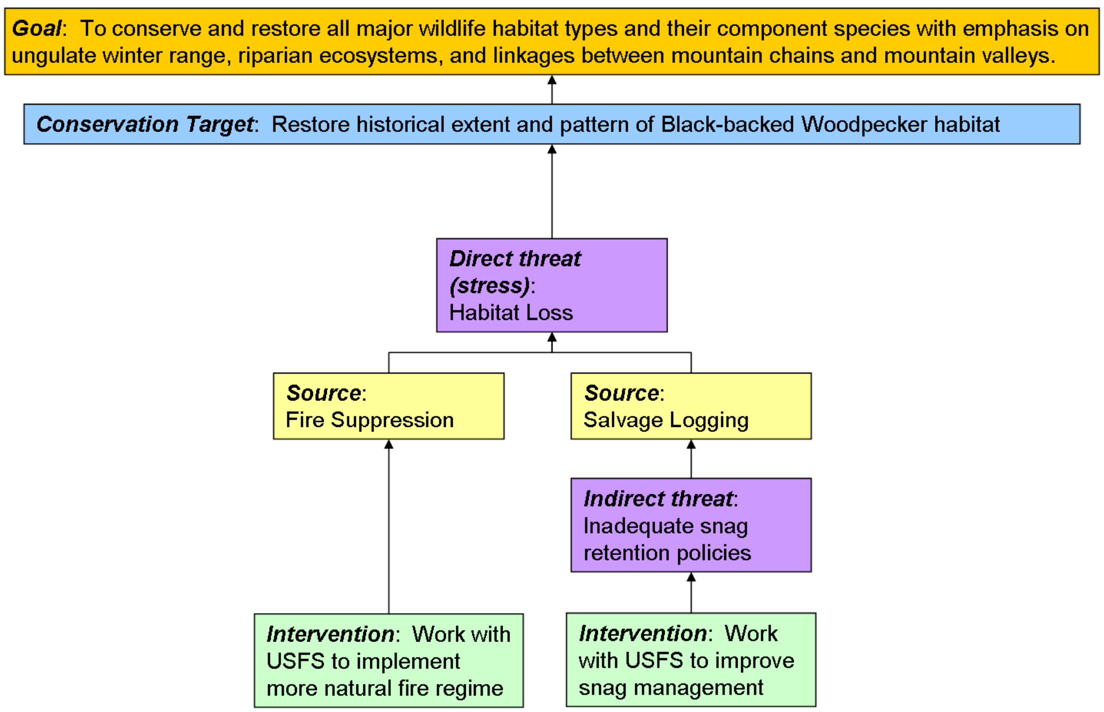
Figure 14. Bighorn Sheep habitat degradation in the Madison Valley.

Black-backed Woodpecker (Picoides arcticus)

Current Status:

Black-backed woodpeckers depend on post-fire habitat following stand-replacement fire. They occur at low densities within suitable habitat in the assessment area and are a species of special concern. Black-backed woodpeckers reach highest densities following stand-replacement fires in mature conifer typically reaching highest densities in burned stands for 2-8 years following a stand replacement fire (Hoyt and Hannon 2002). This species also utilizes stands killed by bark beetles but the degree to which these areas can substitute for stand-replacing fire is uncertain (Burns *et al.* 2000, Saab *et al.* 2002) and predatory woodpeckers such as these may play a significant role in regulating bark beetle populations in forest landscapes (Fayt *et al.* 2005).

Current Threats:



Two major land use practices threaten the long-term maintenance of black-backed woodpecker in the region; fire suppression and salvage logging (Hillis *et al.* 2002). Black-backs are highly dependent on natural fire patterns that create mosaics of recently burned conifer stands (Hutto 1995, Saab and Dudley 1998, Hillis *et al.* 2002, Kotliar *et al.* 2002, Saab *et al.* 2002). Currently fire suppression is nearly ubiquitous within the Madison Valley and only a relatively small percentage of US Forest Service lands can be considered to allow natural fires to progress. Even in these areas, available resources often preclude allowing natural stand replacement fires to proceed unimpeded. Attempts to restore natural fire conditions to Forest Service lands in the assessment area have been hampered by concerns over air quality, wildlife habitat, and public safety. Increasing development at the urban-wildland interface is exacerbating efforts to restore natural fire processes to the forest lands within the Madison Valley.

Extensive salvage logging following fire or beetle outbreak can destroy habitat created by these natural disturbances and negate the positive effects of these disturbances for black-backed woodpeckers and other disturbance dependent species. Regionally, the interval between large fires increased substantially over the last half of the 20th century and historically fire return intervals are highly variable (Hillis *et al.* 2002). Bark beetle outbreaks may provide important habitat for sustaining populations during periods of low fire activity. Extensive salvage logging to remove beetle-killed trees to promote 'forest health' could have negative consequences for the long-term sustainability of black-backed woodpecker populations in the region.

Habitat Analysis:

Primary habitat for black-backs is ephemeral by nature and typically lasts less than eight years at a given location (Hoyt and Hannon 2002). Maps of currently existing black-backed woodpecker habitat are of limited value since their accuracy declines rapidly with time and they may encourage the notion that this species can be effectively managed by protecting existing habitat patches. Therefore, the potential habitat map for black-backs differs from other species in this assessment in that it predicts the habitat quality that would be created by natural fire in addition to potential existing habitat created by bark beetle outbreaks. Patches of potential habitat are scattered throughout the mountainous areas of the assessment area where mature conifer forests occur (Figure 15). Relatively large clusters of potentially high quality habitat occur in the vicinities of Ruby, Bear, and Indian Creeks as well as north of Jack Creek but it is important to emphasize that these areas will only provide habitat following fire disturbances that are likely to produce stand replacement fires in those areas.

Conservation Strategies:

The restoration of natural fire ecology is paramount to the long-term well-being of black-backed woodpeckers, and other fire obligate species. The US Forest Service and other agencies recognize the importance of fire in this ecosystem but current fire management policy does not encourage the maintenance of stand replacement fire regimes (Hutto 1995). Prescribed burning is often targeted towards low intensity fires that are easier to manage but do not produce the high severity stand-replacement fires most beneficial to many fire dependent species. Efforts should be made to aid the Forest Service in restoring natural fire regimes to the Madison Valley. Such restoration will not be easy given that natural and prescribed fires generate concerns about human safety, health, and property while continuing development in the area makes it increasingly difficult to maintain natural fire regimes. The following tools should be employed to promote ecologically functional fire patterns in the region:

- Educate the public about the importance of natural infrequent but high intensity fires in maintaining regional biodiversity.
- Promote projects to create defensible space around developments at the wildland/urban interface including thinning and prescribe burning where warranted.
- Promote the use of prescribe fire that mimics a range of fire intensities and frequency intervals rather than concentrating on frequent, low intensity fires designed primarily to reduce fuel loads.
- Institute policies to discourage development in areas prone to severe fires and that interfere with allowing natural fires to burn.
- Educate people in the urban/wildland interface about fire aware practices so that homes in fire prone areas are designed and maintained to minimize vulnerability to natural fire.

Post fire management can have profound impacts on cavity-nesting birds that use post-fire habitats (Kotliar *et al.* 2002). Kotliar *et al.* (2002) offer five alternatives to severe salvage logging to provide habitat for post-fire dependent birds:

- Leave burned areas alone to undergo natural succession.
- Lightly salvage throughout the burned area leaving many of the largest snags.
- Defer salvage logging for several years post fire to allow black-backed woodpeckers and other fire dependent species to utilize available habitat before snags are removed.
- Salvage part of a burn severely and leave the rest alone.
- Apply a variety of salvage treatments to create a variety of snag species, size, density, and spatial patterns.

Of these, black-backed woodpeckers are likely to benefit most from the first option of leaving areas unsalvaged because they are among the most fire-dependent species. When the size of the area burned by stand-replacing fires is small, this option should be strongly considered.

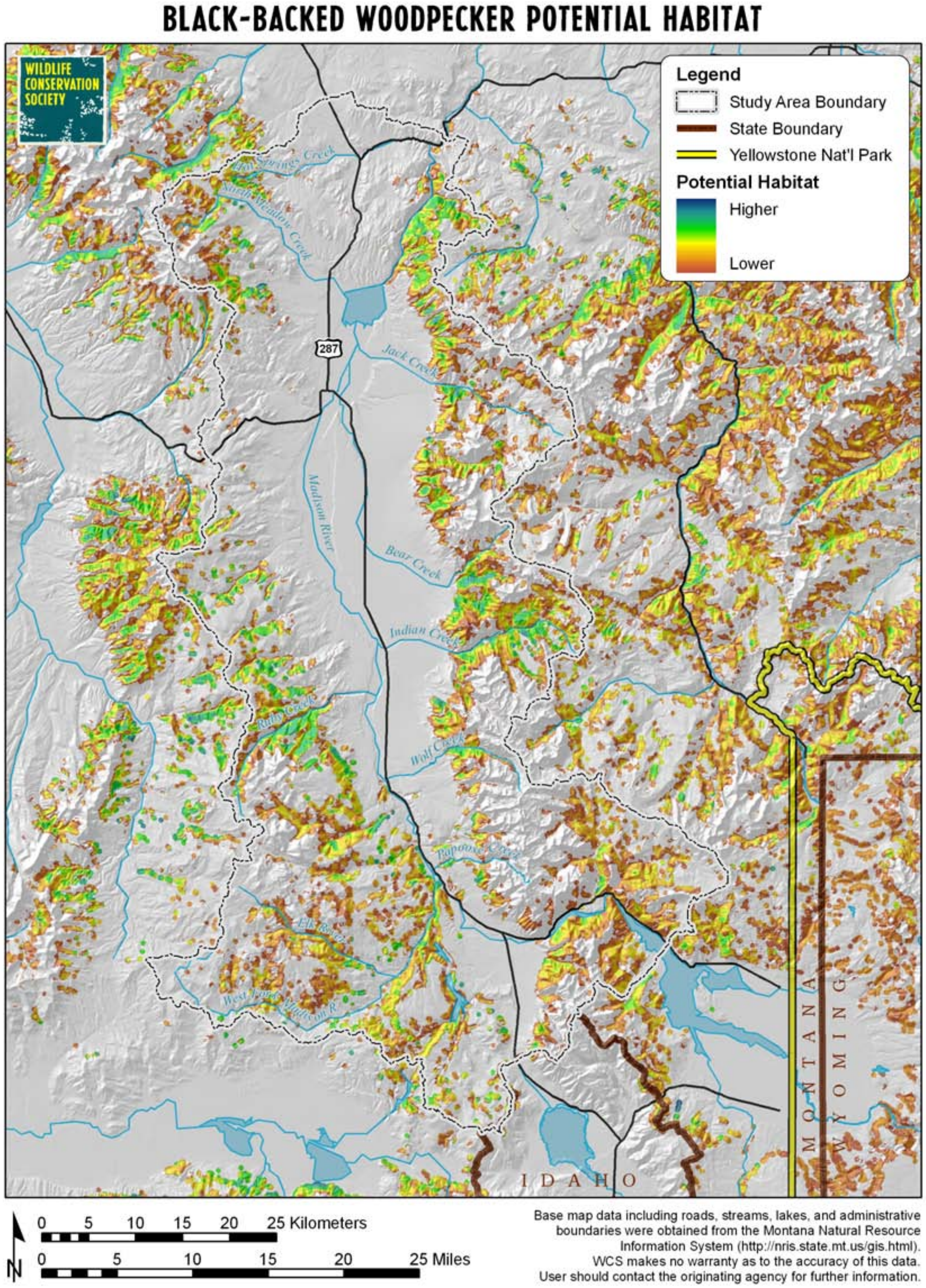


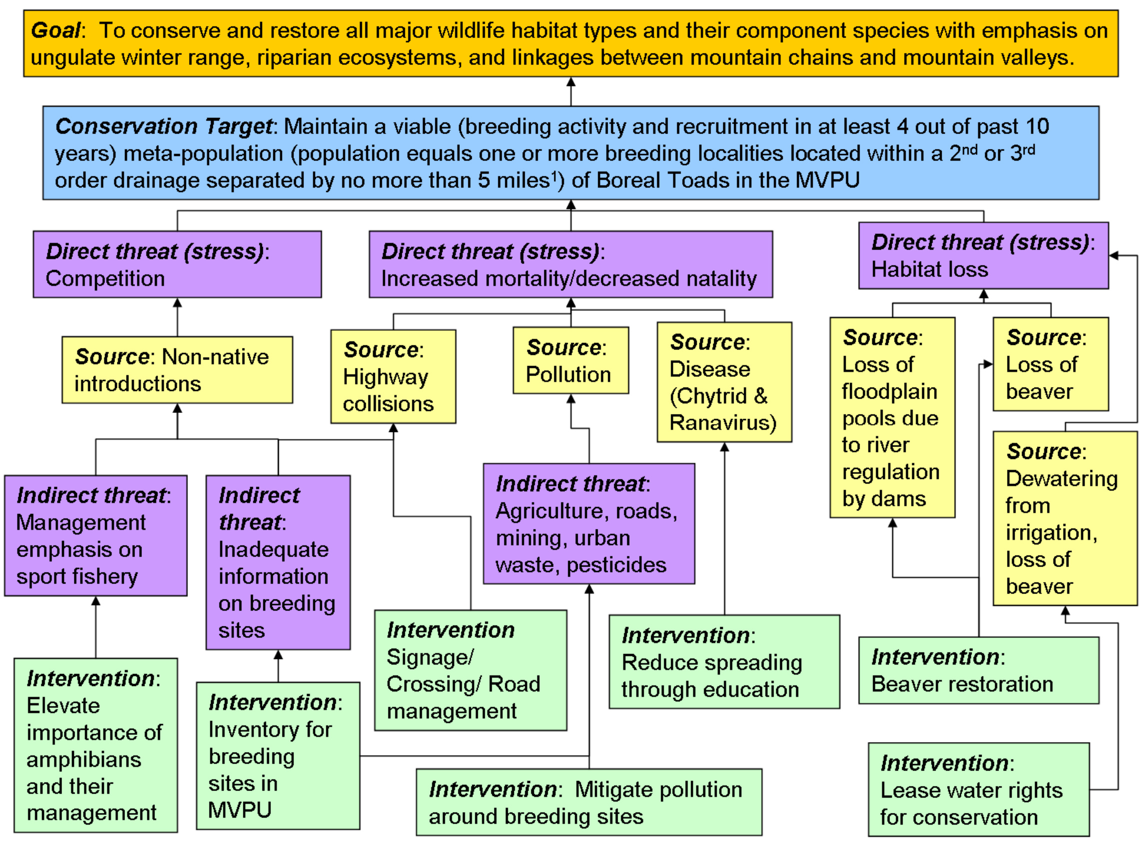
Figure 15. Black-backed Woodpecker potential habitat in the Madison Valley.

Boreal Toad (Bufo boreas boreas)

Current Status:

Amphibians are in the midst of a global extinction event with an estimated one third of all amphibian species on the planet in significant decline or recently extinct (Stuart *et al.* 2004). Within the Greater Yellowstone Ecosystem the northern leopard frog (*Rana pipiens*) is presumed extinct from Yellowstone National Park and surrounding areas and the boreal toad has suffered significant declines leading to its designation as a sensitive species by the USFS. Both northern leopard frogs and boreal toads occur within the Madison Valley assessment area, with the former being presently extremely rare (Maxell *et al*. 2003). A survey of known and suspected boreal toad breeding sites on, and adjacent to, the Gallatin National Forest found 24 confirmed breeding sites at 20 breeding localities with an additional 10 breeding sites potentially active (Atkinson and Atkinson 2003). Population viability analysis from that study indicated that only the population surrounding Hebgen Lake met the criteria for a viable population although it should be noted that the study did not include a comprehensive survey for additional breeding sites, nor did it include portions of the assessment area beyond the Gallatin National Forest.

Current Threats:



Boreal toads, and other amphibians, are vulnerable to multiple threats. Within the Madison Valley, experts identified seven significant threats that are likely responsible for recent population declines.

Historic land management policies on public lands and waterways have emphasized sport fisheries which have led to the widespread introduction of native and non-native fish into formerly fishless lakes, ponds, and streams. Documentation of pre-introduction conditions of waters (whether fish were already present) is often non-existent making it difficult to determine the extent of conversion from fish-free to fish inhabited habitats. Fish prey on amphibians at the egg, larval, metamorph and possibly juvenile stages, and likely compete with amphibians for food. Densities of amphibians of all life stages in the Frank Church River-of-No-Return Wilderness in Idaho are significantly lower in fish-containing than in fishless water bodies (Pilliod and Peterson 2001). It is almost certain that past fish introduction has resulted in significant declines in habitat quality and breeding success of boreal toads in the Madison Valley.

Boreal toads have also suffered from the loss of wetlands. The regulation of the Madison River by dams has resulted in the loss of flood plain pools created by periodic flooding of the formerly free-running river. In addition, significant declines from the historic populations of beaver in the area have led to loss of beaver ponds which are potential breeding habitat for boreal toads, northern leopard frogs, and Columbia spotted frogs. Finally, dewatering of streams has resulted in the loss of side channels and sloughs that formerly provided breeding habitat for boreal toads and other amphibians. The problem of dewatering may be exacerbated by the loss of beaver which tend to raise water tables (Naiman *et al.* 1988) as a consequence of their water impoundment activities.

Boreal toads are vulnerable to vehicle mortality because of their small size and slow speed coupled with the fact they may seek out warm pavement and gravel surfaces for thermal regulation. In the Madison Valley, a heavily trafficked forest road (West Lake Road, GNFR 167) runs parallel to the highest known concentration of breeding habitat at Hebgen Lake. Vehicle collisions likely kill a significant number of breeding adult and dispersing juvenile toads in this area (Atkinson and Atkinson 2002, 2003; Sestrich 2004).

Environmental pollution has been implicated in amphibian deformities and local population declines. Amphibians are particularly vulnerable to pollutants because they are aquatic or semi-aquatic during at least part of their life, often living in small, poorly drained pools susceptible to toxin accumulations. In addition, amphibians have permeable skin that allows toxins to easily pass through the skin and enter their systems. In the Madison Valley, pollution from agricultural fertilizer and pesticides, mines, urban waste, and road pollutants likely contribute to reductions in habitat quality for boreal toads.

Diseases such as chytrid fungus have been linked with devastating declines in amphibian populations resulting in serious ecological consequences (Whiles *et al.* 2006). Chytrid fungus and ranavirus are potential threats to amphibians in the Madison Valley but the current distributions of these diseases in the area are unknown. Only a ranavirus (Iridoviridae) is known from the area (Atkinson and Atkinson 2002). Resistance to these diseases varies among amphibian populations and localities. However, even if amphibians in the Madison Valley prove relatively resistant, the spread of diseases would further stress boreal toads. Additionally, the effect of introduced New Zealand Mudsnails on toads and other amphibians is at this time unknown.

The threats affecting boreal toad populations in the Madison Valley are numerous and varied. It is unlikely that any single threat has been responsible for the recent declines of this species, and other amphibians, in the area. Rather, multiple threats working in concert have likely served to reduce available habitat, degrade habitat quality, and reduce reproduction and survivorship of the species.

Habitat Analysis:

Boreal toads disperse from breeding pools to occupy suitable habitat on the surrounding uplands and are most often encountered within 300m of ponds, lakes, or streams (Keinath and Bennett 2000). Females have been recorded traveling up to approximately 2.5 km from breeding sites and males have been recorded traveling up to 1 Km from breeding sites (Bartelt 2000, Muths 2003). Because boreal toads can utilize small, often ephemeral, pools, side channels and backwater sloughs and National Wetlands Inventory data are not available for the assessment area, potential breeding sites could not be comprehensively mapped. Therefore the potential habitat for this species is likely greater than the amount indicated by our model (Figure 16). However, small and ephemeral pools tend to be relatively unreliable sources of breeding habitat since they are subject to drying and are more vulnerable to disturbance than larger perennial water bodies. Despite the exclusion of small and ephemeral pools in our analysis, the resulting habitat map likely includes the majority of dependable breeding habitat available for boreal toads over multi-year time spans. Potential habitat is widely distributed throughout the high elevation portions of the assessment area and within wetland areas at lower elevations. However, due to the many factors adversely affecting boreal toads, a significant amount of habitat has already been lost throughout the assessment area (Figure 17). The cumulative effects of habitat degradation appear to be most severe in the Hebgen Lake area where the most viable population of boreal toads in the area occurs (Atkinson and Atkinson 2003).

Habitat degradation has fragmented potential habitat for boreal toads likely resulting in increasingly isolated breeding groups. For example, selecting clusters of the best potential habitat capable of supporting at least 20 male territories yields an estimated 16 habitat core clusters with a total area of 900 km^2 (Figure 18). However, using the same methods to select currently effective habitat cores indicates that core habitat has been fragmented into 28 core clusters with the total area reduced to 303 km^2 (Figure 19). Such isolation increases the probability that local extinctions due to unusual weather events or other disturbances are permanent because fragmentation makes re-colonization of breeding sites from neighboring populations less probable. As populations become increasingly fragmented, maintaining connectivity between habitat fragments becomes increasingly important to allow animals to repopulate vacant habitat following catastrophic events. Connectivity analysis indicates that boreal toad habitat was formerly reasonably well connected in the study area. Interpretation of our maps indicates that potential core habitats were relatively large and contiguous with a number of potential linkage zones across the valley in the region of Wolf Creek south to Raynold's Pass linking the Madison and Gravelly ranges. Current effective connectivity (Figures 19, 20, & 21) indicates that core habitats have been fragmented and reduced in size, eliminating all but the southern most linkage zone at Raynold's Pass with no additional linkage between newly formed habitat fragments. All of the potential linkage zones in the valley have experienced at least some degradation, most likely as a result of the increased distance between core habitat patches. It is likely that these analyses under represent the actual potential and effective connectivity in the area because they cannot account for the positive effects that small ephemeral pools and roadside ditches may have on allowing toads to move across the landscape. However, they still serve to illustrate that boreal toads are experiencing widespread habitat loss and degradation as the result of multiple insidious stresses. Moreover, this landscape level view of boreal toad habitat illustrates how chronic loss of marginal habitat can make the species increasingly vulnerable to small-scale events that cause local population extinctions.

Conservation Strategies:

Boreal toads are adversely affected by a number of common and widespread land use activities in the Madison Valley. None of these threats alone are likely responsible for the widespread decline of the species in recent times and many will be difficult to mitigate. However, there are a number of conservation activities that would help to stabilize and restore toad populations and their habitat in the Madison Valley (Maxell 2000). Some of the activities most likely to produce the greatest results are:

- Manage mountain ponds and lakes for boreal toads and other amphibians (see Sestrich 2004 for local example). Fish stocking into historically fishless water bodies has likely cause significant declines in reproductive success of boreal toads (Pilliod and Peterson 2001). Efforts should be made to maintain and restore historically fishless ponds and lakes as amphibian breeding sites. These sites should be well distributed throughout potential habitat to maximize the capacity for re-colonization of areas following local extinctions and promote genetic exchange among neighboring populations.

- Create new breeding sites in the region by restoring beaver wherever feasible. Beaver create water impoundments that are ideal breeding sites for amphibians. These sites may be particularly beneficial for boreal toads because they often contain shrubs and other dense cover around the water margins. Dense cover benefits survival of metamorphs (Atkinson and Atkinson 2003) and aids in the conservation of body moisture (Bartelt 2000). In addition, beaver activities have the potential to raise water tables (Naiman *et al.* 1988) which might serve to alleviate some of the impacts of dewatering.

- Reduce road mortality by constructing crossing structures near Hebgen Lake that would allow amphibians and other wildlife to cross safely under the road to access breeding habitat around the lake. Placing signs along the West Lake Road and Highway 287 near Hebgen Lake warning motorists they are traveling through important habitat for a sensitive species might also reduce mortality.

- Curtail the use of pesticides near breeding sites. Recent studies suggest that herbicides considered safe for use in wetlands may be detrimental to amphibians (Relyea 2005, Relyea *et al.* 2005). Vegetated buffer strips around breeding sites where pesticides are not applied should be used to protect breeding boreal toads from possible impacts of pesticide use. Where noxious weeds are growing near breeding pools, biological and mechanical control measures should be considered. When such measures are not feasible, every effort should be made to minimize exposure of breeding pools to pesticide overspray.

In addition to the above activities, there may be potential to enhance boreal toad and other amphibian habitat through backyard management. Ornamental ponds managed for amphibians rather than traditional ornamental fish could potentially provide reliable breeding sites for amphibians that would otherwise be adversely affected by rural residential development.

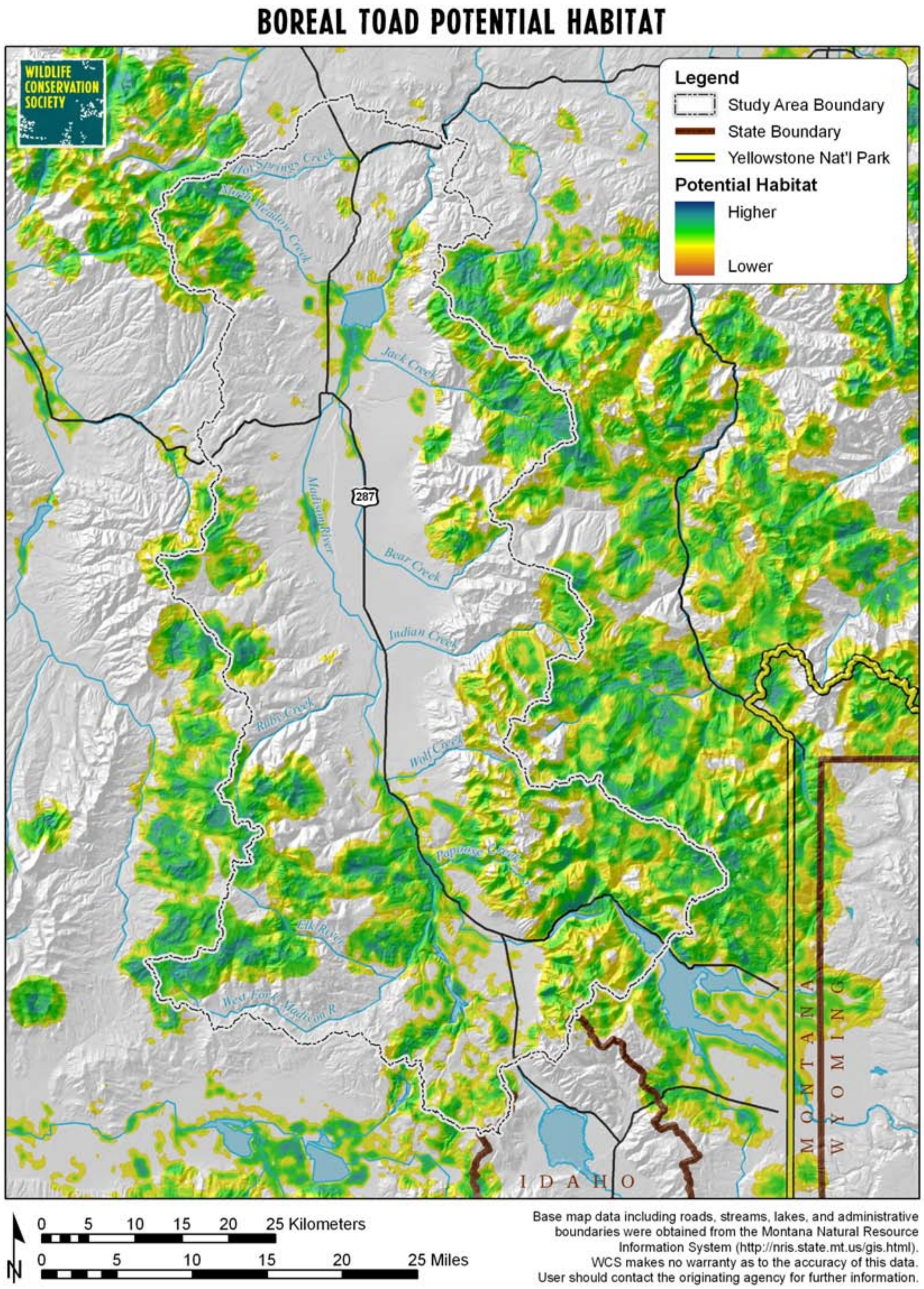


Figure 16. Boreal Toad potential habitat in the Madison Valley.

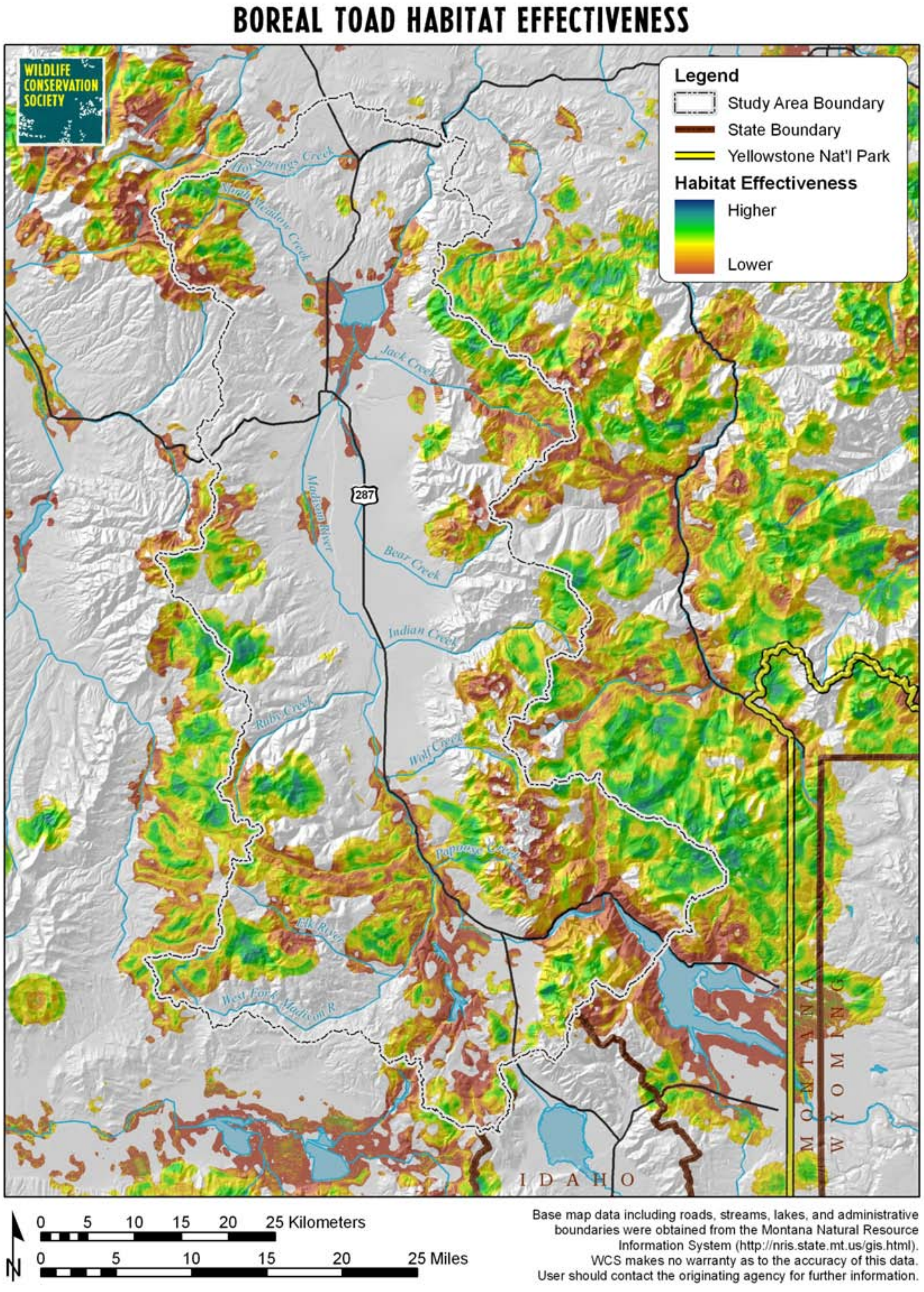


Figure 17. Boreal Toad habitat effectiveness in the Madison Valley.

BOREAL TOAD HABITAT DEGRADATION

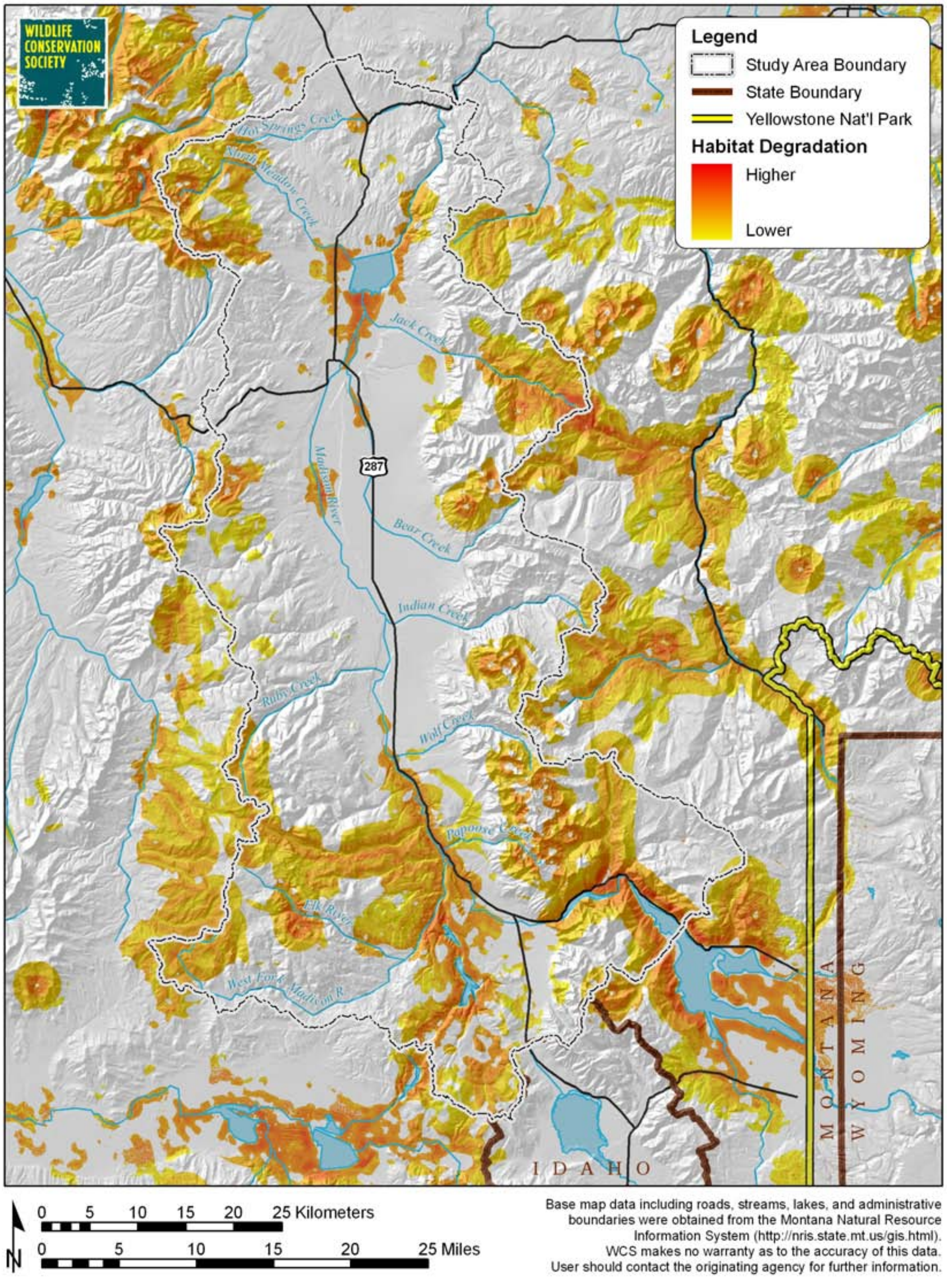


Figure 18. Boreal Toad habitat degradation in the Madison Valley.

BOREAL TOAD POTENTIAL LANDSCAPE CONNECTIVITY

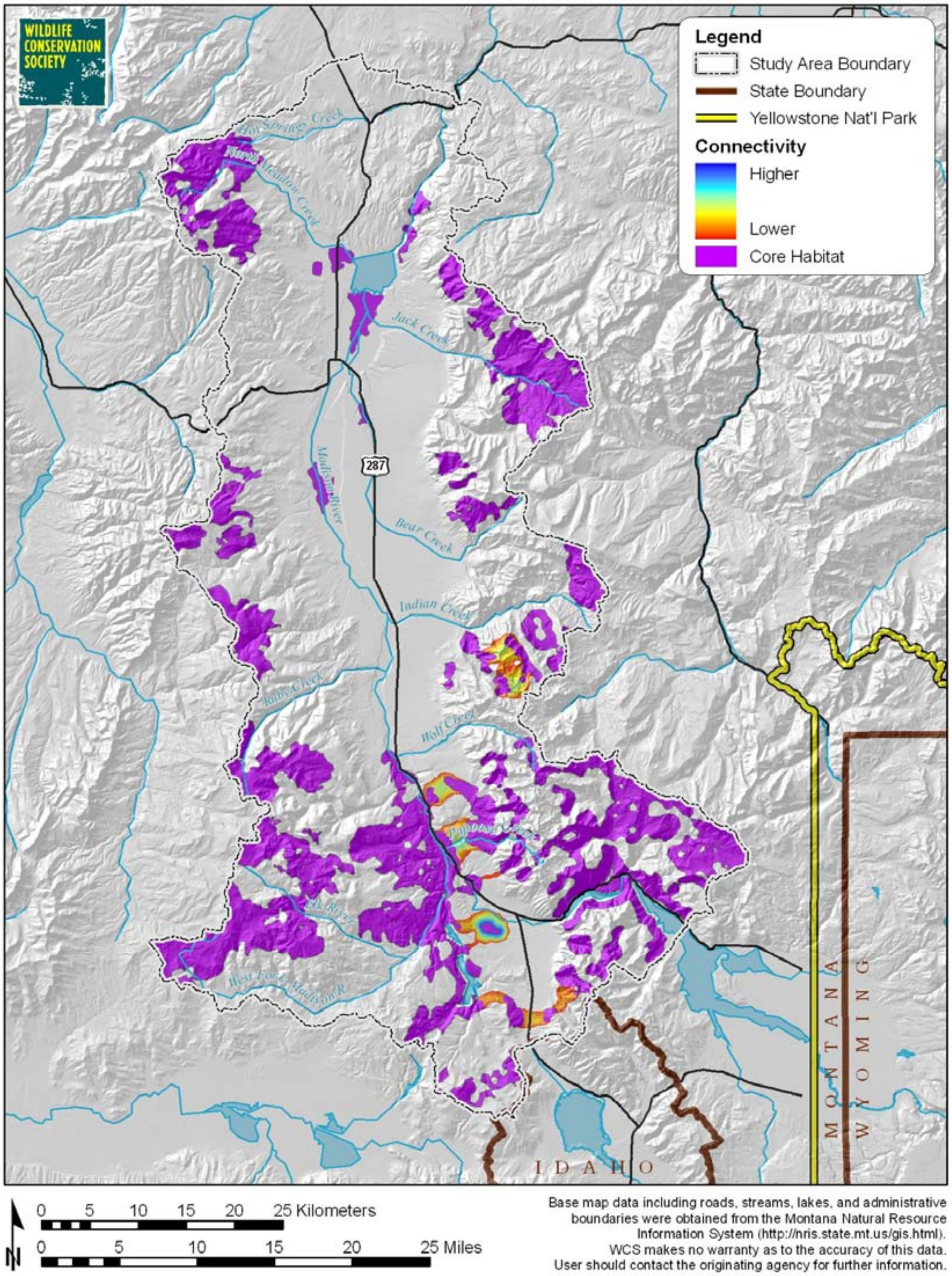


Figure 19. Boreal Toad potential landscape connectivity in the Madison Valley.

BOREAL TOAD LANDSCAPE CONNECTIVITY EFFECTIVENESS

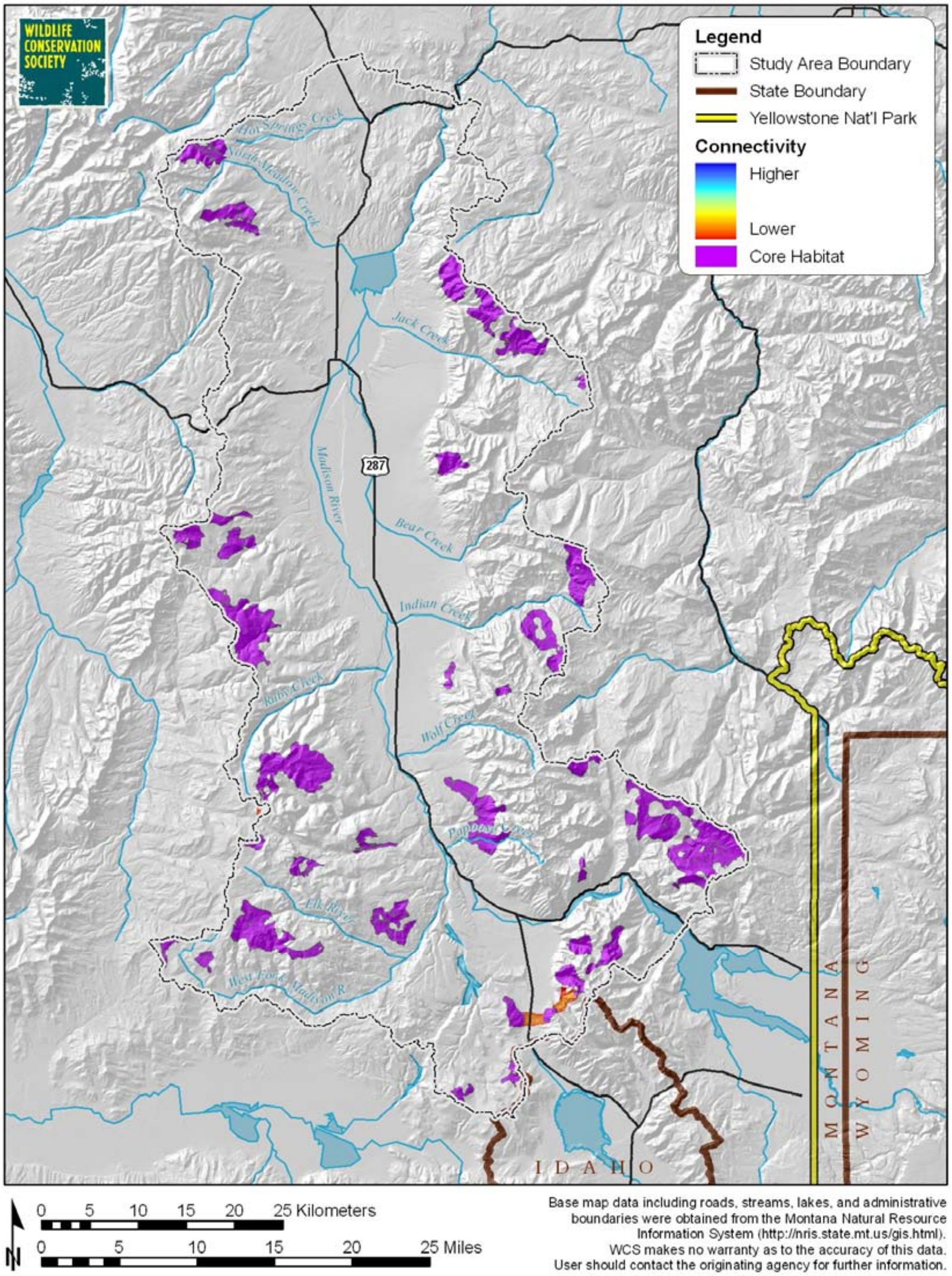


Figure 20. Boreal Toad landscape connectivity effectiveness in the Madison Valley.

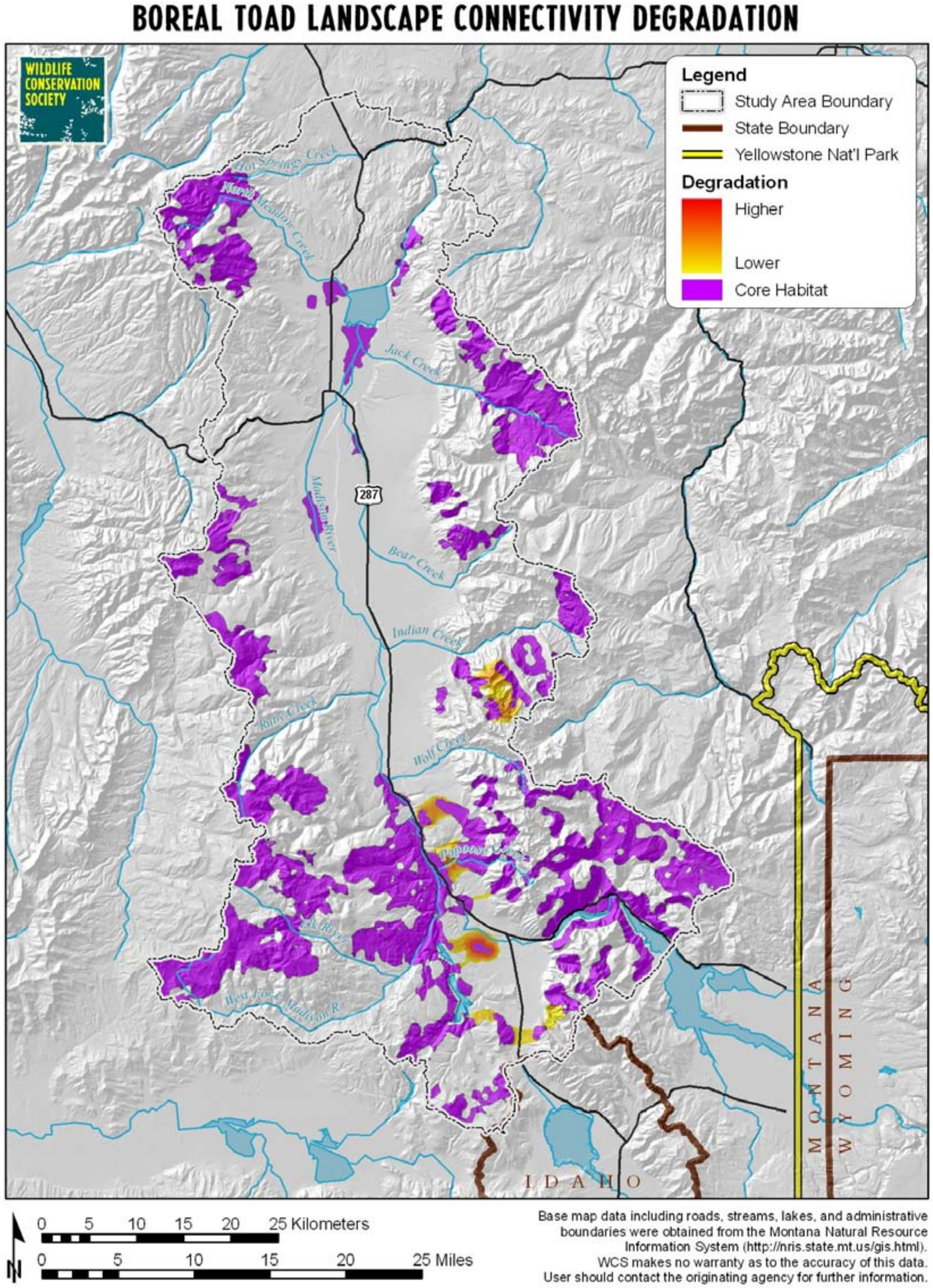


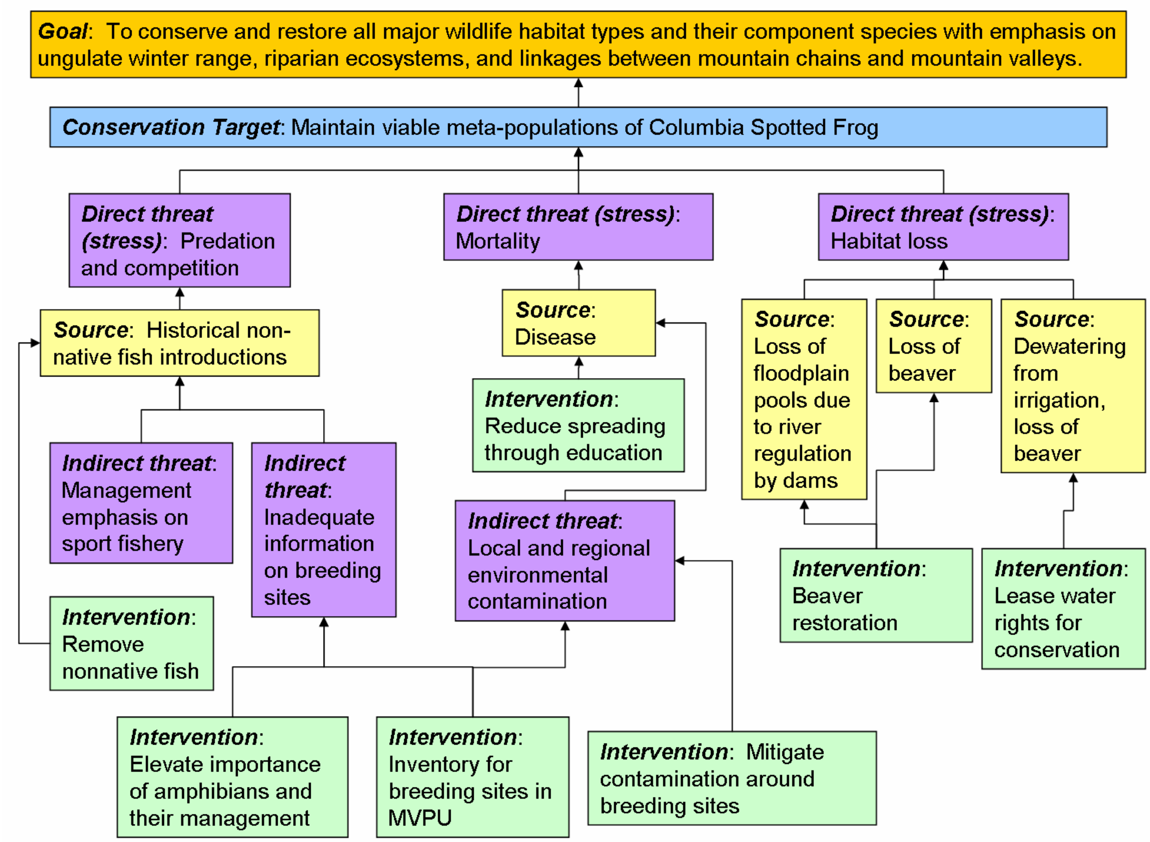
Figure 21. Boreal Toad landscape connectivity degradation in the Madison Valley.

Columbia Spotted Frog (Rana luteiventris)

Current Status:

Columbia spotted frogs are the most common amphibians in the Madison Valley and are found near wetlands through much of the valley. Although they remain common in the valley, loss of habitat and other stressors have probably altered populations of this historically abundant species. Furthermore, its congener, the northern leopard frog, appears to be nearly extinct from the Upper Madison Valley and rare in the Lower. The association of spotted frogs with a wide variety of wetland types and the sensitivity that amphibians demonstrate toward environmental change make this species a good indicator of wetlands ecosystem health at the landscape level.

Current Threats:



Spotted frogs are affected by many of the same stressors having an impact on boreal toads. However, spotted frogs appear to be adaptable to a wider variety of breeding habitats potentially reducing the amount of habitat fragmentation this species is experiencing. Major threats to spotted frogs are stocking of historically fishless lakes and ponds for recreational fishing; loss of wetland habitat through dam regulation of river flows, decline in beaver populations, and dewatering for irrigation; and possibly diseases which are compounded by stress from environmental pollutants. In addition, Columbia spotted frogs migrate between breeding sites and lakes and ponds to overwinter (Pilliod *et al.* 2002) so connectivity between these two habitat types is important.

Habitat Analysis:

Habitat for this species was not modeled due to insufficient data availability. Columbia spotted frogs use a variety of wetland lakes, ponds, ephemeral pools, seeps and backwater sloughs for breeding. National

Wetlands Inventory (NWI) data for the entire assessment area had not been released at the time of analysis and developing a wetlands layer from satellite imagery was beyond the resources available for this project. Therefore, a reasonably accurate assessment of potential breeding habitat was not possible. However, the apparent vulnerability of amphibians to environmental change as evidenced by their global declines makes the Columbia spotted frog a potentially important indicator of wetland health and integrity.

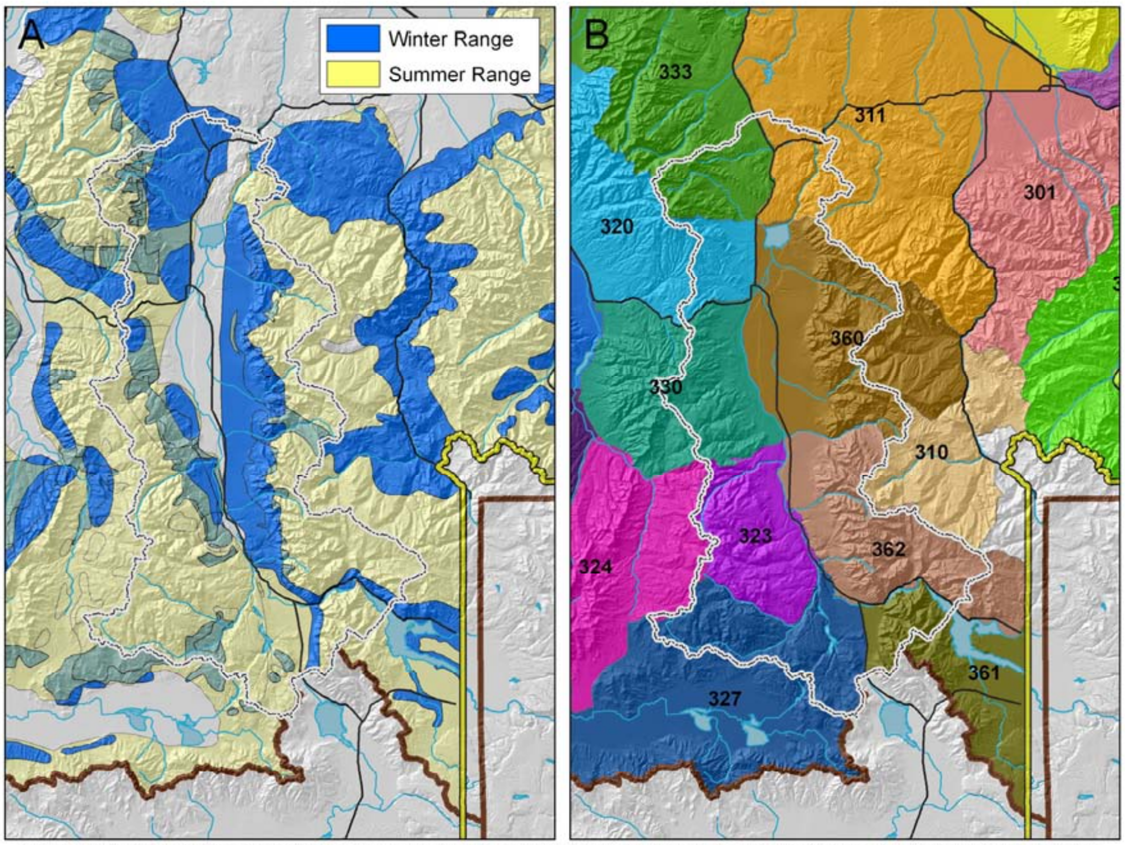
Conservation Strategies:

Columbia spotted frogs would likely benefit from the same conservation strategies suggested for the boreal toad. In addition, spotted frogs migrate to larger lakes (> 3m deep) in the fall to overwinter (Pilliod *et al.* 2002). These migrations often follow the straight-line shortest distance between summer habitat and lakes. Therefore, traditional riparian corridors that follow a more circuitous path between summer and winter habitat may be insufficient for spotted frogs to use as travel corridors. Whenever development or other land use practices are planned near deep lakes and ponds, the migration behaviors of spotted frogs should be accommodated by providing access between lakes and breeding habitat along the shortest distance path. This could be accomplished by establishing barrier-free, vegetated drainage corridors to allow unimpeded travel of frogs during their brief migration.

Elk/Wapiti (Cervus elaphus):

Current Status:

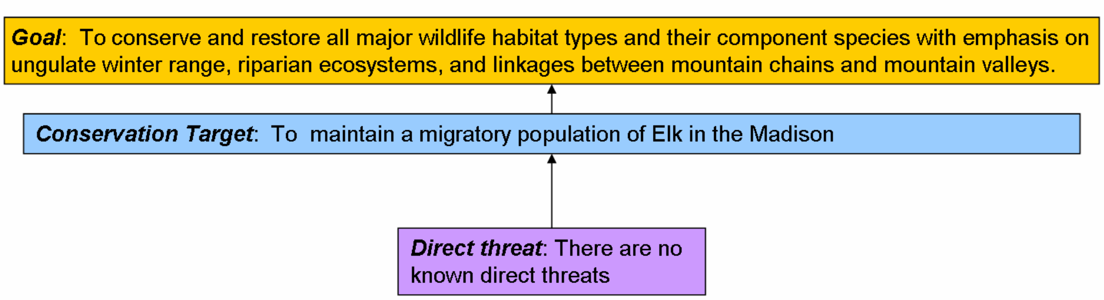
Elk are perhaps the most iconic species of the Madison Valley. Elk are managed as big game throughout the assessment area where they are abundant with an estimated winter population of over 8000 animals. Elk migrate seasonally between summer range in the high country to winter range in the valley bottoms and benchlands (Figure 22A). The abundance of elk in the valley provides an important economic and cultural resource for the region. In addition, elk are a significant source of prey for predators and scavengers such as wolves, grizzly bear, black bear, mountain lion and wolverine. However, elk also compete with domestic livestock for forage and can damage agricultural crops leading to significant controversy over what constitutes appropriate population levels and management.



Data were obtained from Montana Fish Wildlife & Parks and are available online from the Montana Natural Resource Information System (http://nris.state.mt.us/gis.html).

Figure 22. A) Winter and summer range of Elk and B) Elk hunting districts in the Madison Valley.

Current Threats:



There are no known direct threats to the long-term maintenance of migratory elk in the Madison Valley. Elk are an important cultural and economic resource for the valley and are carefully managed to maintain healthy herds for hunting and wildlife viewing. However, this security does not mean that elk do not pose conservation challenges. The abundance of elk in the valley creates a significant amount of wildlife-human conflicts, mostly related to property damage to crops and competition for forage with domestic livestock. Therefore, the challenge of managing elk in the valley appears to be more a matter of balancing various, and often conflicting, social values about what constitutes appropriate population levels than of managing elk based on biological constraints. However, human-wildlife conflicts often increase in areas where biological needs of a species are marginal. As mentioned before, elk migrate in large numbers to wintering grounds at lower elevations in the Madison Valley.

Habitat Analysis:

Elk need to be able to move freely between summer and winter range and, as importantly, among different areas within their winter range (Figures 22A and 24). As development increases in the valley, elk may have fewer opportunities for moving to new areas to find fresh forage. This could lead to increasingly sedentary wintering herds that intensively impact smaller areas rather than more evenly distributing their impacts across the entire range. In addition, herds of elk forced to winter within proximity to human developments are more likely to become habituated which could lead to increased complaints about elk damaging landscaping as well as increasing the risk to human safety. Connectivity along and between the eastern drainages between Jack and Wolf Creeks appear to be particularly important for the movement of elk and other big game (Figure 27).

Conservation Strategies:

Although the long-term future of abundant elk herds in the Madison Valley appears relatively secure, there are a number of conservation strategies that should be considered to preserve the wild character of the Madison Valley elk herds they meet the cultural and economic needs to the widest array of residence and visitors of the valley.

Most importantly, migrating elk herds need to be able to move freely into, and throughout, winter range in the valley. Winter range occurs mainly on private lands in the valley where substantial areas have been placed under conservation easement. Elk damage is likely to be less severe when herds are encouraged to move freely throughout available habitat rather than becoming sedentary in a few locations where their impacts are concentrated on a relatively small proportion of available range. Poorly planned or improper development within the valley could significantly alter movement patterns of elk. Elk are adaptable habitat generalists and it is commonly believed they can adapt to human development. However, this is only a superficial answer to a complex problem. Elk will avoid or become habituated to human landscapes and activities depending on available habitat choices and prior experience. Elk that are not accustomed to human activities are likely to avoid developed areas. If these developments lie within travel corridors between patches of potential habitat, then elk may be reluctant to move to new locations when forage resources become depleted. This could lead to overgrazing and increased wildlife damage in areas where elk feel most secure. Conversely, elk that spend an increasing amount of time near human developments may become habituated to human activities and become sedentary residents within human developments where they are attracted to nutritious forage within managed landscape plantings. Such habituation increases the likelihood of wildlife complaints when elk damage ornamental plantings, creates concerns for human safety, and may increase the propensity for disease transmission within elk and between elk and livestock. Habituated elk also lose the wild character of the species that many people prefer. The problem of habituated elk in residential developments is compounded by the fact that using hunting as a management tool within such areas is difficult, if not impossible. To allow free movement of elk throughout winter range in the valley wide corridors should be maintained between conservation easements on the east side of the valley and around the Wall Creek Wildlife Management area on the west to provide secure passage of elk herds without the risk of avoidance or habituation to human presence.

Hunting access to elk herds needs to be maintained and improved to allow the effective use of this management tool. Hunting is not only useful for managing elk populations, but it can also be effective in redistributing elk in areas where resource or property damage is likely to occur. In addition, elk hunting is an economically important activity in the region and generates broad support for the maintenance of abundant elk populations. Continued residential development within the valley can potentially reduce the effectiveness of hunting as a management tool. Hunting within residential dwellings poses a serious safety issue and differing attitudes about hunting among residents places increasing acreage of elk habitat off limits to hunters. Approval of new developments should consider the potential impacts on the use of hunting as a management tool.

Large predators could be a useful tool in managing elk. The management of large predators such as wolves and bears is a controversial issue due to their potential negative impacts on domestic livestock, pets, and in rare cases, human safety. However, in some cases large predators can regulate prey populations, redistribute game animals across the landscape, and reduce intense spot grazing and resource damage. Such redistribution may be responsible for the recovering riparian communities of the Northern Range of YNP. In addition, large predators can potentially influence game populations within areas of human development where hunting with firearms would not be possible. In an area like the Madison Valley where a perceived overabundance of elk is a major wildlife issue, the potential beneficial effects of large predators on elk populations and distribution should be considered. Continued efforts to improve and develop non-lethal management tools to eliminate problems associated with large predators should be considered among other tools for managing elk within the valley. Currently, the Madison Wildlife Committee is developing programs, scenarios, and tools to address the management of elk within the context of ecological communities, landscapes, and rural economies and cultures.

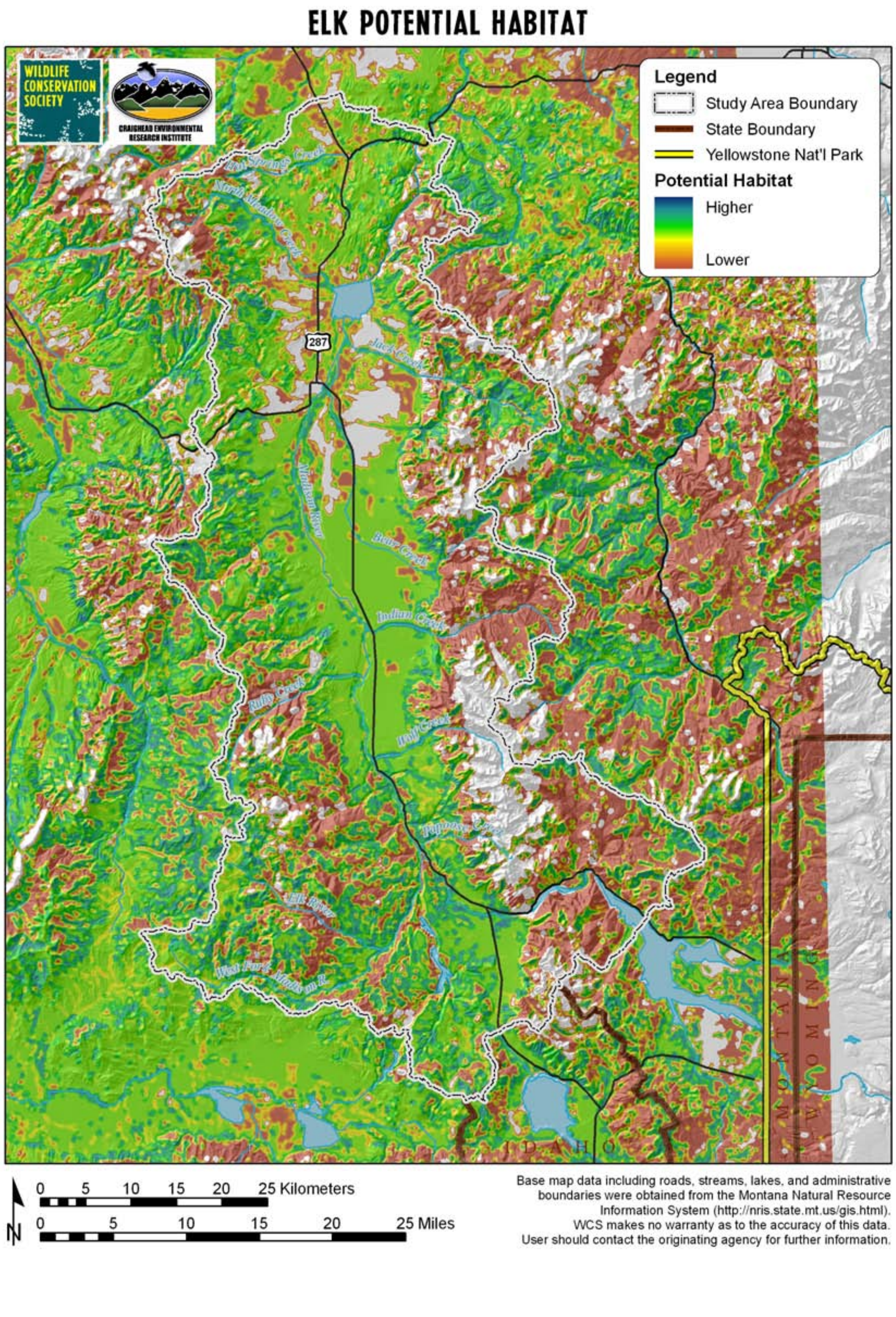


Figure 23. Elk potential habitat in the Madison Valley.

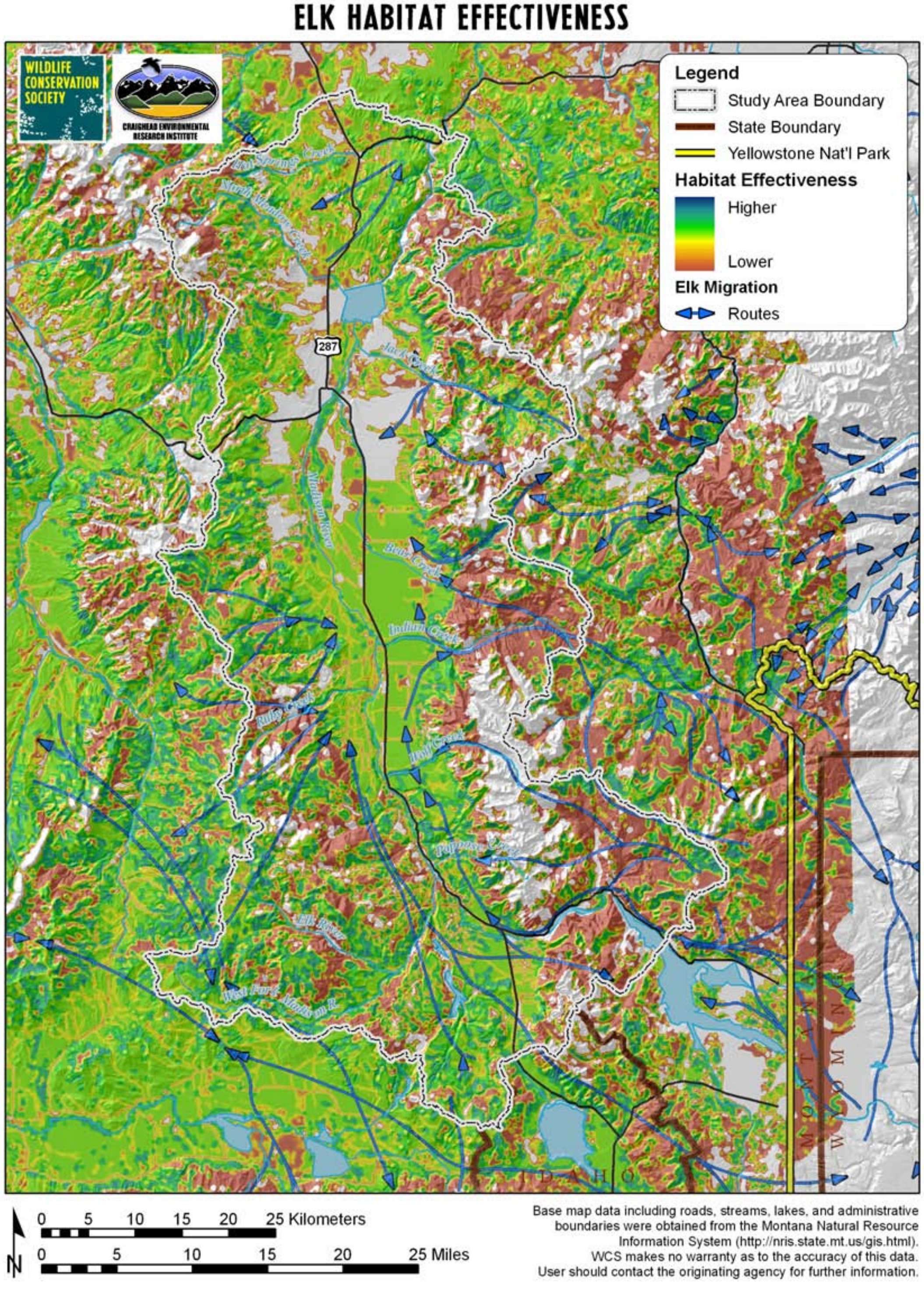


Figure 24. Elk habitat effectiveness in the Madison Valley.

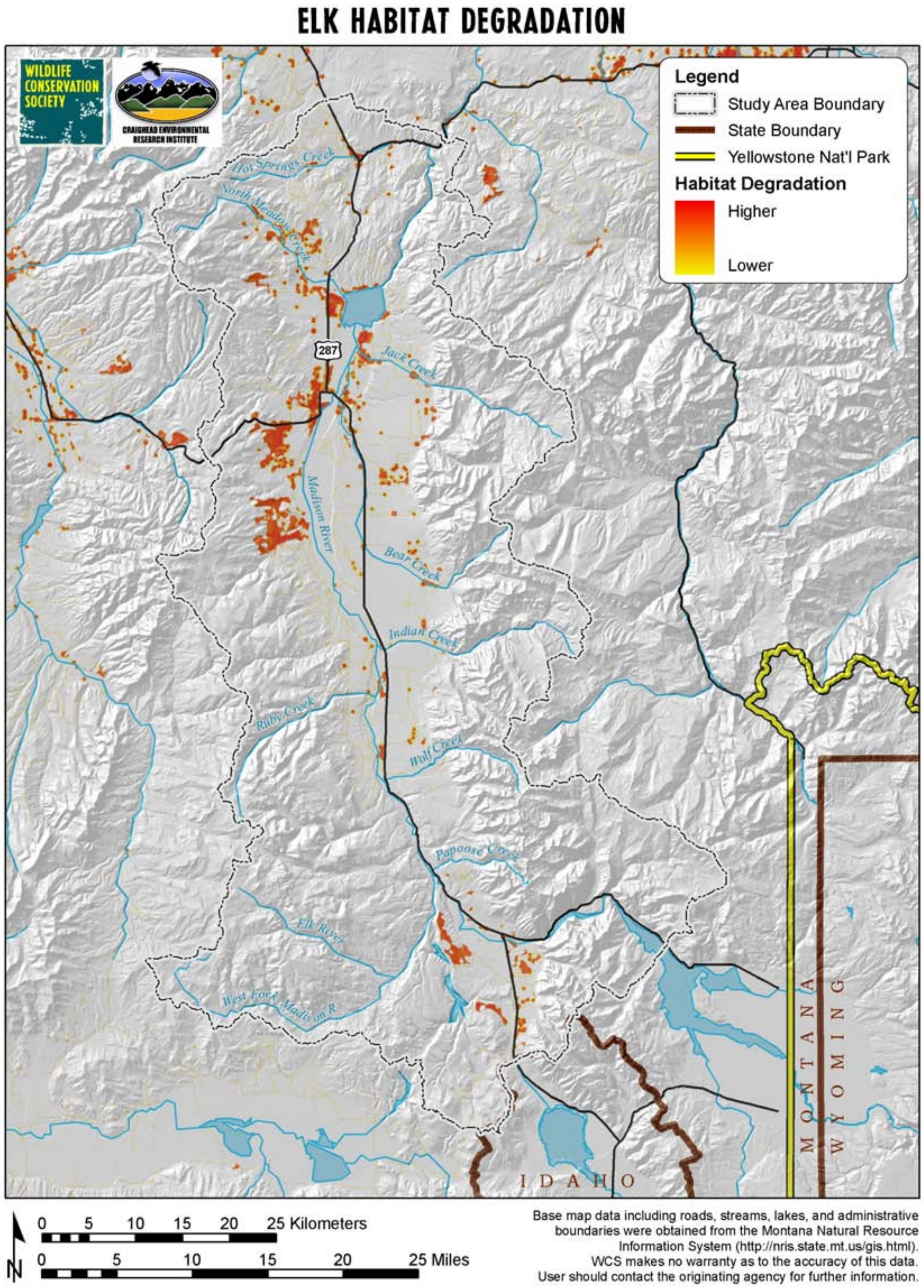


Figure 25. Elk habitat degradation in the Madison Valley.

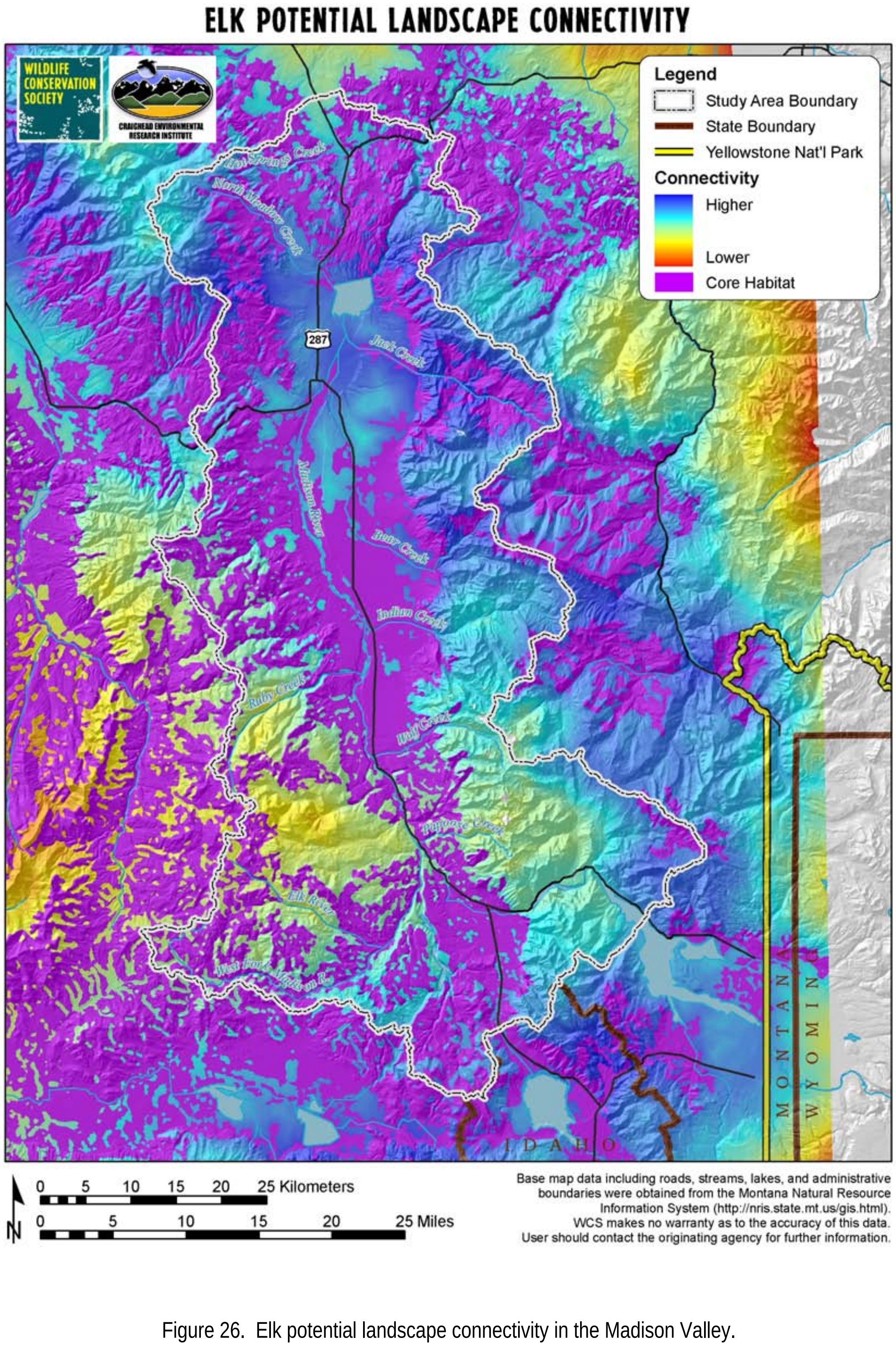


Figure 26. Elk potential landscape connectivity in the Madison Valley.

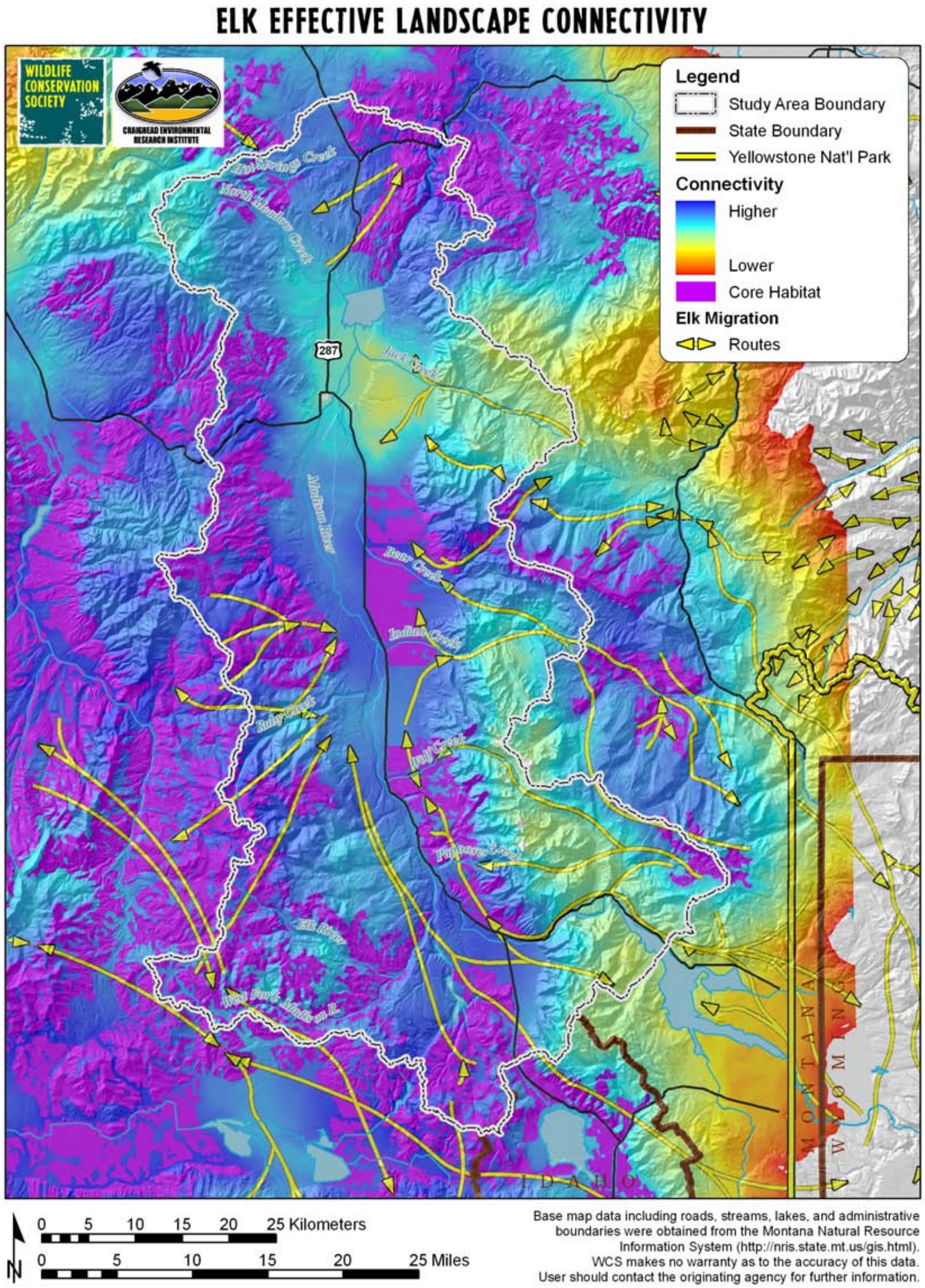


Figure 27. Elk effective landscape connectivity in the Madison Valley.

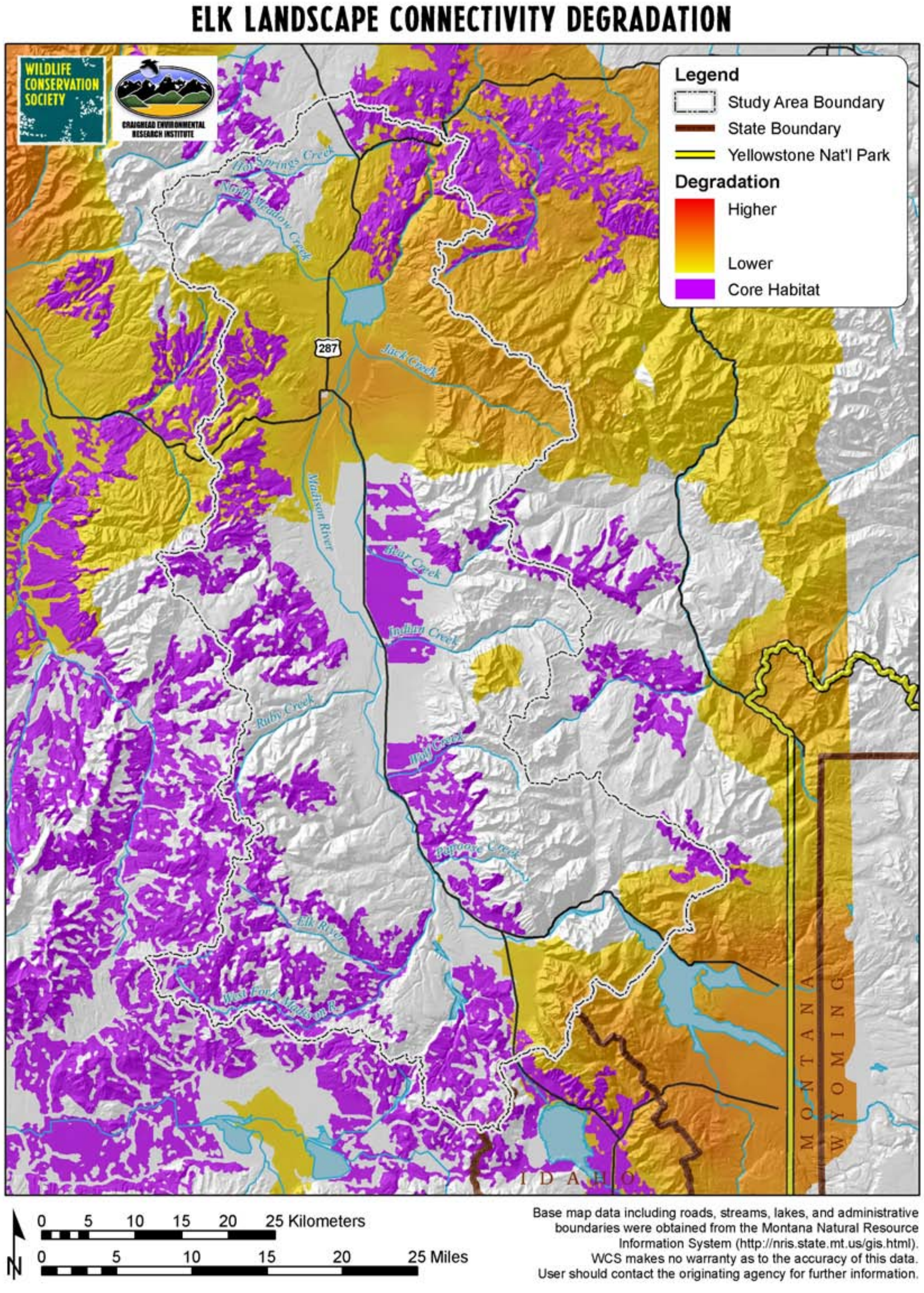


Figure 28. Elk landscape connectivity degradation in the Madison Valley.

Greater Sage-Grouse (Centrocercus urophasianus):

Current Status:

The historic distribution of Greater Sage-Grouse in the Madison Valley is unknown. Some experts believe that sage-grouse were never present in large numbers in the valley but others disagree. Given the regional historic distribution (Figure 29) of sage-grouse and the likely changes in landcover of the past 150 years, it seems likely that sage-grouse were part of the natural fauna of the valley but it is impossible to speculate at what density they occurred. Currently sage-grouse occur within the assessment area at low numbers. There presently appears to be a lek in the Missouri Flats area near Raynold's Pass with another apparent lek somewhere in the vicinity of the Virginia City Hill. Sage-grouse have suffered steep declines across their range, which has prompted petitions for their listing under the Endangered Species Act. To date, no listing has been granted but a substantial amount of effort is going toward managing this species and avoiding listing (US Fish & Wildlife Service, Federal Register 2005). Sage-grouse are currently managed as an upland game bird throughout the assessment area. Montana Fish, Wildlife & Parks has recently completed a statewide management plan for sage-grouse (Montana Greater Sage-Grouse Work Group 2004). This document should be consulted for background information, threats, and conservation actions important for managing sage-grouse and sage-grouse habitat.

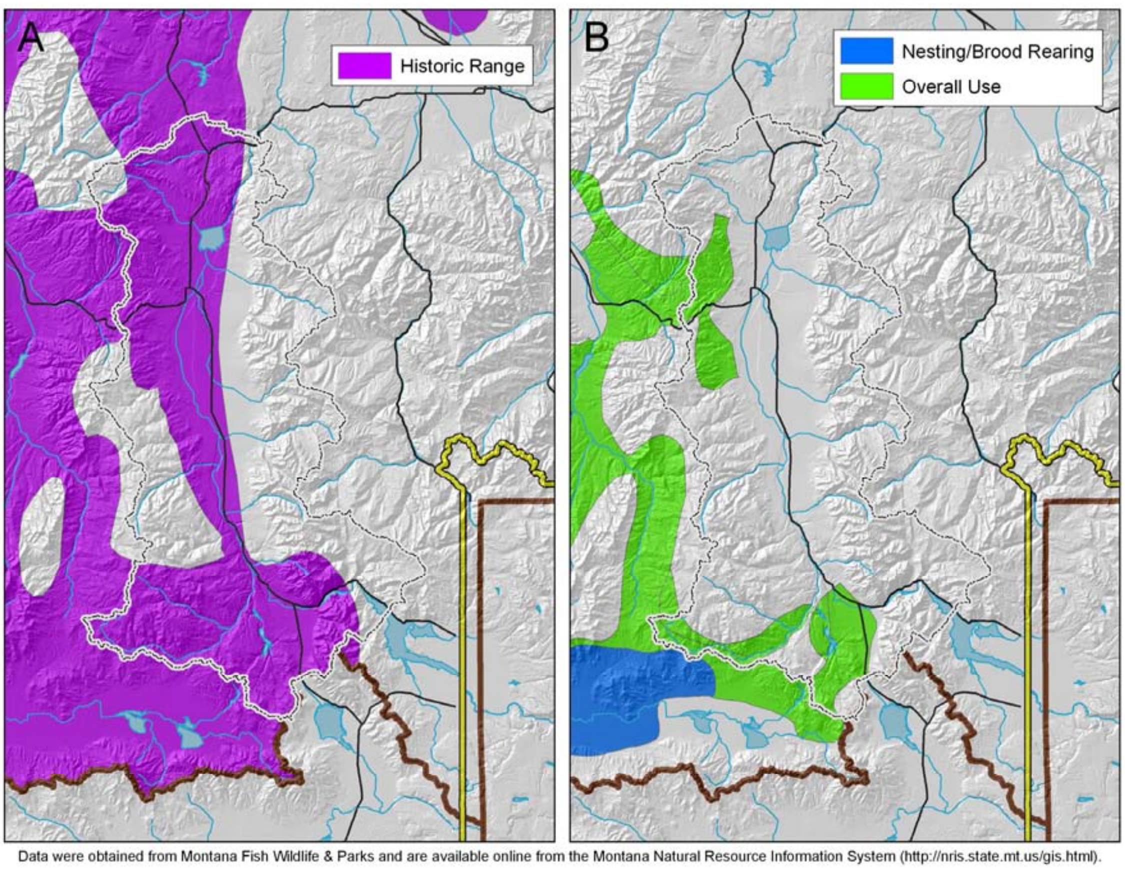
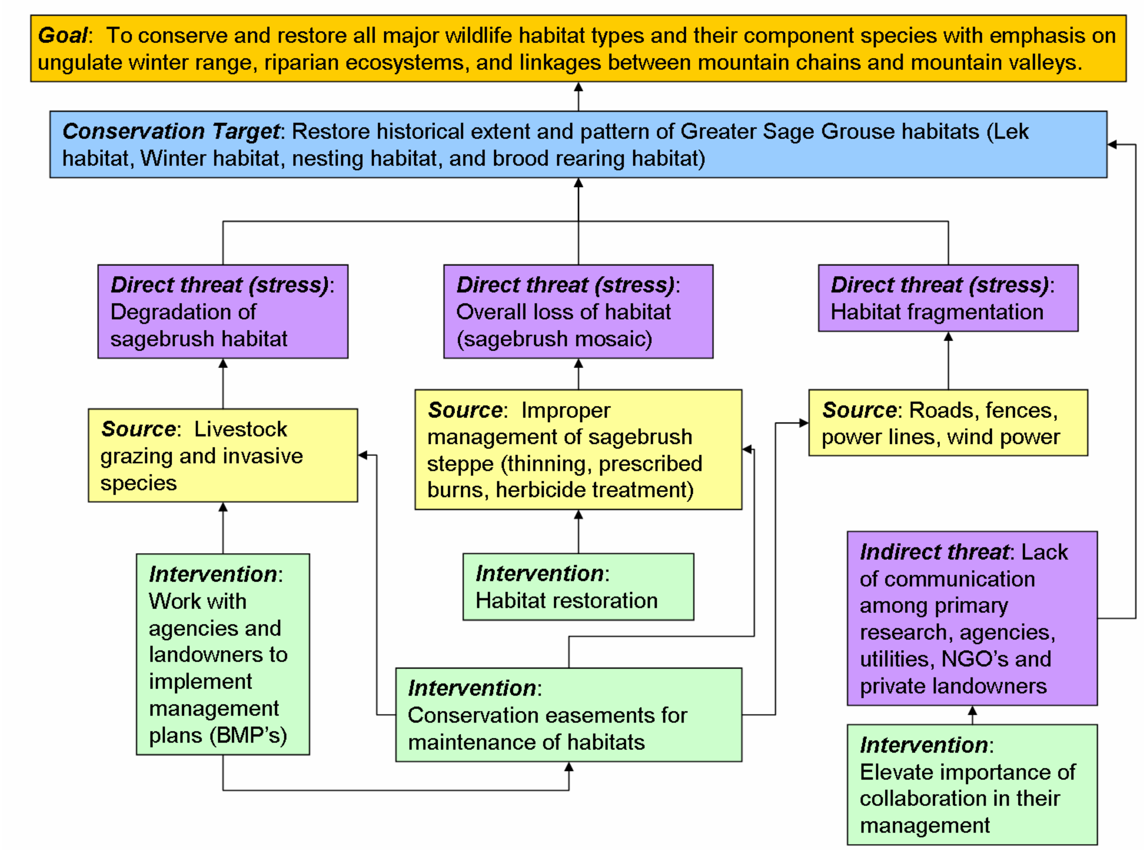


Figure 29. A) Historical range and B) extant seasonal ranges of Greater Sage-Grouse in the Madison Valley.

Current Threats:



Habitat loss appears to be the greatest threat to recovering sage-grouse populations in the Madison Valley. Sage-grouse depend on sagebrush and sage-steppe habitats through the majority of the year. Although it appears that extensive stands of sagebrush were not historically abundant throughout the Madison Valley, and most stands were on the northern, western, and southern reaches of the drainage, the remaining sagebrush habitats have been reduced by a variety of factors. Regionally the conversion of sagebrush and sage-steppe habitat to agricultural crops and tame grass pastures destroyed a significant amount of sage-grouse habitat. Additionally, sagebrush control by burning, spraying, and chaining to improve range conditions for livestock has had a significant impact on sage-grouse habitat and continues to the present. Prescribed burning to control conifer encroachment may have negative impacts on sagebrush habitat yet fire is a natural part of the sagebrush and sage-steppe ecosystems and plays an important role in clearing areas of trees so that sagebrush can establish and survive. Depending upon seed sources, precipitation, soils, and even the subspecies of sagebrush, stands can take a long time to recover following a burn (Lesica *et al*. 2005). *Artemisia tridentata vaseyana* (mountain big sagebrush) stands appeared fully recovered in 32 years, whereas, stands of Wyoming big sagebrush (*A. t. wyomingensis*) may take over 200 years to recover. The authors' sample size for the tall and now rare stands of basin big sagebrush (*A. t. tridentata*) were insufficient to model recovery from fire. Basin big sagebrush is associated with deeper soils of valley bottoms where across the West they were among the first vegetative communities to be converted to agriculture. Furthermore, stands of basin big sagebrush may be extremely important for the winter sustenance of Greater Sage-Grouse.

Historically, fire likely played an important role in maintaining vast landscapes as a patchwork mosaic of sage and sage-steppe habitat in a variety of successional stage providing sage-grouse with an abundance of habitat at any given time. However, sage-grouse habitat may be so reduced and fragmented that fire, either natural or prescribed, reduces available habitat below critical thresholds needed by sage-grouse.

Most recently, increased residential development in the Madison Valley is displacing existing, or potential, sage-grouse habitat, especially in areas such as Raynold's Pass. Compounding the problems with conserving sagebrush habitat is a lack of information about important requirements for sage-grouse management. Sage-grouse can utilize large areas of the landscape as they move among different habitat types to satisfy seasonal needs. Little is known about the importance of patch size, configuration, and pattern needed by sage-grouse at various stages in their life history.

Habitat Analysis:

Sage-grouse use a number of seasonal habitats. Nesting typically occurs near leking grounds in sagebrush habitat that offers sufficient cover to conceal nests from predators. After hatching, hens move their chicks to nearby brood rearing habitat that is typically productive, usually mesic, areas supporting a diversity of forbs that produce abundance of arthropods for chicks to feed upon. In the fall, sage-grouse migrate (often long distances) to winter habitat where mature sagebrush protrudes above snow accumulations providing shelter and food for the grouse.

Potential habitat was mapped for nesting, brood rearing, and winter habitat (Figures 30, 31 & 32). Sagebrush is under represented in satellite-based landcover classifications because it is easily confused with grassland or other shrub communities. To address this problem MT SILC2 data were developed to provide improved classification of sagebrush habitat in southwestern Montana. Unfortunately, this improved classification does not include the entire assessment area and was therefore inappropriate for use in landscape level analysis. Therefore, potential nesting habitat may be under represented (Figure 30). Conversely, winter habitat was determined in part by identifying areas classified as sagebrush that had vegetation protruding above the snow during maximum snowpack in a near average snowpack year (April 10, 2003). The resulting map (Figure 32) probably overestimates the amount of winter habitat used because winter habitat may be determined by habitat availability during severe snow years rather than average years, or sage-grouse may concentrate within the best portions of available habitat patches. Because of these limitations, these maps should be used as a rough estimate of where good habitat for sage-grouse is likely to occur rather than a fine scale model of habitat locations. However, the maps appear to be generally accurate in predicting the best remaining habitats in the area.

The models indicate that the best remaining nesting habitats are located near the Missouri Flats and Antelope Basin areas as well as in the area around the Virginia City Hill (Figure 30). These results are significant because these are the areas with the last evidence of possible leks. Brood habitat does not appear to be limiting sage-grouse in the Madison Valley (Figure 31). This is not surprising given that sage-grouse can utilize a variety of forb rich areas, including alfalfa fields, for rearing chicks. Winter habitat appears to be the limiting resource for sage-grouse in the Madison Valley (Figure 32). Good winter habitat provides an abundance of mature sagebrush, particularly basin big sagebrush (*Artemisia tridentata tridentata*) that is tall enough to protrude above the snow in winter. Most of the mature sagebrush habitat occurs in relatively high elevation benchlands where accumulation of winter snow can cover even large sagebrush shrubs and provide generally harsh conditions for overwintering grouse. Little mature sagebrush remains in the valley bottom and appears insufficient to support wintering grouse populations. However, sage-grouse are capable of migrating large distances to find winter range and it is possible that sage-grouse in the Madison Valley historically sought winter cover outside the assessment area. For this reason, sage-grouse habitat models were extended beyond the assessment area to include areas within the documented migration range of the species. These extended models indicate areas of winter habitat in the Red Rock Lakes NWR and Big Hole Basin where sage-grouse are known to overwinter. Whether grouse in the Madison Valley historically wintered in those areas is unknown.

Habitat effectiveness and habitat degradation were not mapped because of limitations of the modeling methods and available data. The methods used to predict potential habitat distributions do not predict the historic extent of habitat prior to European-American settlement. Rather, they predict habitat potential according to current conditions excluding current human influence. Data were not available of historic vegetation distribution in the assessment area so there is no way to quantify habitat lost. However, given past and present agriculture and range management practices, it is likely that sagebrush habitats have been reduced from their historic distribution within the assessment area. Perhaps more significant is that large areas of historically sagebrush habitat have been converted to irrigated row crops in the Snake River Plain which may have once provided critical habitat for grouse nesting in the Madison Valley, particularly those in the Missouri Flats area.

Conservation Strategies:

Greater Sage-Grouse have been the subject of enormous conservation activity and debate. Because of their steep declines, efforts should be made to retain and restore potential sage-grouse habitat wherever it occurs. Regardless of the historical abundance of sage-grouse in the Madison Valley, it is apparent that sage-grouse were once resident in the valley but essentially have disappeared. In consultation with the statewide management plan (Montana Greater Sage-Grouse Work Group 2004) a number of strategies could be employed to aid sage-grouse restoration in the Madison Valley assessment area:

- Stop loss of sagebrush habitat. Sagebrush has long been considered an undesirable shrub in rangelands and has been the subject of aggressive eradication efforts on both private and public lands. Sagebrush control efforts should first consider the areas potential value as sage-grouse habitat. The absence of sage-grouse in an area should not be an excuse to justify sagebrush control. Rather, the test should be whether an area could provide sage-grouse habitat if the species were present. Sagebrush management efforts should strive to maintain or provide potential breeding habitats supporting 15-25% canopy cover of sagebrush, perennial herbaceous cover averaging ≥ 18 cm in height with ≥ 15% canopy cover for grasses and ≥ 10% for forbs and a diversity of forbs (Barnett and Crawford 1994, Drut et al. 1994, Apa 1998) during spring (Connelly *et al.* 2000). Private landowners should be educated of the wildlife value that sagebrush habitat provides and federal agencies should place more emphasis on the value of maintaining sagebrush habitat before recommending control measures to landowners.
- Improve inventory of sagebrush habitat. Current landcover maps do a poor job of classifying sagebrush habitat. Better maps, including information about shrub height and canopy cover, would allow land managers to determine the potential for sage-grouse restoration in an area and provide valuable information about how best to restore habitat.
- Improve knowledge about Greater Sage-Grouse habitat needs. Much remains unknown about how sage-grouse respond to changes in landscape pattern. Basic questions regarding minimum patch size needs, and the effect of fragmentation and habitat patch dispersion remain unanswered. Likewise, more needs to be learned about movement patterns and site fidelity. It appears that sage-grouse are not good at pioneering new habitat but the degree to which transplantations would be required to get sage-grouse to occupy restored habitat is unclear. Basic questions remain such as to the location of active leks and their occupancy. All of these questions need to be answered before sage-grouse can be effectively managed in the assessment area. For example, once active leks are located and described, active habitat management schemes can be implemented that directly benefit the sage-grouse associated with each lek and the correlated natural history needs (i.e., managing sagebrush stands to provide adequate forb diversity and density for brood rearing, suitable sagebrush/grassland mosaics, and nesting cover) following accepted sage-grouse management guidelines (Connelly *et al*. 2000, Montana Greater Sage-Grouse Work Group 2004)
- Manage sage-grouse on a landscape level. It is not sufficient to address sage-grouse management from within the Madison Valley because birds living in the valley almost certainly spend part of their lives outside the area. A broader view should be taken to first determine why grouse have declined in the valley and where the causes of those declines are located. If the sources of the decline are corrected (e.g. winter and breeding habitat restoration in the Snake River Plain) will current management practices in the Madison Valley allow for species recovery? If not, corrective measures should be taken regardless of whether the species is currently present in the area.

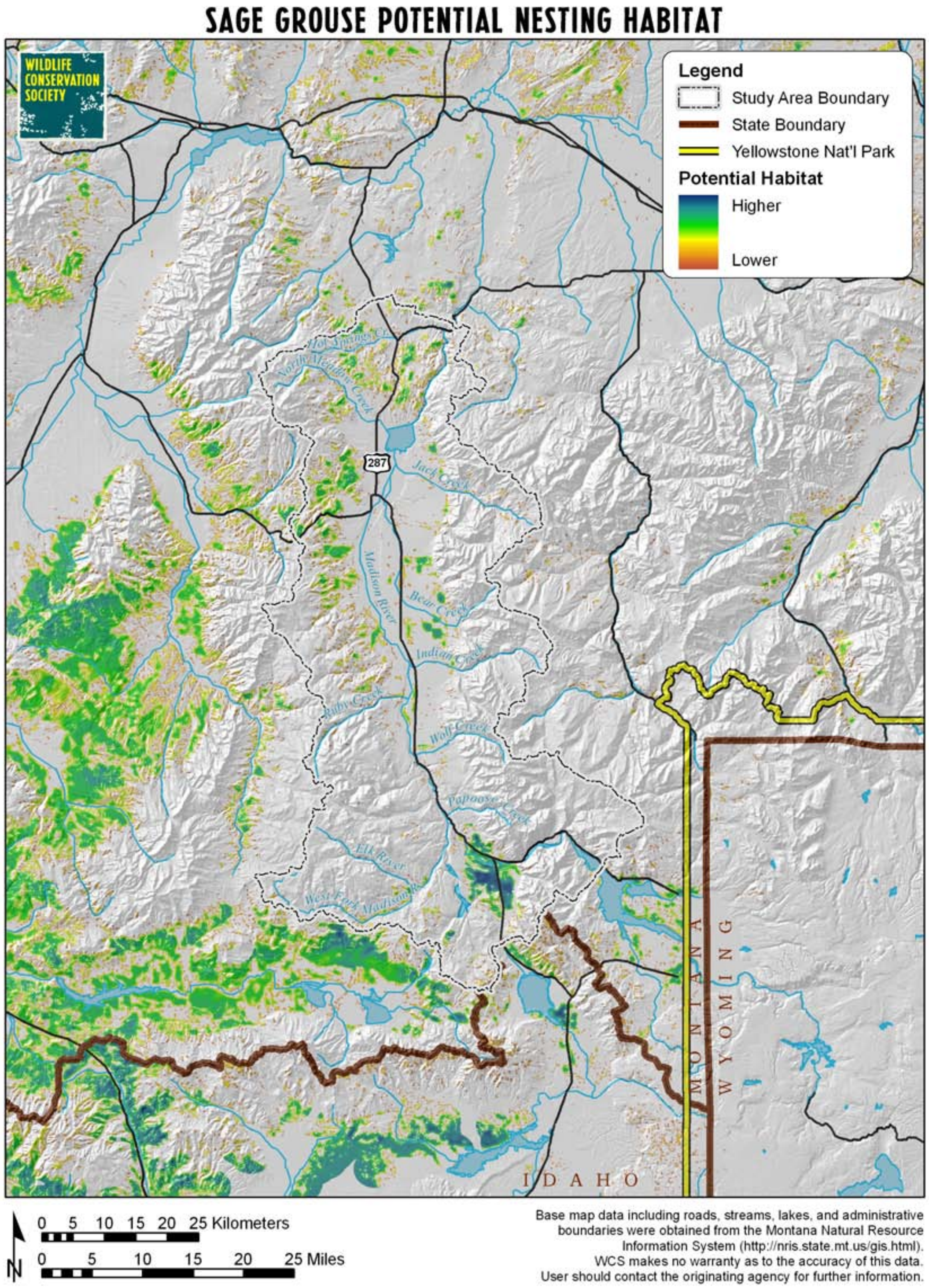


Figure 30. Greater Sage-Grouse potential nesting habitat in the Madison Valley.

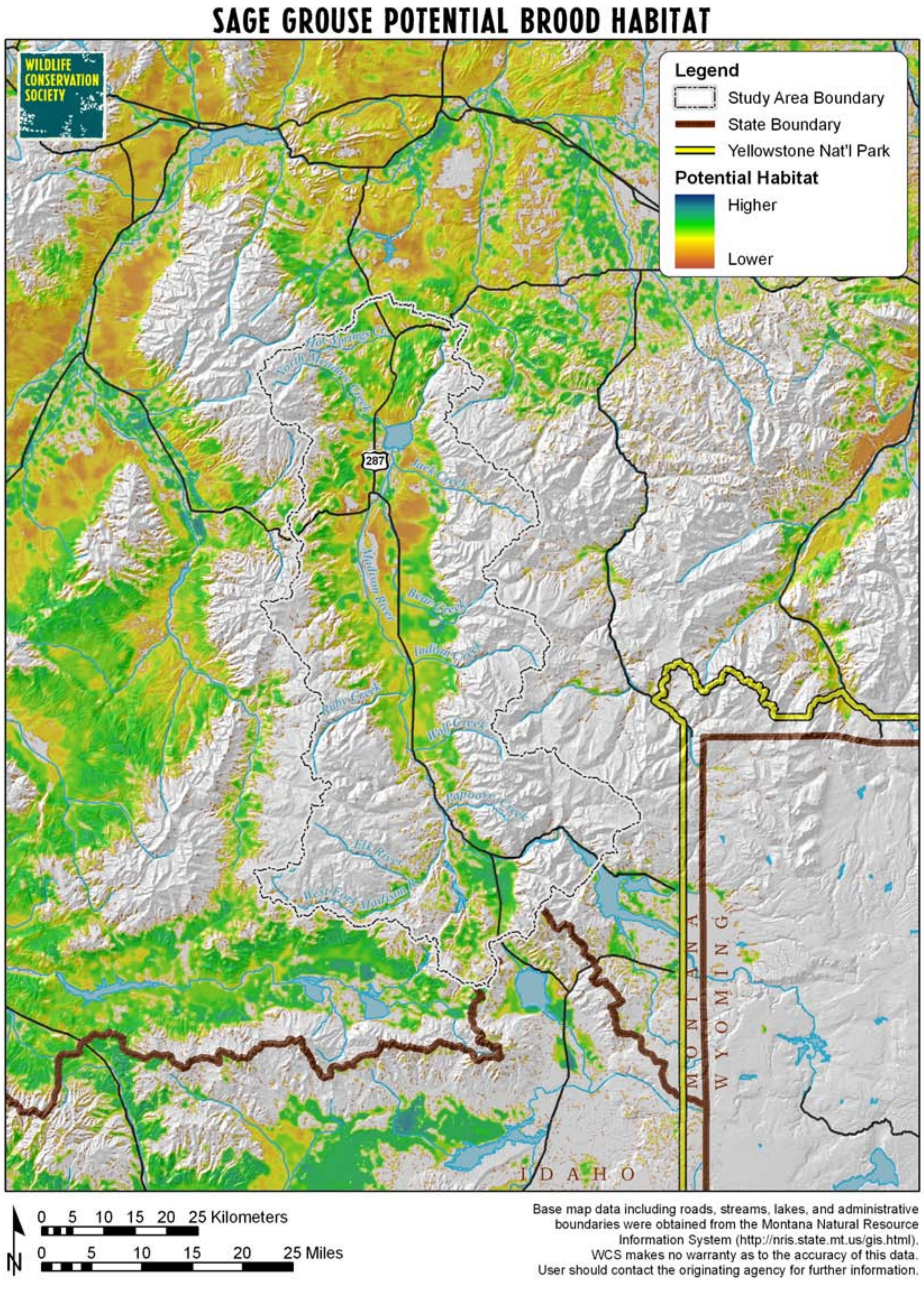


Figure 31. Greater Sage-Grouse potential brood habitat in the Madison Valley.

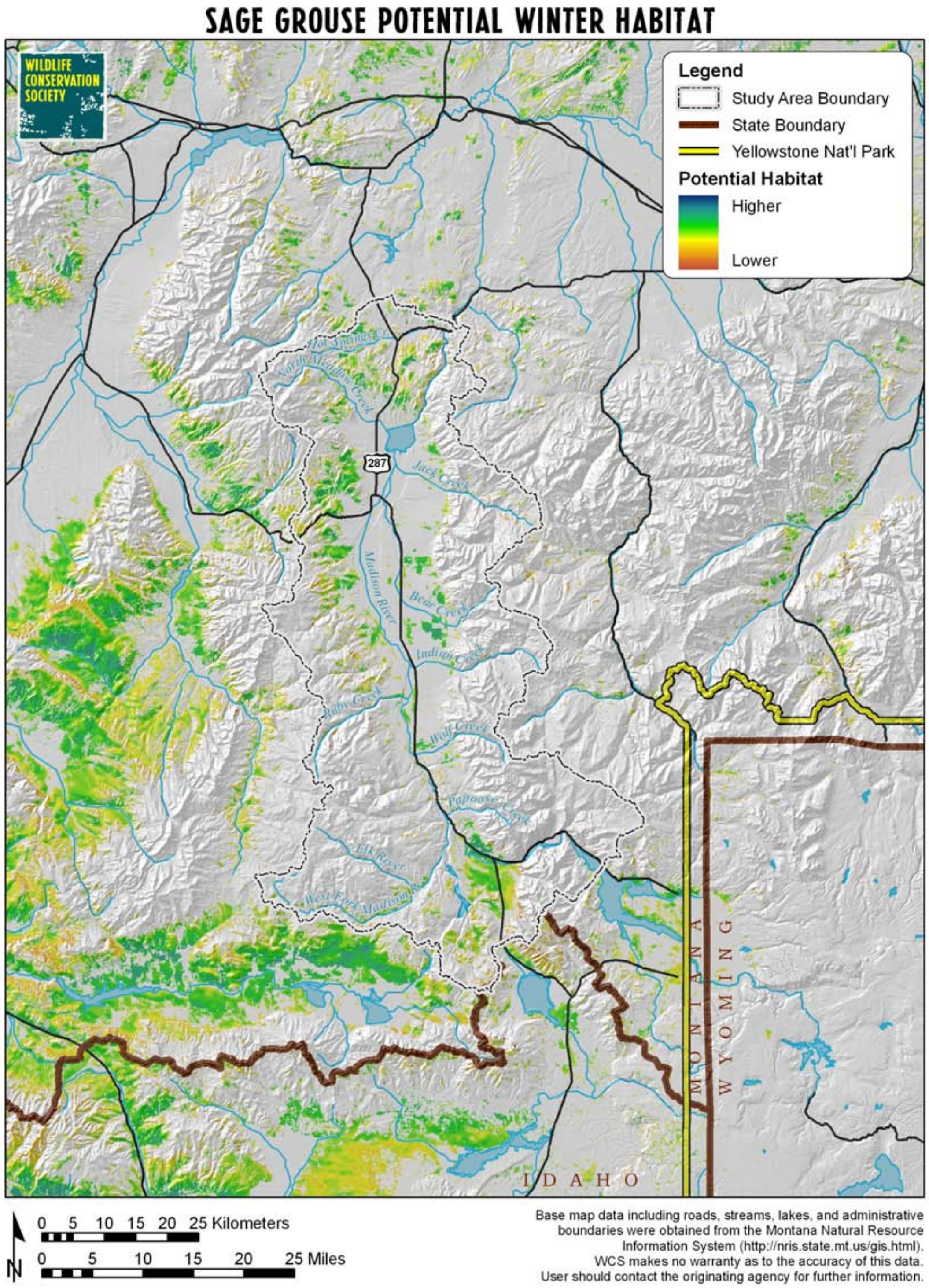


Figure 32. Greater Sage-Grouse potential winter habitat in the Madison Valley.

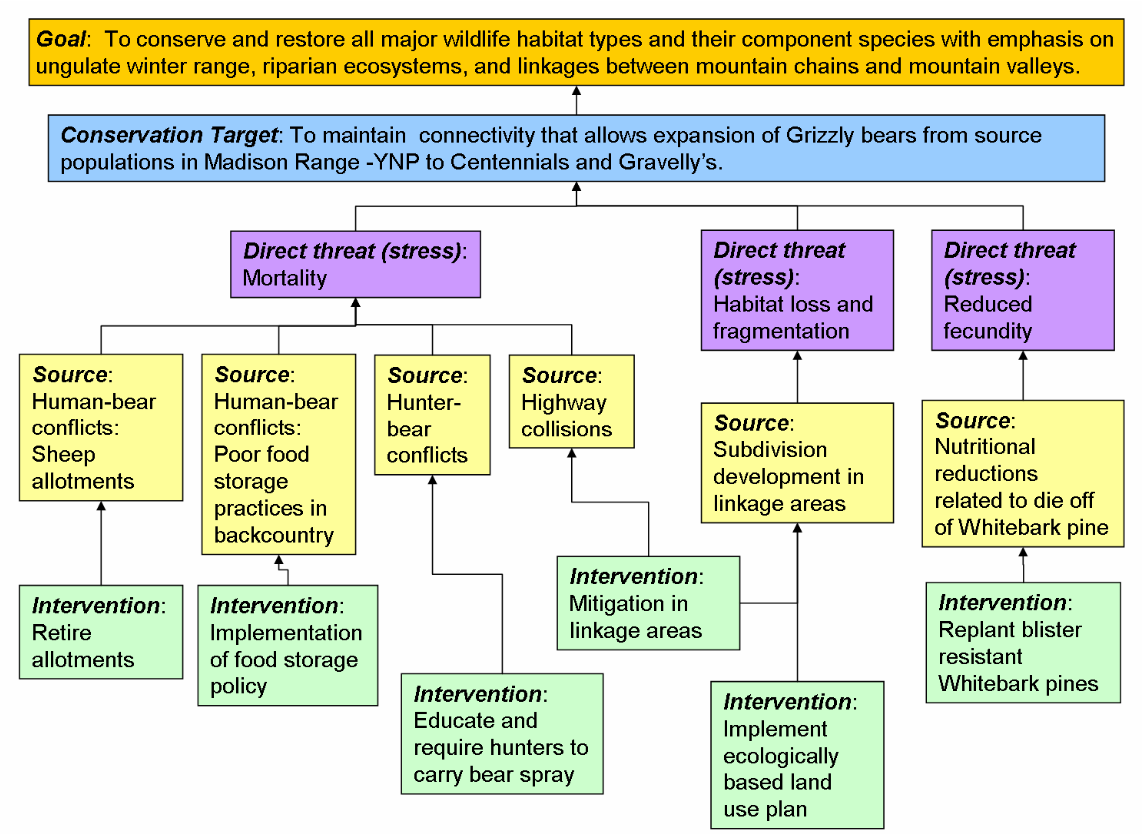
Grizzly Bear (Ursus arctos)

Current Status:

Historically grizzly bears occurred throughout the Madison Valley and perhaps reached highest densities in the productive riparian and adjacent habitats of the valley floor. Over the past 150 years, grizzly bears have declined drastically throughout their historic range which once extended from Alaska to Mexico and from the Pacific coast to near the Mississippi River. By the 1960's, the Yellowstone region was one of the last places in the conterminous 48 states where grizzlies lived. The species was listed in 1967 and is currently designated as a threatened species under the Endangered Species Act (ESA). By the 1970's, the grizzly bear population had declined to an estimated 200 bears in the Greater Yellowstone Ecosystem or Area (GYE). With protection under the ESA, the grizzly population has recovered to a currently estimated 600 bears in the GYE. Within the Madison assessment area, grizzlies occupy nearly all available habitat in the highlands of the eastern rim of the valley which include portions of the designated grizzly bear recovery zone. As grizzly populations have recovered, bears have slowly expanded across the Madison Valley into the Gravelly and Snowcrest Mountains where a small number of grizzlies have recently been documented.

As a federally listed species, grizzly bear management is currently under the authority of the US Fish and Wildlife Service and the Interagency Grizzly Bear Management Team. However, the Yellowstone grizzly bear population is undergoing the delisting process initiated by the federal government (USFWS 2005). If delisting is completed, management authority for grizzlies in the Madison Valley will return to the state of Montana. In addition to the aforementioned Federal Register publication, refer to the Final Conservation Strategy for the Grizzly Bear in the Yellowstone Ecosystem (Interagency Conservation Strategy Team 2003) and the Grizzly Bear Management Plan for Southwestern Montana 2002-2012 (MFWP 2002) for further information.

Current Threats:



Human-caused mortality remains the biggest threat to full grizzly recovery within the GYE. Grizzly bear mortality occurs from a number of causes. Grizzlies occasionally prey on domestic livestock, particularly sheep, which often leads to destruction of bears to protect property. There are currently large sheep grazing allotments in the Gravelly Mountains. As grizzlies continue to re-occupy their former range within the Gravelly Mountains, sheep-bear conflicts are likely to increase with a negative result for the bears. Other conflicts with bears in the backcountry are often the result of poor food storage practices or encounters between hunters and bears when bears are attracted to carcasses and gut piles. Highway collisions are also a major cause of grizzly bear mortality and may have added consequences when narrow habitat linkage zones cross busy highways. Additionally, most low elevation areas in the region are private lands which are experiencing increasing development for residential housing. As bear populations have recovered, bears have expanded into, and across, private lands seeking unoccupied territory. Improper food storage practices in bear country leads to conflicts when bears raid garbage, birdfeeders, barbecues, or pet and livestock feed. Finally, grizzlies occupy large territories that intersect roads. Such conflicts are particularly important within narrow strips of habitat connectivity that are critical for the continued expansion of grizzly bears into their former range. One of the most important linkage zones occurs in the Madison Valley between Wolf Creek and Raynold's Pass.

Grizzly bears also face shortages of an important food source. Whitebark pine is a major fall food source for bears building stores of fat in preparation for winter hibernation. An introduced fungal disease, pine blister rust, has killed a significant amount of whitebark pine stands in the GYE. The full impact of the loss of whitebark pine on grizzly bears is uncertain but it seems likely that the loss of such an important food source could reduce the carrying capacity for grizzly bears in the region. Additionally, pine blister rust serves as a reminder of the vulnerability of wildlife species to introduced disease.

Habitat Analysis:

Grizzly bears are habitat generalists that can adapt to a wide variety of habitat types. However, human encroachment at low elevations has reduced grizzly bear habitat mostly to mountain forests and meadows. Grizzly bears utilize low elevation habitats when there is sufficient space and security where they can avoid human conflicts. High quality grizzly bear habitat remains throughout the mountainous areas surrounding the Madison Valley (Figure 34). Since most of the high quality habitat is on public lands, the majority of potential habitat remains suitable for grizzly bear use (Figure 33) and degradation is primarily located where major roads and residential subdivisions intersect potential habitat at low elevations (Figure 35).

The Madison Valley is critically important for the long-term recovery of grizzly bear populations. The valley is located at the edge of the grizzly bear recovery zone and contains one of the last, and best, potential habitat linkage zones connecting the GYE with vast areas of unoccupied habitat to the west (Figure 36). The area between Wolf Creek and Raynold's Pass provides one of the most outstanding linkage zones for grizzly bears in the GYE (Figure 37). Although much of this area is under conservation easement, a significant portion of the area has been subdivided for residential development making the homeowners in that area critical partners in the long term management of grizzly bears on a continental scale. Due to roads and development in that area, this linkage zone has already suffered some loss of connectivity value (Figure 38) but the area retains sufficiently high value to place it among the highest priority areas for conservation in the valley. In addition to the southern linkage zone, connectivity models indicate a potential second linkage zone for grizzly bears and other wildlife between Norris and the Tobacco Root Mountains (Figure 37). To date, this area has not received the level of conservation attention as has been placed on the southern linkage zone but its potential should not be overlooked.

Conservation Strategies:

It is difficult to overestimate the potential role of the Madison Valley in securing the long-term future of grizzly bears in the Northern Rockies. Vast areas of unoccupied habitat lie to the west of the Madison Valley with a narrow strip of high quality habitat through the valley providing the best potential linkage between these unoccupied areas and the GYE. Maintaining this relatively small strip of habitat as a high quality corridor will allow grizzly bears to continue to expand into formerly occupied range to the west. In addition, this linkage zone will provide a conduit for genetic exchange between the GYE and surrounding grizzly populations. This corridor extends south from Wolf Creek to Raynold's pass with highest connectivity value where Papoose Creek crosses US Hwy 287. Most of the unsubdivided land in this area has already been placed under conservation easement but the subdivided properties are currently at less than 20% buildout. Efforts should be made to work with landowners in the area to maintain the area as the highest quality, and most effective wildlife habitat linkage corridor possible. In addition, a second potential corridor from Norris to Meadow Creek and the Tobacco Root Mountains should be considered a priority for conservation action and wildlife value.

In order to ensure long-term success of grizzly bear recovery in the area, efforts should continue to minimize human-bear conflicts and the subsequent removal of grizzly bears. Both the Beaverhead-Deerlodge and Gallatin National Forests have implemented mandatory bear safe food storage regulations for backcountry users. Obviously enforcement and user education are essential tools to ensure these regulations are effective in reducing conflicts. Additionally, sheep allotments in the Gravelly Mountains where grizzly bears are already beginning to recover should be retired or relocated to avoid conflicts. As previously mentioned in this report, those areas also occur in potential bighorn sheep range so the removal of these allotments would have multiple wildlife benefits. Finally, many grizzly bear mortalities occur when hunters who are confronted by bears choose to defend themselves with firearms. While self-defense with a firearm is a legal bear killing, studies indicate that bear spray is more effective at stopping a charging bear than a bullet. Hunters entering bear country should be required to carry bear spray and be trained in its efficacy and use. Finally, existing state and local laws prohibiting the feeding of wildlife and improper food and garbage storage should be strictly enforced, particularly within areas designated as high quality linkage habitat where the loss of a single bear significantly diminishes grizzly bear recovery progress.

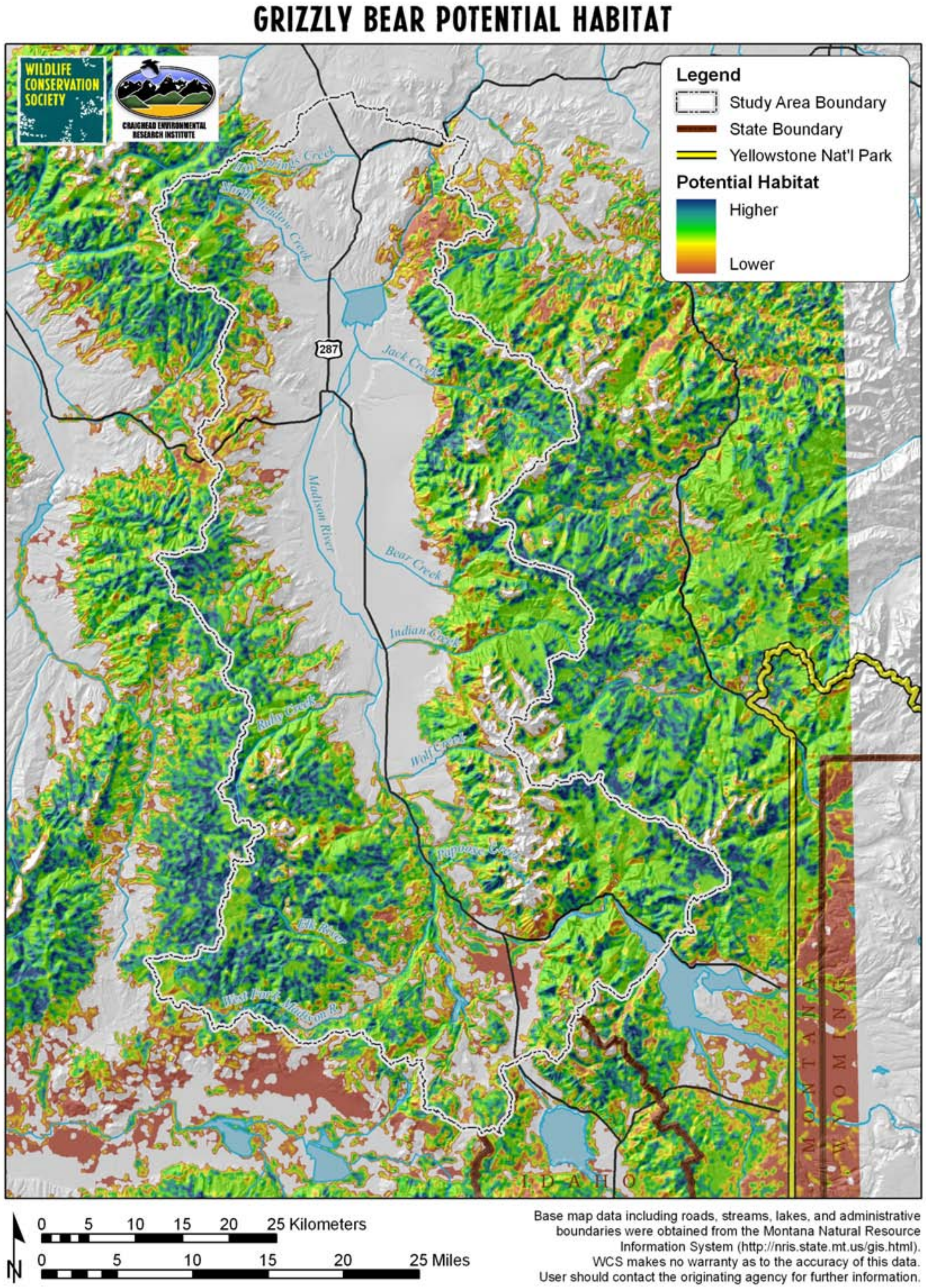


Figure 33. Grizzly bear potential habitat in the Madison Valley.

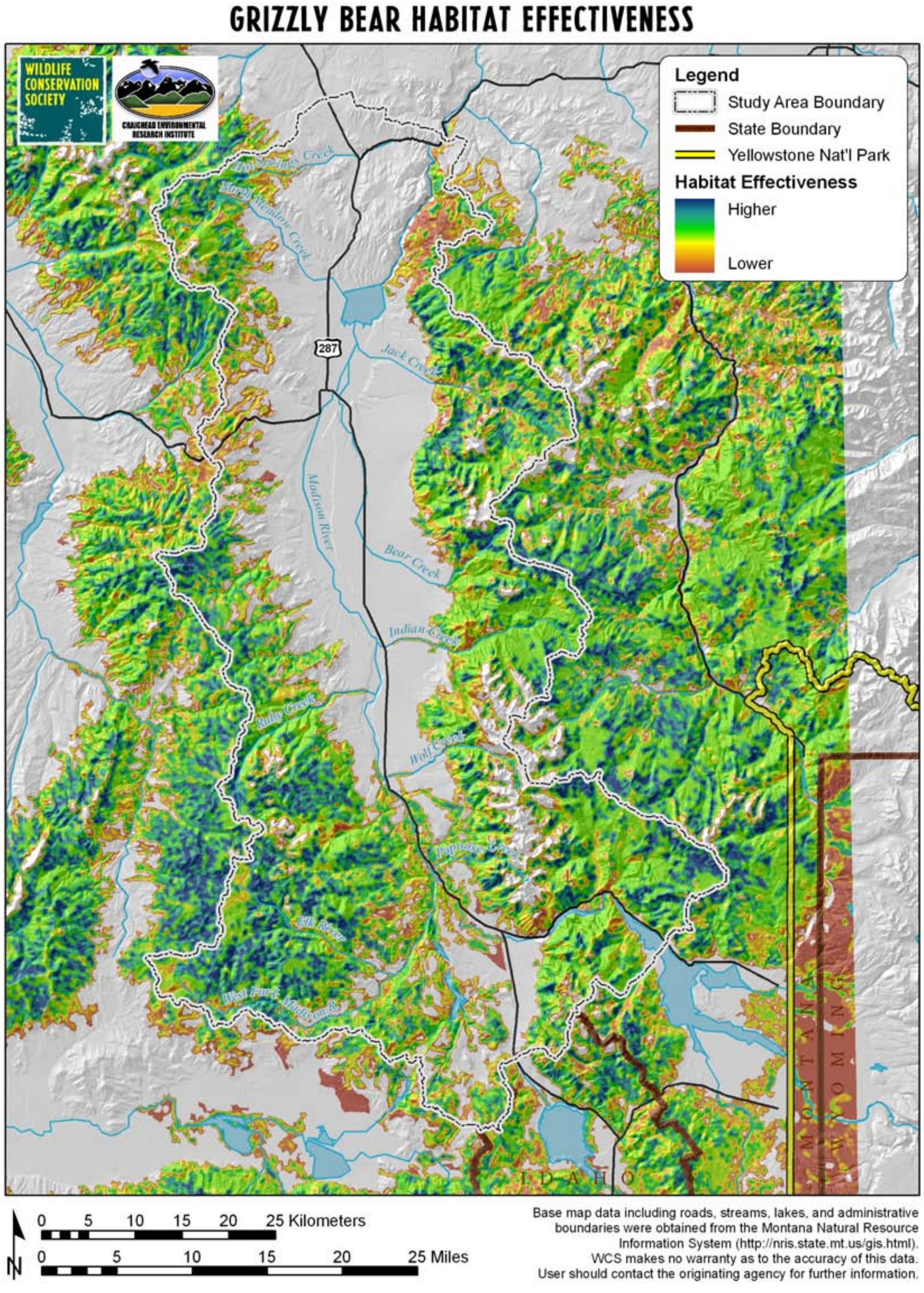


Figure 34. Grizzly Bear habitat effectiveness in the Madison Valley.

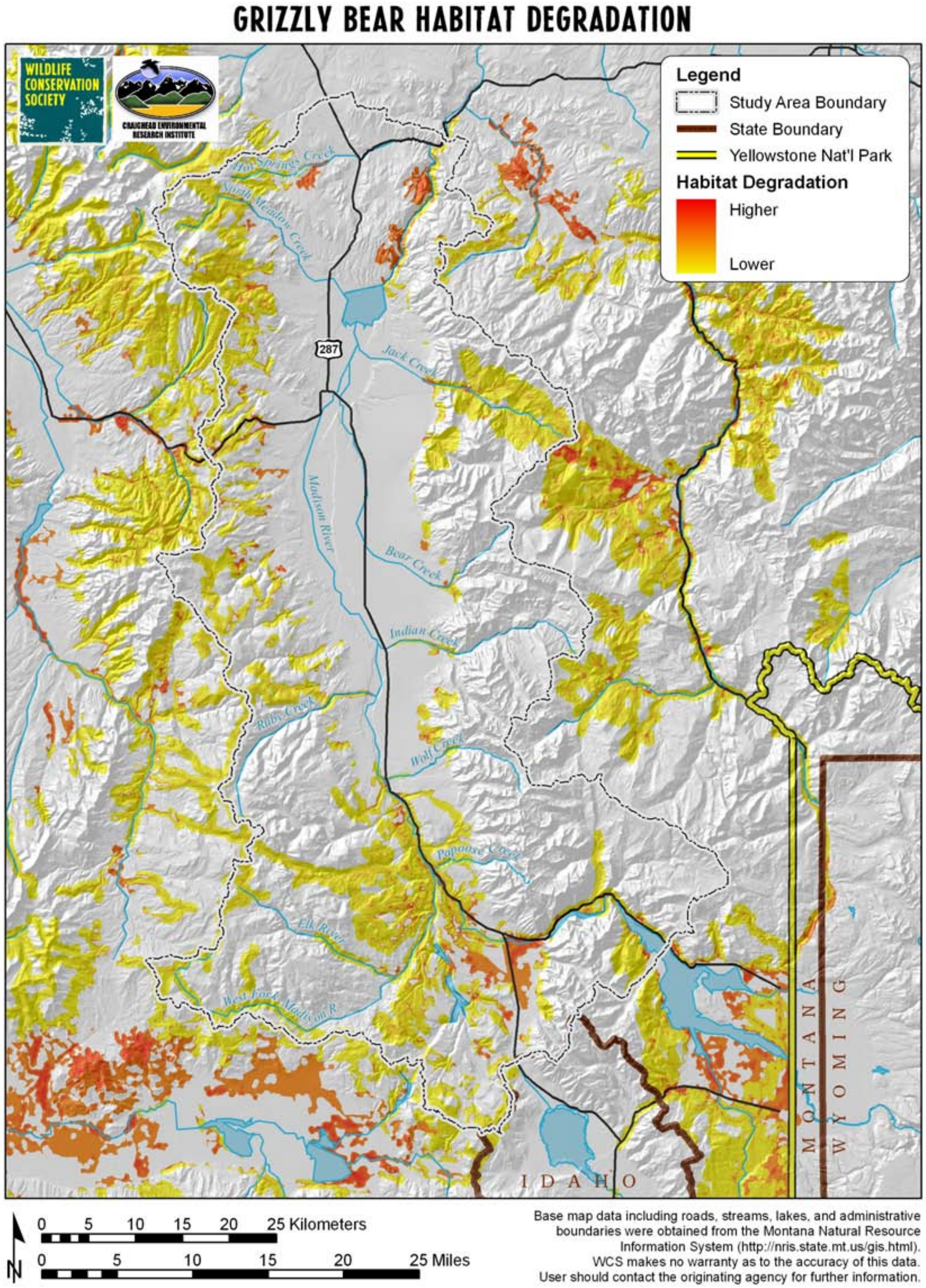


Figure 35. Grizzly Bear habitat degradation in the Madison Valley.

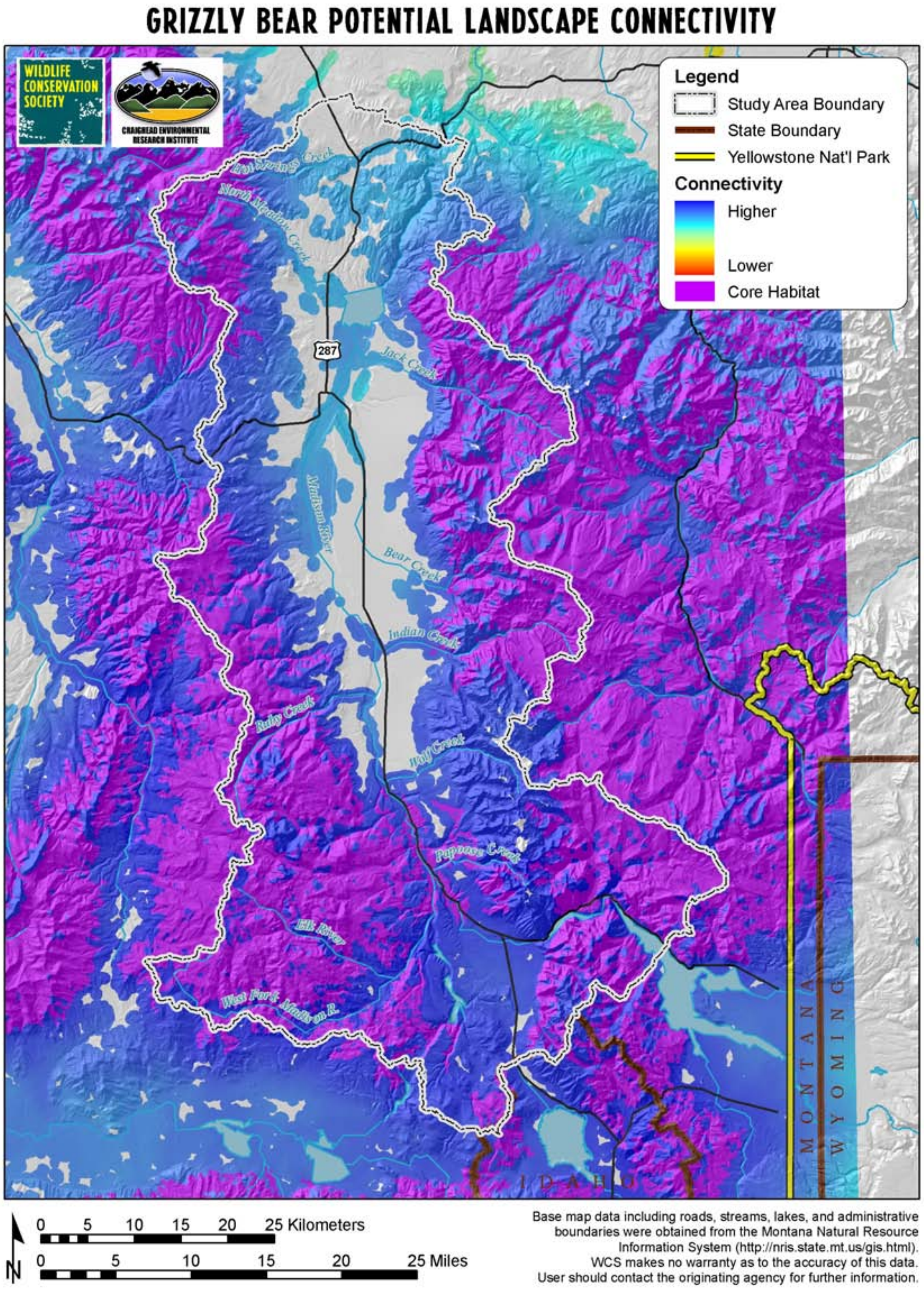


Figure 36. Grizzly Bear potential landscape connectivity in the Madison Valley.

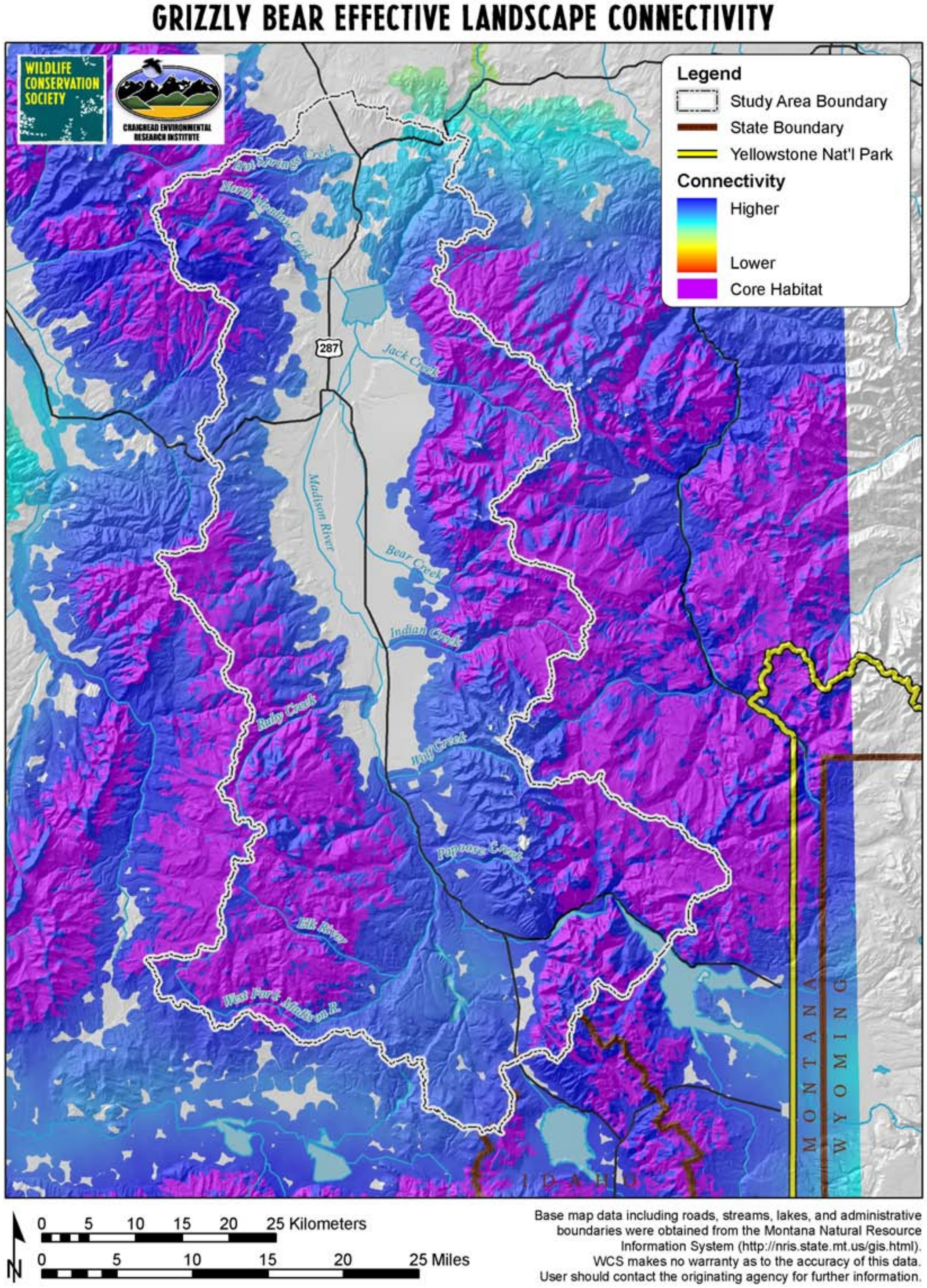


Figure 37. Grizzly Bear effective landscape connectivity in the Madison Valley.

GRIZZLY BEAR LANDSCAPE CONNECTIVITY DEGRADATION

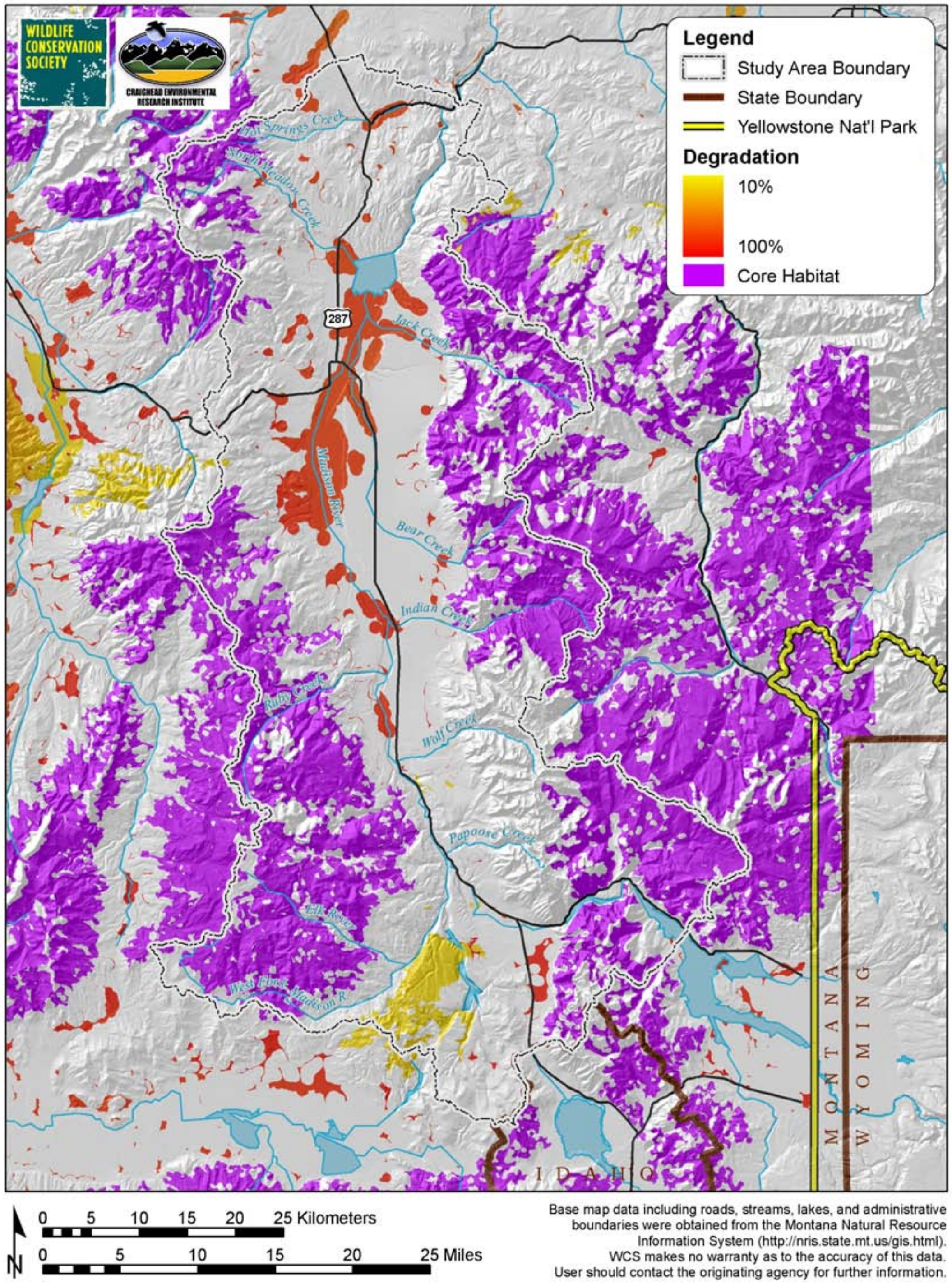


Figure 38. Grizzly Bear landscape connectivity degradation in the Madison Valley.

Moose (Alces alces)

Current Status:

Moose are managed as a big game species throughout the Madison Valley assessment area. Moose are relatively common within suitable habitat throughout the area, particularly within riparian shrub habitats and near early successional shrublands, forests and meadows (Figure 39).

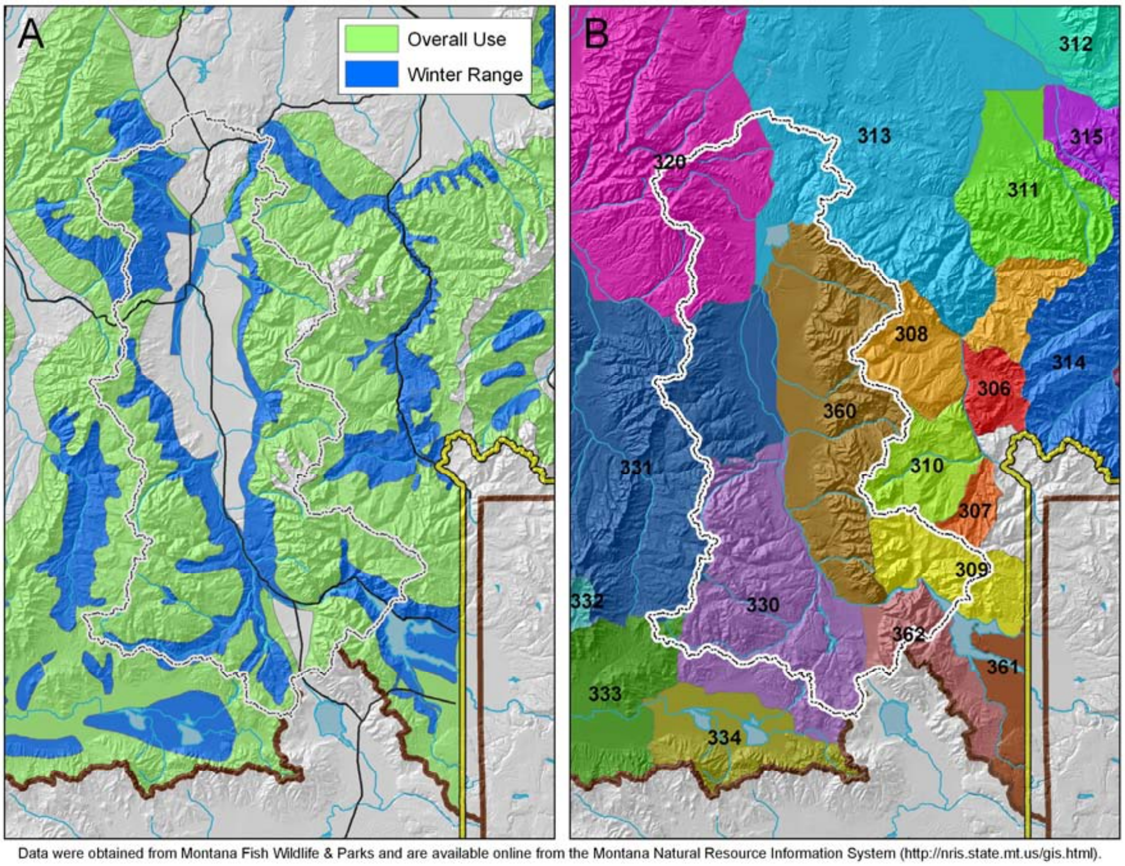
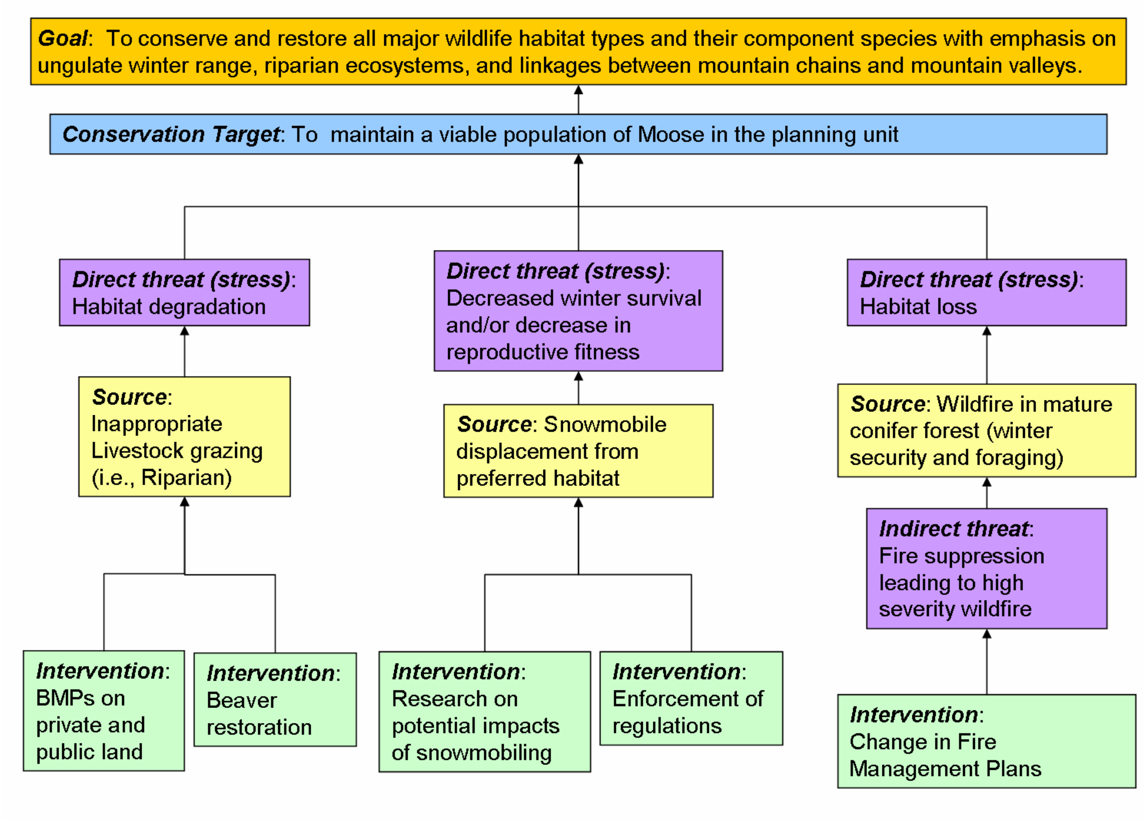


Figure 39. A) Moose seasonal habitat ranges and b) Moose hunting districts in the Madison Valley.

Current Threats:

Moose are relatively secure in the Madison Valley but have probably experienced some habitat loss in the area due to overgrazing in riparian areas, and loss of early successional riparian and aspen habitat from fire suppression and beaver declines. In the winter, moose often seek shelter from deep snows beneath mature conifers which are vulnerable to loss by stand-replacement fire. Finally, it is unknown whether recreational snowmobiling has a negative impact on moose. Moose in the Gravelly Range typically migrate to willow flats at lower elevations in the winter (Knowlton 1960) while those in the Gallatin's move upslope beneath conifers or to southern exposures to avoid deep snows (Stevens 1970). Habitat models (see next section) indicate that moose in the Madison Range behave similar to those in the Gallatin's because snow patterns are similar in these two mountain ranges. The extent to which moose winter range overlaps with snowmobiling activities is unknown, but where they do, it is possible that moose expend energy avoiding this disturbance.



Moose populations in the Red Rock Lakes National Wildlife Refuge may be over utilizing browse in that area which could lead to loss of willow browse and a decline in the areas carrying capacity for moose. If moose from the Madison assessment area are migrating to Red Rock Lakes NWR during winter, then habitat degradation on the refuge could affect moose populations in the Madison Valley.

Within the assessment area, current threats appear minimal. Past grazing practices on public lands have degraded some riparian habitats but with proper grazing management these areas should continue to recover. Perhaps the greatest threat to moose habitat in the area is the loss of natural fires which promote regeneration of willow and aspen stands which are important forage for moose.

Habitat Analysis:

Potential summer moose habitat occurs throughout the montane regions of the assessment area as well as in low elevation willow flats (Figure 40). Moose are adaptable and can feed on a variety of browse and herbaceous vegetation. Studies in the Gravelly and Gallatin Mountains indicate the most important browse species for moose are willow, currant and gooseberry, aspen, subalpine fir, and Douglas fir (Knowlton 1960, Stevens 1970). The major herbaceous forage species was sticky geranium which comprised > 60% of the summer diet (Knowlton 1960). Moose adjust their consumption of browse according to the species locally available. These habitat models probably under represent the amount and quality of potential summer and winter habitat because small patches of willow habitat tend to be undetected in landcover classifications. In addition, satellite based landcover classifications generally do not detect willows and other shrubs that are overtopped by a forest canopy.

Moose migrate in winter to avoid deep snows and maintain access to available browse. In the Gravelly Range deep snows across the Gravelly divide force moose to low elevations where they concentrate around large willow flats in major drainages (Figure 41). In the Madison Range moose can potentially avoid deep snows by moving upslope from the valley bottoms and onto south facing slopes where they browse primarily on Douglas-fir and subalpine fir.

Although fire suppression has likely reduced the amount of early successional vegetation in the assessment area, data were not available to map this habitat loss. Dewatering of streams, loss of beavers, and historic overgrazing have all negatively impacted the health and persistence of riparian habitats important to moose. Unfortunately, accurate and precise data on these communities is sorely lacking for the study area. Therefore, we were unable to map habitat effectiveness for the moose in the Madison Valley.

Conservation Strategies:

Moose appear to be secure within the Madison Valley. Efforts should be made to evaluate and monitor the forage condition for moose in winter concentration areas and adjust harvest quotas to maintain moose within habitat carrying capacity. The potential impact of snowmobiling on wintering moose is unknown. Studies should be conducted to determine whether snowmobile activities overlap with moose winter range, and, if so, what impact, if any, snowmobiling has. Finally, moose are tolerant of human activities which make them frequent residents within rural residential developments. However, moose are large potentially dangerous animals that pose threats to human property and safety. Efforts should be made to educate residents living within moose habitat about land use practices that maintain moose habitat but avoid creating unsafe situations or attracting moose into areas where they will damage property.

In addition to management strategies, there are opportunities to enhance moose habitat within the assessment area. As mentioned previously, fire suppression has led to a decline in aspen and probably willow communities which are both important browse sources for moose. The restoration of natural fire patterns to the area would restore and maintain the historic pattern of early successional habitats upon which moose depend. Likewise, the decline of beaver in the area has undoubtedly resulted in a loss of moose habitat. Beaver impoundments increase the amount of waterline edge and create early successional willow and aspen stands. Beaver restoration could provide an effective and relatively low cost method of habitat restoration and enhancement for moose and other wetlands dependent species.

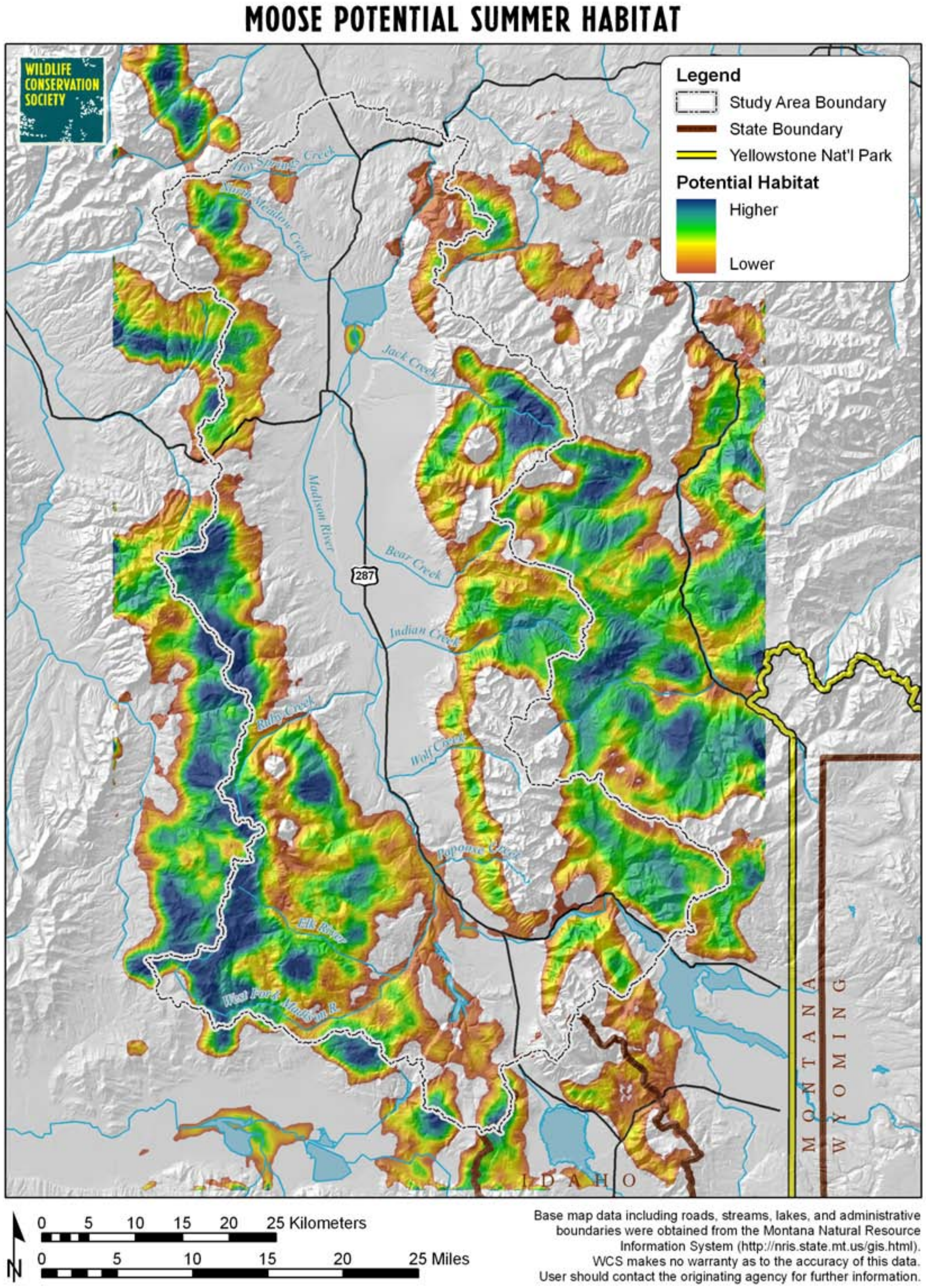


Figure 40. Moose potential summer habitat in the Madison Valley.

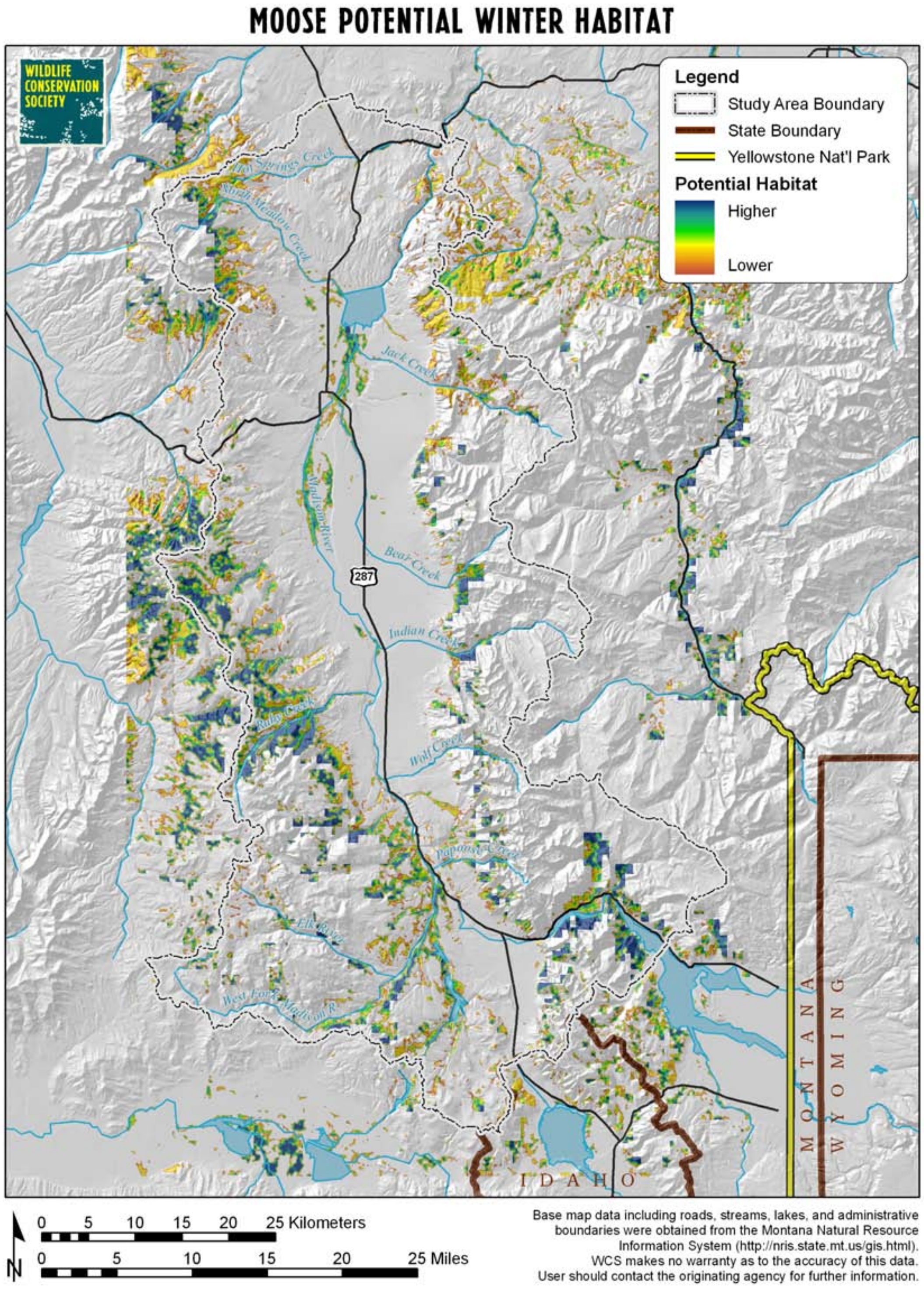
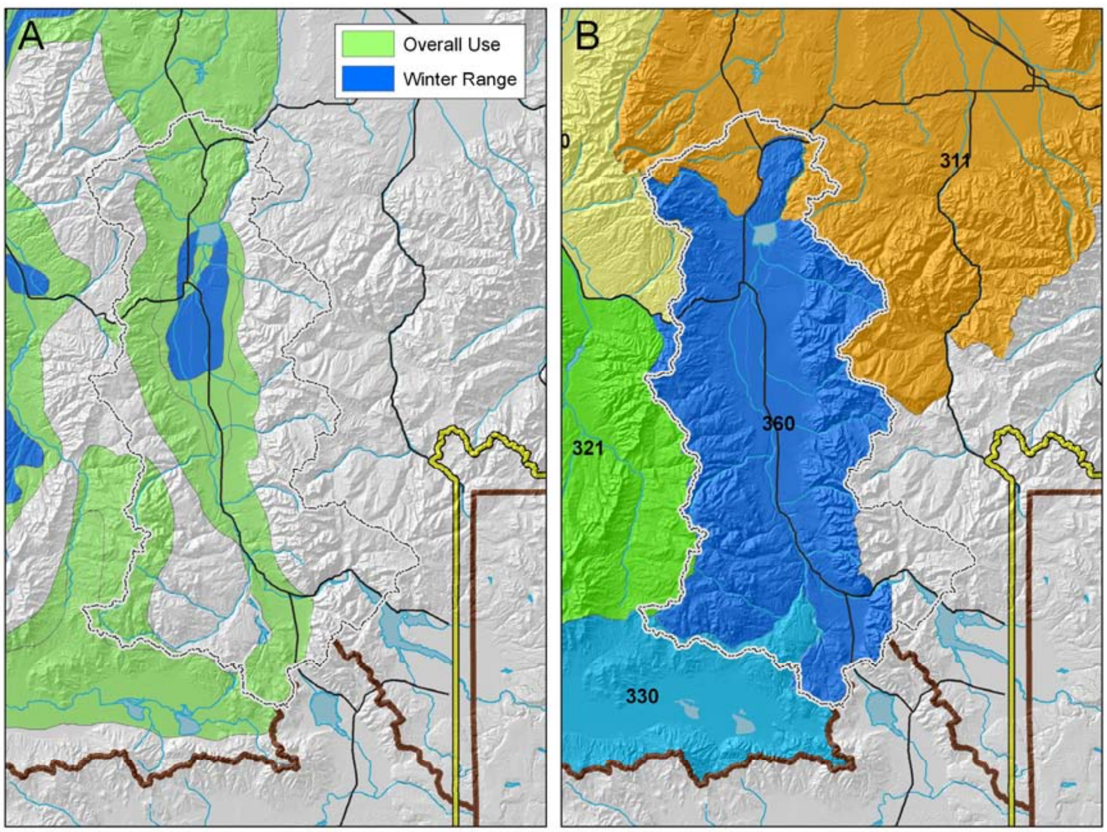


Figure 41. Moose potential winter habitat in the Madison Valley.

Pronghorn Antelope (Antilocapra americana):

Current Status:

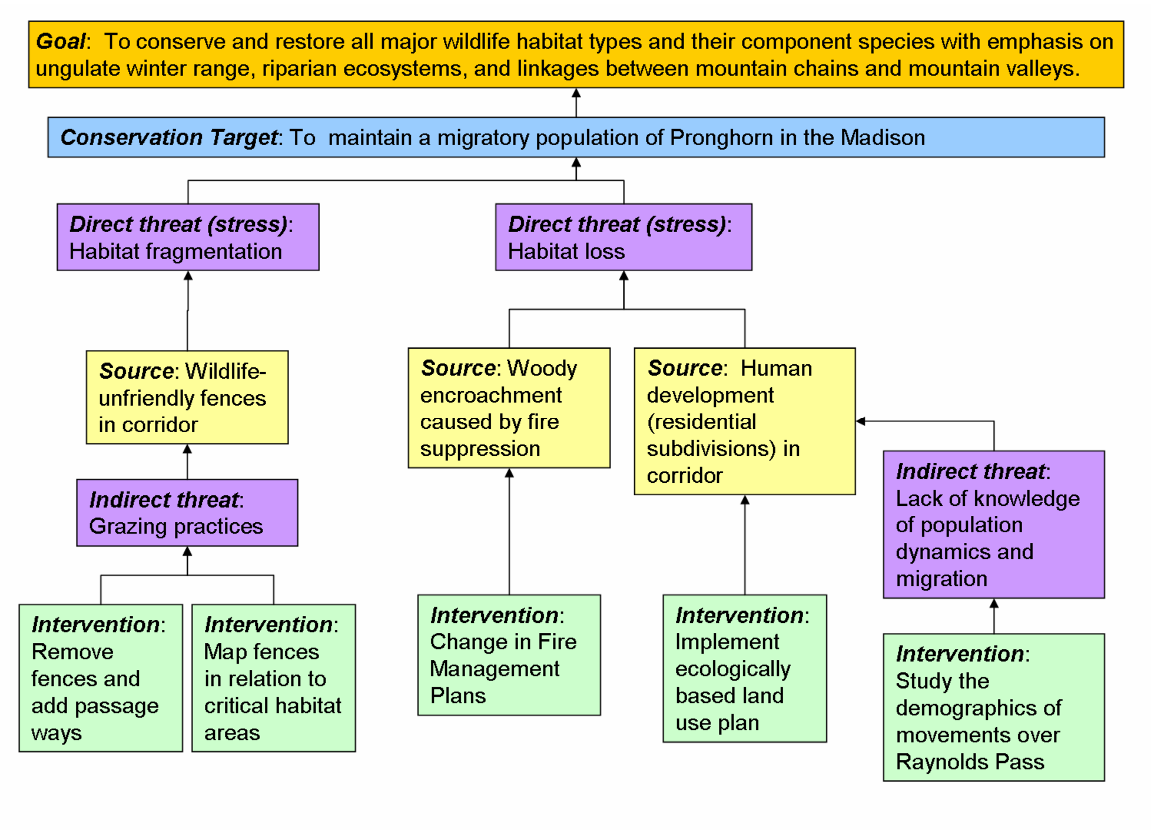
Pronghorn were once abundant throughout the American West but suffered steep declines as European-Americans settled the West. By 1940 pronghorn were apparently extirpated from the Madison Valley but were reintroduced by Montana Fish and Game (now Montana Department of Fish, Wildlife & Parks) sometime around 1956. After reintroduction, the pronghorn population quickly expanded in the Madison Valley and discovered migratory routes. By the late 1960's, pronghorn were migrating between the Madison Valley and the Henry's Lake area of Idaho (Primm 2005). Pronghorn are both year-long residents and seasonal migrants in the Madison Valley (Figure 42A) with some animals migrating up to 140 Km over Raynold's Pass to summer in the Henry's Lake area with migrations typically beginning in April but reported as early as March in mild years. Pronghorn are abundant at low elevations in the valley with a 2005 estimate of over 2000 pronghorn wintering in the valley. Pronghorn are currently managed as a big game species throughout the Madison Valley (Figure 42B).



Data were obtained from Montana Fish Wildlife & Parks and are available online from the Montana Natural Resource Information System (http://nris.state.mt.us/gis.html).

Figure 42. A) Pronghorn seasonal habitat ranges and B) Hunting districts in the Madison Valley.

Current Threats:



The most immediate threat to pronghorn in the Madison Valley is potential loss of migration routes. Improper fencing can be a serious barrier to pronghorn movements because pronghorn rarely jump over vertical obstacles (Nowak 1999) but will crawl under fences if possible. The landcover and topography creates a natural bottleneck for pronghorn movements toward the middle of the valley and reaching its narrowest at Papoose Creek. Improper fencing within this bottleneck zone could potentially block migrating antelope. In addition, rural residential development can destroy habitat and displace animals from remaining habitat although pronghorn often habituate to human presence. Residential development within the migration bottleneck could have significant impacts on pronghorn movements if efforts are not made to maintain habitat connectivity through the area. Fire suppression may result in the loss of habitat by allowing woody species to encroach into grassland steppe.

Habitat Analysis:

Pronghorn prefer open and relatively flat terrain dominated by shrub-steppe or grassland cover where they can easily outrun predators (Figure 43). Pronghorn also utilize agricultural fields for forage. Pronghorn habitat in the Madison Valley is distributed throughout the low elevation areas and extends into high benchlands, montane sagebrush valleys and even the alpine meadows of the Gravelly Range (Figure 44). Habitat connectivity along migration routes is critical to maintaining the migratory herd in the Madison Valley (Figure 46). Pronghorn migrating from the lower Madison Valley to Henry's Lake must pass through several significant bottlenecks of narrow habitat at Wolf, Moose, Squaw, and Papoose Creeks (Figure 47). Development within this bottleneck zone has likely degraded the area's value for pronghorn connectivity (Figure 48) but, at this point, not severely enough to block the migration route.

Conservation Strategies:

Removal of fencing or maintaining pronghorn friendly fencing, particularly within the migration bottleneck zone, is essential for allowing free movement of pronghorn throughout available habitat. Where pronghorn friendly fencing is not possible, crossing structures could be installed at strategic locations along the fence or gates could be left open during migration season. Residents along the migration routes should be educated about the migration and encouraged to maintain open habitats where pronghorn feel secure and to minimize disturbances that may impede pronghorn movements.

Little is known about the dynamics of migrating pronghorn in the valley. It is unknown whether the same individuals migrate every year or whether they winter in the same areas in the Madison Valley each year. It is also unknown which routes pronghorn occupying high elevation summer range in the Gravelly Range are using to migrate between summer and winter habitat. If pronghorn migration is to be maintained in the Madison Valley, more information needs to be gathered to determine how to best manage and preserve this wildlife spectacle for the future.

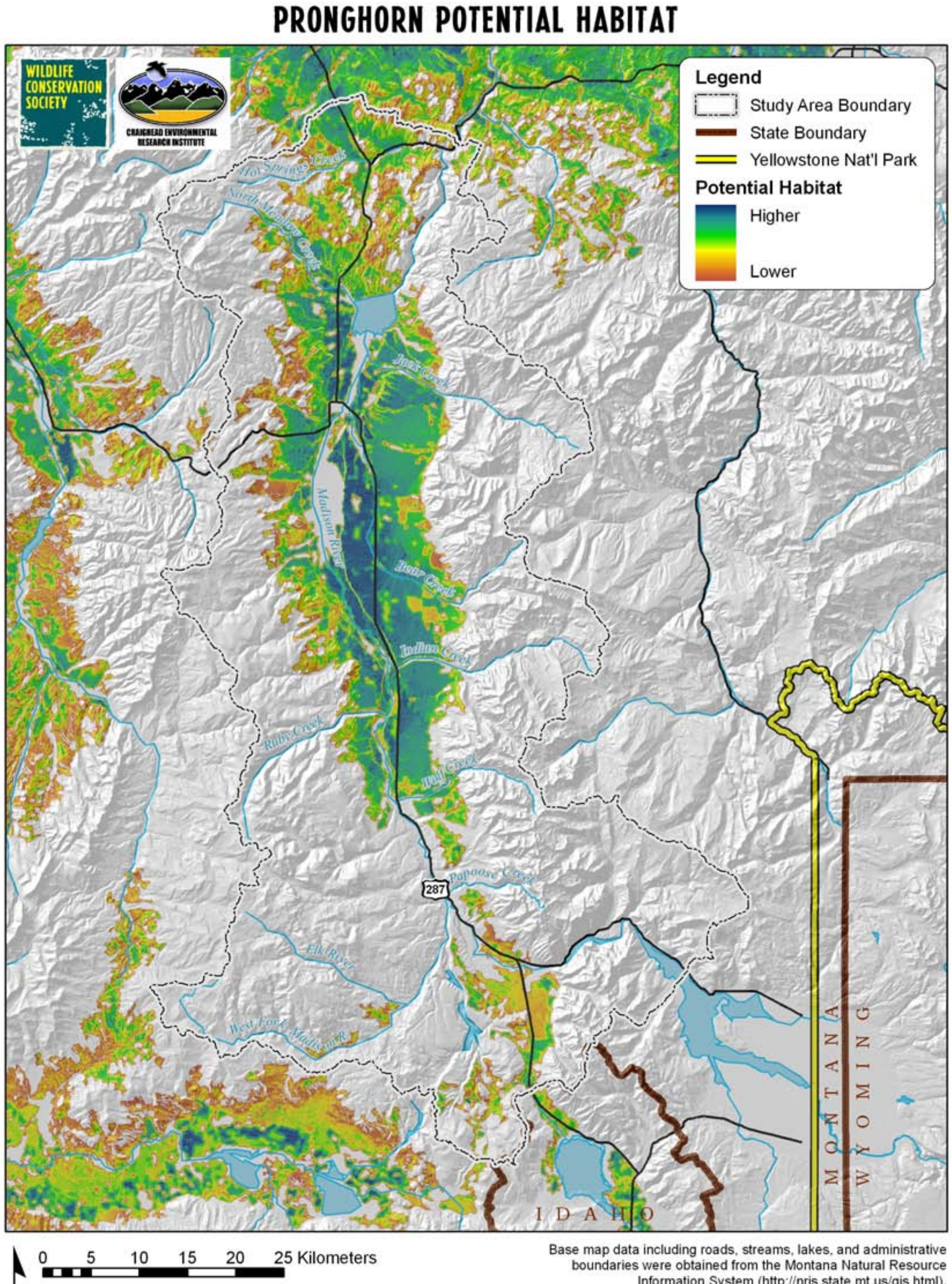


Figure 43. Pronghorn potential habitat in the Madison Valley.

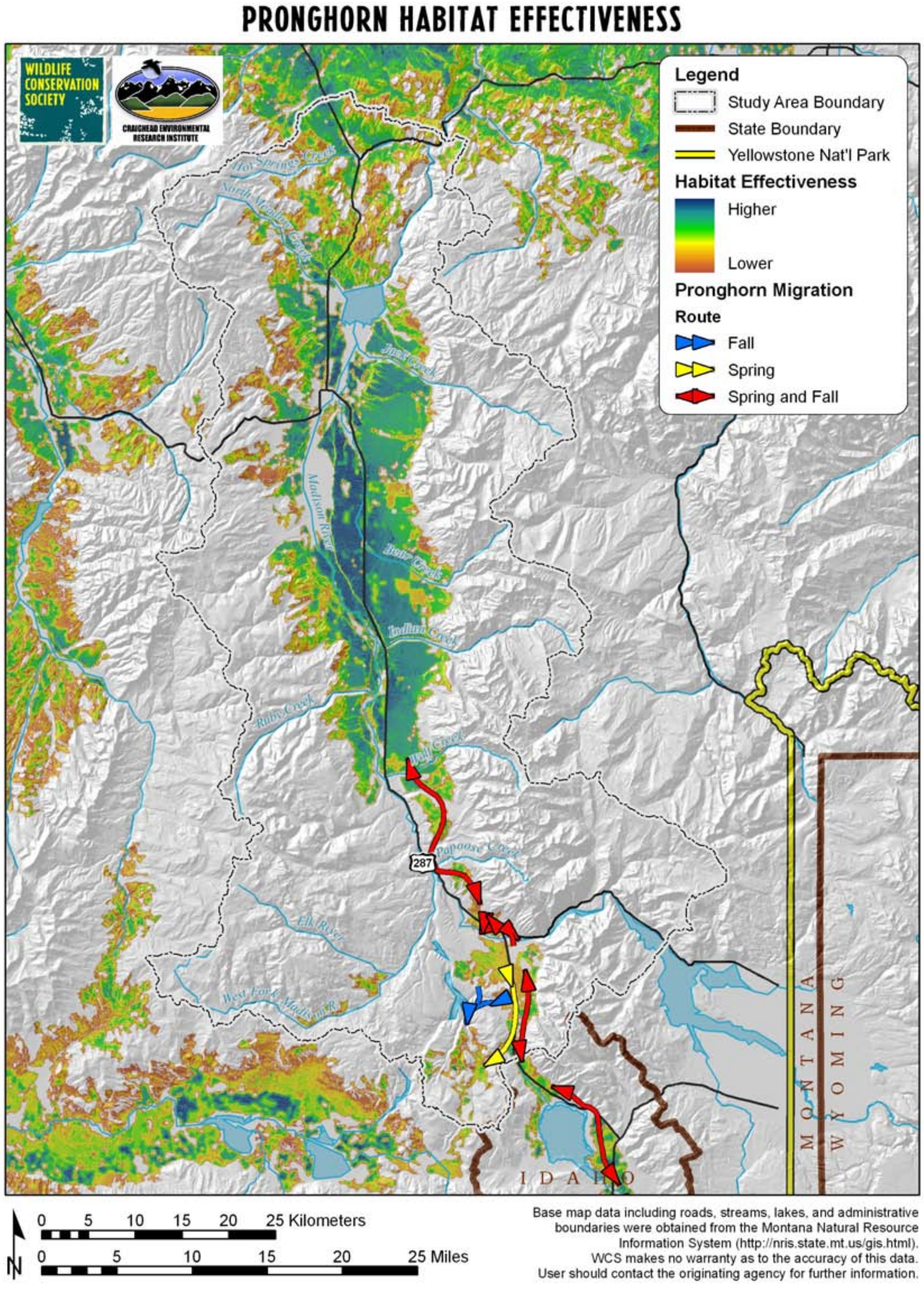


Figure 44. Pronghorn habitat effectiveness in the Madison Valley.

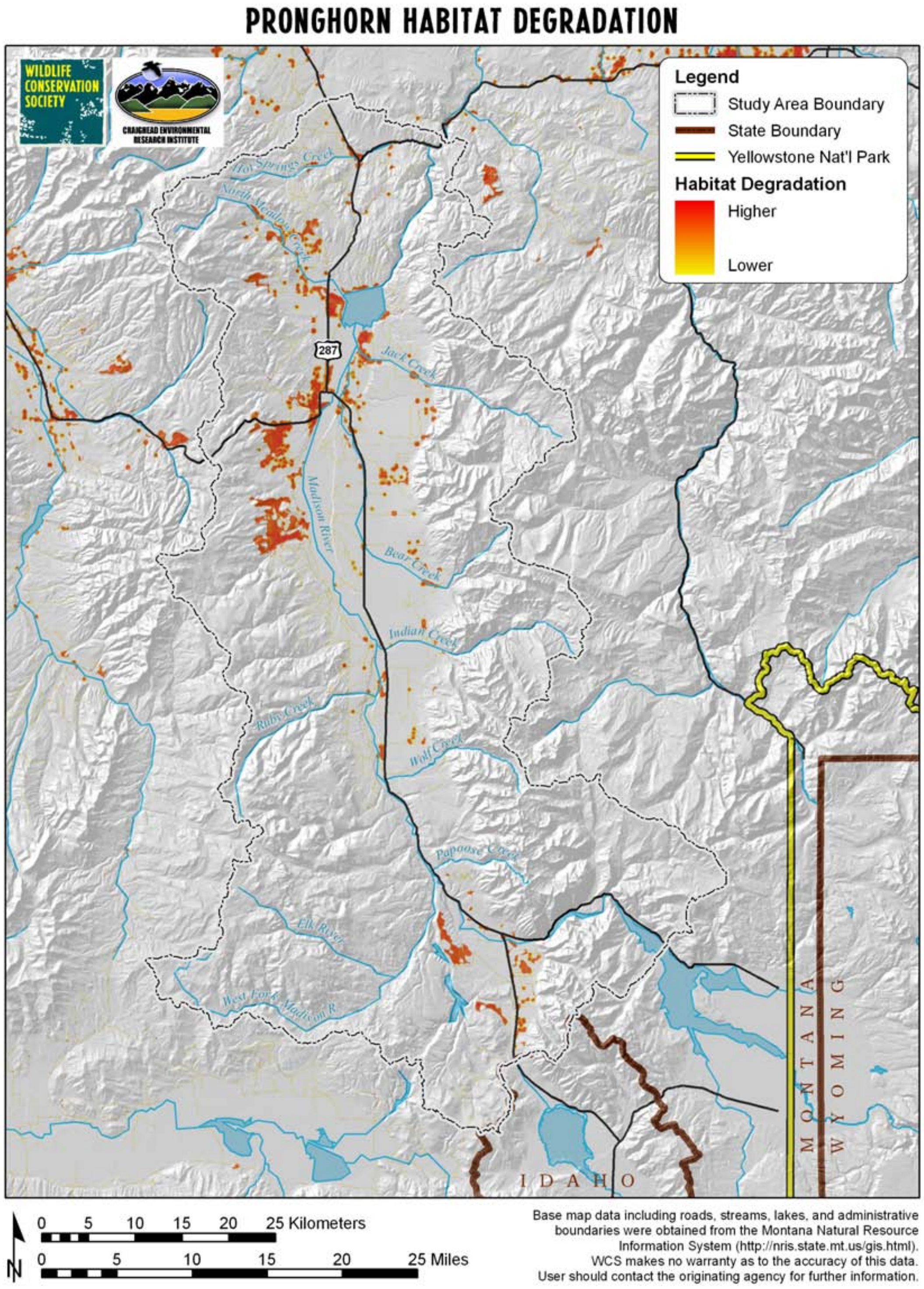


Figure 45. Pronghorn habitat degradation in the Madison Valley.

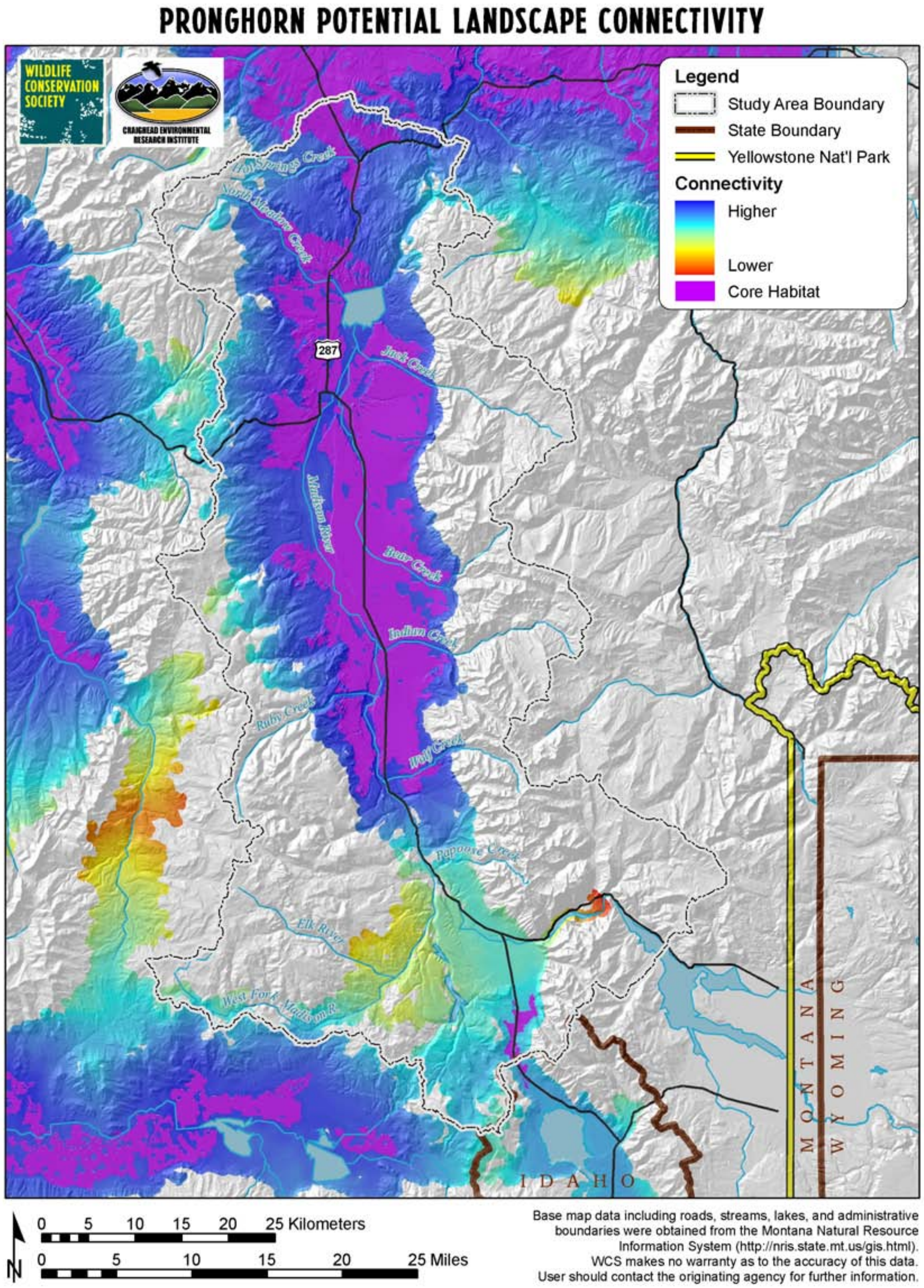


Figure 46. Pronghorn potential landscape connectivity in the Madison Valley.

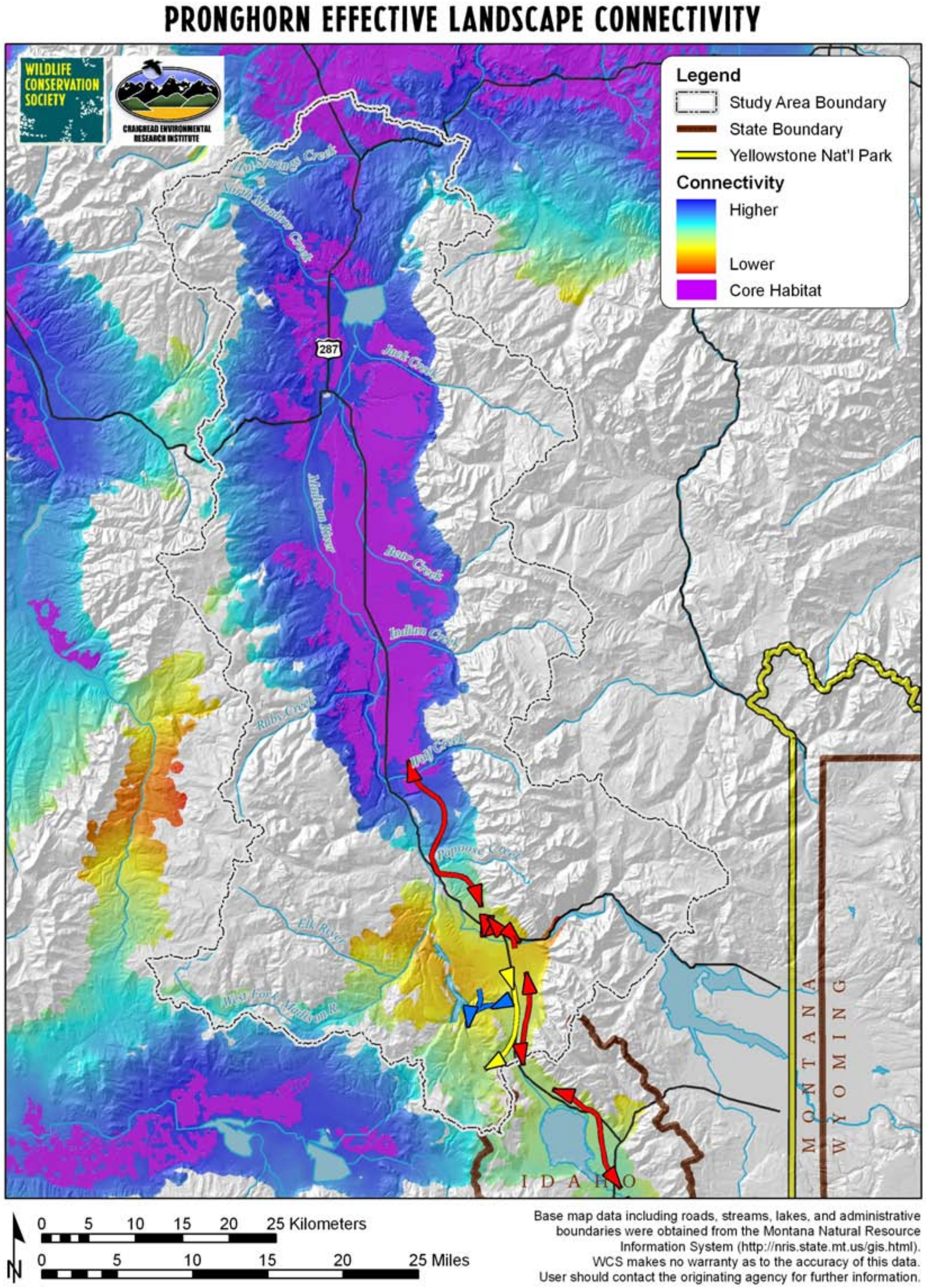


Figure 47. Pronghorn effective landscape connectivity in the Madison Valley.

PRONGHORN LANDSCAPE CONNECTIVITY DEGRADATION

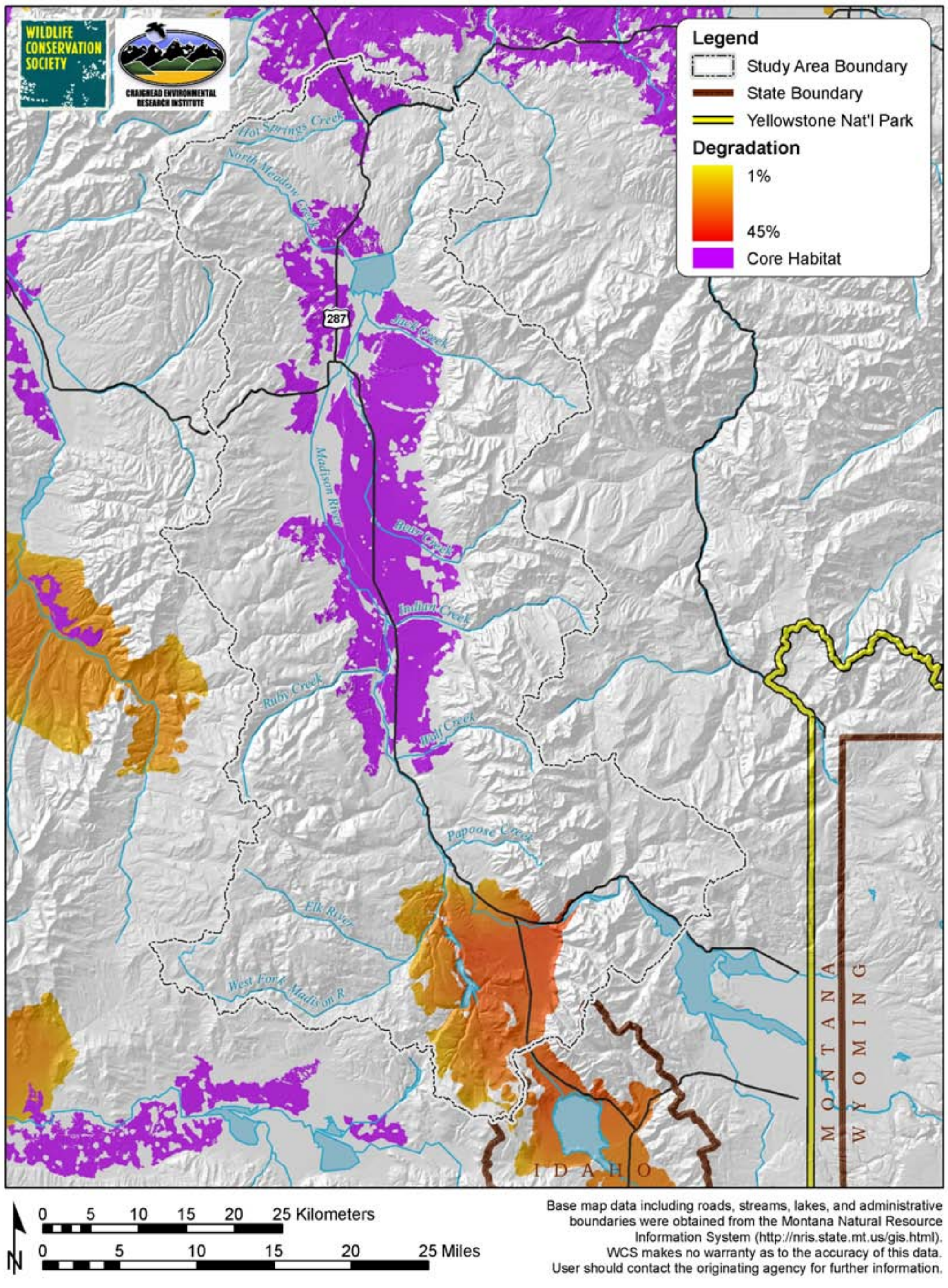


Figure 48. Pronghorn landscape connectivity degradation in the Madison Valley.

Riparian Birds

Red-naped sapsucker (Sphyrapicus nuchalis)

Yellow Warbler (Dendroica petechia)

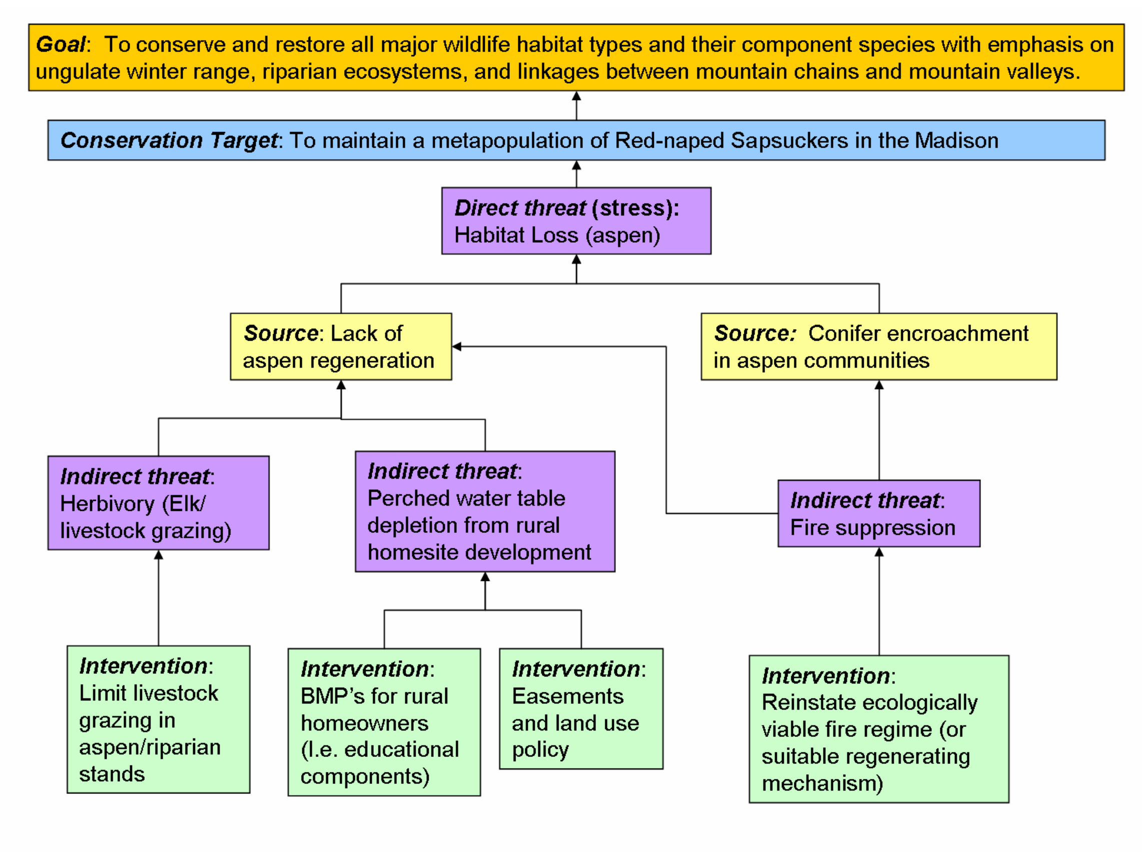
Warbling Vireo (Vireo gilvus)

Current Status:

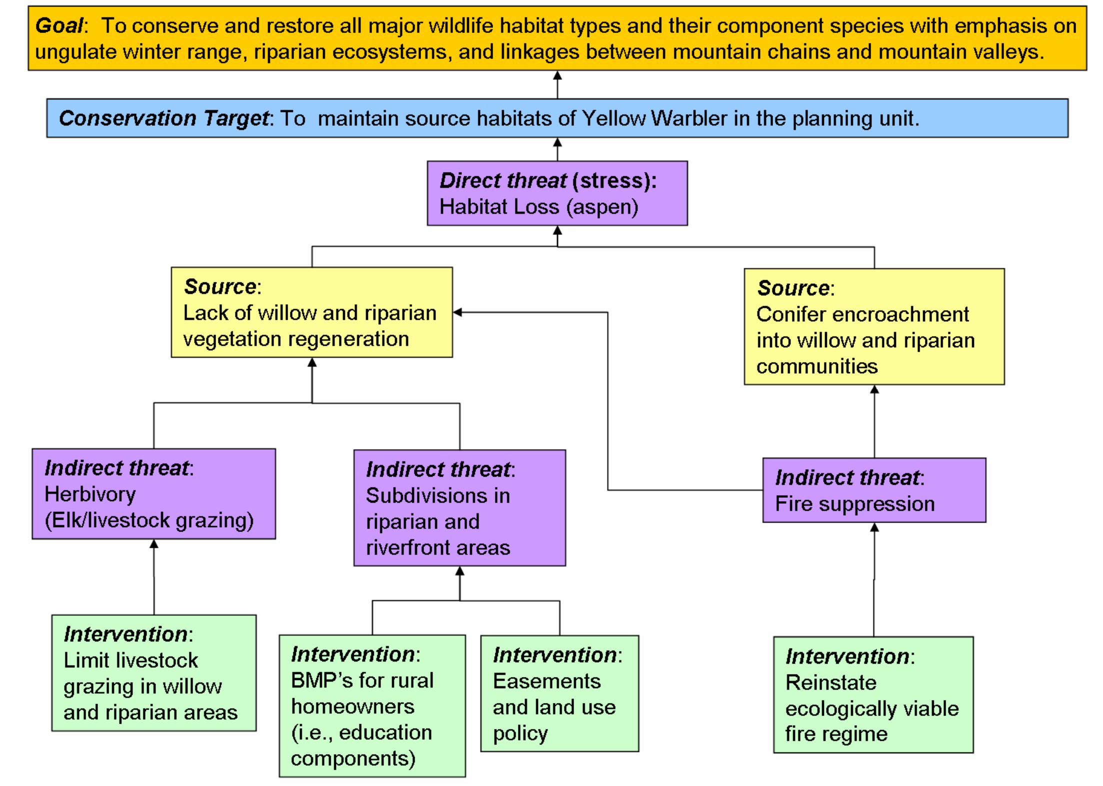
A suite of birds was chosen to represent conservation needs of riparian habitats in a variety of forms. Red-naped Sapsuckers are a signature species of aspen stands (both riparian and upland), Warbling Vireos nest primarily in riparian cottonwood and aspen stands and Yellow Warbler nest in all riparian habitats and mesic shrublands but are most abundant in riparian willow habitat. All of these species are common to abundant within suitable habitat in the Madison Valley. However, declines in the extent of riparian and upland habitats over the past 200 years have probably reduced these species populations from historic levels.

Current Threats:

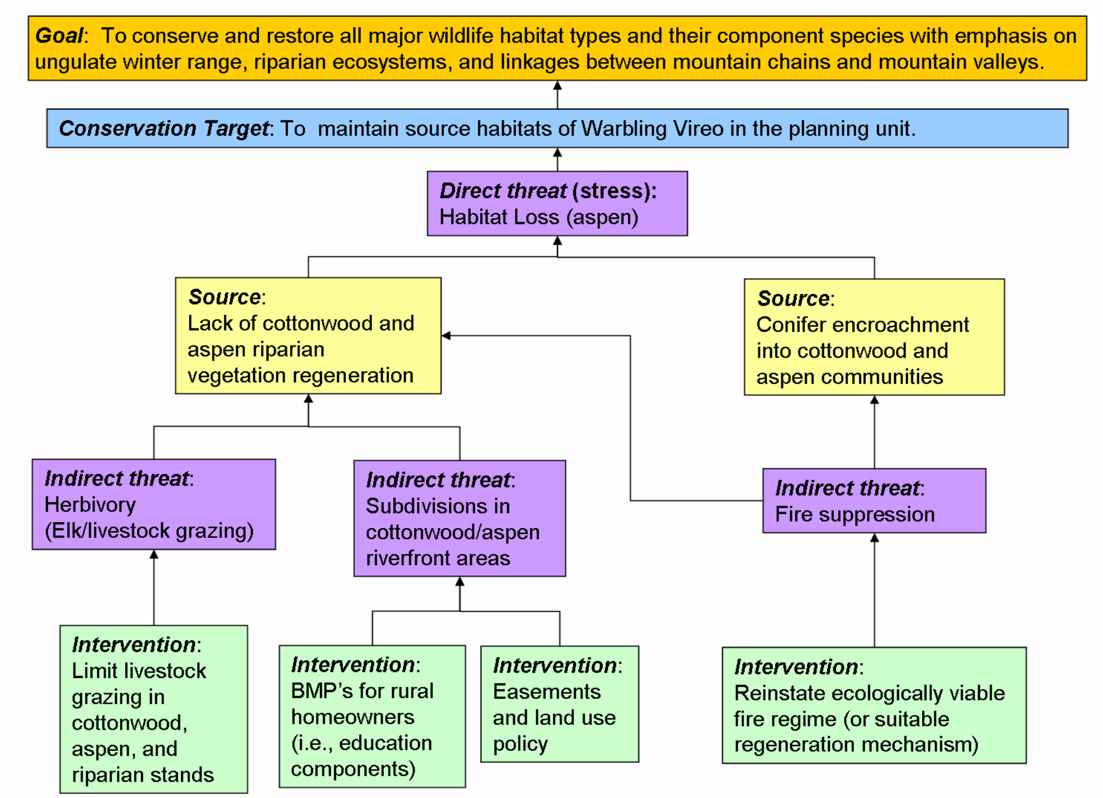
Red-naped sapsucker (Sphyrapicus nuchalis)



Yellow Warbler (Dendroica petechia)



Warbling Vireo (Vireo gilvus)



A number of factors threaten riparian and aspen habitats in the Madison Valley assessment area ranging from overgrazing and subdivision to conifer encroachment. A study in the Gravelly Mountains indicated a 45% decline in pure aspen and mixed aspen/conifer stands between 1947 and 1992 (Wirth et al. 1996). This loss was attributed mainly to conifer encroachment due to fire suppression. Fire suppression has likely also affected the amount of willow habitat in the region since fires often reset habitats to early successional conditions. In addition, aspen are also in decline because of lack of regeneration in some areas. Herbivory from elk and livestock grazing as well as lowering of perched water tables by increased well drilling for residential develop can reduce or eliminate survival of aspen suckers necessary to maintain the stand. This problem may be most acute on private land where to the untrained eye, apparently healthy mature aspen trees mask the fact that the stand will eventually die due to lack of survival of young trees. Cottonwood stands face a similar fate with respect to lack of regeneration due to a loss of flood plain dynamics along rivers needed to establish new seedlings. In addition, cottonwood stands are also vulnerable to herbivory from elk and livestock that negatively affect seedling survival. Finally, disturbance near nesting habitats in all riparian habitat types may reduce nesting success of riparian songbirds. Residential developments along aspen/cottonwood riverfronts create chronic disturbance to nesting wildlife from noise and human activities as well as increased predation and harassment from introduced predators such as dogs and cats (Hansen and Rotella 2002). Moreover, human- and livestock-associated species such as brown-headed cowbirds, house sparrows, European starlings, corvids, skunks, and raccoons may also negatively affect breeding birds at higher rates near and adjacent to development. Additionally, the heavy recreational use of the Madison River and major tributaries may create significant levels of disturbance to songbirds nesting in willow habitat potentially deceasing nesting success.

Habitat Analysis:

Potential habitat appears widespread for Red-naped Sapsucker in the Madison Valley, a model based largely on the extent of aspen stands (Figure 49). However, this map probably under represents the amount of habitat available for this species. Red-naped Sapsuckers prefer aspen stands (but are not aspen-obligates) and, as mentioned previously in this report, aspen appear to be under represented in GAP and other landcover classifications. The US Forest Service developed an improved classification method for detecting aspen in portions of the Beaverhead-Deerlodge National Forest (Wirth *et al.* 1996) but it does not cover the entire assessment area. With sufficient resources, the Forest Service methods could be applied to the entire assessment area to improve evaluation and monitoring of this important habitat type. However, the apparent abundance and distribution of potential Red-naped Sapsucker habitat must be tempered with the perspective that aspen stands are showing regional decline (see above).

Habitat maps based on habitat suitability indices were developed for Yellow Warbler (Schroeder 1982) and Warbling Vireo (Banks *et al.* 1999). However, these maps are not included in this report because of insufficient data to make an accurate assessment. Small songbirds typically select habitats at a finer scale than can be mapped with readily available GIS data. For example, willow shrub canopy height and density are important variables in determining nesting habitat suitability for Yellow Warblers. Given the difficulties inherent in correctly classifying willow landcover types regardless of fine scale structural characteristics of individual stands, it was determined that maps based on available data would be too unreliable to be helpful for conserving these songbirds in this region. To partially address this problem, a landcover map specifically designed to classify riparian habitats was developed (Figure 50) which provides a rough indicator of potential habitat for these two species.

Conservation Strategies:

Riparian areas are important habitats for many wildlife species and also serve an important role in maintaining stream water quality by slowing and filtering surface runoff. A number of activities should be employed to protect and restore riparian habitat in the Madison Valley. These include:

- Restore natural fire patterns to allow natural regeneration of aspen and willow communities and to remove encroaching conifers.
- Restore flood dynamics to the main stem of the Madison River. As mentioned previously, PPL and MFWP are cooperating on assessing the efficacy of spike flows and sediment transport on the Madison River. The results of these experiments should provide important data to assist in the conservation of viable stands of riparian broadleaf communities such as cottonwoods, willows, alders, and aspen.
- Restore beaver to create new wetlands and riparian habitats.
- Zone the entire valley with development setback requirements to protect riparian areas.
- Institute policies for subdivision review that consider the potential impacts on riparian areas (water tables and disturbance levels) before approvals are granted.
- Educate landowners about the importance of aspen and cottonwood regeneration to maintain riparian areas and urge landowners to follow sound livestock management practices.
- Study the impacts of recreational fishing on riparian nesting birds and develop mitigation plans if needed.

RED-NAPED SAPSUCKER POTENTIAL HABITAT

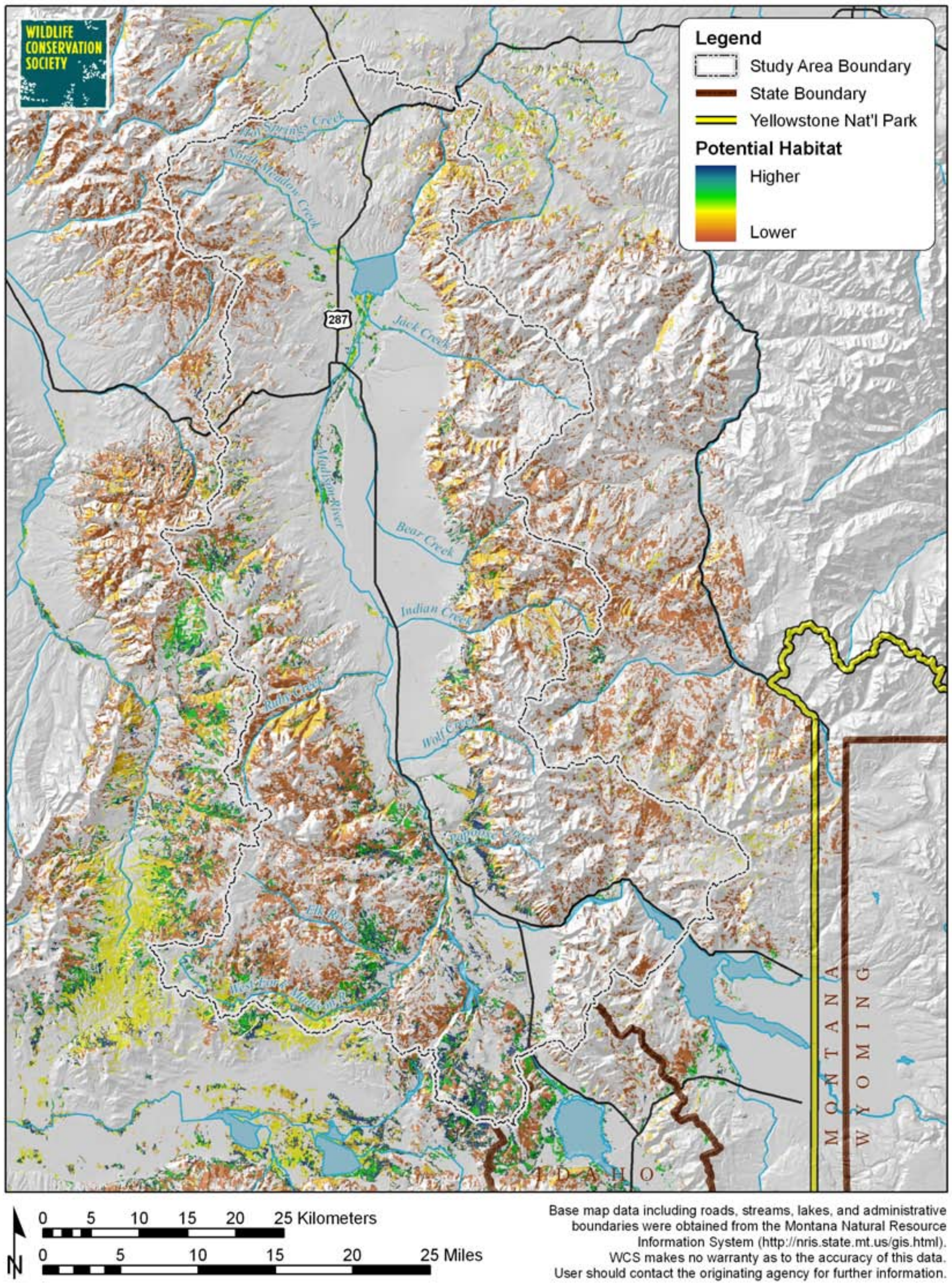


Figure 49. Red-naped Sapsucker potential habitat in the Madison Valley.

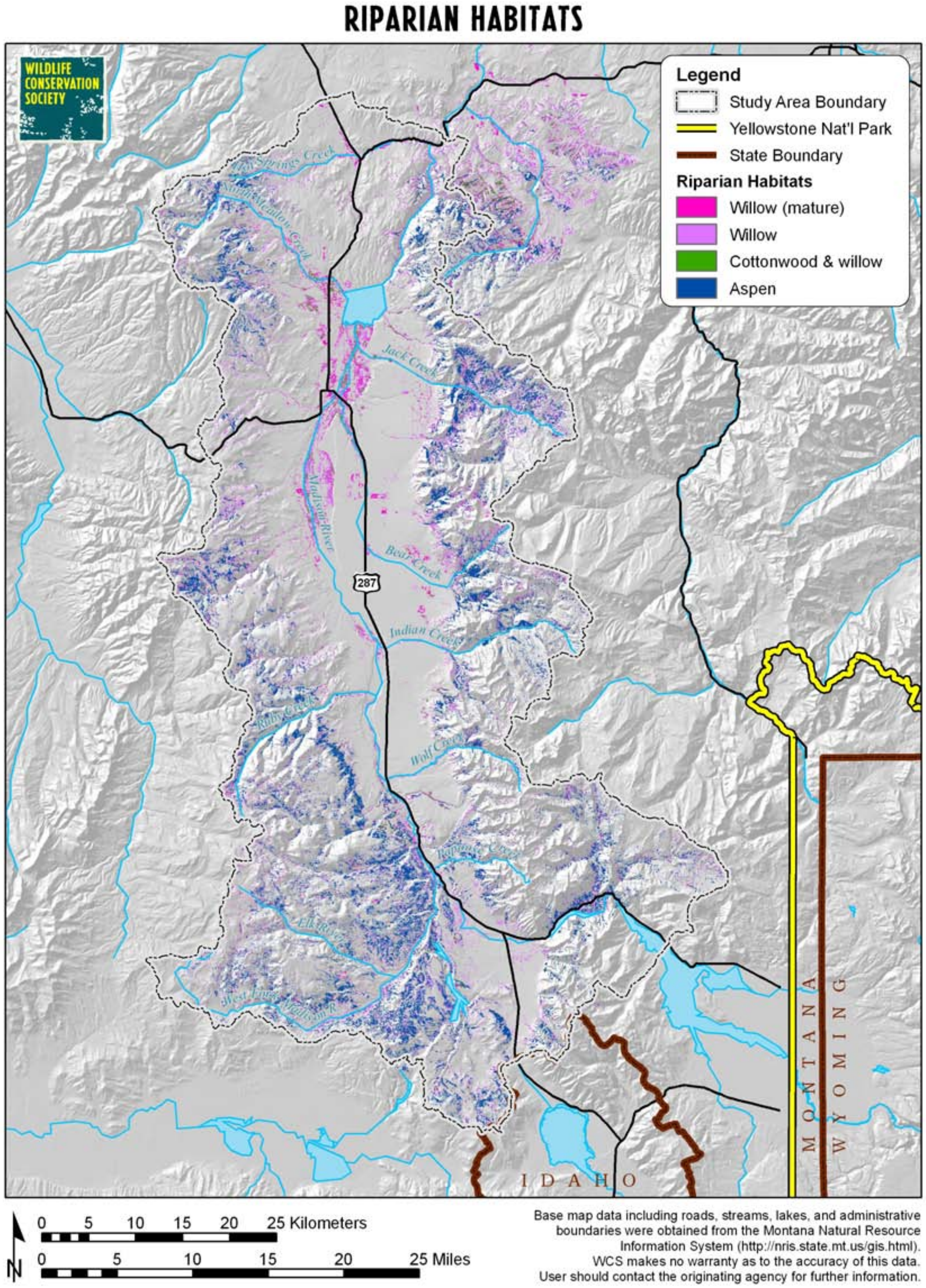


Figure 50. Riparian habitats in the Madison Valley.

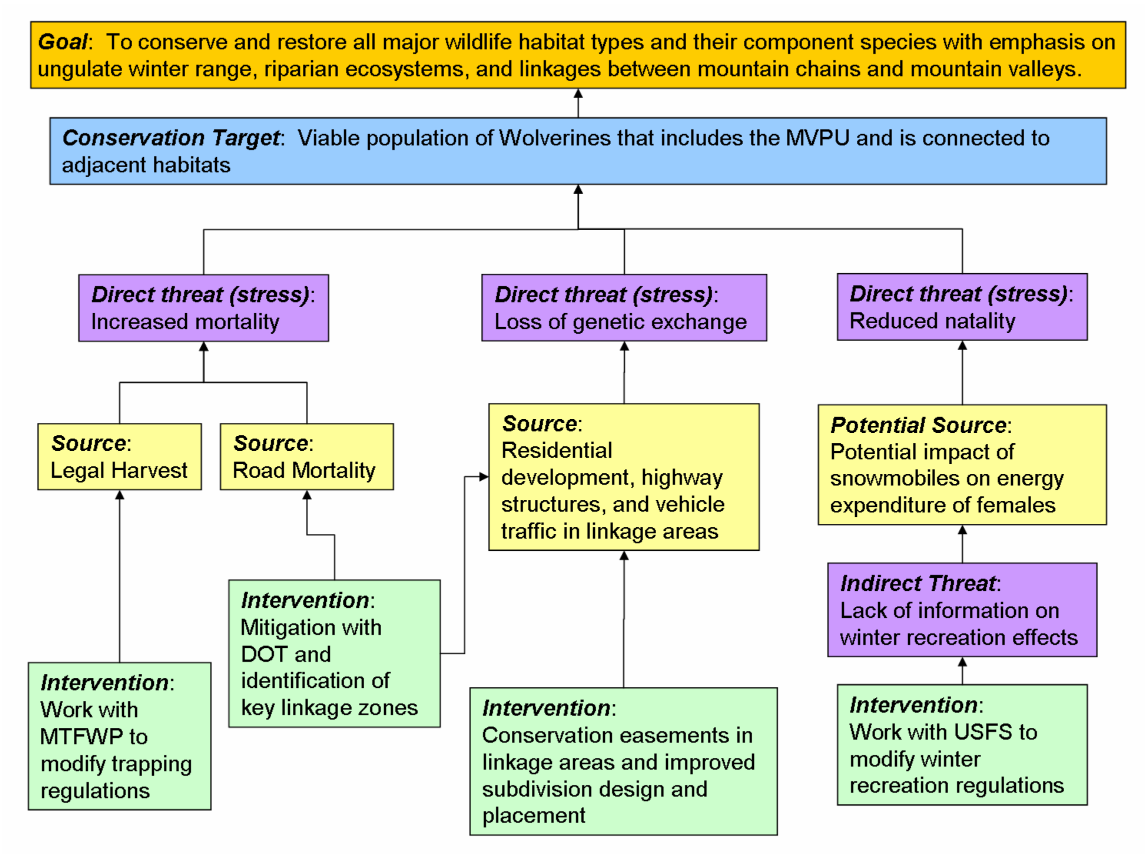
Wolverine (Gulo gulo)

Current Status:

Wolverines are extremely rare and secretive carnivores in the Northern Rockies. Once extirpated from the region, wolverines have recovered much of their former range in Montana, Idaho and northern Wyoming. This species is listed as a species of concern by the US Forest Service and has been petitioned for listing under the Endangered Species Act but listing has been denied. The apparently naturally low population of this species in combination with large home ranges and large area habitat requirements (Inman *et al.* 2005) may make them particularly vulnerable to land use activities on a regional scale. Wolverines are currently managed as a fur bearer in the state of Montana and the entire Madison Valley assessment area is open to trapping.

Because of the large area requirements and low populations of this species, the Madison assessment area is not sufficiently large to support viable populations. However, the area contains high quality habitat and an ongoing study has documented wolverine use of all mountain ranges surrounding the Madison Valley as well as at least one wolverine struck by a vehicle crossing the Valley floor (Inman pers. comm.). The Madison Valley may be important for maintaining regional connectivity within a dispersed population.

Current Threats:



Wolverines are difficult to study and little is known about their life history and habitat needs. More information is needed to adequately address the impact of human activities on this species. However, ongoing studies by the Wildlife Conservation Society and the US Forest Service are beginning to shed light on the habitat needs and potential human impacts on this species.

Wolverines are active during the winter at high elevations and may be affected by recreational snowmobiling in the area. Disturbance by snowmobiles could displace wolverines and disrupt feeding patterns which could reduce reproductive rates by increasing energetic costs for females during critical stages of pregnancy.

Wolverine trapping is legal in Montana where it is tightly regulated. Whether the mortality caused by wolverine trapping is additive or compensatory is unknown as are the long term affects on wolverine populations.

Wolverines often travel among multiple mountain ranges and isolated mountain ranges often support only a few individuals making them vulnerable to loss of habitat connectivity. Rural residential development and increased vehicle traffic in linkage zones may reduce habitat connectivity and increase mortality of animals moving between isolated ranges. Vehicle collisions in general may be a major source of mortality for this species.

Habitat Analysis:

Potential habitat was mapped using logistic regression from wolverine telemetry and GPS locations. The map shows extensive areas of high quality habitat in the high elevations throughout the assessment area. The pattern of potential habitat demonstrates the isolated island-like nature of wolverine habitat with the Madison/Taylor-Hilgard, Gravelly/Snowcrest, and Tobacco Root Ranges forming distinct habitat islands (Figure 51).

Extensive areas of potential habitat show evidence of moderate to severe degradation (Figures 52 & 53). The most severe degradation is in the Big Sky area where development associated with ski resorts overlaps high quality wolverine habitat. Extensive snowmobiling activity in the non-wilderness areas of the mountains may be causing moderate but widespread habitat degradation in the area. The actual effect of snowmobile activity on wolverine is unknown so a conservative approach was used for this model. Areas with the most intense snowmobile activity (> 75% of area tracked) as obtained by aerial surveys was assigned a coefficient of 0.25 meaning that the maximum amount that snowmobiling could reduce habitat quality in the model was 25%. In other words, the best wolverine habitat with the most intense snowmobile activity still retained 75% of its habitat value in the model. Because of the uncertainty regarding the actual effect of snowmobiling on wolverine habitat quality, the results of this model should be interpreted with caution. However, whatever the actual effect of snowmobiling may be, it is clear the effect is widespread through the majority of non-wilderness areas of the assessment area.

Wolverines appear to be able to cross a variety of habitat types and terrain. The availability of radio telemetry and GPS data provided the opportunity to assess the likelihood that wolverines would be able to cross particular habitats. In addition, GPS data from a wide ranging dispersing male (Inman *et al.* 2005) provided insights into the limits of habitat quality that wolverine will travel through. Based on these data, it appears that habitat linkage for wolverine is not limiting in the Madison Valley and no areas of the valley are below the limits of habitat quality where wolverines have been observed (Figures 54 & 55). However, these maps predict the probability that an animal would be willing to cross a particular area but do not predict the probability of success that a wolverine could actually cross a particular area. Areas with the highest quality connectivity are therefore most likely to provide linkage areas where wolverines can successfully traverse from one habitat core to another. Within the assessment area, outstanding potential linkages occur near Papoose Creek and at Raynold's Pass with high quality linkage habitat in between (Figure 55). This area appears to remain effective for high quality wolverine connectivity (Figure 56) although residential development in the area has reduced connectivity slightly between the two corridors and may be narrowing the width of the effective corridors. At low elevations, roads and residential development are the main sources of connectivity loss but snowmobiling may an additional source of loss near Raynold's Pass (Figure 56).

Conservation Strategies:

Because wolverine prefer rugged, high elevation habitat unsuitable for most human development and are located mostly on public land, habitat for this species appears relatively secure within the assessment area. However, wolverine may be vulnerable to a number of threats so the following conservation strategies should be implemented:

- Maintain connectivity between mountain ranges. Within the assessment area the most important linkage zone is the area between Papoose Creek and Raynold's Pass. Development in this area should give a high priority to the areas value as a linkage zone for wolverine and many other wildlife species (e.g. boreal toad, grizzly bear, pronghorn). Highway improvement projects in this area should consider methods to reduce wolverine mortality by providing safe passage across roads in the area.
- Policies regulating snowmobile use on public lands should be reviewed for their potential impacts on wolverines. Surveys indicate that snowmobile use is widespread in the area so any impacts they may have on wolverines are occurring over significant portions of wolverine habitat. In lieu of better information about the impacts of snowmobile use on wolverines, efforts should be made to provide refuges and corridors for wolverines to use to avoid snowmobile activities.
- Trapping regulations should remain flexible to emerging data about wolverine demographics. To date, MTFWP has been an active partner in wolverine studies in the region and has been receptive to modifying regulations according to research findings. This cooperation provides a positive model for managing this elusive and understudied furbearer.

WOLVERINE POTENTIAL HABITAT

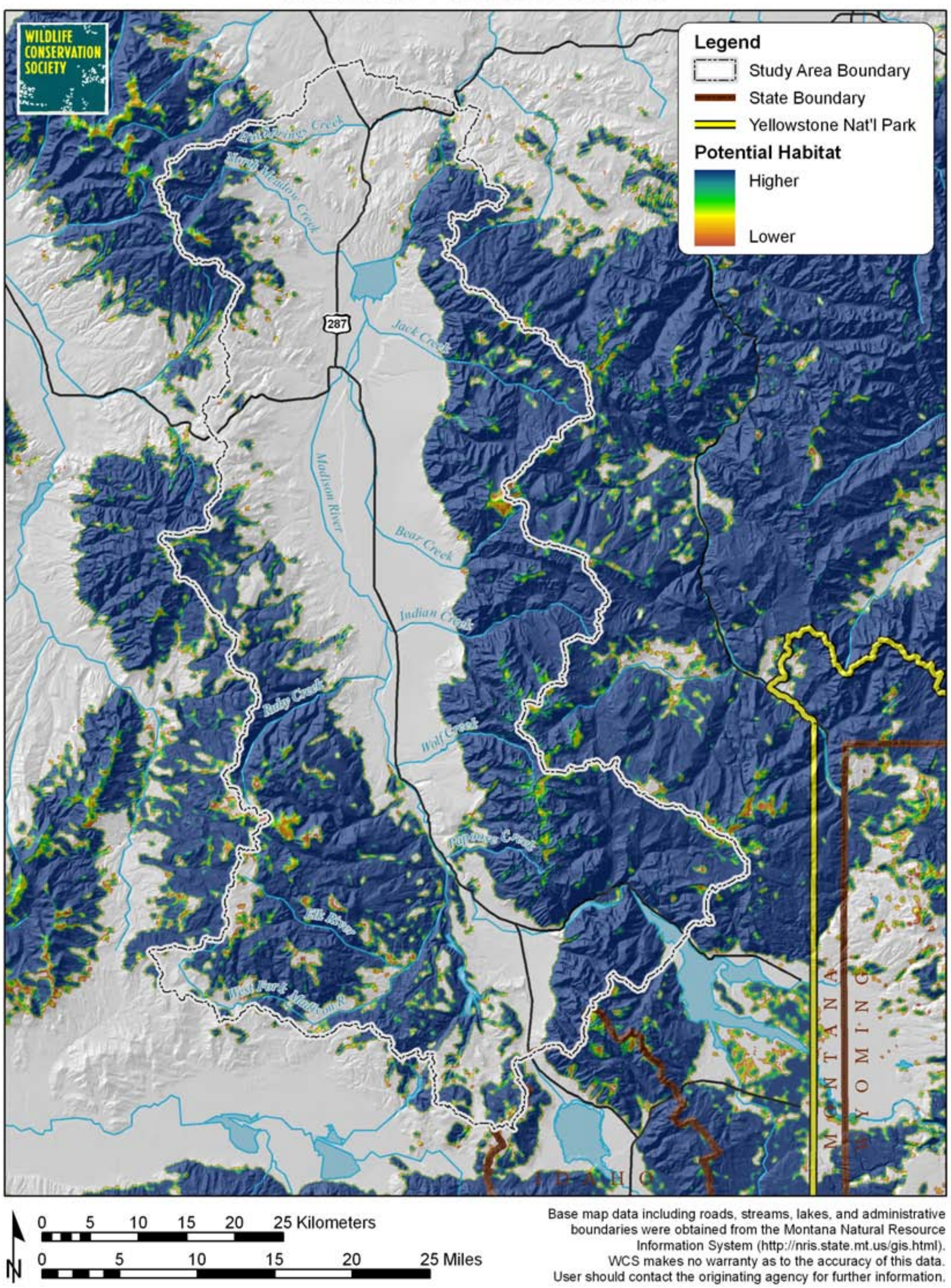


Figure 51. Wolverine potential habitat in the Madison Valley.

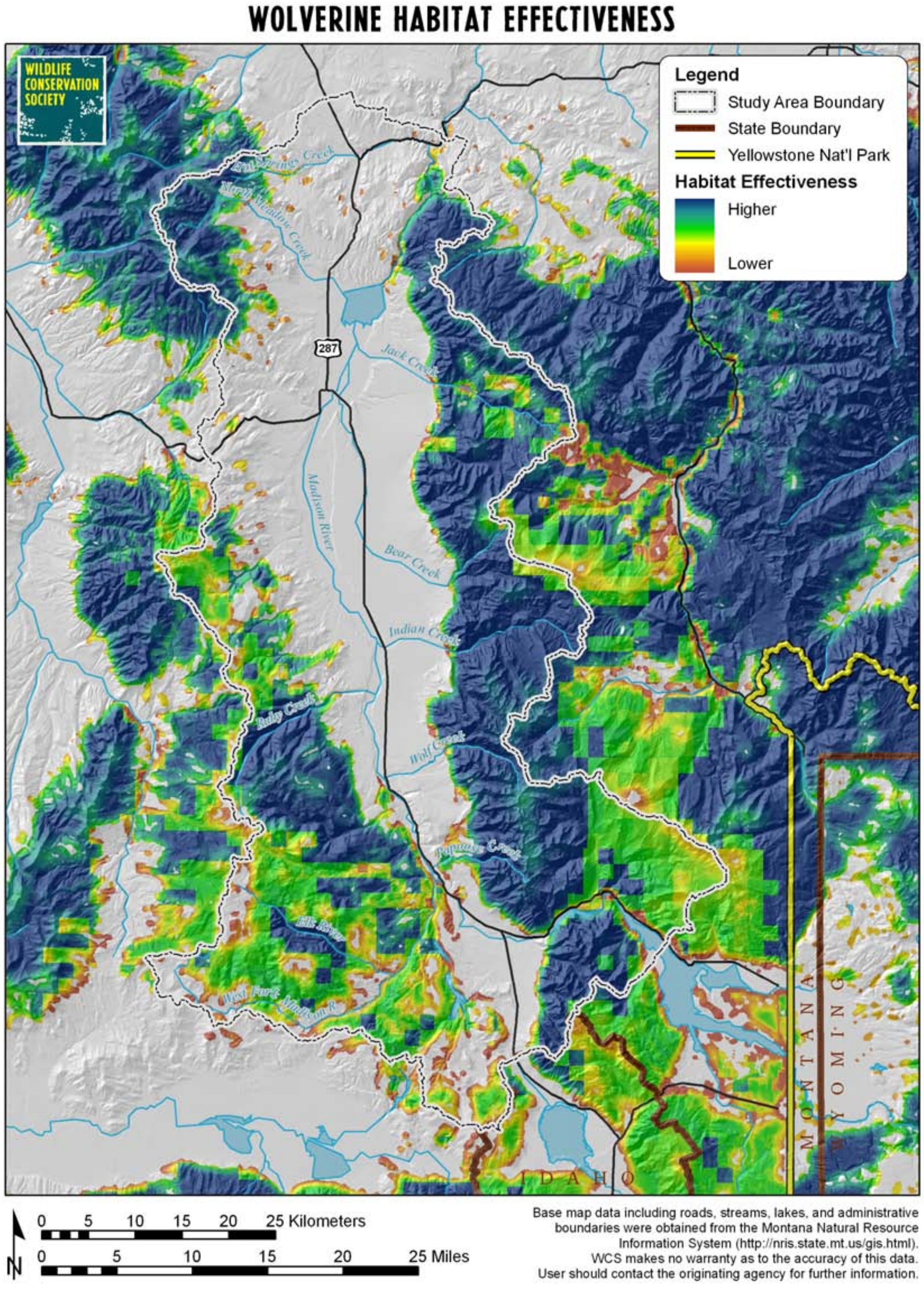


Figure 52. Wolverine habitat effectiveness in the Madison Valley.

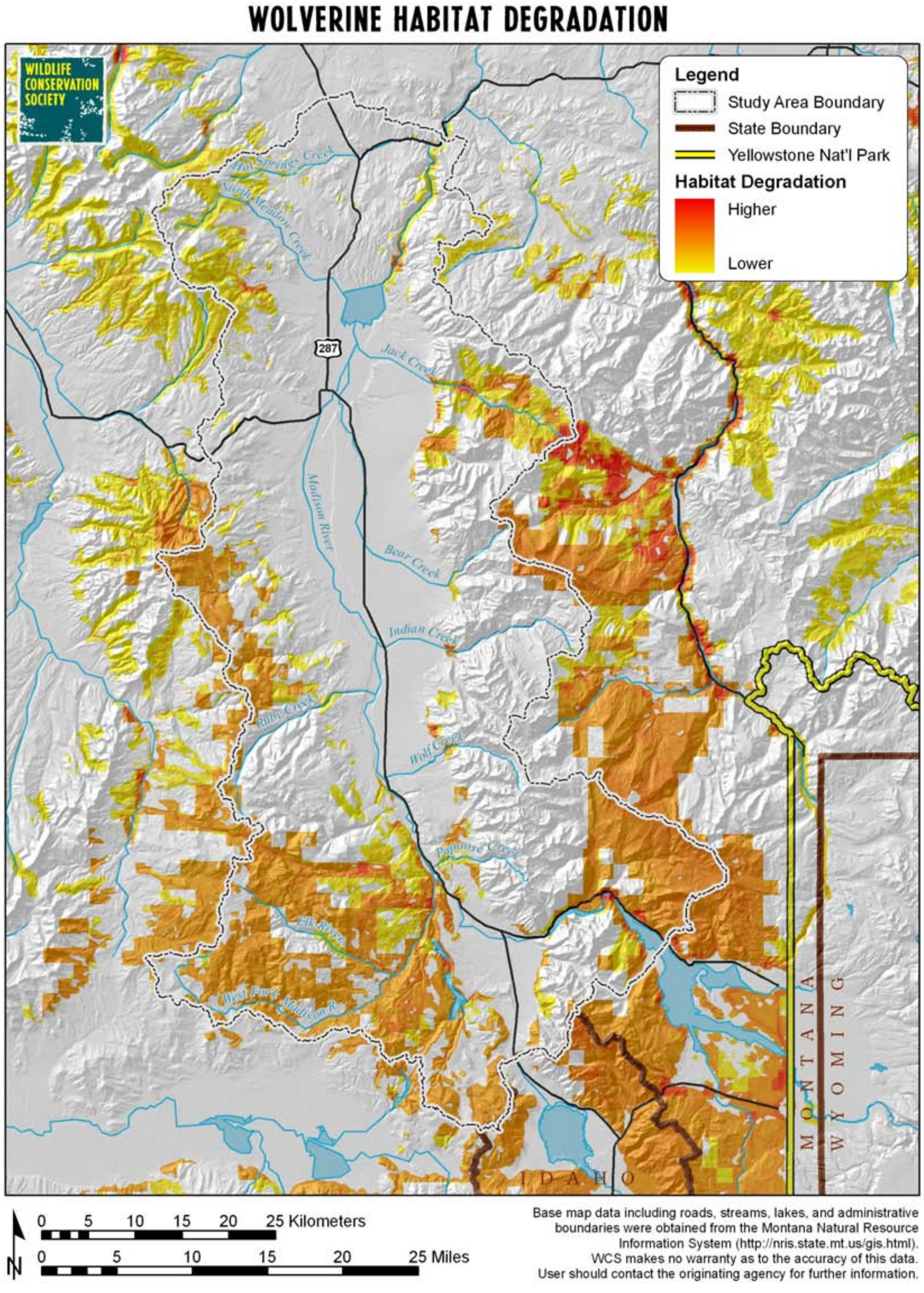


Figure 53. Wolverine habitat degradation in the Madison Valley.

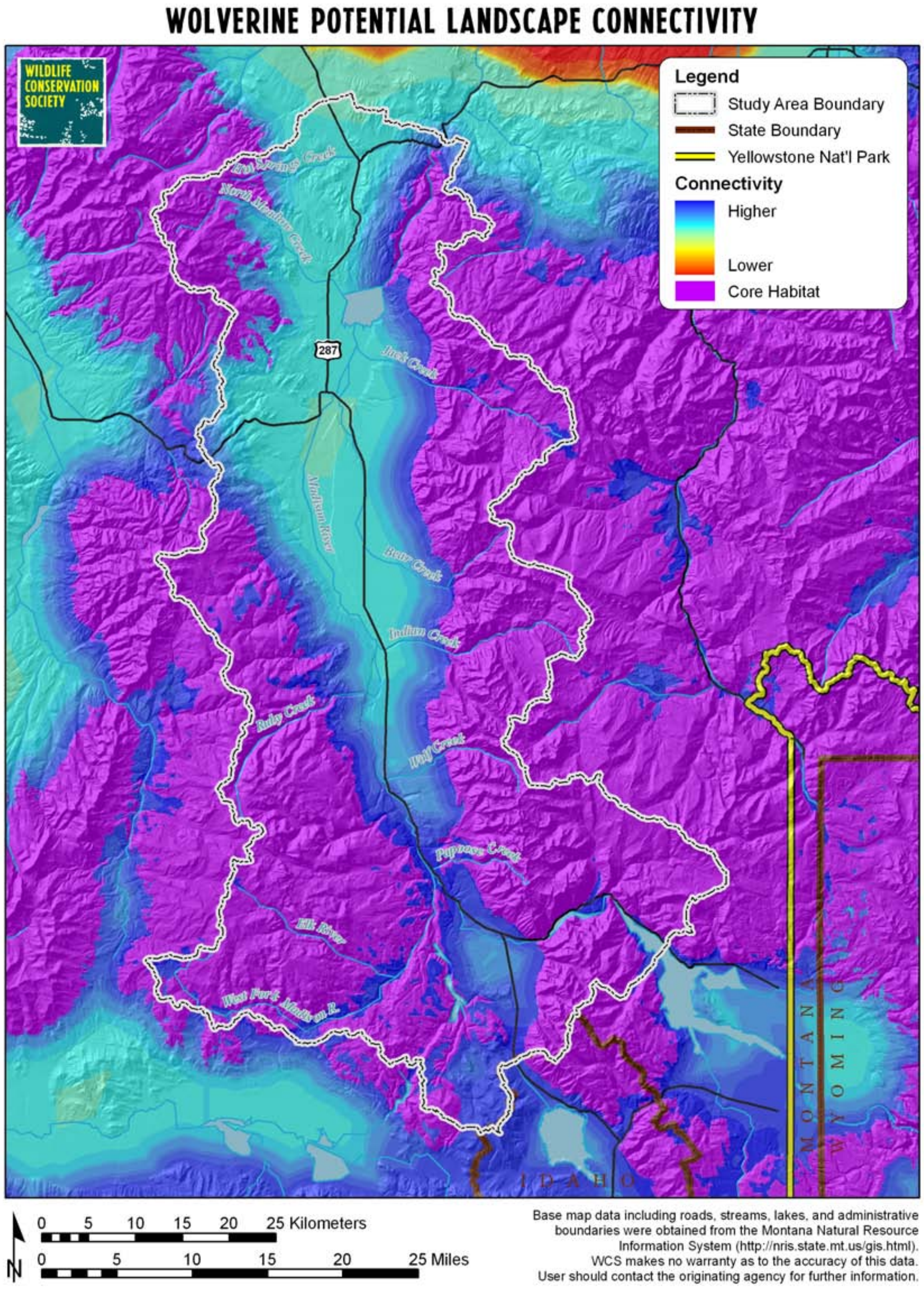


Figure 54. Wolverine potential landscape connectivity in the Madison Valley.

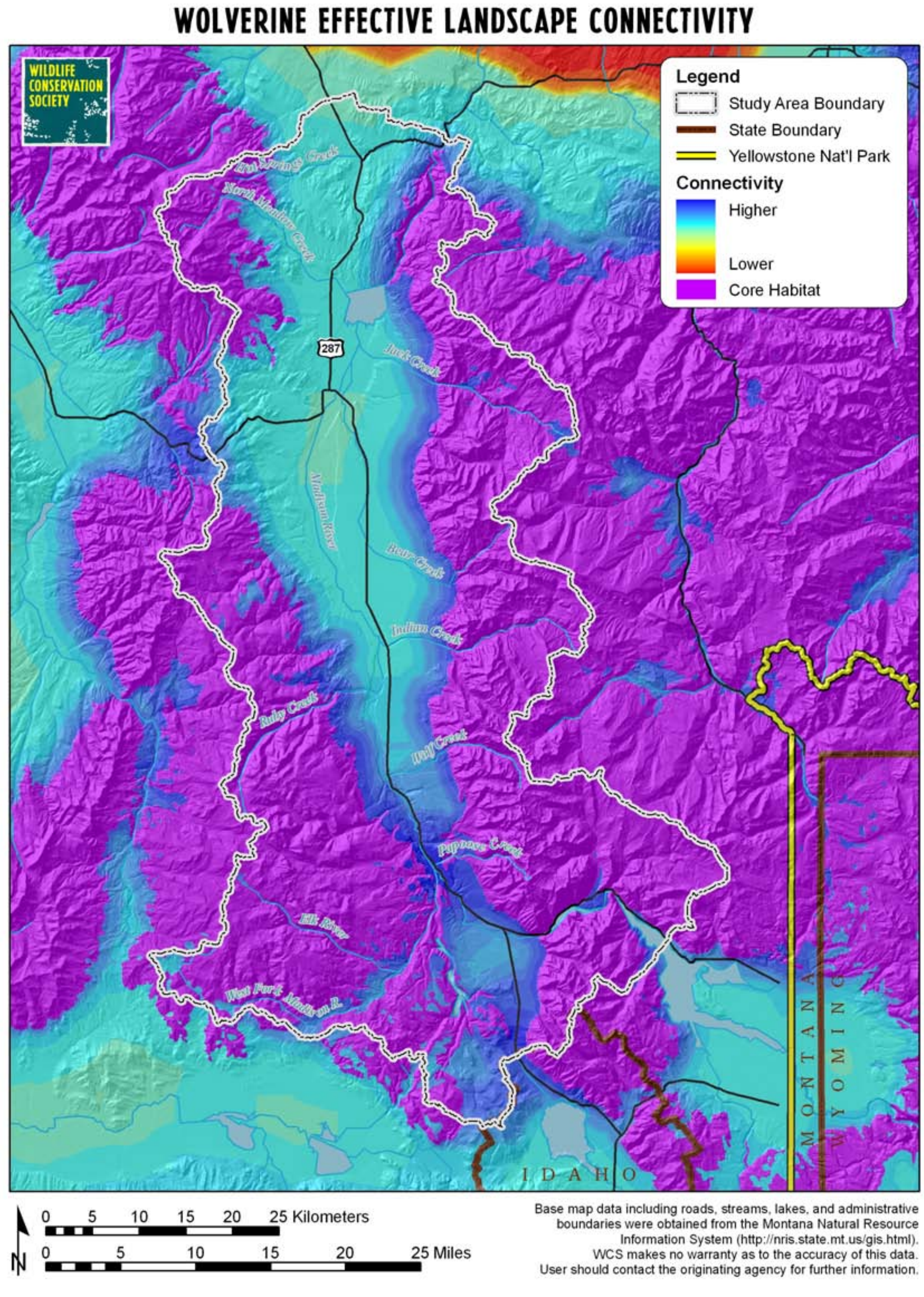


Figure 55. Wolverine effective landscape connectivity in the Madison Valley.

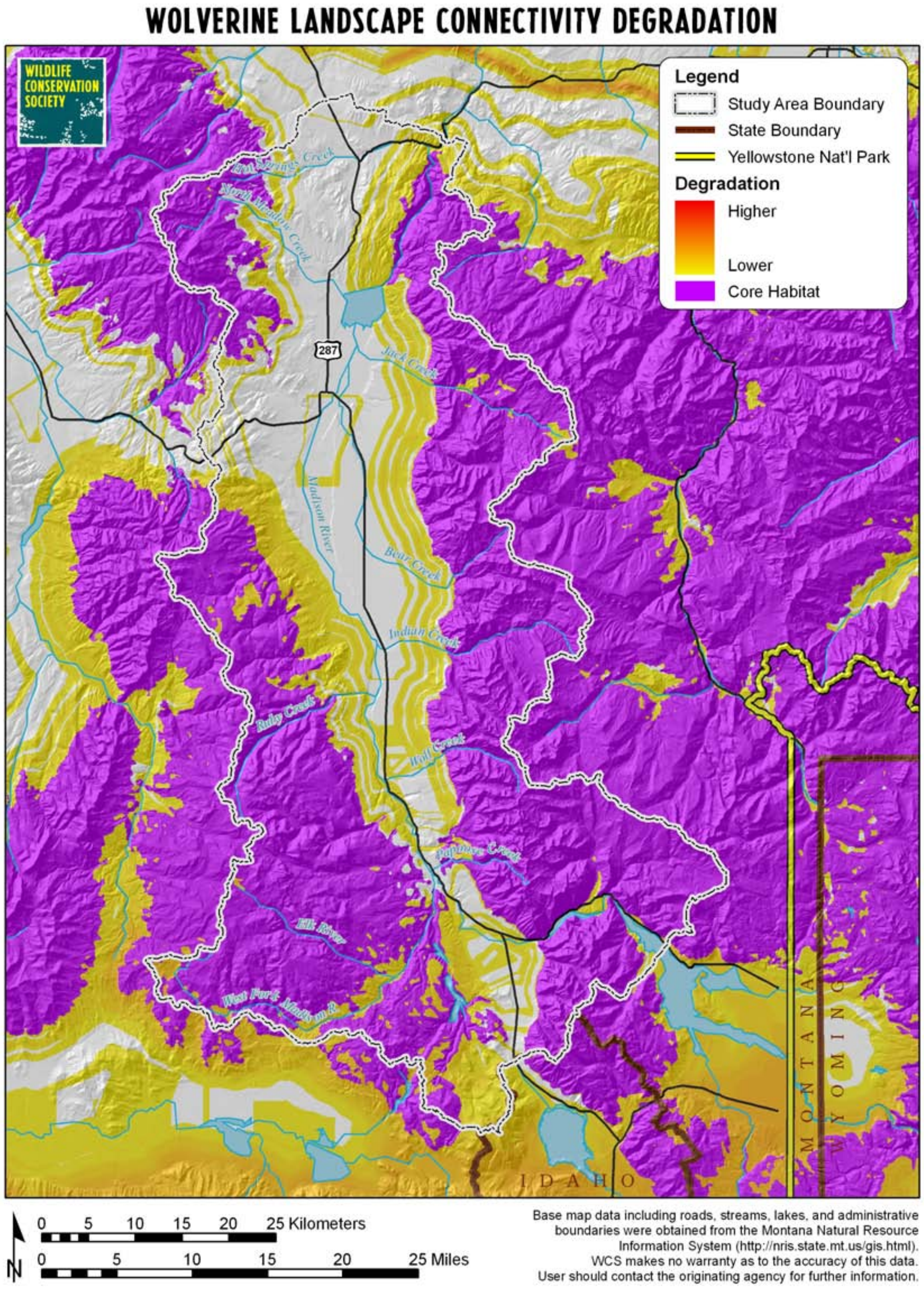


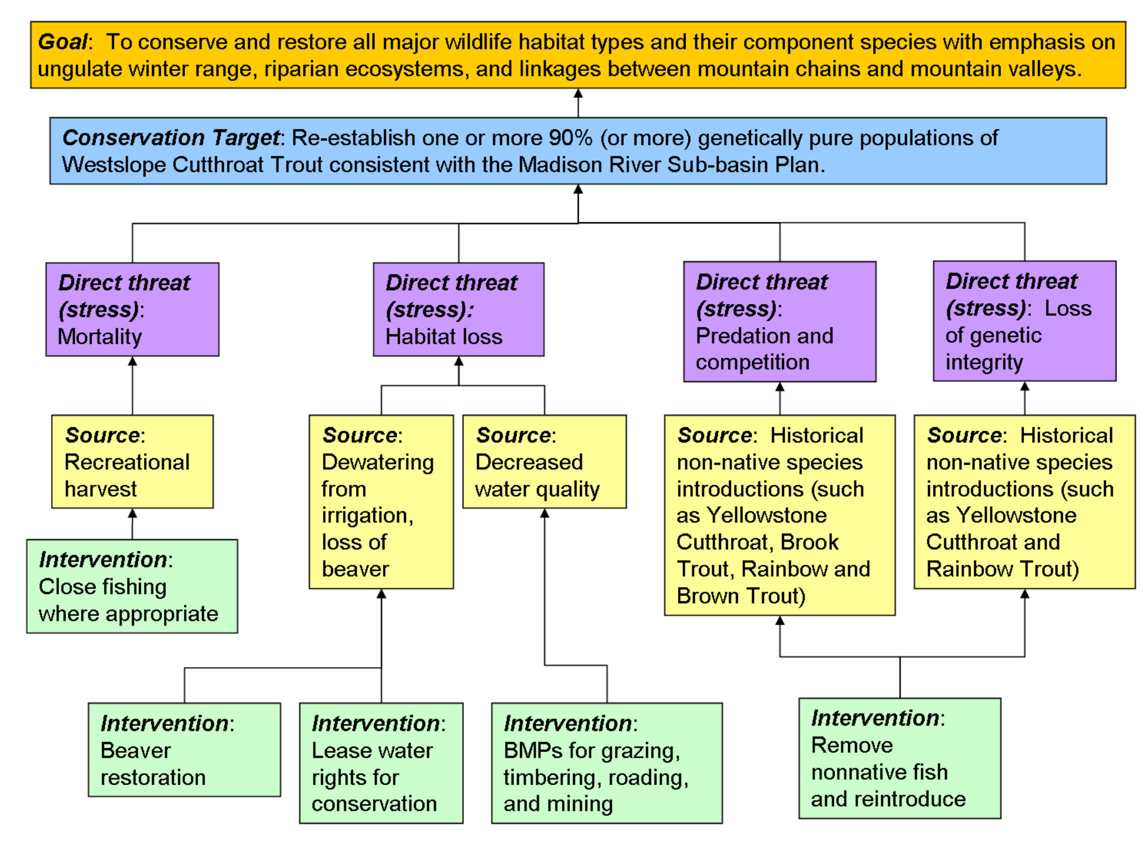
Figure 56. Wolverine landscape connectivity degradation in the Madison Valley.

Westslope Cutthroat Trout (Oncorhynchus clarki lewisi)

Current Status:

Westslope cutthroat trout are arguably one of the most definitive fish of Montana having been described by Lewis & Clark in 1804 near the Great Falls of the Missouri. This recognized subspecies historically was found throughout the Madison River drainage as well as most streams in western Montana. Today, genetically pure populations of westslope cutthroat trout occupy less than 5% (estimates range from 1-4%) of their historical range. Moreover, this distribution is extremely fragmented with populations separated from each other (and hence, incapable of being naturally recolonized) by nonnative salmonids, dewatered stream reaches, natural and unnatural fish barriers, etc. Adding to the conundrum experienced by this species is the observation that allele frequencies between extant populations may vary greatly implying local adaptation, mutation, and/or founder effects or bottlenecks in the histories of these stocks. Westslope cutthroats occupy the tops of trophic webs in mountain streams where they are still found and signify cold clean well aerated streams suffering little long-term ecological degradation. In the Madison River system, westslope cutthroat trout are found in a number of tributaries, however their genetic integrity is quite variable. Currently, an Upper Missouri River Basin Plan is being produced by MFWP for release in early 2007.

Current Threats:



Many extant and historical anthropogenic stressors, including historical over harvest, predation, competition, genetic mixing with introduced nonnative salmonids, and decreased habitat extent and quality affect westslope cutthroat trout. In-stream habitat is negatively impacted through both in-stream factors (i.e., culverts that impede fish movement and lack of woody debris reducing pool habitat and cover while increasing water temperature) as well as factors occurring on upland sites within drainages. Siltation arising from road building, timber harvest, ORV use, fire, and grazing all decrease the habitat quality for this cold water fish. Furthermore, removal and/or degradation of riparian vegetation itself severely affects trout habitat. Population fragmentation is an ongoing threat to the integrity of westslope cutthroat trout.

Habitat Analysis:

Habitat for this species was not modeled due to insufficient data availability. However, in the Madison River basin it is estimated that westslope cutthroat trout historically (*circa* 1800) inhabited approximately 1222 miles of stream (Figure 57). Most of these reaches were characterized by cold and clean running water with healthy riparian communities (not always composed of deciduous and conifers, but, graminoid-dominated meadow habitats, as well). Moreover, pool habitat is necessary for adult overwinter survival in that these sites remain free of anchor ice. Young cutthroats, however, can overwinter in streambed interstices which can increase the threats of fine sediment buildup and embeddedness. Historically, spring runoff events could flush these fines from cutthroat habitats and it appears that some populations can withstand higher sediment loads than others.

Conservation Strategies:

The conservation of westslope cutthroat trout is a topic of great interest and research. Therefore, conservationists should become familiar with local research, threats, and conservation strategies and the Madison Valley is no different. Shepard *et al*. (2003) identified 63 miles of stream comprising 13 conservation populations in the Madison River drainage for greatest conservation efforts (Figure 58). It should be noted that the only 100% genetically pure stocks of westslope cutthroat trout known in the Madison drainage at this time (2006) are found in Wally McClure Creek (a small tributary to Hebgen Reservoir that goes subsurface) and an unnamed tributary to Grayling Creek that is isolated by a road embankment (Pat Clancey, MFWP; pers. comm. 7 Sept 2006).

The first step in conservation of this subspecies should be the preservation of the remaining pure, and nearly pure, stocks. Ongoing research by the University of Montana and Montana Department of Fish, Wildlife and Parks in conjunction with the Westslope Cutthroat Interagency Conservation Team should be the driving force behind these efforts. Moreover, the success of this conservation is reliant upon the health of the aquatic, riparian, and upland communities in each drainage. Here is where land-use planning can be of great benefit. Furthermore, conservation of riparian areas, efforts to reduce erosion caused by roading, logging, ORV use, and grazing [through Best Management Practices (BMP) incorporating on-the-ground monitoring], can have great downstream ramifications increasing the potentials for cutthroat dispersal and/or reintroduction. Decommissioning of roads, and mandating that the few new roads built conform to fish- and beaver-friendly standards should be strongly pursued (see Draft Partnership Strategy for the B-D NF prepared by Ecosystem Research Group, www.ecosystemrg.com).

All resource use activities (timber harvest, reclamation, mining) on public lands and subdivision development activities in new developments should be required to follow the Inland Native Fish Strategy (INFISH) standards for Riparian Management Objectives and Riparian Habitat Conservation Areas (U.S. Department of Agriculture and U.S. Department of the Interior 1995). Education for private landowners should be provided on these standards to assist in reducing negative impacts to aquatic and riparian habitats.

Reintroduction of westslope cutthroat trout may provide hope for this species. However, to make such introduction successful in the long term, other management activities would likely need be applied including catch and release only (already in place), potential removal of nonnative salmonids, implementation of the maintenance of adequate in-stream flows especially during periods of drought, effective reduction and removal of fish entrainment sites, restoration of viable and a widely distributed beaver population, restoration of damaged riparian vegetation to act as silt traps and provide shading yielding cooler water temperatures and to buffer large runoff events, as well as disease-free and local rearing efforts. Little if anything can be done to address the loss of drainage-specific genetic variation that has already happened but use of Remote Site Incubators shows promise in imprinting local behavioral (and potentially genetic) characteristics.

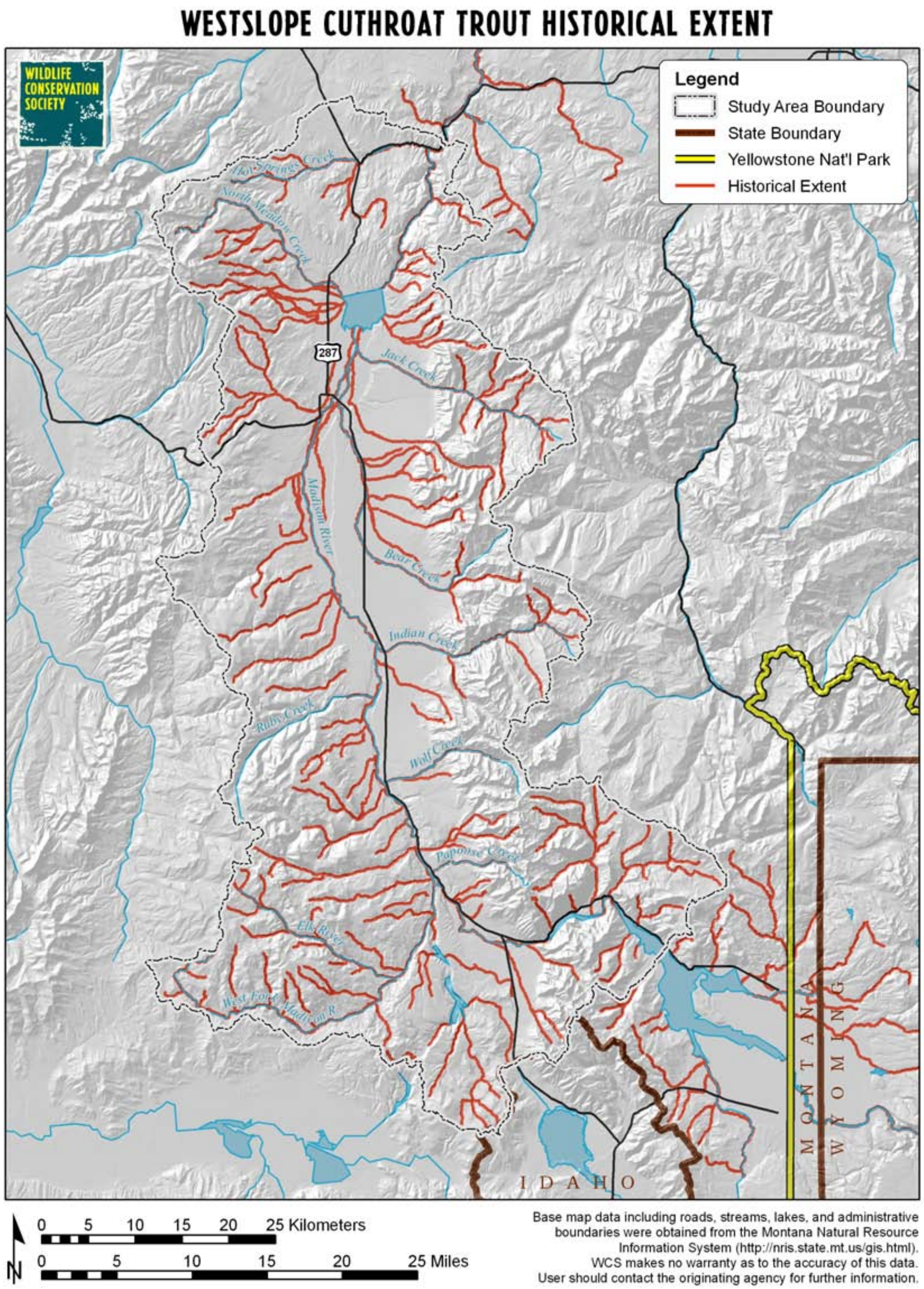


Figure 57. Historical distribution of Westslope Cutthroat Trout in the Madison River drainage.

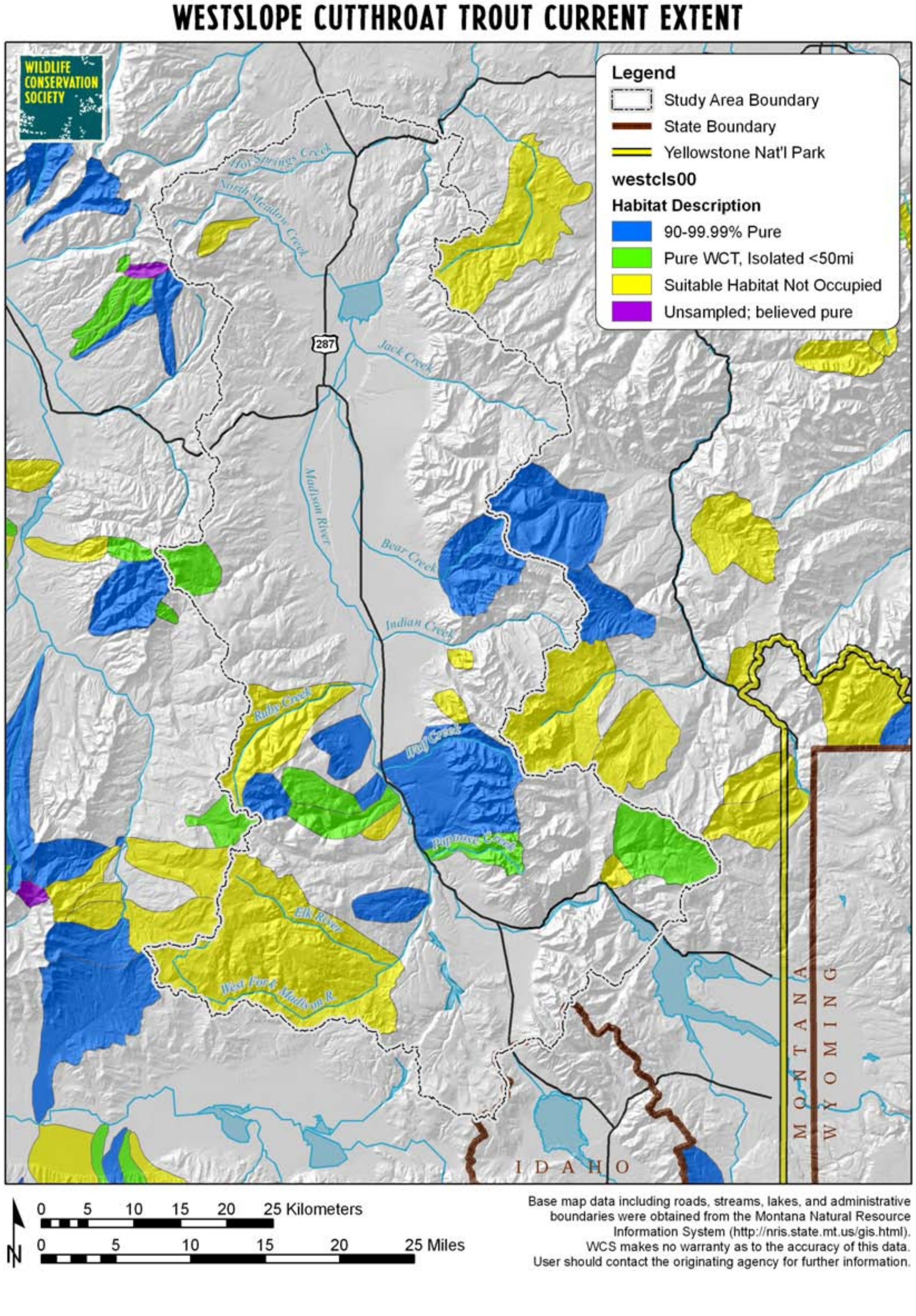


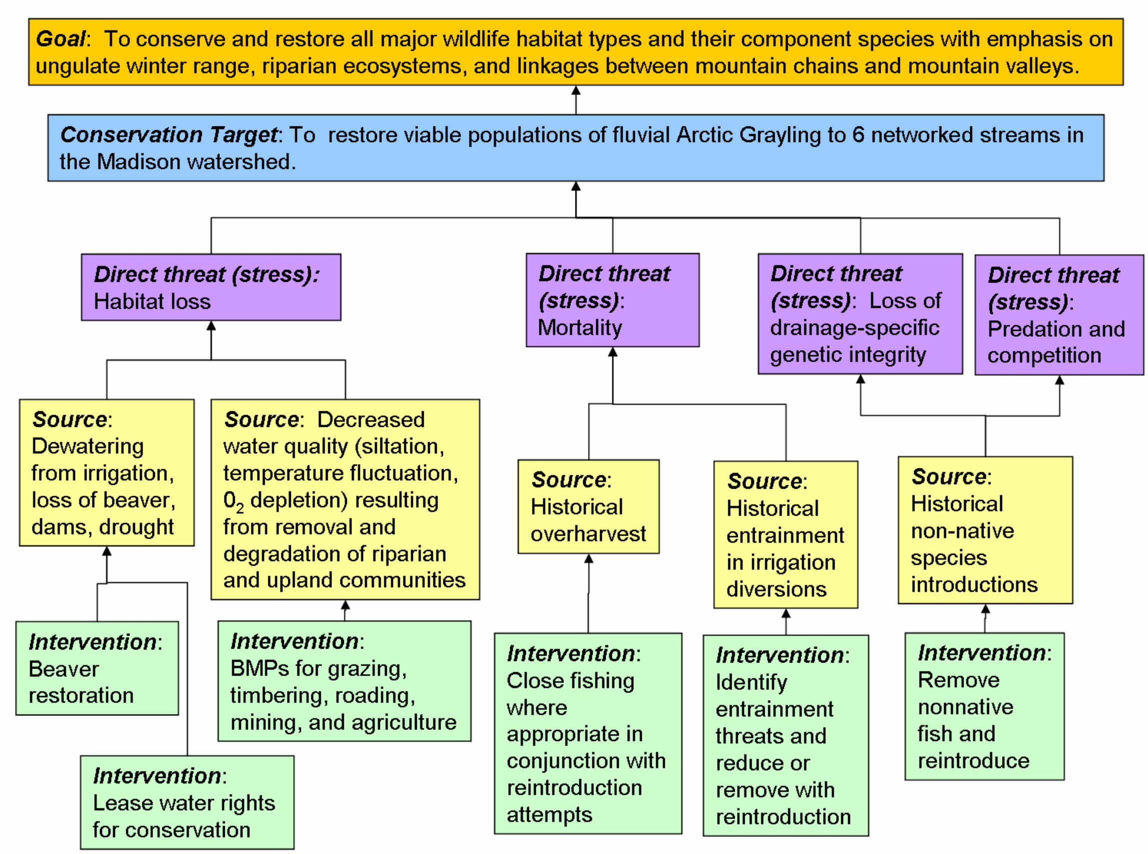
Figure 58. Extant distribution of Westslope Cutthroat Trout in the Madison River drainage.

Fluvial Arctic Grayling (Thymallus arcticus montanus)

Current Status:

Fluvial arctic grayling are likely extinct in the Madison River system. However, in 1994, the USFWS determined to treat the remnant Madison River population as indigenous and furthermore, anecdotal evidence continues to point to a possibility of remnant populations (separate from the adfluvial strains historically introduced into Ennis Lake) remaining in the Upper Madison River. The Madison River population, along with the extant population inhabiting the Big Hole River were identified by the USFWS (59 FR 37738) as the two sole remaining elements making up the Upper Missouri Basin Distinct Population Segment (DPS). It is assumed that only the Big Hole River element exists, the only remnant of a fish found throughout the rivers of the Missouri basin upstream from Great Falls and now confined to 4-5% of its historical range (Kaya 1992). Fluvial arctic grayling (sometimes called the Montana arctic grayling) spend their complete lives in rivers and, to a lesser degree, smaller streams. They are in-stream spawners that do not build redds. This facet of their natural history makes them quite sensitive to sedimentation as well as depredation of eggs by nonnative salmonids. Other grayling stocks (called adfluvial or lacustrine) have been introduced into many Montana lakes including Ennis Reservoir. These fish generally breed in adjacent stream reaches, returning to the lake for the majority of their lives. Adfluvial grayling are behaviorally distinct from the native fluvial grayling. The only remaining native adfluvial grayling are possibly those inhabiting Red Rocks Lakes and Elk Lake.

Current Threats:



Fluvial arctic grayling are, and have been, negatively impacted by many of the same stressors affecting westslope cutthroat trout, namely, overharvest, predation and competition from introduced nonnative fishes, and habitat loss in both quantity and quality. The latter has resulted from land use changes over the past century such as logging, mining, dewatering, and agricultural runoff all leading to higher daily and seasonal water temperatures, greater siltation, and lowered dissolved oxygen levels. Moreover, the deleterious effects of these impacts has been exacerbated by drought and climate change.

Habitat Analysis:

Habitat for this species was not modeled due to insufficient data availability and it cannot be precisely estimated which streams in the Madison Valley historically supported fluvial arctic grayling (Figure 59). This figure may, in fact, overestimate the historical range of the species within the Madison drainage. Grayling are fond of lower and intermediate gradient reaches of larger cool water streams with adults preferring pool habitats. However, historically, in the Madison system, grayling were found in the mainstem Madison River, and Grayling, Cougar, and Duck Creeks (upstream from our project area). Additionally, they were likely found in many of the lower reaches of the Madison's tributaries such as the West Fork, Elk River, North Meadow Creek, Beaver Creek, Watkins Creek, and Jack Creek, among others. Wherever gradients were not high, side channels existed with good riparian cover and deep pools, and often where beavers were active were reaches favored by these natives.

Conservation Strategies:

Reintroduction of fluvial arctic grayling may provide hope for this unique species. The Fluvial Arctic Grayling Workgroup (MFGW) developed a plan to research, protect, and restore fluvial arctic grayling (FGW 1995). Most efforts have been focused on the Big Hole River drainage; however, extension to other drainages is underway (see below). To make such introduction successful in the long term, other management activities would likely need be applied including catch and release only (already in place for fluvial populations in the Madison River drainage for approximately 8 years), potential removal of nonnative salmonids, implementation of the maintenance of adequate in-stream flows especially during periods of drought, effective reduction and removal of fish entrainment sites, restoration of viable and a widely distributed beaver population, restoration of damaged riparian vegetation to act as silt traps and provide shading yielding cooler water temperatures and to buffer large runoff events, as well as disease-free and local rearing efforts. Little if anything can be done to address the loss of drainage-specific genetic variation that has already happened but only fish originating from fluvial stocks must be used for reintroduction efforts. Remote site incubators (RSI) show great promise in the imprinting of fluvial behavior patterns and are successfully and adaptively being implemented in the Upper Ruby River (Magee *et al*. 2005).

The successful conservation of fluvial arctic grayling is reliant upon the health of the aquatic, riparian, and upland communities in each drainage. Here is where land-use planning can be of great benefit. Furthermore, conservation of riparian areas, efforts to reduce erosion caused by roading, logging, ORV use, and grazing [through Best Management Practices (BMP) incorporating on-the-ground monitoring], can have great downstream ramifications, increasing the potentials for grayling dispersal and/or reintroduction. Decommissioning of roads and mandating that the few new roads built conform to fish- and beaver-friendly standards should be strongly pursued (see Draft Partnership Strategy for the B-D NF prepared by Ecosystem Research Group, www.ecosystemrg.com).

All resource use activities (timber harvest, reclamation, mining) on public lands and subdivision development activities in new developments should be required to follow the Inland Native Fish Strategy (INFISH) standards for Riparian Management Objectives and Riparian Habitat Conservation Areas (U.S. Department of Agriculture and U.S. Department of the Interior 1995). Education for private landowners should be provided on these standards to assist in reducing negative impacts to aquatic and riparian habitats.

Experimental reintroduction efforts have been performed in the East and West Gallatin Rivers without great success. Successful reintroduction efforts are continuing in the Upper Ruby River as well as the North and South Forks of the Sun River. More challenges have been met with reintroduction efforts in what has been termed the Missouri River Headwaters taking in the Lower Madison and lower West Gallatin Rivers. Reintroductions are currently underway in Cougar Creek, and the Gibbon and Firehole Rivers in Yellowstone National Park. The former is a tributary to the Upper Madison River whereas the two rivers provide the birth of the Madison River. Ultimately, reestablishment within the Madison River is not without hope and we urge those involved to additionally consider reintroduction to the Upper Madison River, especially in more upstream reaches supporting healthy riparian communities and beaver ponds. Moreover, it is apparent that a change in public attitudes toward such restoration efforts would go long way to increase the chance of long-term success in such a renowned trout stream as the Madison River.

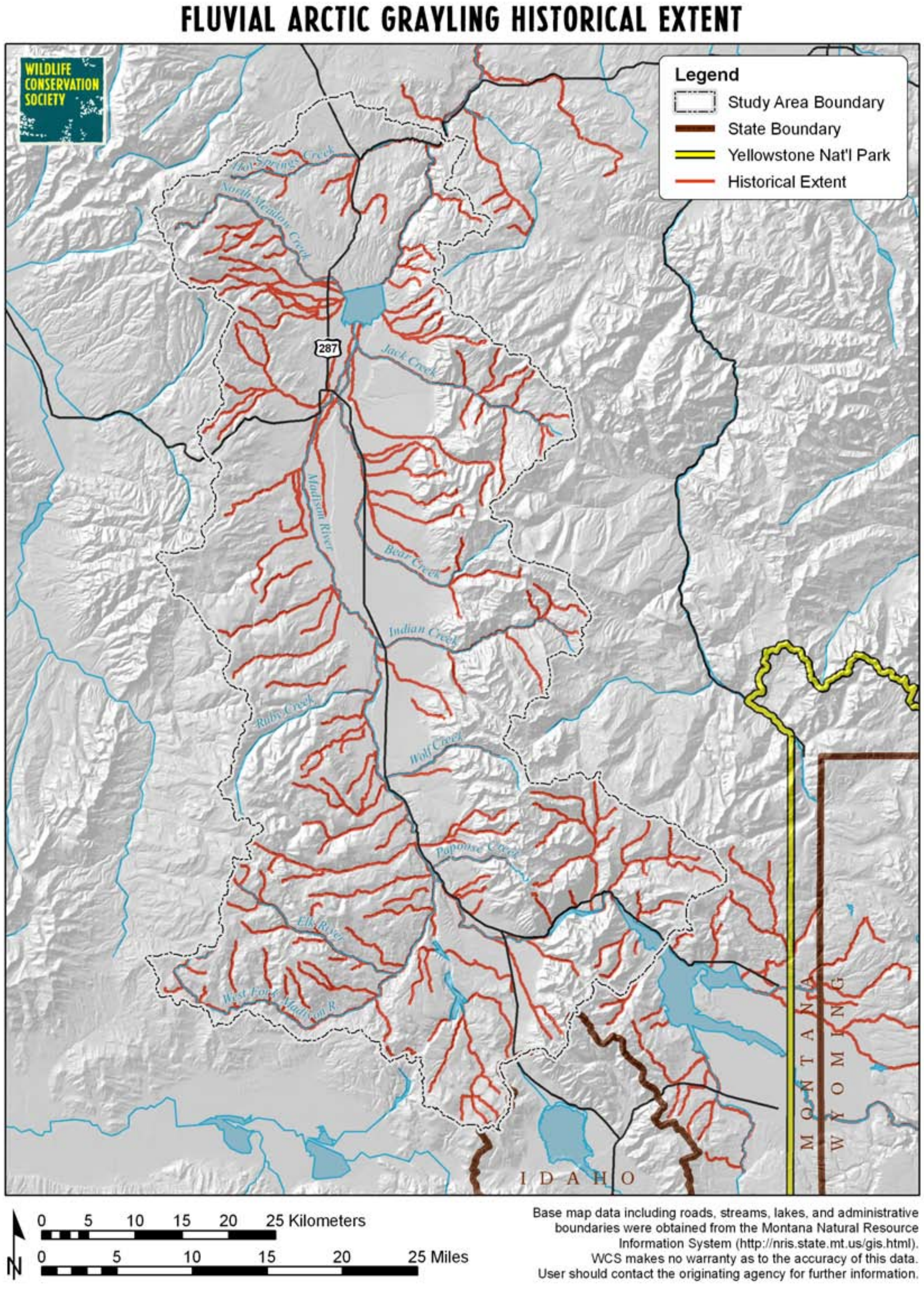


Figure 59. Historical distribution of Fluvial Arctic Grayling in the Madison River drainage.

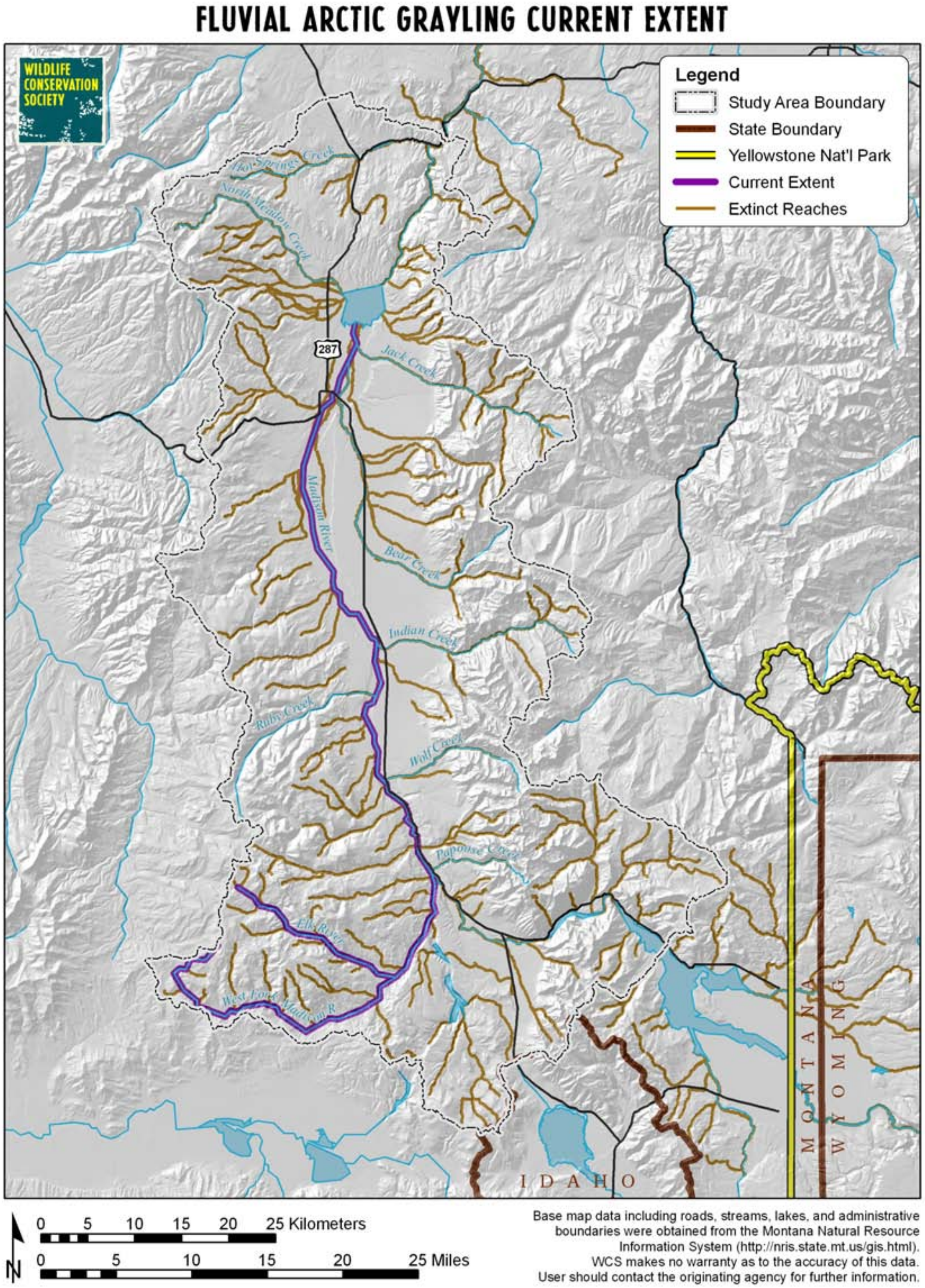


Figure 60. Extant (rumoured) distribution of Fluvial Arctic Grayling in the Madison River drainage.

Summary Analysis

Definitions:

Species results were analyzed in combination to identify conservation priorities in the Madison Valley. The ultimate goal of this assessment is to determine where conservation actions are most needed in the Madison Valley and what actions will be most effective. We analyzed the combined species results to help policy makers, conservationists, and land use planners address several types of conservation goals as described below:

- *Hot Spots:* Areas that support a large number of wildlife species relative to other areas. Protecting habitat and ecosystem function in these areas will preserve habitat for a greater number of species than would similar efforts applied elsewhere. However, there is no guarantee that wildlife diversity hot spots contain a sufficient area or distribution of habitats to sustain populations of all species present. Therefore, conserving only relatively small hotspots, as are found in the Madison Valley, is likely to be a helpful but insignificant step by itself.
- *Connectivity Hot Spots:* Areas with a high probability of use by a relatively large number of species for maintaining access to relatively isolated habitat patches. Connectivity between habitat patches is necessary to allow genetic exchange between semi-isolated populations, allow dispersal and recolonization of species into unoccupied habitats, and to provide individuals with a sufficient amount of habitat within their home range to survive and reproduce. In addition, connectivity may be important for allowing species to more uniformly distribute themselves among available habitat to prevent over utilization of some habitat patches (e.g., elk grazing distribution).
- *Threat Priorities:* Human Activities that have a relatively high negative impact on wildlife compared with other activities. Threats are prioritized either by the number of species they affect or by the severity of their impact. Widespread threats that affect a large number of relatively robust species may be of less concern than threats that affect fewer but highly vulnerable species.

For wildlife diversity and connectivity hot spots, we estimated both potential and currently effective hotspots and estimated the amount of past habitat loss from these results. Documenting past habitat loss or degradation is important for two reasons. It illustrates the amount of habitat that has already been lost which can provide important clues about causes of species declines as well as potential strategies for restoration. Second, areas with past habitat loss or degradation are a good predictor of where future loss or degradation is likely to occur. Therefore, estimating habitat loss provides a benchmark for assessing current conditions as well as a basis for predicting future trends.

Umbrella Effects:

Central to our project has been the assumption that by centering our analyses on focal species that the needs of other species will be accounted for. Figure 61 provides information on the degree to which each focal species may serve as an umbrella for other vertebrate species. Riparian-associated boreal toads and Columbia spotted frogs provided umbrellas for the greatest number of species (the sample comprising 410 vertebrate species). Not surprisingly, focal species that are habitat generalists but require large areas of habitat provided umbrellas for more species than focal species that are habitat specialists and can occupy small patches of habitat. Grizzly bear, moose, and elk provided umbrellas for more species than did pronghorn, black-backed woodpecker, and greater sage-grouse.

However, we see a somewhat inverse relationship between the numbers of species provided an umbrella under each focal species and the vulnerability of species under the umbrella (Figure 62). These results indicate that large area generalist species tend to shelter a relatively large number of other species but a proportionately fewer number of highly vulnerable species than do species that are themselves vulnerable due to narrow habitat requirements or dependence on habitats under severe stress (i.e. aquatic habitats).

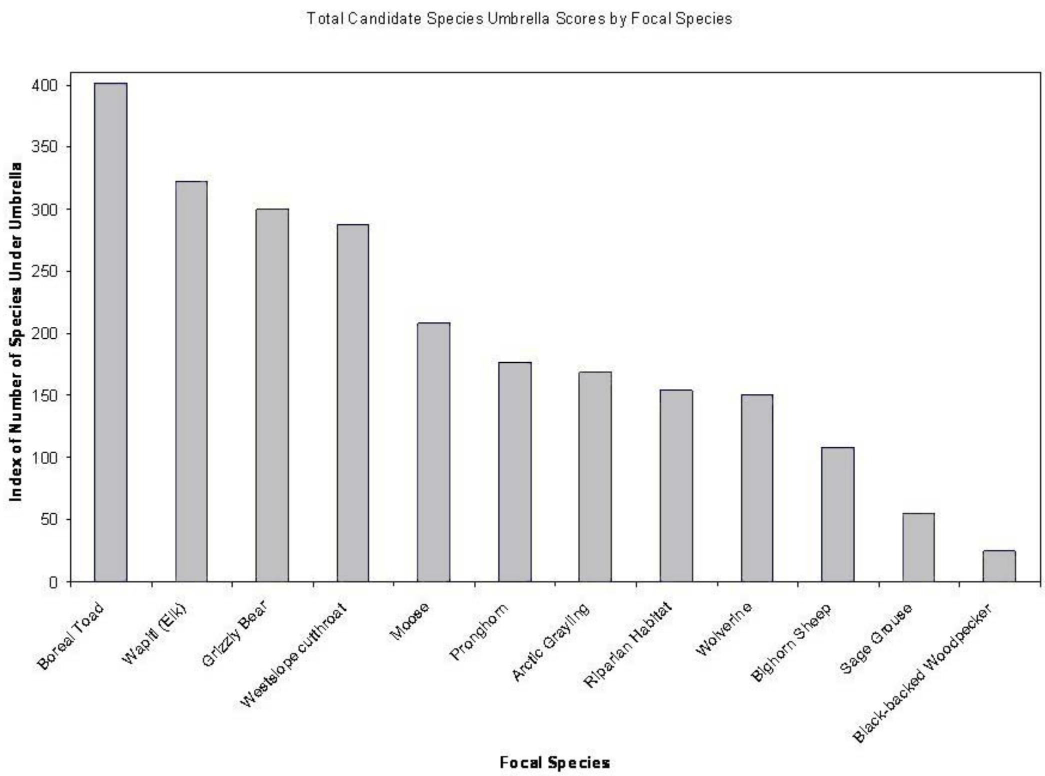


Figure 61. Number of candidate species (of 410) habitat needs provided for by each focal species selected in the Madison Valley.

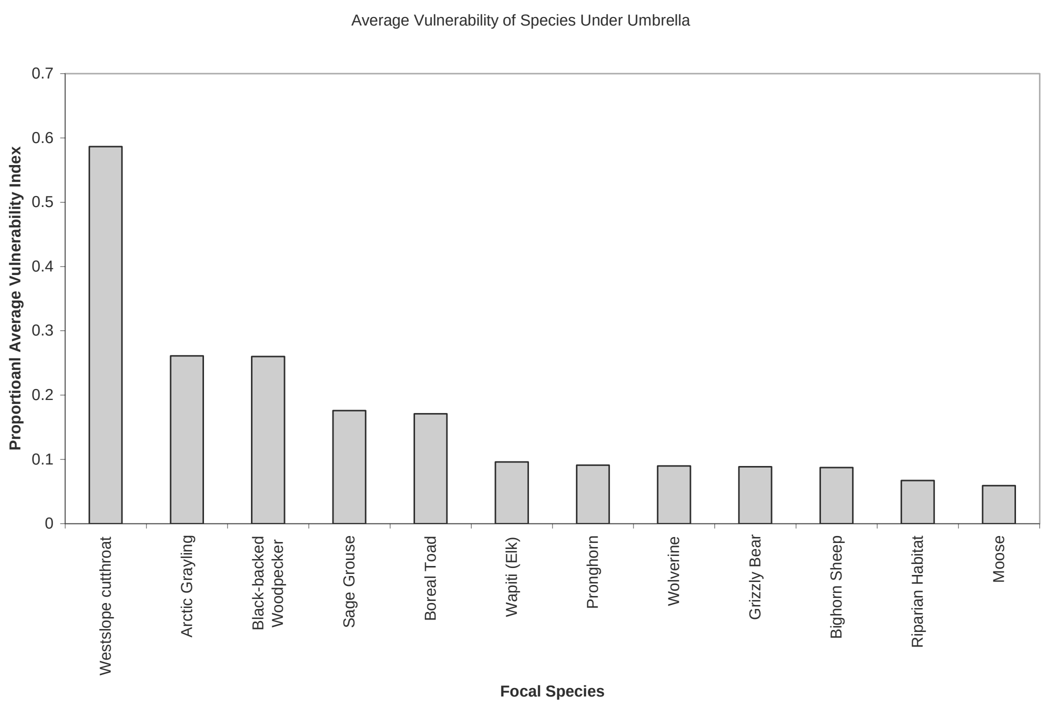


Figure 62. Proportional vulnerability of focal species in the Madison Valley.

When the number of species and vulnerability of species under the umbrella were combined, rankings of focal species were less predictable. Westslope cutthroat trout provided the best overall umbrella score followed by the boreal toad and fluvial arctic grayling (Figure 63).

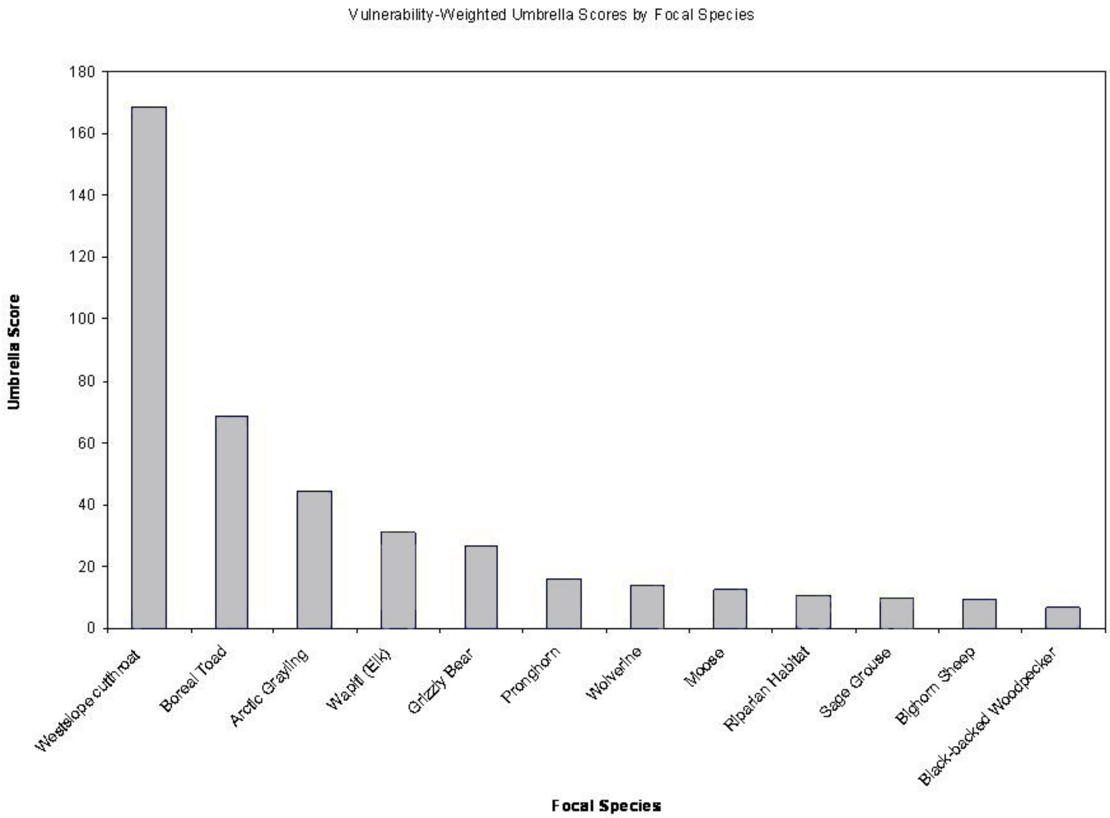


Figure 63. Vulnerability-weighted umbrella scores of focal species in the Madison Valley.

Influence of Threats:

Figure 64 shows the number of candidate species potentially affected by each threat identified through threat analysis. Not surprisingly, roads and subdivisions top the list of threats that potentially impact the most species followed by fire suppression, improper grazing, and domestic sheep allotments to form the top five. When we ranked threats by the average vulnerability scores of species potentially affected, it is clear that threats affecting aquatic, sagebrush, and burned habitats have potential affects on the most vulnerable species (Figure 65). When threats are ranked using a combination of number of species affected and relative vulnerability, roads and subdivisions again top the list of threats with legal harvest, non-native fish introductions, and fire suppression forming the top 5 (Figure 66).

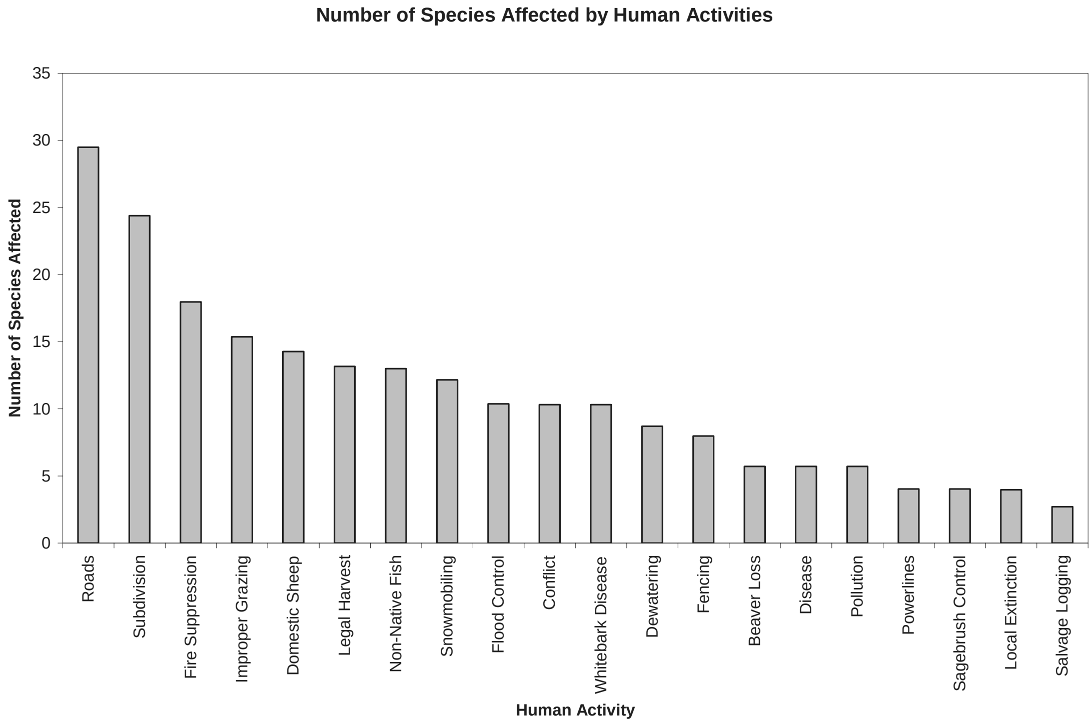


Figure 64. Number of candidate species (of 63) affected by each human activity in the Madison Valley.

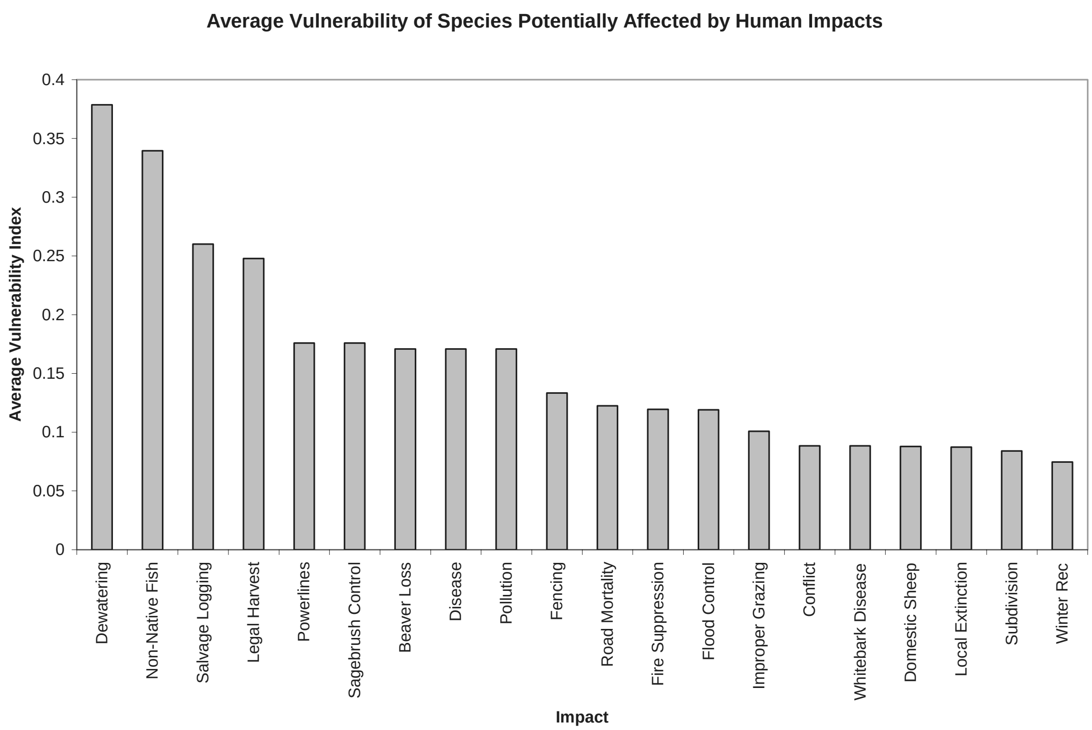


Figure 65. Average vulnerability of candidate species affected by each human activity in the Madison Valley.

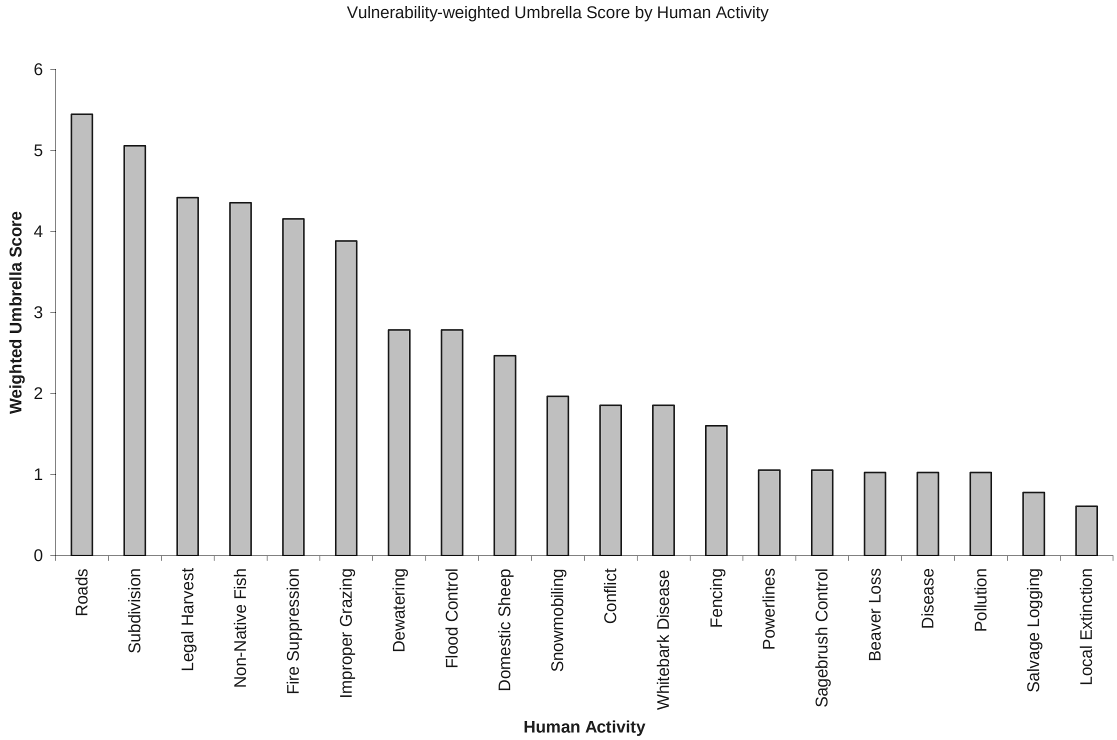


Figure 66. Average vulnerability weighted umbrella score for each human activity in the Madison Valley.

These threat rankings only estimate the relative number of species affected by each threat and the relative vulnerability of species affected. They do not indicate the severity of the threats, how widespread the threats are, or the actual impacts on affected species. For example, roads are ubiquitous across the landscape and affect almost every wildlife species in some way but the type and severity of the impact of roads on individual species varies. Animal-vehicle collisions may have a significantly higher impact on naturally rare populations of grizzly bears, wolverines, or even toads, whereas the much larger number of elk that are killed on roads may have little or no significant impact on the overall population. For other species, mortality caused by attempted road crossings may not be a large problem but loss of habitat connectivity, increased habitat fragmentation, and increased disturbance may be significant problems. Additionally, activities such as legal harvest or grazing may affect several species but the effects may be either positive or negative to species populations depending on whether the activities are conducted properly. Therefore, the rankings presented here should be considered as indicators of the pervasiveness of particular threats within the Madison Valley rather than as indicators of the severity of these threats to wildlife conservation. However, these rankings are useful for setting conservation priorities by indicating those threats that are particularly pervasive and those that are affecting the most vulnerable species.

Hot Spots:

Diversity maps based on the potential distribution of the estimated number of species in the valley and maps based on the distribution of vulnerability-weighted umbrella scores produced nearly identical results so only the vulnerability-weighted maps are presented. We used the combined weighted umbrella values for the area to indicate the distribution of potential wildlife diversity (Figure 63). The highest potential wildlife diversity occurs in the mountainous areas surrounding the valley, which are predominantly public lands. This distribution is not surprising for several reasons. Structurally simple grassland habitats are typified by low species diversity relative to other habitat types such as forest mosaics. Therefore, the number of species expected to occupy even pristine grassland and shrubsteppe habitats characteristic of the valley bottom is less than the number expected in other pristine habitats. Additionally, low elevation grassland and shrubsteppe habitats once provided preferred habitats for grizzly bears which have a high umbrella rating compared with all focal species used in this assessment. Human activities have significantly altered these low elevation areas and they are no longer considered suitable habitat for grizzly bears. Therefore, the current potential umbrella value of low elevation habitats is reduced from historical values. However, this does not mean that grassland and shrubsteppe habitats are of lesser wildlife value than other areas. To the contrary, these habitats support species not found elsewhere, are often the most impacted by human activities so harbor a disproportionate number of declining species, and occur on the most fertile soils capable of supporting abundant populations of some species such as pronghorn and wintering elk. Additionally, as we remarked elsewhere, riparian vegetation is under represented in our GIS datasets, partly due to lack of precision in remote sensing available in the Madison Valley, in addition to lack of accuracy in classification methodologies. Increased availability of high quality data should bring areas supporting healthy riparian vegetation upward in priority.

The current effective distribution of overall diversity remains close to the overall potential (Figures 68 and 67, respectively). This is not surprising given the abundance and diversity of wildlife presently found in the Madison Valley. We furthermore mapped percent loss of potential diversity value across the study area (Figure 69). Degradation is widespread across high quality wildlife areas in the valley but most areas have lost less than 20% of their wildlife diversity potential as estimated by vulnerability-weighted umbrella scores. No areas have lost 100% of their diversity potential but a few areas have lost as much as 70% of their potential. Areas with the greatest impact occur in the area around Big Sky, around Hebgen Lake, and in the wildlife corridor between Papoose Creek and Raynold's Pass. In addition, moderate degradation has occurred along the Jack Creek and North Meadow Creek drainages and within the willow flats south of Ennis Lake. These analyses indicate relatively little loss of potential diversity within low elevations in the Madison Valley. A significant reason for this is likely due to the percentage of area managed as rangeland for livestock production. Ranching typically maintains more natural landscape than alternative land use practices such as row crop agriculture and residential development. However, these analyses under represent the amount of degradation on private lands because they do not account for habitat loss resulting from landcover change. As mentioned in the limitations and assumptions of the methods section of this report, we did not map historic vegetation patterns in the valley. Areas classified as agricultural lands or urban areas were not considered as potential habitat for most wildlife species. Although habitat values in these areas have been significantly degraded historically, this degradation is not reflected in the current analysis.

The results of wildlife diversity hotspot analysis indicate several priority areas for conservation. Priorities are those areas that both provide high quality wildlife habitats and that are most vulnerable to habitat loss. Priority areas based on potential wildlife habitat and wildlife diversity are as follows:

- Papoose Creek to Raynold's Pass: This area contains high biodiversity value because it is located where four mountain ranges (Madison, Gravelly, Centennial, and Henry's Lake) come together forming an area of interconnected mountainous and forest habitats that are interspersed with grasslands and sagebrush steppe. Although this area has received a fair amount of conservation attention with the creation of several conservation easements, the remainder has been subdivided for rural residential housing. Without immediate attention, this area may lose much of its value as a wildlife diversity hot spot showing high habitat diversity and low fragmentation.

- Sagebrush Steppe: Although not the highest diversity habitats in the study area, sagebrush habitats show up on the maps as areas of elevated diversity within low elevations. As indicated in the previous section, sagebrush supports a number of sensitive species. All remaining sagebrush habitats in the valley should be reviewed for potential wildlife value and, in particular, the Missouri Flats area contains a significant amount of sagebrush habitat.

- Norris Hill Area: A broad band of scattered habitat between Bear Trap Canyon and the North Meadow Creek area potentially contains habitat that could support an elevated diversity of species. This dispersed habitat mosaic may provide important stepping stone habitats connecting the Madison and Tobacco Root Mountains for a number of species. Future development in this region should be done carefully to ensure this area continues to provide potentially important linkage habitats. Conservation projects here may also benefit migrating birds, especially those flying at low altitudes or those foraging en route.
- Jack Creek Drainage: Jack Creek provides an important movement route for elk and other big game migrating between summer and winter range. This area has experienced light to moderate potential diversity loss due to residential development. Continued development in this area could impair the drainages value as a wildlife corridor without careful planning. Of particular concern is the possibility that the road along Jack Creek into Moonlight Basin would be improved likely increasing vehicle traffic and travel speeds as well as encouraging more development in the area.
- Madison Willow Flats: An extensive area of willow flats and riparian habitats runs from south of Ennis Lake, past the town of Ennis, and ends near the confluences of Trail and Moran Creeks with the Madison River. This area has experienced low to moderately low levels of degradation due largely to its proximity to roads and development. Efforts should be made protect this area and maintain connectivity with surrounding habitats.   The best connectivity corridors to this area appear to be along Moran and Trail creeks, and extending north to North Meadow Creek.

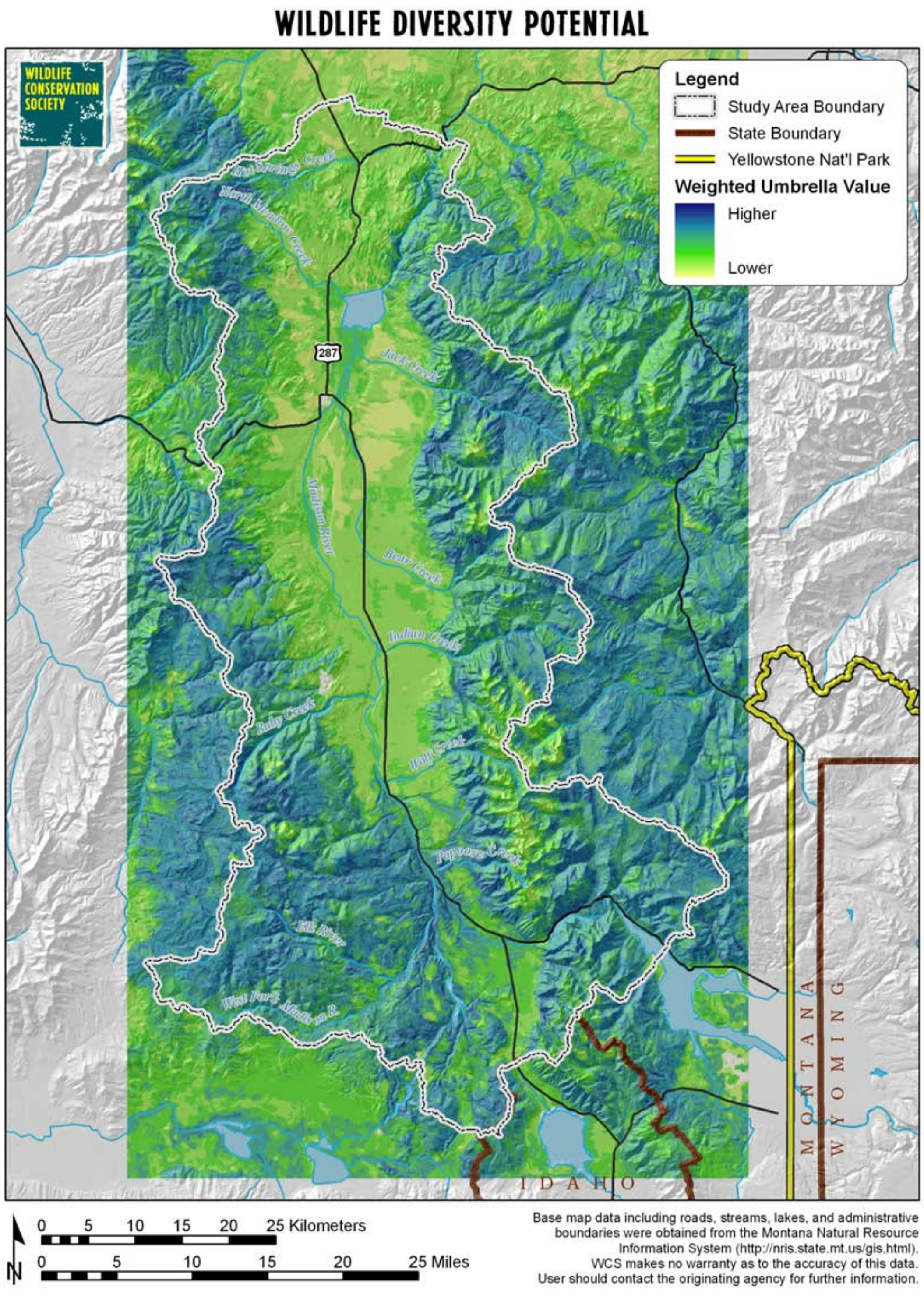


Figure 67. Wildlife diversity potential in the Madison Valley.

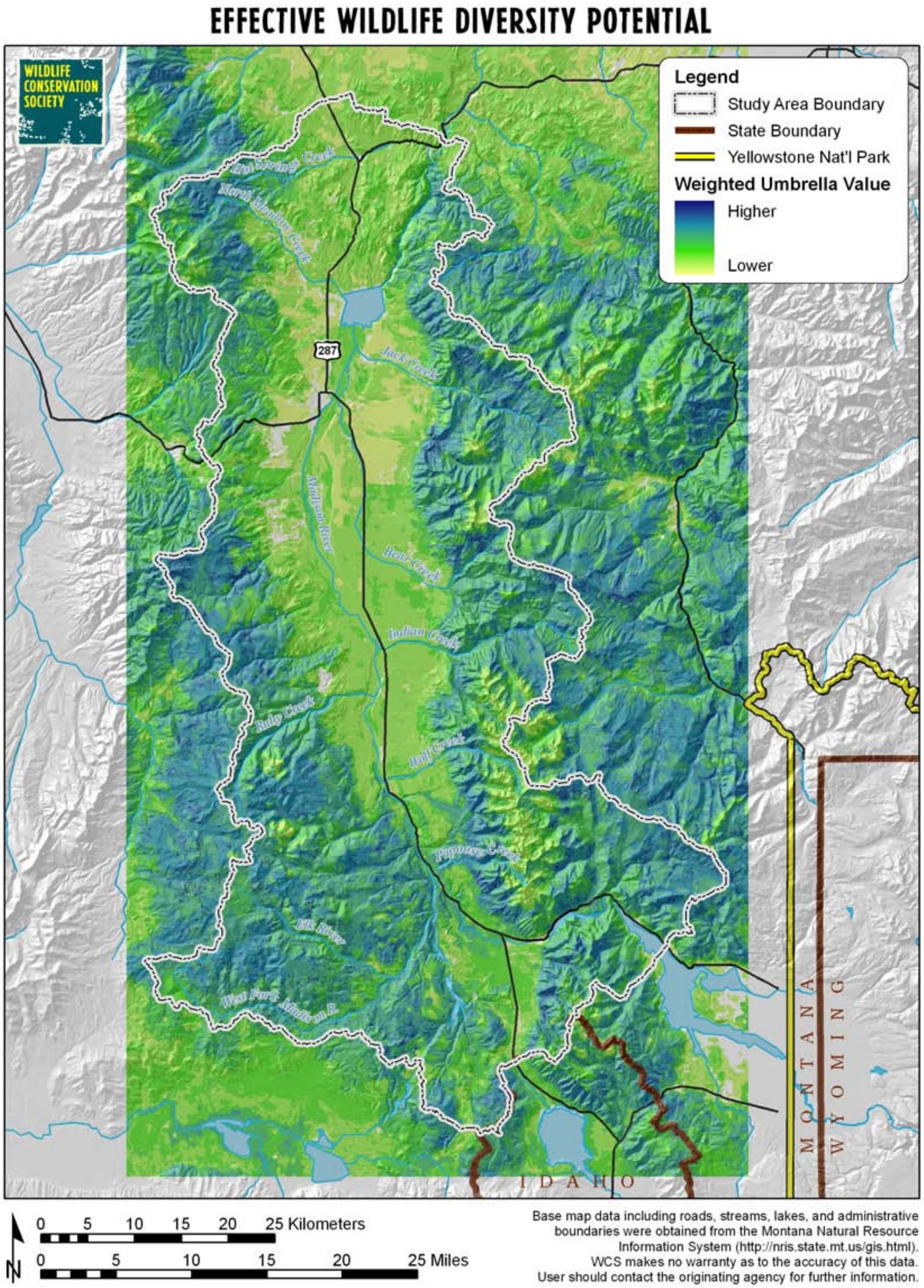


Figure 68. Effective wildlife diversity potential in the Madison Valley.

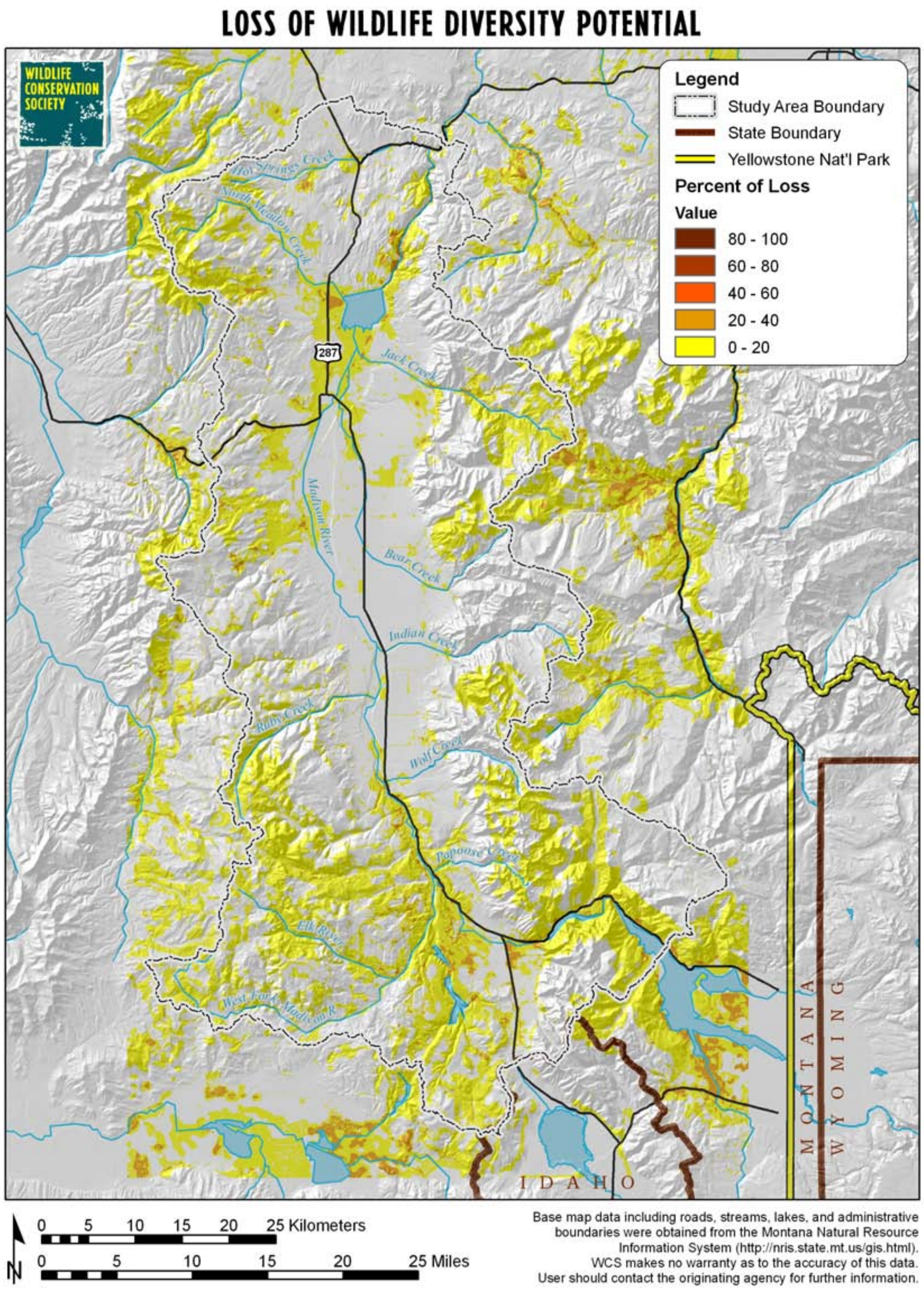


Figure 69. Total loss of wildlife diversity potential in the Madison Valley.

Connectivity Hotspots:

The Madison Valley supports regionally important habitat connectivity for many wildlife species. As human activities continue to fragment habitat, maintaining connectivity between habitat fragments becomes increasingly important for maintaining the long-term health of ecosystems. Five of the focal species used in this assessment depend on movement of individuals between isolated habitat patches to maintain or expand viable populations. These species are boreal toad, elk, grizzly bear, pronghorn antelope, and wolverine. Important areas of connectivity for each of these species were identified and then weighted by their umbrella scores to estimate the potential number of wildlife species using these areas of habitat connectivity. Areas considered important for connectivity were those areas between large blocks of contiguous (core) habitat where the combined distance and habitat quality between cores make it likely that at least some individuals could successfully move along these routes between habitat cores. We combined umbrella scores for the five focal species to estimate the total potential (Figure 70) and current (Figure 71) connectivity values across the landscape. The potential combined connectivity indicates that the Madison Valley once supported broad swaths of connectivity for a significant number of species at both the north and south ends of the valley. In addition, many species were afforded habitat connectivity along the Madison River between Bear Trap Canyon and the drainage north of Wigwam Creek. Current connectivity indicates that significant areas of connectivity still exist in the northern (although reduced in area) and southern portions of the valley but that connectivity along the river in the north central part of the valley has been largely lost. In addition, remaining areas of connectivity, including around the foothills perimeter, have actually increased in value from historic potential. One can see a significant net loss of connectivity value in the north central part of the valley with a net loss of connectivity within the northern, and to a lesser extent, the southern corridors. In contrast, the connectivity value running the central portion of the valley, in the surrounding foothills, and in the remaining areas of connectivity in the northern corridor has increased (Figure 72).

The changes in connectivity indicated by the combined models illustrate the increasing importance of habitat connectivity that result from habitat fragmentation. Development and other human activities tend to reduce the amount of available habitat for wildlife and break large blocks of contiguous habitat into smaller habitat fragments. When this happens, some areas of potential connectivity are lost because either habitat changes between fragments create barriers to movement, or the distances between fragments become to large to be successfully bridged by some species. In addition to loss of connectivity, habitat value can also increase connectivity value in many areas. When habitats are fragmented, areas between fragments that formerly provided core habitat (and therefore not needed for connectivity) may become important areas for movement between habitat fragments. If these new areas of connectivity are lost, then habitat fragments may become unusable because they can't support a sustainable population of animals.

The results of this analysis indicate five priority areas to protect remaining connectivity in the Madison Valley. These priorities are as follows:

- Papoose Creek to Raynold's Pass: This area is one of the most important zones of connectivity in the Greater Yellowstone Ecosystem because it provides quality habitat and security for montane species moving from the western edge of the GYE to mountain ranges to the west. In addition, this area creates a bottleneck for antelope that seasonally migrate between Henry's Lake and the Upper Madison Valley. Continued development in the area could impair the future value of this area for wildlife habitat connectivity.

- Norris Hill to the Tobacco Roots: Although not as high quality as the Papoose to Raynold's corridor, this area contains a mosaic of habitat types that could provide stepping stones of security for animals moving between the Madison and Tobacco Root Ranges. This area is also experiencing increasing development pressure and without careful management, the potential for this area to provide a movement corridor may be lost.

- Perimeter Foothills: The foothills surrounding the Madison Valley have become increasingly important for wildlife moving between isolated habitat patches. This is particularly true for ungulates moving between summer and winter ranges, and among patches of winter range, where they can still find security for movement.
- Central Valley: The Madison Valley once provided a nearly unbroken block of suitable habitat for elk, pronghorn, and other ungulates. However, this habitat has become increasingly fragmented due to roads, development, and other human activities. Much of the valley continues to provide suitable movement habitat for ungulates and connectivity between habitat patches remains adequate. However, careful planning will be necessary to ensure that sufficient areas remain open for wildlife movement to access all available habitat patches.
- Virginia City Hill: This pass connects the northern portion of the Gravelly's with the southern Tobacco Roots containing generally mid-range wildlife diversity values due to its preponderance of big sagebrush. However, scattered copses of Douglas-fir, some generally north to south running ridges, and tall stands of mountain (or perhaps some basin) big sagebrush add to its importance as a wildlife corridor. Raptors migrate over this pass funneling south to the Gravelly's (a known migration site), wolves have been observed moving through the area, and it is likely that an unknown sage-grouse lek functions nearby. Care should be exercised here with regard to housing development as well as road improvements to state highway 287.

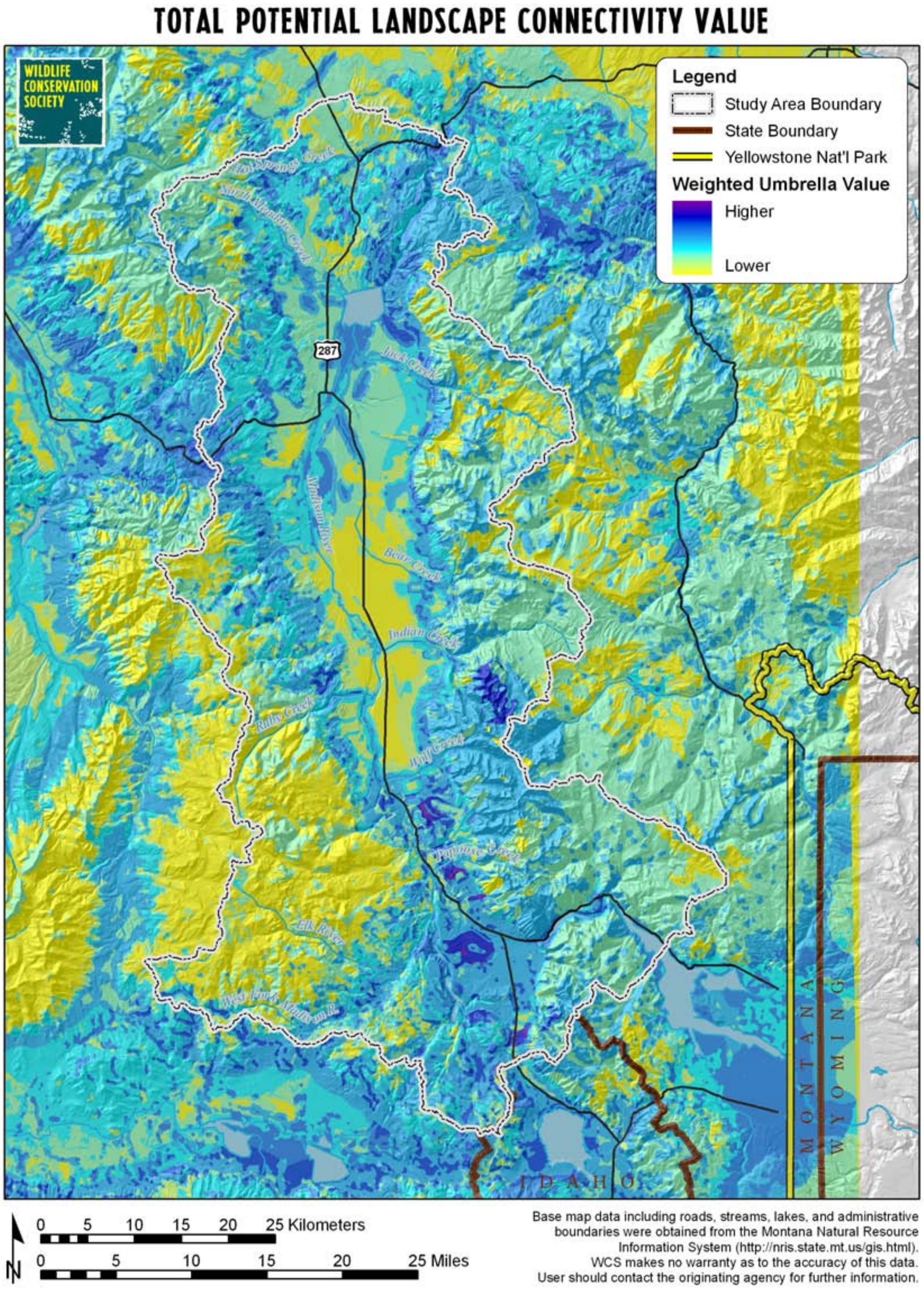


Figure 70. Total potential landscape connectivity value in the Madison Valley.

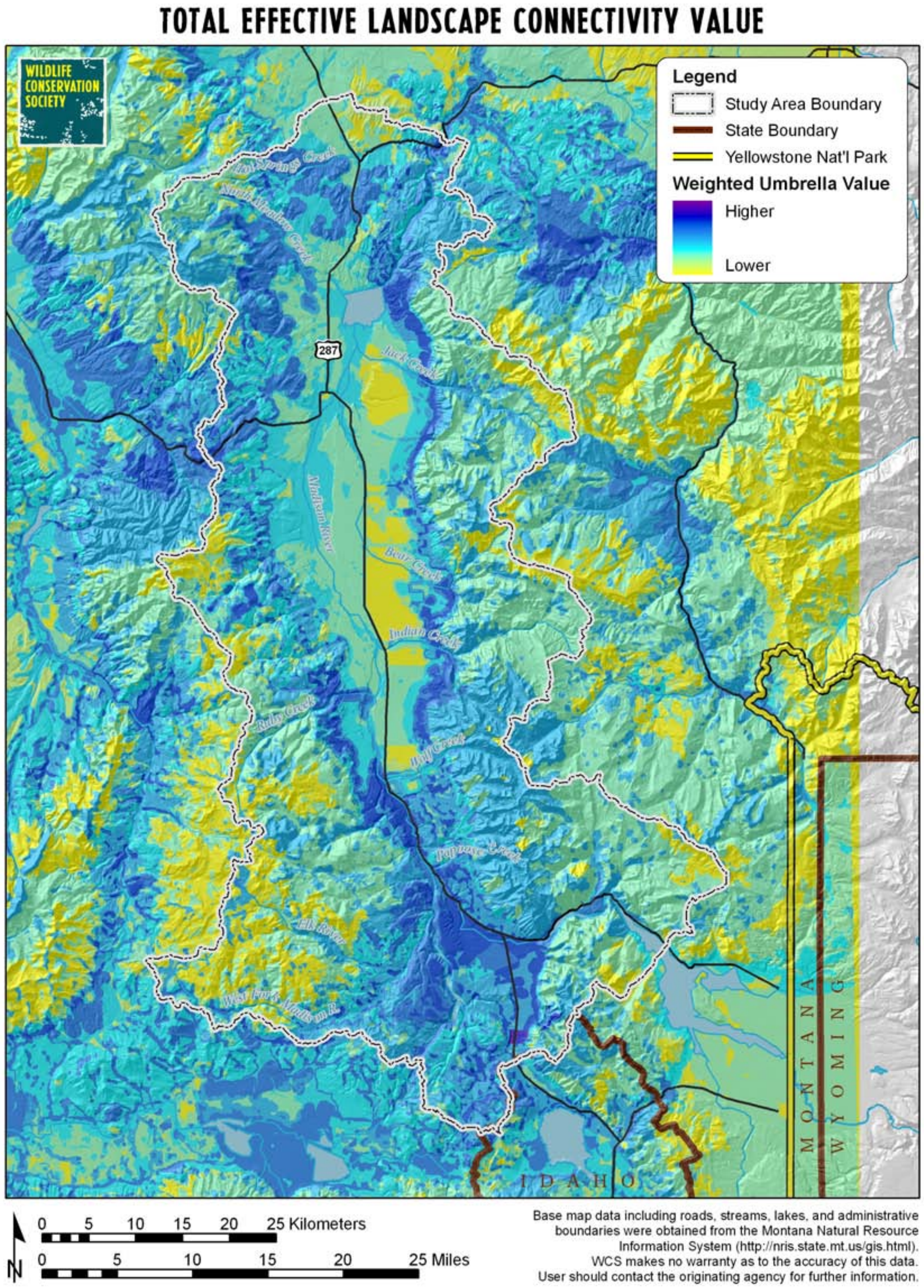


Figure 71. Total effective landscape connectivity value in the Madison Valley.

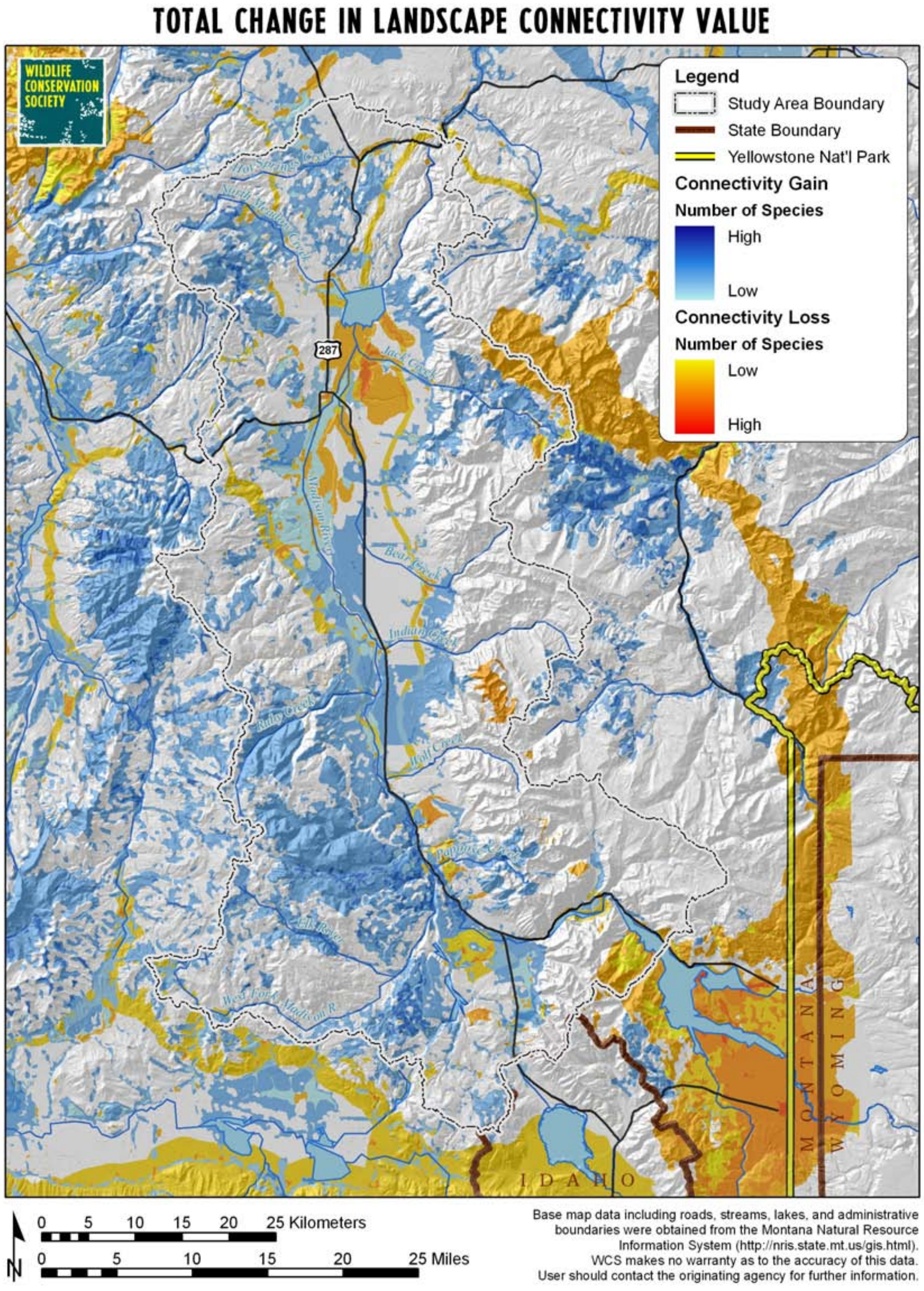


Figure 72. Total change in landscape connectivity value in the Madison Valley.

Conservation Implications:

Summary analyses provide a useful way to determine important wildlife areas, key issues or threats, and potential strategies for maintaining or restoring ecosystem integrity. The results of these analyses show some strong trends indicating the need to consider conservation in the Madison Valley at both regional and local scales and to address private land vs. public land issues separately.

Focal Species Priorities:

It is impossible to prioritize among focal species if the maintenance or restoration of all native wildlife within the Madison Valley is a conservation target. The focal species suite was chosen to provide a minimum set of species that would provide a 100% umbrella for all wildlife native to the Madison Valley. While it is likely that several different suites of focal species could be chosen to serve this function, the selected suites must be considered as a whole. Inadequate management that results in the decline or loss of any individual species in the suite is likely to result in the loss of additional species that were conserved under the umbrella of the lost focal species. These analyses indicate that species with large home range requirements such as grizzly bear, moose, and elk, tend to shelter the largest number of additional species under their umbrellas. However, species with large area requirements tend to be relatively flexible in their habitat requirements and tend to shelter other habitat generalists. It is here where some of the strength of our analyses lay; specifically, such oft-ignored species such as boreal toads and Columbia spotted frogs can capture many of the habitat needs of riparian obligate species that may otherwise be missed. In contrast, species with rather narrow habitat requirements or that depend on highly threatened habitats tend to shelter other species with similar requirements which tend to be some of the most threatened or vulnerable species. For example, to some extent habitat conservation efforts directed toward bighorn sheep that protect cliff habitats may directly benefit such sensitive and cliff-associated species as Peregrine Falcons (*Falco peregrinus*) and certain bats (i.e., Townsend's big-eared bat, *Corynorhinus townsendii*). It is therefore easy to understand why a full suite of focal species are needed to maintain habitat for the majority of wildlife that are not particularly threatened while also providing for those species that are currently threatened or likely to become threatened without appropriate conservation action. As more natural history information is gathered on such historically ignored taxa as caddisflies, dragonflies, butterflies, mollusks, or even roundworms that may exhibit extremely specific habitat needs, these species can be added into the focal suite as special elements without a loss in power or conservation perspective.

Threat Priorities:

These analyses suggest some clear priorities for addressing human activities with respect to wildlife conservation. It is evident that the most vulnerable species in the Madison Valley are species living in aquatic or sagebrush habitats or those that depend on natural fires to maintain suitable habitat. Not surprisingly, these are among the most degraded or imperiled habitats within the assessment area. These habitats should be targeted as conservation priorities and human activities that threaten these habitats should be mitigated to restore species currently in decline. Another conservation priority should be human activities with widespread impacts on a large number of wildlife species such as roads and subdivisions. Below is a list of recommended actions to address conservation threats listed in order of the vulnerability-weighted umbrella rankings:

- *Roads* – Roads are a necessary and ubiquitous feature of the landscape on both public and private lands. High-speed roads are major sources of wildlife mortality, create movement barriers, fragment habitat, and create disturbance. As highway improvement projects are developed, a high priority should be placed on improving wildlife habitat connectivity and reducing vehicle related wildlife mortality. This is most important within areas critical for wildlife habitat connectivity. In addition, a more detailed analysis of wildlife-vehicle accident locations would provide valuable data to ensure that road mitigation resources are used efficiently. Roads on public, particularly on US Forest Service lands are sources of disturbance and provide access for other activities such as hunting/trapping and motorized recreation. The impacts of these activities on wildlife are poorly understood for most species. Forest service travel plans already consider the effects of road access to species of concern and these plans should be updated as additional information becomes available. Furthermore, decommissioning of tertiary roads should be a priority in areas of high wildlife diversity and/or connectivity values.

- *Subdivisions* – Madison Valley has seen unprecedented growth in the past few decades with growth rates predicted to continue to increase. This growth has led to a boon in subdivision development for rural residential housing. However, state and local regulations have not provided the tools needed by land use planners and policy makers to guide growth to maintain the outstanding natural amenities of the valley. At present, there are two major challenges in the valley regarding subdivision development. The first is to develop tools to regulate and provide incentives for future development to occur such that wildlife habitats and other natural amenities are preserved. The second is to address how existing subdivision development could better address wildlife conservation issues. The Madison Valley Growth Solutions Committee sponsored by the Madison Valley Ranchlands Group has taken the lead to initiate a community-based forum for exploring potential solutions to growth in the valley. From a strictly wildlife perspective, it is easy to envision a suite of tools that would safeguard the outstanding wildlife resources of the valley for future generations. A potential suite of tools might include the following:
    - Density driven zoning to insure that sensitive wildlife areas remain lightly populated while directing the highest density developments into areas of lesser importance to wildlife.
    - A wildlife conservation overlay district that would require a more critical standard of review and requirements for development projects proposed within the most important wildlife areas. It should be recognized that higher standards within the overlay district will likely significantly increase property values relative to loosely regulated areas subject to incremental degradation.
    - Provide incentives to replat existing subdivisions within the wildlife conservation overlay district to bring them up to new density zoning and wildlife guidelines. Increased property values created by compliance with new guidelines may provide an economic incentive if the replatting review process can be made easy enough to not present obstacles to developers.
    - An open space initiative to provide funds to purchase easements on private lands so that landowners receive economic compensation for maintaining open space and wildlife habitat to the benefit of all.
    - Transferable development rights to provide a way for landowners to realize some of the development value of their property by selling development rights to increase density in areas where growth is desired. This tool could provide incentives for wildlife conservation by providing bonus development rights when rights are transferred away from important wildlife areas (those areas inside the wildlife conservation overlay).
    - Regulations to protect particularly vulnerable or high quality habitats such as streamside habitat.

  Land use planning tools could be used to guide *where* people live in the valley but wildlife habitat quality is also affected by *how* people live. It is inevitable that an increasing number of people will choose to live in low-density rural developments. Areas of high wildlife importance will undoubtedly command a premium price because those areas are richest in the wildlife and scenic amenities that attract people to live rural lifestyles. Therefore, there is an urgent need to deploy tools to help rural residents protect natural amenities. These tools should include:

- Planned community development to assist new and existing subdivisions with protecting wildlife habitat and natural amenities in their community. Such planning could guide home site development and infrastructure design to minimize negative impacts on wildlife habitats and develop covenants that protect the community's shared values.
    - Education and outreach to raise awareness of rural wildlife issues and possible solutions.
    - Create a support network of experts and potential cost-share sources to assist with habitat maintenance and restoration.
    - Develop a citizen-based community wildlife monitoring program to get rural residents invested in the future of their local wildlife and to assess the success of planned community and land management efforts.

- *Legal Harvest* – Hunting, fishing and trapping are regulated by MT Fish Wildlife and Parks which provides excellent management of game and furbearer species. For the most part legal harvest is of minimal concern as a threat to wildlife in the valley. However, there are a few issues of concern regarding the impact of legal harvest on the long-term sustainability of wildlife populations.
    - Lack of information can be a problem for managing some species. In particular, wolverines have been poorly studied and the long-term consequences of current trapping a not fully known. Within the Madison Valley, the Wildlife Conservation Society has been conducting a long-term study of wolverines and MTFWP has been an important partner in that study. This partnership has allowed new information from field studies to be quickly implemented into revised trapping regulations. This type of collaboration can serve as a model for filling other information gaps to improve management of game and furbearer populations.
    - Recreational fishing may cause unintentional mortality of species such as fluvial arctic grayling and westslope cutthroat trout, even with implementation of catch-and-release regulations. Moreover, it is unknown whether areas of high angling pressure can suffer decreases in songbird reproduction due to disturbance. Unfortunately, recreational fishing may also provide a mechanism for dispersal and colonization by exotic species such as New Zealand mudsnails (*Potamopyrgus antipodaru*) and noxious weeds.
    - Under-harvest of some species such as elk may allow overpopulation of a species. Over population leads to damaged forage resources, increased damage to property and human-wildlife conflicts, increased transmission of disease, and decreased tolerance of wildlife by humans. MTFWP employs a number of tools to increase hunting access on public and private lands. However, efforts should be made to improve education about the importance of hunting and hunting access for managing game populations. The Education Subcommittee of the Madison Valley Wildlife Committee could provide a leadership role in this effort with particular focus placed on educating new landowners and newcomers to the valley.

- *Non-native Fish* – The introduction of non-native fish, particularly non-native trout, in the Madison Valley has created a world class sport fishery that is extremely important to the local and regional economies and cultures. However, the introduction of non-native fish has had consequences to some native wildlife species. Non-native fish compete with, and prey upon native species. This competition and predation has contributed to the decline of several native species such as arctic grayling and westslope cutthroat trout. In addition, non-natives hybridize with some naïve species. In the Madison Valley, many stream reaches are now populated with westslope cutthroat x rainbow trout hybrids. In addition, widespread stocking of both native and non-native fish in historically fishless mountain lakes and ponds may be contributing to amphibian declines. Fish compete with, and prey upon amphibians at all life stages and the negative influence of fish on amphibians has been documented. The combined effects of non-native fish on native fish and amphibians presents a difficult conservation challenge. The traditional approach to conserving and restoring cutthroat trout has been to maintain genetically pure populations that are isolated from non-natives. In some cases stream reaches with natural fish barriers are stocked with native cutthroat to create genetically isolated populations that can't hybridize with non-natives. However, stocking above natural fish barriers often comes at the expense of amphibian habitat since these waters were often historically fishless. Therefore, native fish restoration must be balanced against amphibian restoration to ensure that all species continue to thrive in the Madison Valley. This may require restoring some lakes, ponds, and streams to a historically fishless state while utilizing some isolated and historically fishless waters for westslope cutthroat trout restoration. In addition, the potential benefits of beaver restoration for both amphibian and native fish restoration should be fully explored and implemented as feasible. Artificial fish barriers to protect genetic stocks of westslope cutthroat should also be used wherever practical.

Ultimately, the extent to which the effects of non-native fish can be mitigated may be a question of cultural values. The restoration of native fish and amphibians will likely require the elimination or reduction of some recreational fishing resources and targeted restrictions on recreational fishing. The importance of cultural acceptance may be most acute with respect to fluvial arctic grayling formerly inhabiting the main stem of the Madison River and major tributaries. It is likely that the decline of fluvial arctic grayling in the Madison was directly caused by the introduction of non-native trout that exert heavy predation pressure on grayling. Restoration of grayling will likely depend on the elevation of the cultural value of restoring grayling to the Madison River and public acceptance of potential sacrifices needed to make restoration a success. Improved education and awareness would be the logical first step to bringing fluvial arctic grayling back in the valley.

- *Fire Suppression* – For over 100 years there has been an aggressive policy of fire suppression on public lands in the American West. Within the past 50 years, humans have gained the technology and resources to significantly alter natural fire patterns. During this same period, the importance of natural fire patterns for maintaining healthy ecosystems and wildlife populations has come to the forefront. However, concerns about human property, health and safety make the restoration of natural fire ecology in the Madison Valley extremely difficult. The major obstacles to restoring natural fire ecology are as follows:
    - Public Acceptance: More than a century of fire suppression and decades of Smokey Bear campaigns have created a general negative attitude toward fire among the general public. More recently, land use agencies have promoted the positive role of fire in ecosystems but often emphasize the use of thinning and prescribed burning to promote low intensity ground fires to prevent "unnatural conflagrations". While some ecosystem types such as ponderosa pine forest are characterized by frequent low intensity fires, historical patterns in the Greater Yellowstone Ecosystem are of infrequent high intensity stand-replacement fires interspersed with lower intensity fires. In fact, many species have become highly dependent on stand-replacement, or 'crown' fires to provide habitat. In addition, some people object to fires because of health concerns and discomfort caused by smoke generated by large fires, or because of objections to the aesthetics of a recently burned forest. Increased efforts should be made to educate the public about the crucial role of fire in maintaining the Greater Yellowstone Ecosystem including education about the true historic patterns of fire frequency and intensity. Additionally, education efforts need to emphasis the consequences of continuing the current policies of extinguishing most natural fires in the region.
    - Human-Wildlands Interface: Homes are increasingly being built along public lands boundaries to take advantage of protected views and recreational opportunities. Such

development severely restricts the ability to allow natural fires to burn because of the increased potential for property loss. This is perhaps the greatest obstacle to restoring natural fire patterns in the Madison Valley. To address this problem, new developments at the human-forest boundary should be required to develop and implement fire management plans to create firebreaks and defensible space between developments and forests. Programs should be utilized and/or developed to assist existing rural residential communities to implement plans to create firebreaks and defensible space around their communities. Insurance companies should be encouraged to require or promote fire-safe practices around homes. And finally, the public must accept the chainsaw as an important tool for long-term forest health because thinning will undoubtedly be required to create the fire breaks and defensible space needed before natural fires can be allowed to burn. One mechanism that can work to greatly increase public acceptance of small-scale logging and thinning projects is through the use of horse logging. Horse logging impacts soil considerably less than mechanized harvest, reduces the need somewhat for roads, and in this era of high fuel costs, can out perform mechanized logging on an economic scale. Moreover, it provides an impetus to preserve historical knowledge while simultaneously promoting local economies.

- Wildlife Habitat Concerns: Several prescribed burning proposals have been thwarted over concern for loss of wildlife habitat. In some cases, these concerns may be legitimate and in others, the concerns may address short-term problems at the expense of long-term forest health. The two most controversial aspects with respect to wildlife habitat and fire in the Madison valley concern sagebrush and whitebark pine. Both of these habitat types are adapted to the fire patterns of the Yellowstone Ecosystem but have become sufficiently rare and important for wildlife to warrant special protection. Sagebrush habitats are particularly controversial because historically periodic fires maintained sagebrush habitats regionally. However, sagebrush habitats can take decades to recover from fire. These habitats have been significantly reduced from their historic distribution so there may not be sufficient alternative sagebrush habitat in an area to sustain some wildlife populations while a burned sagebrush patch recovers from fire. Therefore, a zero loss policy for sagebrush and whitebark pine habitats may be warranted with respect to fire management.

- Prescribed Burning: Prescribed burning is a valuable tool for simulating natural fire patterns under controlled conditions. Efforts to expand prescribed burning to restore natural fire conditions on public lands should be fully supported. However, it should be recognized that low intensity fires under controlled conditions cannot adequately replicate intense stand-replacement fires needed to sustain some wildlife species. Prescription burns could be used to create containment zones where high intensity fires could be allowed to burn without risk.

- *Improper Grazing* – Large ungulate grazers are a natural part of the Madison Valley ecosystem. In some respects, domestic livestock grazing replicates natural process once provided by bison and other wildlife species. Therefore, properly managed grazing is generally beneficial to the overall health of the ecosystem. However, there is a history of improper grazing throughout the American West which has left a legacy of negative impacts on native wildlife. Fortunately, as grazing practices have improved in modern times, range conditions have improved in many areas. Within the Madison Valley, overgrazing of riparian areas and aspen stands is a concern but it was beyond the scope of this assessment to conduct a rigorous range inventory to determine if riparian areas or aspen regeneration was being affected by grazing. A valley-wide rangeland inventory would not only improve the ability to gauge grazing practices in the valley, but would also provide valuable information about the potential for improving habitat for grassland and sagebrush adapted wildlife.

- *Dewatering* – Water has always been an important issue in the American West. Dewatering to irrigate crops can have a direct impact on aquatic and riparian habitats by reducing or eliminating stream flows, increasing water temperatures, or dropping water tables. The proliferation of private groundwater wells could also potentially drop water tables resulting in altered stream flows. At present, Indian and Bear Creeks are severely dewatered with significant sections of these reaches going dry in typical summers. Not only does this eliminate aquatic habitat for native fish and amphibians, it also is reducing woody riparian habitat as trees and shrubs die out from lack of water. In addition to protecting surface flows from negative impacts by new developments, the effects of dewatering could be mitigated by purchasing water rights for stream flow conservation and restoring beavers that will raise water tables through pond building activities.

- *Flood Control* – Periodic floods are necessary to maintain some habitat types and many wildlife species benefit from these floods. In particular, cottonwoods depend on periodic flooding for the successful establishment of new stands from seedlings. Without the effects of periodic flooding, cottonwoods regenerate at a much reduced rate. As a consequence, most of the cottonwood groves in the Madison Valley are older mature trees that will eventually die without regeneration. In addition, periodic flooding provides breeding pools for amphibians, habitat for shorebirds and waterfowl, and breeding habitat for fish. The impacts of Hebgen and Madison Dams on the Madison River have been debated mainly because of potential influences on water temperatures and trout fishing. The elimination of natural flood dynamics as a consequence of these dams has received little attention. Dams have been successfully used on other rivers to simulate flood dynamics by sending high volume pulses, or 'spike flows', of water downriver to reconnect rivers to their historic floodplains under controlled conditions. The initiated feasibility study should be continued to determine whether spike flows could be used on the Madison to encourage cottonwood regeneration and restore historic floodplain habitats.

- *Domestic Sheep* – Sheep create unique wildlife conservation challenges because of their potential to spread disease and their vulnerability to predation. Native bighorn sheep and domestic sheep cannot be managed in the same area because domestic sheep carry several diseases that often prove fatal to native bighorns. In addition, domestic sheep are more prone to predation by large carnivores such as bears and wolves than larger species of livestock better capable of defending themselves and their offspring. Several contiguous sheep allotments in the Gravelly Mountains are located within high quality potential bighorn sheep habitat as well as within an area currently being recolonized by grizzly bears. These allotments should be retired or relocated to allow the establishment of a native bighorn herd in the area and to reduce potential conflicts with recovering grizzly populations in the area.

- *Snowmobiling* – The affects of recreational snowmobiling on wildlife are poorly understood. Potential impacts include habitat loss due to avoidance by wildlife of areas with moderate to high snowmobile use, and reduced fitness due to energy expended avoiding snowmobiles or reduced foraging efficiency. Some impacts could be indirect such as reduced reproductive success due to decreased nutritional condition during critical periods. Probably the most vulnerable species to snowmobile disturbance are wolverine, Canada lynx, and moose because these species are most likely to be foraging in areas where they are likely to encounter snowmobiles. Surveys conducted by the Wildlife Conservation Society indicate that snowmobiling is widespread with moderate to high snowmobiling use typically occurring everywhere snowmobiles are allowed on public land within the assessment area. Given our poor understanding of the impacts of snowmobiling on wildlife, and the extreme rarity of some of the species most likely affected, it would be prudent to expand areas off limits to snowmobiles until information is available to indicate that negative impacts to wildlife are within acceptable limits. At a minimum, quiet zones should be maintained within linkage zones between habitat cores to allow free movement of animals between semi-isolated patches of habitat during the winter.

- *Conflict* – Conflict occurs when wildlife damage property or threaten human safety. The main issues of conflict with respect to conserving wildlife in the Madison valley are associated with large predators. Grizzly bears can present an extremely rare, but serious threat to safety when they come into conflict with humans. This problem is most acute during the hunting season when an abundance of game carcasses and gut piles attract grizzlies into areas where humans are present. Secondary to hunter-bear conflicts are problems that occur when food and garbage are improperly stored around campsites and homes. As more people choose to live within grizzly country, this latter problem continues to grow. Often the end result of these types of conflicts is a dead bear. However, bear mortality resulting from these conflicts can be nearly eliminated with proper education. Hunters should be encouraged to use pepper spray instead of bullets to resolve bear encounters and they should be made aware that pepper spray is more effective at stopping bear attacks. Both National Forests in the assessment area now require bear safe food and garbage storage in the backcountry and these regulations should be strictly enforced. In addition, new residents in bear country should receive educational materials about the importance of proper storage and management of food, garbage, barbecues, and bird feeders around their homes.

  Wolves, coyotes, bears, and other carnivores occasionally prey on livestock with conflicts arising from wolf predation being particularly acute. Both lethal and non-lethal measures are used to control wolf predation. While lethal control remains an important tool for addressing wolf predation, it is the least desirable method because it is expensive, usually happens only after depredations have occurred, and often results in the extermination of entire packs. To date, non-lethal preventative actions have had limited success but new approaches such as the range rider program sponsored by the Madison Valley Ranchlands Group and the Predator Conservation Alliance should continue to be explored and evaluated as well as other tools such as aversive conditioning.

- *Whitebark Disease* – One of the most important food sources for grizzly bears in the Greater Yellowstone Ecosystem, whitebark pine, is being destroyed by blister rust; an introduced disease. The long-term consequences of this disease are unknown but as grizzly bears are being petitioned for delisting under the Endangered Species Act, they may have to continue their recovery without the benefit of this extremely important food item. Fewer than 1 in 10,000 whitebark pine trees is resistant to blister rust and the species has been further reduced by decades of fire suppression that has eliminated many of the micro sites where new whitebark pine seedlings can establish. The re-establishment of natural fire patterns in the region would ensure that whitebark pine has an abundance of potential sites for recolonization where hopefully, blister rust resistant trees would proliferate. Ultimately, the long-term success of whitebark pine may depend on replanting the area with disease resistant varieties.

- *Fencing* – Madison County requires the use of wildlife friendly fencing but this has not eliminated problems with fencing and wildlife. Improper fencing can impede wildlife movements and present a direct threat to their safety. Some birds of prey such as rough-legged hawks, often hunt by flying at high speeds just above the ground. These species frequently collide with fences with often fatal results. However, perhaps the greatest impact of fencing on wildlife in the Madison Valley is the restriction of movements of migrating pronghorn. Pronghorn typically do not jump over fences the way deer and elk do but rather crawl under fences at available gaps. Overly tight fences can create impassable barriers for pronghorn or create crossing hazards where pronghorn are likely to become entangled and possibly die. The Madison Valley pronghorn herd undergoes one of the longest animal migrations in the lower 48 states. The continuation of this wildlife migration depends on the ability to cross multiple fences and property boundaries along their route. The present fencing in the valley allows adequate movement of pronghorn to complete their migration but a recent assessment by Steve Primm for the Wildlife Conservation Society indicates that migrating pronghorn may be dependent on learned crossing gaps and opened gates to complete their journey. Therefore, the migration may be vulnerable to changes in landownership or fence improvements that result in closures of existing gaps or critical gates on the migration route. Efforts should be made to ensure that landowners along the route are aware of the importance of their property for the migration so that adequate permeability is maintained. In addition, non-essential fences should be removed along the route and permanent crossing structures should be created to reduce the dependence of migrating pronghorn on human assistance.

- *Power lines* – Power lines have been implicated in the decline of sage-grouse and affect mostly grassland and shrub-steppe adapted wildlife. Large areas of low stature vegetation characterize these habitat types and the species living within these habitats may be particularly sensitive to artificial vertical structures. In the case of power lines, it has been shown that avian predators such as hawks and falcons gain an advantage by perching on telephone poles and transmission lines for hunting which may result in abnormally high predation loss for the species they feed upon. Installing power lines and poles in a grassland or sagebrush steppe may be the equivalent of converting those areas to a low density forest; a habitat type fundamentally different from the original grassland or shrub steppe. It is impractical to suggest the removal of existing overhead transmission lines but new developments within grassland or shrub steppe habitats could be required to install buried cables for phone and electric service to eliminate one of many stressors that affect these habitats.

- *Sagebrush Control* – Historically large areas of sagebrush have been destroyed to improve forage conditions for livestock and sagebrush control remains a common range improvement practice to the present. A variety of methods have been used to control sagebrush including burning, chaining, and spraying. The appropriateness of sagebrush control is confusing since overgrazing can lead to an increase in sagebrush indicating that perhaps controlling sagebrush restores the range to its original condition. In addition, fire historically played an important role in maintaining sagebrush by eliminating trees and competing shrubs from an area and maintaining open conditions where sagebrush could re-establish. However, it is clear that sagebrush dependent species have declined markedly over the last century elevating the status of sagebrush as an important wildlife habitat type. We were unable to determine the historic extent of sagebrush in the valley for this assessment but it seems likely that sagebrush habitats were both more extensive and more mature than they are at present. If thriving populations of sage-grouse and other sagebrush dependent species are to be restored to the Madison Valley, it will require the preservation and restoration of significant areas of sagebrush in the valley. Therefore, it is recommended that sagebrush control programs for forage improvement be weighed against potential long term gains in wildlife conservation for restoring sagebrush habitats. Likewise, burning projects at the forest-sagebrush interface should consider both the short term and long-term consequences of burning to restore sagebrush areas. Obviously, fire played an important role in maintaining sagebrush dependent wildlife when there was an abundance of sagebrush in various stages of recovery following fire to supply wildlife needs. But when sagebrush habitats have been reduced to isolated fragments, even the temporary loss of a sagebrush patch due to fire may prove unacceptable. The Madison Valley may present a unique opportunity for sagebrush restoration. As ranches strive to become more diversified to maintain profitable operations, the restoration of sagebrush habitats and sage-grouse hunting could potentially provide an additional revenue stream that would more than offset any reduction in forage value for livestock.

- Beaver Loss – When William Clark first explored the Madison Valley in 1805, he reported seeing "emmense (*sic*) numbers of beaver and otters". Today, beavers are common in the valley but not nearly as abundant as in former times. Beaver restoration in the valley could potentially benefit a wide variety of wildlife species dependent on aquatic or riparian habitats. Sixty percent of the focal species used in this assessment benefit from the activities of beaver and nearly ½ depend significantly on aquatic or riparian habitats such as those that are produced and maintained by beaver impoundments. Beaver can provide many useful services for humans as well. In addition to providing aesthetically pleasing ponds and potential fishing opportunities, beaver impoundments raise water tables thus alleviating drought stress on surrounding landscapes while helping to maintain private wells in the vicinity. In addition, beaver ponds may provide an inexpensive impoundment for private or community fire protection. However, beaver are not always tolerated because they often build their dams in unacceptable locations, damage trees, and plug irrigation ditches. Tolerance for beaver restoration could be improved through education and outreach by informing the public about the positive, as well as negative aspects of beaver activities and by providing assistance with installing beaver dam control devices that adjust water levels to avoid damage while maintaining beaver ponds.

- *Disease* – Disease was identified as a potential threat for 3 of our focal species. Bighorn sheep are susceptible to several diseases carried by domestic sheep to the extent that the two species cannot inhabit the same areas. Chytrid fungus and ranavirus are two amphibian diseases that have caused major die-offs in other areas but are not known to occur in the Madison Valley. In addition, brucellosis does not directly threaten wildlife in the valley but its presence in elk could potentially alter management of the species as it has for bison outside Yellowstone National Park. Finally, chronic wasting disease is not currently present in the region but remains a potential threat. At present, wildlife in the valley, with the exception of bighorn sheep, do not appear to be significantly impacted by major diseases but monitoring is warranted.

- *Pollution* – Aquatic and semi-aquatic species are disproportionately affected by pollution as runoff carrying pesticides, mine effluent, and other pollutants which accumulate in streams. Several streams in the valley are listed as 'impaired' by the MT Department of Environmental Quality. The hardest hit species in the Madison Valley are probably amphibians that are known to be adversely affected by many pollutants including many common pesticides. In addition to strictly enforcing existing environmental laws, landowners should be educated about alternatives to pesticides, the risks associated with various pesticides that are available, and the proper use of those pesticides.

- *Salvage Logging* – Several studies have shown negative impacts of salvage logging on cavity nesting birds such as black-backed woodpeckers and other wildlife species. Salvage logging removes trees killed by fire or beetle outbreaks and there is a perception among the general public that these trees are useless unless harvested for human use. In reality, burned and beetle-killed trees provide an essential habitat type for a number of habitat specialists. Therefore, salvage logging operations should always ensure that adequate habitat remains to support these specialist species. Post fire management can have profound impacts on cavity-nesting birds that use post-fire habitats (Kotliar *et al.* 2002). Kotliar *et al.* (2002) offer 5 alternatives to severe salvage logging to provide habitat for post-fire dependent birds:
  - Leave burned areas alone to undergo natural succession.
  - Lightly salvage throughout the burned area leaving many of the largest snags.
  - Defer salvage logging for several years post fire to allow BBWO and other fire dependent species to utilize available habitat before snags are removed.
  - Salvage part of a burn severely and leave the rest alone.
  - Apply a variety of salvage treatments to create a variety of snag species, size, density, and spatial patterns.

  Of these, black-backed woodpeckers are likely to benefit most from the first option of leaving areas unsalvaged because they are among the most fire-dependent species. When the size of the area burned by stand-replacing fires is small, this option should be strongly considered.

- *Local Extinction* – Many wildlife species exist at the regional level as patterns of small semi-isolated but interconnected subpopulations collectively known as metapopulations. Small populations are subject to periodic die-offs resulting in the temporary loss of the species from locations where the die-offs occur. Within healthy metapopulations, these local die-offs are reversed by recolonization of the area from nearby subpopulations. This results in a pattern where subpopulations blink in and out over time as they die out and are recolonized from adjacent areas while the populations of the overall metapopulation remains stable. However, as habitat patches become increasingly fragmented and isolated, the ability to recolonize an area following a local die-off is lost so what would have been a temporary local extinction becomes permanent. Several of the focal species in this report exist regionally as metapopulations but bighorn sheep are the most impacted within the study area. Bighorn sheep habitat in the valley occurs as semi-isolated patches in the high country surrounding the valley. Historically, if bighorn went extinct in one of these patches, sheep from a nearby patch would eventually recolonize the area. However, many of these adjacent patches are now vacant so natural recolonization following a local die-off is no longer possible. Long-term stability of bighorn sheep populations in the Madison Valley would likely be improved by restoring bighorn to all available habitats in the Centennial, Gravelly, and Tobacco Root Mountains so that the region can once again function as a healthy metapopulation.

Practical Considerations:

The results of these analyses confirm what was already known, that the Madison Valley supports a stunning assemblage of wildlife and wild places. The results also indicate that a relatively small percentage of unprotected private lands in the valley are critical for maintaining healthy wildlife populations. However, these results do not suggest that all non-critical areas in the valley can be developed without consequences to wildlife. These analyses merely suggest that non-critical areas do not appear to be providing an irreplaceable role for wildlife conservation at the moment. As areas are developed, remaining undeveloped areas will become increasingly important for maintaining healthy wildlife populations so land use planning should strive to retain the maximum amount of contiguous wildlife habitat possible. Also, all analyses of this type have a degree of uncertainty associated with them. Some areas may actually provide a critical function to wildlife that these analyses cannot detect. It is also important to realize that any habitat alteration has consequences and any change results in species losing or benefiting from that change. The challenge is to accurately predict what those changes will be and determine whether they are acceptable for the common good of society.

It is not practical to implement all conservation actions or address all threats listed in these results. Our analysis suggests that the broadest conservation results will be obtained by addressing the threats near the top of the list rather than those at the bottom. However, this list must be viewed with practical scrutiny. For example, legal harvest ranks near the top of the list of threats because it potentially impacts a large number of species. However, regulated harvest in the Madison Valley likely has almost no negative impact on wildlife populations with the possible exception of a few very specific concerns previously mentioned. Addressing these concerns, while important, would not result in broad conservation impacts. In addition, the importance of some threats depends upon the status of other threats. For example, fire suppression ranks among the top threats and is having real impacts on a large number of species. However, the obstacles to restoring natural fire patterns are enormous and unlikely to be overcome in the near future. Although restoring natural fire patterns would address most of the problems associated with conserving black-backed woodpeckers and associated species, the likelihood of this happening is extremely low for the foreseeable future. Until fire patterns are restored, sound salvage logging policies and practices will be extremely important. Because of these interactions, this type of threats prioritization should be considered only as a preliminary assessment as further analysis of the actual severity of their impacts on wildlife, and the costs of addressing them, are needed.

Additional Research Needs:

Several information gaps impeded our ability to develop models or provide accurate assessments of some species. Major information gaps and research needs identified by this assessment are as follows:

Data Needs:

- Sagebrush/Native Grassland inventory: Existing landcover classifications do a poor job of accurately classifying sagebrush habitats and sagebrush structure. This deficiency has been noted by other researchers and is particularly important for managing sage-grouse. In addition, available landcover maps typically do not distinguish between native grasslands and introduced or 'tame' grass pastures. This distinction is critical for accurate assessment of grassland dependent wildlife since planted introduced grasses such as crested wheatgrass, smooth brome, and timothy create monocultures with low plant species diversity and provide relatively little habitat value for wildlife compared to undisturbed native grasslands. Given that these two habitat types comprise the majority of non-cultivated private land in the Madison Valley, obtaining accurate maps of these habitats should be a priority.

- Aspen Inventory: Aspen stands provide critical habitat for a variety of wildlife species but as fire patterns in the region have been altered, aspen stands have declined. It is estimated that the extent of aspens in the Gravelly Mountains declined 45% between 1947 and 1992. However, available landcover maps provide very poor estimates of the location and extent of aspens. The USFS developed effective methods for classifying aspen stands but these improved maps are only available for a portion of the assessment area. Applying these methods across the region would improve our ability to assess and monitor this important habitat type.

- Wetlands Inventory: National Wetlands Inventory data was not available for the whole study area at the time of this assessment. Lack of wetlands inventory likely resulted in an underestimate of potential boreal toad habitat and made modeling habitat for the Columbia spotted frog impractical. However, these data are in progress and should be available for future analysis. Therefore, it is recommended that assessments for these wetlands dependent amphibians by re-analyzed once wetlands inventory data become available.

- Wildlife Inventory: There is very little biological data on wildlife populations in the Madison Valley, especially on private land. A valley-wide inventory of selected wildlife species and their habitats could be a significant aid to fine-tuning the current set of priority areas, identifying additional areas, and improving our understanding of threats and the most appropriate strategies to abate those threats.

Research Needs:

- Rural subdivision: Although conversion of rangeland into low density rural housing is the fastest growing type of land cover change in the American West, little is known about how rural subdivisions alter wildlife populations and distributions. Land use planners need to know what housing densities are appropriate for maintaining wildlife populations and their habitats. But at present, there are no clear answers. Several studies have documented negative changes in wildlife communities around rural subdivisions but almost nothing is known about the specific mechanisms that cause those changes. Several possibilities have been proposed including habitat alteration, increased predation due to domestic pets, and increased disturbance around home sites. Research is needed to determine the relative importance of the various mechanisms impacting wildlife communities and how to better plan and manage rural subdivisions to minimize or eliminate negative impacts. In addition, more information is needed about whether some habitat types are more sensitive to changes brought by rural residential development than others. More research in these areas would allow for better planning and management of rural residential housing for the benefit of both wildlife and people.

- Motorized recreation: The recreational use of motorized vehicles on public lands, particularly snowmobiles and ATV's, has increased dramatically in recent decades and has become an emotionally charged and controversial subject. However, very little is known about the long-term impacts of widespread use of motorized vehicles in the backcountry on wildlife. Clearly, this is a research gap that needs to be addressed as public land managers grapple with managing this increasingly popular activity while protecting natural resources.

- Fire suppression: Fire management on public lands has always been a contentious issue that has received an enormous amount of attention in recent decades. It is nearly universally accepted that fire plays a vital role in the Greater Yellowstone Ecosystem and that restoration of natural fire patterns is desired. However, the obstacles to restoring natural fire patterns are formidable and there is no consensus about the best way to proceed. The federal 'Healthy Forest Initiative' may be a step in the right direction but it is unlikely that the policies and procedures set forth in the initiative or the resources committed are sufficient to actually restore natural fire patterns over large areas of public lands. The confusion is compounded by the current emphasis on low intensity prescribed fires that do not sufficiently replicate natural fire patterns in areas such as the Greater Yellowstone Ecosystem that are characterized by low frequency, high intensity, stand-replacement fires. To restore truly natural fire patterns in the forests surrounding the Madison Valley will require a comprehensive plan to create fire breaks and defensible perimeters around large tracts of public land. A landscape analysis of the area should be conducted to assess the feasibility of establishing defensible perimeters and to explore potential tools for implementing their creation.

- Pronghorn Migration: The Madison Valley boasts a long distance seasonal migration of pronghorn antelope that is one of the many symbols establishing the valley as one of America's premier wild places. However, no study has been conducted to obtain the exact migration route of these animals or herd dynamics of which animals are involved in the migration and where they spend their winters and summers. An assessment of the migration conducted in 2004 indicates the migration route contains several potential bottlenecks and may, at least in part, depend on landowners leaving gates open at appropriate times. A simple radio-tracking study would provide the necessary data to ensure this migration remains as one of the Madison Valley's wildlife attractions.

Conclusion

We have seen that the Madison Valley is a gem within the context of the Greater Yellowstone Ecosystem. Although, we have nearly, or at least functionally, lost fluvial arctic grayling and northern leopard frogs here, we are experiencing expanding grizzly bear populations and soon will enter the stage of state management of this species in addition to wolves. Nearly fully diverse with its historical complement of wildlife, this valley is under threat of development with concurrent losses of wildlife habitat, wildlife diversity, and connectivity, facets of the landscape important to large and small creatures alike. Moreover, the above are measures of ecological health like filtering and groundwater-recharging wetlands and riparian areas, cooling and transpiring cottonwood stands, moisture conserving native grasslands, and sponge-like alpine tundra. All are ultimately very important to the human communities inhabiting all intermountain valleys of the West, the Madison Valley being no exception. In addition, intact ecological systems act to buffer communities (wild and human alike) from catastrophic and chronic events. Now, at a time of rapid ecological change in which we begin to see the effects of global climate change, dispersal and proliferation of environmental toxins, invasion of aggressive plants, fungi, and mollusks, it is even more imperative for us to conserve all the pieces of these ecological communities.

Through our Landscape Species process, we have identified the following nineteen threats affecting the wildlife of the Madison Valley. It may seem a daunting challenge to address that many threats to the valley's ecology. However, through itemizing threats, ranking these threats, investigating the relationships these threats have to individual focal species, and by mapping the locations of these threats on the landscape, we can and have developed a method of improvement. Hence, we are at a position where wise and information-based planning can mitigate severe losses in natural amenities.

Major threats affecting the wildlife of the Madison Valley:

- Roads
- Improper Grazing
- Snowmobiling
- Power Lines
- Pollution
- Legal Harvest
- Flood Control
- Whitebark Disease
- Loss of Beaver
- Local Extinction
- Subdivisions
- Dewatering
- Wildlife-Human Conflict
- Sagebrush Control
- Salvage Logging
- Non-native Fish
- Domestic Sheep
- Fences
- Disease

Priorities Based on Threats

- Conserve and restore aquatic habitats that support fish and amphibians.
- Restore natural fire patterns to restore fire-dependent habitats and fire-dependent species.
- Conserve and restore sagebrush and native grassland habitats.
- Reduce the impact of subdivision development on wildlife.
- Mitigate the impact of roads through improved design of travel corridors.

When we furthermore prioritized conservation efforts based upon the above threats we winnowed these to the following five priorities which we believe will go a long ways toward the maintenance of natural processes and species assemblages in the Madison Valley. We believe that each of these conservation actions is doable at the local level of Madison Valley and, more so, are practical. Conservation and restoration of aquatic habitats will greatly benefit the human residents of the valley, for through conservation of these habitats, clean and adequate flows of water are conserved. Restoration of natural fire regimes can act to reduce long-term danger from catastrophic wildfires while simultaneously providing a complex habitat matrix across the forest. The conservation and restoration of the native grassland/sagebrush steppe mosaic will act to buffer wildfire, can increase grazing capacity, increase soil percolation, and reduce the dangers of noxious weed invasion. Through reducing the impacts of subdivision development on wildlife, we can maintain the natural amenities both long-term and new residents of the valley value, while maintaining a functioning landscape for wildlife. Finally, we can act to mitigate the impacts of roads, especially in conjunction with the aforementioned subdivision planning, on wildlife especially where these roads do, or would, traverse identified travel corridors.

To specifically address the threat of development we have outlined the following facets that may assist planners in making wise land-use decisions. State and local regulations have not provided the tools needed by land use planners and policy makers to guide growth to maintain the outstanding natural amenities of the valley. At present, there are two major challenges in the valley regarding subdivision development. The first is to develop mechanisms to guide future development through regulations and incentives so that wildlife habitats, ecological functions, and other natural amenities are preserved. The second is to consider wildlife needs in current subdivisions. The Madison Valley Growth Solutions Committee sponsored by the Madison Valley Ranchlands Group has taken the lead initiating a community-based forum for exploring potential solutions to growth in the valley. From a strictly wildlife perspective, it is easy to envision a suite of tools that would safeguard the outstanding wildlife resources of the valley for future generations. A potential suite of tools might include the following:

- Density driven zoning to ensure that sensitive wildlife areas remain lightly populated while directing the highest density developments into areas of lesser importance to wildlife.
- A wildlife conservation overlay district that would require a more critical standard of review and requirements for development projects proposed within the most important wildlife areas. It should be recognized that higher standards within the overlay district would likely significantly increase property values relative to loosely regulated areas subject to incremental degradation.
- Provide incentives to replat existing subdivisions within the wildlife conservation overlay district to bring them up to new density zoning and wildlife guidelines. Increased property values created by compliance with new guidelines may provide an economic incentive if the replatting review process can be made easy enough to not present obstacles to developers.
- An open space initiative to provide funds to purchase easements on private lands so that landowners receive economic compensation for maintaining open space and wildlife habitat to the benefit of all.
- Transferable development rights to provide a way for landowners to realize some of the development value of their property by selling development rights to increase density in areas where growth is desired. This tool could provide incentives for wildlife conservation by providing bonus development rights when rights are transferred away from important wildlife areas (those areas inside the wildlife conservation overlay).
- Regulations to protect particularly vulnerable or high quality habitats such as streamside habitat.

Land-use planning tools could be used to guide *where* people live in the valley but wildlife habitat quality is also affected by *how* people live. It is inevitable that an increasing number of people will choose to live in low-density rural developments. Areas of high wildlife importance will undoubtedly command a premium price because those areas are richest in the wildlife and scenic amenities that attract people to a rural lifestyle. Therefore, there is an urgent need to deploy tools to help rural residents protect natural amenities. These tools should include:

- Planned community development to assist new and existing subdivisions with protecting wildlife habitat and natural amenities in their community. Such planning could: guide home site development and infrastructure design to minimize negative impacts on wildlife habitats and develop covenants that protect the community's shared values.
- Education and outreach to raise awareness of rural wildlife issues and possible solutions.
- Create a support network of experts and potential cost-share sources to assist with habitat maintenance and restoration.
- Develop a citizen-based community wildlife monitoring program to get rural residents invested in the future of their local wildlife and to assess the success of planned community and land management efforts.

Priority Areas for Conserving Wildlife Diversity

- Papoose Creek to Raynold's Pass: Intersection of forest and grassland habitats.
- Sagebrush Steppe: important for conservation of grassland and sagebrush dependent species.
- Norris Hill to North Meadow Creek: Provides stepping stone habitats connecting Madison and Tobacco Root Mountains.
- Jack Creek Drainage: Important habitat connecting winter and summer range.
- Madison Willow Flats: Extensive riparian habitat along Madison River.

Modeling wildlife diversity values led us to develop a priority list of diversity hotspots. We believe that through the conservation of these areas, we can conserve the wildlife diversity potential throughout the Madison Valley. Habitat models for focal species were combined to create maps estimating the number and vulnerability of wildlife species with potential habitat across the valley providing a useful conservation tool by indicating where conservation efforts are likely to have the greatest positive impact. Included in this executive summary are maps estimating the existing relative potential wildlife diversity across the valley and the estimated percent loss of wildlife diversity that has already occurred. The highest potential diversity occurs in the mid-elevation mountainous areas surrounding the valley that are predominantly public lands. However, private lands play critical roles in the conservation of wildlife diversity, especially where native habitats have been immune from the plow. They often contain riparian areas where their soils and climate prove more conducive to high species diversity than do higher altitude, harsher areas. Hence, conservation of wildlife diversity, as well as attempts at conservation of overall biodiversity, should be done at a watershed level through local actions.

Priority Areas for Wildlife Connectivity

- Wolf Creek to Raynold's Pass: Regionally important for forest carnivores and migrating pronghorn.
- Norris Hill to North Meadow Creek: Provides stepping stone habitats connecting Madison and Tobacco Root Mountains.
- Central Valley: Important for allowing ungulates to move among habitat patches in the valley bottom.
- Major Drainages and foothills: Needed to allow migration of ungulates between summer and winter ranges. Jack Creek drainage currently the most imperiled.
- Virginia City Hill: Provide movement corridor for ungulates and carnivores in addition to Greater Sage-Grouse habitat.

To protect the remaining connectivity provided by portions of the Madison Valley, specifically connectivity functioning on both local scales and at the scale of linking large roadless areas, our analyses indicated five priority areas to conserve. These priorities are as follows:

- Papoose Creek to Raynold's Pass: This area is one of the most important zones of connectivity in the Greater Yellowstone Ecosystem because it provides quality habitat and security for montane species moving from the western edge of the GYE to mountain ranges to the west. In addition, this area creates a bottleneck for antelope that seasonally migrate between Henry's Lake and the Upper Madison Valley. Continued development in the area could impair the future value of this area for wildlife habitat connectivity.
- Norris Hill to the Tobacco Roots: Although not as high quality as the Papoose to Raynold's corridor, this area contains a mosaic of habitat types that could provide stepping stones of security for animals moving between the Madison and Tobacco Root Ranges. This area is also experiencing increasing development pressure and without careful management, the potential for this area to provide a movement corridor may be lost.
- Perimeter Foothills: The foothills surrounding the Madison Valley have become increasingly important for wildlife moving between isolated habitat patches. This is particularly true for ungulates moving between summer and winter ranges, and among patches of winter range, where they can still find security for movement.
- Central Valley: The Madison Valley once provided a nearly unbroken block of suitable habitat for elk, pronghorn, and other ungulates. However, this habitat has become increasingly fragmented due to roads, development, and other human activities. Much of the valley continues to provide suitable movement habitat for ungulates and connectivity between habitat patches remains adequate. However, careful planning will be necessary to ensure that sufficient areas remain open for wildlife movement to access all available habitat patches.
- Virginia City Hill: This pass connects the northern portion of the Gravelly's with the southern Tobacco Roots containing generally mid-range wildlife diversity values due to its preponderance of big sagebrush. However, scattered copses of Douglas-fir, some generally north to south running ridges, and tall stands of basin big sagebrush add to its importance as a wildlife corridor. Raptors migrate over this pass funneling south to the Gravelly's (a known migration site), wolves have been observed moving through the area, and it is likely that an unknown sage-grouse lek functions nearby. Care should be exercised here with regard to housing development as well as road improvements to state highway 287.

Information Needs

While setting the stage for applied conservation action, it became apparent that our work, and the work of those implementing conservation planning and projects, could be made much more accurate, precise, and efficient if better data were available. Specifically, information on the topics listed in Table 13 will prove to be very valuable for conservation and land-use planning in the Madison Valley.

Areas of valuable data and information needed:

- Baseline Data Needs
  - Sagebrush/Native Grassland Inventory
  - Aspen Inventory
  - Wetlands & Riparian Inventory
  - Wildlife Inventory
- Research Needs
  - Effects of Rural Subdivision on Wildlife/Biodiversity
  - Effects of Motorized Recreation on Wildlife/Biodiversity
  - Effects of Fire Suppression on Wildlife/Biodiversity
  - Description of Pronghorn Migration Ecology within and without the Madison Valley

In conclusion, we have provided what we believe is a useful tool for conservation planning and action in the Madison Valley of Montana. Moreover, through rigorous scientific analyses, we have identified threats that are based upon rankings of these threats to wildlife, ways to mitigate these threats, and most importantly, maps depicting areas where threats occur, greatest wildlife diversity (and loss in diversity) occurs, and important wildlife movement corridors exist (and where they have been degraded). These maps, along with identified tools, can be used by land-use planners, developers, private landowners, land managers, biologists, and conservationists to provide ways to maintain the ecological facets that make the Madison Valley a special place for wildlife and a special place for people who enjoy its natural splendor.

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Appendice A - Methods

Appendix A1. Species Model Methods

Table A1-1 Species Matrix Scores

Species	Urban	Dryland Agriculture	Irrigated Agriculture	Altered Herbabceous	Very Low Cover Grasslands	Low to Moderate Cover Grasslands	Medium to High Cover Grasslands	Meadow	Mixed Mesic Shrubland	Mixed Xeric Shrubland	Saltflat Desert	Sage	Mesic Shrub Grassland	Xeric Shrub Grassland	Xeric Forest	Broadleaf Forest	Lodgepole Pine	Limber Pine	Ponderosa Pine	Douglas-fir	Rocky Mountain Juniper	Douglas-fir and Lodgepole Pine	White Bark Pine	Subalpine Forest	Mixed Xerix Forest	Broadleaf Conifer Forest	Burnt Forest	Water	Riparian Conifer	Riparian Broadleaf	Riparian Broadleaf Confier	Riparian Graminoid Forbs	Riparian Shrublands	Riparian Mixed	Rock	Gravel Pit	Badlands	Barren	Alpine Meadow
Grizzly bear	0	0	0	0	0	0	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	0	0	1
Moose	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1	0	0	1	0	1	0	1	0	1	1	0	1	1	1	1	1	1	0	0	0	0	1
Elk	0	1	1	0	0	1	1	1	1	0	0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	0	0	1	0	1
Boreal Toad	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	1
Wolverine	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	1	0	1	0	1	1	1	0	1	0	0	1	1	1	0	0	0	1	0	0	0	1
Red-naped Sap Sucker	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	1	0	1	1	0	1	1	1	0	1	1	0	0	0	0	0
Warbling Vireo	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	1	1	0	1	0	0	0	1	0	0	1	1	1	0	1	1	0	0	0	0	0
Yellow Warbler	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	1	1	0	0	0	0	0
Columbia Spotted Frog	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	1
Arctic Grayling (fluvial)	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	1	1	1	1	0	0	0	0	1
Greater Sage Grouse	0	1	1	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Bighorn Sheep	0	0	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Pronghorn Antelope	0	1	1	1	1	1	1	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	1	0	0
Westslope Cutthroat Trout	1	0	0	0	0	1	1	1	1	0	0	0	0	0	0	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	1
Black-backed Woodpecker	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Kokanee	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	1	1	1	1	0	0	0	0	0
Golden Trout	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	1	0	1	0	1	1	1	1	1	1	1	1	0	0	1	1	1	1	0	0	0	1
Yellowstone Cutthroat Trout	1	0	0	0	0	1	1	1	1	0	0	0	0	0	0	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	1
Rainbow Trout	1	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1
Brown Trout	1	0	0	0	0	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	1	0	1	1	1	1	1	1	1	0	1	0	0	0
Brook Trout	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	1
Lake Trout	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1	1	1	0	0	0	1	0	1	1	1	1	1	1	1	1	0	0	0	0
Mountain Whitefish	1	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
Carp	1	0	0	0	0	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1	0	1	1	1	1	1	0	1	0	0	0
Goldfish	1	0	0	0	0	1	1	0	0	1	1	1	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	1	1	1	1	0	1	0	0	0
Golden Shiner	1	0	0	0	0	1	1	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	1	1	0	1	0	0	0
Redside Shiner	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0
Utah Chub	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	1	1	0	1	0	0	0
Lake Chub	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0
Flathead Chub	1	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	1	1	1	1	0	1	0	0	0
Fathead Minnow	1	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	1	1	1	1	0	1	0	0	0
Longnose Dace	1	0	0	0	0	1	1	0	0	1	1	1	1	1	1	0	0	0	1	0	0	0	1	1	1	1	0	1	1	1	1	1	1	1	0	1	0	0	0
Black Bullhead	1	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	1	1	0	1	0	0	0
Stonecat	1	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	1	1	1	1	0	1	0	0	0
Mountain Sucker	1	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1

Species	Urban	Dryland Agriculture	Irrigated Agriculture	Altered Herbabceous	Very Low Cover Grasslands	Low to Moderate Cover Grasslands	Medium to High Cover Grasslands	Meadow	Mixed Mesic Shrubland	Mixed Xeric Shrubland	Saltflat Desert	Sage	Mesic Shrub Grassland	Xeric Shrub Grassland	Xeric Forest	Broadleaf Forest	Lodgepole Pine	Limber Pine	Ponderosa Pine	Douglas-fir	Rocky Mountain Juniper	Douglas-fir and Lodgepole Pine	White Bark Pine	Subalpine Forest	Mixed Xerix Forest	Broadleaf Conifer Forest	Burnt Forest	Water	Riparian Conifer	Riparian Broadleaf	Riparian Broadleaf Confier	Riparian Graminoid Forbs	Riparian Shrublands	Riparian Mixed	Rock	Gravel Pit	Badlands	Barren	Alpine Meadow
White Sucker	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	1	0	1	1	1	1	1	1	1	0	1	0	0	0
Long-nosed Sucker	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	1	1	1	1	1	1	0	0	0	0	0
Burbot	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	1	1	1	1	0	0	0	0	0
Bluegill	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	1	1	1	1	0	1	0	0	0
Smallmouth Bass	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	1	1	1	1	0	1	0	0	0
Largemouth Bass	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	1	1	1	1	0	1	0	0	0
Black Crappie	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	1	1	1	1	0	1	0	0	0
Yellow Perch	1	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	1	1	1	1	0	1	0	0	0
Mottled Sculpin	1	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Tiger Salamander	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1
Bullfrog	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	1	0	0	0
Northern Leopard Frog	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	0	1	0	1	0
Boreal Chorus Frog	1	1	1	1	1	1	1	1	1	1	0	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1
Plains Spade Foot	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	0	0	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
Snapping Turtle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0
Painted Turtle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	1	0	0	0
Greater Short-Horned Lizard	0	0	0	1	1	1	1	0	0	1	1	1	1	1	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
Sagebrush Lizard	0	0	0	1	1	1	1	1	0	1	1	1	1	1	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0
Rubber Boa	1	0	0	0	0	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	0	0	0
Racer	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	0	0	0	1	1	0	0	1	1	1	1	1	1	1	0	1	1	0
Western Terrestrial Garter Snake	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1
Common Garter Snake	1	0	1	1	1	1	1	1	1	0	0	0	1	1	1	1	1	1	1	1	0	1	1	1	0	1	0	1	1	1	1	1	1	1	0	1	0	1	0
Milk Snake	0	1	0	1	1	1	1	0	0	1	1	1	0	1	1	0	0	1	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0
Magpie	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0	0	0	1	0	0	0	1	1	1	1	1	1	1	0	1	1	0
Western Rattlesnake	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	0	0	0	1	0	0	0	1	1	1	1	1	1	1	0	1	1	0
Alder Flycatcher	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	1	1	0	1	1	0	0	0	0	0
American Avocet	0	1	1	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	1	1	1	0
American Bittern	0	0	0	1	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0
American Coot	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0
American Crow	1	1	1	1	1	1	1	0	1	1	0	0	1	1	1	1	0	0	0	0	1	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0
American Dipper	1	0	0	0	0	0	0	1	1	0	0	0	1	0	0	1	1	0	0	1	0	1	0	1	1	1	0	1	1	1	1	1	1	1	0	0	0	0	0
American Golden Plover	0	1	1	1	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	0	0	1	0
American Goldfinch	1	1	1	1	0	0	1	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	1	1	0	0	0	0	0
American Kestrel	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1	1	1	1	1	0	0	1	1	1	0	1	1	1	0	0	0	1	0	0	0	1
American Pipit	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
American Redstart	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	1	0	0	0	0	0
American Robin	1	0	1	0	0	0	0	1	1	0	0	0	1	0	1	1	1	1	1	1	0	1	0	1	1	1	1	0	1	1	1	0	1	1	0	0	0	0	0
American Tree Sparrow	1	0	1	1	0	1	1	0	1	1	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	1	1	0	0	0	0	0
American White Pelican	0	0	0	1	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	1	1	0	0	0	1	0
American Wigeon	0	1	1	1	0	1	1	1	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	1	0	0	0
Audubon's Warbler	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	1	1	0	1	1	1	1	1	0	0	1	0	1	0	0	0	0	0	0	0	0

Species	Urban	Dryland Agriculture	Irrigated Agriculture	Altered Herbabceous	Very Low Cover Grasslands	Low to Moderate Cover Grasslands	Medium to High Cover Grasslands	Meadow	Mixed Mesic Shrubland	Mixed Xeric Shrubland	Saltflat Desert	Sage	Mesic Shrub Grassland	Xeric Shrub Grassland	Xeric Forest	Broadleaf Forest	Lodgepole Pine	Limber Pine	Ponderosa Pine	Douglas-fir	Rocky Mountain Juniper	Douglas-fir and Lodgepole Pine	White Bark Pine	Subalpine Forest	Mixed Xerix Forest	Broadleaf Conifer Forest	Burnt Forest	Water	Riparian Conifer	Riparian Broadleaf	Riparian Broadleaf Confier	Riparian Graminoid Forbs	Riparian Shrublands	Riparian Mixed	Rock	Gravel Pit	Badlands	Barren	Alpine Meadow
Baird's Sandpiper	0	1	1	1	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	1	0	1	0
Bald Eagle	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	1	0	0	1	1	0	1	1	1	1	0	0	0	0	0	0	0	0
Bank Swallow	0	1	1	1	1	1	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	1	1	1	0
Barn Swallow	1	1	1	1	1	1	1	0	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	1	1	1	1	1	0	0
Barred Owl	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0	1	0	1	0	1	0	1	0	0	1	1	1	0	0	1	0	0	0	0	0
Barrow's Goldeneye	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	1	0	1	1	1	0	1	1	1	1	1	1	1	0	0	0	0	0
Belted Kingfisher	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	1	0	1	0	1	0	1	1	1	1	1	1	1	0	0	0	0	0
Black Rosy Finch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Black Tern	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0
Blue-winged Warbler	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0
Black-billed Cuckoo	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	1	1	1	0	1	1	0	0	0	0	0
Black billed Magpie	1	1	1	1	1	1	0	0	0	1	0	1	1	1	1	1	0	1	1	0	1	0	0	0	1	1	0	0	1	1	1	0	1	0	0	0	0	0	0
Blackpoll Warbler	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	1	0	1	0	1	0	1	0	0	1	1	1	0	0	0	0	0	0	0	0
Black capped Chickadee	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	1	0	1	1	1	1	1	0	1	1	0	0	1	1	1	0	0	1	0	0	0	0	1
Black-crowned Night-Heron	0	0	0	0	0	0	0	1	1	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0
Black headed Grosbeak	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	1	1	0	1	0	0	0	0	0	0
Black-necked Stilt	0	1	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	1	1	1	0
Black-throated Gray Warbler	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	1	0	1	0	1	1	1	0	0	1	1	1	0	0	0	0	0	0	0	0
Blue Grouse	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	1	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1
Blue Jay	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	0	0	1	1	1	0	0	0	0	0	0	0	0
Blue Winged Teal	0	0	1	1	0	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	1	0	0	0
Bobolink	0	1	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Bohemian Waxwing	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	1	0	0	1	1	1	0	0	0	0	0	0	0	1
Bonaparte's Gull	0	0	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0
Boreal Owl	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0	1	0	1	1	1	0	1	0	0	1	1	1	0	0	0	0	0	0	0	1
Brewer's Blackbird	1	1	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
Brewer's Sparrow	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Broad-tailed Hummingbird	0	0	0	0	0	0	0	1	1	0	0	0	1	0	1	0	1	0	0	1	0	1	0	1	1	1	1	0	0	0	1	1	1	1	0	0	0	1	1
Brown Creeper	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Brown Headed Cowbird	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	0	0
Buff-breasted Sandpiper	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	1	0	1	0
Bufflehead	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	1	0	1	1	0	1	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
Bullock's Oriole	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
Burrowing Owl	1	1	1	1	1	1	1	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
California Gull	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0
Calliope Hummingbird	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1	0	1	1	0	1	0	1	0	1	1	0	1	1	1	1	1	1	0	0	0	0	1
Canada Goose	1	1	1	1	0	1	0	1	1	1	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	1	0	0	0
Canvasback	0	0	0	1	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	1	0	0	0
Carolina Wren	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0
Caspian Tern	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0

Species	Urban	Dryland Agriculture	Irrigated Agriculture	Altered Herbabceous	Very Low Cover Grasslands	Low to Moderate Cover Grasslands	Medium to High Cover Grasslands	Meadow	Mixed Mesic Shrubland	Mixed Xeric Shrubland	Saltflat Desert	Sage	Mesic Shrub Grassland	Xeric Shrub Grassland	Xeric Forest	Broadleaf Forest	Lodgepole Pine	Limber Pine	Ponderosa Pine	Douglas-fir	Rocky Mountain Juniper	Douglas-fir and Lodgepole Pine	White Bark Pine	Subalpine Forest	Mixed Xerix Forest	Broadleaf Conifer Forest	Burnt Forest	Water	Riparian Conifer	Riparian Broadleaf	Riparian Broadleaf Confier	Riparian Graminoid Forbs	Riparian Shrublands	Riparian Mixed	Rock	Gravel Pit	Badlands	Barren	Alpine Meadow
Cassin's Finch	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	1	0	1	0	1	1	1	1	0	0	1	1	0	0	0	0	0	0	0	0
Cassin's Vireo	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	1	0	0	1	1	0	0	1	0	1	0	0	0	0	0	0	0	0
Cattle Egret	0	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	1	0	0	0
Cedar Waxwing	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	1	1	0	1	0	0	0	0	0	0
Chestnut-sided Warbler	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
Chipping Sparrow	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1	1	0	1	1	1	1	0	1	1	1	0	0	0	0	0	0	0	0
Chukar	0	0	0	0	0	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0
CIinnamon Teal	0	0	1	1	0	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	1	0	0	0
Clark's Grebe	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	1	0	0	0
Clark's Grebe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Clay Colored Sparrow	0	0	0	1	0	1	1	0	1	1	0	1	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	0	0	0	0
Cliff Swallow	1	1	1	1	1	1	1	0	1	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	1	1	1	1	1	0	0
Common Goldeneye	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	1	0	0	1	1	1	1	1	1	1	0	0	0	0	1	0	0	0
Common Grackle	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
Common Loon	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1	1	1	1	0	1	0	1	1	1	0	1	1	1	1	1	1	1	0	0	0	0	0
Common Merganser	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	1	1	1	1	1	0	1	1	1	1	0	0	0	0	1	0	0	0
Common Nighthawk	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	0	1	0	0	1	0	0	0	1	1	1	0	1	1	1	1	1	1	0	1	1	1	0
Common Pochard	0	0	0	1	1	0	0	0	0	1	1	1	0	1	1	0	0	1	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0
Common Raven	1	1	1	1	1	1	0	1	0	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	0	0	0	1	0	1	0	1
Common Redpoll	1	1	1	1	0	0	0	0	1	1	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1
Common Tern	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
Common Yellowthroat	0	0	0	1	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0
Cooper's Hawk	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1	1	0	1	0	0	1	1	0	0	1	1	1	0	0	0	0	0	0	0	1
Cordilleran Flycatcher	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	1	0	0	1	1	0	0	1	1	1	0	1	1	0	0	0	0	0
Double-crested Cormorant	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	1	1	1	0	0	1	0	0	0	0	0
Common Woodstork	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	1	1	0	0	0	0	0	0	0	0
Dunlin	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	1	0	1	0
Dusky Flycatcher	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	1	1	0	1	1	1	0	1	1	0	0	0	0	0
Eared Grebe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	1	0	0	0
Eastern Kingbird	0	1	1	0	0	0	1	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	0	0	0	0
Eastern Phoebe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	1	0	0	1	0	0	0	0	0
Eastern Screech	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0
Eurasian Wigeon	0	1	1	1	0	1	1	1	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	1	0	0	0
European Starling	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
Evening Grosbeak	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1
Ferruginous Hawk	0	1	1	1	1	1	0	0	0	1	0	1	0	1	1	1	0	1	0	0	1	0	0	0	1	0	0	0	0	1	1	0	1	1	1	0	1	0	0
Forster's Tern	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0
Fox Sparrow	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0	1	1	1	0	1	1	0	0	0	0	1
Franklin's Gull	0	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	1	0	0	0
Gadwall	0	1	1	1	0	1	1	0	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	1	0	0	0
Golden Eagle	0	1	1	1	1	1	0	0	0	1	0	1	0	1	1	0	0	1	1	1	0	0	0	0	1	0	0	0	0	1	1	0	0	0	1	0	1	0	1
Golden crowned Kinglet	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1

Species	Urban	Dryland Agriculture	Irrigated Agriculture	Altered Herbabceous	Very Low Cover Grasslands	Low to Moderate Cover Grasslands	Medium to High Cover Grasslands	Meadow	Mixed Mesic Shrubland	Mixed Xeric Shrubland	Saltflat Desert	Sage	Mesic Shrub Grassland	Xeric Shrub Grassland	Xeric Forest	Broadleaf Forest	Lodgepole Pine	Limber Pine	Ponderosa Pine	Douglas-fir	Rocky Mountain Juniper	Douglas-fir and Lodgepole Pine	White Bark Pine	Subalpine Forest	Mixed Xerix Forest	Broadleaf Conifer Forest	Burnt Forest	Water	Riparian Conifer	Riparian Broadleaf	Riparian Broadleaf Confier	Riparian Graminoid Forbs	Riparian Shrublands	Riparian Mixed	Rock	Gravel Pit	Badlands	Barren	Alpine Meadow
Grasshopper Sparrow	0	0	1	1	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Gray Catbird	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	0	0	0	0
Gray Flycatcher	0	0	0	0	1	1	0	0	0	1	1	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gray Jay	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	1	1	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	1
Gray Partridge	0	1	1	1	0	1	1	0	1	1	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gray-crowned Rosy Finch	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Great Blue Heron	1	0	1	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	1	0	1	1	1	1	1	1	1	0	1	0	0	0
Great Egret	1	0	1	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	1	0	1	1	1	1	1	1	1	0	1	0	0	0
Great Gray Owl	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1	0	0	1	0	1	0	1	0	1	1	0	1	1	1	1	1	1	0	0	0	0	1
Great Horned Owl	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1
Greater Scaup	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	1	0	0	0
Greater White-fronted Goose	0	1	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0
Greater Yellowlegs	0	1	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	1	1	1	0
Green Tailed Towhee	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
American Green-winged Teal	0	0	0	0	1	1	1	1	1	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	1	0	1	1	1	1	1	1	1	0	1	0	0	0
Gyrfalcon	0	1	1	1	1	1	1	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	1
Hairy Woodpecker	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	1	1	1	1	1	1	0	1	1	1	0	0	0	0	0	0	0	0
Hammond's Flycatcher	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	1	0	1	1	1	0	0	1	1	1	0	0	0	0	0	0	0	0
Harlequin ducks	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1	0	0	1	0	1	1	1	0	1	0	1	1	1	1	0	1	1	0	0	0	0	1
Harris's Sparrow	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0
Hermit Thrush	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	1	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Herring Gull	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0
Hooded Merganser	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	1	1	1	1	1	1	1	1	1	1	0	0	1	0	0	0	0	0
Hooded Oriole	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
Horned Grebe	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	1	1	0	1	0	0	0
Horned Lark	0	1	1	1	1	1	0	1	0	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
House Finch	1	1	0	0	0	0	0	0	1	1	0	0	1	1	1	1	0	0	1	1	1	0	0	0	1	1	0	0	1	1	1	0	1	1	0	0	0	0	0
House Sparrow	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
House Wren	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0	1	1	0	1	0	0	0	0	0	0
Indigo Bunting	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	1	1	0	1	1	0	0	0	0	0
Killdeer	1	1	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	1	1	1	0
Lapland Longspur	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Lark Bunting	0	1	1	1	1	1	0	0	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lark Sparrow	0	1	1	1	1	1	1	0	0	0	0	1	1	1	1	1	0	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0
Lazuli Bunting	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	0	0	0	0	0	1	0	1	0	1	1	1	1	1	1	0	0	0	0	0
Least Flycatcher	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0
Least Sandpiper	0	1	1	1	1	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	1	0	1	0
Lesser Scaup	0	0	1	1	0	0	1	1	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	1	0	0	0
Lesser Yellowlegs	0	1	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	1	1	1	0
Lewis' Woodpecker	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	1	0	0	1	1	0	0	0	0	0	0	0	0
Lincoln's Sparrow	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	1	1	0	0	1	0	1	1	1	0	0	1	0	1	0	0	0	1	1	0	0	0	0	0

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Loggerhead Shrike	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	1	0	0
Long billed Curlew	0	1	1	1	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Long-billed Dowitcher	0	1	1	1	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	1	0	1	0
Long-eared Owl	0	0	1	0	0	0	0	0	1	1	0	1	1	1	1	1	0	0	1	1	1	0	0	1	1	1	0	0	1	1	1	1	1	1	0	0	0	0	0
Macalivry's Warbler	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	1	1	1	1	1	0	0	1	1	1	0	1	1	0	0	0	0	0
Mallard	1	1	1	1	0	1	1	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	1	0	0	0
Marbled Godwit	0	1	1	1	1	1	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	1	1	0	0
Marsh Wren	0	0	1	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0
McCown's Longspur	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Merlin	1	1	1	1	1	1	1	0	0	1	0	1	0	1	1	1	0	1	1	1	1	0	0	0	1	0	0	0	0	1	1	0	0	0	1	0	0	0	1
Mountain Bluebird	0	1	1	0	0	1	1	1	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	1	1	1	0	0	1	0	0	0	0	0	0	0	0	1
Mountain Chickadee	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	1	1	1	0	1	1	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	1
Mourning Dove	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	0	0	0	1	1	0	0	1	1	1	1	1	1	0	1	1	0	0
Mute Swan	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	1	1	0	0	0	0	0
Myrtle Warbler	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	1	1	0	1	1	1	1	1	0	0	1	0	1	0	0	0	0	0	0	0	0
Northern Goshawk	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1
Northern Harrier	0	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0
Northern Mockingbird	0	0	0	0	0	1	1	0	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Northern Pintail	0	1	1	1	1	1	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	1	0	1	0
Northern Pygmy Owl	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	0	0	0	0	0
Northern Rough-winged Swallow	0	1	1	1	1	1	1	0	0	0	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	0	1	1	1	1	0	0	0	0	1	1	1	0
Northern Saw Whet Owl	1	0	0	0	0	0	0	1	1	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	0	0	0	0	0	0	0	0
Northern Shoveler	0	0	1	1	1	1	1	1	1	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	1	0	0	0
Northern Shrike	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	1	0	0	0	0	0	1	0	0	1	0	1	1	1	0	0	0	0	1
Northern Waterthrush	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	1	0	1	0	0	0	0	0	0
Olive sided Flycatcher	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	1	1	1	1	1	0	1	1	1	0	0	0	0	0	0	0	0
Orange crowned Warbler	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	1	1	0	1	1	1	1	1	0	0	1	1	1	0	1	1	0	0	0	0	0
Oregon Junco	1	0	0	0	0	0	0	1	0	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	0	1	0	1	0	0	0	0	0	1
Osprey	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	1	0	0	1	1	0	1	1	1	0	0	0	0	0	1	0	0	0
Pacific Loon	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1	1	1	1	0	1	0	1	1	1	0	1	1	1	1	1	1	1	0	0	0	0	0
Parasitic Jaeger	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0
Pectoral Sandpiper	0	1	1	1	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	1	0	1	0
Peregrine Falcon	0	1	1	1	1	1	1	1	1	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	1	1	1	1	1	0	1	0	1
Pied-billed Grebe	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0
Pied - billed Grebe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	1	0	0	1	1	0	0	1	1	1	0	0	0	0	0	0	0	0
Pine Grosbeak	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
Pine Siskin	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	1	1	1	1	1	1	0	1	0	1	0	1	0	0	0	0	0	1
Pink-sided Junco	1	0	0	0	0	0	0	1	0	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	0	1	0	1	0	0	0	0	0	1
Pinyon Jay	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Prairie Falcon	0	1	1	1	1	1	1	1	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1
Red Crossbill	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	1	1	1	1	1	0	0	1	0	1	0	0	0	0	0	0	0	1

Species	Urban	Dryland Agriculture	Irrigated Agriculture	Altered Herbabceous	Very Low Cover Grasslands	Low to Moderate Cover Grasslands	Medium to High Cover Grasslands	Meadow	Mixed Mesic Shrubland	Mixed Xeric Shrubland	Saltflat Desert	Sage	Mesic Shrub Grassland	Xeric Shrub Grassland	Xeric Forest	Broadleaf Forest	Lodgepole Pine	Limber Pine	Ponderosa Pine	Douglas-fir	Rocky Mountain Juniper	Douglas-fir and Lodgepole Pine	White Bark Pine	Subalpine Forest	Mixed Xerix Forest	Broadleaf Conifer Forest	Burnt Forest	Water	Riparian Conifer	Riparian Broadleaf	Riparian Broadleaf Confier	Riparian Graminoid Forbs	Riparian Shrublands	Riparian Mixed	Rock	Gravel Pit	Badlands	Barren	Alpine Meadow
Red Phalaropes	0	1	1	1	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	1	1	1	0
Red breasted Merganser	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1	0	0	0	0	0	0	0	0
Red breasted Nuthatch	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	0	0	0	0	0	0	0	0
Red eyed Vireo	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
Redhead	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	1	0	0	0
Red-necked Grebe	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	1	1	0	1	0	0	0
Red-necked Phalarope	0	1	1	1	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	1	1	1	0
Red-shafted Flicker	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	1	0	1	1	1	1	0	1	1	1	0	0	0	0	0	0	0	0
Red tailed Hawk	0	1	1	1	1	1	1	0	1	1	0	1	1	1	1	1	0	1	1	1	1	1	0	0	1	1	0	0	1	1	1	1	1	1	1	0	1	0	1
Red-throated Loon	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1	1	1	1	0	1	0	1	1	1	0	1	1	1	1	1	1	1	0	0	0	0	0
Red winged Blackbird	1	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0
Ring-billed Gull	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0
Ring - necked Duck	0	0	1	1	0	0	0	1	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	1	1	1	1	1	1	1	0	1	0	0	0
Ring-necked Pheasant	0	1	1	1	1	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0
Rock Pigeon	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Rock Wren	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	1	1	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	1	1	0
Rose-breasted Grosbeak	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	1	1	0	1	0	0	0	0	0	0
Ross' Goose	0	1	1	1	0	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0
Rough-legged Hawk	0	1	1	1	1	1	1	0	0	1	0	1	0	1	1	1	0	1	1	0	1	0	0	0	1	1	0	0	1	1	1	1	1	1	0	0	1	0	0
Ruby crowned Kinglet	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	1	0	1	1	1	1	0	1	0	1	0	0	0	0	0	0	0	1
Ruddy Duck	0	0	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	1	0	0	0
Ruffed Grouse	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1	1	0	1	0	0	1	1	1	0	1	1	1	0	1	1	0	0	0	0	0
Rufus Hummingbird	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	1	1	0	1	0	1	0	1	1	0	1	1	1	0	1	1	0	0	0	0	1
Sage Thrasher	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sanderling	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0
Sandhill Crane	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0
Savannah Sparrow	0	1	1	1	0	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Say's Phoebe	0	1	1	1	1	1	0	0	0	1	0	1	0	1	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
Scissor-tailed Flycatcher	0	1	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Semipalmated Plover	0	0	1	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	0	0	1	0
Semipalmated Sandpiper	0	1	1	1	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	1	0	1	0
Say's Phoebe	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	1	0	1	0	1	0	1	0	0	1	1	1	0	0	0	0	0	0	0	1
Sharp tailed Grouse	0	1	1	1	1	1	1	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0
Short - billed Dowitcher	0	1	1	1	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	1	0	1	0
Short eared Owl	0	1	1	1	0	1	1	0	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0
Snow Bunting	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Snow Goose	0	1	1	1	0	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0
Snowy Egret	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	1	0	0	0
Snowy Plover	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0
Solitary Sandpiper	0	1	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	1	1	1	0
Solitary Vireo	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	1	0	0	1	1	0	0	1	0	1	0	0	0	0	0	0	0	0

Species	Urban	Dryland Agriculture	Irrigated Agriculture	Altered Herbabceous	Very Low Cover Grasslands	Low to Moderate Cover Grasslands	Medium to High Cover Grasslands	Meadow	Mixed Mesic Shrubland	Mixed Xeric Shrubland	Saltflat Desert	Sage	Mesic Shrub Grassland	Xeric Shrub Grassland	Xeric Forest	Broadleaf Forest	Lodgepole Pine	Limber Pine	Ponderosa Pine	Douglas-fir	Rocky Mountain Juniper	Douglas-fir and Lodgepole Pine	White Bark Pine	Subalpine Forest	Mixed Xerix Forest	Broadleaf Conifer Forest	Burnt Forest	Water	Riparian Conifer	Riparian Broadleaf	Riparian Broadleaf Confier	Riparian Graminoid Forbs	Riparian Shrublands	Riparian Mixed	Rock	Gravel Pit	Badlands	Barren	Alpine Meadow
Song Sparrow	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	1	1	0	0	1	1	1	0	1	1	0	0	0	0	0
Sora	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0
Spotted Sandpiper	0	1	1	1	1	1	1	1	1	0	0	0	1	0	1	1	0	0	0	1	0	1	0	0	0	1	0	1	1	1	1	1	1	1	0	1	0	1	0
Spotted Towhee	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	1	0	0	1	0	1	0	0	0	1	1	0	0	0	1	1	0	1	1	0	0	1	0	0
Sprague's Pipit	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stellar's Jay	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0	1	0	1	1	1	0	1	0	0	1	0	1	0	0	0	0	0	0	0	1
Surf Scoter	0	1	1	1	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	1	0	1	0
Swainson's Hawk	0	1	1	1	1	1	1	0	0	1	0	1	0	1	1	1	0	0	0	0	1	0	0	0	1	1	0	0	0	1	1	1	1	1	0	0	0	0	0
Swainson's Thrush	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	1	0	1	1	1	0	0	1	1	1	0	0	0	0	0	0	0	0
Townsend's Solitaire	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	1	1	1	1	1	1	1	1	0	1	0	1	0	1	0	0	0	0	0	0	0	1
Townsend's Warbler	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	1	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0
Tree Swallow	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	1	0	0	0	1	1	0	1	1	1	0	0	0	0	0	0	0	0
Trumpeter Swan	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	1	0	0	0	0	0	0
Tundra Swan	0	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	1	0	0	0
Turkey Vulture	0	1	1	1	1	1	1	1	0	1	1	1	0	1	1	1	0	1	1	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0	1	0	0
Varied Thrush	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Veery	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
Vesper Sparrow	0	1	1	1	1	1	1	0	0	0	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0
Violet green Swallow	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	1	1	0	0	1	1	1	0	0	0	1	0	0	0	0
Virginia Rail	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0
Western Bluebird	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0
Western Grebe	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	1	0	0	0
Western Kingbird	0	1	1	1	1	1	0	0	0	1	0	1	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Western Meadowlark	0	1	1	1	0	1	1	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Western San	0	1	1	1	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	1	0	1	0
Western Screech-Owl	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	1	1	0	0	0	0	0	0	0	0
Western Tanager	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	1	0	1	1	1	1	0	1	0	1	0	0	0	0	0	0	0	0
Western Wood-Pewee	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	1	1	0	1	1	1	1	1	1	0	1	1	1	0	0	0	0	0	0	0	0
White breasted Nuthatch	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0
White crowned Sparrow	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	1	1	0	0	0	0	1
White-faced Ibis	0	0	1	1	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	1	1	0	0	0	0	0
White-rumped Sandpiper	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0
White throated Swift	0	0	1	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1
White-winged Crossbill	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
White-winged Scoter	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	1	0	0	0
Wild Turkey	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0
Willow Flycatcher	0	1	1	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	1	1	1	0
Williamson's Sapsucker	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	1	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Willow Flycatcher	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	1	1	0	1	1	0	0	0	0	0
Wilson's Phalarope	0	1	1	1	0	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	1	1	1	0
Wilson's Snipe	0	0	1	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0

Species	Urban	Dryland Agriculture	Irrigated Agriculture	Altered Herbabceous	Very Low Cover Grasslands	Low to Moderate Cover Grasslands	Medium to High Cover Grasslands	Meadow	Mixed Mesic Shrubland	Mixed Xeric Shrubland	Saltflat Desert	Sage	Mesic Shrub Grassland	Xeric Shrub Grassland	Xeric Forest	Broadleaf Forest	Lodgepole Pine	Limber Pine	Ponderosa Pine	Douglas-fir	Rocky Mountain Juniper	Douglas-fir and Lodgepole Pine	White Bark Pine	Subalpine Forest	Mixed Xerix Forest	Broadleaf Conifer Forest	Burnt Forest	Water	Riparian Conifer	Riparian Broadleaf	Riparian Broadleaf Confier	Riparian Graminoid Forbs	Riparian Shrublands	Riparian Mixed	Rock	Gravel Pit	Badlands	Barren	Alpine Meadow
Wilson's Warbler	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	1	0	1	0	0	0	0	0	0
Winter Wren	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0
Wood Duck	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	1	1	1	1	1	1	0	0	0	0	0
Wood Stork	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0
Wood Thrush	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
Yellow Rail	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0
Yellow-billed Cuckoo	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1	1	0	0	0	0	0
Yellow breasted Chat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
Yellow-crowned Night-Heron	0	0	0	0	0	0	0	1	1	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0
Yellow headed Blackbird	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
Yellow-shafted Flicker	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	1	0	1	1	1	1	0	1	1	1	0	0	0	0	0	0	0	0
Three Toed Woodpecker	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Whooping Crane	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0
Chestnut-collared Longspur	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spruce Grouse	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Masked Shrew	0	0	0	0	1	1	1	1	0	0	0	1	0	0	0	0	1	0	1	1	1	1	0	1	0	0	0	0	1	1	1	1	1	1	0	0	0	0	1
Pygmy Shrew	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Dusky Shrew	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	0	0	1	1	1	1	1	1	0	0	0	0	1
Water Shrew	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	1	0	0	1	0	1	0	1	1	1	0	1	1	1	1	1	1	1	0	0	0	0	0
Preble's Shrew	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Townsend's Big-ear bat	0	1	0	0	0	0	0	1	1	1	0	0	0	1	1	0	1	1	0	1	1	1	0	1	1	0	0	0	0	0	0	1	1	1	1	1	1	0	0
Big Brown Bat	1	0	1	0	0	1	1	1	0	0	0	0	0	0	0	1	1	0	1	1	0	0	0	0	1	1	0	0	1	1	1	0	0	1	0	1	0	0	0
Silver-haired Bat	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	1	1	0	1	0	1	1	1	0	0	1	1	1	0	0	1	0	0	0	0	0
Hoary Bat	1	0	1	0	0	0	0	1	0	0	0	1	0	0	0	1	1	1	1	1	0	1	0	1	1	1	0	0	1	1	1	0	0	0	0	0	0	0	0
California Myotis	1	1	0	0	1	1	1	0	0	1	0	0	1	1	0	0	0	0	1	0	1	0	0	0	0	0	0	1	1	1	1	1	1	1	0	1	1	0	0
Western Small-foot Myotis	1	0	0	0	1	1	1	0	0	0	0	1	1	1	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0
Long-earred Myotis	0	0	1	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	0	0	1	1	1	1	1	1	0	1	1	0	0
Little Brown Myotis	1	1	1	0	0	1	1	1	0	0	0	0	0	0	1	1	1	0	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Fringed Myotis	0	0	0	0	1	1	1	0	0	1	1	1	1	1	1	0	1	0	1	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0
Long-legged Myotis	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	1	1	0	1	1	1	1	1	0	0	1	1	1	1	1	1	0	1	0	0	0
Yuma Myotis	1	0	0	0	0	1	0	0	1	1	0	1	1	1	1	1	0	0	1	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	0	1	0	0	0
Pika	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Pygmy Rabbit	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Snowshoe Hare	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1	0	1	1	1	0	0	0	0	1	1	1	0	1	1	0	0	0	0	1
Black-tailed Jackrabbit	0	0	0	0	1	1	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
White-tailed Jackrabbit	0	1	0	0	1	1	1	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Mountain Cottontail	0	0	0	0	0	0	1	1	1	1	0	1	1	1	1	1	0	0	1	0	1	0	0	0	0	0	0	0	0	1	1	0	1	1	0	0	0	0	0
Beaver	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0
Porcupine	0	0	0	0	0	0	0	0	1	0	0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	0	0	0	0	1
Northern Pocket Gopher	0	0	0	1	1	1	1	1	1	1	0	1	1	1	1	0	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Species	Urban	Dryland Agriculture	Irrigated Agriculture	Altered Herbabceous	Very Low Cover Grasslands	Low to Moderate Cover Grasslands	Medium to High Cover Grasslands	Meadow	Mixed Mesic Shrubland	Mixed Xeric Shrubland	Saltflat Desert	Sage	Mesic Shrub Grassland	Xeric Shrub Grassland	Xeric Forest	Broadleaf Forest	Lodgepole Pine	Limber Pine	Ponderosa Pine	Douglas-fir	Rocky Mountain Juniper	Douglas-fir and Lodgepole Pine	White Bark Pine	Subalpine Forest	Mixed Xerix Forest	Broadleaf Conifer Forest	Burnt Forest	Water	Riparian Conifer	Riparian Broadleaf	Riparian Broadleaf Confier	Riparian Graminoid Forbs	Riparian Shrublands	Riparian Mixed	Rock	Gravel Pit	Badlands	Barren	Alpine Meadow
Great Basin Pocket Mouse	0	0	0	0	1	1	1	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Southern red-backed Vole	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1	0	1	1	1	0	1	0	0	1	1	1	0	1	0	0	0	0	0	1
Sage Vole	0	0	0	0	1	1	1	0	0	1	0	1	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Long Tailed Vole	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	0	0	1	0	0
Montane Vole	0	0	0	0	1	1	1	1	0	1	0	1	1	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	1	0	0	0	0	1
Meadow Vole	0	1	1	1	1	1	1	1	1	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0
Water Vole	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	1	1	1	1	0	0	0	0	1
Heath Vole	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	1	0	1	1	1	1	1	1	0	0	0	0	1
Bushy Tailed Woodrat	0	0	0	0	0	0	0	0	0	1	1	1	0	1	1	0	0	1	1	1	1	0	0	1	1	0	0	0	1	1	1	0	1	1	1	1	1	0	0
Muskrat	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	1	1	1	0
Northern Grasshopper Mouse	0	0	0	0	1	1	1	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Deer Mouse	1	1	1	0	1	1	1	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	0	1
Western Harvest Mouse	0	0	1	1	1	1	1	0	1	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Norway Rat	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Yellow Bellied Marmot	0	0	0	0	0	0	0	1	0	0	0	1	0	1	1	0	0	1	1	0	1	0	1	1	1	1	0	0	0	0	0	0	0	0	1	0	0	1	1
Northern Flying Squirrel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	1	1	1	1	1	0	0	1	1	1	0	0	0	0	0	0	0	0
Red Squirrel	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	1	0	1	1	1	0	0	1	0	1	0	0	0	0	0	0	0	0
Uinta Squirrel	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Columbian Ground Squirrel	1	1	0	0	1	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Wyoming Ground Squirrel	0	0	0	0	1	1	0	1	1	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Golden-mantled Ground Squirrel	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1
Richardsons Ground Squirrel	1	1	1	1	1	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Yellow Pine Chipmunk	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1	0	1	0	1	1	1	1	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1
Least Chipmunk	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0
Red-tailed Chipmunk	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1	0	1	1	1	1	1	1	0	0	0	0	0	1	0	0	0	0	0	1
Western Jumping Mouse	0	0	0	0	0	1	1	1	1	0	0	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	0	0	0	0	1
Coyote	0	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	0	0	1	0	1
Wolf	0	0	0	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	0	0	1	0	1
Fox	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	1
Cougar	0	0	0	0	0	0	0	1	1	1	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	1	1	1	1	1	1	0	0	1	0	1
Lynx	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	1	1	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1
Bobcat	0	0	0	0	0	0	0	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	0	1	1	1	1	1	1	0	0	1	0	0
Skunk	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	0	1	1	1	1	1	1	0	0	1	0	0
Spotted Skunk	0	1	0	1	1	1	1	0	1	1	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0
Otter	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	1	1	0	0	0	0	0
Marten	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	1	1	0	0	0	0	1	1	1	0	1	1	0	0	0	0	1
Fisher	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1	0	1	1	1	0	1	0	0	1	1	1	0	1	1	0	0	0	0	1
Short-tail Weasel	0	0	0	0	1	1	1	1	1	0	0	0	1	0	1	1	1	1	1	1	0	1	1	1	1	1	1	0	1	1	1	1	1	1	0	0	0	0	0

Species	Urban	Dryland Agriculture	Irrigated Agriculture	Altered Herbabceous	Very Low Cover Grasslands	Low to Moderate Cover Grasslands	Medium to High Cover Grasslands	Meadow	Mixed Mesic Shrubland	Mixed Xeric Shrubland	Saltflat Desert	Sage	Mesic Shrub Grassland	Xeric Shrub Grassland	Xeric Forest	Broadleaf Forest	Lodgepole Pine	Limber Pine	Ponderosa Pine	Douglas-fir	Rocky Mountain Juniper	Douglas-fir and Lodgepole Pine	White Bark Pine	Subalpine Forest	Mixed Xerix Forest	Broadleaf Conifer Forest	Burnt Forest	Water	Riparian Conifer	Riparian Broadleaf	Riparian Broadleaf Confier	Riparian Graminoid Forbs	Riparian Shrublands	Riparian Mixed	Rock	Gravel Pit	Badlands	Barren	Alpine Meadow
Long-tailed Weasel	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	0	0	1	0	1
Least Weasel	0	0	1	0	1	1	1	1	0	0	0	0	1	0	1	1	0	0	1	0	0	0	0	0	1	1	1	0	1	1	1	1	1	1	0	0	0	0	0
Mink	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0
Badger	0	1	0	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coon	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0
Black Bear	0	0	0	0	0	0	0	1	1	0	0	0	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	0	1	1	1	1	1	1	0	0	0	0	1
Bison	0	0	0	0	1	1	1	1	0	1	0	1	1	1	1	0	1	0	0	0	0	0	0	0	1	0	0	0	1	1	1	1	1	1	0	0	0	0	0
Mule Deer	1	1	1	0	0	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	0	0	1	0	1
White Tailed Deet	1	1	1	0	0	0	1	1	1	0	0	0	1	0	0	1	0	0	1	1	0	1	0	0	0	1	1	0	1	1	1	1	1	1	0	0	0	0	0
Mountain Goat	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1

Table A1-2 Species Umbrella Scores

Species	Grizzly Bear Umbrella	Moose Umbrella	Elk Umbrella	Boreal Toad Umbrella	Wolverine Umbrella	Red-naped Sap Sucker Umbrella	Warbling Vireo Umbrella	Yellow Warbler Umbrella	Columbia Spotted Frog Umbrella	Fluvial Arctic Grayling Umbrella	Greater Sage Grouse Umbrella	Bighorn Sheep Umbrella	Pronghorn Umbrella	West slope Cutthroat trout Umbrella	Black-backed Woodpecker Umbrella
Grizzly bear	1.00	0.94	1.00	0.94	0.50	0.69	1.00	0.29	0.96	0.32	0.11	0.32	0.32	0.79	0.11
Moose	1.00	1.00	0.94	1.00	0.69	0.38	0.69	0.44	1.00	0.50	0.00	0.19	0.25	1.00	0.19
Elk	0.86	0.55	1.00	0.97	0.45	0.38	0.41	0.28	0.90	0.34	0.14	0.28	0.38	0.76	0.10
Boreal Toad	0.73	0.43	0.76	1.00	0.35	0.30	0.32	0.24	0.89	0.30	0.14	0.32	0.41	0.65	0.08
Wolverine	1.00	0.79	0.93	0.93	1.00	0.57	0.57	0.29	0.93	0.36	0.00	0.14	0.00	1.00	0.14
Red-naped Sap Sucker	1.00	1.00	1.00	1.00	0.73	1.00	1.00	0.55	1.00	0.55	0.00	0.00	0.18	1.00	0.27
Warbling Vireo	1.00	0.92	1.00	1.00	0.67	0.67	1.00	0.58	1.00	0.50	0.00	0.25	0.25	0.92	0.08
Yellow Warbler	0.89	0.78	0.89	1.00	0.44	0.67	0.78	1.00	0.89	0.56	0.00	0.22	0.44	0.89	0.00
Columbia Spotted Frog	0.82	0.48	0.79	1.00	0.39	0.33	0.36	0.24	1.00	0.33	0.09	0.36	0.39	0.70	0.09
Arctic Grayling (fluvial)	0.82	0.73	0.91	1.00	0.45	0.55	0.55	0.45	1.00	1.00	0.00	0.27	0.45	1.00	0.00
Greater Sage Grouse	0.50	0.00	0.67	0.83	0.00	0.00	0.00	0.00	0.50	0.00	1.00	0.50	0.69	0.46	0.00
Bighorn Sheep	0.75	0.25	0.67	1.00	0.17	0.00	0.25	0.17	1.00	0.25	0.23	1.00	1.00	0.00	0.00
Pronghorn Antelope	0.56	0.25	0.69	0.94	0.00	0.13	0.19	0.25	0.81	0.31	0.38	0.56	1.00	0.38	0.00
Westslope Cutthroat Trout	0.88	0.64	0.88	0.96	0.56	0.44	0.44	0.32	0.92	0.44	0.00	0.20	0.24	1.00	0.13
Black-backed Woodpecker	1.00	1.00	1.00	1.00	0.67	1.00	0.33	0.00	1.00	0.00	0.00	0.00	0.00	1.00	1.00
Kokanee	0.85	0.46	0.69	1.00	0.15	0.31	0.38	0.46	1.00	0.46	0.23	0.46	0.69	0.62	0.00
Golden Trout	0.94	0.72	0.89	0.94	0.61	0.44	0.44	0.22	0.94	0.39	0.00	0.17	0.22	1.00	0.17
Yellowstone Cutthroat Trout	0.88	0.64	0.88	0.96	0.56	0.44	0.44	0.32	0.92	0.44	0.00	0.20	0.24	1.00	0.12
Rainbow Trout	0.85	0.48	0.79	0.97	0.42	0.33	0.36	0.27	0.94	0.33	0.09	0.33	0.33	0.76	0.09
Brown Trout	0.80	0.44	0.76	1.00	0.36	0.36	0.40	0.32	0.96	0.40	0.12	0.32	0.40	0.68	0.04
Brook Trout	0.82	0.71	0.82	1.00	0.47	0.47	0.47	0.41	0.94	0.53	0.00	0.18	0.24	0.94	0.12
Lake Trout	0.93	0.73	0.87	0.93	0.67	0.60	0.60	0.40	0.93	0.53	0.00	0.00	0.20	1.00	0.07
Mountain Whitefish	0.84	0.63	0.89	1.00	0.42	0.42	0.47	0.37	0.95	0.58	0.00	0.32	0.32	0.95	0.11
Carp	0.78	0.39	0.74	1.00	0.30	0.30	0.35	0.30	0.96	0.35	0.13	0.35	0.43	0.65	0.04
Goldfish	0.71	0.29	0.65	1.00	0.12	0.24	0.29	0.35	0.94	0.47	0.18	0.47	0.59	0.53	0.00
Golden Shiner	0.69	0.31	0.63	1.00	0.13	0.25	0.25	0.38	0.94	0.50	0.19	0.44	0.63	0.56	0.00
Redside Shiner	0.88	0.75	0.75	0.88	0.50	0.63	0.63	0.50	0.88	0.88	0.00	0.00	0.38	1.00	0.00
Utah Chub	0.60	0.50	0.70	1.00	0.20	0.40	0.40	0.50	0.90	0.80	0.00	0.20	0.50	0.90	0.00
Lake Chub	0.88	0.75	0.75	0.88	0.50	0.63	0.63	0.50	0.88	0.75	0.00	0.00	0.38	0.88	0.00
Flathead Chub	0.73	0.33	0.60	1.00	0.13	0.27	0.33	0.40	0.93	0.40	0.20	0.40	0.53	0.47	0.00
Fathead Minnow	0.73	0.33	0.60	1.00	0.13	0.27	0.33	0.40	0.93	0.40	0.20	0.40	0.53	0.47	0.00
Longnose Dace	0.77	0.36	0.73	1.00	0.27	0.32	0.32	0.32	0.95	0.45	0.14	0.36	0.45	0.64	0.05
Black Bullhead	0.71	0.36	0.57	1.00	0.14	0.29	0.29	0.43	0.93	0.43	0.21	0.36	0.57	0.50	0.00
Stonecat	0.73	0.33	0.60	1.00	0.13	0.27	0.33	0.40	0.93	0.40	0.20	0.40	0.53	0.47	0.00
Mountain Sucker	0.83	0.67	0.89	1.00	0.44	0.44	0.44	0.39	0.94	0.61	0.00	0.28	0.33	1.00	0.11
White Sucker	0.79	0.58	0.84	1.00	0.47	0.47	0.53	0.37	0.95	0.53	0.00	0.16	0.26	0.89	0.05
Long-nosed Sucker	0.75	0.58	0.83	1.00	0.33	0.50	0.58	0.50	0.92	0.83	0.00	0.25	0.42	0.92	0.00
Burbot	0.75	0.63	0.75	1.00	0.25	0.50	0.63	0.63	0.88	0.75	0.00	0.13	0.38	0.88	0.00
Bluegill	0.67	0.56	0.67	1.00	0.22	0.44	0.56	0.56	0.89	0.67	0.00	0.11	0.33	0.78	0.00
Smallmouth Bass	0.67	0.56	0.67	1.00	0.22	0.44	0.56	0.56	0.89	0.67	0.00	0.11	0.33	0.78	0.00
Largemouth Bass	0.67	0.56	0.67	1.00	0.22	0.44	0.56	0.56	0.89	0.67	0.00	0.11	0.33	0.78	0.00
Black Crappie	0.67	0.56	0.67	1.00	0.22	0.44	0.56	0.56	0.89	0.67	0.00	0.11	0.33	0.78	0.00
Yellow Perch	0.73	0.33	0.60	1.00	0.13	0.27	0.33	0.40	0.93	0.40	0.20	0.40	0.53	0.47	0.00
Mottled Sculpin	0.83	0.61	0.89	1.00	0.39	0.44	0.50	0.39	0.94	0.56	0.00	0.28	0.33	0.94	0.11
Tiger Salamander	0.71	0.42	0.76	0.97	0.34	0.29	0.32	0.24	0.87	0.29	0.16	0.32	0.42	0.63	0.08
Bullfrog	0.75	0.75	0.75	1.00	0.38	0.63	0.63	0.50	1.00	0.88	0.00	0.00	0.38	0.88	0.00
Northern Leopard Frog	0.75	0.44	0.75	1.00	0.31	0.31	0.38	0.25	0.94	0.31	0.13	0.34	0.44	0.63	0.06
Boreal Chorus Frog	0.72	0.44	0.78	0.97	0.36	0.31	0.33	0.25	0.86	0.31	0.17	0.31	0.42	0.67	0.08
Plains Spade Foot	0.66	0.31	0.69	0.93	0.21	0.21	0.28	0.24	0.83	0.28	0.21	0.38	0.55	0.52	0.03
Snapping Turtle	0.86	0.86	0.86	1.00	0.43	0.71	0.71	0.57	1.00	1.00	0.00	0.00	0.43	1.00	0.00

Species	Grizzly Bear Umbrella	Moose Umbrella	Elk Umbrella	Boreal Toad Umbrella	Wolverine Umbrella	Red-naped Sap Sucker Umbrella	Warbling Vireo Umbrella	Yellow Warbler Umbrella	Columbia Spotted Frog Umbrella	Fluvial Arctic Grayling Umbrella	Greater Sage Grouse Umbrella	Bighorn Sheep Umbrella	Pronghorn Umbrella	West slope Cutthroat trout Umbrella	Black-backed Woodpecker Umbrella
Painted Turtle	0.75	0.75	0.75	1.00	0.38	0.63	0.63	0.50	1.00	0.88	0.00	0.00	0.38	0.88	0.00
Greater Short-Horned Lizard	0.57	0.00	0.57	0.93	0.00	0.00	0.07	0.07	0.86	0.14	0.29	0.64	0.71	0.21	0.00
Sagebrush Lizard	0.63	0.06	0.56	0.88	0.13	0.00	0.13	0.06	0.81	0.13	0.25	0.63	0.63	0.31	0.00
Rubber Boa	0.93	0.52	0.86	0.97	0.45	0.38	0.41	0.31	0.93	0.31	0.10	0.31	0.34	0.79	0.10
Racer	0.75	0.36	0.75	0.93	0.29	0.25	0.36	0.29	0.86	0.32	0.18	0.39	0.54	0.57	0.00
Western Terrestrial Garter Snake	0.74	0.42	0.76	0.95	0.37	0.29	0.32	0.24	0.84	0.26	0.16	0.32	0.42	0.63	0.08
Common Garter Snake	0.72	0.48	0.76	1.00	0.41	0.34	0.41	0.31	0.90	0.34	0.07	0.28	0.38	0.69	0.07
Milk Snake	0.63	0.00	0.56	0.94	0.13	0.00	0.06	0.00	0.81	0.13	0.25	0.50	0.56	0.38	0.00
Magpie	0.72	0.34	0.76	0.93	0.28	0.21	0.34	0.24	0.83	0.28	0.21	0.38	0.55	0.55	0.00
Western Rattlesnake	0.74	0.33	0.74	0.93	0.26	0.19	0.33	0.22	0.85	0.30	0.19	0.41	0.56	0.56	0.00
Alder Flycatcher	1.00	1.00	1.00	1.00	0.75	0.88	1.00	0.75	1.00	0.75	0.00	0.13	0.25	1.00	0.00
American Avocet	0.23	0.23	0.54	0.92	0.00	0.15	0.15	0.15	0.69	0.38	0.23	0.23	0.77	0.38	0.00
American Bittern	0.75	0.50	0.75	1.00	0.13	0.25	0.38	0.38	1.00	0.63	0.00	0.38	0.75	0.75	0.00
American Coot	0.75	0.75	0.75	1.00	0.00	0.50	0.50	0.50	1.00	1.00	0.00	0.00	0.75	1.00	0.00
American Crow	0.65	0.24	0.71	1.00	0.18	0.18	0.24	0.35	0.82	0.24	0.24	0.41	0.59	0.53	0.00
American Dipper	0.89	0.78	0.89	1.00	0.56	0.56	0.61	0.50	0.94	0.44	0.00	0.17	0.28	0.94	0.11
American Golden Plover	0.33	0.25	0.58	1.00	0.00	0.17	0.17	0.17	0.75	0.50	0.17	0.33	0.83	0.50	0.00
American Goldfinch	0.69	0.54	0.85	1.00	0.31	0.46	0.54	0.69	0.77	0.46	0.15	0.23	0.62	0.69	0.00
American Kestrel	0.79	0.39	0.79	0.96	0.39	0.25	0.36	0.25	0.86	0.25	0.18	0.39	0.39	0.64	0.07
American Pipit	0.50	0.50	1.00	1.00	0.50	0.00	0.00	0.00	0.50	0.50	0.50	0.50	0.50	0.50	0.00
American Redstart	0.86	0.86	0.86	1.00	0.43	0.71	0.86	1.00	0.86	0.57	0.00	0.14	0.43	1.00	0.00
American Robin	0.90	0.67	0.95	1.00	0.52	0.52	0.57	0.43	0.90	0.29	0.05	0.19	0.24	0.81	0.14
American Tree Sparrow	0.76	0.41	0.76	1.00	0.24	0.35	0.41	0.53	0.88	0.41	0.24	0.41	0.65	0.59	0.00
American White Pelican	0.60	0.40	0.50	1.00	0.10	0.30	0.30	0.30	0.90	0.50	0.20	0.30	0.70	0.50	0.00
American Wigeon	0.60	0.27	0.67	1.00	0.07	0.13	0.20	0.20	0.87	0.40	0.33	0.47	0.80	0.47	0.00
Audubon's Warbler	0.92	0.62	0.92	1.00	0.77	0.46	0.54	0.23	0.92	0.23	0.00	0.15	0.00	0.92	0.15
Baird's Sandpiper	0.31	0.23	0.54	1.00	0.00	0.15	0.15	0.15	0.77	0.46	0.15	0.31	0.77	0.46	0.00
Bald Eagle	0.75	0.58	0.92	1.00	0.58	0.50	0.67	0.33	0.83	0.42	0.17	0.08	0.17	0.75	0.08
Bank Swallow	0.50	0.33	0.72	0.94	0.17	0.28	0.28	0.28	0.78	0.50	0.17	0.22	0.61	0.50	0.00
Barn Swallow	0.55	0.30	0.60	0.90	0.15	0.20	0.25	0.35	0.75	0.40	0.25	0.35	0.70	0.55	0.00
Barred Owl	1.00	1.00	1.00	1.00	0.91	0.82	0.82	0.45	1.00	0.45	0.00	0.09	0.09	1.00	0.18
Barrow's Goldeneye	0.93	0.86	0.93	1.00	0.64	0.71	0.64	0.43	1.00	0.57	0.00	0.00	0.21	1.00	0.14
Belted Kingfisher	0.87	0.80	0.87	1.00	0.60	0.67	0.67	0.47	0.93	0.53	0.00	0.07	0.20	0.93	0.13
Black Rosy Finch	1.00	0.50	0.50	0.50	1.00	0.00	0.00	0.00	0.50	0.50	0.00	0.50	0.00	1.00	0.00
Black Tern	0.75	0.75	0.75	1.00	0.25	0.25	0.50	0.25	1.00	0.75	0.00	0.25	0.50	1.00	0.00
Blue-winged Warbler	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.75	0.00	0.00	0.00	1.00	0.00
Black-billed Cuckoo	1.00	0.89	1.00	1.00	0.56	0.78	0.89	0.78	1.00	0.67	0.00	0.11	0.33	0.89	0.00
Black billed Magpie	0.71	0.29	0.76	1.00	0.29	0.29	0.33	0.33	0.86	0.29	0.24	0.33	0.48	0.52	0.00
Blackpoll Warbler	0.91	0.91	0.91	1.00	0.82	0.64	0.82	0.55	0.91	0.36	0.00	0.18	0.09	1.00	0.18
Black capped Chickadee	0.94	0.65	0.94	1.00	0.65	0.47	0.59	0.35	0.94	0.35	0.00	0.18	0.06	0.88	0.06
Black-crowned Night-Heron	0.92	0.75	0.92	1.00	0.42	0.50	0.67	0.58	1.00	0.58	0.00	0.25	0.42	0.83	0.00
Black headed Grosbeak	0.86	0.86	0.86	1.00	0.71	0.86	0.86	0.86	0.86	0.71	0.00	0.00	0.14	1.00	0.00
Black-necked Stilt	0.18	0.18	0.45	0.91	0.00	0.09	0.09	0.09	0.64	0.27	0.27	0.18	0.73	0.27	0.00
Black-throated Gray Warbler	0.92	0.75	0.92	1.00	0.75	0.58	0.67	0.33	0.92	0.33	0.00	0.17	0.00	0.92	0.17
Blue Grouse	1.00	0.80	1.00	1.00	0.70	0.60	0.50	0.20	1.00	0.20	0.00	0.20	0.00	0.90	0.30
Blue Jay	0.88	0.63	0.88	1.00	0.63	0.63	0.63	0.63	0.88	0.50	0.00	0.00	0.00	0.88	0.00

Species	Grizzly Bear Umbrella	Moose Umbrella	Elk Umbrella	Boreal Toad Umbrella	Wolverine Umbrella	Red-naped Sap Sucker Umbrella	Warbling Vireo Umbrella	Yellow Warbler Umbrella	Columbia Spotted Frog Umbrella	Fluvial Arctic Grayling Umbrella	Greater Sage Grouse Umbrella	Bighorn Sheep Umbrella	Pronghorn Umbrella	West slope Cutthroat trout Umbrella	Black-backed Woodpecker Umbrella
Blue Winged Teal	0.55	0.36	0.73	1.00	0.09	0.18	0.27	0.27	0.91	0.55	0.09	0.36	0.73	0.64	0.00
Bobolink	0.33	0.17	0.83	1.00	0.00	0.00	0.00	0.00	0.67	0.50	0.33	0.33	1.00	0.50	0.00
Bohemian Waxwing	0.89	0.67	0.89	1.00	0.67	0.44	0.56	0.44	0.89	0.56	0.00	0.11	0.00	1.00	0.00
Bonaparte's Gull	0.50	0.38	0.63	1.00	0.00	0.25	0.25	0.25	0.88	0.63	0.13	0.25	0.88	0.63	0.00
Boreal Owl	1.00	0.92	1.00	1.00	1.00	0.67	0.67	0.33	1.00	0.42	0.00	0.17	0.00	1.00	0.17
Brewer's Blackbird	0.33	0.17	0.67	1.00	0.00	0.17	0.17	0.33	0.50	0.17	0.50	0.17	0.83	0.33	0.00
Brewer's Sparrow	1.00	0.00	0.33	1.00	0.00	0.00	0.00	0.00	1.00	0.00	1.00	1.00	1.00	0.00	0.00
Broad-tailed Hummingbird	0.94	0.76	0.94	1.00	0.47	0.47	0.47	0.35	0.94	0.35	0.00	0.24	0.29	0.82	0.18
Brown Creeper	0.86	0.57	0.86	1.00	0.57	0.57	0.43	0.14	0.86	0.14	0.00	0.14	0.00	0.86	0.29
Brown Headed Cowbird	0.74	0.43	0.80	0.97	0.34	0.31	0.34	0.26	0.89	0.29	0.17	0.31	0.46	0.66	0.09
Buff-breasted Sandpiper	0.29	0.29	0.43	1.00	0.00	0.14	0.14	0.14	0.71	0.43	0.14	0.00	0.57	0.43	0.00
Bufflehead	0.93	0.73	0.93	1.00	0.67	0.60	0.60	0.27	1.00	0.33	0.00	0.13	0.00	0.87	0.20
Bullock's Oriole	0.60	0.60	0.80	1.00	0.60	0.60	0.60	0.80	0.60	0.40	0.20	0.00	0.20	0.80	0.00
Burrowing Owl	0.36	0.00	0.50	0.93	0.00	0.00	0.00	0.14	0.64	0.14	0.43	0.57	0.86	0.21	0.00
California Gull	0.00	0.00	0.33	1.00	0.00	0.00	0.00	0.11	0.56	0.22	0.22	0.22	0.56	0.33	0.00
Calliope Hummingbird	0.94	0.89	0.94	1.00	0.61	0.61	0.67	0.44	0.94	0.44	0.00	0.22	0.22	0.94	0.17
Canada Goose	0.65	0.45	0.75	1.00	0.25	0.30	0.40	0.40	0.85	0.40	0.20	0.30	0.55	0.60	0.00
Canvasback	0.44	0.33	0.56	1.00	0.00	0.22	0.22	0.33	1.00	0.56	0.00	0.33	0.78	0.56	0.00
Carolina Wren	0.75	0.00	0.75	0.50	0.25	0.00	0.25	0.00	0.50	0.00	0.25	0.25	0.25	0.50	0.00
Caspian Tern	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.75	0.25	0.00	0.50	0.50	0.25	0.00
Cassin's Finch	0.92	0.67	0.92	1.00	0.58	0.58	0.50	0.33	0.92	0.25	0.00	0.08	0.00	0.83	0.25
Cassin's Vireo	1.00	0.75	1.00	1.00	0.75	0.63	0.88	0.38	1.00	0.38	0.00	0.13	0.00	0.88	0.13
Cattle Egret	0.25	0.25	0.63	1.00	0.00	0.13	0.13	0.13	0.75	0.50	0.25	0.13	0.75	0.50	0.00
Cedar Waxwing	0.86	0.86	0.86	1.00	0.71	0.86	0.86	0.86	0.86	0.71	0.00	0.00	0.14	1.00	0.00
Chestnut-sided Warbler	0.83	0.83	0.83	1.00	0.67	0.50	0.83	0.83	0.83	0.33	0.00	0.33	0.17	1.00	0.00
Chipping Sparrow	0.93	0.60	0.93	1.00	0.60	0.53	0.53	0.33	0.93	0.27	0.00	0.07	0.00	0.87	0.20
Chukar	0.86	0.00	0.57	0.71	0.14	0.00	0.00	0.00	0.71	0.00	0.57	0.43	0.57	0.29	0.00
Clinnamon Teal	0.55	0.36	0.73	1.00	0.09	0.18	0.27	0.27	0.91	0.55	0.09	0.36	0.73	0.64	0.00
Clark's Grebe	0.67	0.50	0.67	1.00	0.00	0.33	0.33	0.33	1.00	0.67	0.17	0.17	0.67	0.67	0.00
Clark's Grebe	1.00	0.55	1.00	1.00	0.64	0.36	0.27	0.00	1.00	0.09	0.00	0.18	0.00	0.91	0.27
Clay Colored Sparrow	0.85	0.38	0.77	1.00	0.15	0.31	0.46	0.38	1.00	0.46	0.23	0.54	0.69	0.54	0.00
Cliff Swallow	0.53	0.26	0.68	0.89	0.11	0.16	0.21	0.32	0.74	0.37	0.21	0.32	0.68	0.53	0.00
Common Goldeneye	0.85	0.69	0.85	1.00	0.62	0.62	0.62	0.31	1.00	0.38	0.00	0.08	0.00	0.85	0.15
Common Grackle	0.50	0.50	0.83	1.00	0.33	0.50	0.50	0.67	0.50	0.33	0.33	0.00	0.50	0.67	0.00
Common Loon	0.94	0.78	0.94	1.00	0.61	0.56	0.67	0.39	1.00	0.44	0.00	0.17	0.22	0.94	0.11
Common Merganser	0.86	0.64	0.86	1.00	0.71	0.57	0.57	0.29	1.00	0.36	0.00	0.07	0.00	0.86	0.14
Common Nighthawk	0.64	0.32	0.71	0.96	0.21	0.29	0.25	0.29	0.82	0.32	0.21	0.29	0.54	0.54	0.04
Common Pochard	0.62	0.00	0.54	0.92	0.08	0.00	0.08	0.00	0.85	0.00	0.31	0.46	0.54	0.23	0.00
Common Raven	0.75	0.43	0.82	0.93	0.50	0.32	0.32	0.18	0.82	0.21	0.18	0.25	0.29	0.68	0.11
Common Redpoll	0.67	0.33	0.67	1.00	0.08	0.17	0.25	0.42	0.75	0.25	0.33	0.42	0.75	0.42	0.00
Common Tern	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.75	0.25	0.00	0.50	0.50	0.25	0.00
Common Yellowthroat	0.89	0.78	0.89	1.00	0.33	0.44	0.67	0.67	1.00	0.56	0.00	0.33	0.67	0.78	0.00
Cooper's Hawk	0.92	0.69	0.92	1.00	0.69	0.54	0.62	0.38	0.92	0.38	0.00	0.15	0.00	0.85	0.08
Cordilleran Flycatcher	1.00	0.83	1.00	1.00	0.67	0.75	0.83	0.50	1.00	0.50	0.00	0.08	0.17	0.92	0.08
Double-crested Cormorant	0.86	0.86	0.86	1.00	0.71	0.86	0.86	0.71	1.00	0.86	0.00	0.00	0.14	1.00	0.00
Common Woodstork	0.83	0.83	0.83	1.00	0.83	0.83	0.83	0.83	0.83	0.67	0.00	0.00	0.00	1.00	0.00
Dunlin	0.29	0.29	0.43	1.00	0.00	0.14	0.14	0.14	0.71	0.43	0.14	0.00	0.57	0.43	0.00
Dusky Flycatcher	1.00	0.82	1.00	1.00	0.45	0.73	0.82	0.64	1.00	0.55	0.00	0.18	0.27	0.91	0.09
Eared Grebe	0.60	0.60	0.60	1.00	0.00	0.40	0.40	0.40	1.00	0.80	0.00	0.00	0.60	0.80	0.00
Eastern Kingbird	0.83	0.42	0.92	1.00	0.17	0.33	0.33	0.42	0.83	0.42	0.33	0.33	0.75	0.50	0.00
Eastern Phoebe	1.00	0.80	1.00	1.00	0.60	0.80	0.80	0.80	1.00	0.80	0.00	0.00	0.20	1.00	0.00

Species	Grizzly Bear Umbrella	Moose Umbrella	Elk Umbrella	Boreal Toad Umbrella	Wolverine Umbrella	Red-naped Sap Sucker Umbrella	Warbling Vireo Umbrella	Yellow Warbler Umbrella	Columbia Spotted Frog Umbrella	Fluvial Arctic Grayling Umbrella	Greater Sage Grouse Umbrella	Bighorn Sheep Umbrella	Pronghorn Umbrella	West slope Cutthroat trout Umbrella	Black-backed Woodpecker Umbrella
Eastern Screech	0.80	0.80	0.80	1.00	0.80	0.80	0.80	0.80	0.80	0.60	0.00	0.00	0.00	1.00	0.00
Eurasian Wigeon	0.60	0.27	0.67	1.00	0.07	0.13	0.20	0.20	0.87	0.40	0.33	0.47	0.80	0.47	0.00
European Starling	0.40	0.40	0.80	1.00	0.40	0.40	0.40	0.60	0.40	0.40	0.40	0.00	0.40	0.60	0.00
Evening Grosbeak	0.89	0.67	0.89	1.00	0.67	0.44	0.44	0.22	0.89	0.22	0.00	0.22	0.00	0.89	0.22
Ferruginous Hawk	0.68	0.26	0.74	0.89	0.26	0.26	0.26	0.26	0.79	0.26	0.32	0.26	0.58	0.53	0.00
Forster's Tern	0.75	0.75	0.75	1.00	0.00	0.50	0.50	0.50	1.00	1.00	0.00	0.00	0.75	1.00	0.00
Fox Sparrow	1.00	1.00	1.00	1.00	0.73	0.73	0.82	0.64	1.00	0.64	0.00	0.27	0.27	1.00	0.09
Franklin's Gull	0.38	0.25	0.63	1.00	0.00	0.13	0.13	0.13	0.88	0.63	0.13	0.25	0.75	0.63	0.00
Gadwall	0.57	0.21	0.64	1.00	0.00	0.14	0.14	0.21	0.86	0.43	0.36	0.43	0.86	0.43	0.00
Golden Eagle	0.67	0.22	0.72	0.89	0.33	0.11	0.22	0.11	0.78	0.22	0.33	0.39	0.50	0.44	0.00
Golden crowned Kinglet	0.80	0.80	0.80	1.00	0.80	0.40	0.40	0.20	0.80	0.40	0.00	0.20	0.00	1.00	0.20
Grasshopper Sparrow	0.50	0.17	0.83	1.00	0.00	0.00	0.00	0.17	0.83	0.50	0.17	0.50	1.00	0.50	0.00
Gray Catbird	0.88	0.75	0.88	1.00	0.38	0.63	0.75	1.00	0.88	0.50	0.00	0.25	0.50	0.88	0.00
Gray Flycatcher	0.57	0.00	0.43	1.00	0.00	0.00	0.00	0.00	1.00	0.14	0.43	0.86	0.86	0.29	0.00
Gray Jay	1.00	0.89	1.00	1.00	1.00	0.56	0.56	0.22	1.00	0.33	0.00	0.22	0.00	1.00	0.22
Gray Partridge	0.60	0.10	0.70	1.00	0.00	0.00	0.10	0.20	0.80	0.20	0.40	0.60	0.90	0.30	0.00
Gray-crowned Rosy Finch	0.67	0.33	0.33	0.67	0.67	0.00	0.00	0.33	0.33	0.33	0.00	0.33	0.00	1.00	0.00
Great Blue Heron	0.73	0.67	0.80	1.00	0.47	0.47	0.60	0.47	0.87	0.53	0.07	0.07	0.27	0.80	0.00
Great Egret	0.71	0.64	0.79	1.00	0.43	0.50	0.57	0.50	0.86	0.57	0.07	0.00	0.29	0.79	0.00
Great Gray Owl	1.00	1.00	1.00	1.00	0.69	0.69	0.69	0.44	1.00	0.50	0.00	0.19	0.25	1.00	0.19
Great Horned Owl	0.74	0.42	0.76	0.95	0.37	0.29	0.32	0.24	0.84	0.26	0.16	0.32	0.42	0.63	0.08
Greater Scaup	0.60	0.60	0.60	1.00	0.00	0.40	0.40	0.40	1.00	0.80	0.00	0.00	0.60	0.80	0.00
Greater White-fronted Goose	0.44	0.33	0.78	1.00	0.00	0.22	0.22	0.22	0.78	0.67	0.22	0.22	0.89	0.67	0.00
Greater Yellowlegs	0.25	0.25	0.50	0.92	0.00	0.17	0.17	0.17	0.67	0.33	0.25	0.17	0.75	0.33	0.00
Green Tailed Towhee	1.00	0.25	0.75	1.00	0.25	0.25	0.25	0.25	1.00	0.00	0.50	0.50	0.50	0.50	0.00
American Green-winged Teal	0.76	0.59	0.82	1.00	0.35	0.41	0.53	0.47	1.00	0.59	0.00	0.35	0.47	0.76	0.00
Gyrfalcon	0.62	0.31	0.77	1.00	0.08	0.15	0.15	0.15	0.85	0.46	0.31	0.46	0.85	0.46	0.00
Hairy Woodpecker	0.93	0.71	0.93	1.00	0.71	0.64	0.57	0.36	0.93	0.29	0.00	0.07	0.00	0.93	0.21
Hammond's Flycatcher	1.00	0.82	1.00	1.00	0.82	0.73	0.73	0.36	1.00	0.36	0.00	0.09	0.00	0.91	0.18
Harlequin ducks	0.94	0.88	0.94	1.00	0.75	0.63	0.69	0.44	1.00	0.50	0.00	0.19	0.19	1.00	0.13
Harris's Sparrow	0.71	0.71	0.71	1.00	0.29	0.57	0.71	0.86	0.86	0.43	0.00	0.14	0.57	0.86	0.00
Hermit Thrush	1.00	0.71	1.00	1.00	0.71	0.57	0.57	0.00	1.00	0.14	0.00	0.14	0.00	0.86	0.29
Herring Gull	0.00	0.00	0.33	1.00	0.00	0.00	0.00	0.11	0.56	0.22	0.22	0.22	0.56	0.33	0.00
Hooded Merganser	0.93	0.73	0.93	1.00	0.67	0.67	0.60	0.33	1.00	0.40	0.00	0.07	0.07	0.93	0.20
Hooded Oriole	0.60	0.60	0.80	1.00	0.60	0.60	0.60	0.80	0.60	0.40	0.20	0.00	0.20	0.80	0.00
Horned Grebe	0.80	0.70	0.80	1.00	0.40	0.50	0.60	0.50	1.00	0.60	0.00	0.10	0.30	0.80	0.00
Horned Lark	0.36	0.14	0.50	0.93	0.14	0.00	0.07	0.00	0.71	0.14	0.43	0.57	0.71	0.21	0.00
House Finch	0.89	0.50	0.83	1.00	0.33	0.39	0.56	0.50	0.89	0.33	0.17	0.28	0.39	0.67	0.00
House Sparrow	0.25	0.25	0.75	1.00	0.25	0.25	0.25	0.50	0.25	0.00	0.50	0.00	0.50	0.50	0.00
House Wren	0.86	0.71	0.86	1.00	0.43	0.71	0.71	0.71	0.86	0.43	0.00	0.14	0.14	0.86	0.14
Indigo Bunting	1.00	0.78	1.00	1.00	0.44	0.67	0.89	0.89	1.00	0.56	0.00	0.33	0.44	0.78	0.00
Killdeer	0.23	0.23	0.46	0.92	0.00	0.15	0.15	0.23	0.62	0.31	0.23	0.15	0.69	0.38	0.00
Lapland Longspur	0.00	0.00	0.50	1.00	0.00	0.00	0.00	0.00	0.50	0.17	0.33	0.33	0.83	0.17	0.00
Lark Bunting	0.44	0.00	0.56	1.00	0.00	0.00	0.00	0.11	0.78	0.11	0.56	0.67	1.00	0.11	0.00
Lark Sparrow	0.60	0.13	0.80	0.93	0.13	0.13	0.20	0.20	0.80	0.20	0.33	0.47	0.67	0.33	0.00
Lazuli Bunting	0.78	0.43	0.74	1.00	0.22	0.30	0.39	0.35	0.96	0.35	0.13	0.48	0.57	0.61	0.04
Least Flycatcher	1.00	1.00	1.00	1.00	0.80	1.00	1.00	1.00	1.00	0.80	0.00	0.00	0.20	1.00	0.00
Least Sandpiper	0.36	0.29	0.57	1.00	0.07	0.14	0.21	0.14	0.79	0.43	0.14	0.36	0.71	0.50	0.00
Lesser Scaup	0.73	0.53	0.80	1.00	0.27	0.33	0.47	0.40	0.93	0.53	0.07	0.27	0.53	0.67	0.00
Lesser Yellowlegs	0.25	0.25	0.50	0.92	0.00	0.17	0.17	0.17	0.67	0.33	0.25	0.17	0.75	0.33	0.00
Lewis' Woodpecker	1.00	0.50	1.00	1.00	0.33	0.50	0.50	0.33	1.00	0.33	0.00	0.17	0.00	0.67	0.17

Species	Grizzly Bear Umbrella	Moose Umbrella	Elk Umbrella	Boreal Toad Umbrella	Wolverine Umbrella	Red-naped Sap Sucker Umbrella	Warbling Vireo Umbrella	Yellow Warbler Umbrella	Columbia Spotted Frog Umbrella	Fluvial Arctic Grayling Umbrella	Greater Sage Grouse Umbrella	Bighorn Sheep Umbrella	Pronghorn Umbrella	West slope Cutthroat trout Umbrella	Black-backed Woodpecker Umbrella
Lincoln's Sparrow	1.00	0.85	1.00	1.00	0.62	0.62	0.62	0.38	1.00	0.23	0.00	0.23	0.31	0.92	0.23
Loggerhead Shrike	0.59	0.24	0.71	0.94	0.06	0.18	0.24	0.29	0.82	0.29	0.35	0.53	0.88	0.35	0.00
Long billed Curlew	0.13	0.00	0.50	1.00	0.00	0.00	0.00	0.00	0.75	0.38	0.25	0.50	0.88	0.38	0.00
Long-billed Dowitcher	0.31	0.23	0.54	1.00	0.00	0.15	0.15	0.15	0.77	0.46	0.15	0.31	0.77	0.46	0.00
Long-eared Owl	0.95	0.55	0.90	1.00	0.35	0.40	0.50	0.40	0.95	0.35	0.20	0.30	0.45	0.65	0.05
Macalivry's Warbler	1.00	0.71	1.00	1.00	0.71	0.64	0.64	0.36	1.00	0.43	0.00	0.07	0.14	0.93	0.14
Mallard	0.61	0.39	0.72	1.00	0.22	0.28	0.33	0.33	0.83	0.50	0.22	0.33	0.61	0.61	0.00
Marbled Godwit	0.36	0.21	0.64	0.93	0.00	0.14	0.14	0.21	0.79	0.43	0.21	0.36	0.86	0.43	0.00
Marsh Wren	0.57	0.29	0.71	1.00	0.00	0.14	0.14	0.29	0.86	0.57	0.14	0.29	0.86	0.57	0.00
McCown's Longspur	0.00	0.00	0.50	1.00	0.00	0.00	0.00	0.00	0.75	0.25	0.25	0.50	1.00	0.25	0.00
Merlin	0.71	0.24	0.71	0.95	0.33	0.14	0.24	0.19	0.81	0.24	0.24	0.38	0.43	0.57	0.00
Mountain Bluebird	0.83	0.50	1.00	1.00	0.50	0.33	0.39	0.17	0.89	0.28	0.11	0.28	0.22	0.78	0.11
Mountain Chickadee	0.93	0.67	0.93	1.00	0.73	0.47	0.47	0.20	0.93	0.20	0.00	0.20	0.00	0.93	0.20
Mourning Dove	0.69	0.34	0.76	0.97	0.24	0.24	0.34	0.31	0.86	0.31	0.21	0.38	0.55	0.55	0.00
Mute Swan	0.63	0.63	0.63	1.00	0.25	0.50	0.50	0.63	0.88	0.63	0.00	0.00	0.50	0.88	0.00
Myrtle Warbler	0.92	0.62	0.92	1.00	0.77	0.46	0.54	0.23	0.92	0.23	0.00	0.15	0.00	0.92	0.15
Northern Goshawk	1.00	0.78	1.00	1.00	0.78	0.56	0.56	0.22	1.00	0.22	0.00	0.22	0.00	0.89	0.22
Northern Harrier	0.69	0.31	0.75	1.00	0.06	0.13	0.25	0.25	0.88	0.31	0.31	0.56	0.88	0.44	0.00
Northern Mockingbird	0.83	0.17	0.83	1.00	0.00	0.00	0.17	0.33	1.00	0.33	0.17	0.83	0.83	0.50	0.00
Northern Pintail	0.43	0.29	0.64	1.00	0.07	0.14	0.21	0.21	0.79	0.36	0.14	0.29	0.64	0.43	0.00
Northern Pygmy Owl	0.95	0.75	0.95	1.00	0.55	0.55	0.60	0.40	0.95	0.35	0.00	0.15	0.20	0.95	0.15
Northern Rough-winged Swallow	0.47	0.24	0.71	0.94	0.24	0.24	0.24	0.24	0.76	0.35	0.24	0.29	0.53	0.41	0.00
Northern Saw Whet Owl	0.95	0.63	0.95	1.00	0.63	0.47	0.53	0.32	0.95	0.21	0.00	0.16	0.05	0.89	0.16
Northern Shoveler	0.63	0.31	0.63	1.00	0.06	0.13	0.25	0.25	0.94	0.38	0.25	0.56	0.81	0.50	0.00
Northern Shrike	0.71	0.38	0.75	1.00	0.21	0.21	0.25	0.29	0.88	0.29	0.21	0.46	0.63	0.58	0.04
Northern Waterthrush	1.00	1.00	1.00	1.00	0.67	1.00	0.83	0.67	1.00	0.83	0.00	0.00	0.17	1.00	0.17
Olive sided Flycatcher	1.00	0.82	1.00	1.00	0.82	0.73	0.55	0.27	1.00	0.36	0.00	0.00	0.00	1.00	0.27
Orange crowned Warbler	1.00	0.80	1.00	1.00	0.67	0.67	0.73	0.47	1.00	0.40	0.00	0.13	0.20	0.93	0.13
Oregon Junco	0.95	0.58	0.95	1.00	0.63	0.42	0.47	0.26	0.95	0.26	0.05	0.21	0.11	0.84	0.11
Osprey	0.75	0.58	0.75	1.00	0.58	0.50	0.58	0.33	0.92	0.33	0.00	0.08	0.00	0.83	0.08
Pacific Loon	0.94	0.78	0.94	1.00	0.61	0.56	0.67	0.39	1.00	0.44	0.00	0.17	0.22	0.94	0.11
Parasitic Jaeger	0.75	0.75	0.75	1.00	0.00	0.50	0.50	0.50	1.00	1.00	0.00	0.00	0.75	1.00	0.00
Pectoral Sandpiper	0.31	0.23	0.54	1.00	0.00	0.15	0.15	0.15	0.77	0.46	0.15	0.31	0.77	0.46	0.00
Peregrine Falcon	0.70	0.40	0.85	0.90	0.25	0.20	0.35	0.30	0.80	0.40	0.15	0.40	0.60	0.60	0.00
Pied-billed Grebe	0.80	0.80	0.80	1.00	0.20	0.40	0.60	0.40	1.00	0.80	0.00	0.20	0.60	1.00	0.00
Pied - billed Grebe	1.00	0.78	1.00	1.00	0.78	0.67	0.89	0.44	1.00	0.44	0.00	0.11	0.00	0.89	0.11
Pine Grosbeak	1.00	0.78	1.00	1.00	0.89	0.56	0.56	0.22	1.00	0.22	0.00	0.22	0.00	0.89	0.22
Pine Siskin	0.93	0.71	0.93	1.00	0.64	0.57	0.50	0.29	0.93	0.36	0.00	0.14	0.07	0.93	0.21
Pink-sided Junco	0.95	0.58	0.95	1.00	0.63	0.42	0.47	0.26	0.95	0.26	0.05	0.21	0.11	0.84	0.11
Pinyon Jay	0.67	0.00	0.67	1.00	0.00	0.00	0.00	0.33	0.67	0.00	0.00	0.00	0.00	0.67	0.00
Prairie Falcon	0.57	0.14	0.64	0.86	0.21	0.00	0.07	0.00	0.71	0.21	0.43	0.57	0.71	0.36	0.00
Red Crossbill	0.93	0.60	0.93	1.00	0.73	0.47	0.47	0.27	0.93	0.27	0.00	0.13	0.00	0.87	0.13
Red Phalaropes	0.29	0.21	0.57	0.93	0.00	0.14	0.14	0.14	0.71	0.43	0.21	0.29	0.79	0.43	0.00
Red breast Merganser	0.86	0.71	0.86	1.00	0.71	0.71	0.71	0.57	1.00	0.71	0.00	0.00	0.00	1.00	0.00
Red breast Nuthatch	0.93	0.60	0.93	1.00	0.67	0.53	0.47	0.27	0.93	0.20	0.00	0.07	0.00	0.93	0.20
Red eyed Vireo	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.67	0.00	0.00	0.00	1.00	0.00
Redhead	0.40	0.30	0.60	1.00	0.00	0.20	0.20	0.20	0.90	0.60	0.10	0.30	0.80	0.60	0.00
Red-necked Grebe	0.75	0.75	0.75	1.00	0.38	0.50	0.63	0.50	1.00	0.75	0.00	0.13	0.38	0.88	0.00
Red-necked Phalarope	0.29	0.21	0.57	0.93	0.00	0.14	0.14	0.14	0.71	0.43	0.21	0.29	0.79	0.43	0.00
Red-shafted Flicker	0.93	0.71	0.93	1.00	0.71	0.64	0.57	0.36	0.93	0.29	0.00	0.07	0.00	0.93	0.21
Red tailed Hawk	0.79	0.41	0.83	0.93	0.34	0.28	0.38	0.28	0.86	0.34	0.21	0.34	0.52	0.62	0.03
Red-throated Loon	0.94	0.78	0.94	1.00	0.61	0.56	0.67	0.39	1.00	0.44	0.00	0.17	0.22	0.94	0.11

Species	Grizzly Bear Umbrella	Moose Umbrella	Elk Umbrella	Boreal Toad Umbrella	Wolverine Umbrella	Red-naped Sap Sucker Umbrella	Warbling Vireo Umbrella	Yellow Warbler Umbrella	Columbia Spotted Frog Umbrella	Fluvial Arctic Grayling Umbrella	Greater Sage Grouse Umbrella	Bighorn Sheep Umbrella	Pronghorn Umbrella	West slope Cutthroat trout Umbrella	Black-backed Woodpecker Umbrella
Red winged Blackbird	0.44	0.33	0.67	1.00	0.00	0.22	0.22	0.33	0.67	0.56	0.22	0.11	0.78	0.67	0.00
Ring-billed Gull	0.00	0.00	0.33	1.00	0.00	0.00	0.00	0.11	0.56	0.22	0.22	0.22	0.56	0.33	0.00
Ring - necked Duck	0.73	0.67	0.80	1.00	0.40	0.47	0.60	0.47	0.93	0.53	0.07	0.13	0.40	0.73	0.00
Ring-necked Pheasant	0.50	0.30	0.80	1.00	0.00	0.20	0.20	0.20	0.80	0.50	0.20	0.30	0.90	0.50	0.00
Rock Pigeon	0.25	0.00	0.50	0.75	0.25	0.00	0.00	0.25	0.00	0.00	0.50	0.00	0.50	0.50	0.00
Rock Wren	0.64	0.09	0.73	0.82	0.18	0.09	0.09	0.00	0.73	0.09	0.18	0.36	0.36	0.55	0.09
Rose-breast Grosbeak	0.86	0.86	0.86	1.00	0.71	0.86	0.86	0.86	0.86	0.71	0.00	0.00	0.14	1.00	0.00
Ross' Goose	0.55	0.36	0.82	1.00	0.09	0.18	0.27	0.27	0.82	0.55	0.18	0.36	0.82	0.64	0.00
Rough-legged Hawk	0.74	0.35	0.83	0.96	0.26	0.30	0.35	0.26	0.87	0.39	0.26	0.30	0.57	0.57	0.00
Ruby crowned Kinglet	0.92	0.75	0.92	1.00	0.67	0.58	0.50	0.25	0.92	0.33	0.00	0.17	0.00	0.92	0.25
Ruddy Duck	0.50	0.38	0.63	1.00	0.13	0.13	0.25	0.13	1.00	0.63	0.00	0.38	0.63	0.75	0.00
Ruffed Grouse	1.00	0.85	1.00	1.00	0.54	0.69	0.85	0.54	1.00	0.46	0.00	0.15	0.23	0.92	0.15
Rufus Hummingbird	0.94	0.88	0.94	1.00	0.63	0.63	0.75	0.50	0.94	0.44	0.00	0.25	0.19	0.94	0.19
Sage Thrasher	1.00	0.00	1.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	1.00	1.00	1.00	0.00	0.00
Sanderling	0.00	0.00	0.20	1.00	0.00	0.00	0.00	0.00	0.60	0.20	0.20	0.00	0.40	0.20	0.00
Sandhill Crane	0.57	0.57	0.86	1.00	0.14	0.29	0.43	0.29	0.71	0.57	0.29	0.14	0.71	0.71	0.00
Savannah Sparrow	0.50	0.25	0.88	1.00	0.13	0.00	0.13	0.13	0.75	0.38	0.25	0.50	0.88	0.50	0.00
Say's Phoebe	0.46	0.00	0.62	0.92	0.08	0.00	0.00	0.00	0.69	0.08	0.46	0.38	0.69	0.23	0.00
Scissor-tailed Flycatcher	0.20	0.00	0.80	1.00	0.00	0.00	0.00	0.00	0.60	0.40	0.40	0.40	1.00	0.40	0.00
Semipalmated Plover	0.30	0.30	0.50	1.00	0.00	0.20	0.20	0.20	0.80	0.50	0.10	0.30	0.80	0.50	0.00
Semipalmated Sandpiper	0.31	0.23	0.54	1.00	0.00	0.15	0.15	0.15	0.77	0.46	0.15	0.31	0.77	0.46	0.00
Say's Phoebe	0.92	0.83	0.92	1.00	0.83	0.67	0.58	0.42	0.92	0.42	0.00	0.08	0.00	0.92	0.17
Sharp tailed Grouse	0.64	0.21	0.71	1.00	0.07	0.21	0.21	0.21	0.86	0.36	0.36	0.43	0.79	0.43	0.00
Short - billed Dowitcher	0.31	0.23	0.54	1.00	0.00	0.15	0.15	0.15	0.77	0.46	0.15	0.31	0.77	0.46	0.00
Short eared Owl	0.67	0.33	0.75	1.00	0.00	0.17	0.25	0.33	0.83	0.42	0.33	0.50	1.00	0.50	0.00
Snow Bunting	0.25	0.13	0.63	1.00	0.13	0.00	0.00	0.00	0.63	0.38	0.25	0.50	0.75	0.38	0.00
Snow Goose	0.55	0.36	0.82	1.00	0.09	0.18	0.27	0.27	0.82	0.55	0.18	0.36	0.82	0.64	0.00
Snowy Egret	0.29	0.29	0.57	1.00	0.00	0.14	0.14	0.14	0.86	0.57	0.14	0.14	0.71	0.57	0.00
Snowy Plover	0.00	0.00	0.20	0.80	0.00	0.00	0.00	0.00	0.60	0.20	0.20	0.40	0.60	0.20	0.00
Solitary Sandpiper	0.40	0.40	0.60	0.93	0.20	0.33	0.33	0.27	0.73	0.47	0.20	0.13	0.60	0.47	0.00
Solitary Vireo	1.00	0.75	1.00	1.00	0.75	0.63	0.88	0.38	1.00	0.38	0.00	0.13	0.00	0.88	0.13
Song Sparrow	0.92	0.75	0.92	1.00	0.50	0.58	0.83	0.67	0.92	0.50	0.00	0.17	0.25	0.92	0.00
Sora	0.80	0.80	0.80	1.00	0.20	0.40	0.60	0.40	1.00	0.80	0.00	0.20	0.60	1.00	0.00
Spotted Sandpiper	0.65	0.52	0.78	1.00	0.35	0.35	0.48	0.35	0.87	0.43	0.09	0.26	0.48	0.65	0.04
Spotted Towhee	0.92	0.46	0.85	0.92	0.31	0.46	0.54	0.54	0.92	0.38	0.23	0.31	0.46	0.62	0.00
Sprague's Pipit	0.00	0.00	0.75	1.00	0.00	0.00	0.00	0.00	0.50	0.25	0.50	0.50	1.00	0.25	0.00
Stellar's Jay	1.00	0.91	1.00	1.00	1.00	0.64	0.64	0.27	1.00	0.36	0.00	0.18	0.00	1.00	0.18
Surf Scoter	0.33	0.25	0.58	1.00	0.00	0.17	0.17	0.17	0.75	0.50	0.17	0.25	0.75	0.50	0.00
Swainson's Hawk	0.74	0.37	0.79	1.00	0.21	0.32	0.32	0.32	0.89	0.42	0.26	0.32	0.63	0.58	0.00
Swainson's Thrush	1.00	0.82	1.00	1.00	0.82	0.73	0.73	0.36	1.00	0.36	0.00	0.09	0.00	0.91	0.18
Townsend's Solitaire	1.00	0.60	1.00	1.00	0.67	0.40	0.40	0.07	1.00	0.20	0.00	0.20	0.00	0.87	0.20
Townsend's Warbler	1.00	1.00	1.00	1.00	1.00	0.75	0.75	0.25	1.00	0.38	0.00	0.13	0.00	1.00	0.25
Tree Swallow	0.77	0.69	0.92	1.00	0.62	0.62	0.62	0.38	0.77	0.31	0.15	0.08	0.15	0.77	0.15
Trumpeter Swan	0.80	0.80	0.80	1.00	0.40	0.40	0.60	0.40	1.00	0.80	0.00	0.20	0.40	1.00	0.00
Tundra Swan	0.44	0.44	0.67	1.00	0.00	0.22	0.33	0.33	0.78	0.44	0.22	0.11	0.78	0.56	0.00
Turkey Vulture	0.67	0.19	0.71	0.90	0.29	0.10	0.24	0.10	0.81	0.14	0.29	0.43	0.52	0.48	0.00
Varied Thrush	1.00	1.00	1.00	1.00	1.00	1.00	0.50	0.00	1.00	0.50	0.00	0.00	0.00	1.00	0.50
Veery	1.00	1.00	1.00	1.00	0.67	1.00	1.00	1.00	1.00	0.67	0.00	0.00	0.33	1.00	0.00
Vesper Sparrow	0.50	0.08	0.75	0.92	0.00	0.00	0.00	0.00	0.75	0.25	0.42	0.42	0.83	0.33	0.00
Violet green Swallow	0.75	0.42	0.83	0.92	0.50	0.42	0.50	0.42	0.67	0.33	0.17	0.08	0.17	0.67	0.00
Virginia Rail	0.80	0.80	0.80	1.00	0.20	0.40	0.60	0.40	1.00	0.80	0.00	0.20	0.60	1.00	0.00
Western Bluebird	1.00	0.63	1.00	1.00	0.63	0.50	0.75	0.38	1.00	0.38	0.00	0.25	0.00	0.75	0.00
Western Grebe	0.67	0.50	0.67	1.00	0.00	0.33	0.33	0.33	1.00	0.67	0.17	0.17	0.67	0.67	0.00

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Western Kingbird	0.55	0.09	0.73	1.00	0.09	0.09	0.09	0.18	0.82	0.18	0.36	0.45	0.73	0.27	0.00
Western Meadowlark	0.60	0.10	0.80	1.00	0.00	0.00	0.00	0.10	0.80	0.30	0.40	0.50	0.90	0.30	0.00
Western San	0.31	0.23	0.54	1.00	0.00	0.15	0.15	0.15	0.77	0.46	0.15	0.31	0.77	0.46	0.00
Western Screech-Owl	0.83	0.83	0.83	1.00	0.83	0.83	0.83	0.83	0.83	0.67	0.00	0.00	0.00	1.00	0.00
Western Tanager	0.91	0.73	0.91	1.00	0.64	0.64	0.55	0.27	0.91	0.27	0.00	0.09	0.00	0.91	0.27
Western Wood-Pewee	0.93	0.73	0.93	1.00	0.73	0.60	0.60	0.33	0.93	0.27	0.00	0.13	0.00	0.93	0.20
White breasted Nuthatch	0.83	0.67	0.83	1.00	0.67	0.67	0.83	0.83	0.83	0.50	0.00	0.17	0.00	0.83	0.00
White crowned Sparrow	0.89	0.89	0.89	1.00	0.56	0.67	0.56	0.56	0.89	0.44	0.00	0.22	0.22	1.00	0.22
White-faced Ibis	0.73	0.64	0.82	1.00	0.27	0.36	0.55	0.55	0.91	0.55	0.09	0.27	0.64	0.73	0.00
White-rumped Sandpiper	0.20	0.20	0.20	1.00	0.00	0.00	0.00	0.00	1.00	0.40	0.00	0.20	0.60	0.40	0.00
White throated Swift	0.80	0.47	0.77	0.93	0.37	0.33	0.37	0.27	0.87	0.30	0.17	0.27	0.40	0.63	0.07
White-winged Crossbill	0.80	0.60	0.80	1.00	0.80	0.40	0.20	0.40	0.80	0.40	0.00	0.20	0.00	1.00	0.20
White-winged Scoter	0.50	0.50	0.50	1.00	0.00	0.25	0.25	0.25	1.00	0.75	0.00	0.00	0.50	0.75	0.00
Wild Turkey	0.83	0.50	1.00	1.00	0.50	0.50	0.67	0.50	0.83	0.33	0.17	0.17	0.17	0.67	0.00
Willow Flycatcher	0.23	0.23	0.54	0.92	0.00	0.15	0.15	0.15	0.69	0.38	0.23	0.23	0.77	0.38	0.00
Williamson's Sapsucker	1.00	0.78	1.00	1.00	0.67	0.67	0.56	0.22	1.00	0.11	0.00	0.11	0.00	0.89	0.33
Willow Flycatcher	1.00	0.90	1.00	1.00	0.60	0.70	0.90	0.80	1.00	0.60	0.00	0.30	0.40	0.90	0.00
Wilson's Phalarope	0.36	0.29	0.64	0.93	0.07	0.14	0.21	0.14	0.71	0.43	0.21	0.29	0.71	0.50	0.00
Wilson's Snipe	0.75	0.63	0.88	1.00	0.13	0.25	0.50	0.50	0.88	0.50	0.13	0.38	0.75	0.75	0.00
Wilson's Warbler	0.86	0.86	0.86	1.00	0.57	0.71	0.71	0.71	0.86	0.57	0.00	0.14	0.29	1.00	0.14
Winter Wren	1.00	1.00	1.00	1.00	1.00	1.00	0.67	0.33	1.00	0.67	0.00	0.00	0.00	1.00	0.33
Wood Duck	0.80	0.80	0.80	1.00	0.50	0.70	0.70	0.70	0.90	0.80	0.00	0.00	0.30	1.00	0.00
Wood Stork	0.75	0.75	1.00	1.00	0.25	0.75	0.75	0.75	0.75	0.75	0.25	0.00	0.75	0.75	0.00
Wood Thrush	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.67	0.00	0.00	0.00	1.00	0.00
Yellow Rail	0.75	0.75	0.75	1.00	0.25	0.25	0.50	0.25	1.00	0.75	0.00	0.25	0.50	1.00	0.00
Yellow-billed Cuckoo	1.00	1.00	1.00	1.00	0.50	0.83	1.00	0.83	1.00	0.83	0.00	0.17	0.50	1.00	0.00
Yellow breasted Chat	1.00	1.00	1.00	1.00	0.67	1.00	1.00	1.00	1.00	0.67	0.00	0.00	0.33	1.00	0.00
Yellow-crowned Night-Heron	0.92	0.75	0.92	1.00	0.42	0.50	0.67	0.58	1.00	0.58	0.00	0.25	0.42	0.83	0.00
Yellow head Blackbird	0.20	0.20	0.60	1.00	0.00	0.00	0.00	0.00	0.60	0.40	0.40	0.00	0.80	0.40	0.00
Yellow-shafted Flicker	0.93	0.71	0.93	1.00	0.71	0.64	0.57	0.36	0.93	0.29	0.00	0.07	0.00	0.93	0.21
Three Toed Woodpecker	1.00	0.83	1.00	1.00	0.67	0.67	0.33	0.00	1.00	0.00	0.00	0.00	0.00	1.00	0.50
Whooping Crane	0.50	0.50	0.83	1.00	0.00	0.33	0.33	0.33	0.67	0.67	0.33	0.00	0.83	0.67	0.00
Chestnut-collared Longspur	0.00	0.00	0.50	1.00	0.00	0.00	0.00	0.00	0.75	0.25	0.25	0.50	1.00	0.25	0.00
Spruce Grouse	1.00	0.80	1.00	1.00	0.80	0.40	0.40	0.00	1.00	0.20	0.00	0.20	0.00	1.00	0.40
Masked Shrew	0.89	0.67	0.94	1.00	0.50	0.44	0.50	0.22	1.00	0.50	0.06	0.39	0.39	0.83	0.11
Pygmy Shrew	1.00	1.00	1.00	1.00	0.67	0.33	0.33	0.00	1.00	0.33	0.00	0.00	0.33	1.00	0.33
Dusky Shrew	1.00	0.73	1.00	1.00	0.55	0.55	0.45	0.36	1.00	0.64	0.00	0.09	0.27	1.00	0.09
Water Shrew	0.94	0.81	0.94	1.00	0.56	0.56	0.63	0.44	1.00	0.50	0.00	0.19	0.31	0.94	0.13
Preble's Shrew	1.00	0.00	0.50	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.75	0.75	0.75	0.25	0.00
Townsend's Big-ear bat	0.84	0.47	0.79	0.89	0.37	0.26	0.32	0.16	0.84	0.16	0.21	0.21	0.42	0.68	0.11
Big Brown Bat	0.75	0.56	0.88	1.00	0.50	0.44	0.56	0.38	0.88	0.44	0.06	0.25	0.25	0.81	0.00
Silver-haired Bat	0.87	0.67	0.93	1.00	0.67	0.53	0.60	0.33	0.87	0.33	0.07	0.13	0.13	0.87	0.13
Hoary Bat	0.88	0.63	0.94	1.00	0.69	0.50	0.56	0.31	0.88	0.25	0.13	0.19	0.13	0.81	0.13
California Myotis	0.63	0.32	0.68	0.95	0.16	0.26	0.32	0.32	0.84	0.47	0.21	0.37	0.58	0.58	0.00
Western Small-foot Myotis	0.58	0.00	0.67	0.92	0.00	0.00	0.08	0.17	0.83	0.17	0.25	0.58	0.58	0.42	0.00
Long-earred Myotis	0.85	0.52	0.85	0.96	0.41	0.37	0.44	0.30	0.93	0.26	0.19	0.30	0.41	0.63	0.07
Little Brown Myotis	0.79	0.58	0.92	1.00	0.42	0.46	0.46	0.29	0.88	0.42	0.08	0.17	0.29	0.83	0.13
Fringed Myotis	0.71	0.18	0.71	0.94	0.18	0.12	0.18	0.06	0.94	0.12	0.24	0.53	0.53	0.41	0.06

Species	Grizzly Bear Umbrella	Moose Umbrella	Elk Umbrella	Boreal Toad Umbrella	Wolverine Umbrella	Red-naped Sap Sucker Umbrella	Warbling Vireo Umbrella	Yellow Warbler Umbrella	Columbia Spotted Frog Umbrella	Fluvial Arctic Grayling Umbrella	Greater Sage Grouse Umbrella	Bighorn Sheep Umbrella	Pronghorn Umbrella	West slope Cutthroat trout Umbrella	Black-backed Woodpecker Umbrella
Long-legged Myotis	0.84	0.63	0.89	1.00	0.58	0.47	0.53	0.32	0.89	0.37	0.05	0.11	0.21	0.84	0.11
Yuma Myotis	0.82	0.45	0.77	1.00	0.27	0.32	0.45	0.41	0.95	0.41	0.14	0.32	0.41	0.68	0.00
Pika	1.00	0.71	0.86	0.86	1.00	0.43	0.29	0.00	0.86	0.14	0.00	0.14	0.00	1.00	0.29
Pygmy Rabbit	1.00	0.00	1.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	1.00	1.00	1.00	0.00	0.00
Snowshoe Hare	1.00	0.92	1.00	1.00	0.75	0.67	0.67	0.42	1.00	0.50	0.00	0.17	0.25	1.00	0.17
Black-tailed Jackrabbit	0.50	0.00	0.50	0.83	0.00	0.00	0.00	0.00	0.83	0.17	0.67	0.83	1.00	0.17	0.00
White-tailed Jackrabbit	0.55	0.09	0.64	0.91	0.09	0.00	0.00	0.09	0.82	0.27	0.45	0.82	0.91	0.27	0.00
Mountain Cottontail	1.00	0.47	0.87	1.00	0.27	0.33	0.53	0.47	1.00	0.33	0.20	0.53	0.53	0.60	0.00
Beaver	0.86	0.86	0.86	1.00	0.43	0.71	0.71	0.57	1.00	1.00	0.00	0.00	0.43	1.00	0.00
Porcupine	1.00	0.64	1.00	1.00	0.55	0.45	0.50	0.36	1.00	0.36	0.05	0.23	0.27	0.82	0.09
Northern Pocket Gopher	0.81	0.25	0.75	1.00	0.25	0.06	0.19	0.13	1.00	0.19	0.19	0.69	0.56	0.50	0.00
Great Basin Pocket Mouse	0.67	0.00	0.67	1.00	0.00	0.00	0.00	0.17	1.00	0.33	0.33	1.00	1.00	0.33	0.00
Southern red-backed Vole	1.00	0.85	1.00	1.00	0.92	0.69	0.62	0.38	1.00	0.46	0.00	0.08	0.08	1.00	0.15
Sage Vole	0.67	0.00	0.67	0.89	0.00	0.00	0.00	0.11	0.89	0.22	0.44	0.78	0.89	0.33	0.00
Long Tailed Vole	0.87	0.50	0.87	0.97	0.40	0.37	0.40	0.27	0.97	0.30	0.13	0.37	0.43	0.70	0.10
Montane Vole	0.86	0.43	0.79	1.00	0.21	0.21	0.21	0.21	1.00	0.43	0.21	0.64	0.71	0.57	0.07
Meadow Vole	0.71	0.41	0.76	1.00	0.18	0.24	0.35	0.35	0.88	0.41	0.29	0.53	0.82	0.53	0.00
Water Vole	0.90	0.90	0.90	1.00	0.60	0.60	0.60	0.40	1.00	0.80	0.00	0.20	0.30	1.00	0.10
Heath Vole	1.00	1.00	1.00	1.00	0.67	0.75	0.58	0.33	1.00	0.58	0.00	0.17	0.25	1.00	0.25
Bushy Tailed Woodrat	0.84	0.37	0.74	0.89	0.37	0.32	0.37	0.21	0.89	0.26	0.21	0.26	0.37	0.58	0.05
Muskrat	0.55	0.55	0.64	0.91	0.27	0.45	0.45	0.36	0.82	0.64	0.09	0.00	0.45	0.64	0.00
Northern Grasshopper Mouse	0.63	0.00	0.50	1.00	0.00	0.00	0.00	0.13	1.00	0.25	0.38	1.00	1.00	0.25	0.00
Deer Mouse	0.78	0.44	0.84	0.94	0.41	0.34	0.31	0.25	0.84	0.31	0.16	0.25	0.38	0.69	0.09
Western Harvest Mouse	0.60	0.10	0.60	1.00	0.00	0.00	0.10	0.20	0.90	0.20	0.40	0.80	1.00	0.30	0.00
Norway Rat	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
Yellow Bellied Marmot	0.93	0.29	0.79	0.93	0.50	0.14	0.21	0.07	0.86	0.14	0.14	0.36	0.14	0.64	0.07
Northern Flying Squirrel	1.00	0.69	1.00	1.00	0.85	0.62	0.62	0.31	1.00	0.31	0.00	0.08	0.00	0.92	0.15
Red Squirrel	0.91	0.64	0.91	1.00	0.73	0.55	0.55	0.27	0.91	0.27	0.00	0.09	0.00	0.91	0.18
Uinta Squirrel	1.00	0.20	0.80	1.00	0.20	0.00	0.40	0.00	1.00	0.00	0.40	0.80	0.40	0.40	0.00
Columbian Ground Squirrel	0.50	0.25	0.63	1.00	0.25	0.00	0.13	0.13	0.75	0.38	0.25	0.75	0.63	0.63	0.00
Wyoming Ground Squirrel	0.75	0.25	0.63	1.00	0.13	0.00	0.25	0.25	1.00	0.13	0.38	1.00	0.88	0.38	0.00
Golden-mantled Ground Squirrel	1.00	0.63	1.00	1.00	0.63	0.38	0.44	0.19	1.00	0.13	0.00	0.25	0.06	0.88	0.19
Richardsons Ground Squirrel	0.25	0.00	0.50	1.00	0.00	0.00	0.00	0.13	0.63	0.13	0.50	0.50	0.88	0.25	0.00
Yellow Pine Chipmunk	1.00	0.40	0.87	1.00	0.40	0.20	0.33	0.20	1.00	0.13	0.20	0.47	0.33	0.60	0.07
Least Chipmunk	0.90	0.00	0.70	0.80	0.20	0.00	0.10	0.10	0.80	0.00	0.40	0.50	0.50	0.40	0.00
Red-tailed Chipmunk	1.00	0.82	1.00	1.00	0.64	0.55	0.55	0.36	1.00	0.27	0.00	0.18	0.18	1.00	0.27
Western Jumping Mouse	0.96	0.65	1.00	1.00	0.57	0.43	0.52	0.30	1.00	0.43	0.04	0.30	0.30	0.91	0.09
Coyote	0.82	0.48	0.88	0.97	0.39	0.33	0.36	0.24	0.91	0.30	0.18	0.33	0.45	0.67	0.09
Wolf	0.90	0.53	0.90	0.97	0.43	0.37	0.40	0.27	0.97	0.33	0.13	0.37	0.40	0.73	0.10
Fox	0.71	0.42	0.71	0.96	0.29	0.25	0.33	0.33	0.83	0.38	0.21	0.42	0.58	0.58	0.00
Cougar	0.95	0.64	0.95	0.95	0.55	0.41	0.50	0.27	0.95	0.32	0.09	0.23	0.27	0.82	0.09
Lynx	1.00	0.88	1.00	1.00	0.88	0.75	0.50	0.38	1.00	0.38	0.00	0.13	0.13	1.00	0.25
Bobcat	0.96	0.58	0.92	0.96	0.42	0.42	0.50	0.33	0.96	0.29	0.17	0.29	0.38	0.71	0.08
Skunk	0.78	0.47	0.84	0.97	0.38	0.34	0.38	0.28	0.88	0.28	0.19	0.31	0.47	0.66	0.09
Spotted Skunk	0.75	0.50	0.75	1.00	0.25	0.38	0.44	0.44	0.94	0.50	0.19	0.44	0.75	0.63	0.00

Species	Grizzly Bear Umbrella	Moose Umbrella	Elk Umbrella	Boreal Toad Umbrella	Wolverine Umbrella	Red-naped Sap Sucker Umbrella	Warbling Vireo Umbrella	Yellow Warbler Umbrella	Columbia Spotted Frog Umbrella	Fluvial Arctic Grayling Umbrella	Greater Sage Grouse Umbrella	Bighorn Sheep Umbrella	Pronghorn Umbrella	West slope Cutthroat trout Umbrella	Black-backed Woodpecker Umbrella
Otter	0.83	0.83	0.83	1.00	0.50	0.83	0.83	0.67	1.00	1.00	0.00	0.00	0.33	1.00	0.00
Marten	1.00	0.91	1.00	1.00	0.82	0.73	0.64	0.36	1.00	0.55	0.00	0.09	0.18	1.00	0.18
Fisher	1.00	0.86	1.00	1.00	0.86	0.71	0.64	0.43	1.00	0.50	0.00	0.07	0.14	1.00	0.14
Short-tail Weasel	0.92	0.63	0.96	1.00	0.50	0.46	0.50	0.33	1.00	0.38	0.00	0.29	0.33	0.83	0.13
Long-tailed Weasel	0.79	0.47	0.85	0.97	0.38	0.32	0.35	0.26	0.88	0.29	0.18	0.32	0.44	0.68	0.09
Least Weasel	0.83	0.56	0.94	1.00	0.33	0.44	0.50	0.39	0.94	0.50	0.06	0.33	0.44	0.72	0.06
Mink	0.86	0.86	0.86	1.00	0.43	0.71	0.71	0.57	1.00	1.00	0.00	0.00	0.43	1.00	0.00
Badger	0.64	0.21	0.64	1.00	0.14	0.07	0.21	0.21	0.93	0.14	0.29	0.71	0.79	0.43	0.00
Coon	0.73	0.73	0.91	1.00	0.36	0.55	0.64	0.64	0.73	0.55	0.18	0.09	0.55	0.82	0.00
Black Bear	1.00	0.70	0.96	1.00	0.57	0.48	0.52	0.35	1.00	0.35	0.04	0.26	0.26	0.83	0.13
Bison	0.88	0.47	0.82	1.00	0.29	0.35	0.35	0.29	1.00	0.47	0.18	0.47	0.59	0.65	0.00
Mule Deer	0.84	0.50	0.91	0.97	0.41	0.34	0.38	0.28	0.88	0.31	0.19	0.31	0.41	0.72	0.09
White Tailed Deet	0.84	0.68	0.95	1.00	0.42	0.47	0.63	0.47	0.84	0.42	0.11	0.26	0.42	0.79	0.11
Mountain Goat	0.88	0.50	0.75	0.88	0.75	0.25	0.13	0.13	0.75	0.13	0.00	0.25	0.13	0.88	0.13
Total Species Umbrella	300.27	208.64	321.93	401.51	150.61	154.88	171.13	136.89	359.00	168.74	54.91	107.94	176.62	287.79	25.17
Proportion	73.24	50.89	78.52	97.93	36.74	37.78	41.74	33.39	87.56	41.16	13.39	26.33	43.08	70.19	6.14

Bighorn Sheep

Potential Habitat: The bighorn sheep model was developed by Smith et al. (1991) and tested and modified by Johnson and Swift (2000) and Zeigenfuss et al. (2000). When applicable, we used the modifications of subsequent authors. Whenever recommendations were in conflict, we used the recommendations that had the greatest amount of supporting data specifically for Rocky Mountain Bighorn sheep.

Core Habitat: Escape terrain is defined as areas with slopes ≥ 60% and were extracted from the 30m DEM. Escape terrain was buffered by 300m to provide areas of core habitat. Areas within 1000m of 2 or more escape terrain surfaces are also considered core habitats. These areas were derived as follows:

Create distance grid from escape cover using spatial analysis.

Multiply the distance grid by -1 to create an inverse surface.

Create flow direction from the inverse distance grid using the 'force flow at edges' option.

Calculate basins from flow direction using the grid 'Basins' command.

Run Zonalmax in grid. Use basins as zonal input and distance from escape cover as value input.

Reclassify zonalmax to extract cells ≤ 500.

The result is a grid of areas within 500m of 2 or more escape surfaces (maximum of 1000m from either surface.

Combine resulting grid with buffered escape terrain to yield potential core habitat.

Areas with ≤ 62% visibility (following Johnson and Swift, 2000) were excluded from potential core habitat. This was done using SILC3 canopy cover data by delineating all areas with ≥ 45% tree canopy cover (classes 4 & 5) and subtracting these areas from potential habitat. Note that this (45% cover) is an arbitrary threshold and will require field data to determine the true relationship between canopy cover and visibility. Finally, all potential core habitat patches with less than 85 Km^2 of contiguous area were discarded according to Zeigenfuss et al. (2000). The HEP also calls for removing areas ≥ 3.2 Km^2 from a water source. Because bighorn can utilize spatially small water sources such as small springs and seeps, data are not available to adequately map their locations across the study area. Since bighorn habitats are restricted to within 500m of rugged terrain and these terrain types occur at higher elevations, we made the assumption that no core habitat areas delineated would exceed the maximum distance from a water source.

Lambing Habitat: Lambing habitat is defined in the HEP as escape cover with southerly exposures, high horizontal visibility and within 1000m of water. Aspect was derived from the DEM and those areas between 90-270 degrees aspect were selected for further delineation as lambing habitat. From the subset of escape terrain, we removed all areas containing confer cover regardless of percent cover to remove areas with potentially low horizontal visibility. As with core habitat, we assumed that all selected areas were within 1000m of a water source. The resulting lambing areas were intersected with the core habitat and summarized for total area by core habitat area. The summary table was joined to the core habitat layer and two permanent attributes were calculated (total lambing area, and percent lambing area) for each core habitat patch.

Summer Habitat: Summer habitat was determined by subtracting areas with ≥ 45% conifer canopy from the 300m buffer around escape terrain (areas < 60% slope within 300m of escape terrain). This layer was intersected with the core habitat layer and summarized by total area of summer habitat by core habitat patch. The summary table was joined to the original core habitat layer to create an attribute of total area of summer habitat for each core habitat patch.

Winter Habitat: Winter habitat is defined as areas within core habitat with southerly exposures and receiving less than 25cm of snowpack. Attempts were made to interpolate snow depth from SNOTEL and NWS weather station data using multiple regression with elevation, aspect, and longitude as covariates but the models did not accurately predict snow depth at low elevations. Instead, Landsat scenes from April 10, 2003 were used to map snow cover over the study area. These scenes were chosen because Early April is typically the month with maximum snowpack in the mountains (SNOTEL data) but thin snow depths at lower elevations have already melted. Additionally, 2002-2003 had near normal snowpack in the mountains so using these scenes should represent something close to the long term means. Using this snow cover map, winter cover was delineated by selecting all areas within core habitats with southerly aspects and no snow cover. The resulting layer was intersected with core habitat and summarized to yield total area of winter cover by core habitat patch. This summary table was joined to the core habitat layer attribute table.

Second Generation Model: The bighorn sheep was modified to address concerns raised by a team of wildlife biologist who reviewed the original model. There were two basic concerns. The first was that the model depicted too much habitat within habitat patches and that actual habitat distribution would be more dissected than the models described. The second was that the model did not describe habitat within areas known to have historically contained bighorn sheep. In addition, the model was modified to produce a range of habitat values in an attempt to convey more information about the habitat being described.

Habitats were assigned a range of values based on landcover type and distance from escape cover. GAP (30m) landcover was reclassified into habitat scores ranging from 0 – 3 (Appendix A2). These scores were rescaled according to the distance from escape terrain by multiplying habitat scores times a distance coefficient derived from the following regression equation:

DistCo = (-0.0014 * EucDist) + 1

where: DistCo = the distance coefficient multiplied by the habitat score

and: EucDist = the Euclidian distance from escape terrain.

This equation produces a coefficient ranging from 1 at zero distance from escape terrain, to 0.3 at the maximum distance of 1000m from escape terrain. Habitat values = 0 were set to NoData.

The problem with the model depicting too much contiguous habitat within core patches was addressed by using a more conservative visibility rule. This was accomplished by changing the visibility threshold from the SILC3 canopy cover layer. The new model reclassifies all areas with conifer canopy cover of ≥ 25% as non-habitat (the original model used a threshold of 45%) thus removing a greater portion of interior conifer forest from habitat consideration.

A connectivity rule was added to the model to predict potential habitat in small but clustered habitat patches. The connectivity rule calculates the maximum distance between the raw core habitat patches (habitat patches of any size) and considers habitat patches within 1 km of each other as part of the same habitat cluster for later testing of minimum patch size. In other words, an assumption is made that sheep can move up to 1 km through non-habitat landscapes to access multiple isolated habitat patches. The steps to accomplish this are as follows:

The raw habitat values were converted to a single integer value of 1 using CON.

Create distance grid from raw habitat using EUCDIST.

Multiply the distance grid by -1 to create an inverse surface.

Create flow direction from the inverse distance grid using the ‘force flow at edges’ option.

Calculate basins from flow direction using the grid ‘Basins’ command.

Run Zonalmax in grid. Use basins as zonal input and distance from raw habitat as value input.

Use CON to extract cells ≤ 500.

The result is a connectivity landscape that includes habitat patches that are connected to other patches if they are within 500m of each other (maximum of 1000m from either patch).

Assign unique values to each contiguous patch of connectivity landscape using REGIONGROUP.

Calculate area of each contiguous connectivity patch using ZONALGEOMETRY.

Assign raw habitat values to areas that have contiguous areas ≥ 85 km^2 using CON.

Habitat Effectiveness: Two threats, sheep grazing allotments and road salting were used to estimate current habitat effectiveness for bighorn sheep. A road salt layer was created by buffering the section of US 287 between its junctions with MT 87 and US 191 using a 50m buffer distance. The two threats were assigned habitat scores (Table A1-3) and were added to potential habitat scores to yield current habitat effectiveness. Using these scores, existing sheep grazing allotments eliminate any potential habitat value for bighorn sheep at a given location.

Table A1-3

Bighorn Sheep Threat Description	Habitat Score
Road Salting	-2
Sheep Grazing Allotment	-3

Black-backed woodpecker

Black-backed woodpeckers are extremely rare coniferous forest inhabitants except in recently burned coniferous forest stands where they may become abundant for 2-3 years following a fire before populations in the burned stand decline (Murphy and Lehnhausen 1998, Hutto 1995). This habitat preference presents a challenge for modeling potential habitat since it is impossible to precisely predict the time, spatial extent, and severity of wildfires. However, sufficient data exists for black-backed woodpecker habitat preferences to model where potential habitat may occur following fire. In particular, Saab et al. (2002) used Landsat TM imagery to predict post-fire habitat use by black-backed woodpeckers. They found that the woodpeckers preferred large stands of Douglas fir forest with high (> 70%) canopy cover. We used readily available GIS data layers to adapt their findings to model potential habitat.

Landcover Score: We reclassified MT and ID 30m GAP landcover into habitat scores for cover type (appendix A2).

Canopy cover: Black-backed woodpecker nests are positively correlated with high canopy cover Douglas fir forest stands (Saab et al. 2002). We used Montana SILC3 canopy cover to reclassify canopy cover classes into habitat scores (Table A1-4) to reflect the woodpecker's preference for burned areas with dense canopy cover in prior to burning.

Table A1-4

SILC3 Canopy Class Description	Habitat Score
1 – 9%	0
10 – 24%	0
25 – 44%	0
45 – 64%	2
65 – 100%	3

Tree size: Tree size has been shown to influence habitat preference of black-backed woodpeckers. Dudley and Saab (2003) reported that for every 5 cm increase in mean tree diameter, male black-backed woodpeckers were 1.03 times more likely to forage within a stand. Saab et al. (2002) found that black-backed woodpeckers nested in snags with larger diameter in proportion to what was available but that they used smaller diameter snags than Lewis's woodpecker. In this study, black-backed woodpeckers nested in snags 39.7 $\pm$ 2.1 cm dbh. Because black-backed woodpeckers appear to select similar but slightly different habitats for foraging and nesting with respect to tree diameter, we developed separate habitat scores for foraging and nesting with respect to tree size and averaged these scores to derive an overall habitat score for tree size. We used Montana SILC3 conifer tree size data to estimate mean dbh within conifer forests. To calculate foraging habitat scores, we used the dbh midpoint values from SILC3 classes to estimate mean dbh at each pixel. Using Dudley and Saab (2003) as a guide, we reclassified the SILC3 classes by multiplying 1.03 times the number of 5 cm increments between the midpoint of the smallest size class and the class being reclassified. These new classes were then rescaled to a range of 0 – 3 (table RR). For nesting, size classes were simply rescaled to reflect the reported preference for trees approximately 40 cm DBH (Table A1-5).

Table A1-5

SILC3 Tree Size Class Description			Habitat Score (foraging)	Habitat Score (nesting)
Sapling	1.0 – 4.9”	DBH	0.14	0
Pole	5.0 – 8.9”	DBH	0.28	1
Medium	9.0 – 14.9”	DBH	0.36	3
Large	15.0 – 20.9”	DBH	0.42	3
Very Large	21.0 – 99.0”	DBH	3.0	2

Habitat scores for landcover, canopy cover, and tree size were added together and divided by 9 to yield an overall landcover habitat score of 0 – 1.

Fire potential: Because these landcover habitat scores reflect post-fire habitat value following a stand replacement burn, we used Fire Severity Condition Class data from USFS Region 1 to weight the habitat scores according to the likelihood that wildfire would result in a stand replacement fire. This was accomplished by converting fire severity classes to coefficients and then multiplying habitat scores by the severity coefficients (Table A1-6)

Table A1-6

Region 1 Fire Severity Current Condition Class	Coefficient
Mixed severity, short interval	0.1
Mixed severity, long interval	0.3
Mixed severity, high elevation	0.1
Stand replacement, forest	1.0
All other classes	0

Beetle-killed Areas: Black-backed woodpeckers are found in areas with high densities of bark beetles and wood boring beetles (Hoyt and Hannon 2002, Koplin 1969, USDA Black Hills National Forest 2000). Black-backed woodpeckers are found with bark beetle outbreaks in northern Idaho where fires have been absent but at lower densities than they are found in recently burned stands in Montana (Hillis et al. 2002). We obtained GIS layers of recent beetle kills from the Gallatin and Beaverhead-Deerlodge National Forests. These beetle data were incorporated into the model by treating beetle-infested areas as surrogates for burned forests. Since beetle-killed stands appear to support lower densities of black-backed woodpeckers than recently burned stands, beetle infested areas were assigned a coefficient of 0.6 resulting in beetle infested areas providing 60% the habitat value of a stand replacement fire. Fire severity and beetle outbreak layers were combined using the cell statistics function of ArcGIS to assign the output grid the maximum coefficient value of the two input layers before multiplying the coefficients with habitat values as described under Fire Potential.

Area requirements: Black-backed woodpeckers use relatively large areas for foraging, particularly following fledging young (Dudley and Saab, 2003). To account for home range requirements, we calculated the focal means of habitat scores described above using a circular neighborhood with a radius of 291.5m which is equivalent to the mean adaptive kernel (AK) home range (196.8 ha) estimated for 3 radio-tagged male black-backed woodpeckers by Dudley and Saab (2003).

Habitat Effectiveness: Habitat effectiveness was not calculated for black-backed woodpeckers because the model only predicts potential habitat that could exist following a stand-replacement fire or beetle outbreak. Fire suppression is the main threat to black-backed woodpecker habitat but is relatively ubiquitous throughout potential habitat. Therefore, the probability that habitat potential for this species will be realized is reduced across the entire study area due to decreased probability of stand-replacement fires in potential habitat.

Boreal Toad

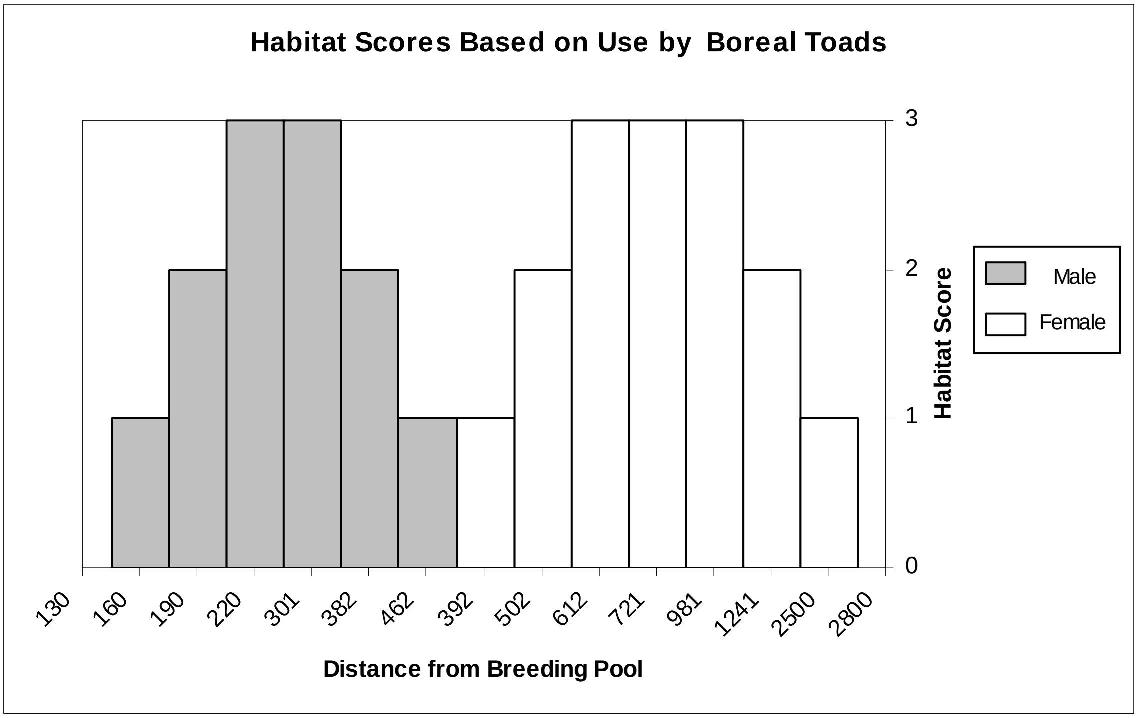
Potential Habitat: Boreal toads are found primarily within 300m of lakes ponds and springs (Keinath and Bennet, 2000). Habitat scores were calculated for four habitat components: wetlands, landcover, edge, and soils. Boreal toads favor habitat within 300m of breeding ponds, prefer spruce-fir and lodgepole forests, show a preference for forest edges, and require mammal burrows that extend below frost line for shelter and hibernation.

Wetlands Score: Wetland habitat scores were assigned by calculating the Euclidian distance from lakes and ponds (MTFWP GIS layer) within 300m of water edge and reclassifying the distances to habitat rankings. Boreal toads show sexually dimorphic preferences with respect to habitat use around breeding ponds with females typically found farther from ponds than males (Bartelt, 2000). Muths (2003) reported mean, mean minimum, and mean maximum distances that male and female toads were found from breeding pools. We used these reported distances to assign habitat ranks by dividing the range of distances between the mean minimum and mean distances, and between the mean maximum and mean distances into equal intervals and assigning the intervals closest to the extremes a value of 1, intermediate intervals a 2, and the interval closest to the mean a 3. This was repeated for each gender (Fig A1-1) and the following habitat scores were assigned (Table A1-7).

Table A1-7

Distance	Habitat Score
0 - 130m	0
130 – 160m	1
160 – 190m	2
190 – 220m	3
220 – 301m	3
301 – 382m	2
382 – 462m	1
462 – 502m	1
502 – 612m	2
612 – 721m	3
721 – 981m	3
981 – 1241m	2
1241 – 1500m	1
1500 – 2500m	1
> 2500m	0

Figure A1-1



Landcover Score: Landcover scores were assigned using 30m GAP reclassified to habitat scores emphasizing fir-spruce and lodgepole habitat (Appendix A2). The raw scores were smoothed by calculating the focal mean of all habitat scores within a 300m radius. This arbitrary radius should be replaced with average home range of boreal toads if such data are available.

Edge habitat was determined using the same methods described for the elk model. Standard deviation of pixels of forest/non-forest edge within 300m radius calculated using the focal statistics function.

Because boreal toads frequently use mammal burrows for shelter and require burrows that extend below frostline for winter hibernacula, deep soils within travel distance of breeding and summer habitats should be incorporated into the model. Unfortunately, detailed soils GIS layers are currently not available for USFS lands so cannot be incorporated at this time. However, should data become available, the methodology is simple. Soils deeper than 1m and within 1000m of water would be scored according to Table A1-8.

Table A1-8

Soil Depth	Habitat Score
0-300m	3
400-500m	2
500 – 1000m	1
> 1000	0

All subvalues calculated for individual habitat components are normalized to the range 0-1. Final Habitat quality is calculated using the following formula

HabQual = con(WetValNrm <> 0, (1*WetValNrm) + (2*HabValNrm) + (1*SoilValNrm) + (0.5 * EdgeValNrm), 0)

where weighting coefficients are subject to further refinement.

A population level filter is also applied to account for the metapopulation characteristics of boreal toads. This filter is based on the assumption that individual breeding ponds create "winking breeding populations" where many individual ponds do not provide breeding habitat or recruitment every year. Therefore complexes of high quality breeding ponds clustered within dispersal distance of breeding toads will provide more robust habitat for maintaining viable populations. To produce this population level habitat, a focal mean with search radius of 462m was calculated from the fine scale habitat quality scores previously described. This radius is based on the mean dispersal distance of males (Muths, 2003). The dispersal distance of males was chosen because it is roughly half the dispersal distance of females. Therefore, breeding pond complexes need to be within male dispersal distance of each other in order for breeding toads of both sexes to have access.

Finally, a genetic population habitat model was creating to estimate the potential areas of genetic exchange among breeding populations. This model was created using the same methods described for the population level filter above except that the mean female dispersal distance of 905m was used. The longer dispersal distance of females allows genetic exchange between breeding populations.

Connectivity Analysis: Connectivity was analyzed using weighted cost-distance surfaces and corridor analysis. Habitat cores were identified as areas with habitat quality ≥1.4 with an area large enough to support ≥ 20 male territories based on mean territory size of 58,929 m^2/male (Muths 2003). The habitat quality threshold of 1.4 was chosen as a compromise between selecting the best habitat and minimizing the number of cores for analysis. Because habitat connectivity depends on the dispersion of core habitats across the landscape and habitat cores have been fragmented or lost due to habitat degradation, habitat cores based on potential and effective habitat were identified separately. Habitat core patches within 500m of each other (approximately the mean maximum distance traveled by males away from breeding ponds, Muths 2003) were treated as a single core habitat complex for connectivity analysis. These methods yielded a total of 15 potential and 28 effective habitat cores. Cost distances were calculated across the entire study area for each habitat core and corridor values were calculated between each pair-wise combination of cores. The cell statistics function was used to extract the minimum corridor value for all pair-wise combinations with a core type (potential vs. effective) to produce a composite surface of the minimum accumulated cost for traveling between cores across the entire study area. Cells with accumulated cost distances > 5 Km were excluded from consideration as connectivity habitat because this is approximately twice the maximum distance from a breeding pond that females are reported to travel (Bartelt 200, Muths, 2003). Corridor cost distances were converted to connectivity scores with a linear regression (Connectivity = -0.0002 * Cost-distance + 1) to provide a range of connectivity scores 0-1.

Habitat Effectiveness: Boreal toads are negatively affected by a variety of human land use activities. We modeled 5 threats likely to degrade boreal toad habitat. These threats and methods for modeling are:

Dewatering – Habitat loss due to dewatering was estimated by calculating the Euclidian distance from the dewatered streams layer and reclassifying the distances to habitat scores (Table A1-7).

Fish Stocking – MTFWP fish stocking data for lakes was obtained from the MFISH database. Lakes that have been stocked with non-native fish or where native fish were introduced (lakes that originally had no fish but were stocked with natives) were extracted from the database layer and retained for further processing. Euclidian distance was calculated from lake polygons and the results were reclassified into habitat scores (Table A1-9).

Loss of Flood Plain Habitat – Natural floodplains were delineated by extracting cells from the slope layer with percent slope ≤ 1.5. Areas within a flood plain were assigned a habitat score of -1.5.

Pollution – Lakes and streams with a listing status of 'impaired' were extracted from the Montana Water Quality layers. Euclidian distance was calculated for the impaired lakes and streams. Distances were reclassified to habitat scores (Table A1-10).

Roads – Weighted road density (Appendix A3) were multiplied by -1.5 to produce habitat scores reflecting the relative effect of road density on boreal toads.

Habitat scores for human activities were totaled and then truncated so that no score was less than -3. These combined threats scores were added to potential habitat to estimate current habitat effectiveness.

Table A1-9

Distance from fish stocked lakes and ponds	Habitat Score
0 - 130m	-0.5
130 – 160m	-0.5
160 – 190m	-1.0
190 – 220m	-1.5
220 – 301m	-1.5
301 – 382m	-1.0
382 – 462m	-0.5
462 – 502m	-0.5
502 – 612m	-1.0
612 – 721m	-1.5
721 – 981m	-1.5
981 – 1241m	-1
1241 – 1500m	-0.5
1500 – 2500m	-0.5
> 2500m	-0.5

Table A1-10

Distance from pollution impaired waters	Habitat Score
0 - 130m	-0.33
130 – 160m	-0.33
160 – 190m	-0.67
190 – 220m	-1
220 – 301m	-1
301 – 382m	-0.67
382 – 462m	-0.33
462 – 502m	-0.33
502 – 612m	-0.67
612 – 721m	-1.0
721 – 981m	-1.0
981 – 1241m	-0.67
1241 – 1500m	-0.33
1500 – 2500m	-0.33
> 2500m	-0.33

Sage grouse

Sage-grouse habitat is broken into 4 component submodels: Potential leks, nesting habitat, brood rearing habitat, and wintering habitat. Lekking habitat is not considered a limiting habitat type (Schroeder et al. 1999) and Leks occur within nesting/wintering habitat complexes and sage-grouse can use burned or human-made clearings where natural clearings are not available (Connelly et. al., 1981). However, breeding habitats in Montana tend to occur within 3 km of leks (Montana Sage-grouse Work Group, 2004) so potential lek sites were modeled and mapped as an aid to predict the best nesting habitats in the area. Overall habitat value is based upon the availability of sufficient habitat of all subtypes within the know migration distances of sage-grouse. Because sage-grouse can migrate considerable distances between habitat types, the analysis extent was extended beyond the Madison Valley. Because model inputs rely on Landsat imagery, the analysis extent was set to the combined extent of image path 39, rows 28-29.

Potential Leks: Leks occur in relatively open areas adjacent to suitable nesting habitat (Patterson 1952, Walkkinen et al. 1992). Leks are characteristically found on gentle (<10%) slopes (Rogers, 1964) and in valley bottoms or draws (Patterson, 1954, Rogers, 1964). To model potential lek sites, tasseled cap soil brightness was calculated using the May 28, 2003 Landsat TM scene to identify areas of relatively bare soil with sparse vegetation cover within sagebrush communities classified in Idaho and Montana 30m GAP landcover. Soil brightness was masked using the reclassified 30m GAP produced in the nesting habitat model identified below. This mask sets all pixels in the brightness scene that do not fall within sagebrush habitat to NoData. Areas with soil brightness values > 170 were retained for consideration as potential lek sites for subsequent model processing. 170 was chosen by manually exploring pixels known to have bare soils or low vegetation cover within the brightness scene and determining the minimum brightness values for areas we are confident lack substantial aerial cover of vegetation. Valley bottoms and draws were determined by calculating curvature from 30m DEM using the same analysis mask explained for soil brightness. Curvatures were reclassed to remove areas with positive (domed) curves and retain only areas that represent valleys and draws.

Nesting Habitat: Sage-grouse prefer nesting in stands of sagebrush with 15-31% sagebrush cover. Nests are typically located beneath the tallest available sagebrush plants and increased concealment cover from surrounding grasses and shrubs is correlated with higher nest success. The nesting model contains two inputs: landcover and NDVI. We used Montana and Idaho 30m GAP for landcover and reclassified to the habitat values listed in Appendix A2. Areas with a landcover habitat score > 0 were extracted to create a separate mask layer used to eliminate unsuitable habitat from the nesting, lekking, and winter habitat models. NDVI was calculated using late May (May 28, 2003) Landsat scene to estimate the amount of standing biomass (concealment cover) at the time of nesting. The NDVI values for the combined (Path 39 Rows 28-29) scene were reclassified into 4 Jenk's natural breaks classes. Natural breaks were chosen because we felt they would most likely reflect disturbance regimes that affect standing cover. The number of classes was arbitrarily chosen (Table A1-11).

Table A1-11

NDVI Value	Habitat Score
-0.800000 - 0.004124	0
0.004124 - 0.096907	1
0.096907 - 0.220619	2
0.220619 - 0.783505	3

Habitat scores for sage habitat (landcover) and nesting cover (NDVI) were added together and divided by 6 for a combined habitat score ranging from 0-1. The focal mean for a circular radius of 500m was calculated to smooth the data and emphasize areas containing large patches of suitable habitat.

Brood Habitat: Brood rearing habitat are areas rich in succulent forbs that support high insect populations. These habitats often occur with sagebrush communities but may also be in other shrub/steppe communities, grasslands, or even irrigated alfalfa fields. Late in the season or during dry years, sage-grouse may tend to concentrate in mesic areas where the most succulent vegetation typical occurs. Landcover (30m GAP) and Fall greenness were used to identify potential brood rearing habitat. Landcover was reclassified to habitat scores (Appendix A2). Tasseled cap greenness was calculated from Oct. 16, 2002 Landsat images. The resulting greenness image was masked to include only areas within potential brood habitat landcover classes. The masked greenness image was reclassified into 4 Jenk's Natural Breaks classes. These classes were assigned habitat scores from 0 – 3 (Appendix A2) with the highest scores assigned to the areas with highest greenness indicating the most succulent vegetation. Landcover and greenness habitat scores were added together and divided by 6 to give an overall habitat score from 0 – 1. A focal mean within a 500m circular radius was calculated to smooth the resulting habitat scores and emphasize habitats with relatively high contiguous area of brood habitat. The smoothed results were again masked to exclude areas within unsuitable landcover types.

Winter Habitat: Sage-grouse need winter habitat where sage brush protrudes above snow cover. Topography influences snow depth so level (< 5%; Beck 1977), and south to southwest facing (Beck 1977, Crawford et al. 2004) sage brush communities are typically preferred. Winter habitat was modeled using USGS 30m DEM and Landsat TM imagery from April, 10, 2003. Slope and aspect were calculated from the DEM. Percent slope and aspect were reclassified to assign habitat scores (Tables A1-12 and A1-13).

Table A1-12

Percent Slope	Habitat Score
0 – 5	3
5 – 20	2
> 20	0

Table A1-13

Degrees Aspect	Habitat Score
-1 – 45	0
45 – 90	1
90 – 135	2
135 – 180	3
180 - 225	3
225 – 270	2
270 – 315	1
315 – 360	0

NDVI was calculated from April 10, 2003 Landsat TM imagery to detect areas where sagebrush protrudes above snow cover. These are good images to use because maximum snowpack typically occurs around April 15 and April snowpack in 2003 was very close to the 30 year average. Therefore, NDVI calculated from these scenes should reveal areas where vegetation extends above the snow surface in an average snowpack year. After NDVI was calculated, pixels containing potential sage-grouse habitat were extracted using the same mask described under lekking habitat above. Masked NDVI values were reclassified into 4 Jenk's natural breaks classes (Table A1-14).

Table A1-14

NDVI Value	Habitat Score
-0.662338 - -0.143310	0
-0.143310 - -0.051446	1
-0.051446 - 0.054197	2
0.054197 - 0.513514	3

Habitat scores for slope, aspect, and NDVI were added together and divided by 9 to produce combined winter habitat scores ranging from 0 – 1. Focal means were calculated for the combined scores using a search radius of 500m to emphasize areas containing large blocks of good habitat. The resulting smoothed grid was then remasked to eliminate areas that fall outside of suitable winter habitat using the habitat mask described earlier.

Landscape Context: Sage-grouse are clearly a landscape species requiring multiple seasonal, and often spatially disparate habitats. Sage-grouse are known to migrate up to 160 km between seasonal habitats (Dalke et al. 1963) with most reported migration travel distances less than 50 km (Connelly 1982, Hofmann 1991, Hulet 1983, and Berry and Eng 1985). However, little is known about minimum patch size of habitats needed to support sage-grouse populations (Connelly et al. 2004). Lack of minimum patch size data makes modeling the landscape context of sage-grouse habitats futile in the Madison Valley. The valley is characterized by numerous small fragments of suitable habitat for each of the seasonal habitat types identified. These fragments are dispersed throughout the low and mid-elevation ranges of the valley with each fragment well within potential migration distance of other seasonal habitat types. However, it is likely that many of these fragments are too small to support sage-grouse seasonal needs but without adequate data, it is impossible to identify habitats that may be isolated by excessive distance to other habitat types.

Moose

Moose are habitat generalists found from alpine meadows to riparian and shrub mosaic lowlands. The predominant requirements of moose are an abundance forage browse and access to security/thermal cover. Because moose can adapt to a wide variety of local conditions over their circumpolar species range, we relied heavily on published studies of moose habitat use within the Gravelly (Knowlton 1960) and Gallatin (Stevens 1970) mountain ranges which are within or adjacent to the Madison Valley study area. Moose often move seasonally between summer and winter habitats so separate models were developed to accommodate the seasonal changes in habitat preference. GAP 30m landcover was reclassified into forage quality scores (Appendix A). Moose feed heavily on browse at all times of the year but will consume more conifer browse (eg. Douglas fir and subalpine fir) in the winter while during the growing season, forage consumed is dominated by leafy browse including riparian willows and mesic shrubs such as service berry and Douglas hawthorn. During the growing season, about 25% of moose diet is provided by succulent herbs, particularly sticky geranium. Because riparian willows are extremely important browse species for moose, and GAP landcover severely underestimates the extent of willow landcover, we used a riparian vegetation landcover map developed by WCS. This willow landcover layer was developed from digital elevation models, hydrology, and Landsat TM imagery (Appendix A2). This improved willow landcover layer replaced the GAP landcover classification wherever the two landcover maps disagreed.

It is widely reported in the literature that moose move away from areas of deep snow in the winter. In the Gravelly Range, moose typically move to lower elevations to concentrate in lowland willow flats along major drainages (Knowlton 1960). In the Gallatin Range, moose often move to higher elevations to occupy slopes in the winter. These apparently opposing behaviors are explained by patterns of winter snow cover. Winter snow cover in the Gravelly Range typically covers the upland spine of the mountain range while lowland drainages remain relatively snow free. In contrast, snow cover in the Gallatin range tends to accumulate in the small mountain valleys while snow depth on montane slopes (particularly those with southern exposures) remains relatively shallow. To model these seasonal shifts in preferred habitat, we used Snow Data Assimilation System (SNODAS) data (Barrett, 2003) to estimate maximum snow depth across the study area. We took the average snow depth for April 1 2004 and April 1 2005 (the only years available) and resampled to 30m pixel resolution. Moose tend to avoid areas with snow depth exceeding 90 cm (Peek et al., 1982). Using a conservative cutoff of 80 cm to account for more severe winters, we eliminated all areas with average SNODAS snow depth ≥ 80 cm from consideration as potential winter range.

Moose seek thermal cover adjacent to feeding habitat to escape deep snow and cold temperatures in the winter and security cover when disturbed during all seasons. Montana SILC3 conifer canopy cover and conifer size class data were used to map thermal and security habitat for moose. Conifer canopy cover and tree size were reclassified into habitat scores (Tables A1-15 and A1-16).

Table A1-15

SILC3 Canopy Class Description	Habitat Score
1 – 9%	1
10 – 24%	2
25 – 44%	3
45 – 64%	4
65 – 100%	4

Table A1-16

SILC3 Tree Size Class Description	Habitat Score (foraging)	Habitat Score (nesting)
Sapling 1.0 – 4.9" DBH	0.14	0
Pole 5.0 – 8.9" DBH	0.28	0
Medium 9.0 – 14.9" DBH	0.36	4
Large 15.0 – 20.9" DBH	0.42	4
Very Large 21.0 – 99.0" DBH	3.0	4

Canopy cover and tree size were combined into a single habitat score using the following formula: ((2 * Tree Size) + Canopy Cover) / 3. We weighted tree size twice as important as canopy cover because we assumed that small clusters of 1-3 trees would provide adequate security regardless of overall canopy cover of the stand but that stands with high canopy cover would provide more security cover and perhaps better thermal protection.

While on winter or summer range, moose occupy a fairly small home range. Moose on summer range in the Gravelly range typically traveled within a 0.5 – 1 mile radius (Knowlton 1960) and Stevens (1970) reported moose in the Gallatin Range to be "… relatively sedentary in winter…". These travel distances were incorporated into the model in 2 ways. First, moose prefer to feed in areas with ready access to thermal/security cover so Euclidian distance was calculated to the nearest high quality (habitat score ≥ 3) thermal/security cover and areas farther than 0.5 miles from security cover were reclassified to zero for forage habitat quality. Finally, the resulting forage habitat quality values were assessed over potential home ranges of moose by calculating the mean forage habitat values within a 1 mile radius.

The resulting maps show the average forage habitat quality within a 1 mile radius that are within 0.5 miles from high quality thermal/security cover and that are relatively snow free during winter in the case of the winter habitat map.

Wolverine

Potential Habitat: Wolverine potential habitat was modeled using logistic regression with a full stepwise selection procedure generated using SAS® software (SAS, 2000). The model was derived from 1284 radio telemetry locations collected from 17 individuals (9 females and 8 males) collected from January, 2001 to August, 2005. Absence data was estimated using 3600 randomly distributed points within the study area. Significant parameters used in the model were: latitude adjusted elevation, forest edge, terrain roughness index, and total tree cover. The full details of the wolverine modeling procedure will be made available following their publication.

Habitat Effectiveness: Human activity inputs for habitat effectiveness were weighted road density, snowmobile activity and building structures (see Appendix A3). Human activities were assigned the degradation coefficients listed in Table A1-17.

Table A1-17

Human Activity	Degradation Coefficient
Structures/Km^2 (Acres/Structure)	
0 – 1.54 (0 – 160)	0
1.54 – 4.12 (160 – 60)	0.33
4.12 – 24.7 (60 – 10)	0.66
>24.7 (< 10)	1.0
Snowmobile Activity (% area tracked / $mile^2$	
0	0
1-10	0.0825
11-33	0.166
> 33	.25
Weighted Road Density (see Appendix A3)	Value * 0.5

After degradation coefficients were assigned, coefficients at each cell location were summed and the totals were multiplied by the potential habitat value to calculate habitat effectiveness.

Habitat Effectiveness: Wolverine habitat effectiveness includes potential influences of road density, residential development, snowmobiling, and trapping.

Roads most likely affect wolverines by increasing mortality as wolverines attempt to cross highways and other roadways. We estimated the impact of roads on wolverine habitat value by multiplying the weighted road density layer by -0.5 giving roads ½ the influence on wolverine habitat as it has on grizzly bear.

Residential development results in direct habitat loss and increased disturbance that probably causes wolverines to avoid some areas containing otherwise suitable habitat. The effect of residential housing was estimated by rescaling structure density scores (Appendix A3) to a range of 0-1 and multiplying by -1 so that the highest housing density cancelled the value of the best habitat.

Snowmobiling activity was surveyed from a fixed-wing aircraft. For each 1 mile square section, the percent area covered by snowmobile tracks was estimated and assigned a usage category of high, medium, low, and no use. These ratings were converted to habitat scores following the conservative assumption that even in the most heavily used snowmobile areas, wolverine habitat would be degraded by no more than 25% (Table A1-18).

Table A1-18

Percent area covered by snowmobile tracks per $mile^2$	Use Rating	Habitat Score
0	No Use	0
1 – 10	Low	0.08
11 – 33	Medium	0.17
>33	High	0.25

Wolverines have approximately a 33% higher survival rate in untrapped versus trapped populations (Inman unpubl.). We assumed that most trapping activities were conducted by accessing areas by snowmobile. Based on this assumption, we assigned a habitat score of -0.33 to all areas that had evidence of snowmobile activity estimated from aerial surveys.

Table A2-1 Montana 30m GAP Habitat Scores per Species

New GAP types	Bighorn Sheep	Grizzly	Elk	Pronghorn	Boreal Toad	Wolverine	Sage Grouse (Nesting)	Sage Grouse (Brood Rearing)	Black-backed Woodpecker	Moose (Summer)	Moose (Winter)	Edge
Urban or Developed Lands	0	0	0	0	0	0	0	0	0	0	0	2
Agricultural Lands - Dry	0	0	2	3	0	0	0	0	0	0	0	1
Agricultural Lands - Irrigated	0	0	2	3	1	0	0	1	0	0	0	1
Altered Herbaceous	0	1	1	1	0	1	0	0	0	0	0	1
Very Low Cover Grasslands	2	1	1	3	0	1	0	1	0	0	0	1
Low/Moderate Cover Grasslands	3	1	2	3	0	1	0	2	0	1	1	1
Moderate/High Cover Grasslands	3	2	3	3	1	1	0	3	0	1	1	1
Montane Parklands/Subalpine Meadows	3	3	3	0	2	1	0	0	0	4	2	1
Mixed Mesic Shrubs	1	2	1	0	3	1	0	3	0	3	3	1
Mixed Xeric Shrubs	3	1	2	3	0	1	0	1	0	1	1	1
Silver Sage	3	1	2	2	0	1	3	3	0	0	0	1
Salt-Desert Shrub/Dry Salt Flats	1	0	1	2	0	1	0	1	0	0	0	1
Sagebrush	3	2	3	2	0	1	3	3	0	3	0	1
Mesic Shrub-Grassland Associations	2	1	2	2	2	1	0	3	0	4	4	1
Xeric Shrub-Grassland Associations	3	1	2	2	0	1	2	2	0	1	1	1
Low Density Xeric Forest	3	1	2	0	0	3	0	0	0	2	2	3
Mixed Broadleaf Forest	1	2	2	0	2	3	0	0	0	3	3	3
Lodgepole Pine	1	2	2	0	1	3	0	0	2	2	2	3
Limber Pine	1	3	2	0	1	3	0	0	0	1	1	3
Ponderosa Pine	1	2	2	0	0	3	0	0	3	2	2	3
Grand Fir	1	3	2	0	2	3	0	0	2	2	2	3
Western Red Cedar	1	3	2	0	2	3	0	0	3	1	2	3
Western Hemlock	1	3	2	0	3	3	0	0	3	1	2	3
Douglas-fir	1	3	2	0	2	3	0	0	3	1	3	3
Rocky Mountain Juniper	2	1	1	1	0	3	0	0	0	1	0	3
Western Larch	1	3	2	0	2	3	0	0	0	1	2	3
Utah Juniper	2	1	1	1	0	3	0	0	0	1	0	3
Douglas-fir/Lodgepole Pine	1	3	2	0	2	3	0	0	3	1	2	3
Mixed Whitebark Pine Forest	1	3	2	0	1	3	0	0	2	0	0	3
Mixed Subalpine Forest	1	3	2	0	1	3	0	0	2	3	4	3
Mixed Mesic Forest	1	3	2	0	3	3	0	0	2	3	3	3
Mixed Xeric Forest	2	2	1	0	1	3	0	0	1	2	2	3
Mixed Broadleaf and Conifer Forest	1	2	2	0	2	3	0	0	2	3	3	3
Standing Burnt Forest	3	1	2	0	1	3	0	0	3	1	1	3
Water	0	0	0	0	0	0	0	0	0	1	0	2
Conifer Riparian	0	3	2	0	3	3	0	0	3	2	3	3
Broadleaf Riparian	0	3	2	0	3	3	0	0	0	4	4	3
Mixed Broadleaf and Conifer Riparian	0	3	2	0	3	3	0	0	2	4	4	3
Graminoid and Forb Riparian	3	2	2	1	3	1	0	0	0	4	4	1
Shrub Riparian	1	3	2	1	1	1	0	0	0	4	4	1
Mixed Riparian	1	3	2	1	2	1	0	0	0	4	4	1
Rock	3	1	0	0	0	6	0	0	0	0	0	2
Mines, Quarries, Gravel Pits	2	0	0	0	0	0	0	0	0	0	0	2
Badlands	3	0	0	0	0	0	0	0	0	0	0	2
Missouri Breaks	3	0	0	0	0	0	0	0	0	0	0	2
Mixed Barren Sites	3	1	0	1	0	6	0	0	0	0	0	2
Alpine Meadows	3	3	3	0	1	6	0	0	0	3	1	1
Snowfields or Ice	1	0	0	0	0	6	0	0	0	0	0	2
Clouds	0	0	0	0	0	0	0	0	0	0	0	2
Cloud Shadows	0	0	0	0	0	0	0	0	0	0	0	2

Table A2-2 Idaho 30m GAP Habitat Scores for Sage grouse

Code	Description	Sage grouse (nesting)	Sage grouse (brood rearing)
1000	Urban	0	0
1001	High Intensity Urban	0	0
1002	Low Intensity Urban	0	0
1101	Disturbed, High	0	0
1102	Disturbed, Low	0	0
2000	Agricultural land	0	1
3000	Non-Forested Lands	0	0
3101	Foothills Grassland	0	3
3102	Disturbed Grassland	0	0
3103	Herbaceous Clearcut	0	0
3104	Montane Parklands and Subalpine Meadow	0	0
3105	Wet Meadow	0	0
3106	Herbaceous Burn	0	0
3107	Shrub/Steppe Annual Grass-Forb	0	0
3108	Dry Meadow	2	3
3109	Perennial Grassland	0	3
3110	Perennial Grass Slope	0	3
3201	Mesic Upland Shrubs	0	0
3202	Warm Mesic Shrubs	0	0
3301	Curlleaf Mountain Mahogany	0	0
3304	Bitterbrush	0	2
3305	Mountain Big Sagebrush	3	3
3306	Wyoming Big Sagebrush	3	3
3307	Basin & Wyoming Big Sagebrush	3	3
3308	Black Sagebrush Steppe	0	2
3309	Silver Sage	3	3
3310	Salt-desert Shrub	0	1
3312	Rabbitbrush	0	2
3315	Low Sagebrush	0	2
3316	Mountain Low Sagebrush	0	0
4000	Forest Uplands	0	0
4101	Aspen	0	0
4102	Cottonwood	0	0
4103	Maple	0	0
4201	Englemann Spruce	0	0
4203	Lodgepole Pine	0	0
4206	Ponderosa Pine	0	0
4207	Grand Fir	0	0
4208	Subalpine Fir	0	0
4210	Western Red Cedar	0	0
4211	Western Hemlock	0	0
4212	Douglas-fir	0	0
4215	Western Larch	0	0
4216	Douglas-fir/Limber Pine	0	0

Table A2-2 Idaho 30m GAP Habitat Scores for Sage grouse

Code	Description	Sage grouse (nesting)	Sage grouse (brood rearing)
4217	Subalpine Pine	0	0
4218	Subalpine fir/Whitebark Pine	0	0
4219	Mixed Whitebark Pine Forest	0	0
4220	Mixed Subalpine Forest	0	0
4221	Mixed Mesic Forest	0	0
4222	Mixed Xeric Forest	0	0
4223	Douglas-fir/Lodgepole Pine	0	0
4225	Douglas-fir/Grand Fir	0	0
4226	Western Red Cedar/Grand Fir Forest	0	0
4227	Western Red Cedar/Western Hemlock	0	0
4228	Western Larch/Lodgepole Pine	0	0
4229	Western Larch/Douglas-fir	0	0
4230	Utah Juniper	0	0
4231	Western Juniper	0	0
4232	Pinyon Pine/Juniper	0	0
4301	Mixed Needleleaf/Broadleaf Forest	0	0
4401	Standing Burnt or Dead Timber	0	0
5000	Water	0	0
6000	Riparian and Wetland Areas	0	0
6101	Needleleaf Dominated Riparian	0	0
6102	Broadleaf Dominated Riparian	0	0
6103	Needleleaf/Broadleaf Dominated Riparian	0	0
6104	Mixed Riparian (Forest and Non-forest)	0	0
6201	Graminoid or Forb Dominated Riparian	0	0
6202	Shrub Dominated Riparian	0	0
6203	Mixed Non-forest Riparian	0	0
6301	Deep Marsh	0	0
6302	Shallow Marsh	0	0
6303	Aquatic Bed	0	0
6304	Mud Flat	0	0
7000	Barren Land	0	0
7201	Sand Dune	0	0
7202	Vegetated Sand Dune	0	0
7300	Exposed Rock	0	0
7301	Lava	0	0
7302	Vegetated Lava	0	0
7800	Mixed Barren Land	0	0
7900	Shoreline and Stream Gravel Bars	0	0
8000	Alpine Meadow	0	0
8100	Alpine Meadow	0	0
9000	Snow, Ice, Cloud or Cloud Shadow	0	0
9100	Perennial Ice or Snow	0	0
9800	Cloud	0	0
9900	Cloud Shadow	0	0

Digital Elevation Models

Digital Elevation Models for the study area were downloaded from the 1-arc second (approximately 30 meters) National Elevation Dataset via the United States Geological Survey (USGS) Seamless Data Distribution System (http://seamless.usgs.gov) in 2005. These data were obtained in geographic coordinates of the North American datum of 1983, and were reprojected in-house to UTM zone 12 coordinates for modeling purposes.

Hydrological Features

Hydrological datasets were obtained from the Montana Natural Resource Information System online GIS database (http://nris.state.mt.us/gis). Streams and lakes data for Greater Yellowstone Area, Montana, Wyoming and Idaho were downloaded in polygon shapefile formats that were developed from 1:24,000 scale USGS quadrangles. These data were obtained in Montana State Plane coordinates of the North American datum of 1983, and were and were reprojected in-house to UTM zone 12 coordinates for modeling purposes.

Landsat TM imagery

Landsat TM imagery from 2002 were acquired for the Madison Valley for use in species models and riparian habitat mapping. These data were compiled through NASA's Commercial Remote Sensing Program. The acquisition dates of these images were relative to a 1990 acquisition baseline, and the images were either cloud-free or contained minimal cloud cover. In addition, only TM images with a high quality ranking in regards to the possible presence of errors such as missing scans or saturated bands were selected. It was important to collect data during periods of peak greenness so NASA adopted an approach for image selection that was based upon a data set containing global 1-kilometer advanced very high-resolution radiometer Normalized Difference Vegetation Index data. Images are projected to the Universal Transverse Mercator map projection, using the World Geodetic System 1984 datum. For more information visit: http://edcsns17.cr.usgs.gov/nsdp/tm_readme.html.

Appendix A3. Human Activity Model Methods

Housing (Structures) Density

The impact of housing density on wildlife habitat was modeled from Gallatin and Madison County structures data (2005) that were obtained from Gallatin County GIS Department and the Madison County Planning Office. Point density of structures was calculated using a 1 km^2 rectangular search neighborhood. The resulting grid was reclassified into habitat degradation values (Table A3-1).

Table A3-1

Structures/Km^2 (Acres/Structure)	Habitat Score
0 – 1.54 (0 – 160)	0
1.54 – 4.12 (160 – 60)	-1
4.12 – 24.7 (60 – 10)	-2
>24.7 (< 10)	-3

All non-zero cells were grown by 4 cells (120m) to conservatively account for potential halo effects around residential structures.

(Weighted) Road Density

The impact of road density on wildlife habitat was modeled from TIGER and USFS county wide roads layer data (2005). Roads were assigned weights by road type (Table A3-2 of weights for Madison County) and for all applications other than antelope, kernel density was calculated using a search radius of either 250m or 500m, dependent on the species of interest. Density values were truncated at 50km^2 and normalized. The weighted roads layer was then converted to a raster layer, values of “20” were reclassified to “10”, all values were multiplied by 0.1 to produce a range of values between 0 and 1, and this raster layer was then added to the density layer to increase impacts within cells actually containing roads. The resulting grid ranges in values between 0 and 2.

Roads were used as a surrogate for fences in the antelope model, based on the idea there are usually fences along roads. The weighted roads layer was converted to a raster as describe above and combined with the Madison County structures data to produce a grid of high impacts where the density of both roads and structures was high (focal sum of combined roads and structures raster was truncated at 50 and normalized), but only in cells containing roads where they were not near structures. The resulting grid was reclassified into habitat degradation values.

Table A3-2. Sequential queries used to select road types and assigned weights for the Madison County GIS roads layer.

GIS Query	Weight
ROADCLASS = 'HWY'	8
ROADCLASS = 'HWY' AND ("ROADNAME" = 'US HWY 287' OR "ROADNAME" = 'US HWY 287 LINK')	10
ROADNAME = 'I-15'	10
ROADCLASS = 'DRIVEWAY'	3
ROADCLASS = 'ALLEY'	5
ROADTYPE = 'TRL' AND "SURFACE" = 'TRAIL'	3
ROADTYPE = 'TRL' AND "SURFACE" = 'DIRT'	2
Weight =0 AND "SURFACE" = 'ASPHALT'	6
Weight =0	4

Roadway Salting

Areas in the valley where major highways are known to be salted regularly in the winter months were buffered using a Euclidean distance radius measurement of 500 meters.

Motor Recreation (Snowmobiling)

Potential motorized recreation use was determined based on current road and trail densities in areas open to motorized recreation that were designated as such in the USFS travel plan. Roads and trails on public lands were mapped using layers acquired from both USFS (Beaverhead-Deerlodge, Centennial-Targhee, and Gallatin National Forests) and the Montana Natural Resource Information System online GIS database (http://nris.state.mt.us/gis). Roads and trails were summarized by length and intersected as binary grids. Neighborhood focal sums were calculated based on the occurrence of roads or trails and output in 30m cell data with circular neighborhoods of 1km (500m) and 2km (1000m). The 30m cell data from 2km neighborhood statistics were averaged by mean and output in 1km cells for display purposes. Trails and roads within wilderness areas were omitted from the analysis.

Grazing

The relative levels of use by grazing animals were determined based on animal unit months (AUM's) that were contained within grazing allotment data from the Montana Bureau of Land Management and the USFS (Beaverhead-Deerlodge, Centennial-Targhee, and Gallatin National Forests). These data were obtained in shapefile format and were reprojected to UTM zone 12 coordinates of the North American Datum of 1983. The datasets were merged based on AUM's and were then expert reviewed by local biologists for verification. Upon review, several grazing animal type changes were made to bring the dataset up to date for the study area extent.

Mining

The impact of mining on wildlife habitat was modeled from the Montana Bureau of Mines and Geology and the Idaho Department of Lands mines datasets (2004). Mining threats were assumed to be limited to direct habitat destruction through mining operations and disturbance associated with active mines. Mine locations were scored according to these parameters: active surface mining = 3, inactive surface or unknown type = 2, and deep shaft mining = 1; wherein 1 is the lowest impact and 3 is the highest impact on the habitat. The data were then converted from the point data to raster at a 100m grid cell based on rank. Neighborhood focal sums were then calculated based on the occurrence of mines within a circular neighborhood of 0.5 km^2 based on expert (EA) knowledge of mine impacts on wildlife.

Water Quality

These datasets contain lakes and streams listed in Montana Department of Environmental Quality's 2002 305(b) Surface Water Quality Assessment Report of water quality determinations. Data classifications adopted from the dataset were: fully supporting all applicable beneficial uses, waters determined to be water quality impaired for one or more beneficial uses, and waters where the information collected to date is not sufficient to complete beneficial use support determinations. The "On-list" attribute was used to select features on the 303(d) List of Impaired and Threatened Waters. The 303(d) List, required by the federal Clean Water Act, focuses on waters in the state which have been assessed as having one or more of their beneficial uses impaired by human-caused pollution.

Dewatering

Habitat loss due to dewatering was estimated based on historical water use patterns in the study area through individual interviews with local experts and biologists from USFS and MT FWP. The data were drawn on 1:24,000 scale hardcopy topographic maps and were digitized in-house to create spatial datasets for use in analysis.

Fish Stocking (Non-native Introductions)

MTFWP fish stocking data for lakes was obtained from the MFISH database. Lakes that have been stocked with non-native fish or where native fish were introduced (lakes that originally had no fish but were stocked with natives) were extracted from the database layer and mapped.

Fire Severity

The USFS National Fire Plan Cohesive Strategy Team dataset was adopted as a proxy for fire severity in order to estimate the potential for habitat alteration due to wildfire. The characterization of likely fire severity was based upon historic fire regimes, potential natural vegetation, cover type, size class, and canopy cover with respect to slope and aspect. Each cover type was assigned a qualitative rating of fire tolerance based upon likely species composition and the relative resistance of each species to fire.

Appendix A4. General Maps' Data Sources

Base Map Data

Base map feature data contained in each atlas map includes the administrative boundaries for Montana state and Yellowstone National Park, and major roads, streams, and lakes. These data were obtained from the Montana Natural Resource Information System online GIS database (http://nris.state.mt.us/gis) in Montana State Plane coordinates of the North American datum of 1983. The Madison Valley Watershed boundary delineates the study area boundary for the conservation assessment and was developed from the fish Wildlife and Parks National Hydrography Dataset (fourth level) hydrological unit coverage in order to define the watershed catchment area of the Madison River above Ennis Lake. The hydrological unit coverage data were obtained in the Lambert Conformal Conic projection of the North American datum of 1983 and were converted to shapefile format for editing. All data were reprojected in-house to UTM zone 12 coordinates for mapping purposes.

Land Ownership

Land ownership is represented by subdivision location and development status (platted, approved for development, under construction, developed), land ownership classification (public or private), and conservation easement ownership of lands in the study area. Subdivision data were obtained from the Madison valley Ranchlands Group in shapefile format and were updated in 2005 from hardcopy maps obtained from Arrow Realty in Ennis. Conservation easements data were obtained from the Montana Natural Heritage Program (http://nhp.nris.state.mt.us/). Parcel data from the Montana Department of Administration Montana Cadastral Database and land ownership (stewardship) data and were obtained from the Montana Natural Resource Information System online GIS database (http://nris.state.mt.us/gis). These data were obtained in Montana State Plane coordinates of the North American datum of 1983, and were reprojected in-house to UTM zone 12 coordinates.

Land Use Classes

The land use classification dataset was developed in-house from local residential input regarding major landowner classification based on land acquisition interest. The intent of use for this dataset is to illustrate the variation in landowner type throughout the valley. These data were originally obtained as land ownership data in Montana State Plane coordinates of the North American datum of 1983, and were updated with land use classes and were reprojected in-house to UTM zone 12 coordinates.

Public Lands Administration

Public lands administration is represented by agency responsible for administering public lands and the spatial relationship to private land areas. Private land parcel data includes subdivisions, individual cadastral parcel boundaries, and conservation easements. Subdivision data were obtained from the Madison Valley Ranchlands Group in shapefile format and were updated in 2005 from hardcopy maps obtained from Arrow Realty in Ennis. Conservation easements data were obtained from the Montana Natural Heritage Program (http://nhp.nris.state.mt.us/). Parcel data from the Montana Department of Administration Montana Cadastral Database, federally designated wilderness area data, and land ownership and managed areas (public lands administration) data were obtained from the Montana Natural Resource Information System online GIS database (http://nris.state.mt.us/gis). These data were obtained in Montana State Plane coordinates of the North American datum of 1983, and were reprojected in-house to UTM zone 12 coordinates.

Infrastructure and Landmarks

Infrastructure datasets used include individual parcel boundaries, land ownership classification, conservation easement locations, cities, landmark type and location, and roads. Parcel data from the Montana Department of Administration Montana Cadastral Database, land ownership and managed areas (stewardship), Montana cities, landmarks and roads were obtained from the Montana Natural Resource Information System online GIS database (http://nris.state.mt.us/gis). These data were obtained in Montana State Plane coordinates of the North American datum of 1983, and were reprojected in-house to UTM zone 12 coordinates. Conservation easements data were obtained from the Montana Natural Heritage Program (http://nhp.nris.state.mt.us/).

Geology

Geological features data were obtained from the Montana Natural Resource Information System online GIS database (http://nris.state.mt.us/gis). Attributes were summarized based on surficial rock type classifications for mapping purposes. These data were obtained in Montana State Plane coordinates of the North American datum of 1983, and were reprojected in-house to UTM zone 12 coordinates for mapping purposes.

Soils

State Soil Geographic (STATSGO) data base for Montana is a digital general soil association map developed by the National Cooperative Soil Survey. STATSGO depicts information about soil that are compiled by generalizing more detailed soil survey maps. The map data are collected in 1by 2 degree topographic quadrangle units and merged and distributed as statewide coverages. The data were accessed via the Montana Natural Resource Information System online GIS database (http://nris.state.mt.us/gis), and were obtained from the Natural Resource Conservation Service in Albers Conical Equal Area projection coordinates of the North American datum of 1927, and were reprojected in-house to UTM zone 12 coordinates.

Ground Water Wells

Point locations and well depth for water wells within Montana and were developed from databases maintained at the Ground-Water Information Center (GWIC) at the Montana Bureau of Mines and Geology. The data were obtained from the Montana Natural Resource Information System online GIS database (http://nris.state.mt.us/gis) in Montana State Plane coordinates of the North American datum of 1983, and were reprojected in-house to UTM zone 12 coordinates for mapping purposes.

Precipitation

Average annual precipitation range for the climatological period of 1961-1990. The dataset was obtained from the Montana Natural Resource Information System online GIS database (http://nris.state.mt.us/gis) in Montana State Plane coordinates of the North American datum of 1983, and were reprojected in-house to UTM zone 12 coordinates.

Land Cover

Land cover has been mapped using Montana Gap dataset develop by the Wildlife Spatial Analysis Lab at the University of Montana, Missoula (www.wru.umt.edu). The raster dataset has 90 meter resolution and was obtained in Albers Conical Equal Area projection of the North American Datum of 1927, and were reprojected in-house to UTM zone 12 coordinates.

Riparian Habitats

Riparian wetland habitats were delineated using normalized vegetation difference indexing (NDVI) methods based upon USGS Shuttle Radar Topography Mission 30 meter digital elevation models (available at http://glovis.usgs.gov) for the Madison Valley. The classification was done using slope percentage values less than 1.5 percent that occurred within 15 meters of open water. These areas were used to represent where the potential spatial distribution of willow and cottonwood habitats would occur naturally. Within these areas further spectral analysis included reclassifying the selected areas within 2002 satellite imagery datasets (Landsat ETM+ imagery August) and visually inspecting the reclassified imagery against corresponding point locations of field collected riparian habitat datasets.

Topography

The topographical features of the landscape are represented from USGS topographical maps. These maps were developed as 30 x 60 minute quadrangle maps at a scale of 1:100,000, and are generally derived from 1:24,000-scale maps.

Physiognomy

Landscape physiognomy was mapped using base map information and USGS national Elevation Dataset digital elevation models and the associated hillshade that was developed from those raster datasets.

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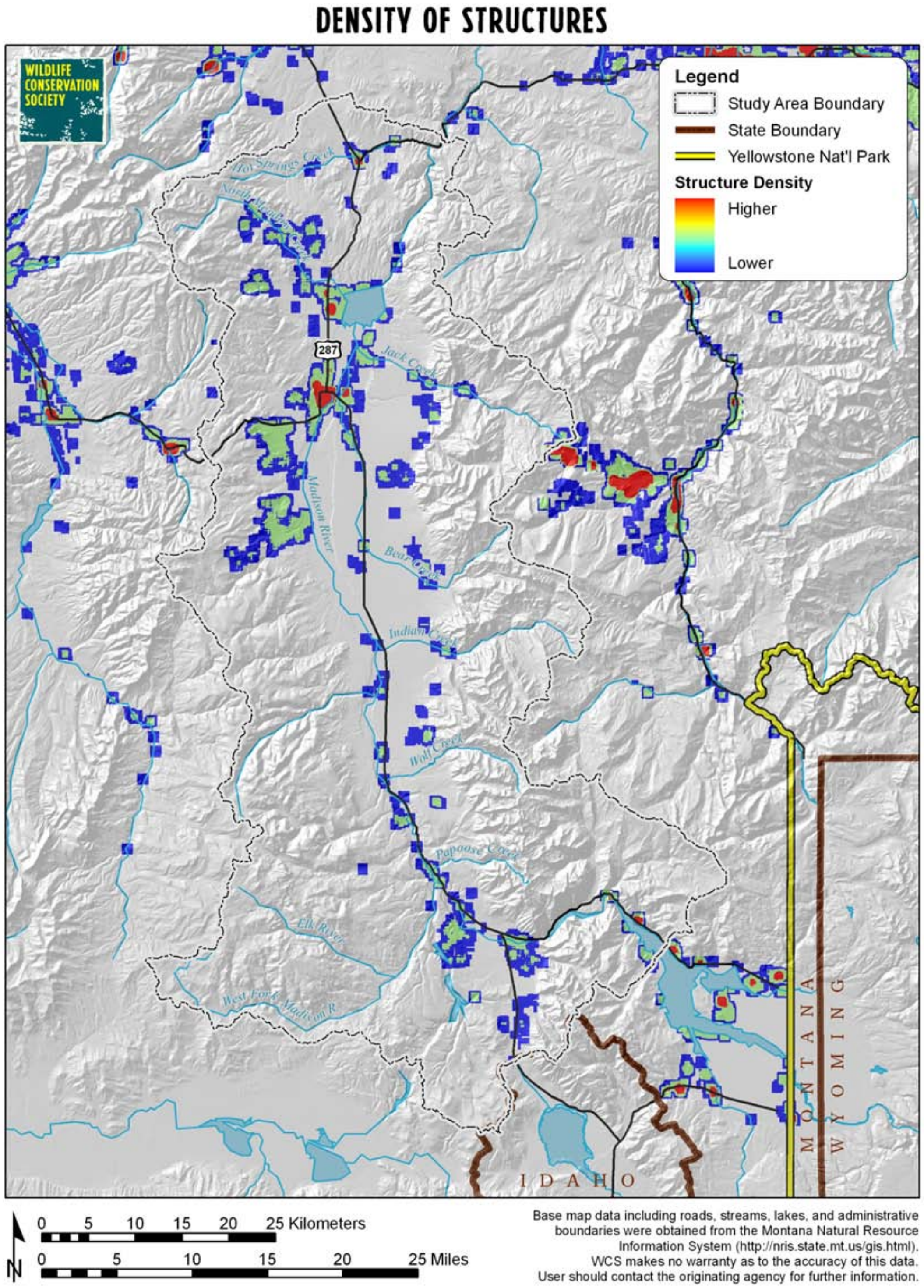
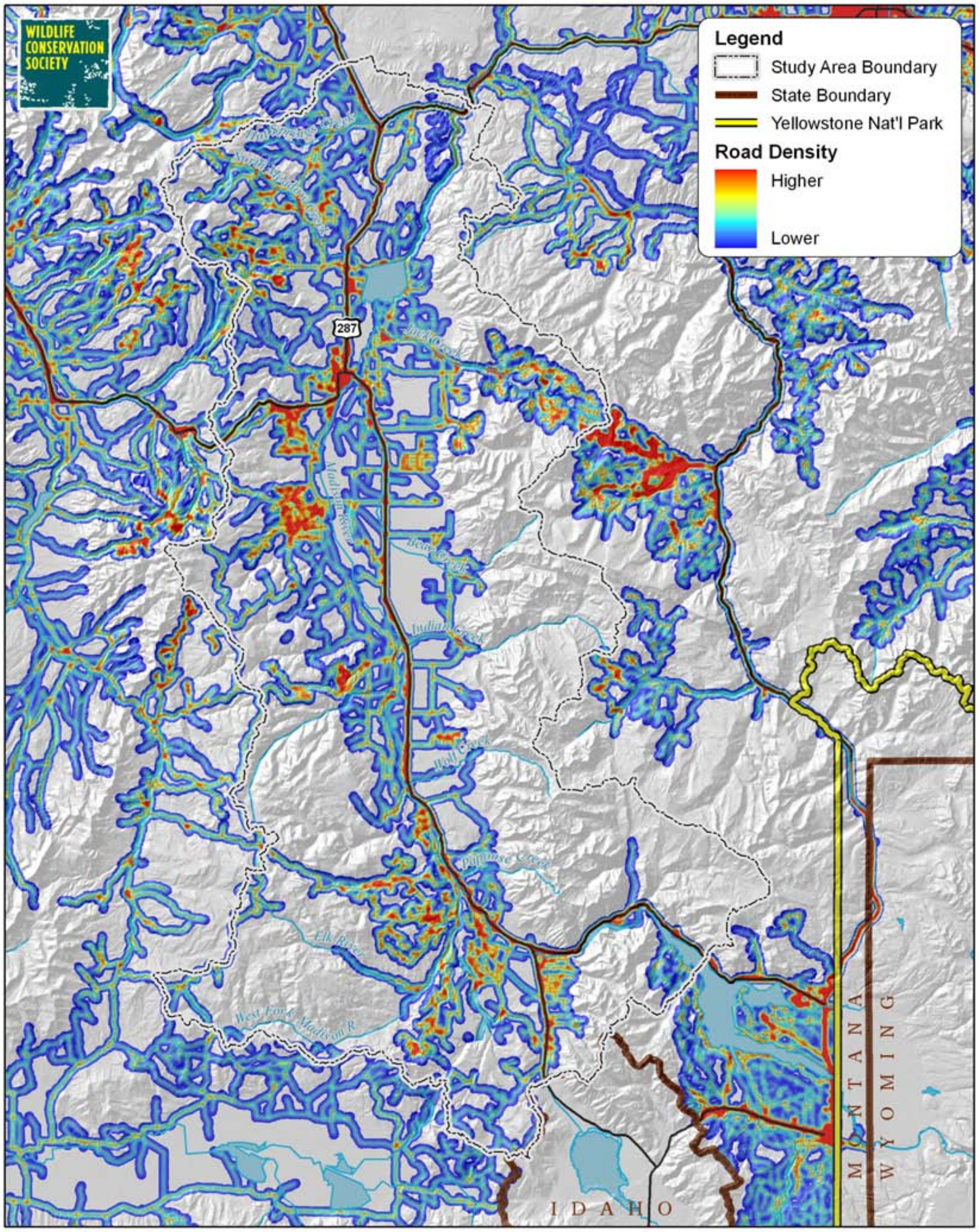
Appendix B. Madison Valley Maps

Human Activity Maps



ROAD DENSITY



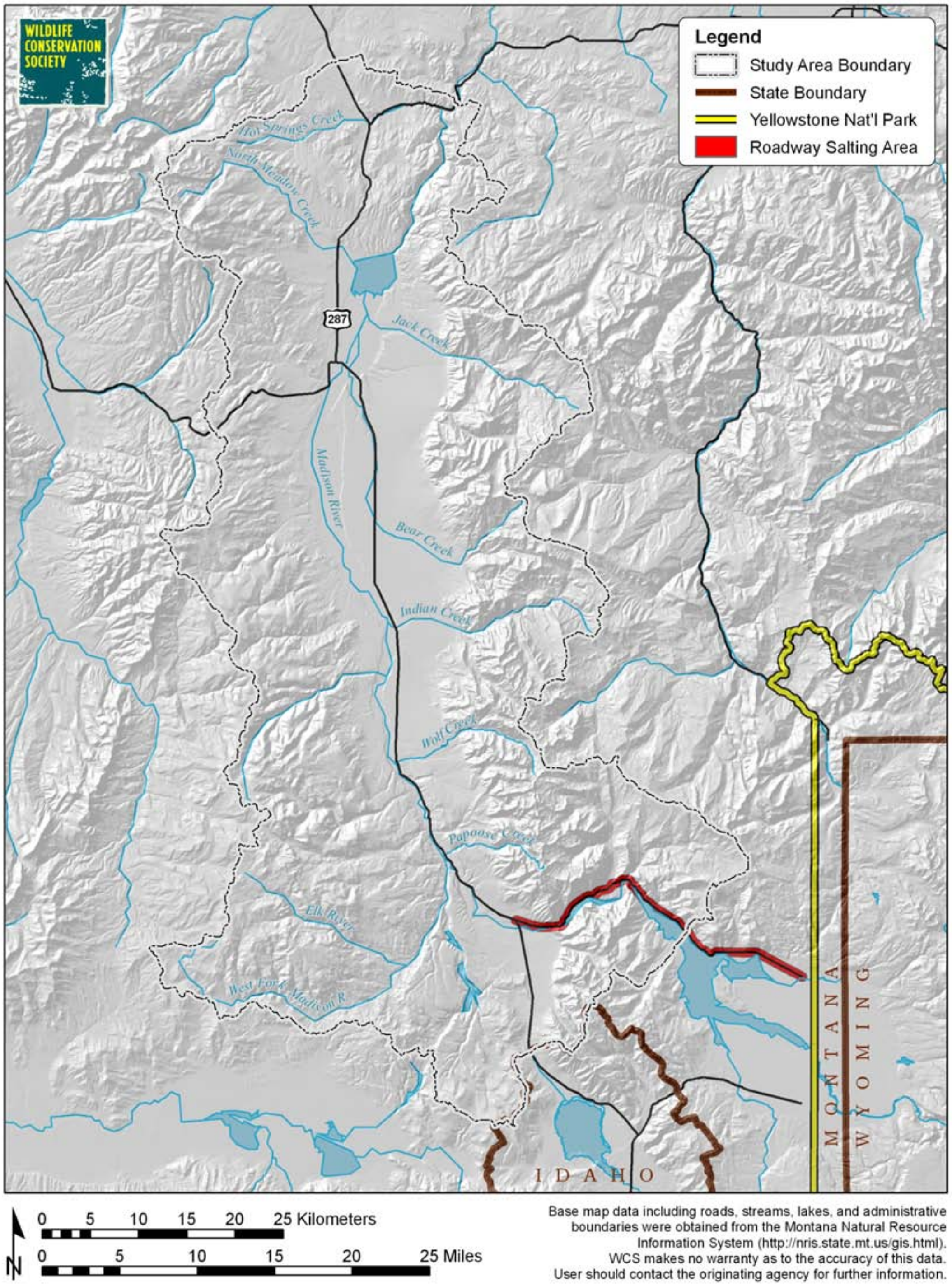
0 5 10 15 20 25 Kilometers

0 5 10 15 20 25 Miles

N

Base map data including roads, streams, lakes, and administrative boundaries were obtained from the Montana Natural Resource Information System (http://nris.state.mt.us/gis.html). WCS makes no warranty as to the accuracy of this data. User should contact the originating agency for further information.

ROADWAY SALTING



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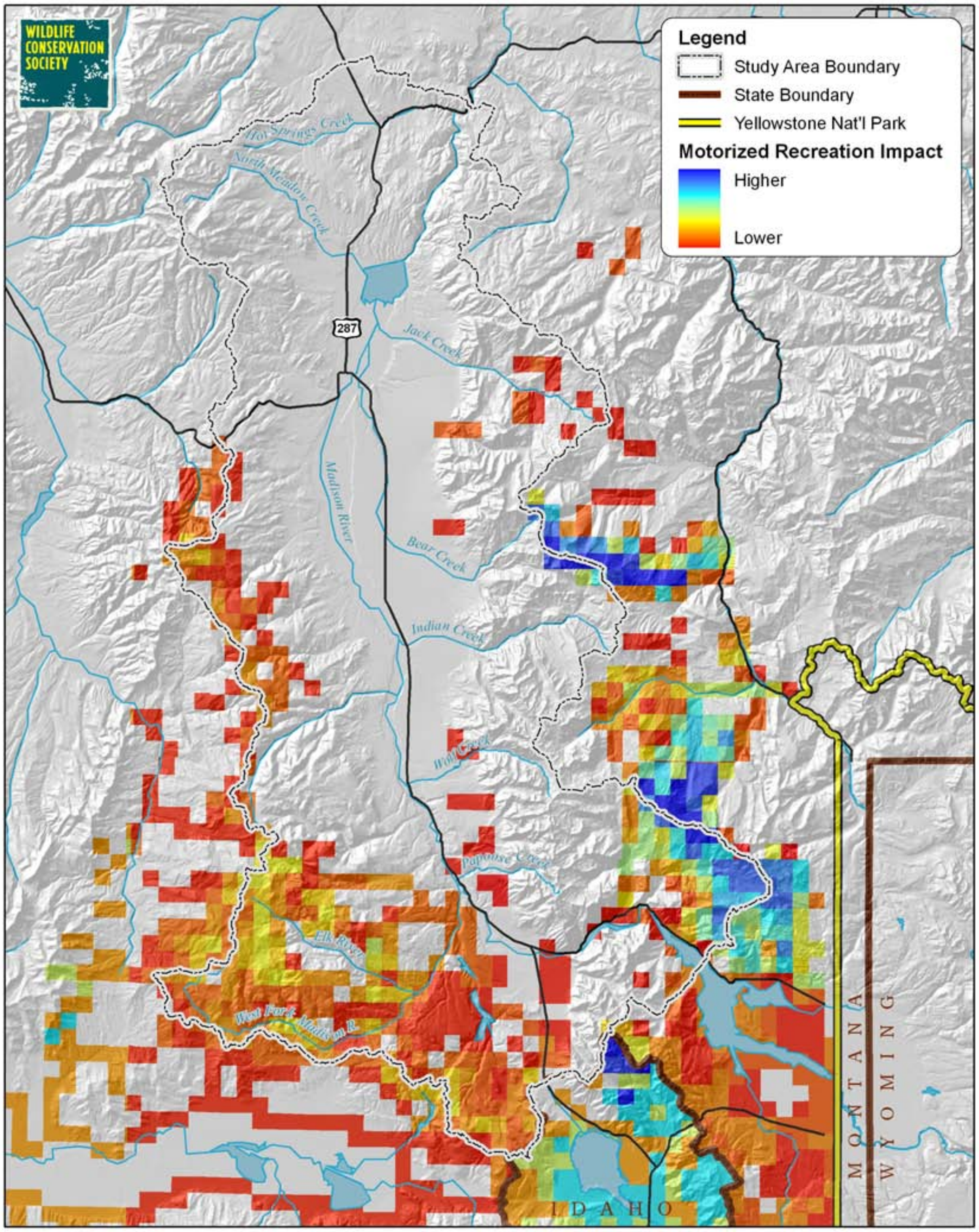
MOTORIZED RECREATION IMPACTS



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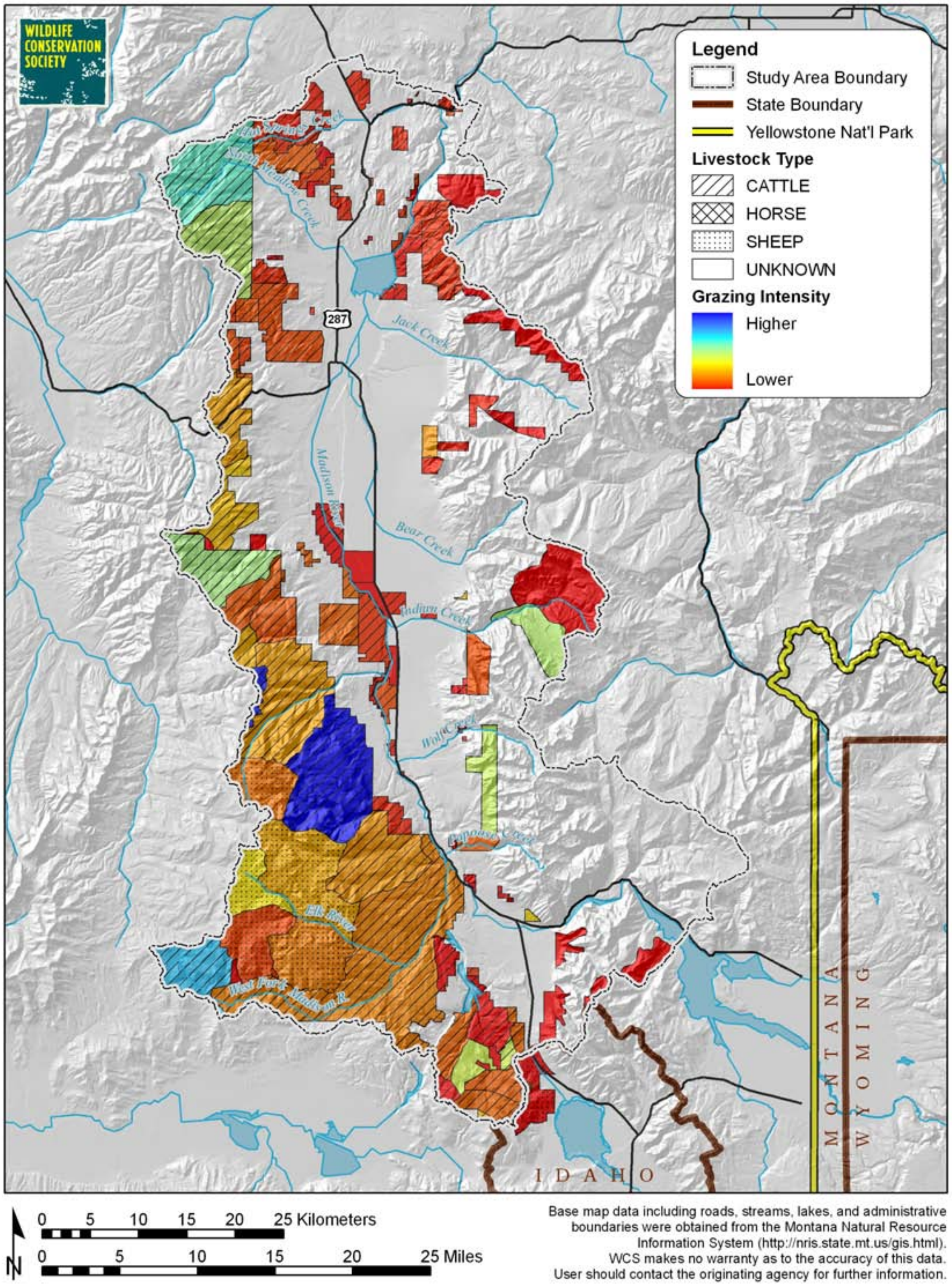
GRAZING TYPE AND INTENSITY



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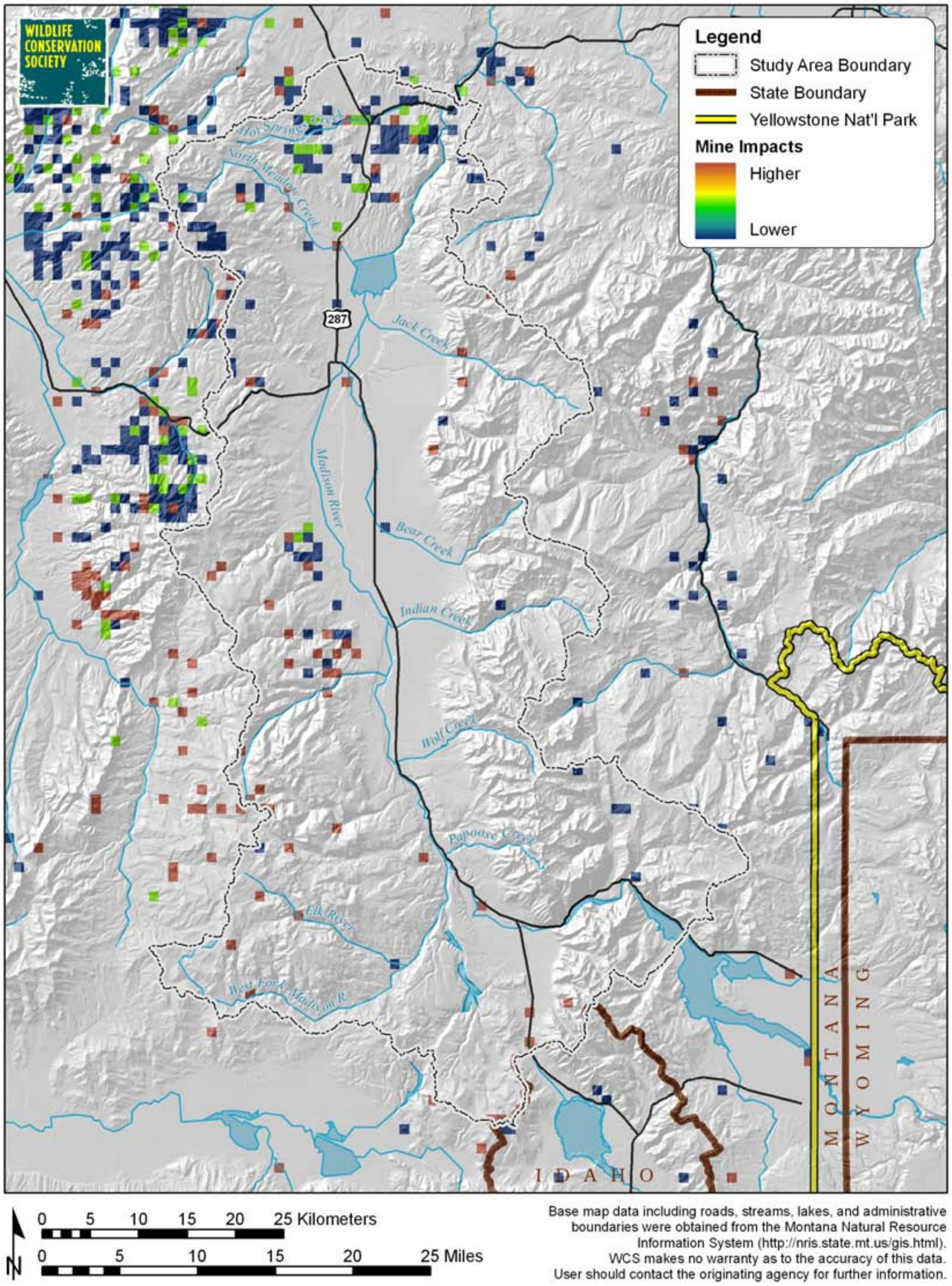
MINING ACTIVITY



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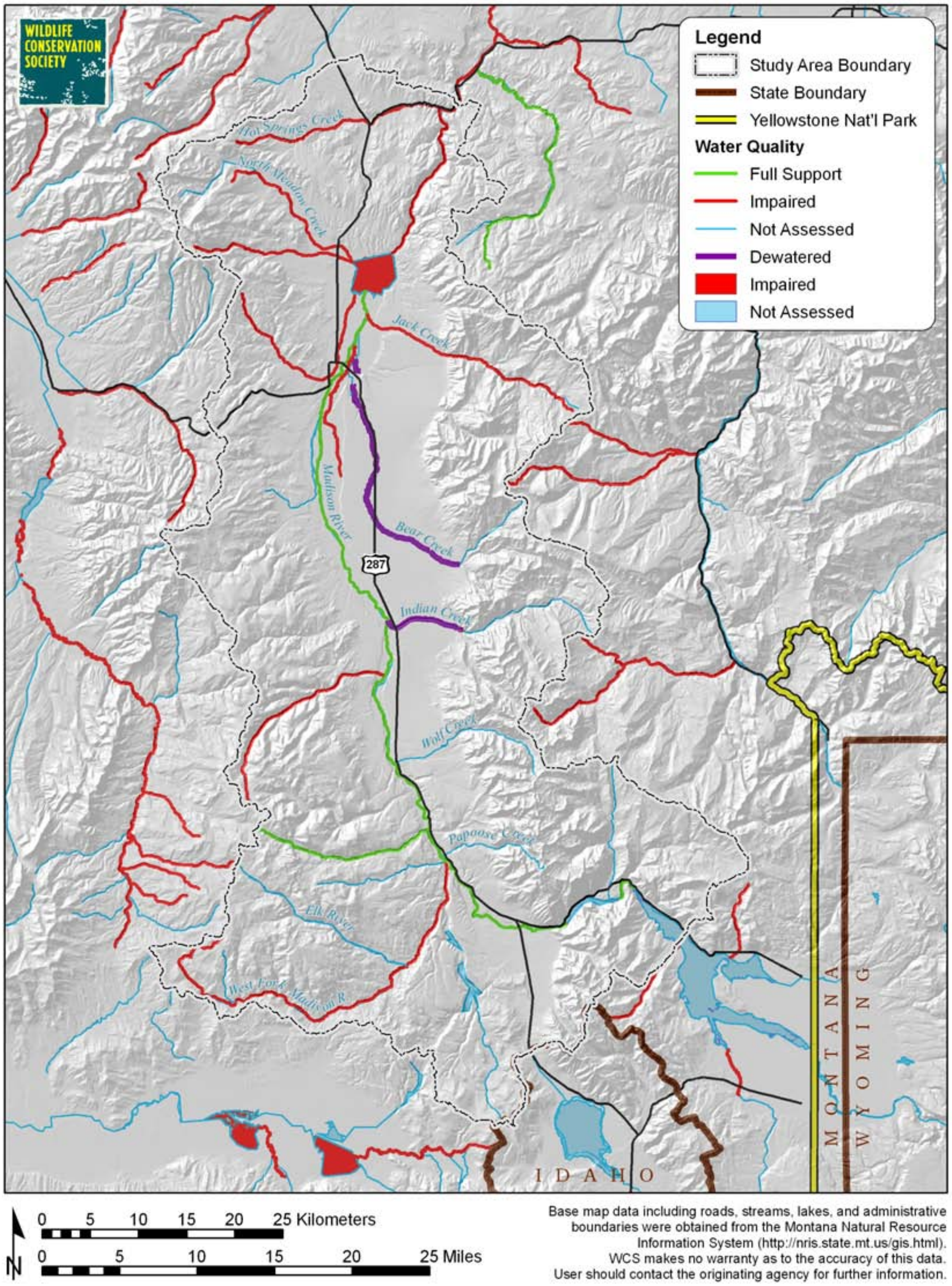
WATER QUALITY AND DEWATERED STREAMS



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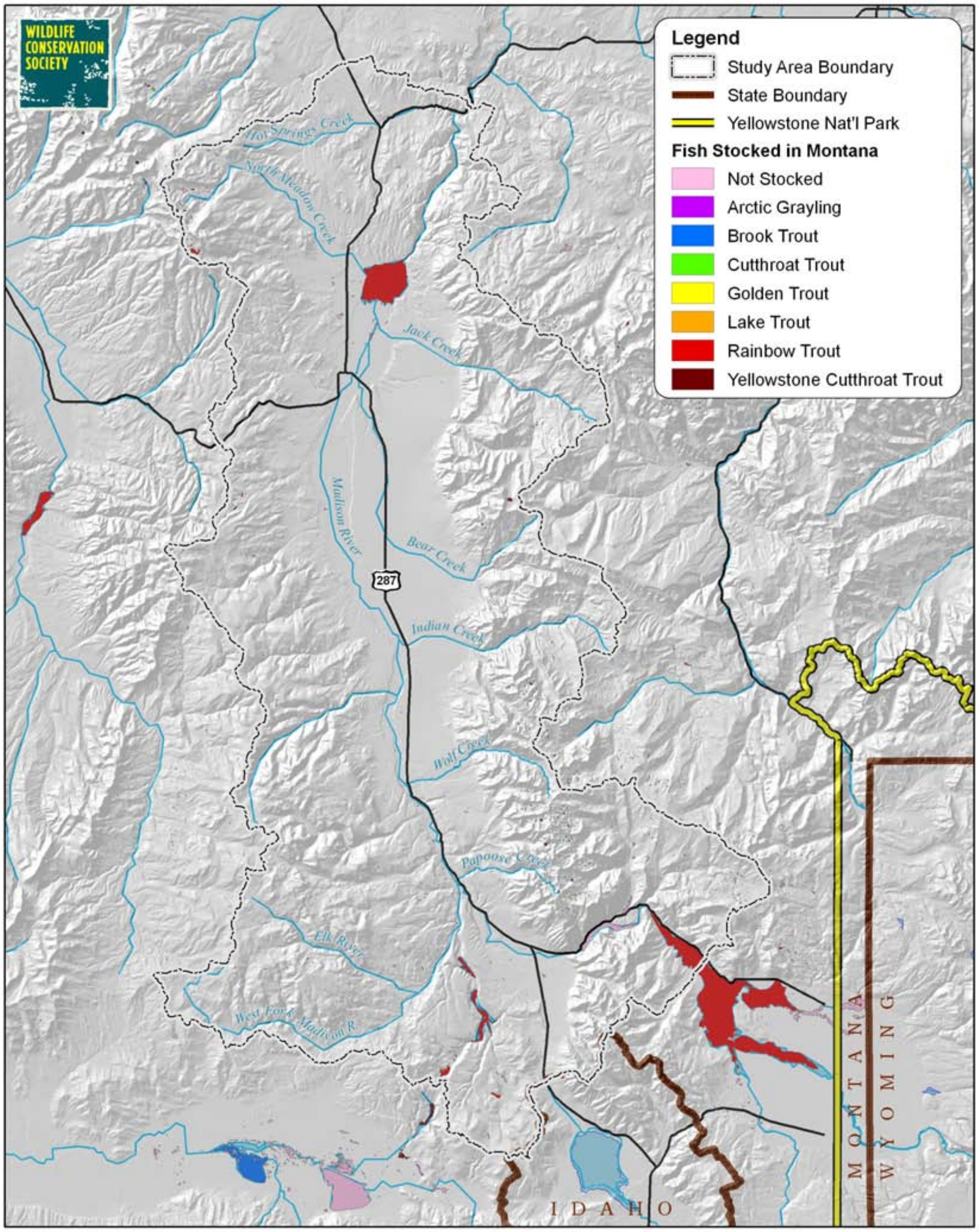
FISH STOCKING IN (MONTANA) LAKES



N
0 5 10 15 20 25 Kilometers
0 5 10 15 20 25 Miles

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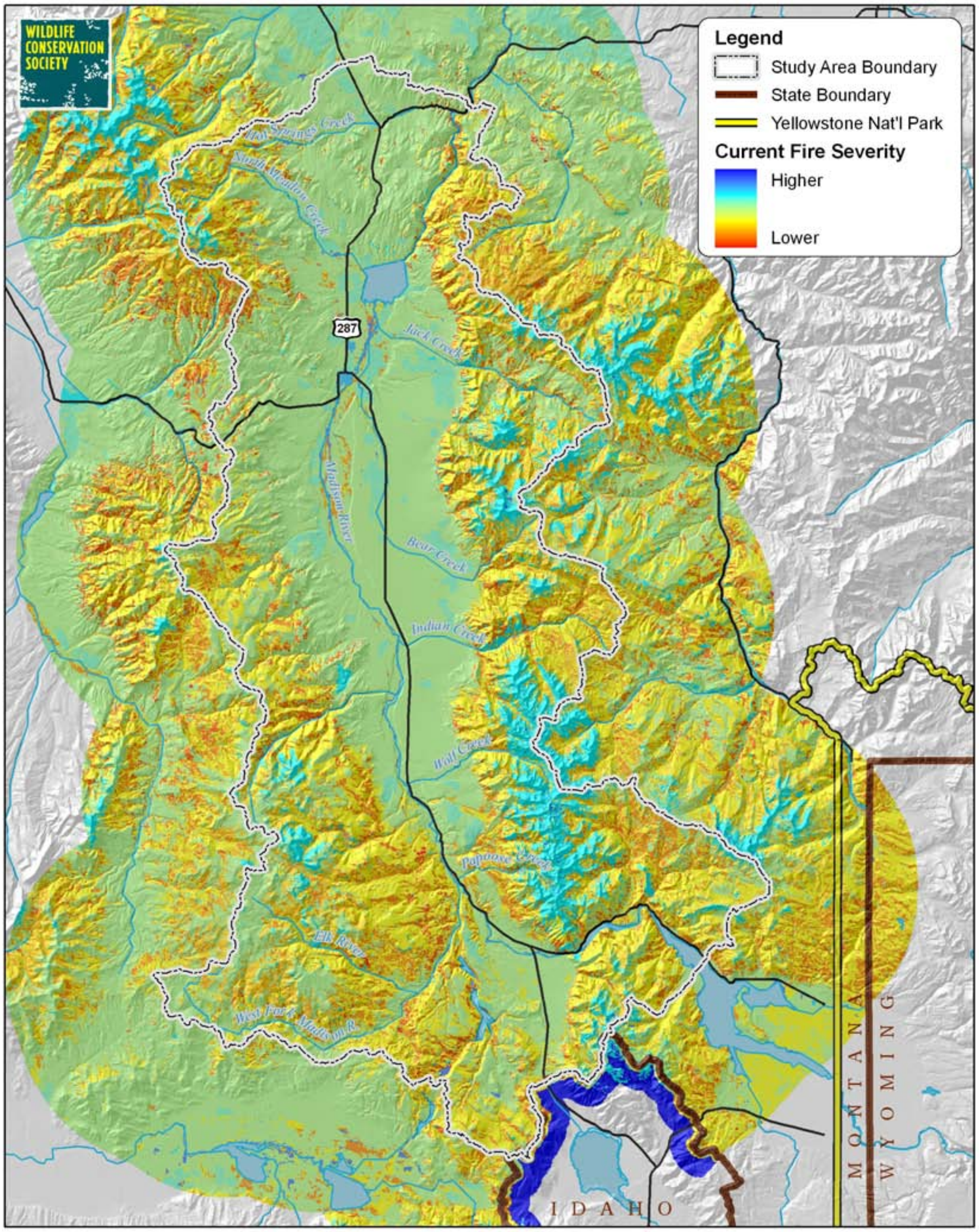
CURRENT FIRE SEVERITY (POTENTIAL HABITAT ALTERATION)



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0 5 10 15 20 25 Miles

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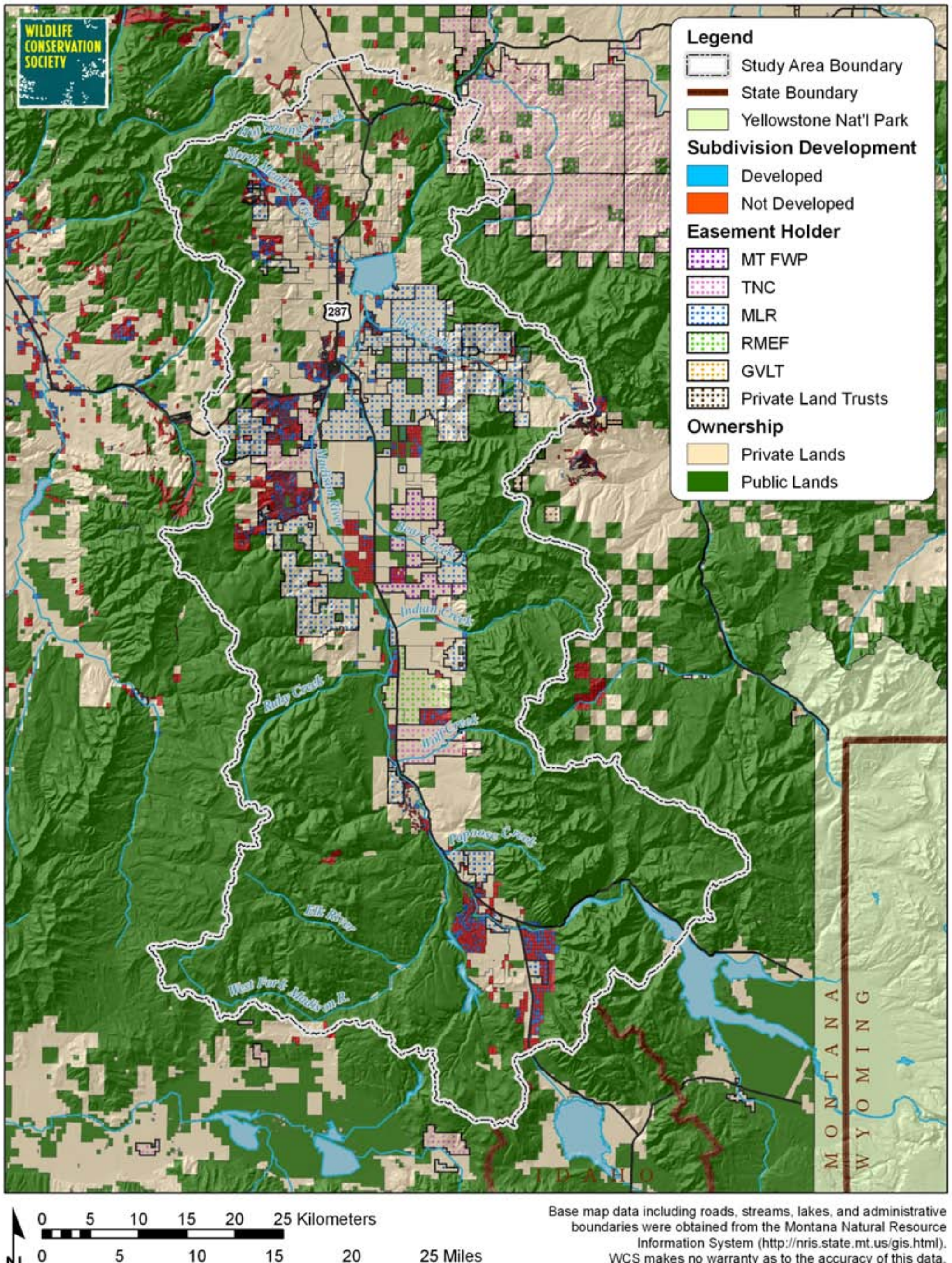
LAND OWNERSHIP



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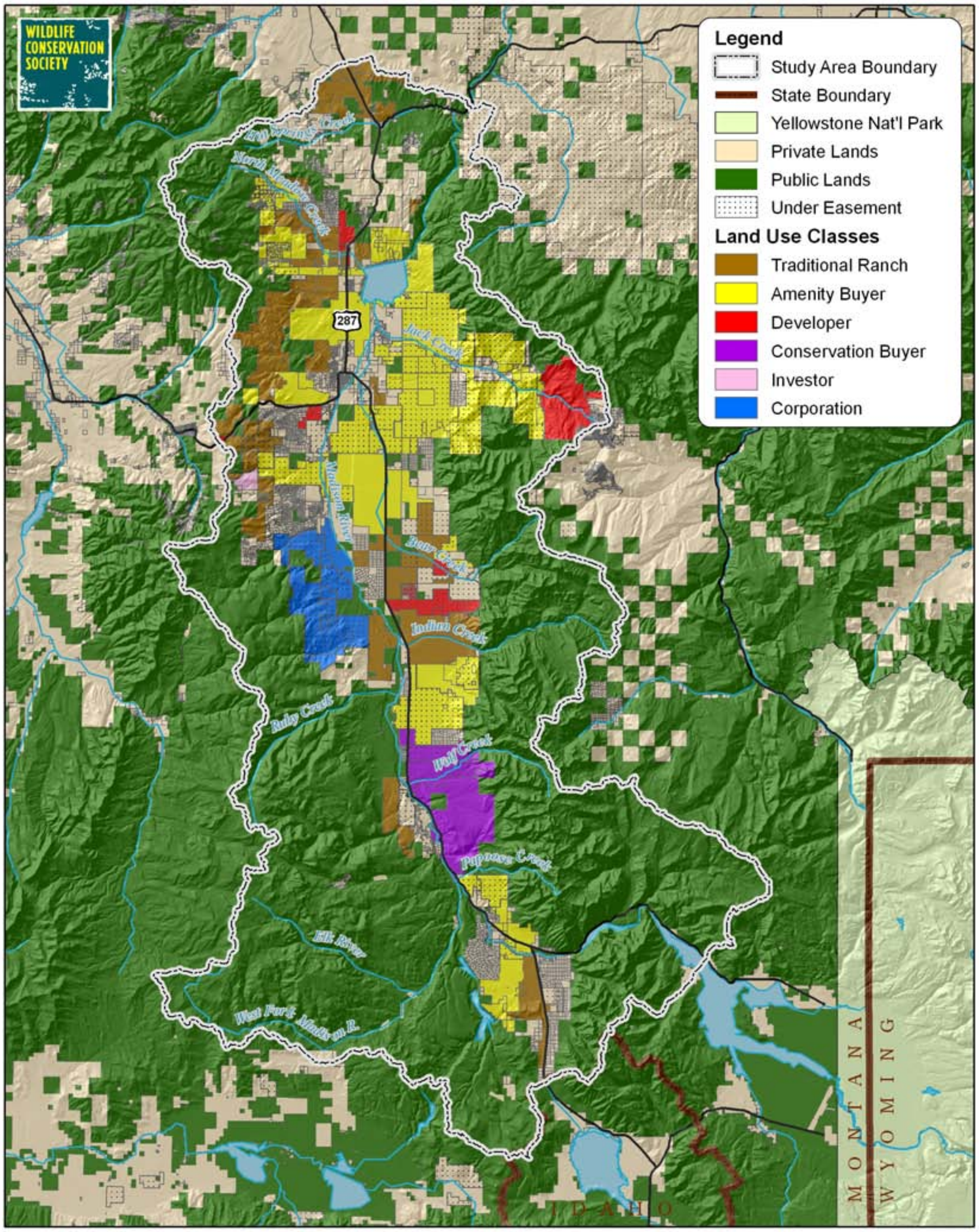
LAND USE CLASSES



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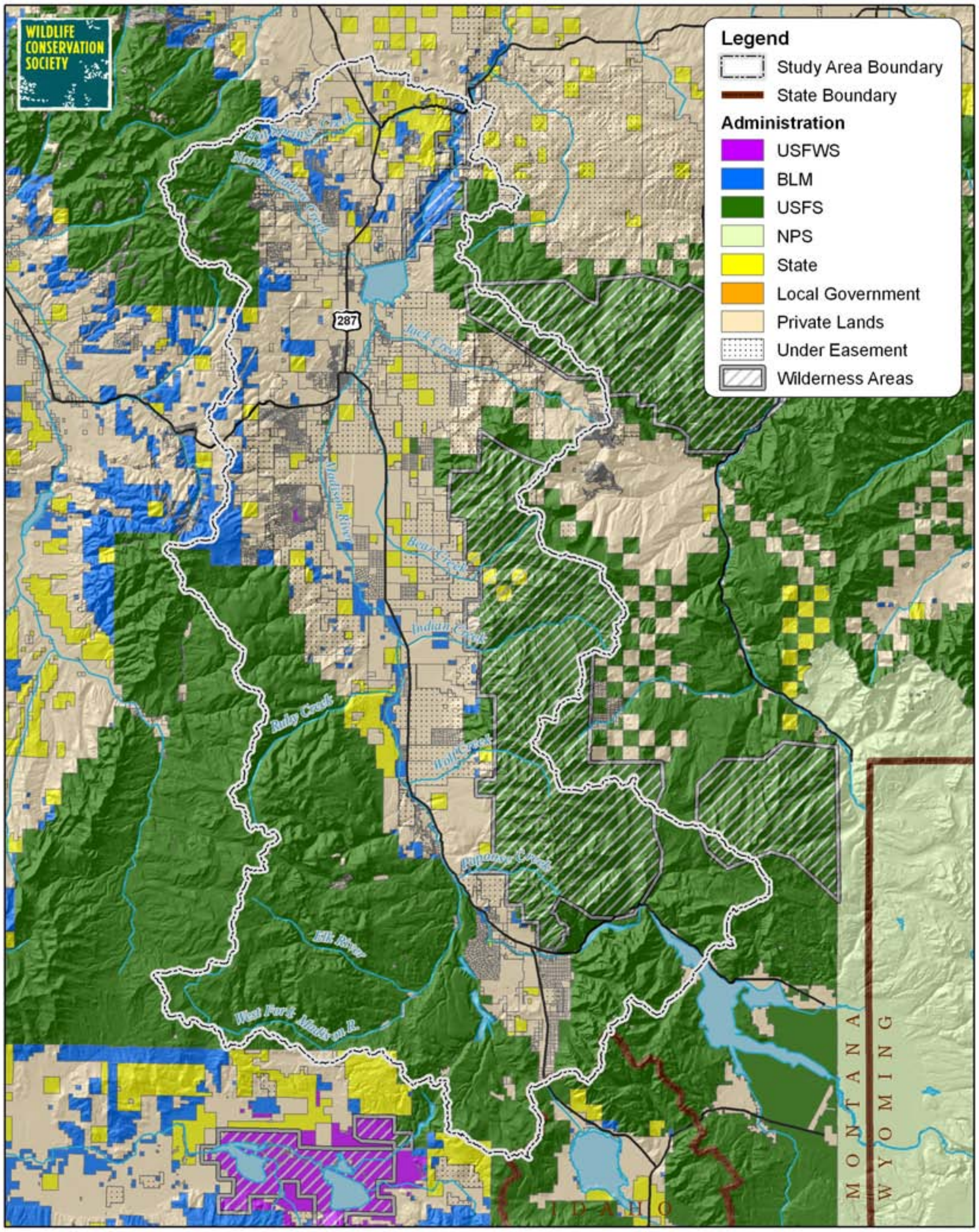
PUBLIC LANDS ADMINISTRATION



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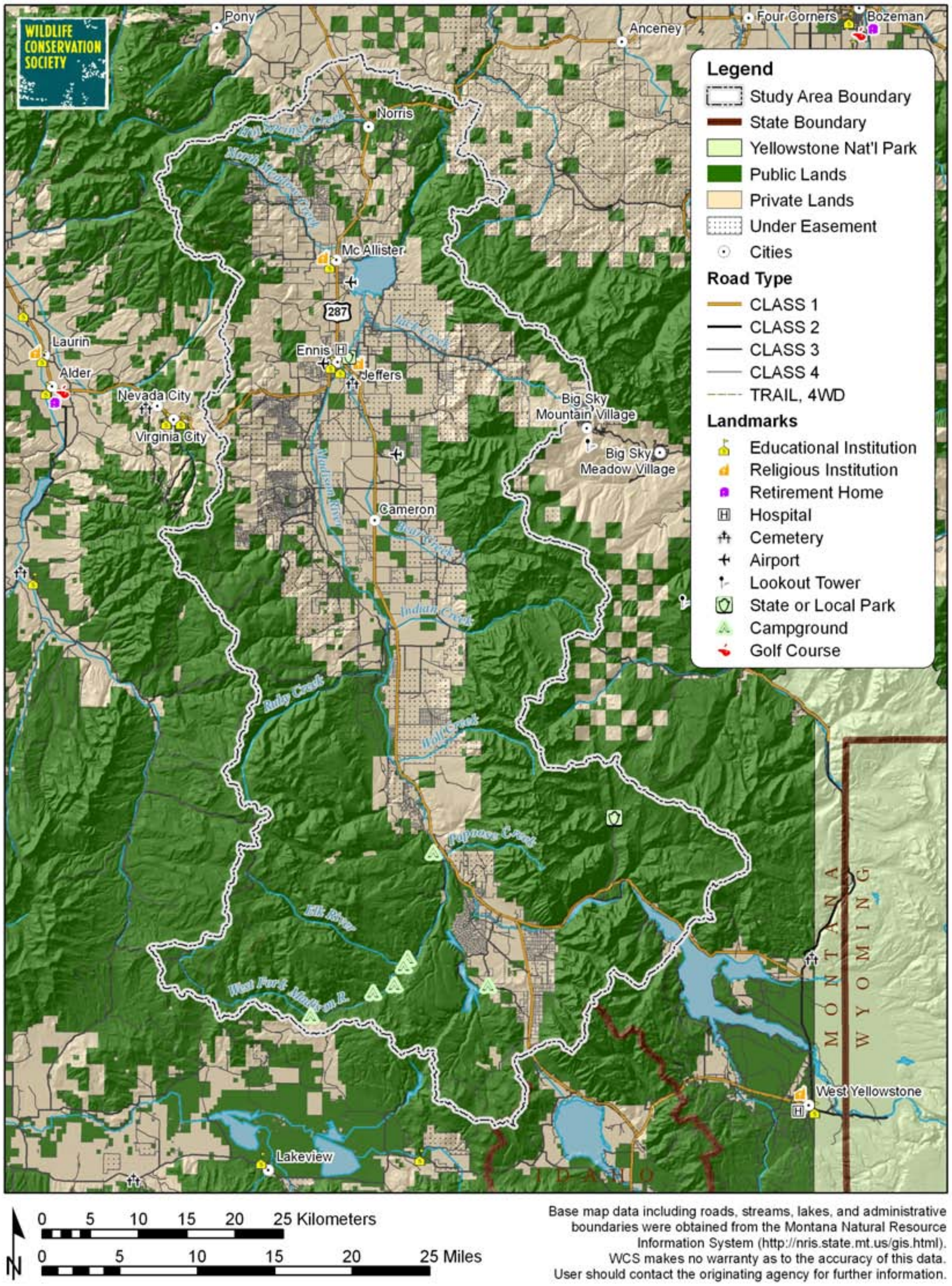
INFRASTRUCTURE AND LANDMARKS



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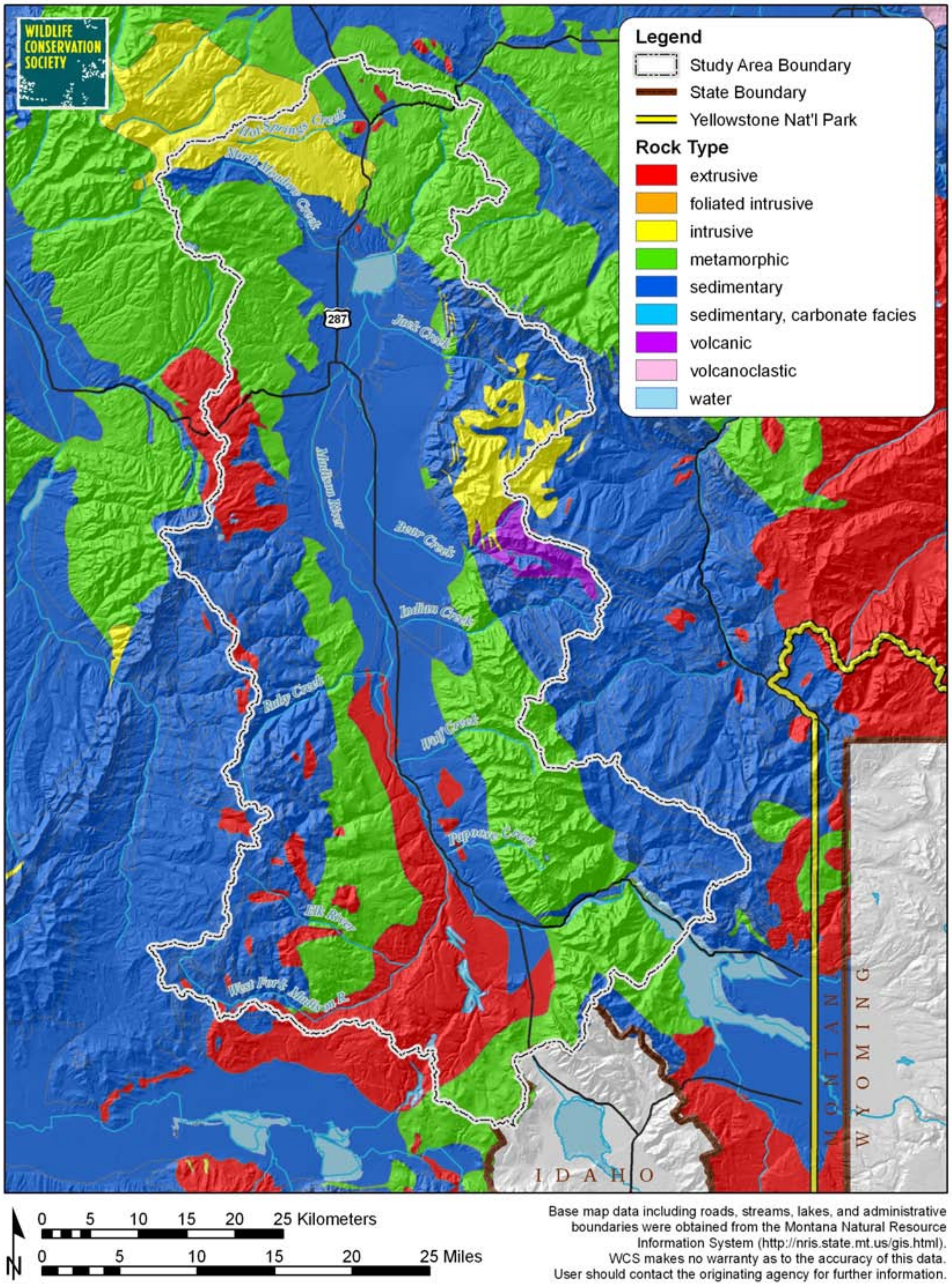
GEOLOGY



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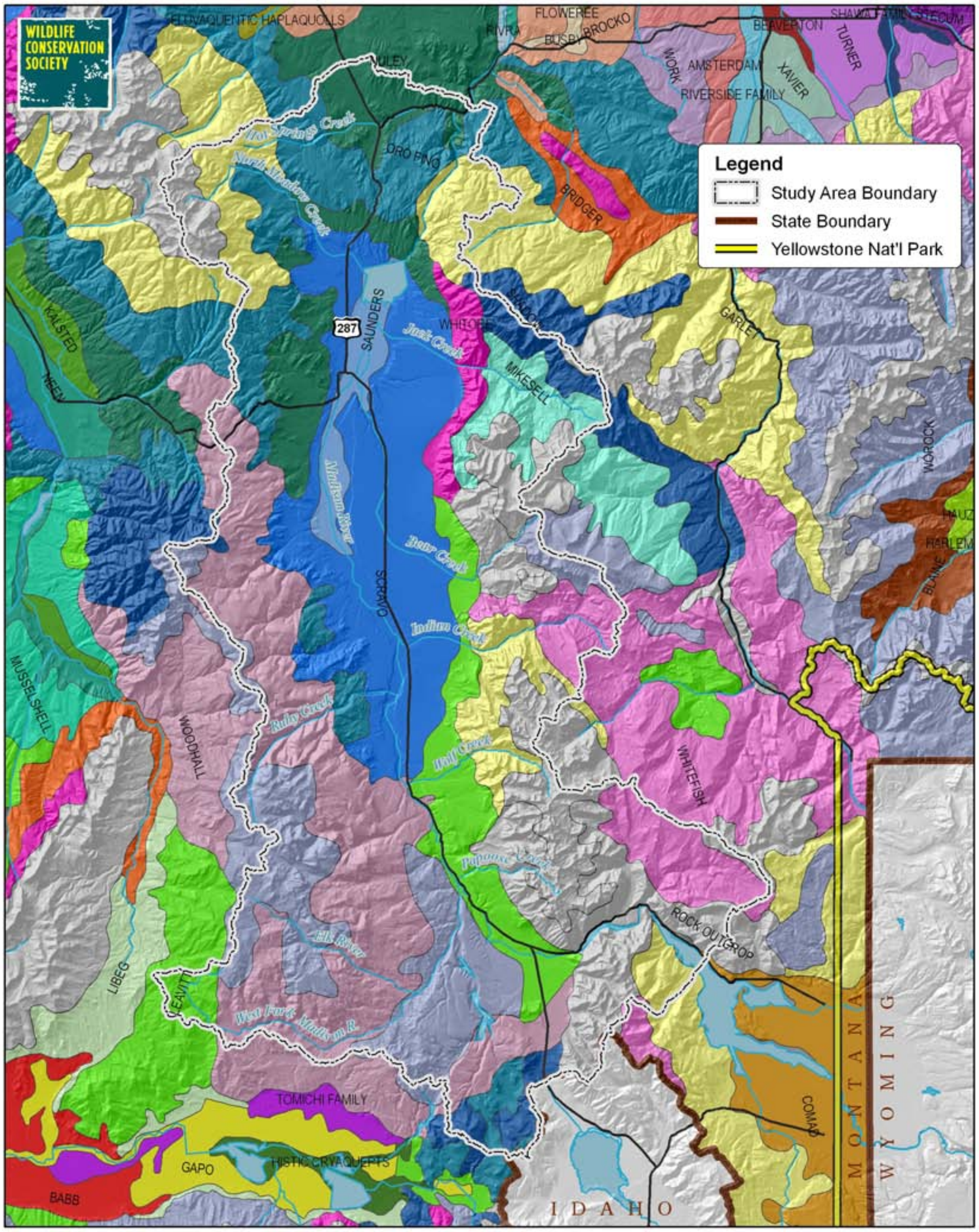
SOIL FORMATIONS



0 6 12 18 24 30 Kilometers

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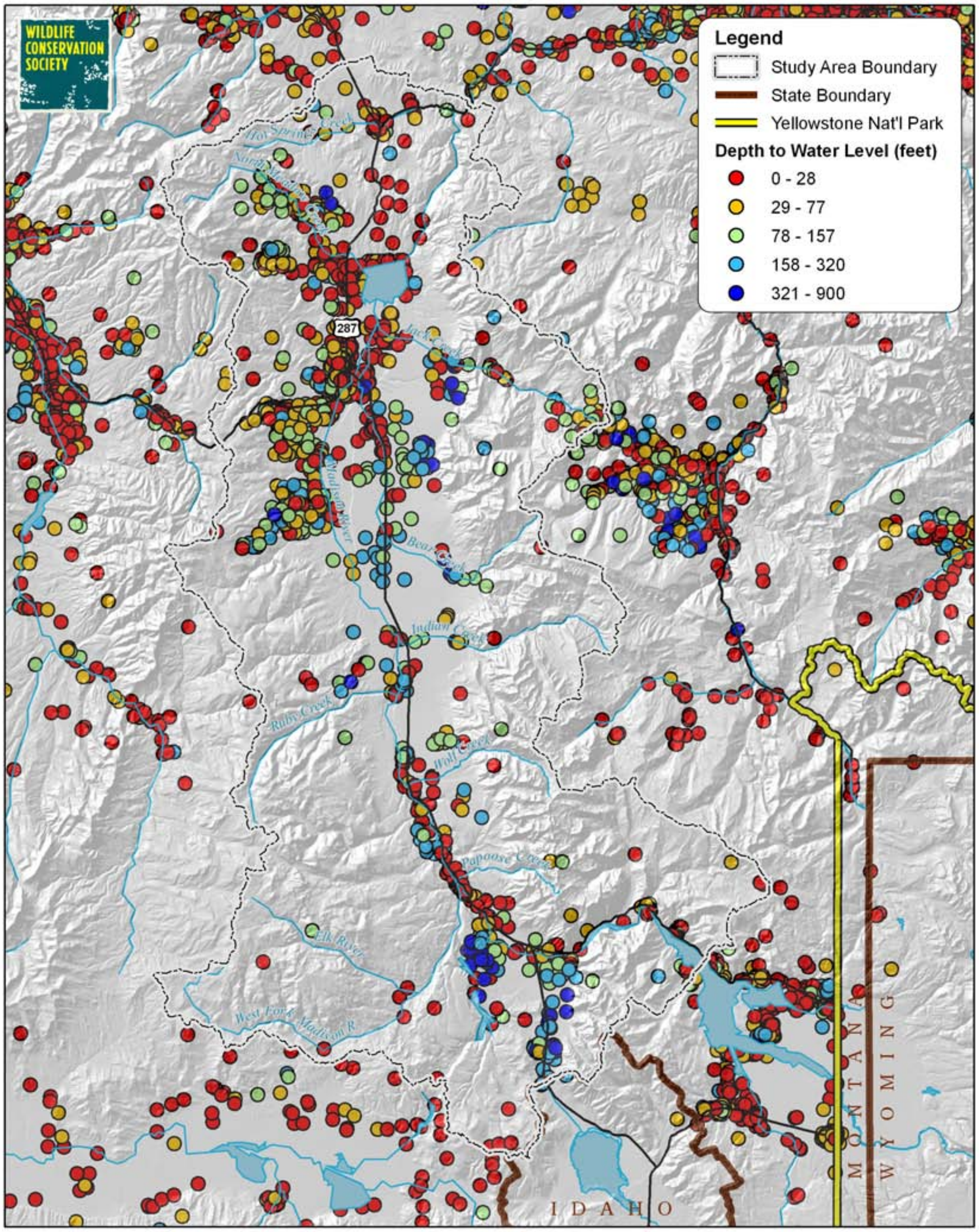
GROUNDWATER WELL LOCATIONS



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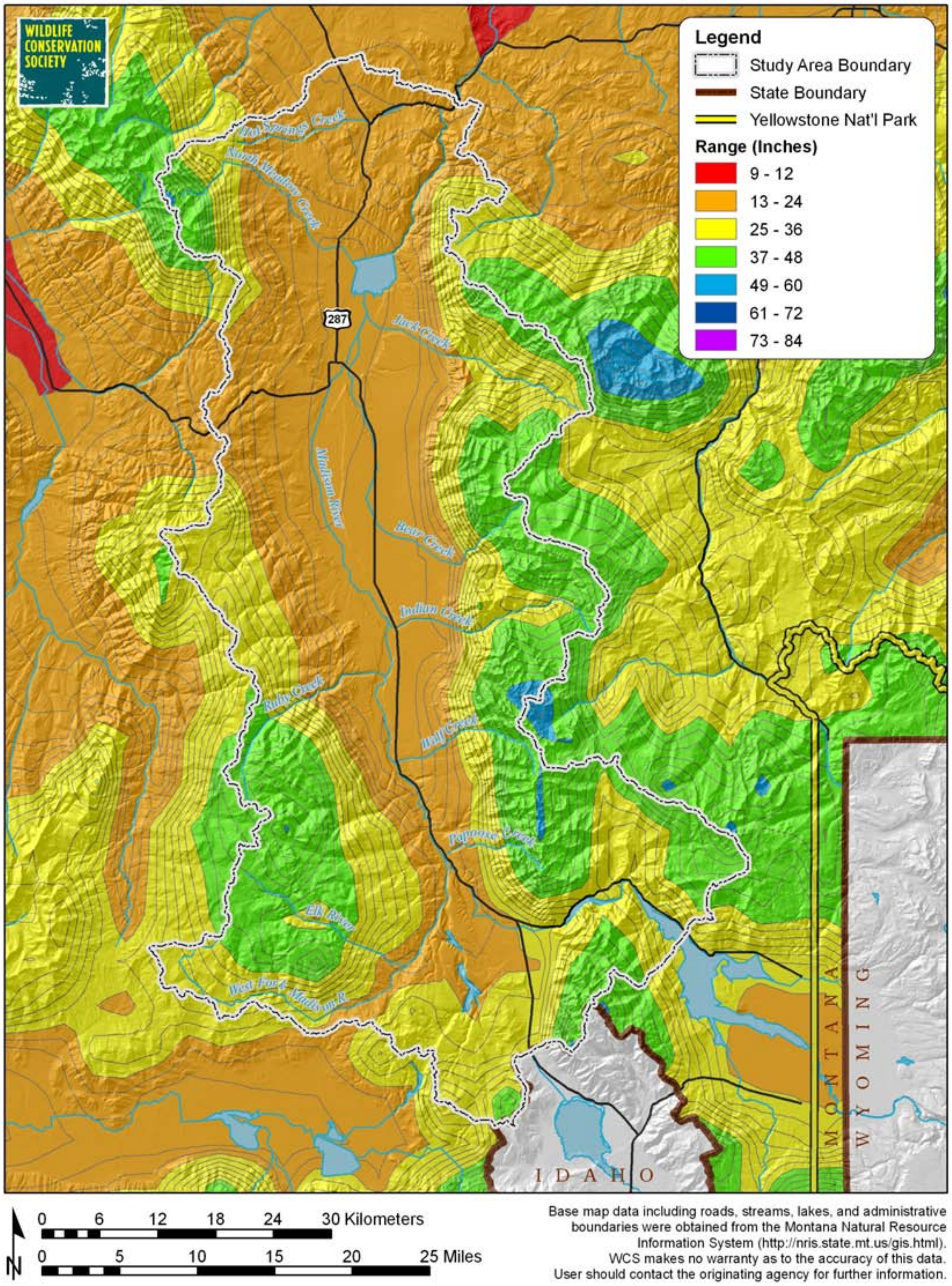
ANNUAL PRECIPITATION AVERAGE



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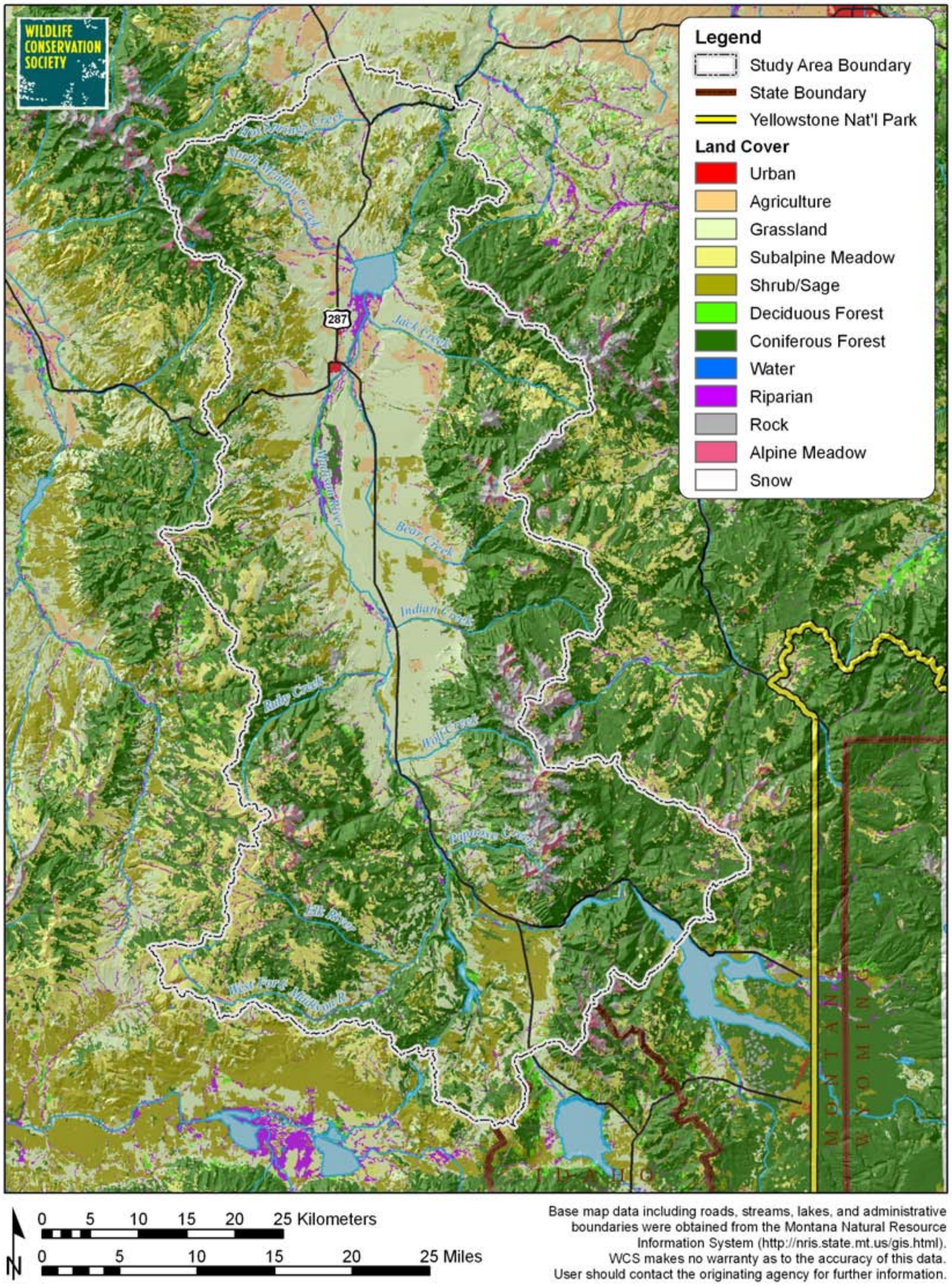
LAND COVER



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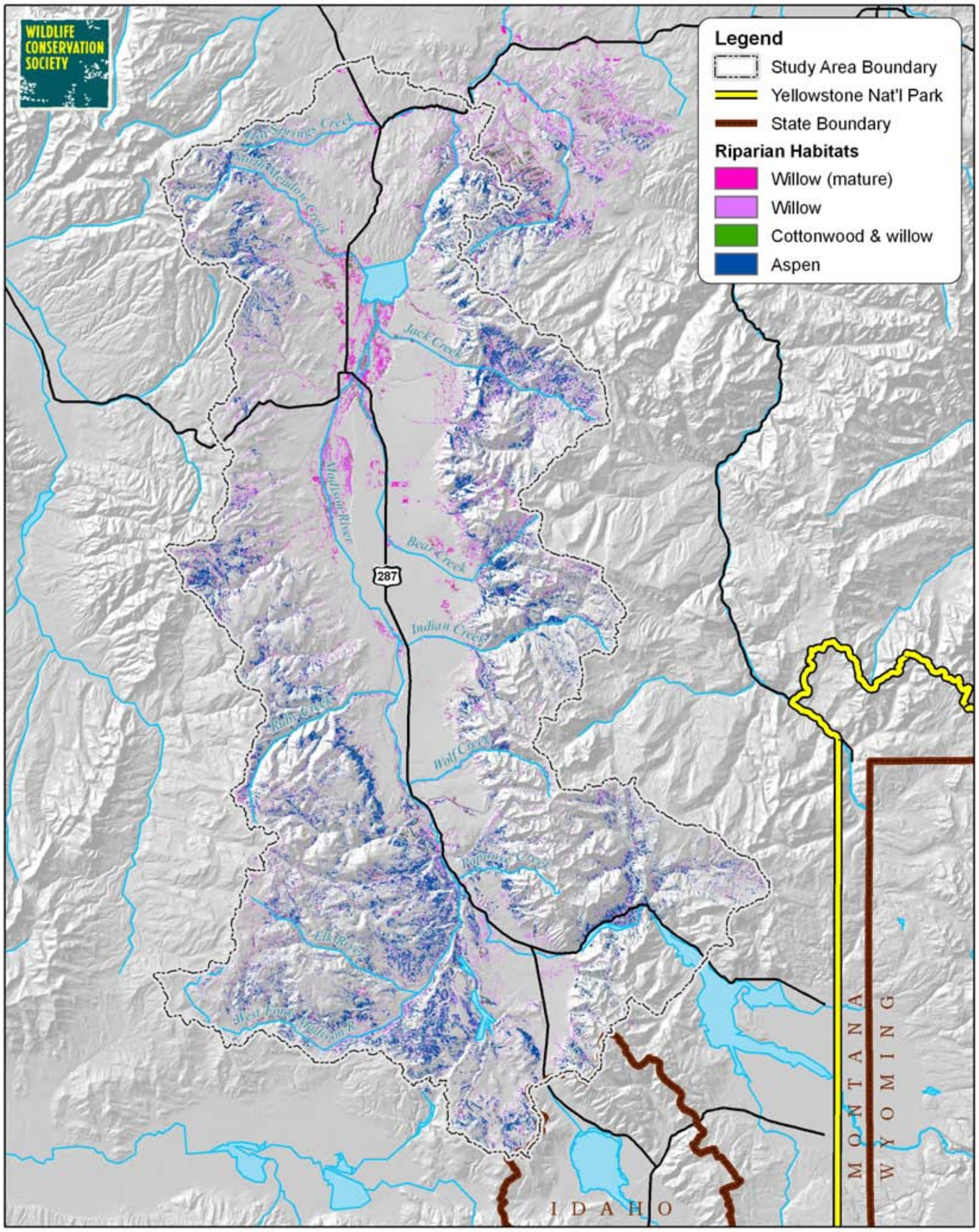
RIPARIAN HABITATS



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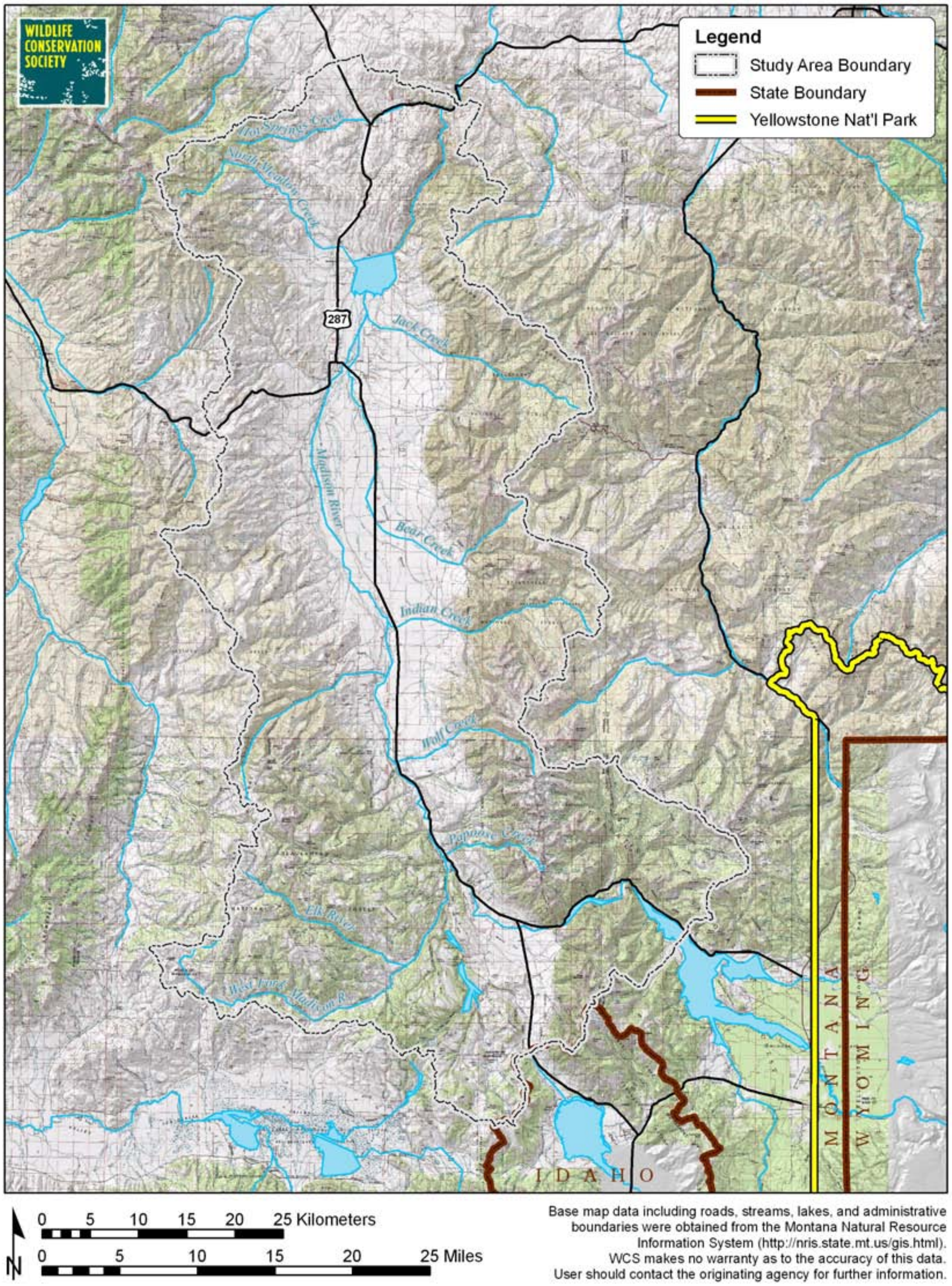
TOPOGRAPHY



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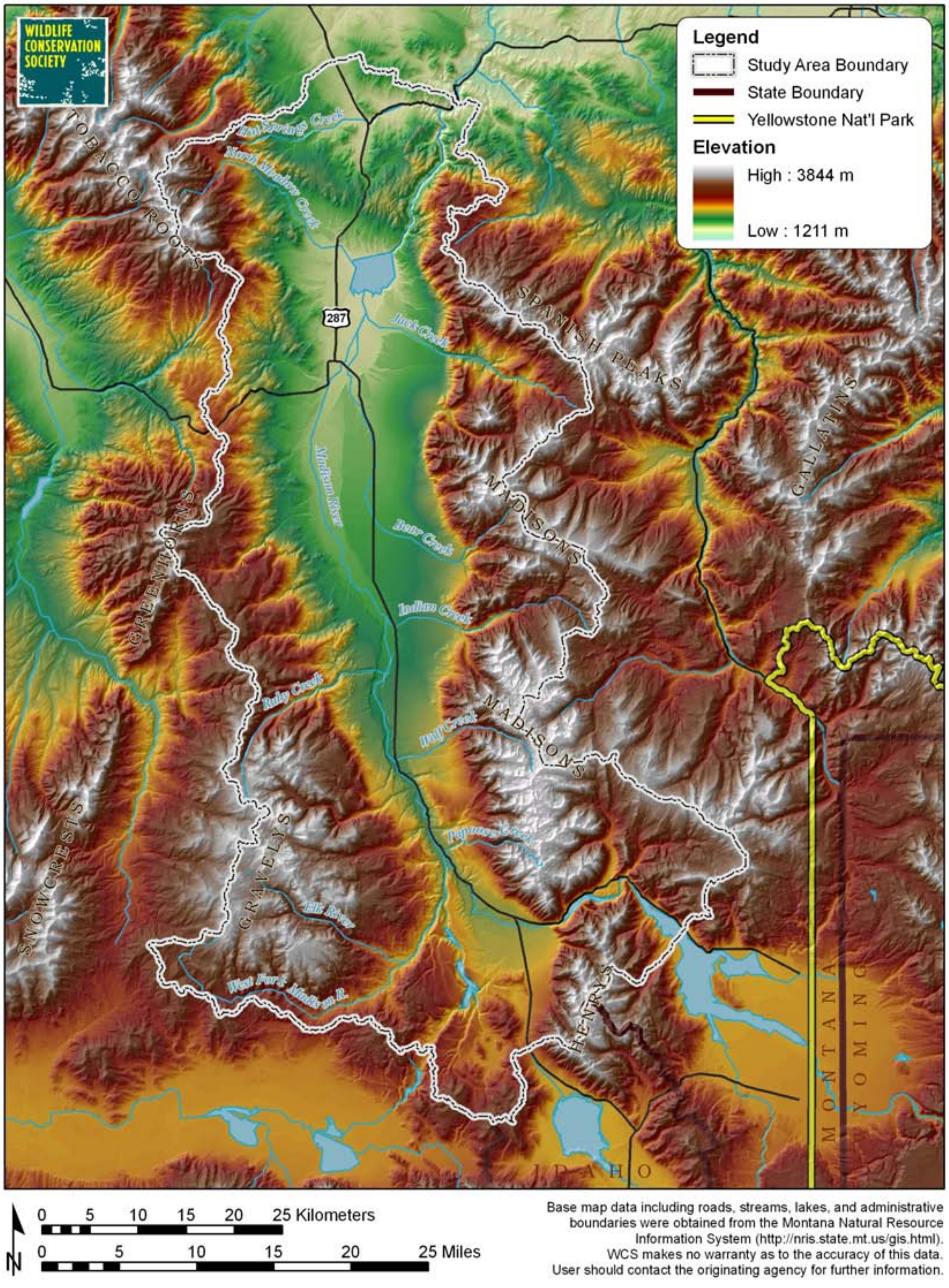
PHYSIOGNOMY



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