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CONSERVATION LEGACY ON A FLAGSHIP FOREST: WILDLIFE AND WILDLANDS ON THE FLATHEAD NATIONAL FOREST, MONTANA

WILDLIFE CONSERVATION SOCIETY

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Wildlife Conservation Society
North America Program
301 North Willson Avenue
Bozeman, Montana
59715

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SUMMARY

Amid the shining mountains and verdant valleys of northwest Montana lies one of the most important National Forests in the United States – the Flathead National Forest. The Flathead NF includes about 2.4 million acres of public land holding a strategic position in the international landscape known as the Crown of the Continent Ecosystem – an amazing set of splendid jewels of landscape beauty and ecological diversity. The Flathead National Forest itself sparkles with a variety of dramatic landscapes, clean headwater sources of blue waters, and diversity of plants and animals – including a community of carnivores (17 species) that appears unmatched in North America for its variety, intactness, and density of species that are rare elsewhere.

The Flathead National Forest has been at the forefront of conservation in America for more than 80 years. Here on the Flathead, the Forest Service provided some of the earliest protection of wildlands in the United States by designating a 'Primitive Area' in the South Fork Flathead River basin in 1931. Less than a decade later, it connected several of these primitive areas into the Bob Marshall *Wilderness Area* … thereby presaging The Wilderness Act of 1964 by nearly 25 years. The Great Bear and Mission Mountains Wilderness areas were added in the 1970s. In 1976, 219 miles of the Flathead River were designated a 'wild and scenic' river under the Wild and Scenic Rivers Act. In 2011, The Nature Conservancy (U.S.) and Nature Conservancy of Canada partnered to secure a ban on mining and energy development in the headwaters of the North Fork Flathead River in British Columbia. Recently, 45,000 acres of corporate lands were transferred to the Flathead NF as part of the Montana Legacy Project.

Thus – from the 1930s to the present day – successive generations of citizens and government leaders have worked hard to save the Flathead country through designation of world-class wildernesses and wild and scenic rivers. Montana Department of Fish, Wildlife, and Parks and various land trusts have invested substantially to protect critical wildlife habitat on state and private lands here as well. These collective achievements constitute a remarkable legacy and great gift … but, in the face of new information and new challenges, it may not have been enough.

Glaciers vanishing from Glacier National Park signal a new era of climate change that may become even more pronounced in coming decades. Climate scientists project that there will be warmer winters and hotter summers, decreasing snowpack and earlier melting in spring, declining stream flows and warmer streams, and longer wildfire season with more severe fires. In response,

animals will need room to roam as they try to track the shifting location of their habitats. The future *health* of the Flathead country will depend upon its *capacity for self-renewal* or resiliency. Such resiliency may depend upon ecological integrity of the place – its wholeness in terms of diversity of genes/native species/ and landscapes. A smart strategy for resiliency going forward is to protect and connect large landscapes that have high topographic and ecological diversity.

Remarkably, there are still opportunities on the Flathead National Forest to build upon the tremendous legacy of wildland conservation and to bring greater resiliency to a changing future. The 'Inventory of Roadless Areas' (IRA) by the U.S. Forest Service tallied 479,416 acres on the Flathead National Forest. These roadless areas present a large-scale opportunity to complete the legacy of conservation in this spectacular and treasured landscape. What is the conservation value of these roadless areas for vulnerable species of fish and wildlife – bull trout, westslope cutthroat trout, grizzly bear, wolverine, and mountain goat – that are important to Montanans and others?

Bull trout and westslope cutthroat trout exhibit high vulnerability. These native fish are adapted for cold waters – especially for spawning and rearing. Bull trout populations are impacted by non-native lake trout and brook trout, whereas westslope cutthroat trout can be hybridized by non-native rainbow trout. Bull trout and westslope cutthroat trout are vulnerable to several detrimental effects associated with roads such as increased sedimentation to streams. Finally, climate change may warm lower-elevation waters past their tolerance. Protection of large networks of waters that are cold, clean, complex and connected and reduction of non-native trout will help conserve these native trout.

About 770 mi of streams on the Flathead National Forest have been designated as *critical habitat* for bull trout, listed as a 'threatened' species under the Endangered Species Act. These waters represent an important stronghold for bull trout in the Pacific northwest. Although several of these critical waters occur in existing Wilderness, many other streams in the North Fork, Middle Fork, and South Fork Flathead River and Swan River basins begin or flow through roadless areas.

A network of cold-water streams (1615 mi) across the Flathead NF supports the last bastions of genetically-pure westslope cutthroat trout in Montana, too. Warmer streams in the future will favor the spread of non-native rainbow trout at lower elevations and their threat of hybridization with westslope cutthroat trout. Cold and clean streams in the roadless areas in the upper North Fork, Middle Fork, and especially the South Fork the Flathead River may offer these native trout some refugia from the advancing threat of hybridization by non-native rainbow trout.

Although resourceful in finding food and habitat, **grizzly bears** are vulnerable to excessive mortality due to their very low reproductive rate. Young females do not disperse very far, which makes bear populations susceptible to landscape fragmentation. Roads with even modest traffic volume can displace bears from key habitats and expose them to greater risk of human-caused mortality. Large areas of productive habitats with security from human disturbance and mortality are key for conserving grizzly bears, which also are listed as 'threatened' under the ESA.

About 53% of the Flathead National Forest has secure areas with high-value habitats for grizzlies, and another 27% has secure areas with moderate-value habitats. Roadless areas comprise 22% of these important habitats. About 7% has attractive habitat but low security due to roads. The highest density of grizzly bears in the lower 48 states thrives on a variety of habitats from valley to mountain peak across the northern Flathead NF and Glacier National Park. Large expanses of roadless areas in the Whitefish Range of the North Fork Flathead and all along the Swan Range provide productive and secure habitats for grizzly bears now, with room to roam in a future of varying conditions.

Wolverines use areas characterized by persistent snow cover during spring for their reproductive habitat, summer habitat, and dispersal routes. Due to their very low reproductive rates, wolverines are vulnerable to human-caused mortality from trapping and appear sensitive to human disturbance near maternal sites. Snowy habitats for wolverines may shrink at lower elevations in the future as a result of warmer climate.

The largest population of the rare wolverine in the conterminous United States roams the rugged terrain of the high country across the Flathead National Forest and Glacier National Park. About 70% of the Flathead NF provides key habitats for wolverines, a species that has been proposed for federal listing as a 'threatened' species. Remaining roadless areas in the high country on the Flathead NF – particularly the Whitefish Range of the North Fork Flathead and along the Swan Range – provide habitat that will help sustain the unique niche and vulnerable populations of this elusive carnivore in a warmer future.

Mountain goats have high vulnerability. They are constrained to live on or near cliffs that provide escape terrain from predators and more accessible forage in winter. Female goats have very low reproduction rates and cannot quickly compensate for excessive mortality (notably hunting). Goats are sensitive to motorized disturbance (especially helicopters). On the Flathead National Forests, mountain goats are found primarily in the Wilderness Areas, but rugged terrain in roadless areas along the southern crest of the Swan Range are part of year-round range.

To **summarize**: the Flathead National Forest is a stronghold for several vulnerable fish and wildlife species that have been vanquished in so many other places. Remarkably, 90% of the Flathead NF has a very high (75%) or high (15%) conservation value for at least 1 of the 5 focal species. About 76% of the Flathead NF has high (35%) or moderate (41%) *composite* scores for this suite of vulnerable species. Importantly, remaining roadless areas account for about 21% of the very high-high importance values for individual species and 23% of the high-moderate composite scores.

Highways, roads, and human settlements fragment intact landscapes. These 'fracture zones' can disrupt wildlife movements, leading to smaller and more isolated populations with less genetic interchange. Consequently, many scientists advocate the need for conservation corridors or linkages between habitats (existing and future) to support necessary movements and greater viability. A complementary strategy is to increase the size and number of protected, ecologically-diverse areas connected by such linkages

There are 2 major highways that have implications for connectivity in the context of the Flathead National Forest and the larger Crown of the Continent Ecosystem. U.S. Highway 2 (and associated railroad) is a major east-west transportation route across the Rocky Mountains between the south boundary of Glacier National Park and the Flathead National Forest. Montana Highway 83 is a major highway running north-south through the broad Swan Valley between the Bob Marshall Wilderness and the Mission Mountains Wilderness. Based upon habitat mapping and using least-cost distance and Circuitscape modeling techniques, we examined the prospects for connectivity for grizzly bears, wolverines, and mountains goats across these highways.

Except for the patches of human settlements, much of the U.S. Highway 2 corridor with its current traffic volume appears to be permeable for connectivity for these wildlife species. The section between Pinnacle (MP 174) and Skyland Creek (MP 194) could be considered as an 'umbrella' linkage zone for these species. Providing security on the adjacent roadless areas on the Flathead NF could facilitate connectivity across the larger region. In the Swan Valley, a stretch of Highway 83 from Goat Creek (MP 58) south to Smith Creek area (MP 45) near Condon and another near the Seeley-Swan Divide (MP 32-34) are used by bears, wolverines, and perhaps mountain goats. Importantly, the roadless portion of the Swan Range could facilitate connectivity between the Bob Marshall Wilderness and the Mission Mountain Wilderness and complement land conservation efforts in the Swan Valley. Any future alteration of either highway should incorporate these key sections into planning for safe passage.

To provide more detailed information for revision of the Flathead National Forest Plan, I summarize conservation scores for these vulnerable species and make recommendations for wildland protection for each of 6 Geographic Areas across the Forest.

North Fork (Flathead): I recommend that 137,872 roadless acres be designated as Wilderness as part of a new wilderness area to include: Tuchuck Mtn - Mount Hefty area, Mount Thompson-Seton and Nasukoin Mtn area, and headwaters of Hay Creek and Coal Creek. I further recommend that 26,341 acres in upper Big Creek and the Smoky Range be managed in roadless condition as 'Backcountry Conservation' with emphasis on non-motorized recreation and conservation of fish and wildlife.

Middle Fork (Flathead): I recommend that 30,229 roadless acres be added to the Great Bear Wilderness to include: Slippery Bill Mountain - Puzzle Creek area and rest of the Twentyfive mile Creek watershed, narrow strip along south side of Highway 2 from Skyland Creek down to Pinnacle Creek, and Essex Creek-Tunnel Creek area. I further recommend that 16,060 roadless acres be managed in roadless condition as 'Backcountry Conservation' to include: upper Granite-Challenge Creek, and a narrow strip along the Middle Fork of the Fathead River from West Glacier east to Grant Ridge.

Hungry Horse: I recommend 93,350 roadless acres in the Swan Range as additions to the Great Bear Wilderness to include: Sullivan Creek and Quintonkon Creek watersheds; Jewel Basin Hiking Area and portions of surrounding drainages – Wheeler, Forest, Aeneas, Graves, Clayton, Wildcat and

Wounded Buck Creeks; and headwaters of Lost Johnny and Doris Creeks. I further recommend that 58,374 roadless acres be managed in roadless condition as 'Backcountry Conservation' to include: northern tip of Swan Range, and narrow strip of land on the east side of Hungry Horse Reservoir from Crossover Mountain north past Great Northern Mountain.

South Fork (Flathead): I recommend 57,037 roadless acres be added to the Bob Marshall Wilderness to include: most of the Bunker Creek basin and Addition Creek-Bruce Creek, and north side (Whitcomb Creek basin) and south side of Spotted Bear River. I also recommend that 21,109 acres in remaining roadless areas at low elevation be managed in roadless condition as 'Backcountry Conservation'.

Salish Mountains: Because this Geographic Area has low importance for these vulnerable species, I do not recommend any wildland protection there.

Swan Valley: I recommend 85,720 roadless acres be added to the Bob Marshall Wilderness to include: roadless lands from Holland Lake north to Inspiration Point, and from Inspiration Point north along the west side of the Swan Range to above Lake Blaine (adjacent to roadless lands in the Hungry Horse Geographic Area). A small area (8,821 roadless acres) at the northwest side of the Swan Range could be managed in roadless condition as 'Backcountry Conservation'.

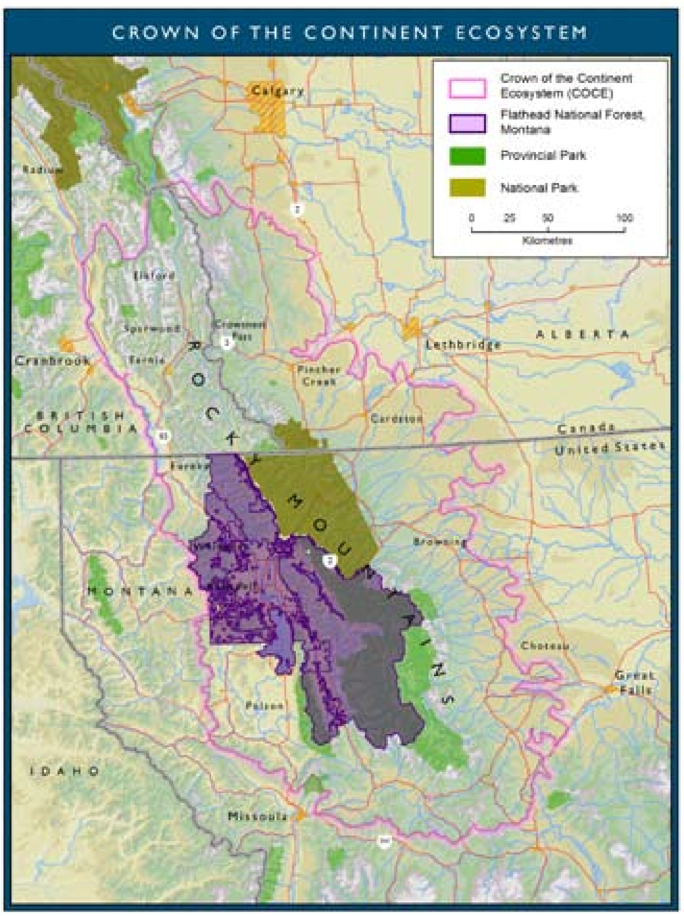
In total, I recommend 404,208 roadless acres on the Flathead National Forest for Congressional designation as National Wilderness and that 130,705 roadless acres be conserved in roadless condition as legislated 'Backcountry Conservation'. Large roadless areas in the Whitefish Range (North Fork Flathead) and Swan Range are vital for these vulnerable fish and wildlife species but have no legislated protection at present. A narrow strip of roadless areas along U.S. Highway 2 (Middle Fork Flathead) is important for regional connectivity between the Flathead NF and Glacier National Park. All of these areas should be accorded highest priority for designated Wilderness in the revised Flathead Forest Plan.

The Flathead National Forest has been at the forefront of conservation in America for more than 80 years – with a stellar history of protecting wild life, wild lands and wild rivers. At present, the Forest clearly is one of the last, best places for vulnerable fish and wildlife species that have been vanquished or diminished in most other areas across the western United States. Now, a new challenge has emerged – climate warming and its myriad consequences.

Successive generations of citizens and government leaders have worked hard to safeguard the rich tapestry and health of the Flathead. Their collective achievements comprise a remarkable legacy and great gift. Now, changing times require leadership anew. Protecting and connecting large landscapes that have diverse topography and ecological features is a smart strategy going forward. The nearly half-million acres of roadless public lands on the Flathead National Forest offer a rare opportunity to complete the legacy of wildlife and wildland conservation on this crown jewel of the National Forest system.

1. FLATHEAD NATIONAL FOREST: ONE OF THE MOST IMPORTANT FORESTS IN THE UNITED STATES

Figure 1. The Flathead National Forest (outer boundary shown in purple) in Montana occupies a large, strategic position within the trans-border Crown of the Continent Ecosystem.



A Spectacular Landscape, Rich in Fish and Wildlife

Amid the shining mountains and verdant valleys of northwest Montana lies one of the most important National Forests in the United States – the Flathead National Forest.

The Flathead NF includes about 2.4 million acres of public land (Figure 1). It occupies a strategic position in the international landscape known as the Crown of the Continent Ecosystem – an amazing set of splendid jewels of landscape beauty and ecological diversity. The Forest is encircled by majestic Glacier National Park on the northeast; wilderness and/or roadless lands of the Lewis and Clark and Lolo National Forests on the east and south; the Flathead Indian Reservation of the Confederated Salish and Kootenai Tribes on the southwest; and the Ten Lakes Scenic Area and roadless lands on the Kootenai National Forest on the northwest. The North Fork of the Flathead River has its headwaters in the remote, southeast corner of British Columbia.

The Flathead National Forest itself sparkles with a variety of dramatic landscapes, clean headwater sources of blue waters, and diversity of plants and animals. It encompasses a rich tapestry of habitats extending from broad valleys along the Flathead and Swan Rivers to the magnificent peaks of the Mission Range and the Continental Divide. Elevations vary from 3,080 feet in valleys to 9,356 feet on Holland

Peak – a range of 6,276 feet. Coupled with a complex topography, this range of elevation offers a wide variety of environmental conditions and physical niches. Whereas the northern sections of the Flathead NF were covered by ice sheets during the last glacial period about 20,000 years ago (Clark et al. 2009), other areas were free of ice during this period. These areas provided multiple refugia for both plants and animals and influenced many of the distribution patterns of biota today. More recently, disturbances like insects and fire have created new patterns at local scales. All of these factors have set the stage for a diverse assemblage of plant and animal species.

Due to its complex topography, glacial and recent history of disturbance, and convergence of regional vegetation biomes, the Flathead NF is one of the most diverse ecosystems in the temperate latitudes of the U.S. Its geographic position in North America provides a meeting of plant species from other regional floras, such as boreal and even Beringian. Plant communities are arrayed along 4-6 different ecological zones from valley to peak. The Forest has about 1100 species of vascular plants, as its neighbor Glacier National Park has 1132 species (Lesica 2002) and adjacent lands of British Columbia have 1065 species (Hebda 2010). Dominant tree species include Engelmann spruce, subalpine fir, lodgepole pine, Douglas-fir, and western larch. Grand fir, western white pine, ponderosa pine, and aspen also occur. The flora is in a remarkably natural state, with a low proportion (about 11%) of non-native species (Hebda 2010).

Water is abundant on the Flathead National Forest. Major rivers include the North, Middle and South Forks of the Flathead River as well as the Swan River. These rivers eventually flow into Flathead Lake, the largest freshwater lake west of the Great Lakes. Dozens of subalpine lakes grace the Jewel Basin Hiking Area and the Mission Mountain Wilderness. Glacial potholes, fens, and bogs are common water features across the Forest. The clean, cold, and structurally complex streams and lakes provide high quality habitat for native bull trout and westslope cutthroat trout. These vulnerable species have been much reduced in distribution and populations size elsewhere across their historic range. The varied aquatic habitats host many other important fish, amphibian, and aquatic invertebrate species too.

Here roam the wild hunters – wolf, grizzly bear, cougar, lynx, wolverine, fisher and others – that have been vanquished from more settled areas. In fact, the assembly of carnivores here (17 species) appears unmatched in North America for its variety, intactness, and density of species that are rare elsewhere (Weaver 2001). Several are federally listed as 'threatened' species. With its outstanding richness and abundance of carnivore species, the Flathead NF may serve as a source area for carnivore populations throughout the Crown of the Continent Ecosystem. More than 200 species of birds occur in the rich mosaic of aquatic and terrestrial habitats.

This astonishing legacy of diverse and intact populations of native fish and wildlife did not happen by chance. Rather, it was the direct outcome of concerned citizens – from Montana and across America – who cherished these natural values and acted to protect treasured wildlands and their splendid diversity.

Figure 2. Flathead National Forest, Montana, with its legacy of large Wilderness areas and opportunity for protecting nearly half-million acres of remaining roadless areas proximal to Glacier National Park.

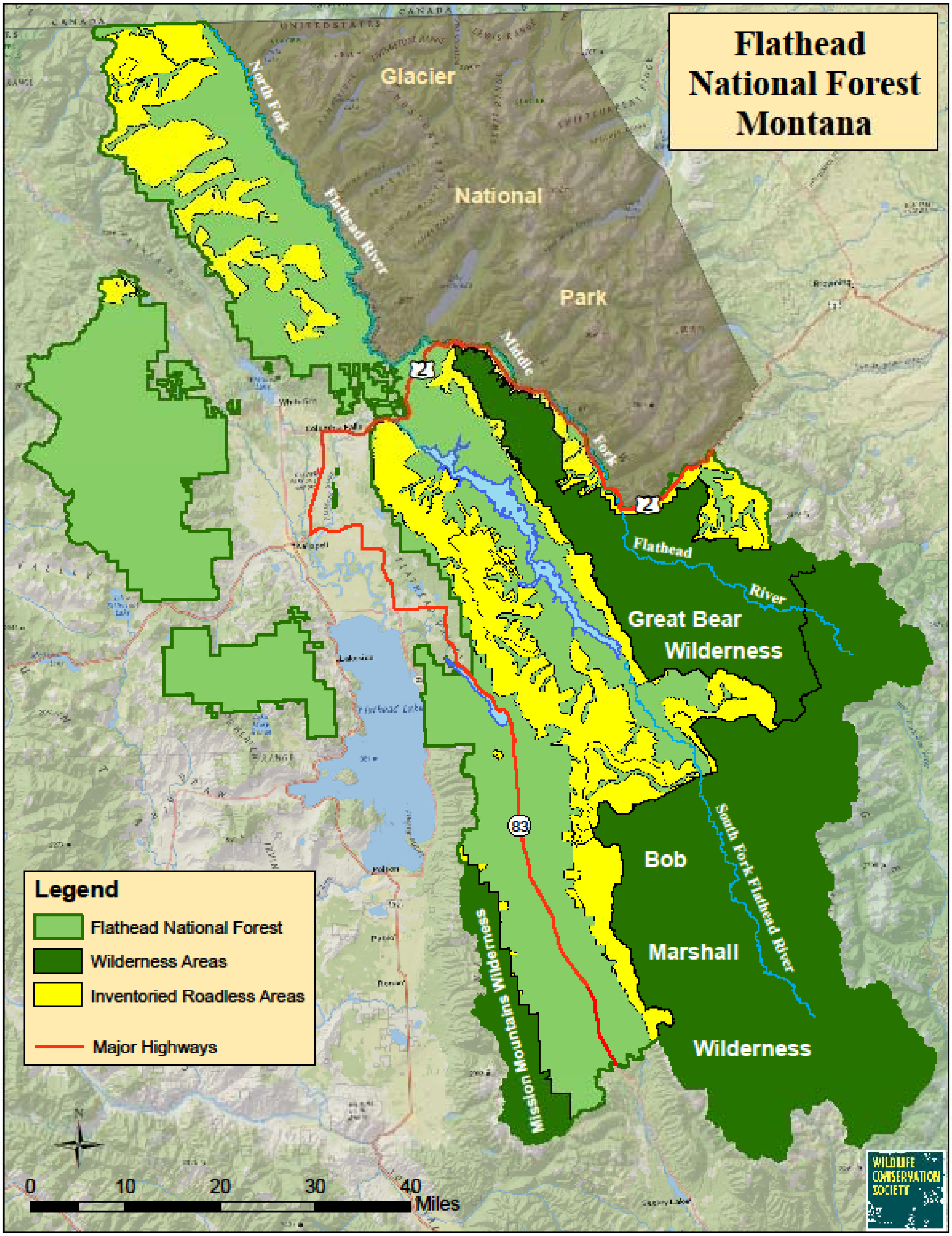


Figure 3. The Chinese Wall – 1000 feet high and 13 miles long – is the iconic centerpiece of the vast Bob Marshall Wilderness in Montana.

Photo: Rick and Susie Graetz

Conservation Commitment: Legacy of Protected Lands and Waters

Bob Marshall Wilderness

During the 1930s, the U.S. Forest Service designated wildlands south of Glacier National Park as 'primitive areas' – including large areas on the Flathead National Forest (Figure 2). These included the South Fork (Flathead River) area in 1931, the Pentagon area in 1933, and the Sun River area in 1934. Following the premature death of the wilderness visionary Bob Marshall in 1939, the U.S. Forest Service coalesced these primitive areas and designated about 950,000 acres as the Bob Marshall Wilderness Area "as a monument to his memory". The 'Bob' (as it is often called) now encompasses 1,011,603 acres and was brought into the national wilderness system in 1964 following passage of the Wilderness Act. About 712,334 acres (70%) of the Bob Marshall Wilderness protects the headwaters of the South and Middle Forks of the Flathead River on the Flathead National Forest. Perhaps the most ecologically-intact mountain wilderness in the country, the 'Bob' includes rugged peaks, big river valleys, more than 100 lakes, large meadows and extensive coniferous forests (Graetz and Graetz 2004). The Chinese Wall, an imposing limestone precipice that towers 1,000 feet for 13 miles, is the centerpiece (Figure 3). But, designation of the Bob Marshall Wilderness left out several significant areas that may people believed warranted protection.

Great Bear Wilderness

During the 1970s, Montana citizens called for greater protection of the wild Middle Fork Flathead River and its larger watershed. In 1978, Montana Senator Lee Metcalf – inspired by the notion of *room to roam for grizzly bears* – led Congressional protection of 288,099 acres known as the Great Bear Wilderness. This wilderness encompasses the entire upper drainage of the Middle Fork Flathead River from the Continental Divide west to the Flathead Range. It lies entirely within the Flathead National Forest. Large cirque basins and serrated ridges testify to the glaciated history of this rugged landscape.

Mission Mountains Wilderness

The Mission Mountains cradle one of the densest concentrations of alpine lakes in the U.S. Rockies. Intercepting westerly flow of moist Pacific airstreams, these spectacular mountains capture and store tremendous amounts of precious snow and water. With more than 350 lakes, ponds and pools and sparkling clear streams, the Missions are a natural water tower (Graetz and Graetz 2004). The eastern slopes of the Mission Mountains on the Flathead National Forest are draped by diverse forests of Engelmann spruce and subalpine fir, lodgepole pine, western larch, western red cedar and ponderosa pine as they drop down into the Swan Valley. The U.S. Forest Service classified a part of the Missions as a primitive area back in 1931. Finally, in 1975, Congress designated 76,220 acres as the Mission Mountains Wilderness. In 1982, the Confederated Salish and Kootenai Tribes established the Mission Mountains Tribal Wilderness encompassing 91,778 acres on the adjacent western slopes of the Mission Mountains (CSKT 2005).

Wild, Scenic, and Recreation Rivers

In 1976, 219 miles of the Flathead River were designated a 'wild and scenic' river under the Wild and Scenic Rivers Act. Designated sections of the Flathead River include the (1) North Fork from the Canadian border downstream to its confluence with the Middle Fork, (2) Middle Fork from its headwaters to its confluence with the South Fork, and (3) South Fork from its headwaters to Hungry Horse Reservoir. About 97.9 miles were designated as 'wild', 40.7 miles as 'scenic', and 80.4 miles as 'recreational'.

Montana Legacy Project lands

More recently, The Nature Conservancy and the Trust for Public lands used a substantial appropriation from Congress to acquire >310,000 acres of lands in western Montana from the Plum Creek timber company. Known as the Montana Legacy Project, this bold initiative represented the largest, private conservation land purchase in U.S. history. In the past, the pattern of checkerboard ownership between private company and public agencies made conservation at the larger scale very difficult. Now, most of this land will transfer to U.S. Forest

Service, Montana State Trust Lands, and Montana Fish, Wildlife and Parks Department. In the Swan Valley, about 44,700 acres transferred to the Flathead National Forest. This historic deal underscores the continuing commitment of Montanans and others to safeguard these treasured landscapes.

Trans-border Flathead Protection

The North Fork of the Flathead River flows southward about 31 miles in British Columbia and 47 miles in Montana, where it forms the western boundary of Glacier National Park next to the Flathead National Forest. The watershed is 1590 mi^2 in size, with about 62% in Montana. Many wide-ranging wildlife and even fish species move back and forth across this border (Weaver 2001). Development of this trans-border watershed has been a continuing controversy since the 1980s due to proposed plans for open-pit coal mines and numerous oil & gas leases. In early 2011, The Nature Conservancy (U.S.) joined with Nature Conservancy of Canada to secure a ban on mining and energy development in the Canadian section of the North Fork of the Flathead River. Currently, a legislative bill entitled the 'North Fork Watershed Protection Act' is winding its way through Congress. If passed, the bill would furnish permanent protections on 430,000 acres of Flathead NF parcels along the North and Middle Forks of the Flathead River, placing them off limits to hard-rock mining, mountaintop-removal coal mining, and oil and gas development. Collectively, these efforts furnish an exemplary model of international cooperation in conservation informed by science (Hauer and Muhlfeld 2010).

Thus – for 80 years – successive generations of citizens and government leaders have worked hard to save the Flathead country through designation of world-class wildernesses and wild and scenic rivers. Montana Department of Fish, Wildlife, and Parks and various land trusts have invested substantially to protect critical wildlife habitat on state and private lands here as well. These collective achievements constitute a remarkable legacy and great gift … but, in the face of new information and new challenges, it may not have been enough.

Going Forward: Meeting the Challenge of Climate Change with Resiliency

One challenge facing conservation of wildlife and wildlands over the past century has been the ever-expanding footprint of humans – urban and rural sprawl, superhighways and forest roads, dams and diversions. But scientists are alerting us to a new challenge for the next century: climate change. What changes in climate can we anticipate over the next 50-100 years? What will be the ecological consequences? What might comprise thoughtful responses to this new challenge?

Over the past 100 years, a new array of instruments has enabled climate scientists to measure trends and variability in temperature, precipitation, snowpack and other climate variables with greater accuracy and better geographic representation. Attempting to predict *future* climate conditions, though, is a daunting but important endeavor. Projecting climate change depends, of course, upon the (1) assumed scenario of greenhouse gas (GHG) emissions and (2) variables and relationships used to build any specific climate model. The empirical record of past climate change helps scientists better understand the performance of a model. In an attempt to develop robust projections, researchers increasingly are using *ensembles* of different climate models to examine implications of different GHG scenarios.

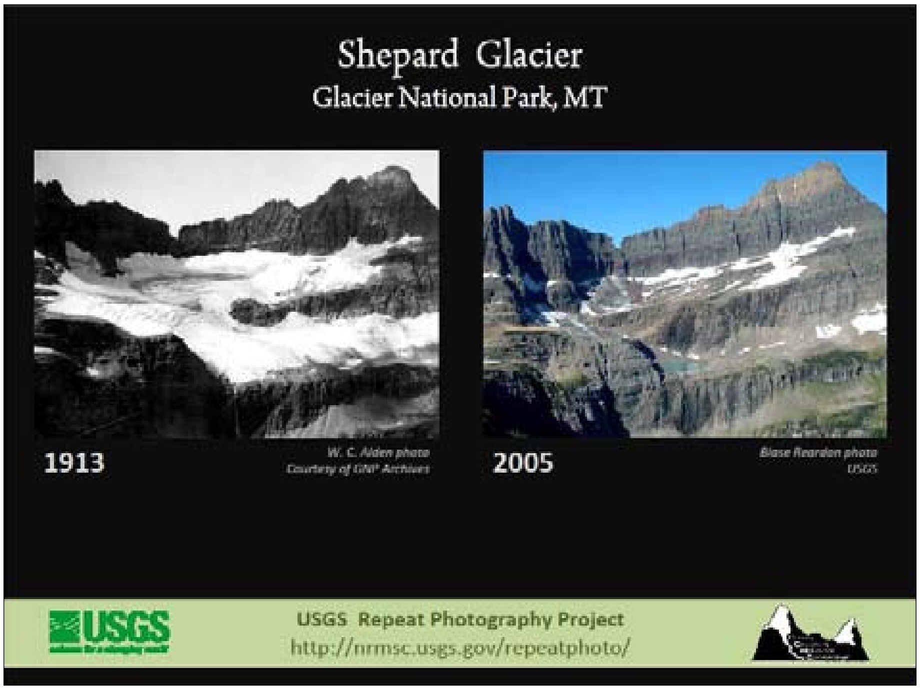
I examined patterns and trends reported by a diverse set of investigators in several recent climate assessments encompassing the Columbia River basin of western Montana and southeast British Columbia. Key references include: Graumlich and Francis (2010), McWethy et al. (2010), Pederson et al. (2010), Pederson et al. (2011), Murdock and Werner (2011), Hamann et al. (2013), and Pacific Climate Impacts Consortium (2013). The authors represent several university/agency climate research groups (including University of Montana, Montana State University, USGS, and NPS). Taken together, these represent some of the best available analyses and projections of future climate conditions for the Crown of the Continent. There is strong agreement among the assessments, too. Although there is still uncertainty in precise climate projections (especially for complex environments like mountains), climatologists expect that patterns and trends in climate over the past 50-100 years will continue and perhaps accelerate under even moderate GHG scenarios.

Here, I synthesize the major findings from recent research to describe climate patterns over the past 100 years as well as projected changes over the next 40 years (2015-2055). This lays the foundation for anticipating changes in future environmental conditions that vulnerable fish and wildlife may encounter.

△ Disappearing glaciers

Perhaps the most iconic impact of climate change in western Montana has been the disappearance of glaciers from Glacier National Park (Figure 4). Of 150 glaciers in the Park in1850 (covering 39 mi^2 total), only 25 (6 mi^2 total) remain today. Increasing temperature during the critical spring and summer melting season has accelerated the retreat of glaciers. If trends continue, scientists expect glaciers will disappear from Glacier Park by 2030 (Hall and Fagre 2003, McWethy et al. 2010, White 2013).

Figure 4. Melting of glaciers in Glacier National Park signals an era of changing climate.



△ Warmer winters and hotter summers

Over the past 100 years, mean annual temperature (MAT) in western Montana has increased 1.3° C (2.3° F), nearly twice the rise in global temperature (Pederson et al. 2010). The largest increase has taken place in winter, when minimum temperatures rose +2.4° C and maximum temperatures +1.8° C. The average number of days below-freezing in winter has dropped from 186 days to 170 days, due mostly to warmer days in early spring (Westerling et al. 2007). Temperatures have warmed dramatically since the early 1980s and hot temperatures have occurred longer through the summer (Bonfils et al. 2008, McWethy et al. 2010, Pederson et al. 2010). This increase in summer temperature has been 3 times greater at higher elevations. Such accelerated warming at high elevations has been reported from many areas across the globe (Pepin and Lundquist 2008).

Climatologists project that by 2050, annual temperatures will be 1.4° – 3.1° C (2.5° – 5.5° F) warmer than now (Barnett et al. 2005, McWethy et al. 2010, Pederson et al. 2010, Murdock and Werner 2011). Both winters and summers will become warmer, with intense heat waves in summer becoming more common and longer in duration. There will be fewer, shorter, and less intense episodes of really cold weather in winter. For example, in western Montana, major river valleys may have average daily maximum temperature in winter above 0° C (32° F) by 2020s, tributary valleys by 2040s, and many mid to high-elevation sites by 2080s (S. Running and J. Oyler, University of Montana, *in prep*.). There still could be large variability (1.0° – 1.8° C) in temperatures between years and decades due to ENSO and PDO events (Murdoch and Werner 2011).

△ Variable precipitation patterns

During the 20th century, there have been periods of drought and periods of greater precipitation in western Montana. Indeed, the high variability in seasonal, annual, and decadal patterns of precipitation overrides any strong century-long trends (Selkowitz et al. 2002). Precipitation patterns are more difficult to predict than temperature, especially in the complex terrain of mountains. Summers are likely to become even hotter and drier, which could increase evapotranspiration. Various models suggest a slight increase or decrease (-10% → +10%) in annual precipitation in the Crown region, characterized by perhaps slight increases in winter (0% → +10%) and slight decrease in summer (0% → -10%) (Murdock and Werner 2011). More intense precipitation events may occur (Groisman et al. 2005).

△ Decreasing snowpack and earlier melting in spring

Annual snowpack level (indexed by April 1 Snow Water Equivalent, SWE) has declined by 15 to 30 percent throughout the Rocky Mountains during the second half of the 20th century (Mote et al. 2005, Pierce et al. 2008) and by approximately 20% in western Montana (Pederson et al. 2011). More of the winter precipitation in the western United States has been falling as rain rather than snow – especially at lower elevations – due to significant increases in number of days when temperatures are above freezing (Knowles et al. 2006, McWethy et al. 2010). Rain-on-snow events have become more frequent at low to mid-elevations, increasing the prospects for winter flooding (Hamlet and Lettenmaier 2007). Over the past 50 years, warmer temperatures have led to earlier runoff in the spring (by 1-4 weeks) and reduced base-flow of streams in the summer and autumn across western United States (Stewart et al. 2005, Hildago et al. 2009). In western Montana, for example, average snowmelt advanced about 8 days earlier in the spring between 1969 and 2006 than previously (Pederson et al. 2011).

For the future, climatologists project that, due to warmer temperatures during winter, there will be more rain and less snow falling at low and mid elevations (Knowles et al. 2006). This will result in less snowpack, shorter snow season, and earlier melt in spring (Mote et al. 2005, Pederson et al. 2011). Most areas in western Montana will experience 10-40% decrease in April 1 SWE by 2050s (S. Running and J. Oyler, University of Montana, *in prep*).

△ Declining stream flows and warmer streams, particularly by late summer

Approximately 60-80% of surface water flow in the interior Mountain West is governed by the amount of snowpack (Barnett et al. 2005). Over the past 50 years, there has been a general decline in stream flows associated with reduced snowpack (Barnett et al. 2008). In the Rockies, for example, water flow in August decreased by an average of 31% (range 21-48%) during 1950-2008 (Leppi et al. 2010). In the Flathead River, summer base flows decreased about 11% between 1978 and 2007 (C. Muhlfeld, USGS, *unpublished data*). The decline in snowpack has reduced recharge of aquifers, resulting in less water available for groundwater flow into streams and decreasing the base flow during the key summer period (Rood et al. 2008). In western Montana, increased precipitation during spring may have buffered the annual streamflow from more severe declines due to decreased snowpack alone (Pederson et al. 2011). With warmer air temperatures, loss of shading cover along streams due to wildfire, and lower stream flows by August, stream temperatures have also increased (Isaak et al. 2010, Arismendi et al. 2012). Moreover, both the year-to-year variability in stream flow and multi-year duration of drought conditions are increasing (McCabe et al. 2004). Researchers project that these trends in stream flows will continue in the future, with adverse consequences for coldwater native trout and other biota (Jones et al. 2013).

△ Longer season of wildfire, with severe fires across more of the landscape

Wildfires, of course, have long been a feature of landscapes and driver of ecological processes across western North America. Beginning in the mid-1980s, large forest fires have become more frequent and much more severe than in previous decades (Running 2006). Compared to the 1970-1985 period, for example, there has been a 6-fold increase in number of acres burned each year and the fire season is about 78 days longer (Westerling et al. 2006). Notably, much of the increased fire activity has occurred in forests at higher elevations (5500 to 8500 feet), where snowpack levels normally keep wildfire activity low. More intense fires have swept across streams, and the loss of critical shading has exacerbated warming of streams (McKenzie et al. 2004, Dunham et al. 2007, Pettit and Naiman 2007). As temperatures continue to climb in the future accompanied by earlier snowmelt and hotter, drier summers, there will likely be a longer fire season with severe fires across more of the landscape (Spracklen et al. 2009, McWethy et al. 2010).

△ Spread of insects, invasive weeds, and non-native fish

In the wake of milder winter temperatures, populations of mountain pine beetle have exploded in recent years across western North America (Logan et al. 2003, Nordhaus 2009). More than 5 million acres of Montana's forests have been affected by the current infestation. In addition, warmer summers with longer droughts have stressed many coniferous tree species, enabling bark beetles to expand to higher elevations and new host species – such as the whitebark pine (Logan et al. 2003). Along with warmer temperatures and prolonged droughts, wildfire and land alterations have promoted spread of invasive plant species such as cheatgrass and spotted knapweed (Bradley 2009) and non-native rainbow and brook trout to the detriment of native, cold-water trout (Dunham et al. 2002, Rahel and Olden 2008). Climate change may alter the transport and establishment of new invasive species, distribution and impact of existing species, and effectiveness of control strategies (Hellmann et al. 2008).

△ Shifting distribution of plants and animals

As conditions become warmer and more arid in the future, different plant species will become stressed and will need to shift in response to changes in temperature and soil moisture (Rehfeldt et al. 2006). At lower elevations, forests will decline in density and extent, and some may transition to shrub-dominated sites and grasslands (Fagre 2007). In the middle sections of mountain slopes, the structure and composition of forest communities will change as different species shift mainly upward or to different aspects. With warming and longer growing seasons at higher elevations, trees could fill-in alpine meadows more over time (Klasner and Fagre 2002).

During warming episodes in past millennia, distribution of animals in North America generally shifted north in latitude and upward in elevation, too (Pielou 1991). In the mountains, various mammals shifted distribution upward in elevation or perhaps to a different aspect and consequently did not have to shift as far north as those in flatter areas (Guralnick 2007, Lyons et al. 2010). Of course, there were no roads and other human infrastructure back then that posed barriers to shifts by species in response to climate change. In recent years, researchers have documented similar shifts northward and upward (Parmesan 2006, Moritz et al. 2008). But, there may be niche or physiological constraints to such adaptive movements. As alpine animals like pikas shift upward, they may find temperatures too warm even on mountaintops; 4 of 10 local pika extirpations in the Great Basin happened after 1999 (Beever et al. 2011).

Implications of Climate Change for Conservation in Western Montana

From this litany of past and projected changes in climate, there appears to be strong consensus that western Montana will continue to get warmer. It's sobering to see how relatively small changes in average temperature (1°- 2° C) and snow-rain thresholds already have resulted in large ramifications for water resources such as snowpack and summer stream flow.

Projected changes in climate will set many ecological changes cascading into motion, putting increasing pressure upon plants and animals to adapt their niche or move to track preferred environmental conditions. Although species' responses to environmental change differ, their primary response to large climatic changes during the Quaternary period was to shift their geographical distributions, albeit at much slower pace than will be required under most climate change scenarios (Huntley 2005). Scientists are already documenting changes in species distribution over recent decades (e.g., Parmesan 2006). Furthermore, because species respond individualistically, composition and structure of ecosystems will change in the future as novel assemblages come together (Williams and Jackson 2007). Complex ecological interactions may affect species beyond simply changes in their climatic 'envelope'.

More people may move into the western Montana as a response to more intense climate change (heat, drought, sea rise) elsewhere (e.g., Strauss et al. 2012). Resource development pressures may intensify and expand as humans scramble for dwindling fossil-fuel and water resources (Turner et al. 2010). Ever-increasing numbers of people across the landscape would only exacerbate current challenges of habitat fragmentation and mortality risk. What does all of this imply for conservation strategies to maintain species, ecosystems, and the critical services they provide society?

One key conservation concept involves *resilience* thinking (Walker and Salt 2006). 'Resilience' can be defined as the capacity of species or system to withstand disturbance and still persist (Holling 1973, Folke et al. 2004). Plants and animals evolved in ecosystems where natural disturbances varied in frequency, intensity, duration, and extent – thereby resulting in different spatial and temporal patterns of change (Pickett et al. 1989). Over millennia, animals developed important behaviors and ecological traits that imbued them with resilience to certain kinds and levels of disturbance (Weaver et al. 1996, Lavergne et al. 2010). But as human activities accelerate rates of disturbance across a greater extent of the landscape, the combination of rapid change and simplification can undermine the evolved resiliency of species and render their populations more fragile.

Importantly, the resilience framework does not require an ability to precisely predict the future, but only a qualitative capacity to devise systems that can withstand disturbance and accommodate future events in whatever surprising form they may take. *One of the key messages of resilience thinking is to keep future options open through an emphasis on ecological variability across space and time,* rather than a focus on maximizing production over a short time (Walker and Salt 2006).

This kind of resilience thinking is reflected in several 'climate-smart' strategies identified by scientists and managers from around the world (Hannah and Hansen 2005, Heller and Zavaleta 2009, Mawdsley et al. 2009, Graumlich and Francis 2010, Hansen et al. 2010, Davison et al. 2012). A broad consensus has emerged on the following actions to enhance resiliency in the face of climate change:

- ✓ Protect large landscapes with high topographic and ecological diversity
- ✓ Enhance connectivity among such key landscapes
- ✓ Reduce other pressures on species and ecosystems

In an ever-changing world where impacts of habitat loss and fragmentation, invasive species, and climate warming are accelerating, vulnerable species will persist longer with well-designed networks of core refugia and connectivity that offer ecological options (Carroll et al. 2009, Hodgson et al. 2009). Thus, protecting ecologically-diverse roadless areas in legislated Wilderness and other non-motorized categories (e.g., legislated 'Backcountry') is a sound and robust strategy in response to climate change (Figure 5).

Figure 5. Large, intact areas of diverse topography from valley bottoms to peaks and secure from human disturbance can serve as important 'safe havens' for vulnerable fish and wildlife under increasing pressures of resource extraction/motorized recreation and changing climates.

Photo: John Weaver

Purpose, Goals and Objectives, and Organization of the Report

Remarkably, there are still opportunities on the Flathead National Forest to build upon the tremendous legacy of wildland conservation and to bring greater resiliency to a changing future.. The 'Inventory of Roadless Areas' (IRA) by the U.S. Forest Service tallied 479,764 acres on the Flathead National Forest (Figure 1). **These roadless areas present a large-scale opportunity to complete the legacy of conservation in this spectacular and treasured landscape. One of the key science questions for policy considerations is: What is the conservation value of these roadless areas for vulnerable species of fish and wildlife that are important to Montanans and others?**

The purpose of this report is to inform discussions and decisions about land and resource management in the revision of the Forest Plan for the Flathead National Forest (FNF) in Montana. The goal is to assess the conservation value of roadless areas on this flagship forest for a suite of vulnerable fish and wildlife species. Specific objectives are to: (1) compile and critically examine the latest scientific information about conservation needs of these species, (2) identify current and future key areas for these species using empirical data and models, (3) assess options for connectivity across Highways 2 and 83, and (4) make recommendations for various levels of land conservation such as 'Wilderness' or 'Backcountry Conservation Area'. The approach involves synthesis of available spatial data into maps of conservation value for vulnerable species and a geographical narrative to draw attention to key areas.

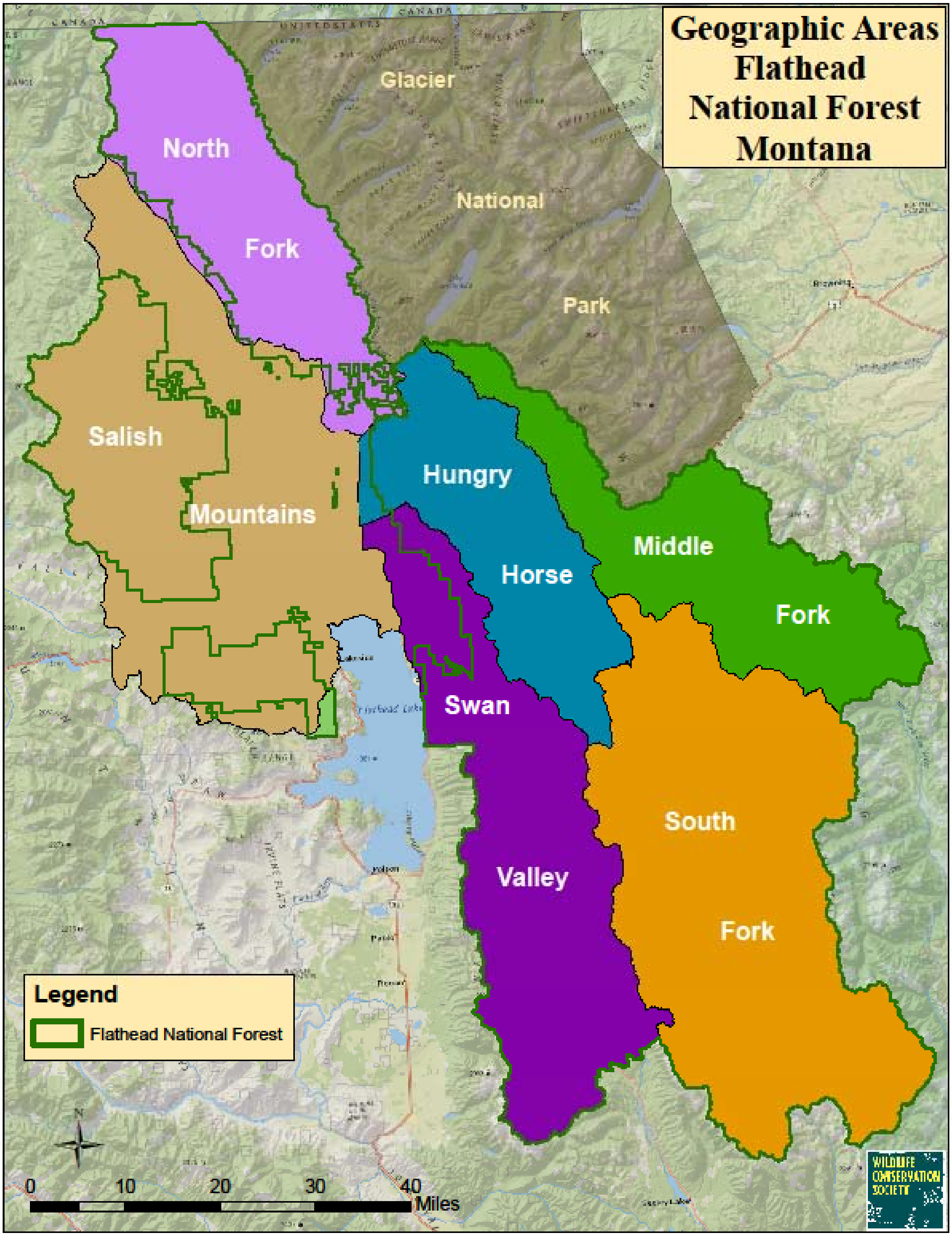
The Wildlife Conservation Society has woven together several lines of contemporary thinking about planning for wildlife conservation into a concept called 'landscape species' (Sanderson et al. 2002). It is based on the notion that species which use large, ecologically diverse areas can serve as useful 'umbrellas' or surrogates for conservation of other species. The approach is especially useful if a <u>suite</u> of species is chosen considering area requirements, heterogeneity of habitats, ecological functionality, and socioeconomic significance (Carroll et al. 2009). For assessing the conservation value of the Flathead National Forest, I selected the following suite of vulnerable fish and wildlife species: bull trout (*Salvelinus confluentus*), westslope cutthroat trout (*Oncorhynchus clarki lewisi)*, grizzly bear (*Ursus arctos horribilis*), wolverine (*Gulo gulo*), and mountain goat *(Oreamnus americanus*).

In Chapter 2, I provide a vulnerability synopsis for each species based upon its ecology, demography, and behavior. Next, I describe the method for scoring conservation importance (current and future) of lands or waters for the species. Based upon a synthesis of local, empirical data and/or habitat models, I identify and discuss key conservation areas for the species in each of 6 Geographic Areas across the Flathead NF (area of Forest Service lands in parens): (1) North Fork (Flathead) (325,867 ac), (2) Middle Fork (Flathead) (370,097 ac), (3) Hungry Horse (286,497 ac), (4) South Fork (Flathead) (790,550 ac), (5) Salish Mountains (257,623 ac), and (6) Swan Valley (364,450 ac) (Total = 2,395,084 ac) (Figure 6). After presenting this information for each species, I close the chapter by summarizing the composite scores (of all 5 species) across the Flathead National Forest.

In Chapter 3, we map key linkages or corridors across U.S. Highway 2 (along the south boundary of Glacier National Park) and Montana Highway 83 (through the Swan Valley between Mission Mountain Wilderness and Bob Marshall Wilderness) that would facilitate connectivity across the larger landscape.

In the closing Chapter 4, I present (a) multi-species composite values, and (b) make recommendations for wildland protection for each of the Geographic Areas across the Flathead National Forest. To facilitate agency use of this information, I have listed the pertinent literature in each of the chapters. In Appendix I, I provide a detailed examination of vulnerability for each of the five focal species, along with supporting literature for that particular species.

Figure 6. Six geographic areas across the Flathead National Forest, Montana, so designated to faciltate discussions about revision of the Forest Plan.



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2. KEY CONSERVATION AREAS FOR VULNERABLE FISH AND WILDLIFE

Introduction

In this chapter, I provide a brief synopsis of vulnerability for 5 species of native fish and wildlife. A detailed profile with supporting literature citations is provided in Appendix I, and I strongly encourage people to read the full profiles. Next, I describe the methods for scoring areas of conservation value for that particular species and provide supporting literature citations. Lastly, I provide GIS-based maps of the distribution of key conservation areas for the species across the Flathead National Forest, as well as a table summarizing the amount of area (acres) in each conservation value for the 6 Geographic Areas. I highlight key areas of conservation value in a geographical narrative.

Vulnerability Profiles

Vulnerability refers to the susceptibility of species to disturbances of various kinds. Over millennia, species have evolved a variety of mechanisms that enabled them to withstand environmental disturbance and still persist (high resistance and/or resiliency). Yet some species seem more vulnerable than others. What factors contribute to their vulnerability?

Following Weaver et al. (1996), I postulate a basic attribute of vulnerability (lack of resistance or resiliency) at each of three hierarchical levels: individual, population, and metapopulation. Because disturbances occur at different spatial and temporal scales, no single level of organization can respond adequately to all disturbances. Hence, the nested structure decreases vulnerability to disturbance by linking the system across hierarchical levels.

At the individual level, an animal can exhibit narrow physiological tolerance to an environmental condition or little behavioral flexibility in food acquisition and selection of habitat (i.e., 'specialist'). For example, if there is change in food availability or suitability of habitat, an individual may not be able to substitute one resource for another.

At the population level, native fish may have little resistance to invasion by non-native fish and are vulnerable to hybridization and/or competition. Some mammals cannot compensate for excessive mortality with increased reproduction and/or survivorship to mitigate demographic fluctuations. High survivorship and longevity of reproducing adult females typically is critical to the continued well-being of many mammal populations.

At the metapopulation level, dispersal enables animals to augment an existing population or re-colonize an area where a population has been extirpated. Dispersal usually refers to movements by juvenile animals when leaving their natal range after reaching the age of independence (adults occasionally disperse, too). Dispersal is successful only if the individual survives, establishes a home range, finds a mate and reproduces. Successful dispersal is the mechanism by which declining populations are supplemented, genes are shared across the landscape, and functional connectivity of meta-populations is established. Where landscapes have been fragmented by human disturbance, animals may not be able to disperse successfully

In reference to human disturbance, niche flexibility addresses the problem of loss or change in habitat conditions. Capacity for greater productivity enables populations to compensate for overexploitation or to come through a genetic 'bottleneck' more quickly. Dispersal addresses the problem of habitat fragmentation at a landscape scale. As human activities accelerate rates of disturbance across a greater extent of the landscape, the combination of rapid change and simplification can undermine the evolved resiliency of species and render their populations more fragile. Cumulative effects can accrue that threaten their persistence. One of the key messages of resilience thinking is to *keep future options open through an emphasis on ecological variability across space and time*, rather than a focus on maximizing production over a short time.

I provide a brief synopsis of vulnerability for 5 species of native fish and wildlife. Each profile addresses the following factors: (1) niche flexibility, (2) resistance to hybridization (fish) or reproductive capacity and mortality risk (mammals), (3) dispersal and connectivity, (4) sensitivity to human disturbance, and (5) response to climate change. A detailed profile with supporting literature citations is provided in Appendix I, and I strongly encourage people to read the full profiles.

Methods for Scoring Conservation Importance

To assess the relative importance of areas across the Flathead National Forest in Montana, I developed a scoring system to quantify the conservation values for vulnerable fish and wildlife species. The scoring system comprised 2 relative ranks: *Very High* Importance = score of 3 and *High* Importance = score of 2. In the case of grizzly bears, I assigned Moderate Importance = score of 1 to areas of very high or high habitat values, but high mortality risk due to roads. This highlighted potentially valuable areas that may warrant strategic management attention.

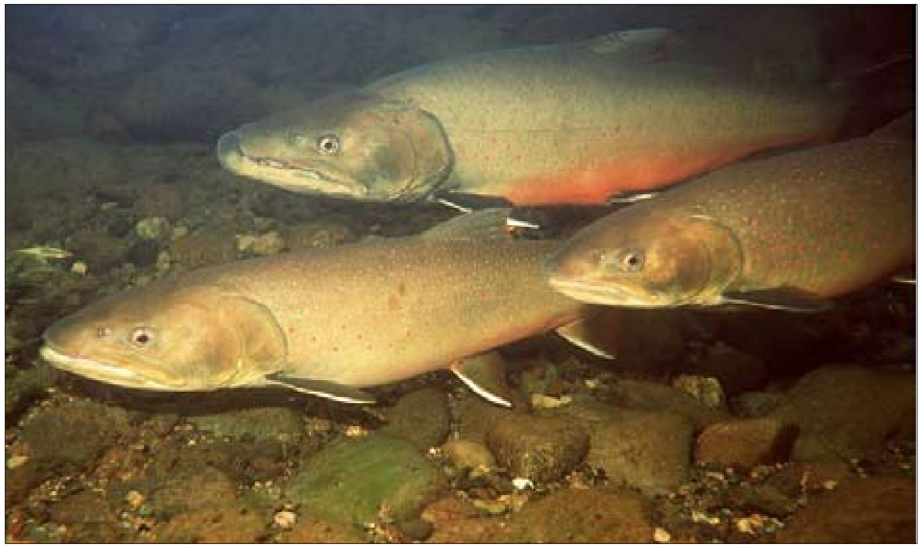
I customized the scoring criteria for each vulnerable species to reflect attributes that are important to the long-term persistence of that species. In several cases, a higher score incorporates either direct assessment or consideration of future habitats under warming climate – with the intent of providing some future options for that species. For example, in the case of wolverines, places where snow cover persists during a critical spring period are a critical element of their distribution and population ecology. I assigned a high score (2) to areas where such snow cover is likely to remain until the year 2050 under different climate-change scenarios. Details of the scoring system are provided under each species.

Description of Key Areas of Conservation Value

I used the scored maps of very high and high importance to identify key conservation areas for each species. I summarize the total area in each category across the Flathead NF and note what proportion occurs within roadless areas. For each Geographic Area, I provide a more detailed narrative of the key streams or lands for the species within that unit.

Although synthesis of existing information was central to this assessment, I believe strongly in the value of field reconnaissance. Since 1985, I have spent many days afield on the Flathead National Forest in various research and management capacities. During 2009-2014, I hiked and rode horse-back many miles on and off trails in reconnaissance of specific roadless areas for this report.

Bull Trout


US Fish and Wildlife Service

Vulnerability Profile

Bull trout exhibit **high vulnerability** due to low resistance to a variety of factors. They have a stringent demand for cold waters – especially for spawning and rearing. Bull trout populations are impacted by non-native lake trout and brook trout. Although adult bull trout can move long distances, human fragmentation of hydroscapes can have acute effects on dispersal and connectivity. Bull trout are vulnerable to several detrimental effects of human activities associated with roads such as increased sedimentation into streams. Finally, climate change may warm lower-elevation waters past their tolerance. This may result in loss of suitable habitat, smaller and more isolated populations, and lower population viability. Protection of clean, cold, structurally-complex and well-connected habitat from invasion by non-native fish remains a central strategy in the conservation of bull trout. For a more detailed profile and supporting literature, see Appendix I: pp 120-126. Bull trout in Montana are federally listed as 'threatened' under the Endangered Species Act and critical habitat has been designated (USFWS 2010).

Methods for Scoring Conservation Importance

The primary challenge in conservation of bull trout is to maintain viable populations with genetic integrity in suitable aquatic habitats that are cold, clean, complex, and connected (USFWS 2002). Crucial habitats included lakes, main stems of rivers, and tributaries to capture all the various life history stages and full range of migration/resident strategies. As climate change unfolds, however, waters at lower elevations may become too warm for bull trout, especially for spawning and rearing (Rieman et al. 2007, Isaak et al. 2010). Tributaries may provide important future options (refugia) due to higher elevation and the input of cooler groundwater (Jones et al. 2013).

The U.S. Fish and Wildlife Service designated critical habitat for bull trout on October 18, 2010 (USFWS 2010). Critical habitat included (1) tributary streams where spawning and rearing (SR) occurred, and (2) rivers/streams or lakes/reservoirs where bull trout foraged, migrated, and/or overwintered (FMO). For occurrence of bull trout in this report, I used the map of critical habitat designated by U.S. Fish and Wildlife Service. For the North Fork Flathead River, I also used the most recent distribution map of SR and FMO habitat based upon research by aquatic biologists (C. Muhlfeld, USGS, *personal communication*).

Accordingly, I assigned the following importance scores for bull trout:

Very High	(3)	=	spawning and rearing habitat in upper tributaries (SR)
High	(2)	=	rivers/lakes for foraging, migration, over-wintering (FMO)

Key Conservation Areas

Cold-water drainages in the Flathead River and Swan River watersheds have been deemed a stronghold for bull trout in the Columbia River system (USFWS 2010). Approximately 470 mi of streams with *very high* conservation value (spawning and rearing, SR) and 293 mi of *high* conservation value (foraging-migration-overwintering, FMO) on the Flathead National Forest have been designated as *critical habitat* by the US Fish and Wildlife Service (Table 1, Figure 7). About 33.3 mi (7%) of SR habitats and 17.7 mi (6%) of FMO habitats occur on remaining roadless areas. Of course, the ecological integrity of upland areas within a watershed affects the health of the streams and lakes. Moreover, bull trout using different tributaries have unique genetic differences (Kanda and Allendorf 2001). Thus, maintaining local populations is vital to safeguard genetic diversity and to promote long-term persistence of bull trout (Spruell et al. 2003). A major concern in conservation and recovery of bull trout in the Flathead River basin is competition and predation by non-native lake trout (Martinez et al. 2009, USFWS 2010).

North Fork: Bull trout migrate upwards of 150 mi between Flathead Lake and upper tributaries of the North Fork (into B.C.) during their long life history (Fraley and Shepard 1989, Muhlfeld and Marotz 2005). The entire North Fork Flathead River and many of its tributaries have been designated as critical habitat for bull trout. Designated tributaries on the Flathead National Forest with their source in the roadless Whitefish Range include: Trail Creek, Whale Creek and South Whale Creek, Red Meadow Creek, Coal Creek and South Fork Coal Creek, Cyclone Creek, and Big Creek and its upper tributary Hallowat Creek. Moose Creek, Hay Creek, and Moran Creek provide FMO habitat. None of these areas are protected by Wilderness designation.

Middle Fork: The upper Middle Fork of the Flathead River and its major tributaries within the Great Bear Wilderness and Bob Marshall Wilderness have been designated as critical habitat. Designated streams within roadless areas include headwaters of Granite Creek and Morrison Creek. In addition, several short streams in the narrow roadless area adjacent to U.S. Highway 2 flow into the lower Middle Fork, which has been designated as critical habitat.

Hungry Horse: Wounded Buck Creek, Wheeler Creek, Quintonkon Creek, and Sullivan Creek have been designated as critical habitat as SR habitat. In addition, numerous streams throughout this Geographic Area flow into Hungry Horse Reservoir, which has been designated critical habitat (FMO). Little of this area is protected by Wilderness designation.

South Fork: The entire South Fork of the Flathead River and several of its major tributaries have been designated as critical habitat. Those within the Bob Marshall Wilderness include Youngs Creek, Gordon Creek, Big and Little Salmon, and White River. Outside the wilderness, Bunker Creek (SR) and the Spotted Bear River (FMO) have been designated, too.

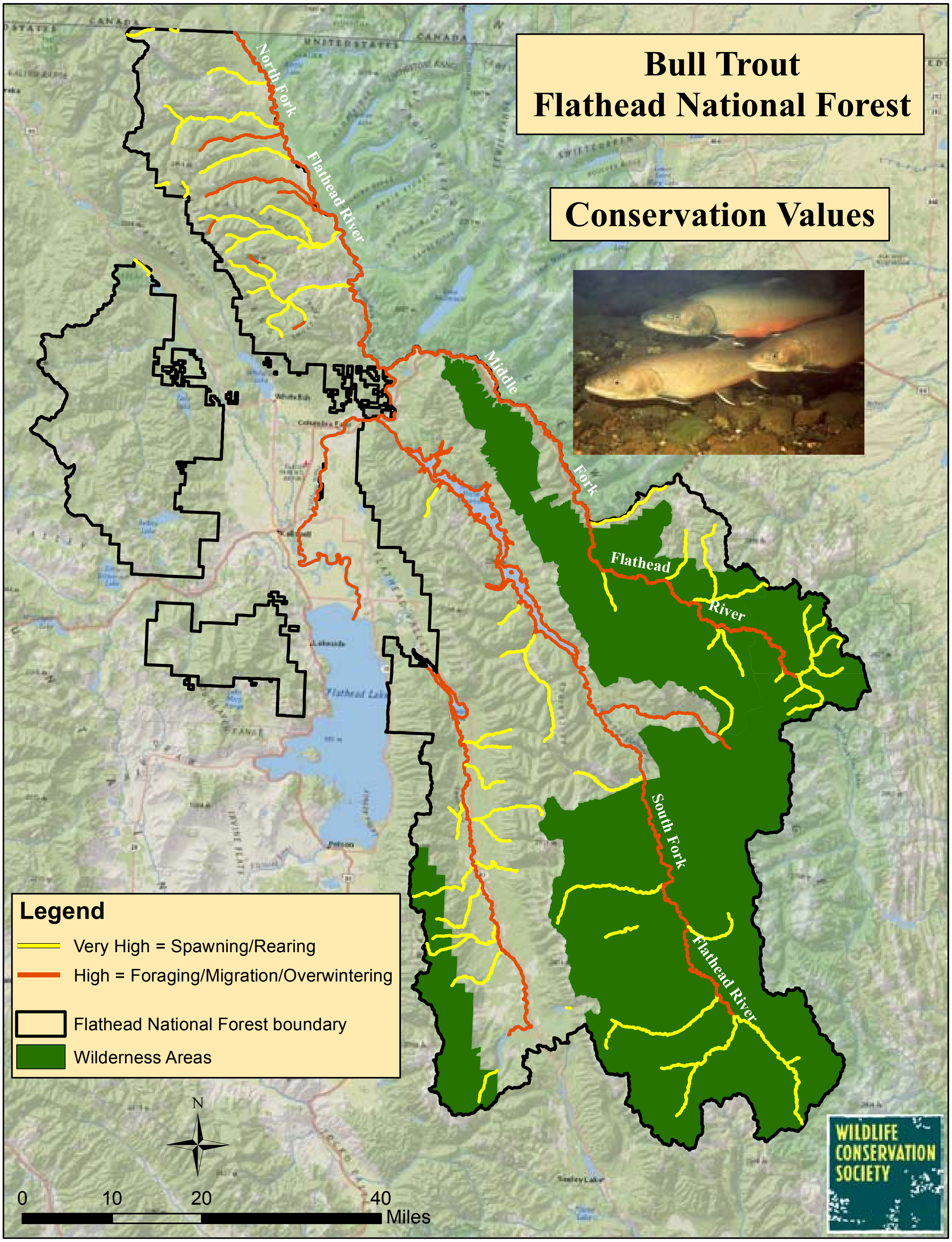
Salish Mountains: No streams on Flathead National Forest lands within this Geographic Area have been designated as critical habitat for bull trout.

Swan Valley: The entire Swan River, including Swan Lake, has been designated as critical habitat. Designated waters with their source in the roadless Swan Range include: Holland Lake, Lion Creek, Squeezer Creek, Goat Creek, Soup Creek, and both South Fork and North Fork Lost Creek. Several tributaries descending from the Mission Mountains on the west side of the Swan Valley have been designated as critical habitat for bull trout. These include Elk Creek, North and South Forks Cold Creek, Jim Creek, Piper Creek, and North and South Forks Woodward. Headwaters of these streams occur within the Mission Mountains Wilderness, while lower stretches run through roaded areas.

Table 1. Length (mi) of streams and percentage with bull trout conservation values in Wilderness, roadless, and other areas by designated Geographic Areas on the Flathead National Forest, Montana.

	Very High CV (3)				High CV (2)			
Geographic Area	**Length**	**Wild**	**Roadless**	**Other**	**Length**	**Wild**	**Roadless**	**Other**
North Fork	127.6	0.0	9.6	90.4	70.1	0.0	7.6	92.4
Middle Fork	98.7	77.7	7.1	15.2	74.1	57.0	0.8	42.2
Hungry Horse	26.1	0.0	24.1	75.9	16.1	0.0	0.0	100.0
South Fork	115.1	90.4	3.7	5.9	78.7	52.2	15.0	32.8
Salish Mtns	2.5	0.0	0.0	100.0	0.0	0.0	0.0	0.0
Swan Valley	99.9	16.9	3.5	79.6	54.3	0.0	0.0	100.0
TOTAL %	100.0	42.0	7.1	50.9	100.0	28.4	6.0	65.6
TOTAL mi	469.9	197.6	33.3	239.0	293.3	83.3	17.7	192.3

Figure 7. Location of key streams and critical habitat for bull trout, Flathead National Forest, Montana.



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Westslope Cutthroat Trout

Michael Ready

Vulnerability Profile

Westslope cutthroat trout exhibit **high vulnerability** due to low resistance and resiliency to human impacts. Like bull trout, they are adapted to a cold-water niche – especially for spawning and rearing. Moreover, westslope cutthroat have especially low resistance to invasion and genetic swamping by non-native trout. Due to the wide-spread introduction of rainbow trout, most of the remaining genetically-pure populations of westslope cutthroat trout are now confined to headwater streams – where they have low growth and productivity. Westslope cutthroat trout are vulnerable to several detrimental effects of human activities associated with roads such as increased sedimentation into streams and surreptitious release on non-native trout. Finally, climate change may counteract the thermal advantage of westslope cutthroat trout in cold waters, lead to further genetic introgression by non-native trout, and further isolate remnant pure populations in headwaters. The net consequence will be lower population viability. Two strategies appear useful: (1) safeguarding large, well-connected networks that retain genetically-pure populations of westslope cutthroat trout, and (2) installing barriers to protect selected cutthroat populations and/or stocking streams with natural barriers with genetically-pure specimens. For a more detailed profile and supporting literature, see Appendix I: pp 127-132.

Methods for Scoring Conservation Importance

Maintaining genetic integrity of westslope cutthroat trout in suitable cold-water habitat is widely considered to be a primary challenge in their conservation. The status assessment of westslope cutthroat trout designated populations with ≤10% genetic introgression as 'conservation populations' (Shepard et al. 2005). Although including hybridized populations is subject to debate, some fish managers argue that elimination of any genetically-contaminated population might result in loss of unique phenotypic, genotypic, and behavioral variations

(Dowling and Childs 1992). Others have recommended that only genetically pure populations of westslope cutthroat trout should be protected because this would best safeguard their evolutionary legacy, protect local adaptations presumed important for long-term persistence, and minimize opportunity for spread of introgression (Allendorf et al. 2004). However, there are documented cases where WCT populations with slight introgression (5-10%) have recovered over time to 100% genetic integrity (Bennett and Kershner 2009). Moreover, the best prospects for conservation of pure westslope cutthroat trout involve spacious watersheds (or upper portions) where large, more viable WCT populations can reside in genetic security (Hilderbrand and Kershner 2000).

Following the multi-state assessment of genetic status and conservation needs of westslope cutthroat trout (Shepard et al. 2005 [updated 2009]), I mapped two levels of 'conservation populations' of westslope cutthroat trout: (1) *Core Conservation Populations* = ≥99% genetic purity and (2) *Conservation Population* = ≥90% but <99% genetic purity. I also distinguished streams where genetic integrity had been tested from those where genetic integrity had been assumed (mostly within Wilderness areas). For this report, I used the latest information (2013) on genetic status of sampled streams (Muhlfeld et al. 2009; J. Bower, Montana FWP/ M. Boyer, Montana FWP/ C. Muhlfeld, USGS – *unpublished data*).

Accordingly, I assigned the following importance scores for westslope cutthroat trout:

Very High	(3)	=	populations of ≥99 % genetic purity
High	(2)	=	populations of ≥90 % but <99% genetic integrity

Key Conservation Areas

About 1456 mi of streams with *very high* conservation value and 149 mi of *high* conservation value for westslope cutthroat trout (WCT) occur on the Flathead National Forest, Montana (Table 2, Figure 8). Of those streams with pure populations of WCT, about 59% occur in Wilderness areas, 11% in roadless areas, and 30% in roaded Forest areas. Of streams with WCT populations having slight introgression, about 16% occur in Wilderness areas, 8% in roadless areas, and 76% in roaded Forest lands. The Flathead NF – especially the South Fork Flathead River watershed – is a major stronghold for westslope cutthroat trout.

North Fork Flathead: Westslope cutthroat trout occur throughout the North Fork Flathead River watershed, albeit with a wide spectrum of genetic integrity. Most of the genetic introgression by non-native rainbow trout has occurred in the lower-elevation, warmer streams in the lower section of the drainage, which are closer to the main source of hybridization in Abbot Creek (Boyer et al. 2008, Muhlfeld et al. 2009b). Nonetheless, numerous streams in the North Fork Flathead River still have pure strains of westslope cutthroat trout: Colts Creek; Trail Creek and its tributaries Tuchuck Creek, Yakinikak and Ketchikan Creek, Moose Creek, Red Meadow Creek (but Red Meadow Lake may becoming a source of introgression), upper Hay Creek, Dead Horse Creek, upper sections of Big Creek and tributaries, and tributaries of Canyon Creek (Kimmerly

Creek, Dupuy Creek) (Muhlfeld et al. 2009a, Muhlfeld et al. 2009b, M. Boyer, Montana FWP, *unpublished data*). Most of these occur in streams with either headwaters and/or occupied reaches in roadless areas.

Middle Fork: In the upper Middle Fork Flathead River drainage (above Bear Creek), westslope cutthroat trout have tested as genetically-pure in the main stem and assumed pure in the vast network of tributaries. They are found in the following streams in roadless areas: Challenge Creek (tested), Puzzle Creek, Morrison Creek, Granite Creek, Dodge Creek and Skyland Creek. In the lower section of the Middle Fork Flathead River, Essex Creek and Tunnel Creek contain genetically-pure populations of westslope cutthroat trout.

Hungry Horse: The South Fork Flathead River drainage is considered the stronghold for pure populations of westslope cutthroat trout due to the large network of streams free of genetic invasion by rainbow trout (M. Deleray, Montana FWP, *personal communication*). All of the east-side tributaries to Hungry Horse Reservoir contain genetically-intact WCT populations (majority have been tested), with sections of their headwaters flowing through roadless areas. Nearly all of the west-side streams descending from the roadless Swan Range have genetically-pure populations, including: Sullivan Creek and its tributaries, Quintonkon Creek, Forest Creek, Jones Creek, Graves Creek, Clayton Creek, Wounded Buck and Wildcat Creeks, and Doris Creek. Montana FWP has an active program to eliminate non-native trout in some headwater lakes, where they are causing genetic introgression downstream (Montana FWP 2005).

South Fork: Most of the upper South Fork Flathead River drainage lies within the Bob Marshall Wilderness and has widespread, pure populations of westslope cutthroat trout (with exception of Gorge Creek and Big Salmon Lake Creek). In the roadless areas, several streams contain pure populations of WCT: both forks of Bunker Creek and String Creek; Addition, Bruce and Tin Creeks; and a portion of Spotted Bear River and its tributaries Big Bill Creek and Whitcomb Creek.

Salish Mountains: Several small streams in the Salish Mountain area have isolated populations of pure WCT. Altogether, these amount to 2.5% of total length of all streams with pure WCT on the Forest and all occur in roaded landscapes.

Swan Valley: Unfortunately, the genetic integrity of westslope cutthroat trout has been compromised in many streams throughout the Swan River drainage. On the east side of the valley, streams with genetically-intact populations of WCT or their source waters in roadless areas include Cooney Creek, Dog and Pony Creeks, South Fork Lost Creek, Bond Creek and Groom Creek. A few streams flowing out of the Mission Mountain Wilderness on the west side of the Swan Valley retain pure populations of WCT. None of the remaining small patches of roadless area there have much value for these native trout.

Table 2. Length (mi) of streams and percentage with westslope cutthroat trout conservation values in Wilderness, roadless, and other areas by designated Geographic Areas on the Flathead National Forest, Montana.

	Very High CV (3)				High CV (2)			
Geographic Area	Length	Wild	Roadless	Other	Length	Wild	Roadless	Other
North Fork	160.7	0.0	27.4	72.6	91.2	0.0	2.8	97.2
Middle Fork	365.0	83.3	5.9	10.8	0.0	0.0	0.0	0.0
Hungry Horse	221.2	10.4	27.8	61.8	3.6	0.0	0.0	100.0
South Fork	626.4	83.3	6.1	10.5	28.6	68.9	18.9	12.2
Salish Mtns	36.7	0.0	0.0	100.0	3.6	0.0	0.0	100.0
Swan Valley	55.6	20.7	7.6	71.6	21.9	18.3	17.8	63.9
TOTAL %	100.0	58.7	11.6	29.7	100.0	15.9	7.9	76.2
TOTAL mi	1465.6	860.7	169.6	435.3	148.9	23.7	11.8	113.4

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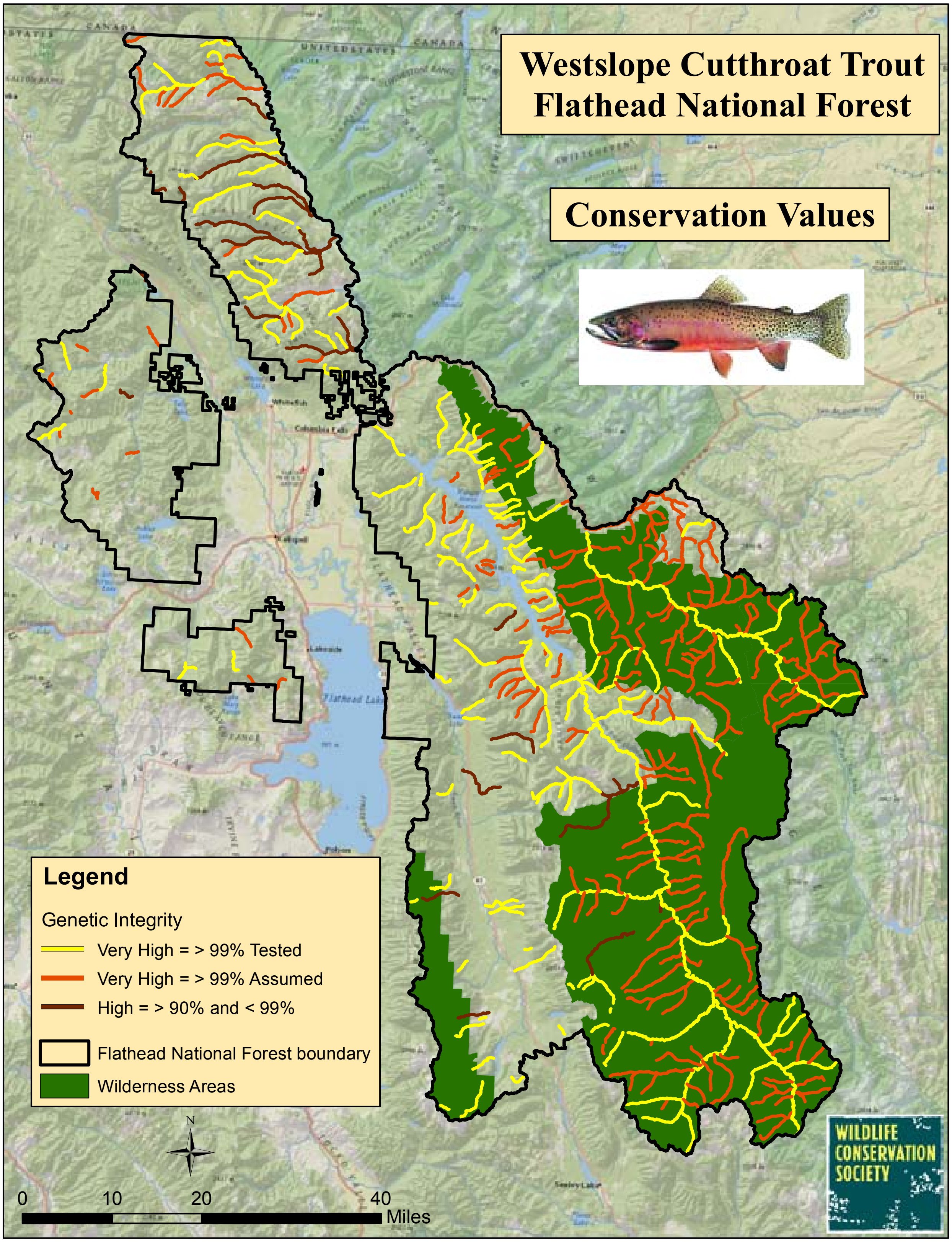
Figure 8. Location of key streams and conservation values for westslope cutthroat trout, Flathead National Forest, Montana.



Grizzly Bear

Milo Burcham

Vulnerability Profile

Despite their resourcefulness, grizzly bears exhibit **high vulnerability** due to low population resiliency. They require secure access to quality forage both in spring and late summer – fall, but roads with moderate traffic volume can displace bears from key habitats. Young females do not disperse very far and adult females do not readily cross major highways, which makes bear populations susceptible to landscape fragmentation. Most importantly, bears have very low reproduction and cannot quickly compensate for excessive mortality. Numerous studies have demonstrated that road access into high-quality habitats can increase encounter rates with people and lead to displacement, habituation, or mortality of bears. How bears may respond to climate changes remains uncertain, but more human activity could restrict their movements and elevate mortality risk as bears search for suitable habitats. Altogether, this does not provide much resiliency in human-dominated landscapes. For a more detailed profile and supporting literature, see Appendix I: 133-140. In the U.S., the grizzly bear is federally listed as a threatened species under the Endangered Species Act.

Methods for Scoring Conservation Importance

The key to successful grizzly bear conservation is to manage both from the bottom-up for secure access to important food resources and from the top-down for lower risk of human-caused mortality (Weaver et al. 1986, Nielsen et al. 2010). Accordingly, I combined data and maps of (1) high-quality habitat components as well as (2) zones of displacement and mortality risk around roads.

To map habitat for grizzly bears, I devised a model that incorporates *primary* and *secondary* habitat components. Primary habitat components of very high value included areas where grizzly bears direct their foraging at various seasons

– productive riparian zones, avalanche chutes, patches of huckleberry resulting largely from fires, and slab rock sites (Mace and Bissell 1985, McLellan and Hovey 1995, Waller and Mace 1997, Graves et al. 2011). Secondary habitat components included other (non-overlapping) habitats of various forest, grass, and shrub types also used by grizzly bears (R. Mace, Montana FWP, *unpublished data*). To map these primary and secondary habitat components, I placed a grid of 1-km^2 cells across the grizzly bear recovery zone on the Flathead NF (total = 10,031 grid cells).

To delineate productive riparian habitats, I mapped rivers and tributary streams having the following attributes: low stream gradient (0-3%), moderate-high stream sinuosity, multiple channels, and/or abandoned oxbows/meanders. I inspected <u>each</u> cell using on-line Bing aerial photographs at scales down to 1:5,000.

To map avalanche chutes, again I used on-line Bing aerial photographs at scales down to 1:5,000. I inspected each 1-km^2 cell for presence (rather than the total number) of avalanche chutes with a clear path of green vegetation between stringers of trees. I did not map chutes that appeared to be primarily composed of rock rubble nor the 'head' of the chute if it appeared barren. I measured the width of the chute at the broadest point and tallied whether it was < or ≥ 100 m because there is some suggestion that bears select the wider chutes (Serrouya et al. 2011). I evaluated this mapping approach by comparing it to a surficial geology map of Glacier National Park (Carrara 1990) and found that I had identified all the avalanche chutes delineated on that map. I also compared my mapping with a map of avalanche chutes and rock formations prepared in 2005 for the Northern Continental Divide grizzly bear ecosystem under the supervision of Tabitha Graves (courtesy T. Graves, USGS, *unpublished data*). My mapping criteria yielded a slightly more conservative map of areas with green avalanche chutes (exclusive of rocky sites). For some more remote areas of the Bob Marshall Wilderness, I relied exclusively upon the Graves map.

Although huckleberry grows on a wide variety of sites, the most productive patches typically are found on relatively open, mesic sites at mid-high elevations 20-80 years of age, often following a fire (Martin 1983, Simonin 2000). Huckleberries occur in avalanche chutes and/or the adjacent forest stringers, too. Logged sites can be productive for shorter duration if the ground has not been scarified and heavily planted (Zager et al. 1983). I developed a model of huckleberry distribution using the following variables and parameters gleaned from various studies (Pfister et al. 1977, Martin 1983, compilation in Simonin 2000):

Elevation	1400 – 1999 m
Tree dbh (surrogate for stand age)	≤9.9" (20 – 80 years)
Canopy Closure	10 – 25 %
Aspect	NW (315°) → SE (135°)

(Note: Although this model is based on scientific studies and accords with some known sites, it should be considered provisional as it has not received extensive ground-truthing.)

I mapped secondary habitat components of high value using the latest version (12) of the Region 1 Vegetation Mapping Program (VMap) for the Flathead National Forest (Brown and Barber 2012). This program uses a combination of satellite imagery (30m Landsat Thematic Mapper) and airborne acquired imagery (1m National Agriculture Imagery Program), coupled with field sampling to devise algorithms for training the classification, with an accuracy of 70% - 90% for all attributes. I used the mid-level database (minimum mapping unit of 1 acre) and the 40% dominance rule for assigning tree species.

Richard Mace, grizzly bear biologist for Montana Fish, Wildlife, and Parks, kindly provided an analysis specifically requested for this assessment. The availability of various VMap cover types was determined on each of 4 cardinal aspects for both the North Fork Flathead River and Swan River Geographic Areas. I filtered out land cover types with <2% coverage and retained the following types: herbaceous, shrub, Douglas fir, lodgepole pine, larch mix, spruce, and subalpine fir. To determine use by bears, I partitioned telemetry locations of grizzly bears into 2 seasonal periods: (1) spring-early summer (emergence from dens until July 15), and (2) late summer-fall (July 16 until den entry). Based upon significant selection and overall high use by grizzly bears, I defined and mapped secondary habitat components as the following 5 cover types and aspect: (1) herbaceous-S, (2) shrub-S, (3) Douglas fir-S, (4) larch mix-N/E/S, and (5) subalpine fir-N/E/S. Finally, for scoring conservation value in 1-km grid cells, I filtered out those cells where the secondary habitat component comprised ≤10% of the cell area.

This simple habitat model performed well based upon the high percent of locations within areas predicted by the model:

1. average 89% (range 80-92%) of 24,200 locations of radio-collared female grizzly bears in the North Fork, South Fork, and Swan Valley Geographic Areas (data from the Northern Continental Divide Grizzly Bear Project kindly provided R. Mace, Montana FWP), and
2. 95% of 4329 locations of radio-collared female grizzly bears in the Hungry Horse and South Fork Geographic Areas (data from Waller and Mace 1997 provided by R. Mace, Montana FWP).

Finally, I created a security-zone map by buffering all highways, primary roads, and secondary roads by 500 m on each side (Mace et al. 1996, Northrup et al. 2012). Areas ≤ 500 m from such roads were defined as low security, whereas areas ≥ 500 m was deemed high security (Gibeau et al. 2001). With these GIS layers, I mapped and scored each 1-km^2 grid cell (following Nielsen et al. 2006):

1. primary habitats or 'safe harbours' (very high-quality habitat and high security) = score of 3
2. secondary habitats (high-quality habitat and high security) = score of 2
3. 'attractive sinks' (very high or high-quality habitats but low security) = score of 1.

Such an approach facilitates identification of conservation areas for grizzly bears (and non-critical areas) and enables managers to target *strategic* sites to improve security by modifying motorized access.

Key Conservation Areas

According to the habitat model, about 80% (2,090,318 ac) of the Flathead National Forest provides suitable habitat for grizzly bears (Table 3, Figures 9-10). Of these lands, about 60% (1,261,000 ac) scored as *very high* conservation value because they contain primary habitat components in a secure setting (>500 m from open road). About 228,318 ac of these sites occur in roadless areas. Another 31% (653,622 ac) scored as *high* value with secondary habitat components in a secure setting. About 194,252 ac of these sites occur in roadless areas. Altogether, roadless areas across the Forest contain 422,570 ac of key grizzly bear habitat. Another 8.4% (175,614 ac) of lands with very high or high habitat value received a *moderate* ranking because they occur within 500 m of an open road and thus have low security. Some of these roads offer a strategic opportunity for gaining conservation value through access management. Population surveys have documented very high densities of grizzly bears in Glacier National Park and the northern portions of the Flathead National Forest (Kendall et al. 2008, Kendall et al. 2009). Hence, the Flathead National Forest represents a major stronghold for grizzly bears in the lower 48 states.

North Fork: The North Fork has long been considered a key area for grizzly bears, with individuals moving between the Flathead NF, Glacier National Park, and adjoining portions of southeast British Columbia. It also supports many family groups of bears, which contribute to the demographic importance of the area. About 292,867 ac of very high and high quality habitat for grizzly bears occurs on the Flathead NF portion of the North Fork. Importantly, about 43% or 126,385 ac occurs in roadless areas. Another 55,000 acres received a moderate score because they have low security due to open roads. Much of the productive riparian habitat lies along the North Fork Flathead River, whereas avalanche chutes and huckleberry patches occur at higher elevations. None of the grizzly bear habitat in the North Fork is protected by Wilderness designation.

Middle Fork: About 84% of the 332,537 ac of very high and high quality habitat for grizzly bears lies in the Great Bear and Bob Marshall Wildernesses. Roadless areas provide another 33,879 ac (10%) of suitable habitat. Key roadless areas for grizzly bears include (1) the area south of Marias Pass, around Puzzle Creek-Slippery Bill Mountain, in upper Twenty-five Mile Creek, and along the Continental Divide adjacent to the Badger-Two Medicine area; and (2) Dickey Creek – Tunnel Creek area between U.S. Highway 2 and the Great Bear Wilderness.

Hungry Horse: About 235,736 ac of very high and high quality habitat for grizzly bears occurs throughout the northern Swan Range, with 113,174 ac (48%) in roadless areas. Grizzly bears occur commonly from Sullivan Creek north to Jewel Basin and Wounded Buck Creek, with adult females favoring the more remote areas (Mace and Waller 1996). Grizzly bears are also spending more time on the roadless west slopes of the Swan Range adjacent to the Flathead Valley in the vicinity of Blaine Mountain (R. Mace, Montana FWP, *unpublished data*). None of the grizzly bear habitat in the Swan Range is protected by Wilderness designation. Much of the primary grizzly bear habitat on the east side of Hungry Horse Reservoir lies within the Great Bear Wilderness, but the roadless section between Unawah Mtn and Crossover Mtn has good habitat in the basins.

South Fork: About 86% of the 701,905 ac of very high and high quality habitat for grizzly bears lies in the Great Bear and Bob Marshall Wildernesses. Roadless areas provide another 63,690 ac (9%) of suitable habitat. Some of these roadless areas are especially important for grizzly bear, notably Bunker Creek-Addition Creek-Bruce Ridge where numerous locations of radio-collared bears have been recorded and habitat components are abundant.

Salish Mountains: The Salish Mountains lay outside the recovery zone for grizzly bears in the Northern Continental Divide Ecosystem and are not addressed in the Forest Plan.

Swan Valley: About 351,659 ac of very high and high quality habitat for grizzly bears occurs in the Swan Valley. Importantly, about 24% or 85,442 ac occurs in the roadless part of the Swan Range on the east side of the Swan Valley. The southern section (Wolverine Peak north to Inspiration Point) has a high density of primary habitats for grizzly bears and connects to the adjacent Bob Marshall Wilderness. The northern section (Inspiration Point north to Jewel Basin) along the Swan Crest is contiguous with grizzly bear habitat in the adjacent roadless area in the Hungry Horse and South Fork (Bunker Creek) geographic areas. In recent years, numerous radio-collared grizzly bears have been documented using the mixed-ownership lands in the central valley floor of the Swan Valley during spring, summer, and fall (R. Mace, Montana FWP and others, *unpublished data*). Ten of 11 known mortalities during 2000-2005, however, occurred in the valley bottom.

Table 3. Area (ac) of grizzly bear conservation values in Wilderness, roadless and other areas by designated Geographic Areas on the Flathead National Forest, Montana.

	Very High CV (3)				High CV (2)				Mod CV (1)			
Geographic Area	**Area**	**Wild**	**Roadless**	**Other**	**Area**	**Wild**	**Roadless**	**Other**	**Area**	**Wild**	**Roadless**	**Other**
North Fork	122,988	0	58,310	64,678	169,879	0	68,075	101,804	52,233	0	4,757	47,476
Middle Fork	286,715	254,299	20,067	11,350	45,822	25,866	13,812	6,143	7,602	98	1,776	5,728
Hungry Horse	130,287	17,881	74,041	38,365	105,449	2,607	39,133	63,710	49,611	0	5,043	44,568
South Fork	550,598	509,354	32,456	8,788	151,307	98,128	31,234	21,945	7,757	5	705	7,047
Salish Mtns	0	0	0		0	0	0		0	0	0	0
Swan Valley	170,494	59,931	43,444	67,120	181,165	14,140	41,998	125,028	58,411	176	1,743	56,492
TOTAL %		66.7	18.1	15.1		21.5	29.7	48.8		0.1	8.0	91.9
TOTAL ac	1,261,082	841,465	228,318	190,301	653,622	140,741	194,252	318,630	175,614	279	14,024	161,311

Figure 9. Location of key habitat components for grizzly bears, Flathead National Forest, Montana.

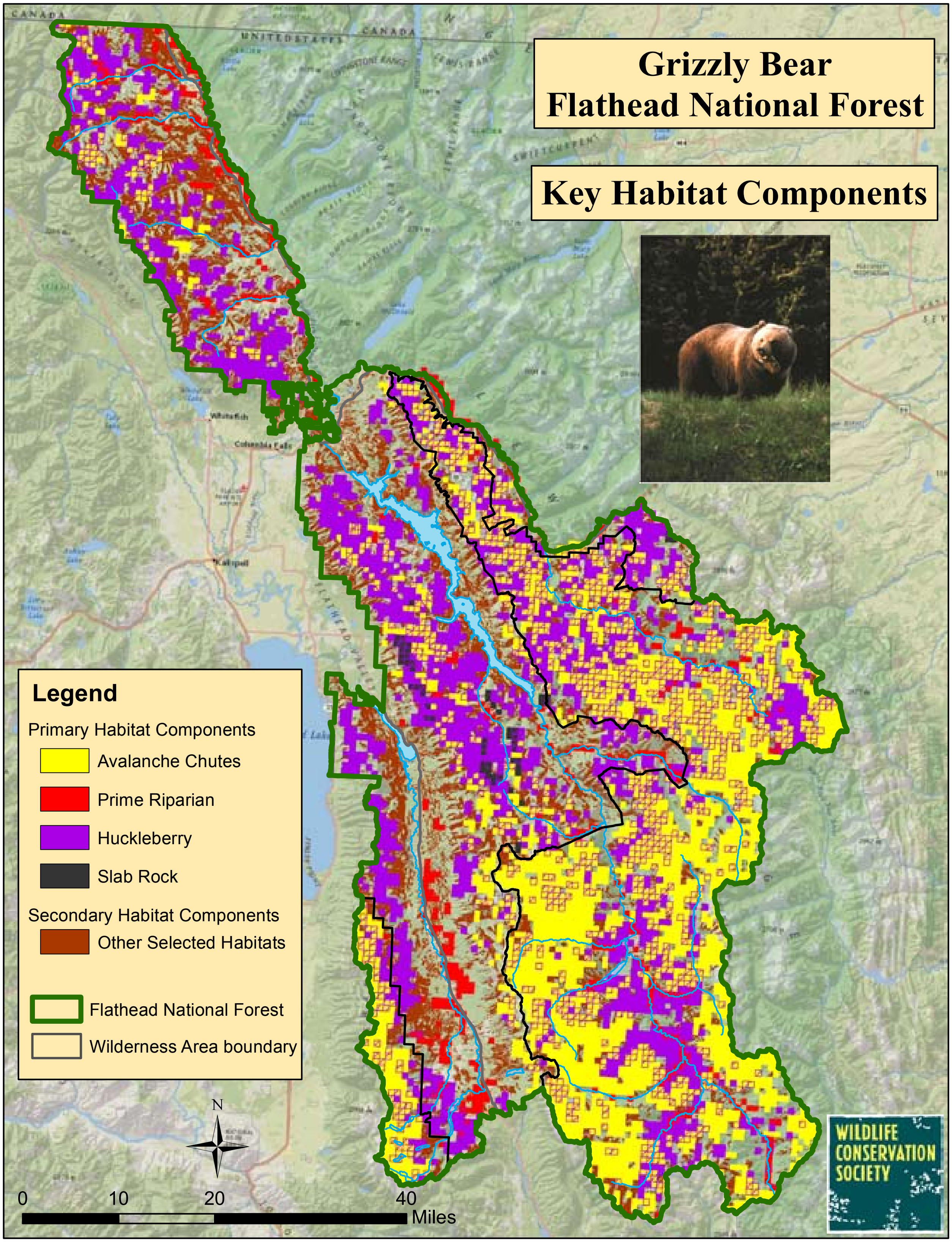
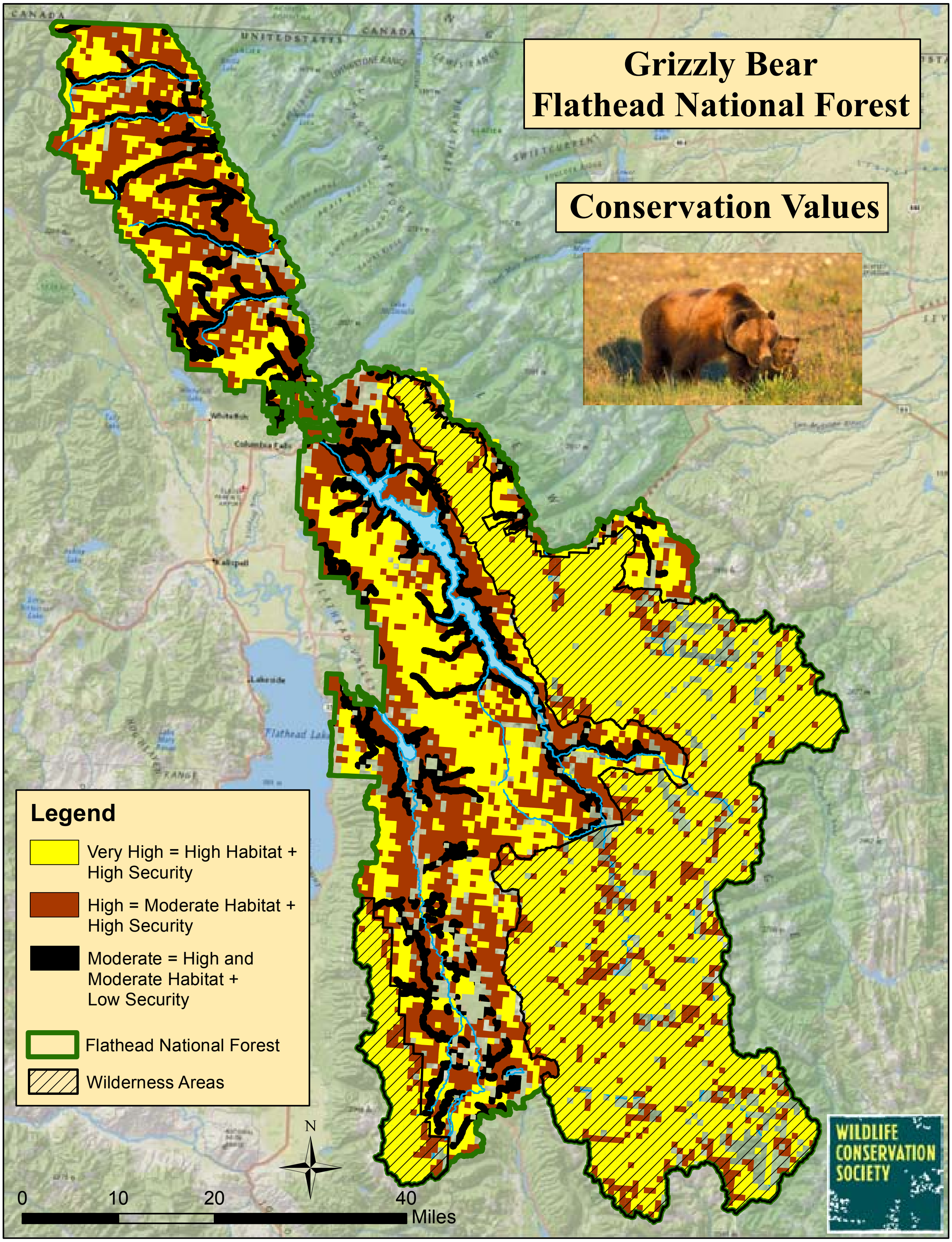


Figure 10. Location of conservation values for grizzly bears, Flathead National Forest, Montana.



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Wolverine

Photo: Larry Master

Vulnerability Profile

Wolverines exhibit **high vulnerability**. Although they have a broad foraging niche, wolverines select areas characterized by persistent snow cover during spring for their reproductive habitat, summer habitat, and dispersal routes. Wolverines have very low reproductive rates. Consequently, they cannot sustain high mortality rates, which can be exacerbated by trapping pressure – especially in areas of disjunct habitat patches. Trapping also may obviate the likelihood of successful dispersal by juvenile wolverines, which could impact the viability of meta-populations across a larger region. Wolverines appear sensitive to human disturbance near natal den sites, and major highways may impede movements leading to fragmentation. Due to their multi-faceted adaptation to snow environments, wolverines appear particularly vulnerable to reductions in suitable habitat at lower elevations resulting from projected warming climate. For a more detailed profile and supporting literature, see Appendix I: pp 141-147. The wolverine was proposed for federal listing as a 'threatened' species under the Endangered Species Act on February 4, 2013 (USFWS 2013).

Methods for Scoring Conservation Importance

I examined 2 verified models that predict suitable habitat for wolverines. The 'Copeland' model uses snow cover to predict geographic occurrence of wolverines across its circumboreal range (Copeland et al. 2010). These investigators developed a composite of MODIS satellite images (7 years from 2000-2006) that represented persistent snow cover throughout April 24 – May 15, which encompasses the end of the wolverine's reproductive denning period. Approximately 89% of summer and 81% of winter telemetry locations from 8 study areas in western North America concurred with spring snow coverage. Moreover, about 90% of 62 known wolverine den sites in North America occurred within spring snow cover for 5-7 years (J. Copeland, *unpublished data*). Pathways of dispersal by wolverines also appear limited largely to areas of spring snow cover (Schwartz et al. 2009). Thus, many central features of wolverine ecology – historical occurrence, habitat use across gender/age/seasons, den sites and dispersals – correspond to this bioclimatic envelope of spring snow cover.

The 'Inman' model delineates suitable habitat for resident adult wolverines, reproductive females, and dispersers across the western United States (Inman 2013). This model addresses 6 key components of wolverine ecology: food, competition, escape cover for young wolverines, birth sites, dispersal, and human disturbance. To delineate primary habitat used by resident adults, the researchers used logistic regression to compare habitat characteristics associated with 2,257 telemetry locations collected form 12 female and 6 male wolverines with those of random locations in the Greater Yellowstone Ecosystem. They also analyzed habitat characteristics for 31 natal den and rendezvous sites to identify maternal habitat. Their best model included 2 snow variables (April1 snow depth, distance to snow on April 1), 3 topographic variables (latitude-adjusted elevation, terrain ruggedness index, distance to high-elevation talus), 1 vegetation variable (distance to treecover), and 2 human variables (human population density, road density). This model performed well against 4 independent data sets and historical records of wolverine (Inman 2013, Murphy et al. 2011).

I tested the performance of each wolverine model on the Flathead National Forest with data from the pioneering field study of wolverines conducted during the late 1970s in the South Fork of the Flathead River in western Montana (Hornocker and Hash 1981). About 74% and 78% of 199 locations of adult wolverines during all seasons fell within the areas predicted by the Copeland and Inman models, respectively (J. Weaver, Wildlife Conservation Society, *unpublished data*). Both models missed many of the same locations, which were at slightly lower elevation during winter than predicted by the model. The Copeland model provided slightly more conservative maps of primary habitat, whereas the Inman model provided slightly more conservative maps of maternal habitat.

I identified key conservation areas for wolverines by combining or overlaying the 2 models and mapping the maximum extent of suitable habitat. I chose to map the maximum extent of habitat for 2 reasons: (1) direction and strength of the differences between models varied in complex patterns across the Flathead NF (and larger Crown ecosystem), and (2) a conservative approach in accounting for all areas deemed suitable habitat seemed warranted due to the proposed federal listing of wolverines as a 'threatened' species. I understand that the U.S. Fish and Wildlife Service also uses a combined model.

Because wolverine appear to be an obligate to areas covered by snow during spring (Copeland et al. 2010, Inman et al. 2012, Inman 2013), climate change projections of lesser snowpack will negatively affect wolverine habitat. Using an ensemble of climate-change models, McKelvey et al. (2011) estimated loss of wolverine habitat in the Columbia River basin by year 2045 of 27% in Montana and 12% in B.C. (the decrease in the Flathead region may be closer to the B.C. estimate). Because snow cover may be lost disproportionately at lower elevations of wolverine habitat, I approximated this loss by subtracting snow class 2 from the Copeland model, which appeared visually to best approximate the loss of snow cover in the Flathead region. For the Inman model, I assumed a warming scenario of 2º C (3.5º F) for western Montana by the year 2050 (per McWethy et al. 2009). Using a mid-point for moist and dry adiabatic lapse rates of 3.5º F/ 1000 ft elevation yielded an upslope shift of 1000 feet for lower bound of suitable habitat,. Due to varying patterns across the Flathead NF, the combined model produced an estimated 11% loss of primary habitat.

Accordingly, I assigned the following importance scores for wolverine:

Very High	(3)	=	Maternal Habitat
High	(2)	=	Current and Future Primary Habitat
Moderate	(1)	=	n.a. because current habitat was deemed equally important as future

Key Conservation Areas

According to the combined model, about 70% (1,674,938 ac) of the Flathead National Forest provides suitable primary habitat for wolverines (Table 4, Figure 11). About 55% (929,579 ac) of the current primary habitat serves as maternal habitat. The modeling of climate effects on snowpack at the year 2050 suggest about an 8% loss of primary habitat (at the lower elevations) but little loss of maternal habitat. Importantly, roadless areas across the Forest contain (1) 420,412 acres or 25.1% of the current primary habitat, (2) 369,378 acres or 26.6% of the future primary habitat, and (3) 259,506 acres or 27.9% of the maternal habitat for wolverines. The Flathead National Forest represents a major stronghold for wolverine in the lower 48 states, and its close proximity to Glacier National Park provides added conservation value.

North Fork: About 244,818 ac of primary habitat for wolverine is dispersed throughout much of the North Fork Flathead River basin, with 128,660 ac (53%) in roadless areas. Large blocks of primary wolverine habitat are rather ubiquitous across all of the roadless sections on the west side of the river. Blocks of maternal wolverine habitat are large and well-connected in the northern roadless sector of the North Fork Flathead River basin but become progressively smaller and less connected toward the south and southeast. None of the wolverine habitat in the North Fork is protected by Wilderness designation.

Middle Fork: About 85% of the 335,478 ac of primary wolverine habitat in the Middle Fork Flathead area lies in the Great Bear and Bob Marshall Wildernesses. Roadless areas provide another 36,616 ac (11%). Key roadless areas for wolverine include (1) the area south of Marias Pass, with maternal habitat along the Continental Divide, Slippery Bill Mountain, and in upper Twenty-five Mile Creek; and (2) Paola Ridge - Tunnel Ridge which provides a mix of primary and maternal habitat.

Hungry Horse: About 186,379 ac of primary habitat for wolverine occurs throughout much of the northern Swan Range basin, with 111,157 ac (60%) in roadless areas. This area was the focus of the first field study of wolverine in North America during the late 1970s by Maurice Hornocker and Howard Hash (1981). Those researchers estimated the density to be 1 wolverine per 25 mi^2, and home ranges (MCP) averaged 150 mi^2 for females and 165 mi^2 for males. Locations of radio-collared wolverine were distributed throughout the Swan Range west of Hungry Horse Reservoir, and particularly concentrated from Jewel Basin north to Doris Mountain.

Primary wolverine habitat occurs throughout the narrow roadless area along the east side of Hungry Horse Reservoir, whereas maternal habitat occurs at higher elevations mostly inside the Great Bear Wilderness. Some maternal habitat occurs in the roadless stretch from Logan Creek south to Crossover Mountain. Radio-collared wolverines used the Hungry Horse drainage northeast of the reservoir during summer and winter.

South Fork: About 89% of the 662,289 ac of primary wolverine habitat in the South Fork Flathead area lies in the Bob Marshall and Great Bear Wildernesses. Another 58,561 ac (9%) occurs in roadless areas. Key roadless areas for wolverine include (1) Bunker Creek-Addition Creek where numerous locations of radio-collared wolverine were gathered in the 1970s, and (2) north side of Spotted Bear River adjacent to the Great Bear Wilderness. Some wolverines initially radio-collared in Bunker Creek were legally trapped by commercial trappers in Lost Creek in the Swan Valley.

Salish Mountains: Small, isolated patches of wolverine primary habitat are scattered through the Salish Mountains, comprising only 1.7% of wolverine habitat on the Flathead NF. Only a trace of maternal habitat occurs there.

Swan Valley: In the roadless part of the Swan Range on the east side of the Swan Valley, there is about 85,000 ac of primary wolverine habitat with much of it suitable for maternal habitat. The southern section (Wolverine Peak north to Inspiration Point) is part of a large, connected complex that extends into the Bob Marshall Wilderness. The northern section (Inspiration Point north to Jewel Basin) along the Swan Crest is contiguous with wolverine habitat in the adjacent roadless area in the Hungry Horse and South Fork (Bunker Creek) geographic areas.

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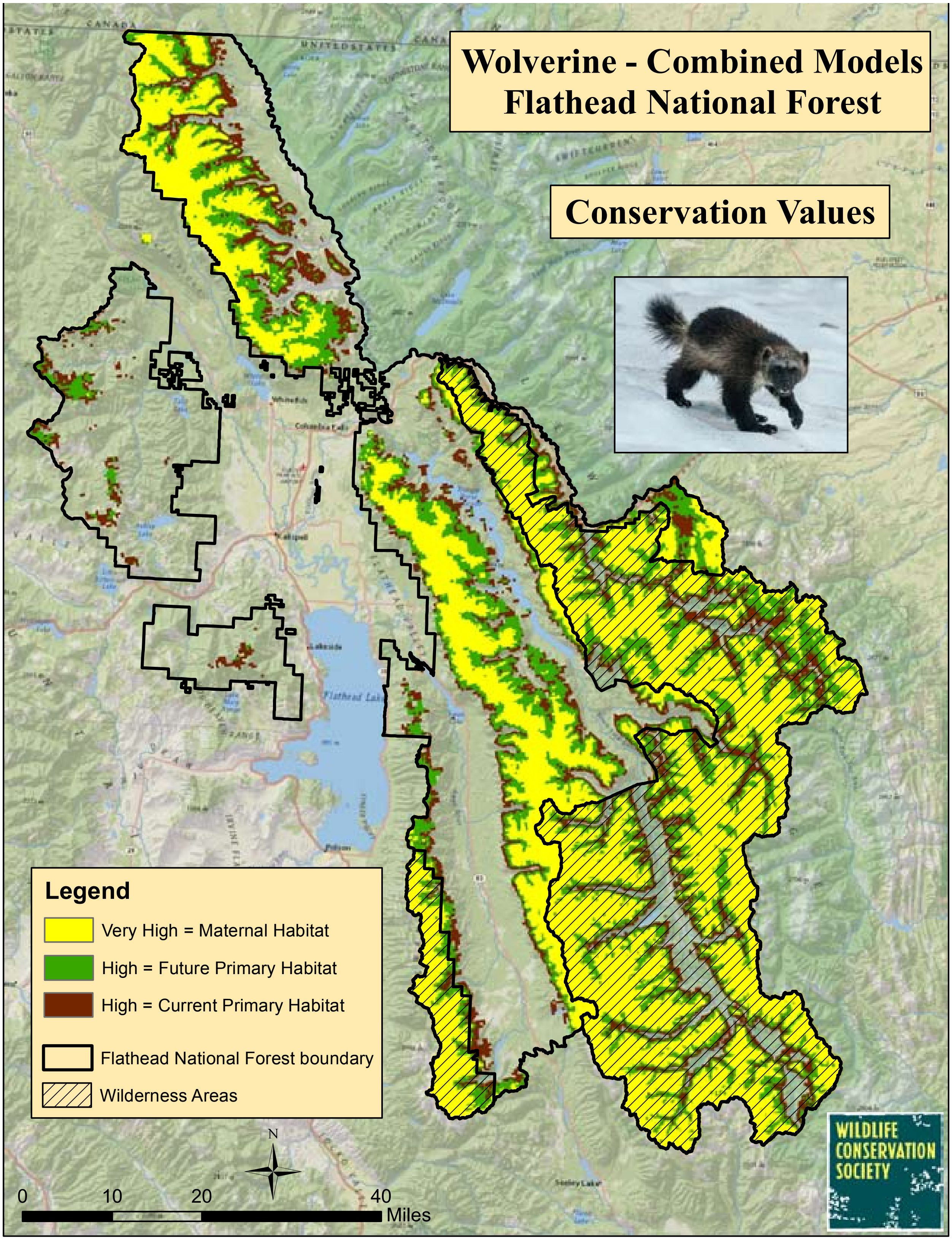
Table 4. Area (ac) and percent of wolverine habitats in Wilderness, roadless and other areas by designated Geographic Areas on the Flathead National Forest, Montana.

	Maternal Habitat (3)				Future Primary Habitat (2)				Current Primary Habitat (2)			
Geographic Area	Area	Wild	Roadless	Other	Area	Wild	Roadless	Other	Area	Wild	Roadless	Other
North Fork	119,785	0.0	69.3	30.7	192,692	0	58.6	41.4	244,818	0	52.6	47.4
Middle Fork	177,513	89.2	9.7	1.1	283,604	86.5	10.7	2.8	335,478	85.2	10.9	3.9
Hungry Horse	96,139	19.1	70.2	10.7	156,455	12.9	63.6	23.4	186,379	11.1	59.6	29.3
South Fork	414,648	91.5	7.8	0.8	575,781	90.2	8.4	1.4	662,289	89.3	8.8	1.9
Salish Mtns	57	0.0	0.0	100.0	0	0.0	0.0	0.0	28,735	0.0	0.0	99.9
Swan Valley	121,075	44.1	49.0	6.9	179,836	38.5	43.7	17.8	217,239	34.2	39.3	26.4
TOTAL %	55.5	65.6	27.9	6.5	82.9	61.5	26.6	12.6	100.0	58.1	25.1	16.8
TOTAL ac	929,217	609,274	259,506	60,799	1,388,368	854,463	369,378	164,527	1,674,938	972,403	420,412	282,108

Figure 11. Location of key habitats and conservation values for wolverines, Flathead National Forest, Montana. Map based upon combined data from Copeland model and Inman model (see text for details).



Mountain Goat

Photo: Steven Gnam Photography

Vulnerability Profile

Mountain goats exhibit **high vulnerability**. They are constrained to live on or very near cliffs that provide escape terrain from predators and more accessible forage in winter. Female goats have very low reproduction and cannot quickly compensate for excessive mortality (notably hunting). Goats, particularly males, do disperse modest distances which may provide connectivity among some populations. Mountain goats are sensitive to motorized disturbance (especially helicopters) and are vulnerable to over-harvest when roads facilitate easier access by hunters. In terms of climate-smart conservation strategies, maintaining secure access to a variety of aspects among cliffs and reducing other pressures could provide options. For a more detailed profile and supporting literature, see Appendix I: pp 148-151. Mountain goats are managed as a 'big game' species in Montana.

Methods for Scoring Conservation Importance

For distribution of mountain goat summer ranges, we develop a step-wise model. First, we calculated terrain ruggedness following a method developed by Poole et al. (2009) to define escape terrain for mountain goats. We used the curvature function in ArcGIS to generate a curvature grid (at 30m resolution) and then did a moving window analysis for standard deviation within a 90m radius of each grid cell. This provided a measure of the variability of the rate of change in slope for each grid cell. Thus, a high ruggedness value would indicate a high degree of change in slope and cliff complexity, which have been a diagnostic feature of other models of suitable habitat for mountain goats (Gross et al. 2002). Escape terrain was defined as pixels with a ruggedness value ≥1.854 (the top 3 of 5 classes when displaying the grid using natural breaks). Next, we constrained the model to escape terrain between elevation contours of 1900 m and 2500 m. Finally, we buffered those areas by 300 m as a conservative estimate of foraging distance away from escape terrain (Chadwick 1983, Hamel and Côté

2007). For distribution of mountain goat winter ranges (November-March), we used the same step-wise model but made two adjustments. We limited winter range to south-southwest aspects (157° - 247°) and lowered elevation by 200m to the 1700 m contour (Chadwick 1983, Poole et al. 2009).

This model performed well throughout the Crown of the Continent Ecosystem. On the Flathead National Forest in Montana, about 84% of 813 summer-fall locations during 1980-2009 fell within 90 m of predicted habitat (records kindly provided by J. Vore and E. Wenum, Montana FWP, *unpublished data*). Nearly all the areas mapped as occupied goat range there in the late 1940's (Casebeer et al. 1950) were characterized by extensive patches of suitable summer and winter habitat in our model. Elsewhere, about 90% of 1190 summer locations and 70% of 452 winter locations in southeast B.C. occurred within summer habitat predicted by the model (data from B.C. Fish and Wildlife Branch in Weaver 2013a). In southwest Alberta, 95% of 508 summer locations fell within predicted summer habitat and another 3% within 90 m (data courtesy of M. Jokinen, Alberta Conservation Association in Weaver 2013b).

Accordingly, I assigned the following importance scores for mountain goats:

Very High	(3)	=	suitable winter habitat
High	(2)	=	suitable summer habitat

Key Conservation Areas

Based upon the model of mountain goat habitat, about 61,643 ac of winter habitat and 189,621 ac of summer habitat occur on the Flathead National Forest (Table 5, Figure 12). About 84% of the winter habitat and 87% of the summer habitat for mountain goats is located in existing wilderness areas. Because some of the Wilderness boundaries coincide with hydrographic divides, however, there can be important habitat on the other side of the ridge just outside the Wilderness. These areas include nearly 10,000 ac of vital winter habitat and 24,000 ac of summer range. Below, I note certain key roadless areas that are contiguous with more extensive habitats inside wilderness areas.

North Fork: According to Casebeer et al. (1950), upwards of 40-50 mountain goats occurred during the late 1940s in three areas in the North Fork Flathead River basin: (1) Mount Thompson Seton – Hornet Mountain – Cleft Rock Mountain north of Whale Creek (est. 15 goats), (2) Nasukoin – Mount Young – Lake Mountain north of Red Meadow Creek (est. 30 goats), and (3) Smoky Range between Big Creek and Canyon Creek (est. 5 goats). Patches of suitable habitat for mountain goats, however, appear small and scattered. It is doubtful if any goats occur in any of these areas at this time (T. Thier, Montana FWP, *personal communication*).

Middle Fork: In the upper reaches of the Middle Fork of the Flathead River, mountain goats occupy the roadless section of the Puzzle Creek basin around Crescent Cliff and a few occur on roadless Slippery Bill Mountain, too. Mountain goats occur on adjacent lands in the rugged portions of the Badger-Two Medicine area (Lewis and Clark National Forest) between Running Crane Mountain and Big Lodge Mountain. These animals may use some habitat on the Flathead side of the Continental Divide. Some of the goats using mineral licks at the well-known site at Snowslide Gulch on the Middle Fork Flathead River (mile post 189.5 along U.S. Highway 2) may come down from Snowshed Mountain in the Great Bear Wilderness (Singer and Doherty 1985).

Hungry Horse: Most of the goat habitat high above the east shoreline of Hungry Horse Reservoir lies inside the Great Bear Wilderness. A section from Unawah Mountain south to Circus Peak, however, laps over into the roadless area. A narrow ribbon of habitat along the crest of the Swan Range from Doris Mountain south to Con Kelly Mountain was mapped as occupied by goats during the late 1940s (Casebeer et al. 1950). At present, though, only a few goats still persist on isolated rugged peaks in Jewel Basin.

South Fork: Much of the South Fork Geographic Area lies within the Bob Marshall Wilderness, where rugged mountains provide extensive habitat for mountain goats. Outside the Wilderness, the lower banded cliffs and high peaks encircling Bunker Creek provide key maternal range for mountain goats (Chadwick 1983, Montana FWP *unpublished data*).

Salish Mountains: There is no suitable habitat for mountain goats in the Salish Mountains Geographic Area.

Swan Valley: The crest of the Swan Range from Wolverine Peak above Holland Lake north to Con Kelly Mountain is traditional maternal habitat for mountain goats (Casebeer et al. 1950). Important areas include the crest from Holland Peak to Swan Peak – which connects to key goat ranges extending further eastward into the Bob Marshall Wilderness to form an extensive complex. Further north, important sites include Warrior Mountain, Thunderbolt Peak, Spring Slide Mountain, and Con Kelly Mountain. Historically, goats used cliffs at lower elevation for crucial winter range in places such as lower Bond Creek and Lion Creek, too. Extensive road building for timber harvest and liberal hunting seasons during the 1960s and 1970s, however, may have facilitated excessive harvest of goats in the Swan Range (Chadwick 1983). Mountain goats occupy rugged terrain throughout much of the Mission Mountains, with nearly all the suitable habitat within the Mission Mountain Wilderness.

Table 5. Area (ac) and percent with mountain goat conservation values in Wilderness, roadless, and other areas by designated Geographic Areas on the Flathead National Forest, Montana.

	Winter Habitat (3)				Summer Habitat (2)			
Geographic Area	Area	Wild	Roadless	Other	Area	Wild	Roadless	Other
North Fork	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Middle Fork	9,172	93.4	6.5	0.1	38,126	94.7	5.0	0.3
Hungry Horse	4,410	60.3	39.2	0.5	9,218	46.3	52.9	0.7
South Fork	36,552	94.4	5.6	tr	107,704	93.6	6.4	tr
Salish Mtns	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Swan Valley	11,509	51.6	46.8	1.5	34,573	69.3	30.2	0.5
PERCENT	100.0	83.8	15.8	0.4	100.0	87.1	12.7	0.2
TOTAL Ac	61,643	51,678	9,745	222	189,621	165,080	24,089	452

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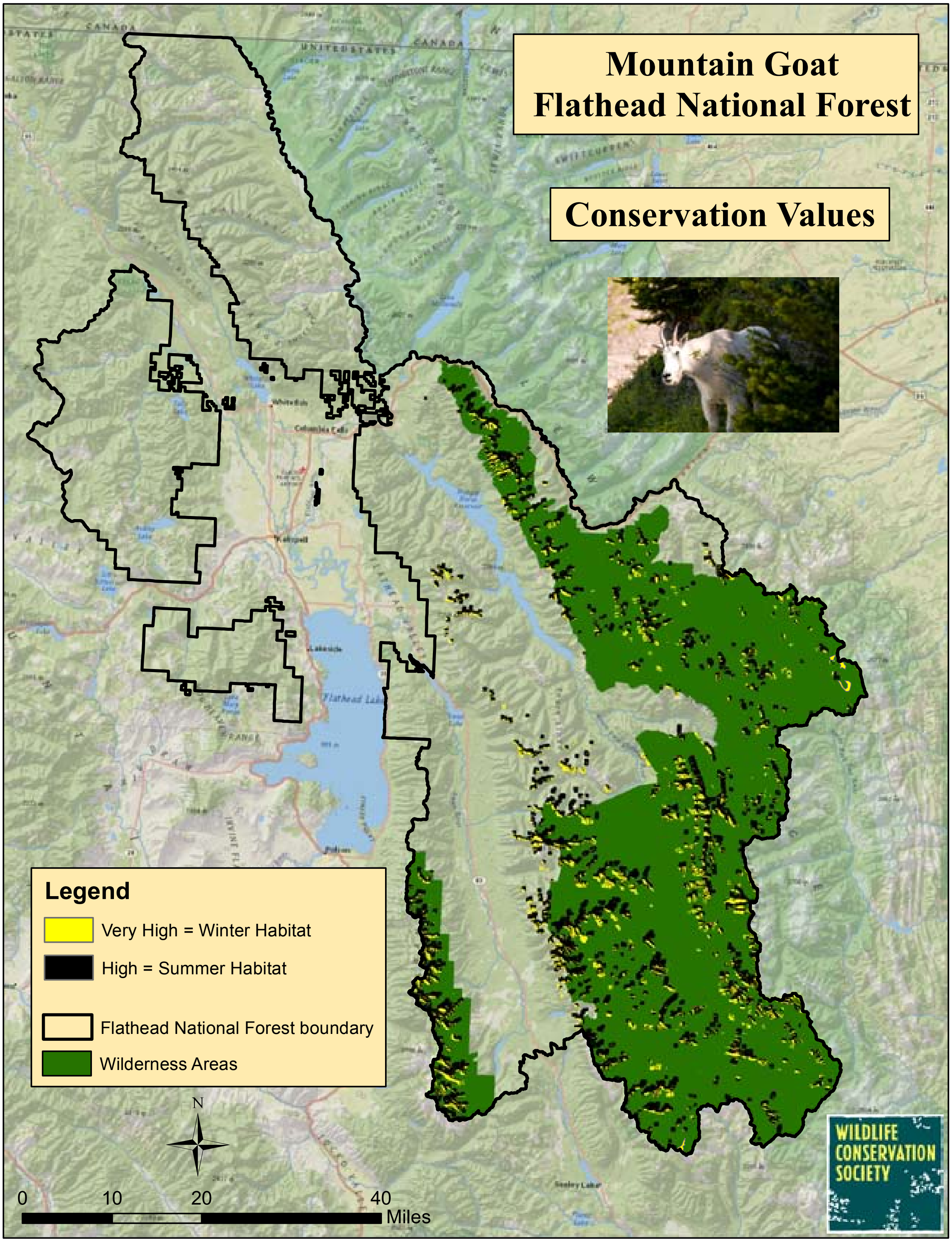
Figure 12. Location of key seasonal habitats and conservation values for mountain goats, Flathead National Forest, Montana.



Synthesis of Conservation Values across the Flathead National Forest

Species Importance Values and Composite Scores

To consider the importance of the Flathead National Forest for these species in another way, I summarized and mapped conservation values with 2 measures: (1) *species importance values*, and (2) *composite scores*. Both measures were tallied using a grid of 1-km^2 (0.39-mi^2) cells draped across the Flathead National Forest (total of 10,031 cells).

Each of these vulnerable species receives special management attention (federally listed as a 'threatened species' or as a 'sensitive species'/ 'species of concern' on state or National Forest list). So, I mapped *species importance values* (SIV) whereby a grid cell with a score of 3 (**very high**) or 2 (**high**) for any single species was highlighted. It should be noted that the SIV of 2 may represent a less critical but still essential component of the species' ecology and range (e.g., summer habitat for mountain goats).

Other sites may be important for several of the species. To derive a *composite* score, I simply summed up the values across all 5 species for each cell. Although the maximum tally for a cell could have been 15 (highest score of 3 *x* 5 species), the maximum realized score was 14. I distinguished the top 50% of scores (8-14) as **high** and the next 25% lower scores (4-7) as **moderate**. In some places, the composite score might be **low** (1-3), but the site has very high value (3) for 1 of the vulnerable species. Given the small size of grid cell, it would be surprising if, for example, bull trout and mountain goats occurred in the same cell.

The Flathead National Forest is rich in conservation value for several vulnerable fish and wildlife species that have been vanquished in so many other places. Remarkably, 90% of the Flathead NF has a very high (75%) or high (15%) value for at least 1 of the 5 focal species (Table 6, Figure 13). Because the Geographic Areas designated for Flathead NF planning varied in size, *density* of SIV (area with SIV/land area) was calculated for comparisons. All of the Geographic Areas had density of SIV (very high + high) ≥94%, with the exception of the Salish Mountains which had a very low value of 9%.

About 76% of the Flathead NF has high (35%) or moderate (41%) composite scores for this suite of vulnerable species (Table 7, Figure 14). The density of composite values among Geographic Areas varied between 69% and 94% - with the notable exception again of the Salish Mountains area with 1%.

Past conservation efforts led by citizens and the Forest Service has protected about 68% of the very high-high importance values for individual species and 56% of the high-moderate composite scores in Congressionally-designated Wilderness Areas (Bob Marshall, Great Bear, and Mission Mountains) on the Flathead National Forest (Tables 6-7, Figures 13-14). But remaining roadless areas account for about 21% of the very high-high importance values for individual species and 23% of the high-moderate composite scores. These roadless lands offer a unique opportunity to complete the legacy of wildlife and wildland conservation on this crown jewel of the National Forest system.

Figure 13. Distribution of importance values for any of 5 focal species, Flathead National Forest, Montana.

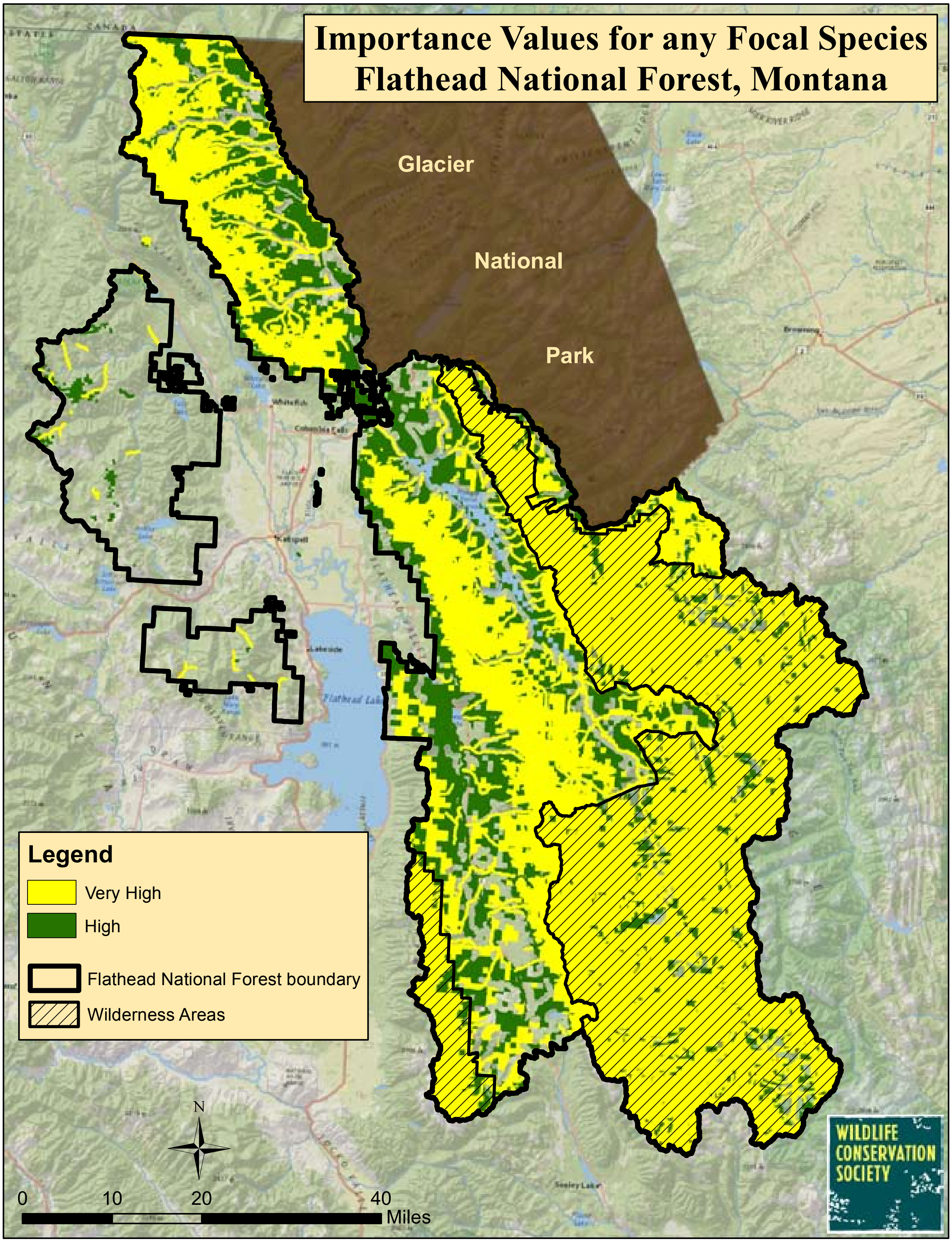


Figure 14. Distribution of composite scores for all focal species, Flathead National Forest, Montana.

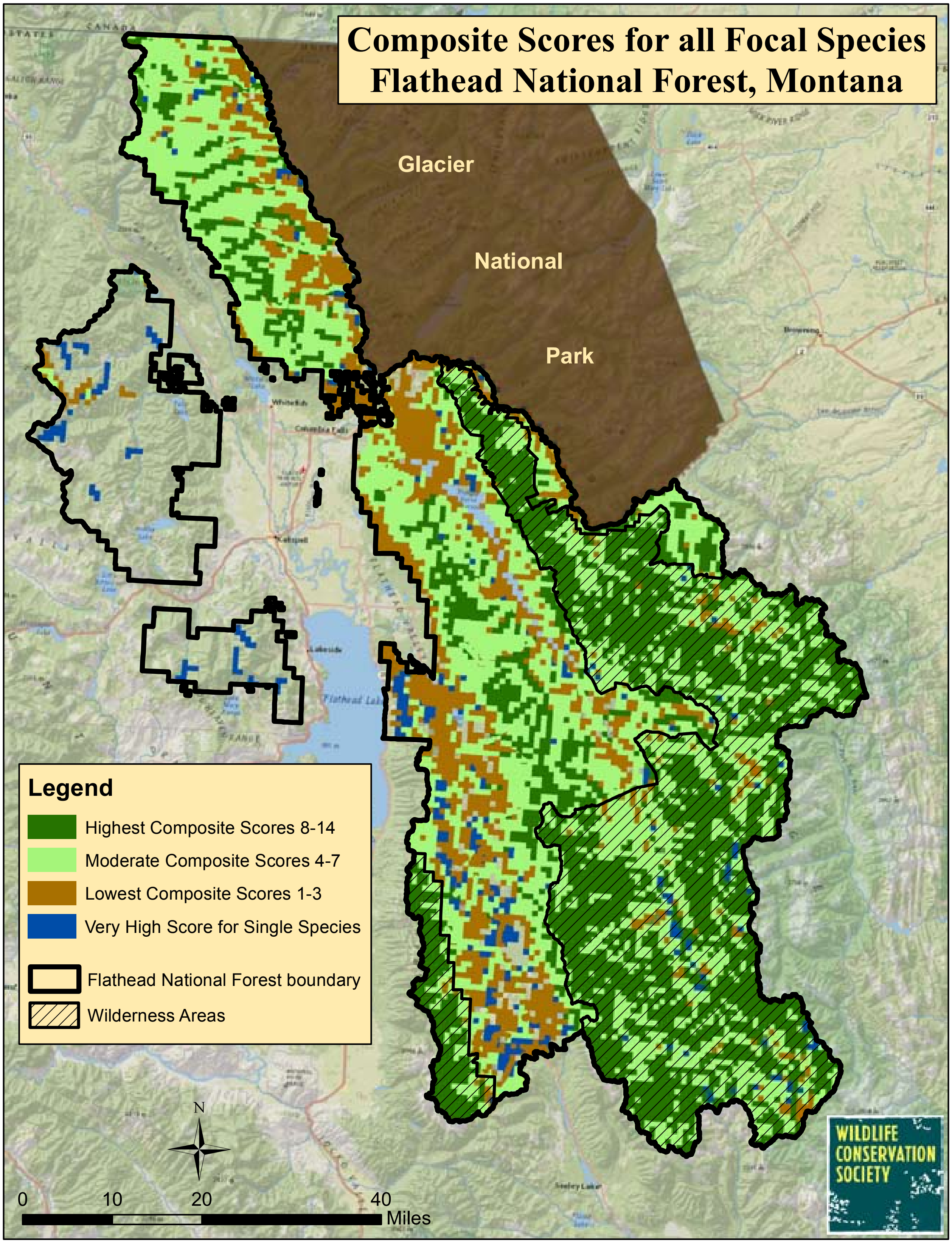


Table 6. Area (ac) and percent of species importance values in Wilderness, roadless and other areas by designated Geographic Areas on the Flathead National Forest, Montana.

	Species Importance Value = 3				Species Importance Value = 2			
Geographic Area	Area	Wild	Roadless	Other	Area	Wild	Roadless	Other
North Fork	248,629	0.0	45.5	54.5	91,398	0.0	23.0	77.0
Middle Fork	340,820	85.1	10.1	4.8	24,271	45.0	24.0	31.0
Hungry Horse	206,489	9.8	49.6	40.6	64,024	0.7	30.4	68.9
South Fork	724,539	87.8	8.1	4.1	45,431	54.2	23.1	22.7
Salish Mtns	20,936	0.0	0.8	99.2	1,478	0.0	7.6	92.4
Swan Valley	259,987	25.8	28.7	45.5	137,140	6.2	13.6	80.2
TOTAL %	100.0	56.3	21.2	22.5	100.0	12.2	20.8	66.9
TOTAL ac	1,801,400	1,013,884	382,908	404,608	364,282	44,478	75,631	243,633

Table 7. Area (ac) and percent of composite scores in Wilderness, roadless and other areas by designated Geographic Areas on the Flathead National Forest, Montana.

	Highest Scores 8-14				Moderate Scores 4-7				Low Scores 1-3			
Geographic Area	Area	Wild	Roadless	Other	Area	Wild	Roadless	Other	Area	Wild	Roadless	Other
North Fork	62,054	0.0	34.8	65.2	208,088	0.0	48.2	51.8	89,429	0.0	16.6	83.4
Middle Fork	207,616	90.6	6.1	3.3	141,615	74.8	16.8	8.4	25,438	44.1	22.8	33.1
Hungry Horse	70,922	25.1	50.3	24.6	144,856	1.8	52.2	46.0	82,883	0.2	16.1	83.7
South Fork	412,594	92.2	6.1	1.7	312,009	80.8	11.9	7.3	61,912	62.9	16.2	20.9
Salish Mtns	0	0.0	0.0	0.0	2,642	0.0	5.3	94.7	25,354	0.0	0.6	99.4
Swan Valley	81,743	62.8	31.2	5.9	168,658	12.7	33.6	53.7	191,213	1.8	6.5	91.7
TOTAL %	100.0	76.4	14.4	9.2	100.0	39.1	30.0	30.9	100.0	11.3	11.9	76.8
TOTAL ac	834,929	637,965	120,396	76,568	977,868	382,202	293,400	302,266	476,229	53,828	56,569	365,832

3. LINKAGES ACROSS MAJOR HIGHWAYS: KEEPING IT CONNECTED

Introduction

It appears that the most important mechanism by which species coped with previous large-scale climate changes has been to move and colonize newly suitable habitat (Huntley 2005). Such shifts have already been documented in numerous species in response to contemporary changes in climate (Parmesan 2006). However, habitat fragmentation and human developments can interfere with the ability of species to track shifting climatic conditions. Consequently, many scientists advocate the need for conservation corridors or linkages between habitats (existing and future) to support necessary movements (Chetkiewicz et al. 2006, Rudnick et al. 2012). A complementary strategy is to increase the size and number of protected, ecologically-diverse areas connected by such linkages (Hodgson et al. 2009). Two books Corridor Ecology (Hilty et al. 2006) and Safe Passages: Highways, Wildlife, and Habitat Connectivity (Beckman et al. 2010) provide outstanding overviews of current projects, practices, and partnerships across the country – including several from the Crown of the Continent Ecosystem.

There are 2 major highways that have implications for connectivity in the context of the Flathead National Forest and the larger Crown of the Continent Ecosystem. U.S. Highway 2 (and associated railroad) is a major east↔west transportation route across the Rocky Mountains between the south boundary of Glacier National Park and the Flathead National Forest. Montana Highway 83 is a major highway running north↔south through the broad Swan Valley between the Bob Marshall Wilderness and the Mission Mountains Wilderness. Providing for connectivity across Highway 2 and Highway 83 is vital to regional conservation of wide-ranging wildlife species. Here, we contribute an assessment of linkage options across these highways for grizzly bear, wolverine, and mountain goat. Brent Brock, Craighead Environmental Research Institute, carried out the connectivity analyses to identify key linkages across the major highways.

Methods

We modeled connectivity across Highways 2 and 83 using both least-cost distance (LCD) models (Walker and Craighead 1997) and newer methods using circuit theory (CT) (McRae et al. 2008). Both approaches require delineation of suitable source and destination patches on either side of the highway, plus a resistance map quantifying the relative travel cost of movement through each cell in the landscape (see review by Zeller et al. 2012). Both methods produce a continuous surface quantifying the relative value of each map cell for movement among specified patches, accounting for the effects of both distance between patches and cost of movement. As they differ in their assumptions, formulation, and interpretation, the approaches are generally considered to be different but complementary (McRae et al. 2008, Singleton and McRae 2013). Rainey (2012) provides an excellent examination of the 2 methods.

Least-Cost Distance modeling for focal species has been the most widely used method for designing linkages to connect patches of habitat (e.g., Beier et al. 2011). The objective of LCD modeling is to identify the swath of land that minimizes the ecological cost of movement through a landscape for a species. LCD models calculate the cumulative cost-weighted distance of all paths between pairs of patches by summing the cost-weighted distance values encountered in each cell along all possible paths, then assigning each cell the value of the least costly path among all patch pair combinations passing through it. Thus, the least costly path between patches can be identified, along with other alternative low-cost paths. Least cost corridor models were run in ArcGIS 10.2 using the 'cost distance' and 'corridor' Spatial Analyst tools.

Circuit theory models treat the landscape as an electrical circuit, quantifying the probability of current (moving animals) passing from a source patch through any given node (cell) in the landscape to a destination patch (McRae et al. 2008). The CT approach is unique because it accounts for path redundancy. Cells with many possible paths passing through them (i.e. bottlenecks or pinchpoints) are assigned high probability of movement. Circuit theory models were run in CircuitScape® 4.0 (McRae & Shah 2008), with the final composite map reflecting cumulative density of current.

For each species and application, we provide specific details (below) on (1) defining and mapping source and destination patches, and (2) developing cost or resistance surfaces. In general, we excluded areas of human development along the major highways based on the conservative assumption that human settlements are simply impermeable to movement by these wary species. Within a 1 km-wide strip on either side of Highways 2 and 83, we digitized all residential and commercial points (from a high-resolution Bing satellite image) and buffered them with a radius of 250 m. The resulting footprint of settlement was considered impermeable and applied as a mask to the habitat maps. Highway mitigation efforts will likely be more effective if they focus away from sites of human development.

For the corridor analysis, we simply created a 2-patch scenario, with a region on each side of the major highway. We ran 'Create Corridor Raster' (using 'Linkage Assistant', a custom ArcGIS toolbox developed by the Craighead Environmental Research Institute) to generate cost-distance surfaces for each source/destination patch and calculate the least-cost corridor between each patch pair. A final corridor surface was generated by calculating the cell-based minimum for all pair-wise corridor surfaces. Finally, we extracted the 'top *x* percent' of corridor values which provided useful discrimination of putative linkages for the particular species in these landscapes. Typically, this value was 10% but varied. Here are further details pertinent to each species.

Grizzly Bear: Primary and secondary habitat components comprised the source patches (see Chapter 2: 40-48, Figure 9). Patches <4 mi^2 (10 km^2) were removed on the assumption that larger patches might serve as blocks of core habitat (Mace and Waller 1998, Gibeau et al. 2001), rather than smaller ones serving as 'stepping stones'. In addition, we removed from sources those areas within 500m of the highway as well as human settlements buffered by 250-m. Even extremely low density of exurban residences can cause source habitats for grizzly bears to become mortality sinks (Schwartz et al. 2012).

For the cost surface, we assigned the following cost weights to the grizzly bear habitat model:

Habitat Model	Cost Weight
0	5
1	2
2	1
3	0

Thus, the primary habitat components (score = 3) had no cost assigned to them, whereas the secondary components (score = 2) were assigned a slight cost of 1. Where these components occurred within 500m of an open road and thus low security, they were assigned a cost of 2. We assigned a cost weight of 20 to areas within 500 meters of the major highway or within the buffered areas around human settlements. Lastly, primary and secondary patches <4 mi^2 were assigned a cost weight of 0 (CD models) or assigned as short circuit patches (CT models), so that small patches could serve as stepping stones for movement.

Wolverine: We used the combined version of the wolverine models developed by Copeland et al. (2010) and Inman (2013) to define current primary habitat as source patches (see chapter 2: 49-51 for details, Figure 11). We ran a separate analysis that modeled a future scenario of climate change that eliminated lower elevation habitats. Again, we imposed a minimum-size threshold of >4 mi^2 (10 $km^{2)}$ to distinguish patches that might serve as core blocks of multi-day habitation. To develop the cost surface, we rescaled the habitat suitability values 1-100, then calculated landscape resistance as the inverse of suitability [1 – Suitability]. Lastly, primary patches <4 mi^2 were assigned a cost weight of 0 (CD models) or assigned as short circuit patches (CT models), so that small patches could serve as stepping stones.

Mountain Goat: Both summer and winter habitats comprised the source patches as they often occur on the same mountain massif (see Chapter 2: 56-59, Figure 12). Goats often occur in small groups on small cliffs, so no minimum patch size threshold was applied. We characterized the cost surface using an index of terrain ruggedness (TRI) (Riley et al. 1999). We inverted and rescaled ruggedness values into classes 1-10. For grid cells that overlapped the highway or buffered human developments, we weighted the TRI class scale by 10X.

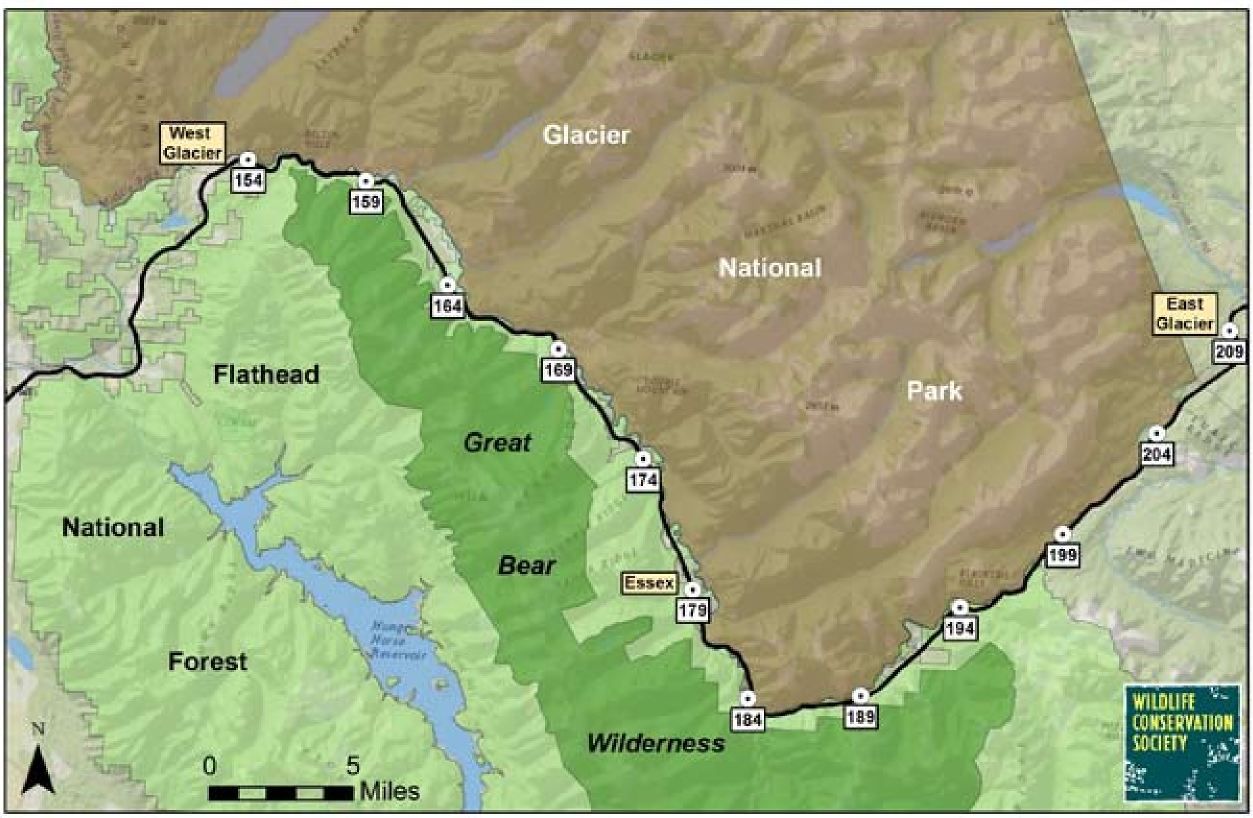
We ran both the LCD and the Circuitscape models for all 3 species for both Highways 2 and 83. Here, we show only the Circuitscape-model maps because they essentially mimicked the LCD maps but provided greater discrimination among relative linkage values. In the following maps, 'warmer' colors (red-orange) indicate higher connectivity scores and 'cooler' colors the lower scores. Because these models cover relatively local areas where suitable habitat patches are large and widespread, the results are not as dramatic as in more fragmented landscapes.

Finally, it should also be noted that such analyses of connectivity depict the relative degree of connectivity compared among areas along the highway – not a *probability* of linkage or crossing. In the absence of data on animal crossings, there is uncertainty in choosing percent cutoffs for mapping putative linkages. In most cases, it is simply unknown what degree of fragmentation along a highway and/or what level of traffic volume leads to it being impermeable to crossings. Nonetheless, connectivity modelling is useful in delineating spatial hypotheses about which areas are *relatively* better for linkages. Moreover, these analyses can suggest which roadless areas have added value due to an adjacent linkage.

Highway 2 along the South Boundary of Glacier National Park

U.S. Highway 2 (and associated railroad) is a major east↔west transportation route across the Rocky Mountains between the south boundary of Glacier National Park and the Flathead National Forest (Figure 15). The section between Columbia Falls and Marias Pass/Continental Divide is about 60 miles, with another 11 miles east to East Glacier, Montana. The highway parallels the Middle Fork of the Flathead River for about 31 mi, which is designated a Wild and Scenic River. The Great Bear Wilderness and narrow strips of roadless areas on the Flathead National Forest border the highway up to Marias Pass at the Continental Divide. Thus, the highway and railroad is a narrow transportation corridor set in a forested, mountainous wildland. According to the Montana Department of Transportation (MDT), the annual average daily traffic (AADT) at 6 monitoring points along this section in 2012 was 1800 vehicles (range 1420-2130) (http://www.mdt.mt.gov). This traffic volume is down slightly from the 1968 vehicles AADT recorded 1999-2001 by Waller (2005).

Figure 15. Location of U.S. Highway 2, with mile-post markers every 5 miles between West Glacier and East Glacier, Montana.



Grizzly Bear:

Primary and secondary habitats for grizzly bears occur in very close proximity (0-1 mi) to Highway 2 along much of the highway between West Glacier and East Glacier, Montana. Consequently, the connectivity models projected a broad zone of high connectivity (top 10%) there, except for the more dense human settlements (Figure 16). To facilitate greater discrimination of relative connectivity along the highway, we buffered it by 1-km on each side and re-stretched the linkage values therein for display purposes. Here, we note specific sections that appear to rank *slightly* higher in a relative sense. Researchers Richard Mace (Montana FWP) and John Waller (Glacier National Park) kindly provided data on documented crossings of Highway 2 by radio-collared grizzly bears.

(1) Moccasin Creek and Nyack (MP 160-162) – This section encompasses some of the extensive Nyack floodplain area along the Middle Fork Flathead River. On the south side, it includes a thin strip (<0.6 mi) of roadless area on the Flathead National Forest adjacent to the Great Bear Wilderness.

(2) Stanton Creek (MP 169-173) – This linkage lies in the Stevens Canyon section of the highway, adjacent to the Great Bear Wilderness. Grizzly bear crossings have been documented here.

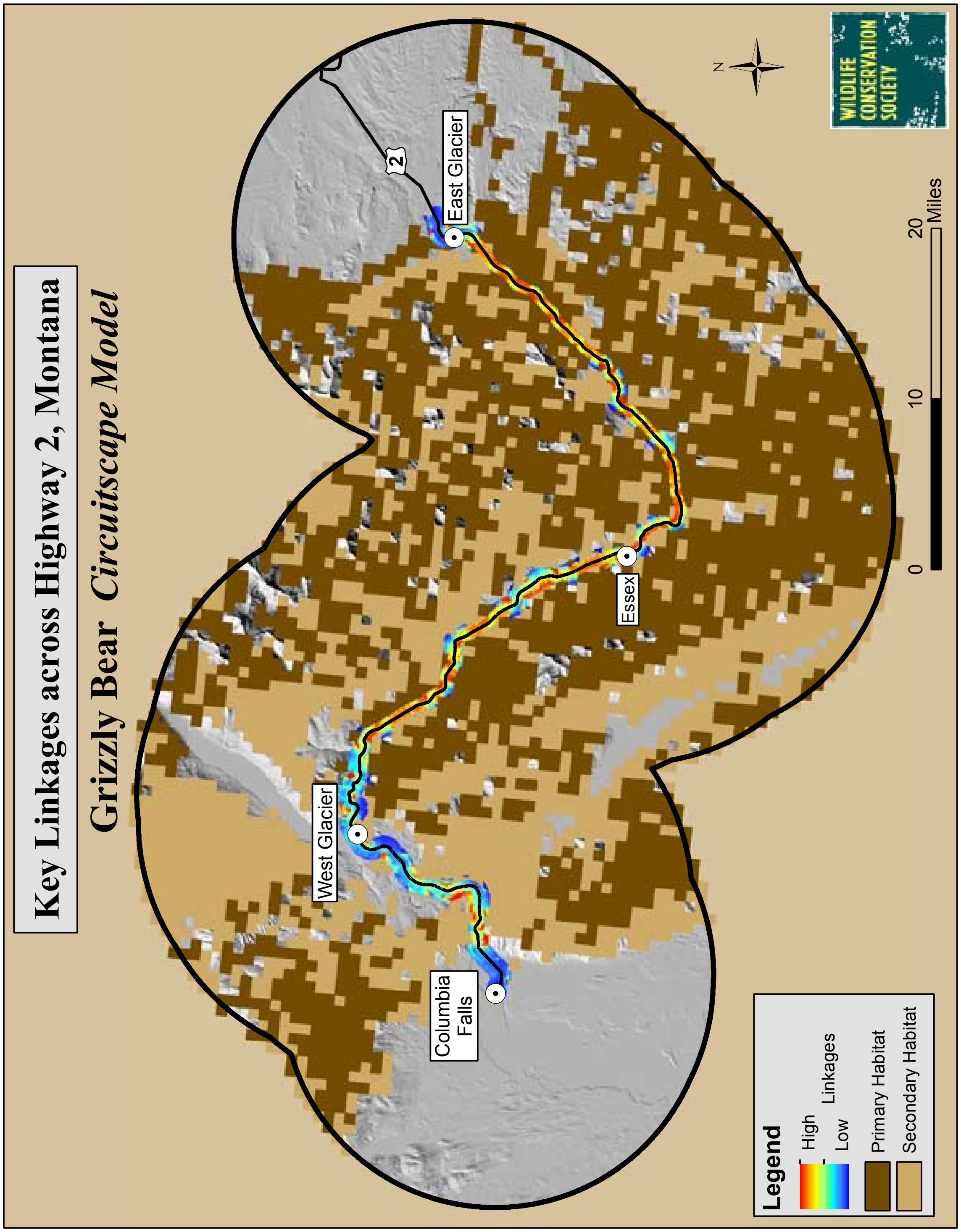
(3) Paola Creek (MP 175) to Skyland (MP 194) – This extensive linkage (except the Essex and Giefer residential areas) would connect to roadless areas on the Flathead NF that have high-quality grizzly bear habitat. Two crossings have been documented near Pinnacle (MP 175), 4 between Devil Creek and Giefer Creek (MP 189-192), and 2 near Skyland Creek (MP 193-194).

(4) Marias Pass to nearly East Glacier Park (MP 197-208) – This includes the most continuous section of Highway 2 with the highest ranking for linkage potential. Although the landscape is fairly open, there are few human settlements. At least 33 crossings of grizzly bears (including family groups) have been documented along this section (Waller 2005; R. Mace, Montana FWP, *unpublished data*; T. Luna, *personal communication*).

Both models also point out a possible narrow linkage zone between the towns of Columbia Falls and Hungry Horse through Badrock Canyon. Primary grizzly bear habitats, however, are rather sparse.

During 1999-2001, researchers monitored the movements of 25 grizzly bears along Highway 2 and associated railroad, mostly east of Marias Pass (Waller 2005, Waller and Servheen 2005). During this period, traffic volume on the highway averaged 82 cars/hr with higher volumes during daylight; trains averaged about 1.2/hr, with more during nighttime. Thirteen different grizzlies crossed Highway 2 at least once during the study for a total of 131 crossings. Interestingly, most of the crossings (64%) were made by 2 subadult bears (1M, 1F), and adult females appeared most sensitive to traffic (especially when accompanied by cubs). Most crossings occurred at night (85%) when traffic volume on the highway was low (average = 30 cars/hr). Traffic flow at the time (2300-0700 hrs) that bears actually crossed the highway averaged about 11 cars/hr. Frequency of bears crossing Highway 2 was lower than expected assuming random movements. Researchers opined that connectivity was still functional along Highway 2 and attributed this to several factors: low volume

Figure 16. Key linkages across U.S. Highway 2 for grizzly bears according to Circuitscape model, Flathead National Forest and Glacier National Park, Montana. Linkage values displayed using a histogram equalize stretch, with 'warmer' colors (red-yellow) representing higher values.



of highway traffic at night, narrow width of highway, limited human developments, and expansive protected habitats on both sides of the highway. Based upon the empirical data, they hypothesized that a threshold of nearly100 cars/hr might pose barrier to grizzly bears crossing highway 2. In Banff National Park, Canada, grizzly bears also crossed the trans-Canada highway less frequently with higher traffic volume (Chruszcz et al. 2003).

Wolverine*:*

Primary habitat for wolverines occurs in close proximity (0-4 mi) to Highway 2 along much of the highway between West Glacier and East Glacier, Montana. Consequently, the connectivity models projected a broad zone of high connectivity (top 10%) along this part of Hwy 2, except for the more dense human settlements. To facilitate greater discrimination of relative connectivity along the highway, we buffered it by 1-km on each side and re-stretched the linkage values therein for display purposes.

For wolverines, the Circuitscape model indicated that several sections of the highway appear to have relatively higher connectivity (Figure 17).

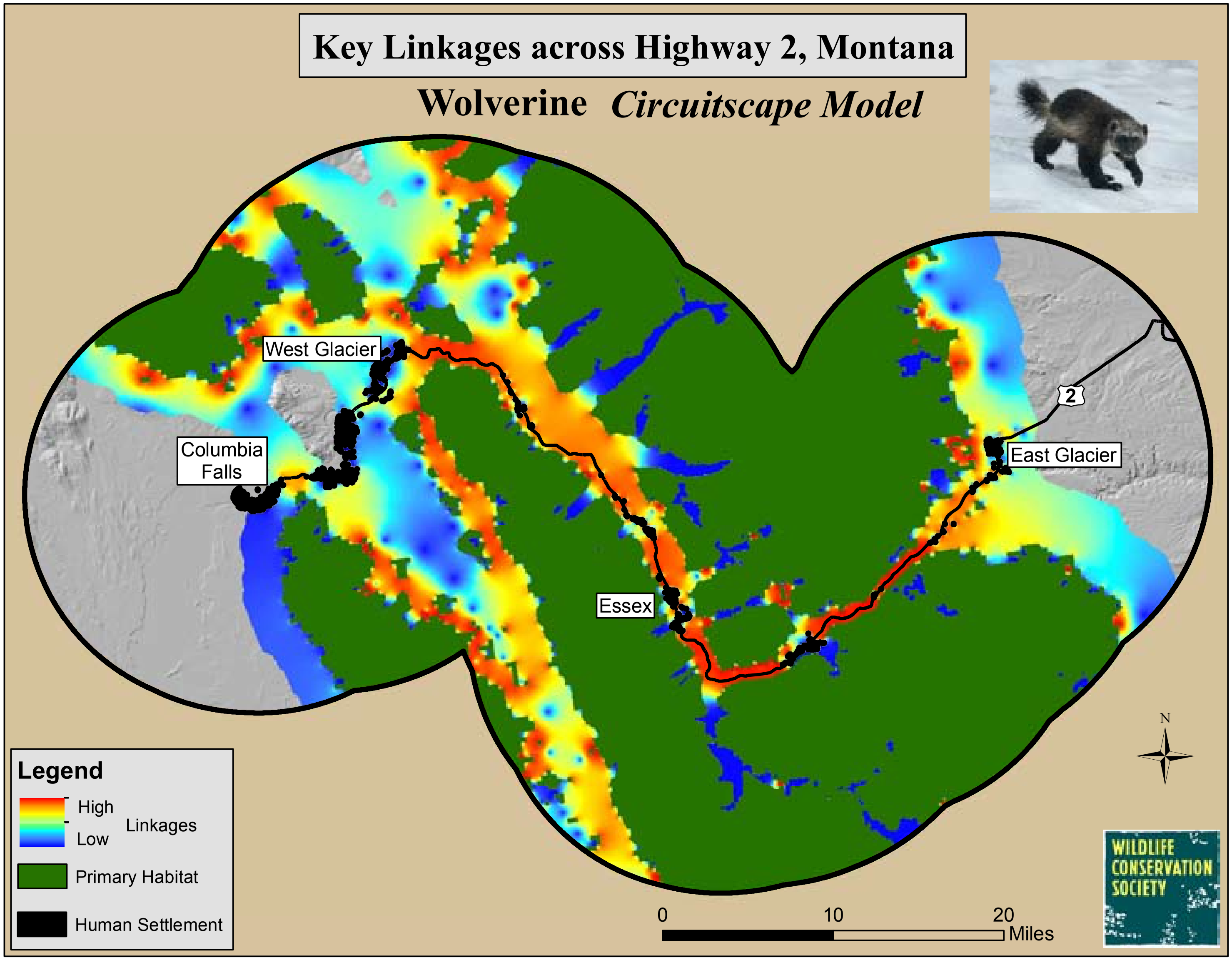
(1) Essex (MP 180.2) to Devils Creek (MP 189.0) and Giefer Creek (MP 192.0) to about 4 miles east of Marias Pass (MP 202.0) – Along these two sections, Highway 2 climbs from 3800 ft elevation to 5200 ft at Marias Pass. Adjacent terrain is rugged, and the entire area receives heavy snowfall in winter. Consequently, wolverine habitat comes down close to the highway, and the paucity of human developments reduces impediments to passage. The broad suitability of linkage through this section would connect wolverine habitat in Glacier National Park with roadless areas and the Great Bear Wilderness south of the highway on the Flathead National Forest.

(2) Pinnacle (MP 175.0) to near Dickey Creek (MP 178.0) – This section is separated from the previous one only by the buildings and activity around Essex. The gap in primary habitat for wolverine is only about 2 miles wide here. The linkage could connect the Park Creek basin in Glacier National Park with the roadless Paola-Tunnel Ridge area on the Flathead National Forest. Wolverines were trapped on the south side of the highway in this area when the trapping season was open years ago.

(3) east of West Glacier (MP 156) to Ousel Creek (MP 159) – This section would link a terminus of wolverine habitat at the west end of the Great Bear Wilderness with an discrete patch of habitat on the Belton Hills in Glacier National Park.

Scant information is available on wolverine crossings along U.S. Highway 2. In the Greater Yellowstone Ecosystem, Packila et al. (2007) documented 43 crossings of U.S. or State highways by 12 wolverines. Subadults making dispersal or exploratory movements comprised the majority (76%) of road crossings, most of which were made during January–March. On a Wyoming highway

Figure 17. Key linkages across U.S. Highway 2 for wolverines according to Circuitscape model, Flathead National Forest and Glacier National Park, Montana. Linkage values displayed using a histogram equalize stretch, with 'warmer' colors (red-yellow) representing higher values.



where traffic volume commonly exceeded 4,000 vehicles per day, four different wolverines (2F, 2M) crossed the highway 16 times. At least 3 crossings occurred within a 4-km section where forest cover bordered close to the highway, about 4 km from the nearest human settlement.

Major highways with significantly greater traffic volume, however, can impact wolverine movements. Along the Trans Canada Highway between Yoho and Banff National Parks with 25,000 vehicles per day, wolverines avoided areas within 100 m of the highway in winter and preferred areas >1100m away from the highway. Wolverines made repeated approaches and retreats and only crossed 3 of 6 times (Austin 1998). More recently, wolverines crossed the Trans-Canada Highway in Banff National Park using underpasses and overpasses only 10 times during 2009-2013 as revealed by remote cameras (A. Clevenger, Western Transportation Institute, *personal communication*). Researchers speculate that the low number of crossings could be due to this section of the Bow Valley being wider and/or presence of a wolf pack.

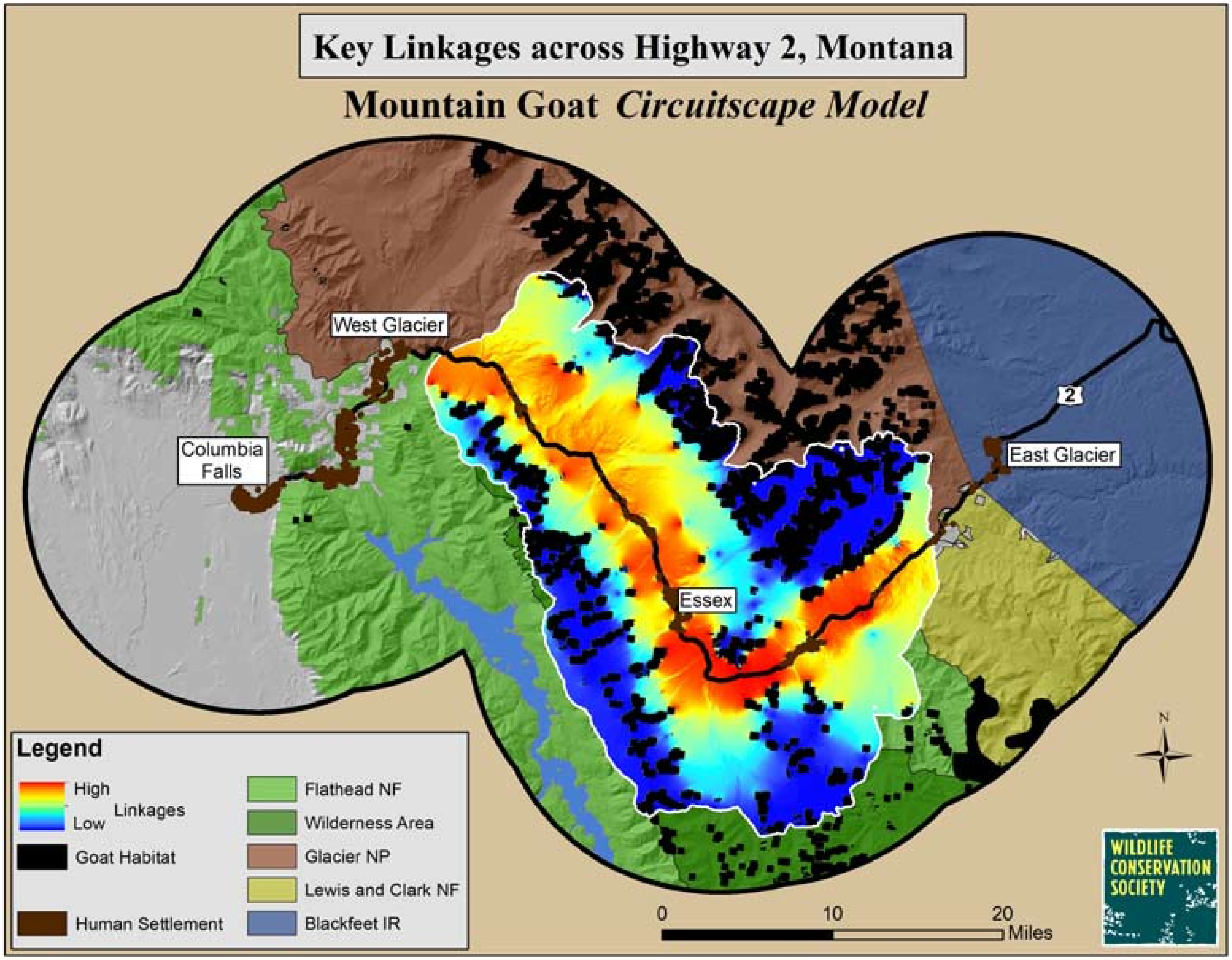
Mountain Goat:

Mountain goats and their rugged habitats occur along both sides of Highway 2 between West Glacier and Marias Pass, but habitat patches are separated by 7-9 miles across the highway (Figure 18). The Circuitscape model mapped several putative linkages within this zone:

(1) In a relative sense, the best and largest connectivity zone for mountain goats along Hwy 2 occurs from Essex (MP 180) east to Devil Creek (MP 189) where goat habitats are separated across the highway by only 2-3 miles. One site is the well-known goat underpass at MP 182.5, which connects goat habitat on the north side in Glacier National Park (Running Rabbit Mountain) with habitat on the south side in the Great Bear Wilderness on the Flathead National Forest (Snowshed Mountain). According to Singer and Doherty (1985), goats from Running Rabbit Mountain in Glacier National Park intermixed at the mineral lick with goats traveling from the Flathead National Forest directly to the south and west. These Flathead NF goats crossed the Middle Fork Flathead River to reach the lick. In about 1978, however, a new mineral lick immediately on the south side was uncovered by river action or newly discovered by these goats. The two herds may not mix often anymore, as few observations of goats crossing the river have been recorded. An alternative linkage might connect goat habitat on Running Rabbit Mountain with the Tranquil Basin-Devils Hump area on the Flathead NF.

(2) Other but more tenuous linkages involve sources further from the highway and utilize 'stepping-stones' of habitat for connectivity. One example involves Rampage Mountain in Glacier National Park as a stepping stone, then across Highway 2 in the MP 175-177 section to more continuous patches of habitat south of the highway on Paola Ridge on the Flathead National Forest.

Figure 18. Key linkages across U.S. Highway 2 for mountain goats according to Circuitscape model, Flathead National Forest and Glacier National Park, Montana. Linkage values displayed using a histogram equalize stretch, with ‘warmer’ colors (red-yellow) representing higher values.

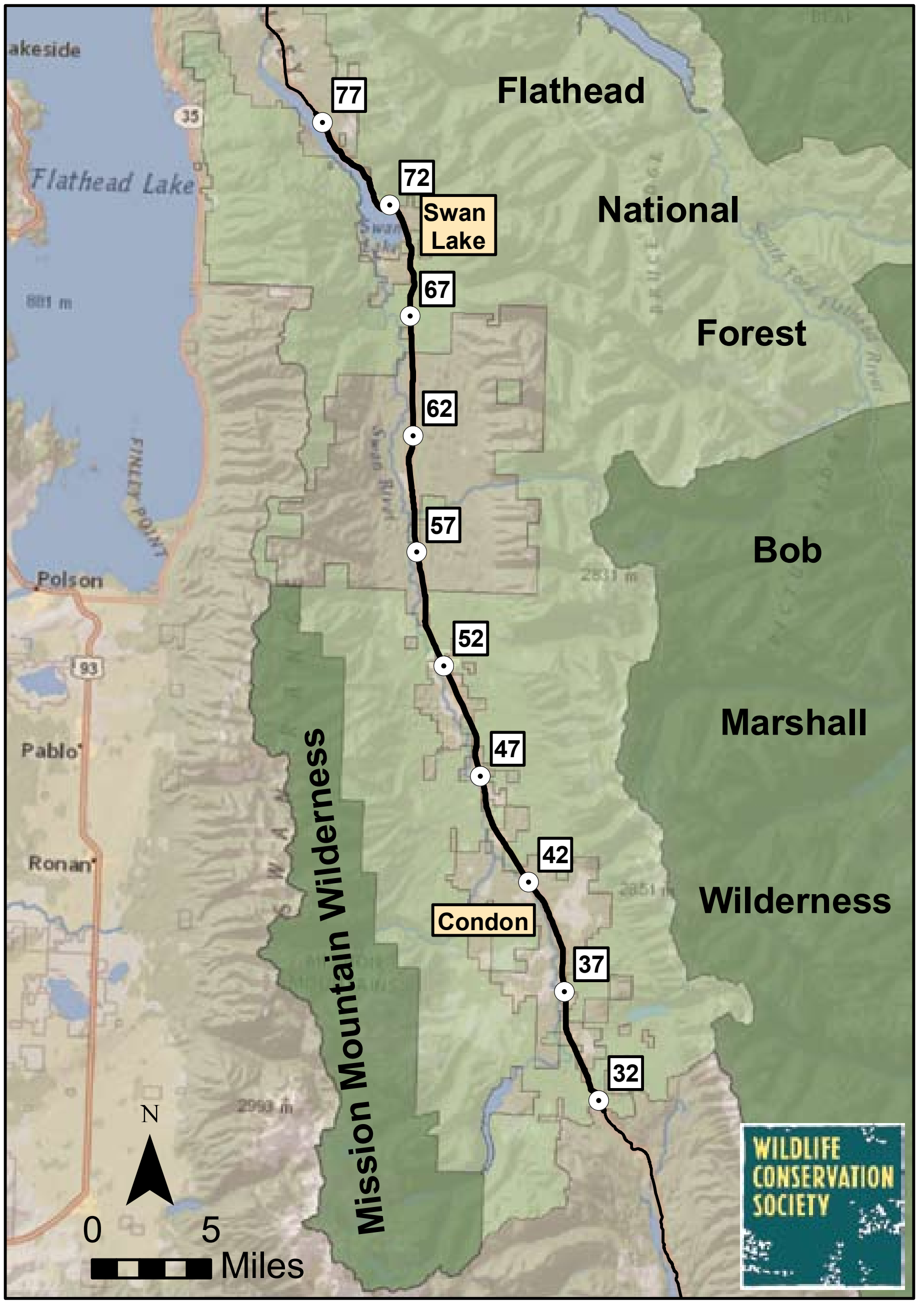


Summary: Except for the patches of human settlements, much of the U.S. Highway 2 corridor with its current traffic volume appears to be permeable for connectivity for these wildlife species. The section between Pinnacle (MP 175) and Skyland Creek (MP 194) seems to offer relatively better opportunity for safe passage. Roesch (2010) also found that the section east of Essex (MP 179-184) had the highest density of wildlife trails (most likely elk and deer) and considered it a principal crossing zone. Hence, this section MP 175-194 could be considered as an 'umbrella' linkage zone for multiple species of large mammals. Therefore, providing security on the adjacent roadless areas on the Flathead National Forest along this section appears important in facilitating connectivity across the larger region. This would encompass the narrow strip of roadless area along the Middle Fork of the Flathead River from Pinnacle Creek up to Bear Creek, thence up Bear Creek to Skyland Creek.

Highway 83 through the Swan Valley

Montana Highway 83 is a major highway running north↔south through the broad Swan Valley of Montana (Figure 19). The valley is framed by the Swan Range/Bob Marshall Wilderness on the east and the Mission Mountains /Mission Mountains Wilderness on the west. We assessed the section within the Flathead National Forest boundary between Swan Lake and the Seeley-Swan Divide, a distance of 46 miles. According to the Montana Department of Transportation (MDT), the annual average daily traffic (AADT) at 5 monitoring points along this section in 2011 was 920 vehicles (range 660–1180) (http://www.mdt.mt.gov) – or about one-half of the traffic volume along U.S. Highway 2.

Figure 19. Location of Montana Highway 83, with mile-post markers every 5 miles between the Flathead National Forest boundaries north of Swan Lake town site and the Seeley-Swan divide, Montana.



Grizzly Bear*:*

Primary and secondary habitats for grizzly bears – especially riparian sites and wetlands – occur in very close proximity (0-3 mi) to Highway 83 from Swan Lake south past Condon to the Seeley-Swan Divide. Consequently, the connectivity models projected a broad zone of high connectivity (top 10%) along much of the highway, except for the more dense human settlements (Figure 20). To facilitate greater discrimination of relative connectivity along the highway, we buffered it by 1-km on each side and re-stretched the linkage values therein for display purposes. Here, we note specific sections where named creeks cross the highway that appear to rank *slightly* higher in a relative sense.

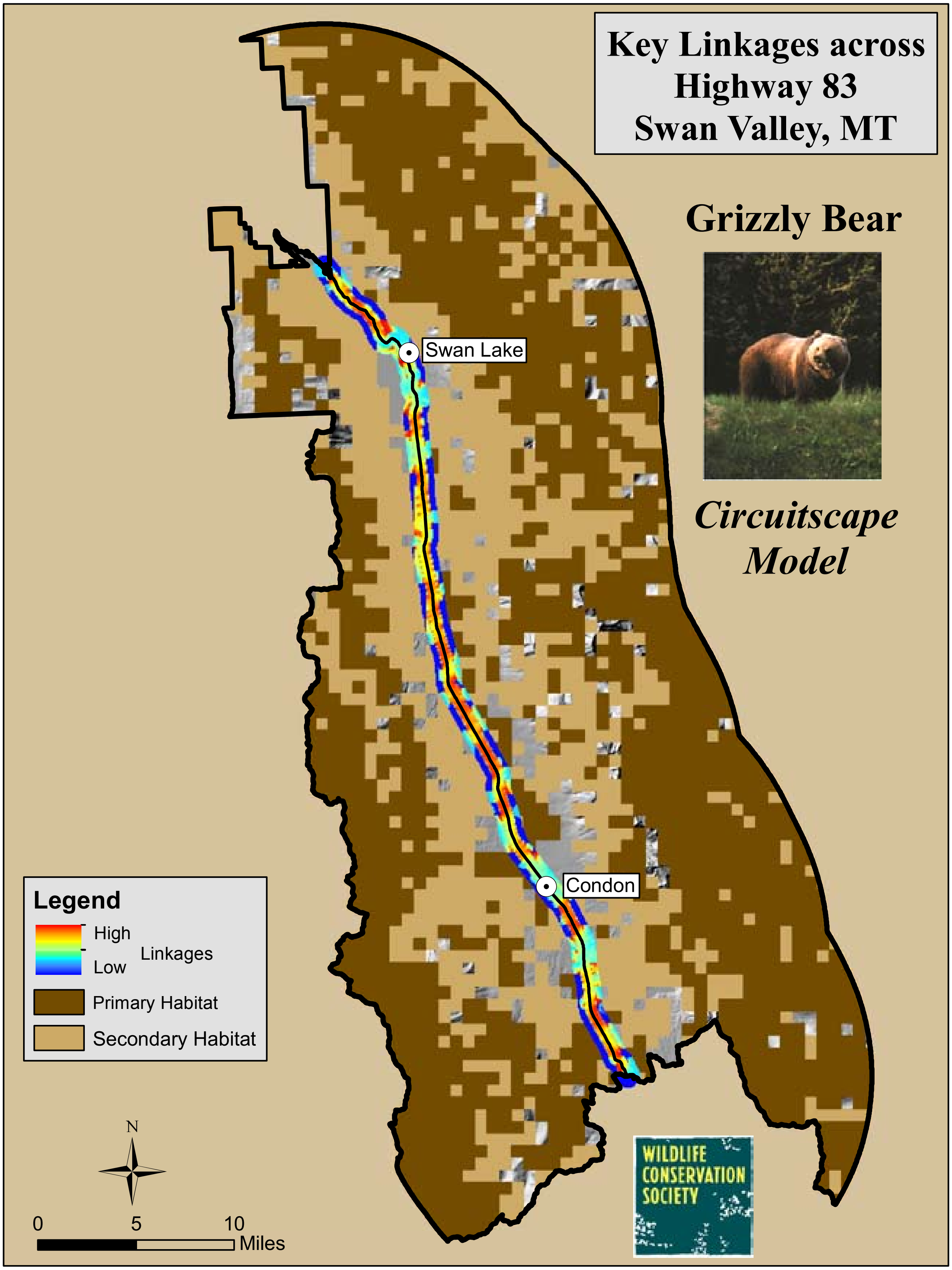
(1) Goat Creek (MP 58) to Smith Creek (MP 45) – This center section of the Swan Valley highway has high linkage ranking almost continuously for about 13 miles. Human settlements are sparse and scattered, and grizzly bear habitat components are close to the highway. This section sits between the north end of the Mission Mountain Wilderness to the west, and the northwest end of the Bob Marshall Wilderness to the east. Telemetry locations of grizzly bear are quite common in the valley bottom (especially in the southern portion), and the relative density of documented bear crossings of Highway 83 has been high – particularly near Pony Creek (MP 48-49) and Smith Creek (MP 45-46) (Baty et al., n.d.).

(2) Cooney Creek (MP 41) to Barber Creek (MP 37.8) – South of the settlement of Condon, another linkage of high ranking occurs between Cooney Creek and Buck Creek for about 3 miles. Again, there are numerous bear locations in this part of the valley, and the relative density of known bear crossings has been high – especially between Buck and Barber Creeks (Baty et al., n.d.).

(3) Holland Creek (MP 36.5) to Pierce Creek (MP 32) – A high-ranking linkage occurs at Holland Creek and extends for 4 miles south towards Seeley-Swan Divide. Numerous bear locations have been documented in this part of the valley, and the relative density of documented bear crossings of the highway has been high – particularly near Holland Creek and meadows (Baty et al., n.d.).

These linkage sections are situated in the central and southern portions of the Swan Valley that are framed by the Bob Marshall Wilderness on the east and the Mission Mountain Wilderness on the west. A strip of roadless area flanks the valley on the east side adjacent to the Bob Marshall Wilderness. It contains valuable habitat components for grizzly bears including avalanche chutes, huckleberry patches, and alpine basins. Protecting that roadless area could enhance prospects for connectivity between the Bob Marshall Wilderness and the Mission Mountain Wilderness. Grizzly bears have been using private and corporate timber lands in the bottom of the Swan Valley increasingly over the past 15-20 years. Providing habitat security and minimizing mortality risk to grizzly bears there will be essential for sustaining connectivity for bears, too. The transfer of certain parcels to the Flathead National Forest as part of the Montana Legacy Project should facilitate such stewardship.

Figure 20. Key linkages across Montana Highway 83 for grizzly bears according to Circuitscape model, Swan Valley - Flathead National Forest, Montana. Linkage values displayed using a histogram equalize stretch, with 'warmer' colors (red-yellow) representing higher values.



Wolverine:

Primary habitat for wolverines in the Swan Valley occurs at higher, more rugged terrain. Distances between suitable habitats across the valley vary from about 7 miles at the north end to 9-10 miles south of Condon (Figure 21). Consequently, the models projected less connectivity across the highway 83 compared to that for grizzly bears. Nonetheless, the Swan Valley lies in a favorable snow belt, which may favor more wolverine use at lower elevations than usual. Here, we note specific sections where named creeks cross the highway that appear to rank slightly higher in a relative sense.

(1) Goat Creek section (MP 59-61) which might connect wolverine habitat in upper Goat Creek roadless area on the east to upper Woodward Creek at the north end of the Mission Mountains;

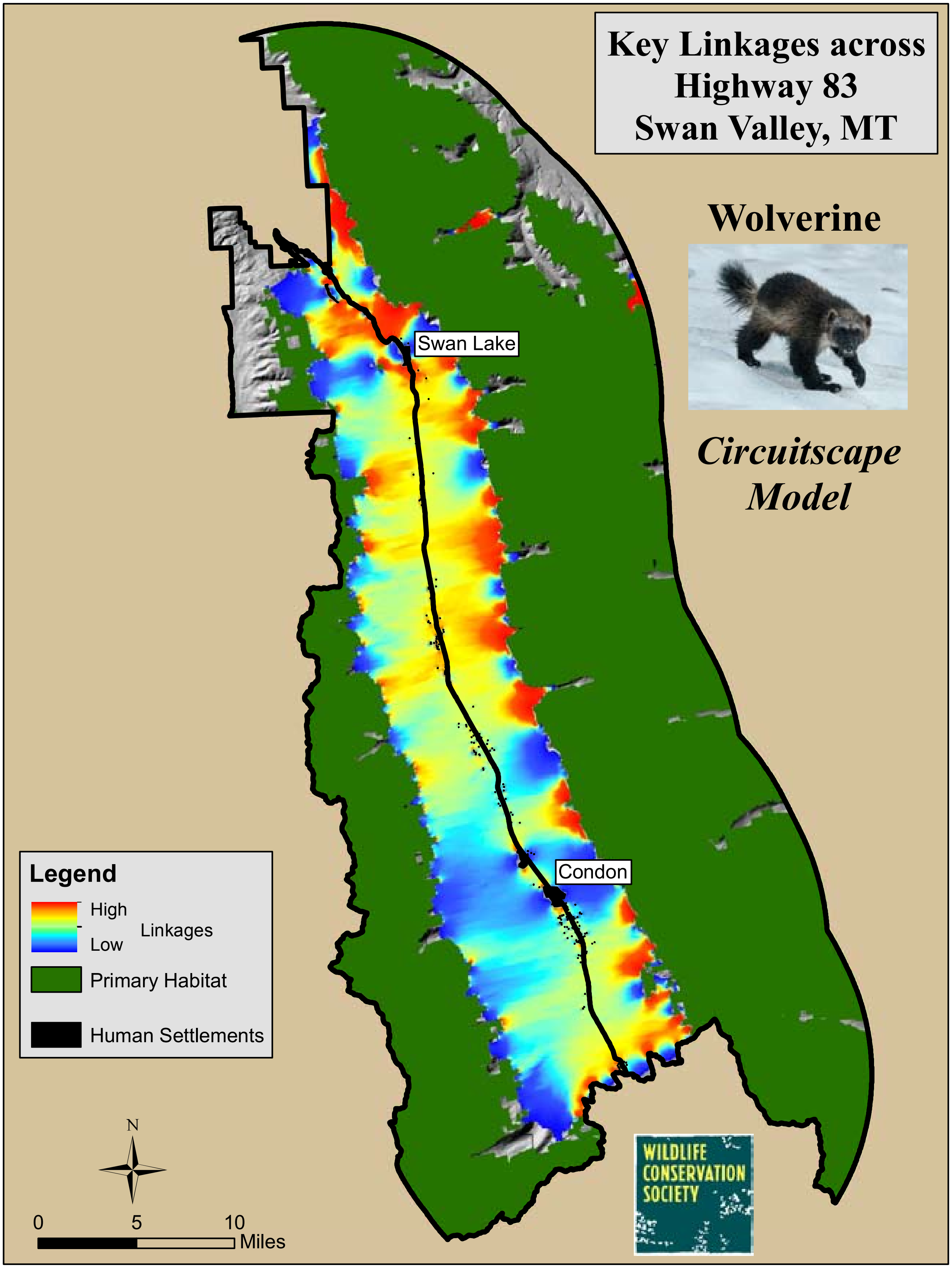
(2) Squeezer Creek section (MP 56-57) which might connect wolverine habitat in roadless area near Swan Peak on the east to upper Fatty Creek at the north end of the Mission Mountains Wilderness;

(3) Salmon Prairie (MP 50) which might connect wolverine habitat in upper Lion Creek roadless area on the east to Jim Lakes Basin in the Mission Mountains Wilderness; and

(4) Seeley-Swan Divide (MP 32-34) which might connect rugged terrain in the roadless area near Wolverine Peak and upper Holland Lake basin on the east to south end of the Mission Mountains Wilderness above Lindbergh Lake

One of the notable aspects of the wolverine connectivity map is the higher-value linkage habitats in the roadless area on the east side of the Swan Valley – particularly in the following areas: North and South Forks of Lost Creek, upper Goat Creek, upper Lion Creek, Smith Creek Pass, and from Rumble Lake to upper Holland Lake and Wolverine Peak. Connectivity modelling at broader scales by other researchers suggests that this mountain axis may be important for gene flow by wolverines across the larger region (Schwartz 2009).

Figure 21. Key linkages across Montana Highway 83 for wolverines according to Circuitscape model, Swan Valley - Flathead National Forest, Montana. Linkage values displayed using a histogram equalize stretch, with 'warmer' colors (red-yellow) representing higher values.



Mountain Goat:

The broad, forested floor of the Swan Valley provides little suitable habitat for mountain goats. Through most of the valley, habitat patches on one side of the highway are separated by at least 10-12 miles from habitat patches on the other side. It is not known if (or how frequently) mountain goats move across the valley. But – <u>if</u> they do – these analyses indicate the better linkages. So, it's in a relative sense that the connectivity models project three putative linkages across Highway 83 for mountain goats (Figures 22):

(1) Salmon Prairie section (MP 49-52) where the model suggested a broad zone (not great habitat) that might connect rugged habitat in the northern sector of the Mission Mountain Wilderness (headwaters of Piper Creek) to the northwest corner of the Bob Marshall Wilderness (Union Peak);

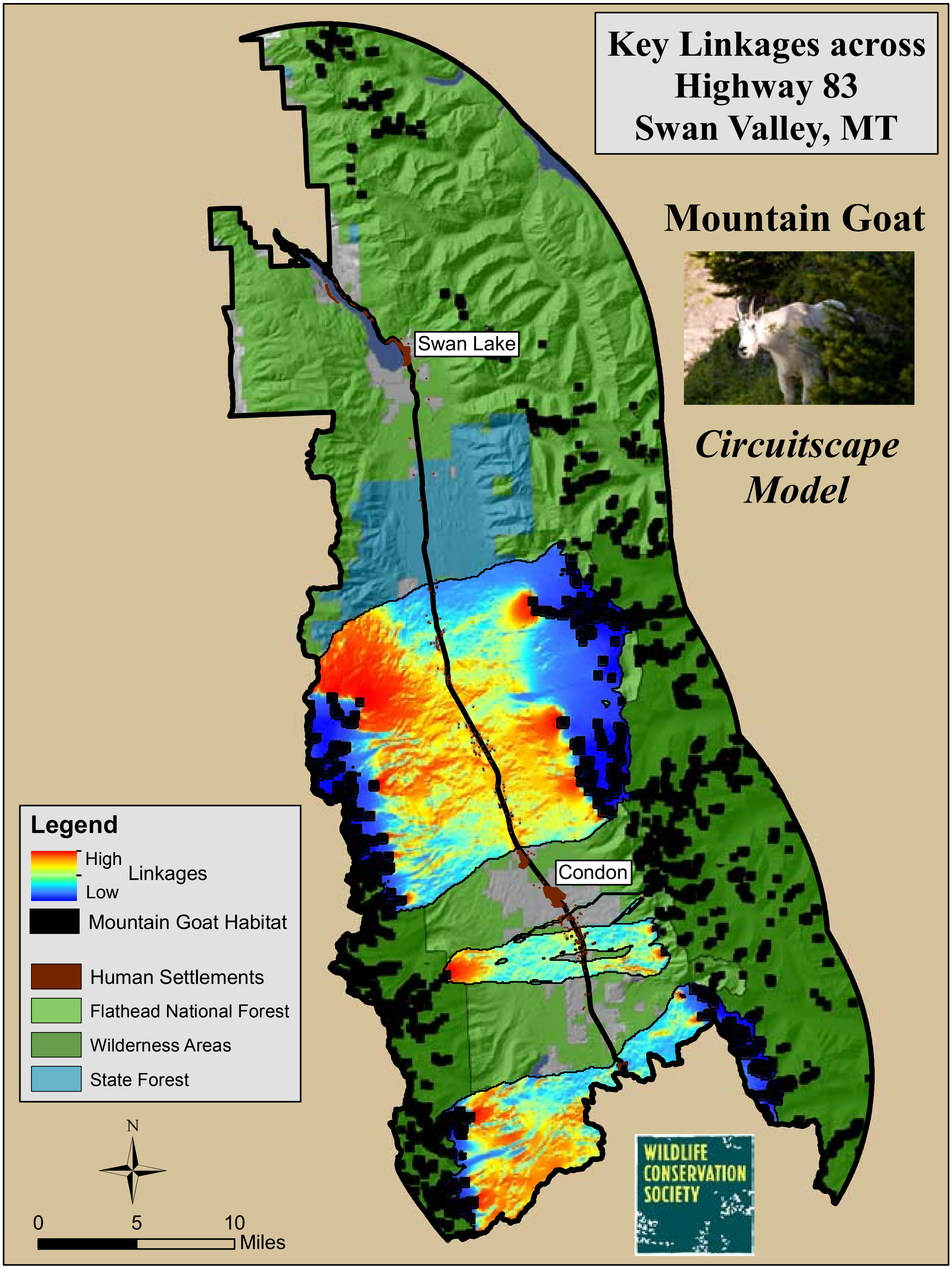
(2) At the south end of the Swan Valley, the model depicted a possible linkage connecting the south end of the Mission Mountain Wilderness eastward across the Hwy 83 summit to Wolverine-Carmine Peaks on the Bob Marshall Wilderness boundary south of Holland Lake.

(3) The model suggests another possible linkage across the middle of the valley south of Condon. But the lack of suitable terrain on either side of the highway makes this route problematic.

Summary: Although each of these vulnerable species has its own habitat requirements, these connectivity models suggest overlap in linkages in the central part of the Swan Valley, particularly along a 13-mile stretch from Goat Creek (MP 58) south to Smith Creek area (MP 45) near Condon. Another linkage at the south end of the Swan Valley along the Seeley-Swan Divide (MP 32-34) might be used by bears, wolverines, and perhaps mountain goats.

Even more striking is the overlap in key habitats among these species in the strip of roadless area that borders the Swan Valley on the east. Protection of these roadless areas on the Flathead National Forest may be important in facilitating connectivity between the Bob Marshall Wilderness and the Mission Mountain Wilderness. This would complement the Montana Legacy Project, where about 44,700 acres of timber corporation lands (Plum Creek Company) in the Swan Valley were purchased and transferred to the Flathead National Forest.

Figure 22. Key linkages across Montana Highway 83 for mountain goats according to Circuitscape model, Swan Valley - Flathead National Forest, Montana. Linkage values displayed using a histogram equalize stretch, with 'warmer' colors (red-yellow) representing higher values.



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4. WILDLIFE AND WILDLANDS ON THE FLATHEAD NATIONAL FOREST

Role of Protected Wildlands in Conservation of Vulnerable Fish and Wildlife

Over the past century, the ever-expanding footprint of humans – urban and rural sprawl, superhighways and forest roads, dams and diversions – has resulted in the loss of wildlife habitat and many other environmental effects. Roads, vehicle traffic, and associated human activity can have a variety of substantial and cumulative effects upon species and ecosystems (see reviews of research findings by Olliff et al. 1999, Trombulak and Frissell 2000, Gucinski et al. 2001, Forman et al. 2003, Coffin 2007, Fahrig and Rytwinski 2009, Beckman et al. 2010 and *hundreds* of references therein).

- Placement of roads in or near floodplains/riparian zones can increase sedimentation, re-route water and nutrients, cause collapse of unstable hillsides, and pose barriers to movement of fish and other aquatic organisms. Such effects may show up years later and/or miles downstream.
- Road maintenance and vehicles introduce chemical contaminants that degrade air and water.
- Roads facilitate spread of invasive plants and unsanctioned introduction of nonnative fish, which has become a major threat to native plants and animals.
- Roads reduce available habitat due to direct removal or displacement. Depending upon the type, volume of traffic, and duration of traffic, animals can be displaced from 100 m to 2 km from a road or major facility. In some cases, motorized traffic such as snowmobiles or helicopters can displace animals from their selected habitats in winter, which can negatively affect their energy balance. (Some animals can habituate to road traffic that is predictable in space and time.)

* New roads open up access into remote areas, which can lead to increased mortality from poaching, incidental killing, and excessive harvest. Grizzly bears, wolverines, mountain goats and even bull trout and westslope cutthroat trout are vulnerable to the effects of new access and inadequate regulations.

* Road access can result in animals like grizzly bears obtaining rewards of available food or garbage, resulting in relocation or killing the animal after repeat episodes.

* Roads may pose an impermeable barrier to many small organisms, and a partial barrier to larger species. Roads cause landscape fragmentation that can result in smaller populations, greater isolation, and less genetic exchange – which increases the risk of local extirpation. Moreover, as climate changes, fish and wildlife will need to move to find new sites and foods for sustaining their ecological needs. Roads can restrict animal movements in response to climate change.

* Because roads fragment landscapes into smaller patches at an exponential rate, even a single major road can have substantial fragmentation effect. In other cases, a single road arguably may have little detrimental effect upon fish and wildlife populations. But the cumulative impacts of multiple activities and a spidery network of many roads often results in substantial and cascading effects upon animal populations and ecological processes.

* In conclusion, the physical imprint of a road itself can have impacts, particularly on fish and aquatic ecosystems due to sedimentation and barriers to passage – *regardless of the level of traffic or human behavior*. Risk of mortality from direct shooting (legal hunting or poaching) and spread of invasive species increases as access expands – *regardless of traffic volume*. Increasing levels of traffic volume reduce amount of useable habitat via displacement (or shifts to nighttime use) and reduces permeability of roads to wildlife crossing.

In many areas of the country, the unrelenting proliferation of human developments and roads has resulted in loss of crucial habitats for fish and wildlife, fragmentation of landscapes, and impoverishment of biodiversity and valuable ecosystem services. A common strategy among managers facing risk to valued resources is to minimize their exposure by placing them in 'safe havens' or refugia. Indeed, the powerful role of refugia in persistence of populations has emerged as one of the most robust concepts in modern ecology. Refugia are 'safe havens' from habitat loss and overexploitation. Both the ecological profiles and the historical record of extirpations attest to the need for some form of refugia for vulnerable fish and wildlife species (Weaver et al. 1996).

On the Flathead National Forest in Montana, roads proliferated dramatically starting in the 1960s as timber harvest operations greatly expanded. Today, there are approximately 1,046 mi of forest roads opened year-round, 381 mi of seasonally-closed forest roads, and 959 mi of historic roads across the Forest.

Fortunately, the legacy of large protected wildernesses and wild and scenic rivers provided just such safe havens for vulnerable species – bull trout, grizzly bears, wolverines, and mountain goats.

But projected changes in climate will bring new and novel challenges. It will change environmental conditions and place increasing pressure upon plants and animals, thereby putting many ecological changes into motion. Recently, conservation biologists have applied the concept of safe havens for biodiversity in the context of climate change (Keppel et al. 2012). In the Central Interior of British Columbia, for example, ecologists and land planners have been modeling climate refugia for vulnerable species to identify conservation areas (Kittel et al. 2011, Rose and Burton 2011). Such refugia can be especially robust strategies when they include large areas with high topographic and ecological diversity, which are effectively connected.

In an ever-changing world where impacts of habitat loss and fragmentation, invasive species, and climate warming are accelerating, vulnerable species will persist longer with well-designed networks of core refugia and connectivity that offer ecological options (Carroll et al. 2009, Hodgson et al. 2009). Thus, protecting and connecting ecologically-diverse roadless areas in legislated Wilderness and other non-motorized categories (e.g., legislated 'Backcountry') is a sound and robust strategy in response to climate change

Here, I synthesize information on key areas for these vulnerable fish and wildlife species and provide recommendations on wildland protection in each of the Geographic Areas across the Flathead National Forest.

Protection of Wildlands for Vulnerable Fish and Wildlife

The 'Inventory of Roadless Areas' (IRA) by the U.S. Forest Service tallied **479,764 roadless acres** on the Flathead National Forest (Figure 1). In addition, in a new policy directive for wilderness evaluation (Chapter 70 in Forest Service Handbook [FSH] 1909.12 for Land Management Planning), the Forest Service has specified that the following kinds of forest roads do not disqualify an area from consideration for wilderness:

a. those roads maintained to level 1,
b. temporary routes or those that are identified for decommissioning, or
c. those roads where disinvesting in future maintenance reverts road status to a level 1.

Level 1 roads are defined in the Forest Service Handbook (FSH 7709.59 - chapter 60) as follows:

> These are roads that have been placed in storage between intermittent uses. The period of storage must exceed 1 year. Basic custodial maintenance is performed to prevent damage to adjacent resources and to perpetuate the road for future resource management needs. Emphasis is normally given to maintaining drainage facilities and runoff patterns. Planned road deterioration may occur at this level. Appropriate traffic management strategies are to "prohibit" and "eliminate" all traffic. These roads are not shown on motor vehicle use maps. Roads receiving level 1 maintenance may be of any type, class, or construction standard, and may be managed at any other

maintenance level during the time they are open for traffic. However, while being maintained at level 1, they are closed to vehicular traffic but may be available and suitable for non-motorized uses.

Thus – in addition to the IRA lands – other areas with Level 1 roads can also be considered for wilderness evaluation, which is an important shift in land policy.

I devised the following set of management categories for conserving roadless wildlands on the Flathead National Forest, Montana: (1) Wilderness, (2) Backcountry Conservation, and (3) Wildland Restoration Zone.

For those roadless areas that have *high* composite scores for the suite of vulnerable species, I usually recommend **Wilderness** designation. In a few areas with key sites for these vulnerable fish and wildlife, I also included some adjoining lands with Class 1 roads. These areas would become legislated Wilderness under the Wilderness Act of 1964 as either additions to existing Wilderness or a new unit in the national system. For areas that have *moderate* composite scores for these species, I recommend a **Backcountry Conservation** designation. Backcountry is a management designation commonly used by National Forests for roadless areas to emphasize remote recreation opportunity with less strict standards than in Wilderness areas. Here, I expand the concept to emphasize management for conservation of these vulnerable species and wildland habitats. Ideally, backcountry conservation areas would be legislated to ensure permanent protection (as in the proposed Rocky Mountain Front Heritage Act).

In some areas on the Flathead National Forest, primitive roads penetrate rather deeply into narrow mountain ranges – notably in the Swan Range and the Whitefish Range. Most of these roads were constructed for timber harvest back during the 1960-1970s. In recognition of the important fish and wildlife values in the Swan and Whitefish Range, the Flathead NF has closed several of these roads on a year-round or seasonal basis. Although the Flathead NF has demonstrated commendable leadership with this program, some roads receiving either legal or illegal use by motorized vehicles may still impact wildlife. Accordingly, I proposed a category called *Wildland Restoration Zone* where certain strategic roads would be de-commissioned or otherwise permanently closed and returned to more natural condition. Such restoration would increase security value of adjacent lands for vulnerable wildlife and enhance the configuration (less edge exposure to deleterious impacts) of recommended Wilderness areas.

The intent of this approach is to inform choices about designation of roadless areas, not to automatically render an outcome. For example, a high composite score across all species would strongly indicate that a roadless area should be recommended for Wilderness. On the other hand, a lower composite score might suggest a 'Backcountry' designation. If a very high score for a particular species, however, was embedded in the low overall score, then that might warrant consideration for Wilderness.

In making recommendations for wildland protection on the Flathead National Forest, I considered the geographic distribution of the composite scores, areas important for connectivity across the broader landscape, and ecological options (range-of-elevation and latitude) for resiliency in the face of changing climates. In the next section, I synthesize pertinent information about the singular and composite scores for vulnerable fish and wildlife in remaining roadless areas, then make recommendations for Wilderness (high-priority lands) and Backcountry (medium-priority lands) designation.

North Fork Geographic Area

Synthesis of Conservation Values

The North Fork Geographic Area has high conservation value for the suite of vulnerable fish and wildlife species, especially in the northern portion of the unit. It has 62,054 ac of the highest composite scores (8-14) and 208,088 ac of the moderate scores (4-7) (Table 6, Figure 23). About 21,595 ac (35%) of the highest composite scores and 100,298 ac (48%) of the moderate scores occur in the roadless portions of this Geographic Area. In terms of importance values for individual species, it has 248,629 ac of *very high* values and 91,398 ac of *high* values. About 113,126 ac (46%) of the *very high* values and 21, 022 ac (23%) of the *high* ones occur in roadless areas (Table 7). Several roadless areas in the North Fork Flathead River basin have **outstanding** value for conservation of vulnerable fish and wildlife and Wilderness.

- Nearly all of the roadless area in the North Fork has very high value for at least one or more of these vulnerable species. Much of the area scored **moderate** in composite value, and several places – notably in the headwaters of and along Trail Creek (Tuchuck Mtn-Mount Thompson Seton), Moose and Red Meadow Creek (Nasukoin Mtn), and Hay and Coal Creeks – scored **high**.
- The portion of the North Fork from the U.S.-Canadian border south to Coal Creek has large roadless blocks with a mix of high and moderate composite value. The entire North Fork Flathead River and nearly all of its tributaries with their source in the roadless Whitefish Range have been designated as critical habitat for bull trout. Several drainages in the northern sector still have genetically-pure populations of westslope cutthroat trout – including Colts Creek, Trail Creek and several tributaries, Moose Creek, and upper Red Meadow Creek. Most of the Flathead NF lands comprise primary habitat for wolverines, with extensive maternal habitat at higher elevations. Secondary and primary habitat components for grizzly bears are widespread in this northern portion, with a concentration of avalanche chutes and huckleberry patches at higher elevations. The highest densities of grizzly bears reported for interior North America have been documented in the trans-border area of the North Fork Flathead (McLellan and Shackleton 1988, Kendall et al. 2008, Kendall et al. 2009). Moreover, this section connects with important wildlife areas in the British Columbia section of the trans-border Flathead (Weaver 2001, Weaver 2013). Considerable range of elevation and northward connectivity with the headwater basin of the North Fork Flathead River in B.C. provides options for movement in response to climate change.

- ❖ Roadless areas in the southerly section of the North Fork also have patches of high conservation value, but they are smaller in size, less well-connected, and closer to areas with intensive resource extraction and/or non-native species. Big Creek and its tributaries have been designated as critical habitat for bull trout, and most have genetically-pure populations of westslope cutthroat trout. Some areas have productive habitat for grizzly bears, but extensive roads penetrate further westward and compromise habitat security. Blocks of maternal wolverine habitat become smaller and more isolated at the southern tip of roadless areas. These may shrink even further in the future if warming winter temperatures reduce critical snowpack at low to mid- elevations. More of the conservation value for these vulnerable species is found in the roadless headwaters of drainages closer to the Whitefish Divide.
- ❖ The North Fork Geographic Area occupies a very strategic position in the larger Crown of the Continent Ecosystem and provides important connectivity (east↔west) with Kootenai National Forest and Glacier National Park and (north↔south) with British Columbia.

Recommendations for Wildland Protection

None of these important roadless areas in the North Fork are protected by Wilderness designation. The Forest Service Inventory of Roadless Areas (IRA) tallied 136,659 ac in this unit. But there are severable areas with class I roads (e.g., upper Coal Creek) that could be eligible for wilderness evaluation.

I recommend that 137,872 roadless acres be designated as Wilderness (Table 8, yellow highlight areas in Figure 24). I recommend the following areas be designated as part of a new wilderness area:

- ✓ Tuchuck Mtn - Mount Hefty area,
- ✓ Mount Thompson-Seton and Nasukoin Mtn area, and
- ✓ Headwaters of Hay Creek and Coal Creek (including some level 1 roads).

These additions would protect the highest-value habitats for these vulnerable fish and wildlife species, enhance connectivity with both Glacier National Park and the Canadian Flathead, and provide options for future responses to climate change. Importantly, it would underscore a strong American commitment to protect the ecological integrity of the trans-boundary Flathead region. In addition, many of the streams here also have been deemed eligible for Wild and Scenic River designation – including Trail, Whale, Moose, Red Meadow, and Coal Creek (Colburn et al. 2012).

I further recommend that 26,341 acres be managed in roadless condition as 'Backcountry Conservation' with emphasis on non-motorized recreation and conservation of fish and wildlife (Table 8, green areas in Figure 24). These are sites that have moderate composite value but have high value for 1 or more of these vulnerable fish and wildlife. Areas recommended for Backcountry designation include:

- northern tributary basins of Big Creek, and
- the Smoky Range.

Big Creek has been deemed eligible for Wild and Scenic River designation, too.

Figure 23. Distribution of composite scores for all focal species, North Fork Geographic Area, Flathead National Forest, Montana.

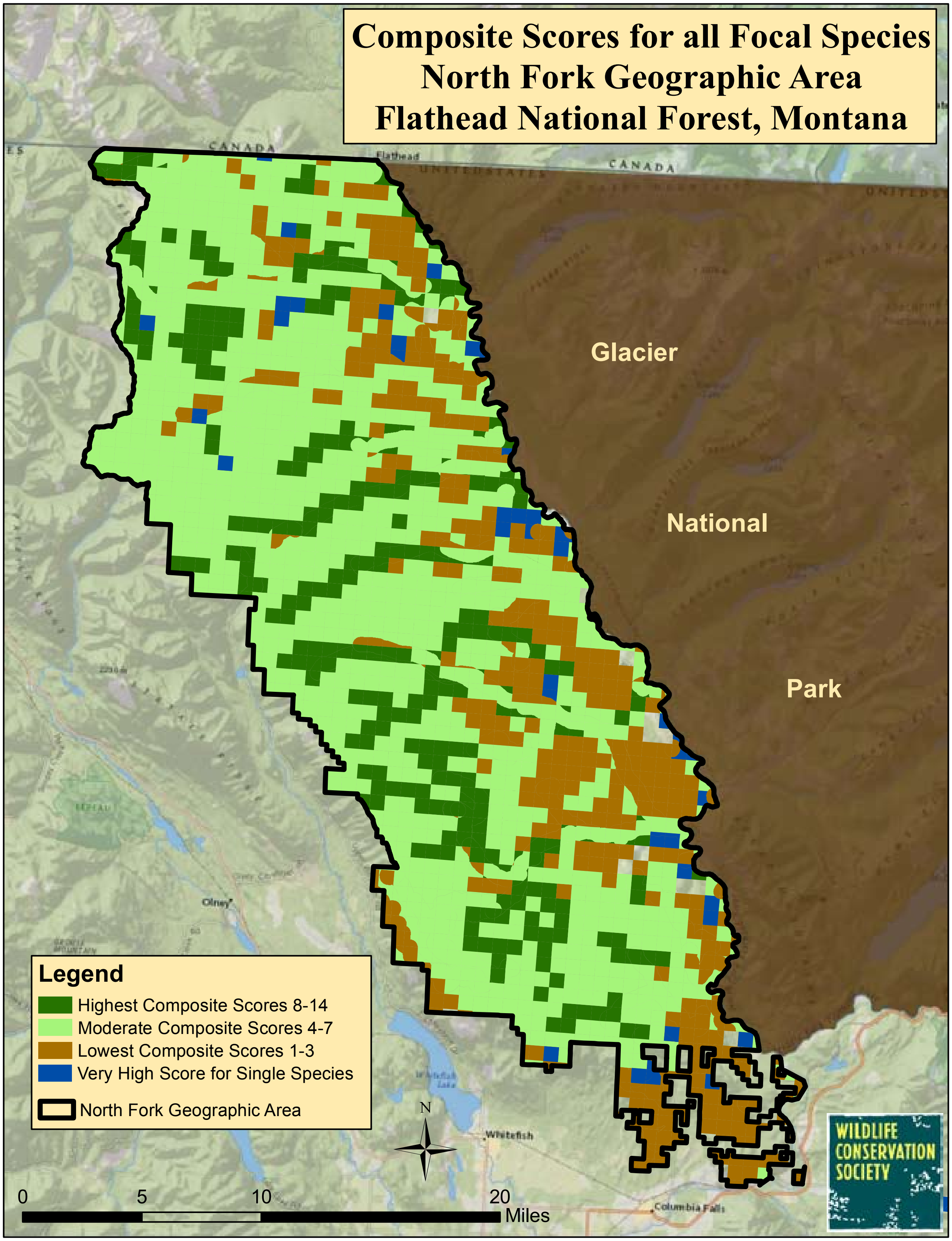
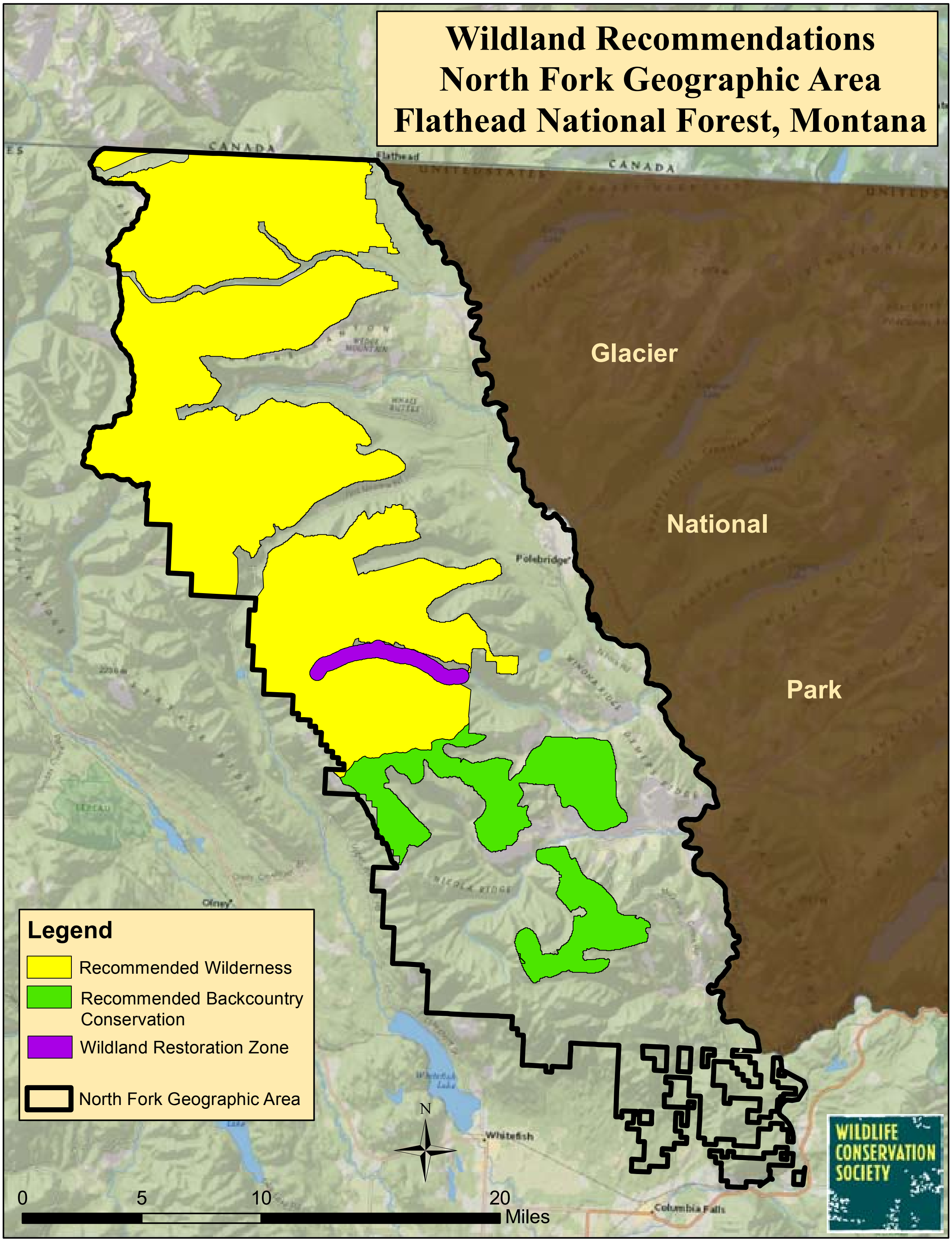


Figure 24. Recommendations for Wilderness, backcountry conservation, and wildland restoration zone, North Fork Geographic Area, Flathead National Forest, Montana.



Several primitive roads extend westward from the North Fork road and penetrate deeply into the Whitefish Range. In recognition of the important fish and wildlife values in these basins, the Flathead National Forest has closed several of these roads on a year-round or seasonal basis. Nonetheless, some of these seasonal roads still receive unauthorized use by ATV and/or snowmobiles which, in some cases, may impact wildlife. I recommend that 7.0 miles of seasonal road #1684 on the south side of Coal Creek be considered for wildland restoration (de-commissioned or otherwise permanently closed and returned to more natural condition). An alternate road (#317B) runs along nearly the entire length of Coal Creek on the north side. This would enhance habitat security for several species, as well as the spatial integrity (less fragmentation) of lands recommended for Wilderness designation.

Middle Fork Geographic Area

Synthesis of Conservation Values

The Middle Fork Geographic Area has about 207,616 ac of the highest composite scores (8-14) and 141,615 ac of moderate scores (4-7) (Table 6, Figure 25). Much of the Middle Fork Flathead River watershed is protected within the Great Bear Wilderness and the Bob Marshall Wilderness. <u>About 12,665 ac (6%) of the highest composite scores (8-14) and 23,791ac (17%) of the moderate scores (4-7) occur in the roadless portions of the Geographic Area</u>. In terms of importance values for individual species, it has 340,820 ac of very high values and 24,271 ac of high values (Table 7). <u>About 34,423 ac (10%) of the *very high* values and 5,825ac (24%) of the *high* values occur in roadless areas</u>. Some of the remaining roadless areas in the Middle Fork Flathead River basin have **outstanding** value for conservation of vulnerable fish and wildlife and Wilderness values, and they also may facilitate regional connectivity across U.S. Highway 2 with Glacier National Park.

- The area south of Marias Pass has important values for the conservation of vulnerable fish and wildlife, especially around Slippery Bill Mountain (including Puzzle Creek) and Twentyfive Mile Creek, each of which scored high in composite scores. The headwaters of Morrison and Granite Creeks scored very high for bull trout and westslope cutthroat trout. Slippery Bill Mountain has numerous avalanche chutes – and riparian zones extend along Puzzle Creek, Crescent Creek, and Morrison Creek – that provide excellent habitat for grizzly bears. Slippery Bill Mountain and Crescent Cliff also scored very high in conservation value for wolverine and mountain goat. Grizzly bears, wolverine, and goats move back and forth across the Continental Divide into the Badger-Two Medicine roadless area. Both elk and mountain goats made extensive use of a large mineral lick at the head of Puzzle Creek. Twentyfive Mile Creek, a tributary of the Middle Fork Flathead River, forms the northeast boundary of the Great Bear Wilderness in this area. It contains high composite values, with very high conservation values for westslope cutthroat trout, grizzly bear, and wolverine.

- ❖ Other roadless lands in this upper section have moderate composite scores but with very high scores for some species. Pure populations of westslope cutthroat trout have been documented in Challenge Creek and are assumed to occur in upper Granite and Skyland. There are important habitats for both wolverine and grizzly bear along the Continental Divide.
- ❖ A narrow strip of roadless lands extends along U.S. Highway 2 between West Glacier and Marias Pass. Although these lands may seem inconsequential due to the small size, some sections appear quite important for two reasons: (1) high composite value, and/or (2) promote regional connectivity between the Flathead National Forest and Glacier National Park. In the lower Middle Fork Flathead River section, the roadless area between Tunnel Creek and Essex Creek has high composite scores. The Middle Fork has been designated as critical habitat for bull trout, and pure populations of westslope cutthroat trout occur in Essex Creek and Tunnel Creek. Upper Essex and Dickey Creeks and Paola-Tunnel Ridges have very high value for grizzly bears and wolverines. The roadless strip along Bear Creek just above the confluence with the Middle Fork Flathead River also has high composite scores. Bear Creek is designated as critical habitat for bull trout and may serve as a spawning/rearing area. It is assumed to contain a pure population of westslope cutthroat trout. The section between the confluence and Giefer Creek also has primary habitat for grizzly bears. The connectivity analyses (see Chapter 3) suggest that the section between Pinnacle Creek (Highway 2 MP 175) and Skyland Creek (MP 194) encompasses a multi-species, 'umbrella' linkage zone.

Recommendations for Wildland Protection

For the Middle Fork Geographic Area, the Forest Service IRA tallied 42,765 ac. But there are several areas with class I roads (e.g., Twentyfive Mile Creek) that could be eligible for wilderness evaluation.

I recommend 30,229 roadless acres in the Middle Fork Geographic Area as additions to the Great Bear Wilderness (Table 8, yellow areas in Figure 26):

- ✓ Slippery Bill Mountain - Puzzle Creek area and rest of the Twentyfive mile Creek watershed,
- ✓ narrow strip along south side of Highway 2 from Skyland Creek down to Pinnacle Creek, and
- ✓ Essex Creek-Tunnel Creek area.

All of these areas have predominantly high composite scores and likely provide crucial connectivity between the Great Bear Wilderness, the roadless Badger-Two Medicine area, and Glacier National Park.

I further recommend that 16,060 roadless acres be managed in roadless condition as 'Backcountry Conservation' with emphasis on non-motorized recreation and conservation of fish and wildlife (Table 8, green areas in Figure 26):

- upper Granite-Challenge Creek area, and
- narrow strip of roadless lands along the Middle Fork of the Fathead River from West Glacier east to Grant Ridge.

Figure 25. Distribution of composite scores for all focal species, Middle Fork Geographic Area, Flathead National Forest, Montana.

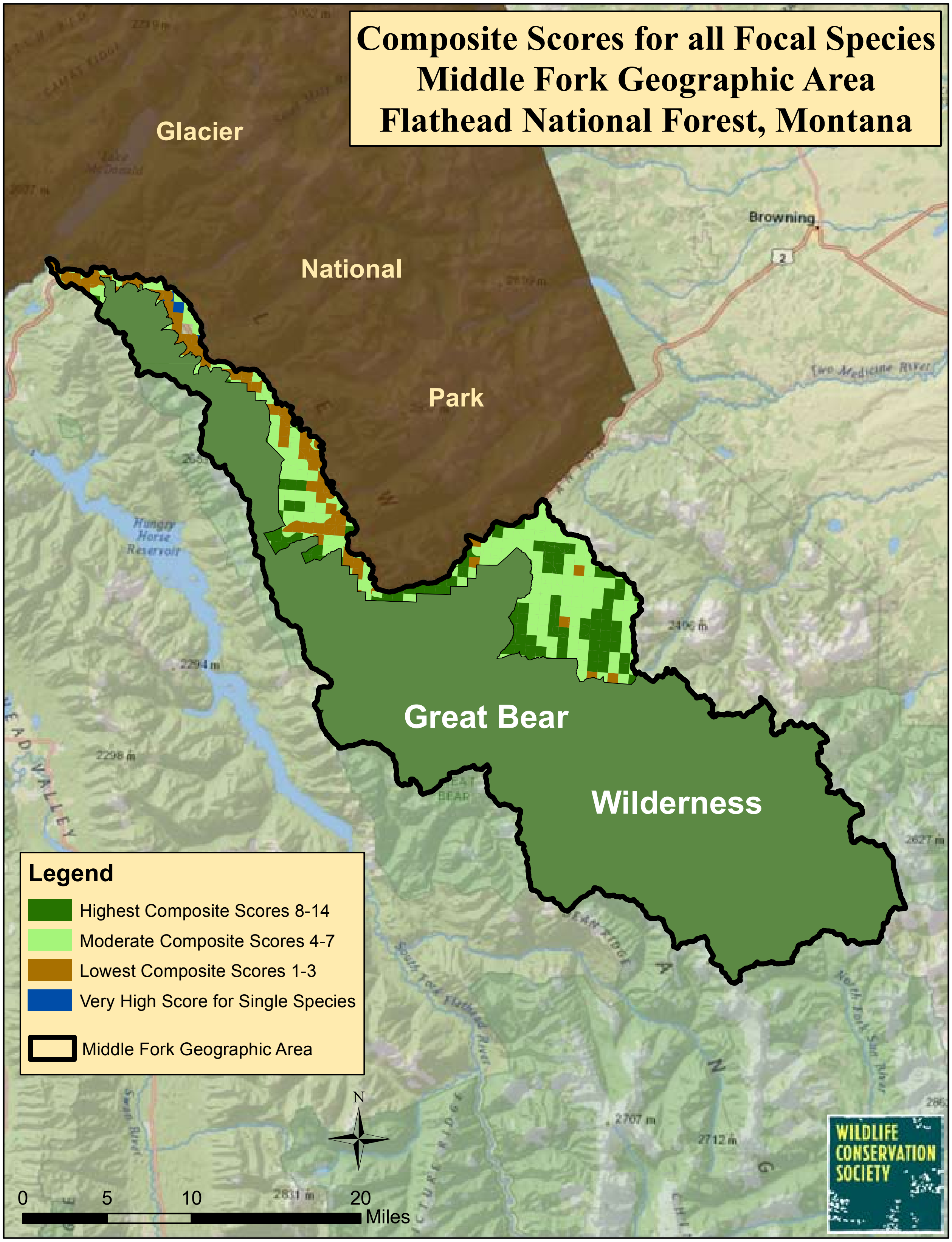
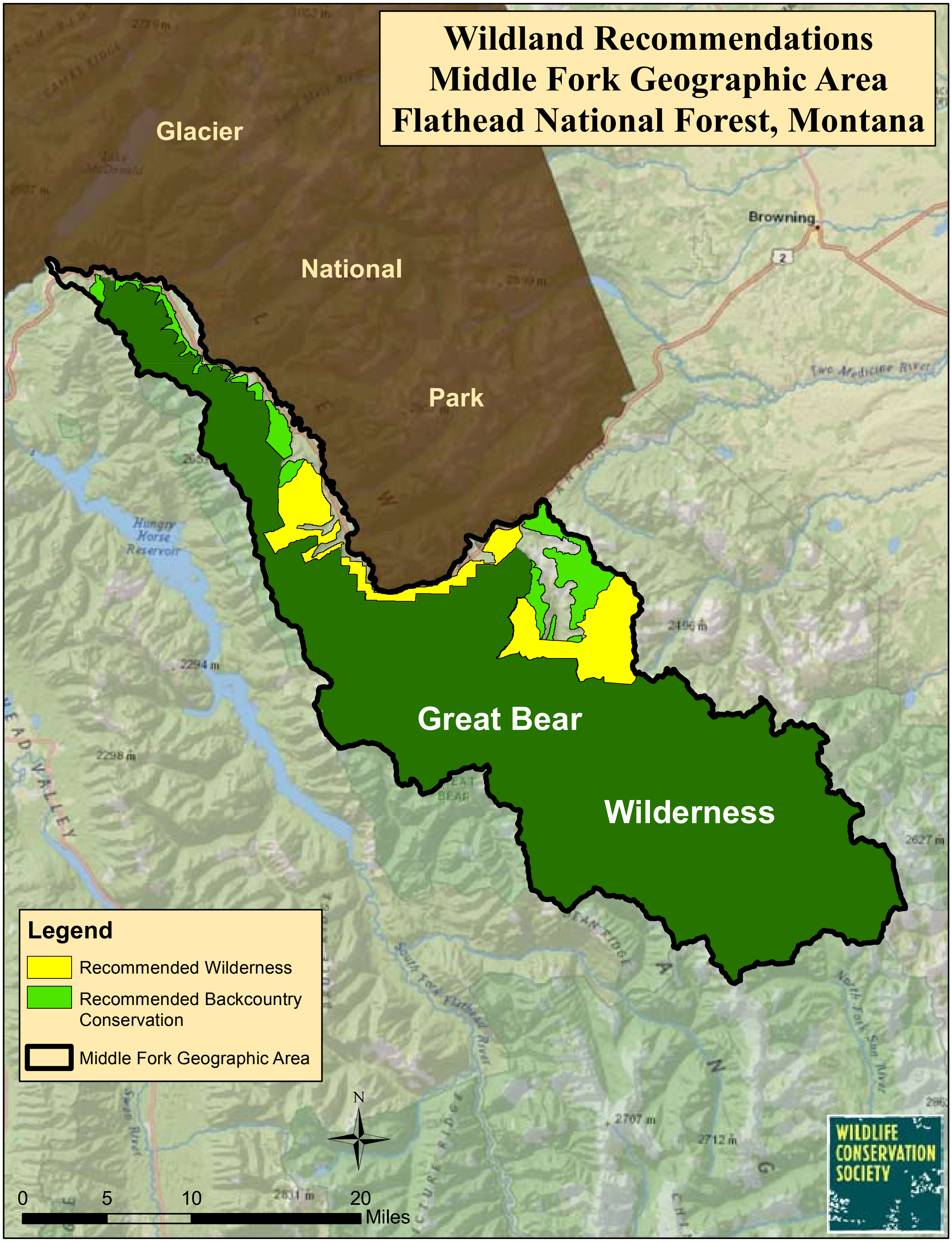


Figure 26. Recommendations for Wilderness and backcountry conservation, Middle Fork Geographic Area, Flathead National Forest, Montana.



- Although these areas have predominantly moderate composite scores, certain sites have high composite scores and very high values for individual species. Moreover, conserving these roadless lands in 'backcountry' status would support the larger goal of keeping the interface between the Great Bear Wilderness and Glacier National Park from becoming fragmented. Both Granite and Morrison Creeks have been deemed eligible for Wild and Scenic River designation (Colburn et al. 2012).

Hungry Horse Geographic Area

Synthesis of Conservation Values

The Hungry Horse Geographic Area has high conservation value for the suite of vulnerable fish and wildlife species, especially along the eastern slopes of the Swan Range west of Hungry Horse Reservoir. It has 70,922 ac of the highest composite scores (8-14) and 144,856 ac of the moderate scores (4-7) (Table 7, Figure 27). About 35,674 ac (50%) of the highest composite scores (8-14) and 75,615 ac (52%) of the moderate scores (4-7) occur in the roadless portions of the Geographic Area. In terms of importance values for individual species, it has about 206,489 ac of the very high values and 64,024 ac of high values (Table 6). About 102,419 ac (50%) of the very high values and 19,463 ac (30%) of the high values occur in roadless areas. Most of these conservation values lie outside the narrow strip of the Great Bear Wilderness on the east side of this Geographic Area. Consequently, several roadless areas have **outstanding** value for conservation of vulnerable fish and wildlife and Wilderness values. Here, I detail these conservation values for the west and east side of the Hungry Horse Geographic Area.

❖ **West Side – Sullivan Creek watershed north to Jewel Basin**

Sullivan Creek and Quintonkon Creek have **high** composite scores throughout the watersheds. For bull trout, all of Sullivan Creek and the lower section of Quintonkon Creek have been designated critical habitat for spawning. Genetically-pure populations of westslope cutthroat trout have been documented in Quintonkon and Sullivan Creeks and are assumed to be pure in the west tributaries of Sullivan Creek (Ball, Branch, Connor, and Slide Creeks). Most of the mountain goat habitat along the Swan Crest lies on the Swan Valley side, but goats may occur at times at the head of Ball Creek (Hall Peak), Branch Creek (Con Kelly Mtn), and the very headwall of Sullivan Creek. Nearly all lands in these watersheds comprise primary habitat for wolverines, with extensive maternal habitat at higher elevations. Numerous avalanche chutes (especially upper Quintonkon Creek), huckleberry patches, and slab rock terraces provide primary habitat components for grizzly bears across these watersheds. The South Fork grizzly bear study recorded locations of female bears throughout much of this area, too. Closure of the old logging roads up the tributaries of Sullivan Creek has provided important security for bears.

❖ **West Side – The Jewel Basin Hiking Area and surrounding area**

Jewel Basin has a notable concentration of high composite scores for these vulnerable species. Importantly, high and moderate scores extend into roadless areas on the south (Wheeler Creek), east (Forest, Aeneas, and Graves Creeks), and north (Clayton, Wildcat and Wounded Buck Creeks) sides of Jewel Basin. Critical habitat for bull trout spawning has been designated in lower Wheeler Creek and Wounded Buck Creek. Genetically-pure populations of westslope cutthroat trout have been documented in Forest, Jones-Aeneas-Graves, Knieff, Goldie, Clayton, Wounded Buck and Wildcat Creeks. Jewel Basin represents the northern extent of suitable habitat for mountain goats along the Swan Crest, with goats observed around Big Hawk Mtn, Three Eagles Mtn and Mount Aeneas. Nearly all lands in these watersheds comprise primary habitat for wolverines, with extensive maternal habitat at higher elevations in the roadless areas. The South Fork wolverine study recorded numerous locations of wolverines in Jewel Basin and Wildcat/Wounded Buck drainages. For grizzly bears, the watersheds surrounding Jewel Basin are particularly notable for their concentration of avalanche chutes (especially Wheeler, Jones-Aeneas, and Wildcat-Wounded Buck Creeks) and huckleberry patches. The South Fork grizzly bear study recorded locations of female bears throughout Jewel Basin and surrounding *roadless* lands (with a notable concentration in Wheeler Creek).

❖ **Northern tip of the Swan Range**

The roadless area from Lost Johnny Creek north to Columbia Mountain has predominantly moderate composite scores, with occasional low scores. No critical habitat for bull trout has been designated in this area. A genetically-pure population of westslope cutthroat trout has been documented in Doris Creek. Much of the area provides primary habitat for wolverine, with maternal habitat in the higher elevations (head of Lost Johnny Creek, Otila Basin, and Silver Run Creek). Interestingly, the South Fork wolverine study recorded numerous locations of an adult female wolverine with young along the Swan Crest. Huckleberry patches comprise the primary habitat component here for grizzly bears; secondary forest components, however, are common. Grizzly bear researchers have recorded numerous locations of bears in Lost Johnny and Doris Creek watersheds and west of Doris Mtn.

❖ **East Side – Crossover Mountain north past Great Northern Mountain**

A portion of the Great Bear Wilderness extends downslope on the east side of the Hungry Horse Geographic Area from Great Bear Mtn south to Unawah Mtn. A narrow strip (0.1-4 mi) of roadless area parallels the Wilderness at mid to lower slopes; to the north and south, the roadless area extends to the top of the ridge. Composite scores for the vulnerable species are mostly moderate throughout this narrow strip of roadless lands, with a cluster of high scores in the section from Unawah Mtn south to Crossover Mtn. No critical habitat for bull trout has been designated in this area. But 16 streams flowing into the east side of Hungry Horse reservoir have been documented to contain genetically-pure populations of westslope cutthroat trout. Although most of the suitable habitat and records for mountain goats and wolverines occur inside the Wilderness portion, some habitat for each species extends into the roadless section between Unawah Mtn and Circus Peak. Similarly, primary habitats for grizzly bears are clustered in the area between Unawah Mtn and Crossover Mtn.

Figure 27. Distribution of composite scores for all focal species, Hungry Horse Geographic Area, Flathead National Forest, Montana.

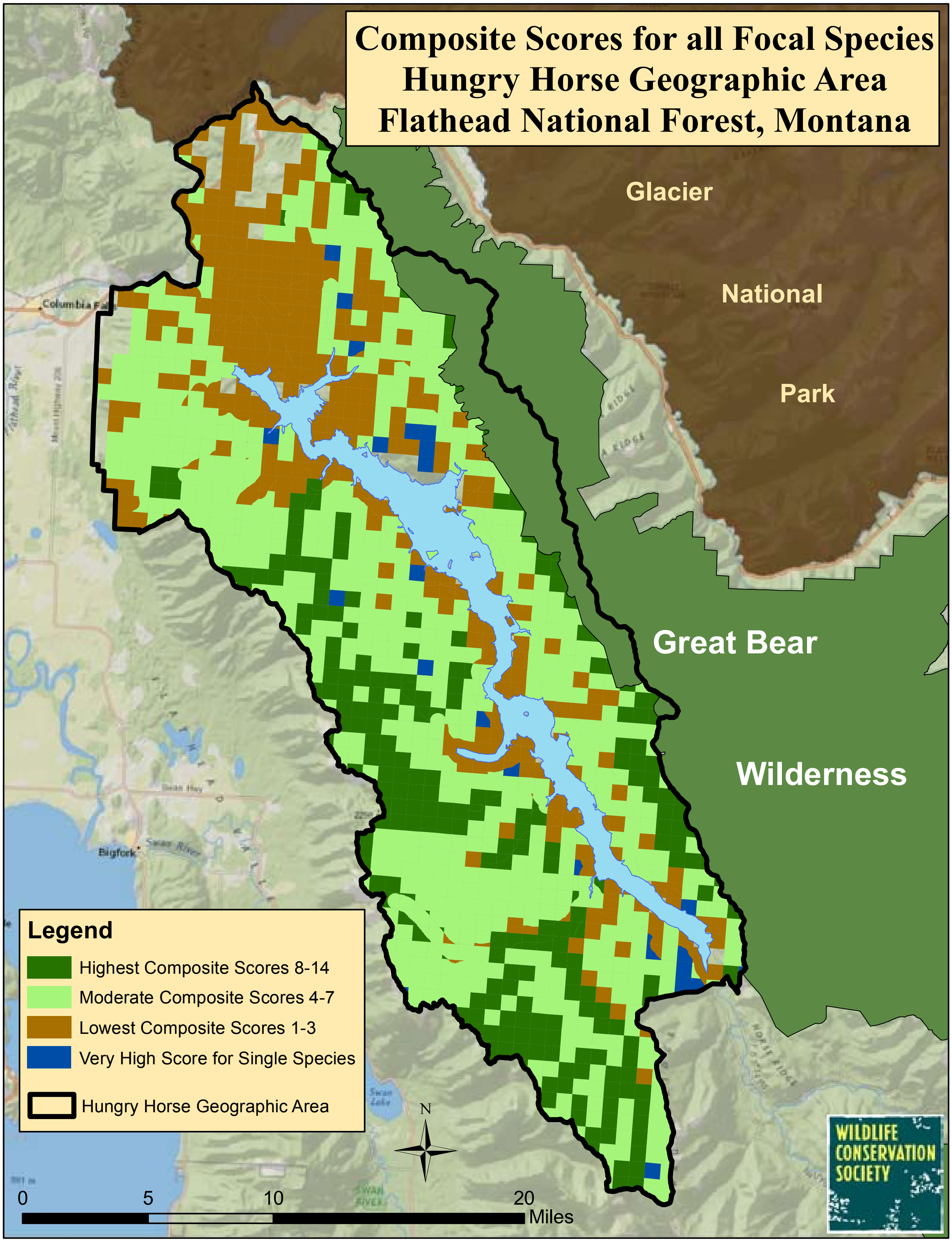
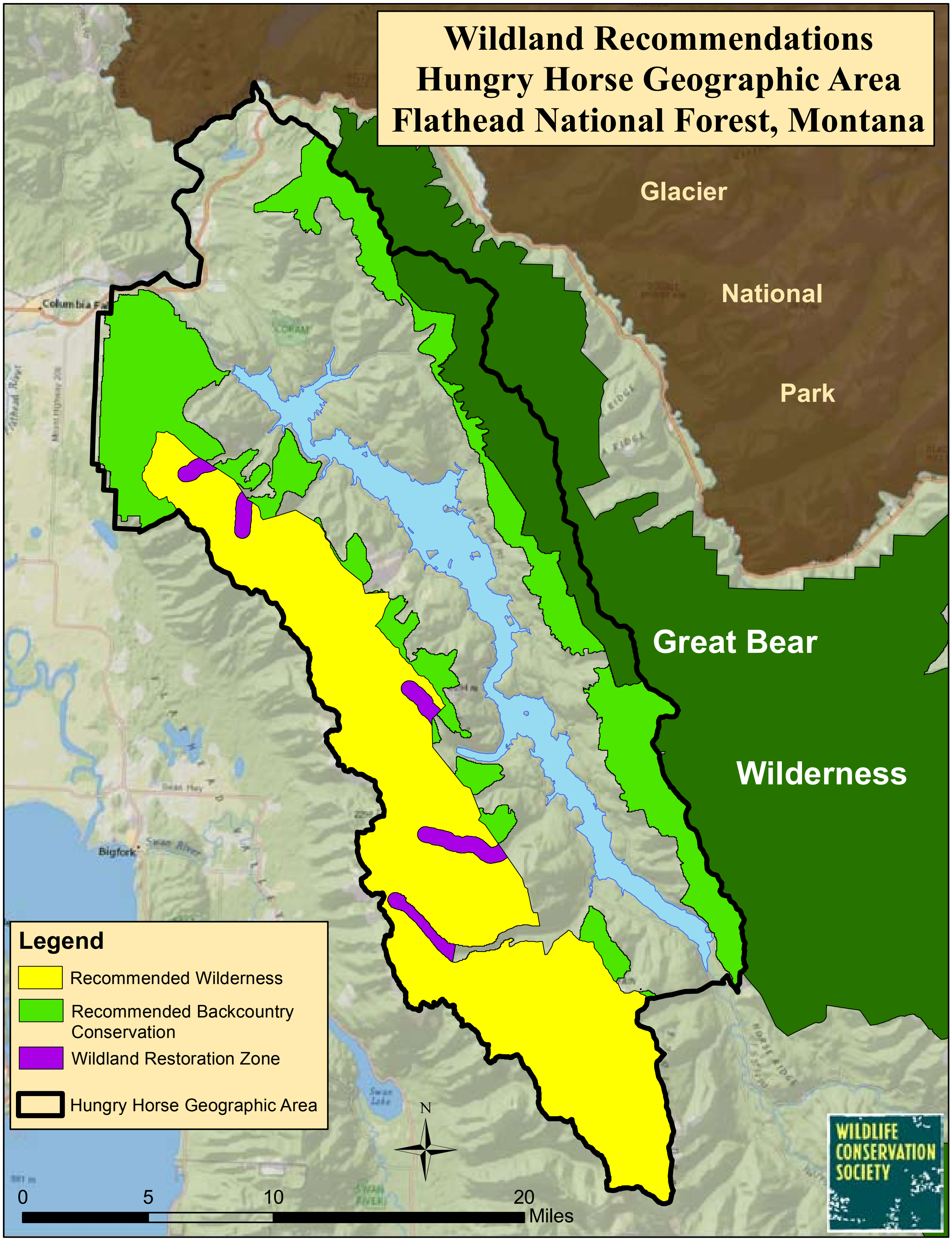


Figure 28. Recommendations for Wilderness, backcountry conservation, and wildland restoration zone, Hungry Horse Geographic Area, Flathead National Forest, Montana.



Recommendations for Wildland Protection

None of the northern Swan Range west of Hungry Horse Reservoir is protected by Wilderness designation. For the Hungry Horse Geographic Area, the Forest Service IRA tallied 127,129 ac. I recommend 93,350 roadless acres in the Swan Range as additions to the Great Bear Wilderness (Table 8, yellow areas in Figure 28):

- ✓ Sullivan Creek and Quintonkon Creek watersheds,
- ✓ Jewel Basin Hiking Area and portions of surrounding drainages – Wheeler, Forest, Aeneas, Graves, Clayton, Wildcat and Wounded Buck Creeks, and
- ✓ headwaters of Lost Johnny and Doris Creeks.

These areas scored high in composite value or provided vital habitats for individual species. Moreover, Wilderness designation for these lands would complement recommended Wilderness for the west side of the Swan Range in the Swan Valley Geographic Area as well as the important Bunker Creek watershed in the South Fork Geographic Area. Both Quintonkon and Sullivan Creeks have been deemed eligible for Wild and Scenic River designation (Colburn et al. 2012).

I further recommend that 58,374 roadless acres be managed in roadless condition as 'Backcountry Conservation' with emphasis on non-motorized recreation and conservation of fish and wildlife (Table 8, green areas in Figure 28):

- northern tip of Swan Range including Columbia and Doris Mountain,
- remaining parcels of roadless lands at lower elevations between the recommended Wilderness and Hungry Horse reservoir, and
- narrow strip of land on the east side of Hungry Horse Reservoir from Crossover Mountain north past Great Northern Mountain.

Although these areas have predominantly moderate composite scores, certain sites have high composite scores and very high values for individual species.

Finally, I recommend 11.8 miles of seasonally-open roads be closed or decommissioned, including (purple areas in Figure 28):

- ★ upper Quintonkon Creek (road # 381) – 3.5 mi
- ★ upper Wheeler Creek (road # 895F) – 3.6 mi
- ★ Grave Creek above Handkerchief Lake (road # 897) – 1.8 mi
- ★ Upper Lost Johnny Creek (road # 895B) – 1.6 mi
- ★ Upper Doris Creek (road # 895A) – 1.3 mi

These roads penetrate deeply toward the crest of the Swan Range and into the area recommended for Wilderness. Typically, they have high composite scores or very high importance values for certain species.

South Fork Geographic Area

Synthesis of Conservation Values

The South Fork Geographic Area has high conservation value for the suite of vulnerable fish and wildlife species. It has 412,594 ac of the highest composite scores (8-14) and 312,009 ac of moderate scores (4-7) (Table 7, Figure 29). Much (85%) of the South Fork Geographic Area lies within the Bob Marshall Wilderness. About 25,168 ac (6%) of the highest composite scores (8-14) and 37,129ac (12%) of the moderate scores (4-7) occur in the roadless portions of the Geographic Area. In terms of importance values for individual species, it has 724,539 ac of the very high values and 45,431 ac of the high values. About 58,688 ac (8%) of the very high values and 10,495 ac (23%) of the high values occur in roadless areas (Table 7). Several roadless areas in the South Fork Flathead River basin – particularly the Bunker Creek drainage and tributaries of the Spotted Bear River – have **outstanding** value for conservation of vulnerable fish and wildlife and Wilderness values.

- ❖ The Bunker Creek watershed has a notable concentration of high composite scores. It has been designated critical habitat as a spawning stream for bull trout. Pure populations of westslope cutthroat trout have been documented in upper Bunker Creek and its tributaries. High-quality winter and summer habitat for mountain goats occur in rugged terrain at higher elevations and also along cliff bands at lower elevations, with numerous records of goats observed there. Much of the higher country throughout Bunker Creek basin is maternal habitat for wolverine, with numerous locations recorded there and even along the creek bottom during the first-ever field study of wolverines in the 1970s. Most of the Bunker Creek area also provides primary habitat components for grizzly bears. Mace and Waller (1996) recorded telemetry locations of female grizzly bears throughout the Bunker Creek basin.

- ❖ The Addition-Bruce Creek area immediately north of Bunker Creek has a predominance of high composite scores for these species, too. A pure population of westslope cutthroat trout has been documented in Addition Creek. Mountain goats occur along the rugged terrain above Little Creek, a tributary to Addition Creek. Maternal habitat for wolverine occurs throughout the higher elevations, with several locations recorded there and along Addition Creek. The area provides a mix of primary and secondary habitat components for grizzly bears, again with numerous telemetry locations of grizzly bears recorded.

- ❖ Further north, the Tin-Soldier Creek area has a mix of moderate and low composite scores. Pure populations of westslope cutthroat trout have been documented in both creeks. The area provides primary habitat for wolverine (but little maternal habitat). Some primary habitat components occur, mostly near Bruce Ridge where grizzly bear telemetry locations have been recorded.

Figure 29. Distribution of composite scores for all focal species, South Fork Geographic Area, Flathead National Forest, Montana.

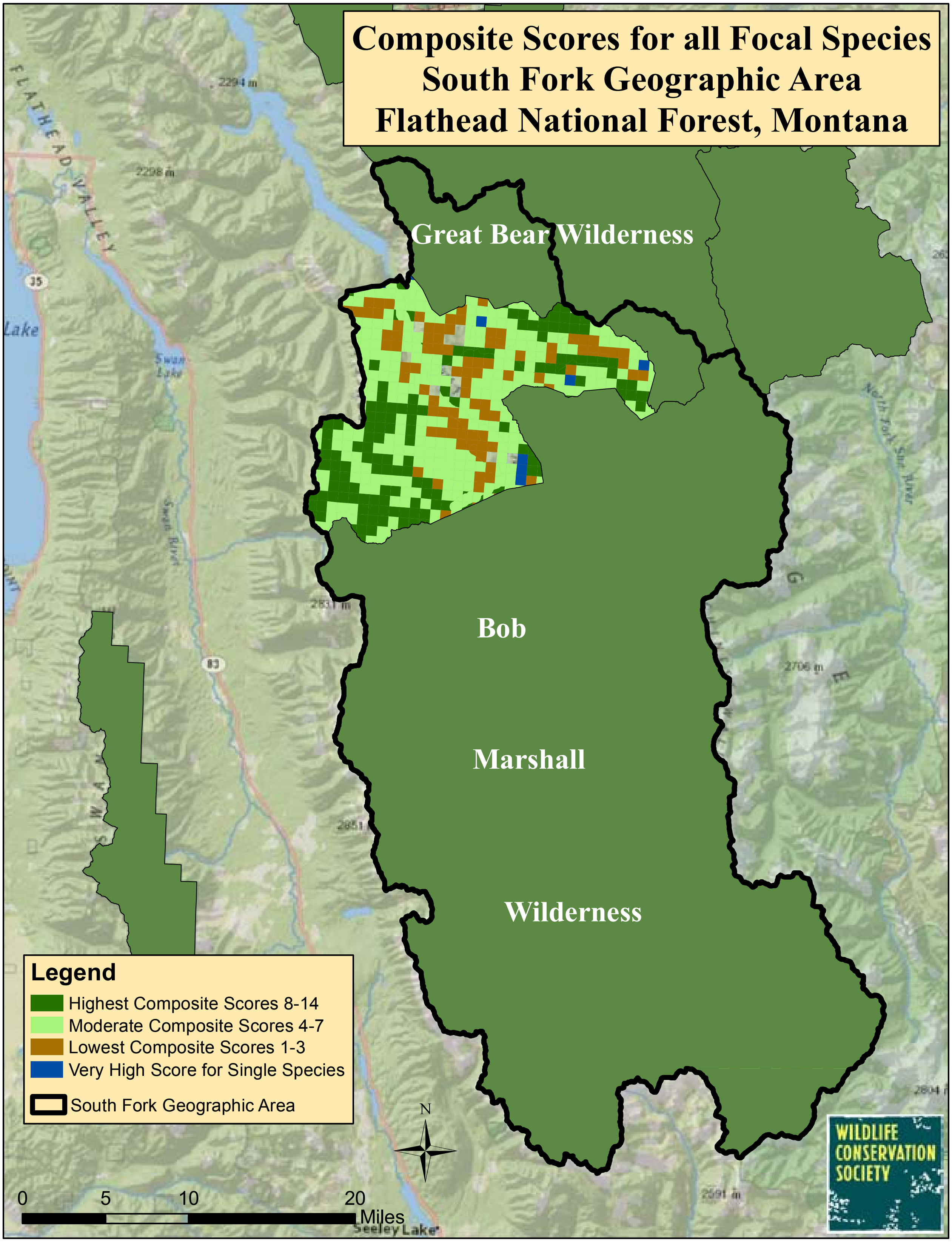
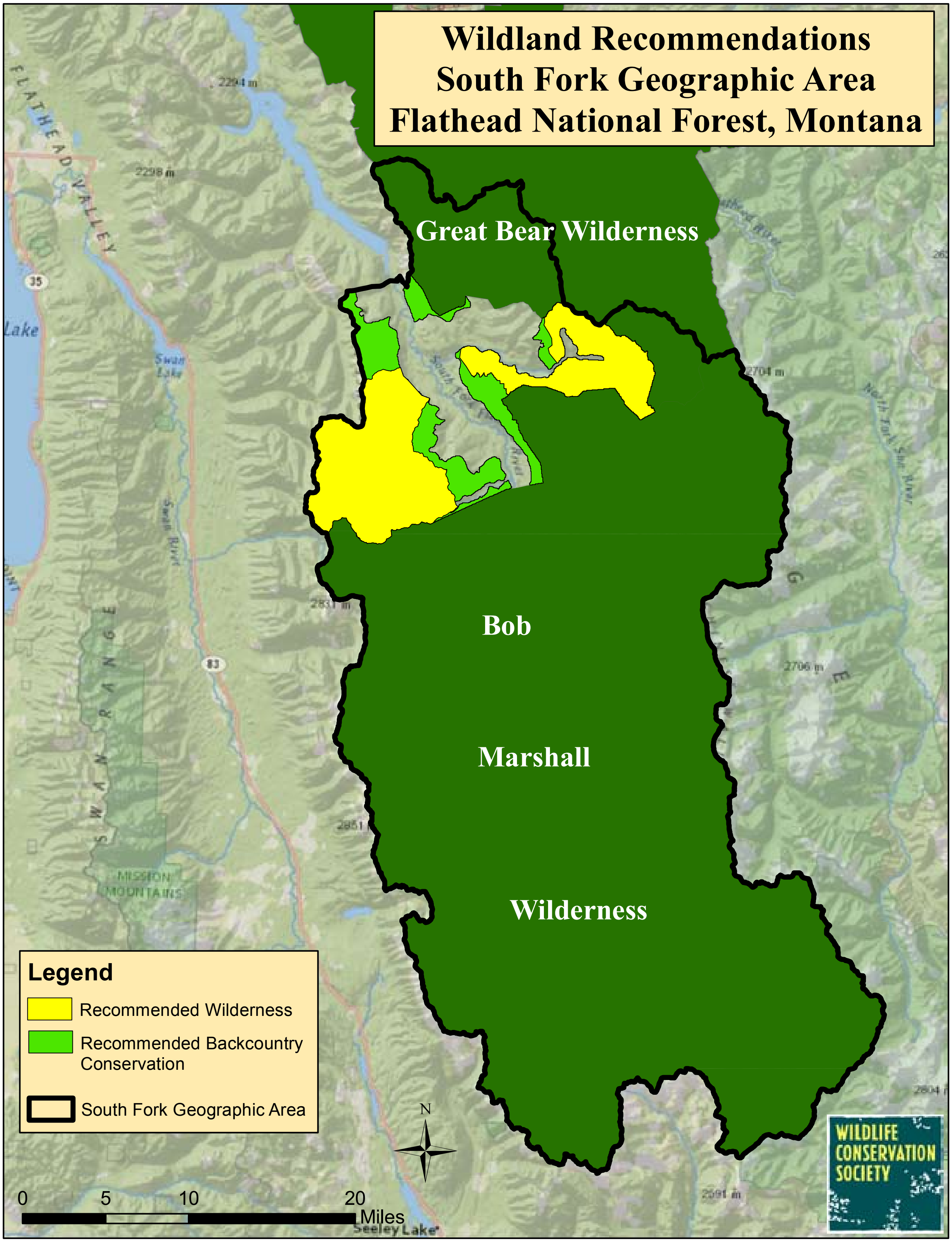


Figure 30. Recommendations for Wilderness, backcountry conservation, South Fork Geographic Area, Flathead National Forest, Montana.



- ❖ The Spotted Bear River area has a predominance of moderate composite scores. One localized sites of high scores is the upper Whitcomb Creek basin on the north side of the Spotted Bear River, adjacent to the Great Bear Wilderness. A pure population of westslope cutthroat trout is assumed to occur in Whitcomb Creek. Small patches of suitable mountain goat habitat occur on Whitcomb Peak and near Gunsight Pass. Much of the Whitcomb Peak basin and Dean Ridge is maternal habitat for wolverines. The area has a scattered mix of secondary habitat components and some primary habitats for grizzly bear. Another area of high composite score occurs along the south side of the Spotted Bear River – which has been designated as critical habitat for bull trout, contains a pure population of westslope cutthroat trout, and has productive riparian habitats for grizzly bear.

Recommendations for Wildland Protection

For the South Fork Geographic Area, the Forest Service IRA tallied 72,345 ac. I recommend 57,037 roadless acres in the South Fork Geographic Area as additions to the Bob Marshall Wilderness (Table 8, yellow areas in Figure 30):

- ✓ most of the Bunker Creek basin and Addition Creek-Bruce Creek, and
- ✓ north side (Whitcomb Creek basin) and south side of Spotted Bear River.

These areas have predominantly high composite scores and important juxtaposition to existing wilderness areas. In addition, Spotted Bear River has been deemed eligible for Wild and Scenic River designation, and I would strongly endorse a recommendation by the Campaign for Montana's Headwaters to consider Bunker Creek eligible for designation as well (Colburn et al. 2012).

I further recommend that 21,109 roadless acres be managed in roadless condition as 'Backcountry Conservation' with emphasis on non-motorized recreation and conservation of fish and wildlife (Table 8, green areas in Figure 30):

- remaining roadless areas at lower elevation along both sides of the South Fork Flathead River.

These areas have predominantly moderate composite scores, but certain sites have very high values for individual species.

Salish Mountains Geographic Area

The Forest Service IRA tallied 5,499 roadless ac for the Salish Mountains Geographic Area, but it has little value for this suite of vulnerable species. In terms of importance values for individual species, it has about 1% of the very high values and 0.4% of the high values on the FNF (Table 6, Figure 13). None of the very high values and or high values occurs in roadless areas. There are no areas with high composite scores and only 0.3% with moderate scores (4-7) on the Flathead National Forest (Table 7, Figure 14). Only 5% of moderate scores occur in roadless areas. With such low importance, I have chosen not to present any additional tables or maps because I do not recommend any wildland protection in this Geographic Area.

Swan Valley Geographic Area

Synthesis of Conservation Values

The Swan Valley Geographic Area has about 81,743 ac of the highest composite scores (8-14) and 168,658 ac of the moderate scores (4-7) (Table 7, Figure 31). About 25,504 ac (31%) of the highest composite scores (8-14) and 56,669 ac (34%) of the moderate scores (4-7) occur in the roadless portions of the Geographic Area. In terms of importance values for individual species, it has 259,987 ac of the very high values and 137,140 ac of high values. About 74,616 ac (29%) of the very high values and 18,651 ac (14%) of high values occur in roadless areas (Table 6). Nearly all of the roadless area along the Swan Crest on the east side of the Swan Valley Geographic Area has **outstanding** value for conservation of vulnerable fish and wildlife. It also has added value due to adjacent Wilderness (Bob Marshall) and roadless lands (Hungry Horse and South Fork Geographic Areas) that have high composite scores, too.

- **East Side – Holland Lake north to Inspiration Point:**
  This section lies adjacent to the Bob Marshall Wilderness and has high value for several vulnerable species. The entire Swan River up to Lindbergh Lake has been designated critical habitat for bull trout; several tributaries (Goat Creek, Squeezer Creek, and lower Lion Creek) also have been designated critical habitat as spawning areas. Some of the last streams in the Swan Valley with genetically-pure populations of westslope cutthroat trout occur here (Cooney, Dog, Pony, Owl, and lower Smith Creeks). Roadless lands along this east side provide important winter and summer habitat for mountain goats going back and forth across the Swan Crest, with numerous records of their occurrence. Nearly all of this roadless section is maternal habitat for wolverine and should persist for several decades in this snowy area. Much of the higher country contains primary habitat components (especially avalanche chutes) and secondary habitats for grizzly bears. Due to its high level of habitat security, most of this roadless area provides very high or high conservation value for grizzlies. Much of this roadless area is an integral part of a larger block of habitat that extends eastward into the adjacent Bob Marshall Wilderness.

- **East Side – Inspiration Point north to above Lake Blaine:**
  The area from Inspiration Point north along the west side of the Swan Crest up to the Jewel Basin area has a mix of moderate and high composite scores for these species. Importantly, it connects to areas on the Hungry Horse side of the crest that have high composite scores (e.g., Bunker and Sullivan Creeks). Several tributaries to the Swan River (lower Soup Creek, South and North Forks Lost Creek) have been designated critical habitat for bull trout as spawning habitat. Several streams harbor remnant populations of genetically-pure westslope cutthroat trout with sections or headwaters in the roadless area (South Fork Lost Creek, lower Bond, Groom, and lower Wolf Creek). Mountain goats inhabit rugged terrain along the Swan Crest (Warrior Mtn north to Con Kelly Mtn and a few cliffs in Jewel Basin). For wolverines, the Swan Crest and high basins provide vital maternal habitat,

Figure 31. Distribution of composite scores for all focal species, Swan Valley Geographic Area, Flathead National Forest, Montana.

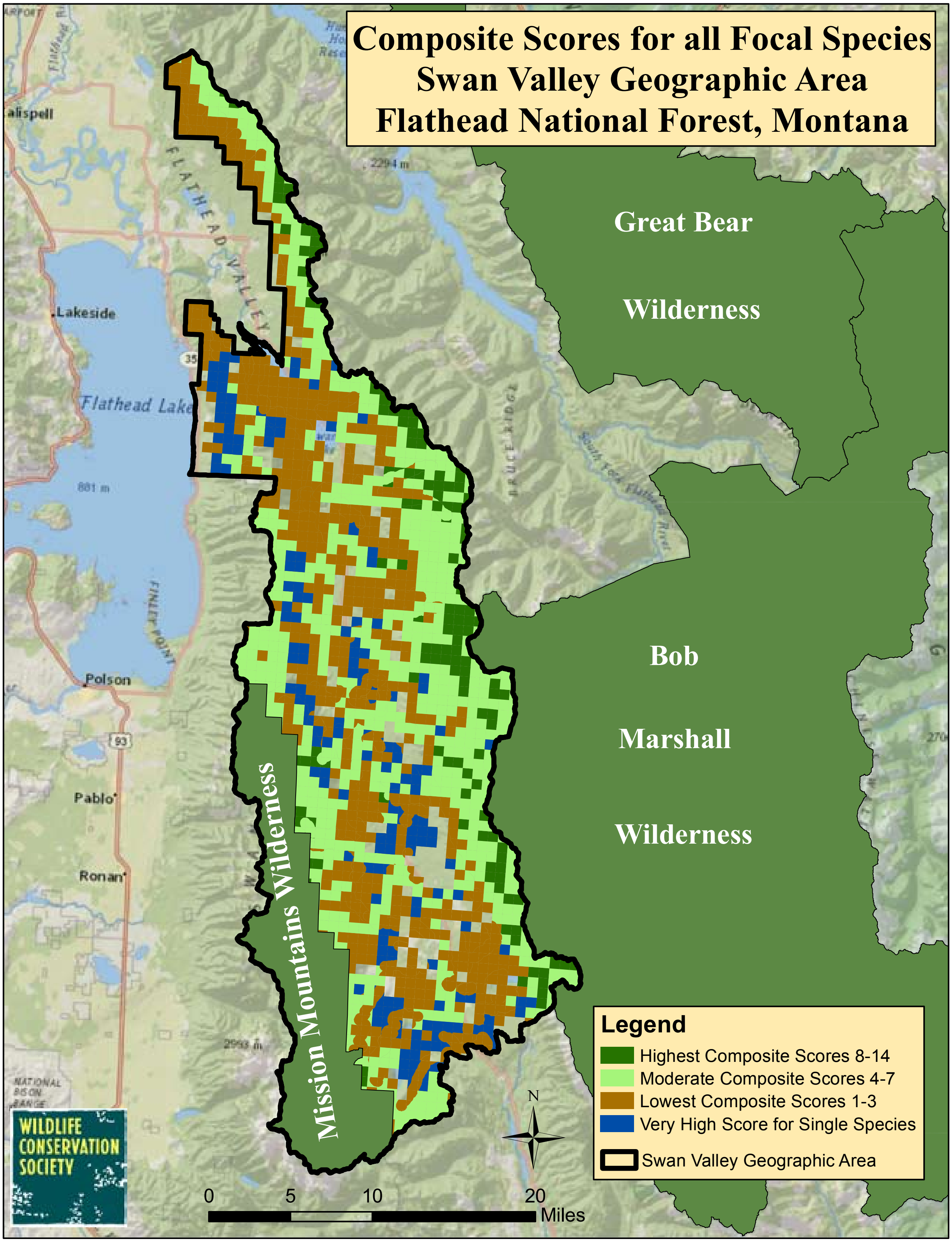
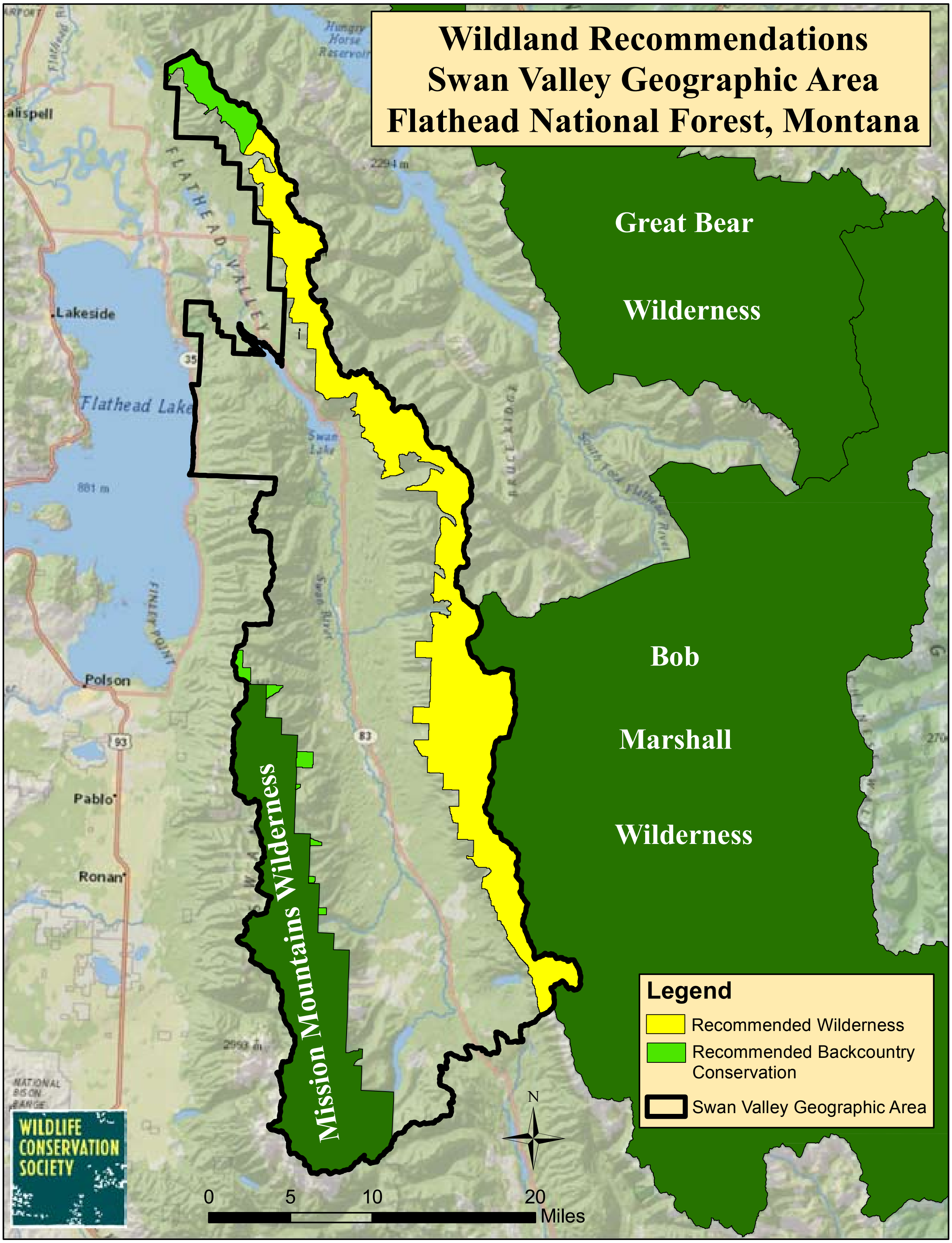


Figure 32. Recommendations for Wilderness and backcountry conservation, Swan Valley Geographic Area, Flathead National Forest, Montana.



with primary habitat at mid-elevations. The wolverine study during the 1970's recorded numerous wolverine locations all along the Swan Crest in this section. Much of this roadless section provides primary habitat components (especially avalanche chutes and huckleberry patches) and some secondary habitats for grizzly bears. The South Fork study recorded numerous locations of female grizzly bears in the high country all along the Swan Range. Due to its large variation in elevation and terrain, the Swan Range may provide critical options in the face of climate change.

Composite scores for these vulnerable species decrease in the northern tip of this roadless section of the Swan Crest (north of Jewel Basin to above Lake Blaine). It does not contain streams of direct conservation value for bull trout or westslope cutthroat trout nor habitat suitable for mountain goats. It does have primary habitat for wolverine, with some maternal habitat along the crest; several wolverine locations have been recorded on the Hungry Horse side of the crest. There are some primary habitat components (avalanche chutes and some huckleberry patches) for grizzly bears, and researchers have recorded some locations of collared females here.

❖ **West Side – Adjacent to Mission Mountain Wilderness:**
The small and scattered parcels of roadless lands at lower elevations generally have moderate or low composite scores for these vulnerable species. North Fork Elk Creek and Piper Creek have been designated critical habitat as spawning streams for bull trout. The genetic integrity of westslope cutthroat trout in Piper Creek has slight introgression. None of the parcels have suitable habitat for mountain goats. None have maternal habitat for wolverine, and the primary habitat may decline in the future with warming climates. These particular parcels have rather low habitat values for grizzlies.

Recommendations for Wildland Protection

For the Swan Valley Geographic Area, the Forest Service IRA tallied 95,019 ac. I recommend 85,720 roadless acres in the Swan Valley Geographic Area as additions to the Bob Marshall Wilderness (Table 8, yellow areas in Figure 32):

- ✓ Roadless lands from Holland Lake north to Inspiration Point, adjacent to the Bob Marshall Wilderness, and
- ✓ Continuing north from Inspiration Point along the west side of the Swan Range to above Lake Blaine, adjacent to roadless lands in the Hungry Horse Geographic Area.

These additions would protect most of the highest-value habitats for these vulnerable fish and wildlife species and provide options for responses to climate change. They could also enhance connectivity for wildlife across the Swan Valley between the Bob Marshall and Mission Mountain Wilderness (see Chapter 3 for connectivity analysis across Highway 83). In addition, Lion Creek has been deemed eligible for Wild and Scenic River designation, and I would endorse a recommendation by the Campaign for Montana's Headwaters to consider Goat Creek eligible for designation as well (Colburn et al. 2012).

I further recommend that 8,821 roadless acres be managed in roadless condition as 'Backcountry Conservation' with emphasis on non-motorized recreation and conservation of fish and wildlife (Table 8, green areas in Figure 32):

- northern tip of this roadless section on west side of the Swan Range above Lake Blaine to north of Jewel Basin, and
- small parcels on west side of Swan Valley adjacent to Mission Mountain Wilderness.

These areas have predominantly moderate composite scores, with a few high scores for certain species.

Across the Flathead National Forest: Summing Up

In the previous sections, I have tallied the composite values for vulnerable species and mapped recommendations for wildland protection for each of the Geographic Areas on the Flathead National Forest. This provided important detail but fragmented the overall view of wildlands at a larger scale. Here, I sum up my recommendations for wildland protection across the Flathead National Forest.

The Flathead National Forest is rich in conservation value for several vulnerable fish and wildlife species that have been vanquished in so many other places. Remarkably, 90% of the Flathead NF has a very high (75%) or high (15%) value for at least 1 of the 5 focal species (Table 6, Figure 13). About 76% of the Flathead NF has high (35%) or moderate (41%) composite scores for this suite of vulnerable species (Table 7, Figure 14). Remaining roadless areas account for about 21% of the very high-high importance values for individual species and 23% of the high-moderate composite scores. These roadless lands offer a unique opportunity to complete the legacy of wildlife and wildland conservation on this crown jewel of the National Forest system.

After careful consideration of these conservation values and field reconnaissance, I recommend **404,208 roadless acres on the Flathead National Forest for Congressional designation as National Wilderness** (Table 8, yellow areas in Figure 33). I further recommend that **130,705 roadless acres be managed in roadless condition as 'Backcountry Conservation'** with emphasis on non-motorized recreation and conservation of fish and wildlife (Table 8, green areas in Figure 33). Protecting these wildlands will secure habitats for year-round ranges, safeguard genetic integrity, enhance connectivity, and provide options for ecological resiliency. Large roadless areas in the Whitefish Range (North Fork Flathead) and Swan Range are vital for these vulnerable fish and wildlife species but have no legislated protection at present. A narrow strip of roadless areas along U.S. Highway 2 (Middle Fork Flathead) is important for regional connectivity between the Flathead NF and Glacier National Park. All of these areas should be accorded highest priority for designated Wilderness in the revised Forest Plan for the Flathead National Forest.

Table 8. Recommended Wilderness and Backcountry Conservation areas (ac) and Wildland Restoration Zones (mi) by Geographic Area, Flathead National Forest, Montana.

Geographic Area	Wilderness	Backcountry Conservation	Wildland Restoration
North Fork	137,872	26,341	7.0
Middle Fork	30,229	16,060	n/a
Hungry Horse	93,350	58,374	11.8
South Fork	57,037	21,109	n/a
Swan Valley	85,720	8,821	n/a
TOTAL	404,208	130,705	18.8

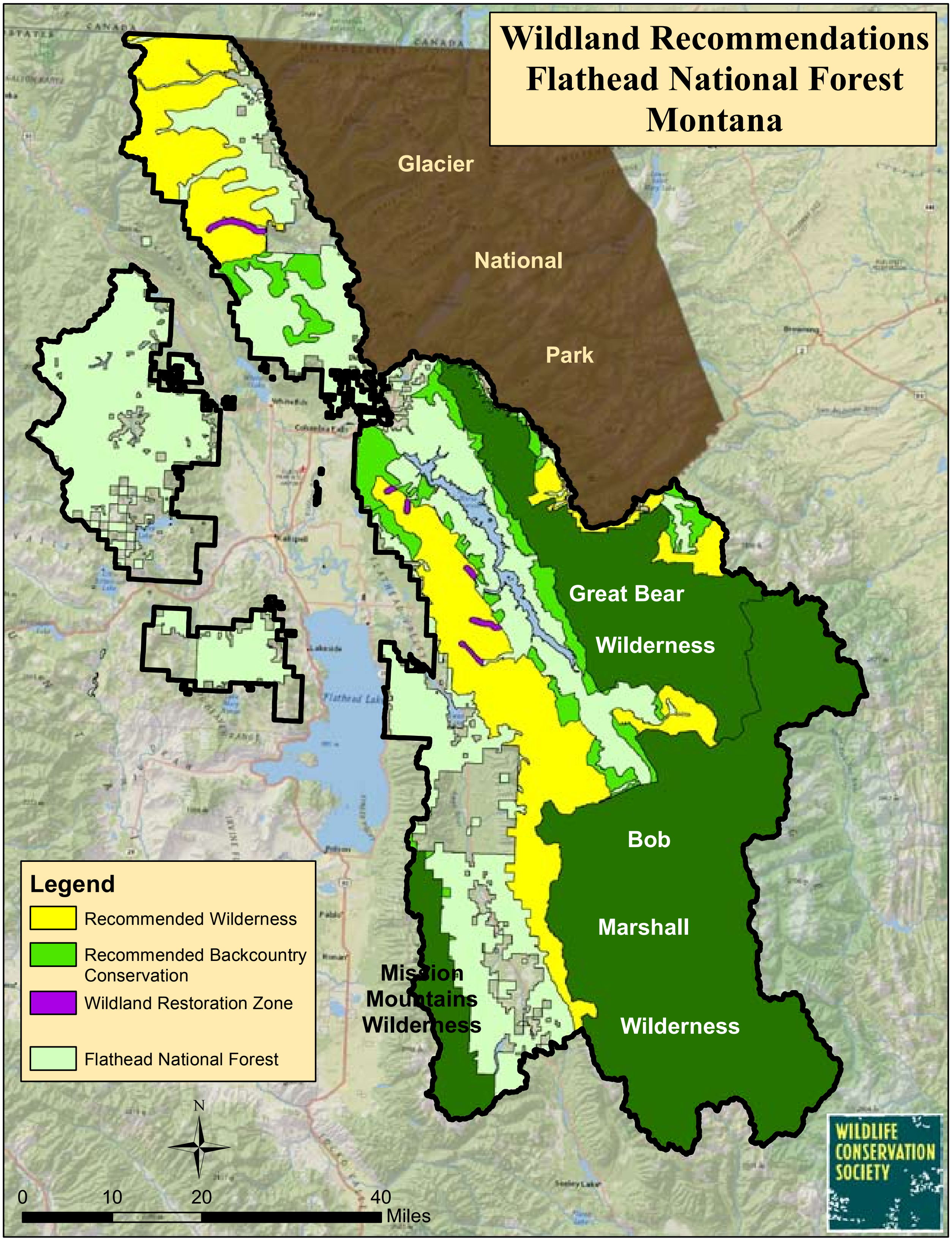
Completing the Conservation Legacy on the Flathead National Forest

The Flathead National Forest has been at the forefront of conservation in America for more than 80 years. Here on the Flathead, the Forest Service provided some of the earliest protection of wildlands in the United States by designating a 'Primitive Area' in the South Fork Flathead River basin in 1931. Less than a decade later, it connected several of these primitive areas into the Bob Marshall *Wilderness Area* … thereby presaging The Wilderness Act of 1964 by 25 years. The notion of protecting free-flowing *wild* rivers from dams envisioned by the famed ecologists John and Frank Craighead was inspired in part by their adventures on the Middle Fork of the Flathead River. Subsequently, the Wild and Scenic Rivers Act was passed in 1968, with 219 miles of the Flathead River designated under the Wild and Scenic Rivers Act in 1976. In more recent times, the Flathead NF has blazed new ways of managing public values on public lands on management issues ranging from fire to grizzly bears.

Today, the Flathead National Forest is one of the most important forests in America. It sparkles with a variety of dramatic landscapes, clean headwater sources of blue waters, and diversity of plants and animals. Due to its complex topography and convergence of regional vegetation biomes, the Flathead NF is one of the most diverse ecosystems in the temperate latitudes of the U.S. Moreover, the Flathead NF occupies a strategic position in the international landscape known as the Crown of the Continent Ecosystem – an amazing set of splendid jewels of landscape beauty and ecological diversity.

In this assessment, I have examined the conservation value of the Flathead National Forest and its remaining roadless areas for a set of vulnerable fish and wildlife species. Clearly, the Flathead NF is a stronghold for these species that have been vanquished or diminished in most other areas across the western United States.

Figure 33. Recommendations for Wilderness, backcountry conservation, and wildland restoration zone, Flathead National Forest, Montana.



- ★ The waters of the Flathead River basin provide the cold, clean, complex and connected habitat that is critical for native bull trout, a threatened species. Indeed, the Flathead River basin is widely acknowledged to be a stronghold for bull trout in the American West. Although several of these critical waters occur in existing Wilderness, many other streams designated as critical habitat begin or flow through roadless areas. As the region's climate continues to warm, these tributaries will provide the best likelihood of remaining sufficiently cold for bull trout.

- ★ The network of cold-water streams across the Flathead NF supports many of the remaining genetically-pure populations of westslope cutthroat trout in Montana, too. Warmer streams in the future will favor the spread of non-native rainbow trout at lower elevations and their threat of hybridization with westslope cutthroat trout. Hence, higher tributaries will offer the most likely refugia for this cold-water native species. In the longer perspective, cold and clean streams in the roadless area of the upper North Fork, Middle Fork, and especially the South Fork of the Flathead River will become ever more important for westslope cutthroat trout.

- ★ The highest density of grizzly bears in the lower 48 states thrives on a variety of habitats from valley to mountain peak across the Flathead National Forest and Glacier National Park. Not only do roadless areas provide additional security for grizzly bears from human disturbance and mortality, they also enable wide-ranging movements now and into a future of varying conditions.

- ★ The largest population of the rare wolverine in the conterminous United States roams the rugged terrain of the high country across the Flathead National Forest and Glacier National Park. Because the distribution and ecology of wolverines appears strongly linked to areas characterized by persistent snow cover, climate warming may diminish suitability of habitats at lower elevations. The remaining roadless areas on the Flathead NF provide habitat in the high country that will help sustain the unique niche and population viability of this elusive carnivore.

- ★ On many of the narrow crests and peaks, goats may rest on ledges inside a Wilderness area but forage on the roadless side of the ridge. Some roadless areas on the Flathead NF (southern Swan Range) have high conservation value for this vulnerable species.

- ★ The wild hunters – wolf, grizzly bear, cougar, lynx, wolverine, fisher and others – have been vanquished from more settled areas. The community of carnivores (17 species) on the Flathead National Forest appears unmatched in North America for its variety, intactness, and density of species that are rare elsewhere. Several are federally listed as 'threatened' species.

The Flathead National Forest in Montana is truly one of the last, best places for these vulnerable species. The legacy of protected lands and waters in the past has been instrumental in their conservation during a time of expanding timber harvest and forest roads, construction of major highways, and building of large dams and numerous diversions.

Now, a new challenge – climate warming and its myriad consequences – has been added to the top of the list. The future *health* of the Flathead country will depend upon its *capacity for self-renewal* or resiliency (Leopold 1949). Such resiliency may depend upon ecological integrity of the place – its wholeness in terms of diversity of genes/native species/ and landscapes. The diverse and complex terrain across the Flathead National Forest offers a notable range of future options for plants and animals during climate change. But such advantageous resiliency can be fully realized only if fish and wildlife have room to move unfettered across large, connected landscapes.

Successive generations of citizens and government leaders have worked hard to safeguard the rich tapestry and health of the Flathead country. Their collective achievements comprise a remarkable legacy and great gift. Now, changing times require leadership anew. A smart strategy for resiliency going forward is to protect and connect large landscapes with high topographic and ecological diversity. The nearly half-million acres of roadless public lands on the Flathead National Forest offer a rare opportunity to complete the legacy of wildlife and wildland conservation on this crown jewel of the National Forest system.

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APPENDIX 1 – VULNERABILITY PROFILES FOR SELECTED FISH AND WILDLIFE SPECIES

Framework for Vulnerability Profiles

Vulnerability refers to the susceptibility of species to disturbances of various kinds. Over millennia, species have persisted by a variety of mechanisms that buffered environmental disturbance at various spatial and temporal scales. Yet some species seem more vulnerable than others. What factors contribute to their vulnerability?

The concept of *resilience* can guide our thinking about vulnerability. Resilience can be defined as the capacity of species to withstand disturbance and still persist (*sensu* Holling 1973, Folke et al. 2004). Species can be considered as nested hierarchies of individuals, populations, and meta-populations in which the higher levels provide context for mechanisms at lower levels. Persistence may be accomplished by 'spreading the risk' (e.g., separate small herds of bighorn sheep will be less vulnerable than a single large herd to spread of a virulent disease). Because disturbances occur at different spatial and temporal scales, no single level of organization can respond adequately to all disturbances. Hence, the nested structure increases resilience by linking the system across hierarchical levels (Pickett et al. 1989).

Following Weaver et al. (1996), I postulate a basic mechanism of resistance or resiliency at each of three hierarchical levels: individual, population, and metapopulation. At the individual level, an animal can exhibit physiological tolerance to an environmental condition or behavioral flexibility in food acquisition and selection of habitat. For example, in the face of environmental change, an individual may substitute one resource for another in its diet, thereby ameliorating flux in food availability.

At the population level, native fish may have little resistance to invasion by non-native fish and are vulnerable to hybridization and/or competition. Some mammals compensate for excessive mortality with increased reproduction and/

or survivorship, thereby mitigating demographic fluctuations. High survivorship and longevity of reproducing adult females typically is critical to the continued well-being of many mammal populations.

At the metapopulation level, dispersal enables animals to augment an existing population or re-colonize an area where a population has been extirpated. Dispersal usually refers to movements by juvenile animals when leaving their natal range after reaching the age of independence (adults occasionally disperse, too). Dispersal is successful only if the individual survives, establishes a home range, finds a mate and reproduces. In landscapes fragmented by human disturbance, successful dispersal is the mechanism by which declining populations are supplemented, genes are shared across the landscape, and functional connectivity of meta-populations is established (Gilpin and Hanski 1991).

In reference to human disturbance, niche flexibility addresses the problem of loss or change in habitat conditions. Capacity for greater productivity enables populations to compensate for overexploitation or to come through a genetic 'bottleneck' more quickly. Dispersal addresses the problem of habitat fragmentation at a landscape scale. Resiliency, however, have definite limits. As human activities accelerate rates of disturbance across a greater extent of the landscape, the combination of rapid change and simplification can undermine the evolved resiliency and render their populations more fragile. Cumulative effects can accrue that threaten their persistence. One of the key messages of resilience thinking is to *keep future options open through an emphasis on ecological variability across space and time*, rather than a focus on maximizing production over a short time (Walker and Salt 2006).

In this section, I use this framework of resilience to assess vulnerability for 5 species of native fish and wildlife. Each profile addresses the following factors: (1) niche flexibility, (2) resistance to hybridization (fish) or reproductive capacity and mortality risk (mammals), (3) dispersal and connectivity, (4) sensitivity to human disturbance, and (5) response to climate change.

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Bull Trout Vulnerability Profile

Populations of bull trout have declined throughout much of their native range in the United States (Rieman et al. 1997, USFWS 2002). Bull trout have declined due to cumulative effects of over-fishing and catch-and-release mortality, degradation of habitat from industrial and recreational activities, impacts from non-native fish (competition with lake trout and hybridization by brook trout), and loss of stream connectivity due to dams on larger rivers. (Fraley and Shepard 1989, Kitano et al. 1994, Rieman et al. 1997, Baxter et al. 1999, Martinez et al. 2009). Bull trout in Montana are federally listed as 'threatened' under the Endangered Species Act and critical habitat has been designated (USFWS 2010). Warmer stream temperatures from climate change will degrade bull trout habitat over time (Jones et al. 2013).

Niche Flexibility: Bull trout are one of the most thermally sensitive coldwater species in western North America. Warm but sub-lethal temperatures can alter metabolism, growth, and competitive interactions for cold-water trout, whereas high water temperature can cause direct mortality. Laboratory studies suggest that peak growth in bull trout occurs between 52°- 60° F (10°-15° C), whereas the upper lethal temperature is about 70° F (21° C) (Selong et al. 2001). Across the range of bull trout in northwestern United States, spawning and rearing occurs mostly in streams where the maximum daily temperature during August – September is <54° F (<12° C) (Dunham et al. 2003). In the Flathead River system in Montana, a new spatial model estimated August stream temperatures of spawning and rearing habitat for bull trout at <55° F (<13° C) and foraging, migrating, and overwintering habitat at <57° F (<14° C) (Jones et al. 2013). Bull trout select stream reaches for spawning where upwelling of ground water provides cooler and well-oxygenated conditions (Baxter and Hauer 2000, USFWS 2010). In winter, warm groundwater and beaver ponds inhibit formation of anchor ice, which otherwise would cause high mortality as young trout emerge (Jakober et al. 1998).

Resistance to Hybridization: Because fish have external fertilization, hybridization is more common in fishes than in any other vertebrate taxa (Leary et al. 1995). In undisturbed ecosystems, reproductive isolation is maintained by spatial and temporal isolation during the spawning period. Barriers to interbreeding may be lost, however, due to introduction of non-native species and exacerbated by habitat alterations. Non-native fish can also displace native fish through predation and competition.

Competition with non-native lake trout (*Salvelinus namaycush*) in lakes is considered the most significant threat to recovery and conservation of bull trout in several areas (Martinez et al. 2009). Lake trout prey on young bull trout and can completely displace bull trout in mountain lakes due to substantial overlap in their niches (Donald and Alger 1993, Fredenberg 2000). For bull trout that winter in Flathead Lake and Swan Lake, lake trout represent a significant threat to their recovery.

Brook trout can reproduce with bull trout, thereby producing mostly sterile hybrids which reduce reproductive potential in populations (Leary et al. 1993, Kitano et al. 1994). In addition, they can depress foraging by bull trout (Nakano et al. 1998) or out-compete them for scarce resources (Gunckel et al. 2002). Brook trout can displace or push bull trout from lower elevations, with greater displacement in streams with smaller patches initially or with lower stream gradients (Rieman et al. 2006). Conversely, they may invade from higher elevation if introduced to a headwater lake (Adams et al. 2001). Brook trout are moving into higher gradient/higher elevation streams that once were considered refugia for bull trout (McMahon et al. 2007).

Dispersal and Connectivity: Connectivity throughout a watershed is critical for bull trout for in terms of migration strategies, population persistence and genetic diversity. Bull trout express a variety of life history strategies, depending upon where they migrate after 1-3 years as juveniles in natal streams. Some bull trout remain in their natal streams (*resident*), some migrate into larger tributaries (*fluvial*), and others migrate into lakes (*adfluvials*). In the Flathead River system, bull trout migrate up to 160 mi (250 km) upriver from Flathead Lake to spawn in their natal tributaries in British Columbia (Fraley and Shepard 1989).

Most bull trout populations are small in size (even smaller in terms of genetically effective size) and are connected to a larger metapopulation via low rates of dispersal among populations (Dunham and Rieman 1999, Rieman and Allendorf 2001). Bull trout exhibit high fidelity to selected spawning sites, which can be located at specific patches. Much of the genetic variation in bull trout occurs at very fine geographic scales (Spruell et al. 1999, Warnock et al. 2010, Ardren et al. 2011), especially below and above barriers (Costello et al. 2003). For example, in the Flathead River drainage, researchers found that adjacent populations were highly isolated in terms of reproduction (Kanda and Allendorf 2001, Meeuwig et al. 2010). Hence, it's vital to maintain local populations to safeguard genetic diversity and to promote long-term persistence (Spruell et al. 2003).

Ensuring connectivity in the dendritic or branching structure of stream networks, however, can be challenging (Fagan 2002, Meeuwig et al. 2010). In a linear feature like streams, all patches may be at risk regardless of distance when a toxic pollutant enters at the headwaters and flows downstream. Conversely, fragmentation near the bottom of a network can affect much more of the watershed than if it happens at a higher branch.

Sensitivity to Human Disturbance: Bull trout are vulnerable to a wide range of human disturbances.

- The combination of slow growth, late age at maturity, low fecundity, longevity, and high catchability render bull trout particularly susceptible to overfishing, even with per-capita angler restrictions (Post et al. 2003). Some over-exploited populations have recovered in 10 years after zero-harvest regulations were implemented (Johnston et al. 2007). Roads increase ready access for angler mortality and poachers – particularly in small lakes and tributary streams where bull trout are especially vulnerable (Parker et al. 2007).

- Dams can pose the biggest threat by blocking fish movements, resulting in genetic isolation and loss of migratory populations and altering natural flow regimes and river habitats (Hagen 2008, Muhlfeld et al. 2011). Such blockage can be detrimental to migratory populations that require diverse, connected habitats for different life stages (Muhlfeld and Marotz 2005). Conversely, a large reservoir may support abundant forage fish and support large, migratory populations if connected to high quality spawning and rearing habitat (e.g., Hungry Horse reservoir and South Fork Flathead River).
- Improper timber harvesting practices and associated roads/culverts can increase sedimentation into spawning streams, block access for trout, remove riparian cover and increase stream temperatures (Baxter et al. 1999, Ripley et al. 2005).
- Mining and oil and gas activities can cause massive chemical pollution of streams and major mortality of fish (Moore et al. 1991), while associated roads can increase sedimentation and provide access (Ripley et al. 2005). Major highways and railroads can increase the potential for catastrophic spill of toxic substances, too.
- Agricultural practices can de-water streams, increase water temperature, degrade stream banks and increase sedimentation, and disrupt migrations.
- Finally, purposeful stocking in the past and continued illegal releases of non-native trout have resulted in the most challenging threat to native bull trout in the Flathead River basin (USFWS 2002).

When these activities overlap in space and time, significant cumulative effects can arise. A common denominator in these various impacts is roads, which can affect hydrology of streams and increase access to vulnerable fish populations. In the Kakwa River basin of Alberta, the likelihood of bull trout occurrence decreased with an increase in the percentage of sub-basin harvested for timber and road density (Ripley et al. 2005).

Response to Climate Change: Bull trout will likely be vulnerable to several manifestations of climate change. Over the past several decades in western Montana, there has been decreased snowpack and more rain-on-snow events and flooding in winter, accelerated melting of snow and earlier runoff in spring, reduced recharge of groundwater and lower base flows, warmer stream temperatures and longer periods of drought in summer, and increased sedimentation due to more wildfires. The net result has been warmer water and lower base flows at low-mid elevations, particularly in late summer and fall when bull trout are migrating and spawning. These changes are projected to continue into the future (see Chapter 1 for fuller discussion of climate change and references).

Warmer temperatures and drought could render the lower elevation sections thermally unsuitable for foraging, migration, and overwintering (FMO) habitat and spawning and rearing (SR) habitat for these cold-adapted fish – thereby raising the lower-elevation limits and/or disconnecting the 2 habitats (Rieman et al. 2007, Jones et al. 2013). Some of the most dramatic increases in stream temperatures could occur in areas that are burned severely by wildfire and lose the shading cover of streamside trees and shrubs (Issak et al. 2010). In addition, warmer stream temperatures could enable non-native brook trout to invade higher reaches of streams, conceivably raising the prospects of competition and hybridization (McMahon et al. 2007).

The net outcome would be continued shrinkage of the cold-water niche for bull trout, thereby reducing both the size and connectivity of remaining suitable patches and eventually resulting in fewer bull trout (Rieman et al. 2007, Haak et al. 2010, Isaak et al. 2010, Wenger et al. 2011). One might postulate that bull trout in the Flathead River basin of Montana would be at lower risk due to the more northerly location and higher elevation (Haak et al. 2010). A recent model using a conservation scenario of climate warming, however, estimated a potential loss of 58% FMO habitat in the main stems of the Flathead River and 36% loss of SR habitat in the lower-elevation tributaries by the year 2059 should air temperatures increase by 6° F (3.3° C) (Jones et al. 2013).

Conclusion: Bull trout exhibit **high vulnerability** due to low resistance to a variety of factors. They have a demanding cold-water niche – especially for spawning and rearing – and low resistance to warming water. Bull trout have low resistance to invasion by non-native trout, too. Although adult bull trout can move long distances, human fragmentation of hydroscapes can have acute effects on dispersal and connectivity. Bull trout are vulnerable to several detrimental effects of human activities associated with roads. Finally, climate change may impact the stringent cold-water niche of bull trout and lead to smaller, more isolated populations that could be less viable and thus more vulnerable. Protection of clean, cold, structurally-complex and well-connected habitat from invasion by non-native fish remains a central element in the conservation of bull trout.

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Westslope Cutthroat Trout Vulnerability Profile

Westslope cutthroat trout (WCT) is one of 15 recognized subspecies of native cutthroat trout in western North America (Behnke 2002). In Montana, westslope cutthroat trout occupy the upper Missouri River drainages east of the Continental Divide and the upper Columbia River drainages west of the divide. At present, genetically-pure populations of WCT occupy about 8-10% of entire historic range and <3% of their historic range in Montana, mainly confined to headwater streams (Shepard et al. 2005).This decline has been associated with introductions of non-native fish, habitat changes, and over-exploitation. Montana Department of Fish, Wildlife and Parks (FWP) listed the westslope cutthroat trout as a State 'species of special concern', followed by a statewide Memorandum of Understanding and WCT Conservation Agreement in 1999.

Niche Flexibility: Like bull trout, westslope cutthroat trout also have stringent requirements for cold water. Laboratory studies suggest that optimum temperature for growth and long-term persistence in westslope cutthroat trout is about 55-59° F (13-15° C), whereas the upper lethal temperature is about 68° F (20° C) (Bear et al. 2007). Rainbow trout, a nonnative competitor and source of genetic introgression, have a greater capacity for growth at warmer temperatures and a higher upper limit of lethal temperature at 76° F (24° C) in the laboratory. In the North Fork Flathead River in Montana, non-hybridized westslope cutthroats were found in stream reaches where average summer temperatures ranged from 44°-53° F (6.6°-11° C) (Muhlfeld et al. 2009b). Brook trout, another non-native competitor, have similar optimum temperatures as westslope cutthroat trout but can tolerate a wider range of temperatures (Shepard 2010).

Thus, westslope cutthroat trout may find refugia in higher elevation streams with colder temperatures (Paul and Post 2001, Rasmussen et al. 2010). Suitable habitat for spawning and rearing occurs in low-gradient streams with cold, well-oxygenated water and clean gravels, with cover provided by large woody debris or boulders and riparian vegetation that stabilizes banks and provides shade.

Resistance to Hybridization: Westslope cutthroat trout have low resistance to hybridization and genetic introgression by non-native trout. Indeed, interbreeding between westslope cutthroat trout and rainbow trout and the resulting loss of genomic integrity is widely considered the greatest threat to the persistence of pure westslope cutthroat trout throughout their range (Shepard et al. 2005). Rainbow trout produce fertile offspring when crossed with cutthroat trout, resulting in genetic introgression. In early stages, populations may be comprised of admixtures of both hybrids and non-hybridized westslope cutthroats. But, in the absence of barriers, introgression often spreads until a hybrid swarm develops, and the native cutthroat genomes become extinct (Leary et al. 1995).

In the Flathead River drainage in northwest Montana, genetic introgression of native westslope cutthroat trout by rainbow trout spread rapidly between 1984 and 2004 (Hitt et al. 2003, Boyer et al. 2008). The source of rainbow trout appears to have been a singular source in the lower part of the drainage (Abbott

Creek), with hybridization spreading upstream (Boyer et al. 2008). The spawning periods of both rainbow trout and especially hybrids overlap with those of native westslope cutthroats (Muhlfeld et al. 2009a). Westslope cutthroat trout migrated greater distances and spawned in headwater streams, whereas rainbow trout and hybrids spawned lower in the drainage. Hybridization was more likely to occur and spread in streams with warmer temperatures at lower elevations, increased number of roads crossing streams, and closer proximity to the main source of hybridization (Muhlfeld et al. 2009b).

Although the amount of introgression decreases with greater distance from the source (isolation by distance), the spread of hybridization has been facilitated both by stepping-stone invasion and by long-distance dispersal and straying of hybrids and rainbow trout. Importantly, researchers have documented that as little as 20% hybridization can result in a 50% decline in reproductive success (Muhlfeld et al. 2009c). The conservation implication is that even low levels of genetic introgression may facilitate continued expansion of hybridization and place native cutthroat trout at risk, unless source populations of non-native trout are suppressed or eliminated.

An interesting case of recovery-by-dilution has been documented at the head of the Elk River in southeast B.C. During years of high runoff, rainbow trout were swept from a summit lake downstream, which resulted in some introgression of westslope cutthroat trout (6% hybrids: Rubidge et al. 2001). Recent monitoring, however, has indicated that this effect has been diluted over time (Bennett and Kershner 2009). Nonetheless, this case illustrates that RBT stocking of high-elevation lakes is a misguided practice that can facilitate the spread of hybridization downstream through much of the stream network (Adams et al. 2001). Bennett (2007) recommended a ban on stocking of any fertile rainbow trout.

In addition, brook trout are another widespread non-native species in the western United States which have affected native cutthroat trout (Peterson et al. 2004). They have a similar niche with cutthroat trout and can displace the natives in warmer waters at most elevations (Shepard 2010). Hence, barriers to prevent invasion by brook trout has become an important conservation strategy for preserving viable populations of westslope cutthroat trout (Shepard 2010), along with removal of non-native fish (Quist et al. 2004). Growth and reproductive success of the native cutthroats may decline, however, if confined to small, very cold headwater reaches (Coleman and Fausch 2007) and jeopardize their long-term viability (Fausch et al. 2009).

Dispersal and Connectivity: Various genetic studies have detected substantial genetic differentiation in westslope cutthroat trout among drainages; hence, it may be necessary to manage them separately to maintain genetic diversity across a region (beta-diversity) and its evolutionary legacy (Taylor et al. 2003, Drinan et al. 2011). Hence, translocation of WCT from 1 drainage to augment a population in another drainage could be detrimental to maintaining genetic diversity across the region.

The vulnerability of westslope cutthroat trout to genetic hybridization accentuates the trade-off dilemma between connectivity and isolation (Fausch et al. 2009). Theoretically, small and isolated populations have a greater likelihood of extirpation than those that are large and well-connected due both to systematic and random pressures (Gilpin and Hanski 1991). Consequently, a common conservation strategy is to promote connectivity between populations to facilitate both demographic and genetic exchange. In the case of stream fish, however, such connectivity also enables competition and genetic introgression by non-native species … hence, the dilemma. Fausch et al. (2009) proposed a framework to explicitly examine the trade-offs in specific situations. Where non-native trout do not occur, fish biologists recommend maintaining large areas of interconnected habitats within drainages to furnish options for movements by juvenile fish, provide diverse habitats, and support migratory and resident life histories (Shepard 2010, Muhlfeld et al. 2012).

Sensitivity to Human Disturbance: The biggest human threat to native westslope cutthroat trout has been purposeful stocking of rainbow trout in the past (and continued illegal releases), resulting in loss of genetic integrity (Shepard et al. 2005).

Nonetheless, degradation of habitat quality by various land uses has also been a major contributing factor. Roads built for timber harvesting, oil & gas exploration and development, mining, and motorized recreation (ATVs) can increase sedimentation into spawning streams, block access for trout from hanging culverts, alter stream channels and flow patterns, remove riparian cover and increase stream temperatures Problems often arise at crossings of small streams, especially in the headwaters where impacts can propagate downstream Moreover, roads increase ready access for fish exploitation and mortality by anglers (westslope cutthroat trout are susceptible to over-fishing). Agricultural practices can de-water streams, increase water temperature, degrade stream banks and increase sedimentation, and disrupt migrations. Mining and oil and gas activities can cause massive chemical pollution of streams and major mortality of fish (*see* the Alberta Westslope Cutthroat Trout Recovery Plan 2012-2017 for a thorough discussion and documentation of these myriad impacts.) The strong implication is that protected areas without any roads or low road density safeguard habitat for vulnerable and threatened populations of westslope cutthroat trout.

Response to Climate Change: Like bull trout, westslope cutthroat trout appear quite vulnerable to myriad effects of climate change (Williams et al. 2009, Haak et al. 2010). Climate change is projected to have major effects on the hydrologic regime, including: decreased snowpack and more rain-on-snow events, accelerated melting of snow and earlier runoff in spring, increased flooding, and reduced recharge of groundwater and lower base flows. Increased warming and evapotranspiration will result in warmer stream temperatures in summer, longer periods of drought, as well as loss of shading cover along streams and increased sedimentation due to more wildfires. The net result of such changes will be warmer water and lower stream levels at low-mid elevations, particularly in late summer.

At the more northerly and higher elevation limits of cutthroat trout distribution, a warming climate may gradually improve habitat suitability and promote greater growth and recruitment (Sloat et al. 2005). However, warmer stream temperatures likely will enable rainbow trout to invade even further upstream, where they will compete and hybridize with westslope cutthroat trout (Dunham et al. 2002, Rahel et al. 2008, Muhlfeld et al. 2009b). These warmer temperatures may also elevate the lower limits of suitable stream habitat for coldwater trout, thereby squeezing them between lower reaches that are too hot and upper reaches that are too small (Williams et al. 2009, Isaak et al. 2010, Jones et al. 2013). The net result would be continued shrinkage in habitat and population numbers, rendering them less resilient (Hilderbrand and Kershner 2000). Intense and widespread wildfires could have greater proportional impacts on these residual habitats and populations (Brown et al. 2001, Dunham et al. 2007, Haak et al. 2010). Cascading effects may occur, for example, when warmer winters enable outbreaks of mountain pine beetle in lodgepole pine forests … leading to fire-killed stands … leading to pre-emptive or salvage logging and new roads on vulnerable sites … resulting in significant soil erosion to streams and fish already stressed by other factors.

Conclusion: Westslope cutthroat trout exhibit **high vulnerability** due to low resistance and resiliency to human impacts. They have a cold-water niche – especially for spawning and rearing – and low resistance to warming water. Moreover, westslope cutthroat have especially low resistance to invasion by non-native trout. Due to the wide-spread introduction of rainbow trout, many of the genetically-pure populations are now confined to headwater streams – where they have low growth and productivity. Westslope cutthroat trout are vulnerable to several detrimental effects of human activities associated with roads. Finally, climate change may counteract the thermal advantage niche of westslope cutthroat trout and lead to further isolation of smaller populations in headwaters. Two strategies appear useful: (1) safeguarding large, well-connected networks that retain genetically-pure populations of westslope cutthroat trout, and (2) stocking streams with natural barriers with genetically-pure specimens and/or installing barriers to protect selected cutthroat populations (Rahel et al. 2008).

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Grizzly Bear Vulnerability Profile

The grizzly bear is federally listed as a threatened species under the Endangered Species Act.

Niche Flexibility: Grizzly bears exhibit considerable flexibility in their foraging and habitat use over space and time (Schwartz et al. 2003a). Although grizzly bears in the trans-border Crown of the Continent Ecosystem use a wide variety of foods, four main groups compose most of their diet: grasses and sedges, forbs and forb roots, berries, and mammals (including ungulates and rodents) (Craighead et al. 1982, Mace and Jonkel 1983, Hammer and Herrero 1987b, Aune and Kasworm 1989, McLellan and Hovey 1995, Nielsen et al. 2010). Here, grizzly bears fed on: (1) ungulates (usually carrion of winter-killed elk and moose or new-born calves), grasses and sedges, and glacier lily (*Erythronium grandiflorum*) bulbs and hedysarum (*Hedysarum* spp.) roots in spring; (2) grasses, horsetails (*Equisetum arvense*), forbs like cow parsnip (*Heracleum lanatum*) and angelica (*Angelica arguta*), and insects (ants, cutworm moth larvae) in summer; (3) huckleberries (*Vaccinium* spp.) and russet buffaloberries (*Shepherdia canadensis*) in late summer; and (4) berries, ungulates (gut-piles, weakened animals), roots, and whitebark pine nuts (when and where available) in fall.

There are several key habitats that provide 1 or more of these seasonally important foods. Avalanche chutes on steep mountain slopes produce a diversity of foods, including grasses, horsetail, glacier lily and cow-parsnip, and berry-producing shrubs such as serviceberry (*Amelanchier alnifolia*) in the lower and middle sections of the chute and huckleberry in the adjacent stringers of open conifer trees (Mace and Bissell 1985, McLellan and Hovey 2001a, Waller and Mace 1997, Ramcharita 2000). Various sections of the chute produce foods from early spring through summer and even autumn. Bears of each gender select for these avalanche chutes (Zager et al. 1983, Waller and Mace 1997, Apps et al. 2004, Serrouya et al. 2011), and they may be especially important to females with cubs-of-the-year who choose to reside in high, secluded basins in rugged terrain (McLellan and Hovey 2001, Theberge 2002).

Slab rock habitats are uplifted, exposed and often terraced bedrock. Soil develops occurs between the terraces, resulting in a unique vegetation community. Grizzly bears in the South Fork Flathead River area in western Montana forage on various forbs such as spring beauty (*Claytonia lanceolata*), glacier lily, and (*Lomatium sandbergii*) on these terraces (Waller and Mace 1997).

Riparian areas adjacent to streams, lakes, and wetlands represent another critical habitat for grizzly bears, particularly during spring and again in fall. Key foods include grasses and sedges, horsetails, hedysarum, cow parsnip, buffaloberry, and occasional moose (Mace and Bissell 1985, McLellan and Hovey 2001). Abundance of female grizzly bears has been positively correlated with riparian and mesic cover types (Graves et al. 2011).

Although bears consume a diverse array of foods during spring and early summer, they focus upon berries in late summer and fall for weight gain and fat deposition necessary for successful hibernation and reproduction. One of the most important in the Rocky Mountains is huckleberry which, interestingly, provides high energy value but low protein leading to small but fat female bears (Welch et al. 1997, McLellan 2011). Huckleberries flourish on relatively open, mesic sites burned by wildfire between 20 and 80 years ago, depending upon fire intensity and site conditions (Martin 1983, Zager et al. 1983, Waller and Mace 1997, Simonin 2000, McLellan and Hovey 2001). However, berry production varies greatly among years (Hobby and Keefer 2010), which appears influenced by variable weather patterns (Holden et al. 2012). In the transborder Flathead River basin, both huckleberry and buffaloberry occur which researchers believed may ameliorate shortfalls in berry production by either species (McLellan and Hovey 1995, Hamer 1996).

In the face of a shortfall in nutritious food, bears move widely in search of food – which may increase encounters with humans (Mattson et al. 1992). This substantially increases the risk of immediate human-caused mortality, management capture and translocation with problematic success, and food-conditioning or habituation which may lead to future problems (T. Manley, Montana FWP, *personal communication*). Diversity of foods enables switching by bears, which may contribute toward sustaining a relatively stable and high density grizzly bear population (McLellan and Hovey 1995).

Reproductive Capacity and Mortality Risk: Grizzly bears exhibit very low reproductive potential and cannot readily compensate for high mortality (Schwartz et al. 2003a). Females produce their first litters at approximately 4-8 years of age and are most productive between 8-25 years of age (Schwartz et al. 2003b). They average 2 cubs per litter, with an average interval between litters of 3 years, for an annual production of only 0.5 – 0.8 cubs per year. It's estimated that the average female grizzly bear may produce only 3-4 surviving daughters during a full lifetime. There is no conclusive evidence of a sharp reproductive response or increased survival of young that would compensate for increased mortality (McLellan 1994, Craighead et al. 1995).

Consequently, grizzly bear populations cannot absorb high mortality levels. Survival – particularly of adult females – is the most important factor influencing population growth and long-term viability of grizzly bear populations (Boyce et al. 2001). Specifically, annual survivorship of female grizzly bears should be ≥92% to maintain stable populations (Eberhardt 1990, Garshelis et al. 2005), but this is a difficult and expensive metric to measure. Known mortality rates from human causes should not exceed 4%, with deaths of females not to exceed 30% of that level (US Fish & Wildlife Service 1993).

Most mortality of grizzly bears is human-caused, either from direct shooting or removal by agency personnel if bears become habituated (loss of wariness) or conditioned to human food and garbage (Mattson et al. 1996, McLellan et al. 1999, Gibeau et al. 2002, Benn et al. 2005). Across 13 study areas in the interior mountains of western North America, people killed 75% of 77 grizzly bears that died while radio-collared between 1975 and 1997 (McLellan et al. 1999). It was estimated that approximately half of the deaths would not have been detected without the aid of radio-collars.

This human-caused mortality of grizzly bears often occurs around human settlements and/or within 1 km of roads – especially where open roads are proximal to streams or avalanche chutes in spring and berry patches at lower elevations during late summer-fall (McLellan and Shackleton1988, Mace et al. 1996, Nielsen et al. 2004, Herrero et al. 2005). In the Alberta Central Rockies Ecosystem, 89% of human-caused mortalities (n=172) were within 500 m of a road on provincial lands (Benn 1998). As resource extraction (e.g., oil and gas exploration and development, logging, mining) and motorized recreation expands into hitherto remote areas, road construction provides entry for hunters, poachers, and new sources of food and garbage which elevates mortality risk. Of special concern is human access into areas of naturally rich habitat that attract bears into situations having high risk of mortality ('attractive sinks': Delibes et al. 2001, Nielsen et al. 2006, Ciarniello et al. 2007). The Alberta Grizzly bear Recovery Plan, for example, emphasizes that "human use of access (specifically, motorized vehicle routes) is one of the primary threats to grizzly bear persistence" (Alberta SRD 2008:9).Provision of 'security areas', where bears can meet their energetic requirements while minimizing contact with people, has emerged as a critical component of contemporary management for grizzly bears (Weaver et al. 1996, Gibeau et al. 2001, Herrero et al. 2005, Ciarniello et al. 2007, Nielsen et al. 2010).

Dispersal and Connectivity: Relatively little is known about dispersal in grizzly bears. Dispersal by young bears appears to be a gradual process over months or even years (McLellan and Hovey 2001b). Compared to many other carnivores, young grizzlies do not seem to disperse very far from their natal range. In the trans-boundary Flathead area, the average dispersal distance was 10 km for females (longest = 20 km) and 30 km for males (longest = 67 km) (McLellan and Hovey 2001b). Sub-adult females often establish home ranges that overlap their mother's. The implication is that female grizzly bears are unlikely to colonize disjunct areas even at modest distances.

In the Canada-US border region, Proctor et al. (2012) reported extensive genetic and demographic fragmentation that corresponded to settled mountain valleys and major east-west highways. Both female and male bears reduced their movement rates with increasing settlement and traffic volume but at different thresholds. When human settlement increased to >20% along a fracture zone (e.g., river valley), female grizzlies reduced their movement rates sharply. Males continued to cross these zones but at lower rates than less settled areas. In areas with >50% settlement, both females and males exhibited much reduced movements in response to traffic, settlement, and mortality. Only 1 female grizzly bear was detected as a migrant across Highway 3 in the Southern Canadian Rockies of B.C. (Apps et al. 2007).

In contrast, researchers have documented both female and male grizzlies crossing the Continental Divide between Alberta and British Columbia between Highway 3 and the US border (summarized in Weaver 2013). Enough movements by male bears may mediate gene flow for now, but the low rate of female grizzly bear movements appears insufficient to augment a declining population or colonize one that has been extirpated. Hence, fragmentation of south-north connectivity is a real conservation concern. Proctor et al. (2012) recommended (1) securing key linkage habitats across fracture zones that would enable connectivity for female bears, and (2) maintaining large core populations as sources of dispersers.

Sensitivity to Human Disturbance: Grizzly bears are vulnerable to human disturbance at different spatial and temporal scales. Earlier studies indicated that grizzly bears avoid roads 100-900 m away and human settlements even further (Mattson 1987, McLellan and Shackleton 1988, Kasworm and Manley 1990, Apps et al. 2004, Waller and Servheen 2005, Roever et al. 2010, Northrup et al. 2012). The *type* of human activity on a road may affect grizzly bear use. In the trans-border Selkirk Mountains, most of the radio-collared females and males selected against roads open to the general public (Wielgus et al. 2002). Most female bears also selected against roads closed to the public, perhaps because they were in the general vicinity of open roads. But neither female nor male bears selected against restricted roads open to forestry-use only where people were working at a focal site.

In terms of displacement, the *volume of vehicle* traffic may be as important as the road itself. In western Montana, Mace et al. (1996) reported that all collared bears avoided areas within 500 m of roads having >60 vehicles per day. For roads having 11-60 vehicles per day, the majority of sample bears avoided areas within 500 m during spring (7/11), summer (6/10), and fall (8/9). For roads with 10 or fewer vehicles per day, some bears avoided while others did not. In southwest Alberta, Northrup et al. (2012) reported similar findings for bear use within 500 m of roads: (1) for roads with *low* traffic volume (<20 vehicles per 24 hr), bears used areas at night (even crossing roads); but (2) bears avoided or strongly avoided roads with moderate (20-100 vehicles per 24 hr) and high (>100 vehicles per day), respectively. Gated roads had the lowest traffic volumes of any roads. Bears were more likely to cross Highway 2 in Montana at nighttime when traffic volume was lower (Waller and Servheen 2005).

At a larger spatial scale of composite home ranges (CHR), road density was lower (0.6 km/km^2) within the CHR of adult female bears than outside (1.1 km/km^2) in the Swan Mountains of western Montana (Mace et al. 1996). Approximately 50% of their CHR was un-roaded and >80% of their telemetry locations occurred in blocks of undisturbed habitat > 9 km^2. Many land and resource agencies have embraced the conservation target: core habitat should have road densities below 0.6 km/km^2.

Northrup et al. (2012) suggested that this should be amended as follows: to mandate that the majority of these roads should have low volume (<20 vehicles per 24 hr period).

In Glacier National Park and adjacent Forest Service lands in the North Fork Flathead River, researchers detected more female and more male grizzly bears in areas of low road density during summer 2000 (Graves et al. 2011). They concluded that closing and removing roads may increase the number of bears when mesic habitat and low road density habitat are nearby.

Grizzly bear populations can live in large areas that contain some roads and certain kinds of human activities (e.g., McLellan and Shackleton 1988, Mace et al. 1996). Yet, some bears will displaced from some key habitats and incur direct mortality and/or non-lethal conflicts with humans that result in their eventual removal from the population (Mattson et al. 1996, Herrero et al. 2005). Overall, both the history of grizzly bears in the lower 48 states where grizzly bears have lost 99% of their historical range (Mattson and Merrill 2002) and contemporary studies (Mace et al. 1996, Theberge 2002, Apps et al. 2004) indicate that grizzly bear populations persist longer in areas secure from human settlement and *motorized* access and associated mortality (Gibeau et al. 2001, Nielsen et al. 2006, Graves et al. 2011).

Response to Climate Change: With their general resourcefulness and wide-ranging ability, grizzly bears would seem capable of adapting to direct effects of climate change (Servheen and Cross 2010). The most likely ecological effects of warming climate in the Southern Canadian Rockies may be greater plant productivity in currently cold sites and greater extent of berry-producing shrubs due to greater frequency of forest fires (depending upon intensity). On the other hand, less snow could mean decreased avalanche activity. Perhaps the largest implication of climate change for grizzly bears, though, is the extent to which humans will (1) migrate into the Southern Canadian Rockies as a response to more intense climate change (heat, drought, sea rise) elsewhere, and (2) expand development in a scramble for dwindling fossil-fuel and water resources. Ever-increasing numbers of people across the landscape would only exacerbate current challenges of habitat fragmentation and mortality risk.

Conclusion: Despite their resourcefulness, grizzly bears exhibit **high vulnerability** due to low population resiliency. They require secure access to quality forage in spring and late summer – fall, but roads with moderate traffic volume can displace bears from key habitats. Young females do not disperse very far and adult females do not readily cross major highways, which makes bear populations susceptible to landscape fragmentation. Most importantly, bears have very low reproduction and cannot quickly compensate for excessive mortality. Numerous studies have demonstrated that road access into high-quality habitats can increase encounter rates with people and lead to displacement, habituation, or mortality Altogether, this does not provide much resiliency in human-dominated landscapes.

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Wolverine Vulnerability Profile

The wolverine was proposed for federal listing as a 'threatened' species under the Endangered Species Act on February 4, 2013 (USFWS 2013).

Niche Flexibility: Wolverines are opportunistic, generalist feeders that exhibit broad regional and seasonal flexibility in their diet (Copeland and Whitman 2003). Comparatively little is known about their summer diet, but they likely use a variety of foods including ground squirrels and marmots, ungulate carrion, microtines, birds, and berries (Magoun 1987, Lofroth et al. 2007). With their traditional burrow sites and early emergence of young, marmots may comprise an important prey in late spring and summer for female wolverines raising young kits (Copeland and Yates 2006, Lofroth et al. 2007, Inman et al. 2012a). For the remainder of the year, wolverines subsist largely on carrion and occasional kills of ungulates (moose, caribou, mountain goats, elk, and deer) (Hornocker and Hash 1981, Banci 1987, Lofroth et al. 2007). Other carnivores such as wolves may be important provisioners of carrion (Banci 1987), but there may be a tradeoff for wolverines between scavenging the food resource and avoiding competition and predation with larger predators (Van Dijk et al. 2008, Inman et al. 2012b).

In the western U.S. and Canada, wolverines occur primarily at higher elevations in the subalpine and alpine life zones (Aubry et al. 2007, Copeland et al. 2007, Krebs et al. 2007, Inman 2013). Several researchers have pointed out the strong concordance of wolverine occurrence and persistence of snow cover during spring (mid-April thru mid-May), which covers the end of wolverine denning period (Aubry et al. 2007, Copeland et al. 2010). Female wolverines dig long tunnels in the snow (and under fallen trees/large boulders in the snowpack) for birthing ('natal' dens) and early rearing of kits ('maternal' dens) and may reuse the same sites in subsequent years (Magoun and Copeland 1998, Copeland and Yates 2006). It has been postulated that these snow dens provide thermal insulation and refuge from predators, which aids survival of the young. Later in summer, females 'park' their young at 'rendezvous sites' in talus fields composed of large boulders, often in subalpine cirque basins (Copeland and Yates 2006). Based upon 3917 radio locations of wolverines recorded from 5 study areas in Montana, Idaho, and Wyoming, about 88% of summer locations and 84% of winter locations fell within areas covered by snow during the spring period (calculated from data in Copeland et al. 2010). Nonetheless, certain areas with persistent snow cover may not be occupied by wolverines. Additional factors such as latitude-adjusted elevation and terrain ruggedness also help explain habitat selection by wolverines (Inman 2013). Researchers have offered a 'refrigeration-zone' hypothesis which suggests that caching foods in cold micro-sites allows them to reduce competition from insects/bacteria/other scavengers and extend availability of scarce food resources (Inman et al. 2012a).

With their large plantigrade feet, compact body, and dense fur, wolverines are well adapted to travel and live in snowy environments, which may offer them a competitive advantage over other carnivores (Copeland and Whitman 2003, Inman et al. 2012a). In such low-productivity environments, though, wolverines must range widely in constant search for food (Chadwick 2010).

Thus, their home ranges are large relative to their body size, with average annual home ranges (MCP and adaptive kernel methods) of 110 – 156 mi^2 (280 - 400 km^2) for adult females and 300 – 600 mi^2 (772 - 1,525 km^2) for adult males (Hornocker and Hash 1981, Copeland 1996, Krebs et al. 2007, Inman et al. 2012b).

Reproductive Capacity and Mortality Risk: Wolverines have a very low reproductive rate, which may reflect the tenuous nutritional regime for this scavenger. Based upon post-mortem analyses of trapped wolverines, an average of 63% of females (range of averages 50-85%) had fetuses at 2+ years of age (nearly 3-yr-old) (Rausch and Pearson 1972, Liskop et al. 1981, Banci and Harestad 1988, Anderson and Aune 2008). Based upon field monitoring of 56 adult female wolverines in Scandinavia during 141 reproductive seasons, Persson et al. (2006) reported an average age at first reproduction of 3.4 years. Percent of adult females (≥3 years) pregnant in any year in the lab studies varied from 73% to 92%, and average litter size *in utero* varied from 2.2 to 3.5 kits. In the Scandinavian study, an average of 53 % of adult females reproduced (yearly average was 58%), with average litter size of 1.88. Availability of food in the current winter (a variable commodity) influences reproduction by females and a poor winter can affect reproduction in the subsequent year, too (Persson 2005). The net result is low annual production, usually <1.0 offspring per adult female (Copeland and Whitman 2003, Persson et al. 2006). Few female wolverines in the wild are likely to reproduce past the age of 8 years (Rausch and Pearson 1972). Given average parameters and assuming annual survivorship of 0.50 for COYs/Sub-adults and 0.80 for adult females (Krebs et al. 2004, Squires et al. 2007), the average female wolverine may only produce one-two female offspring during her lifetime that survive to reproduce. This is very low, even compared to other large carnivores (Weaver et al. 1996).

With such low reproductive capacity, wolverines cannot sustain or compensate for high mortality.

They are susceptible to trapping at bait sites during winter, particularly in years when carrion availability is low. Trapping and hunting accounted for 35% of 62 mortalities recorded during 1972-2001 in 12 telemetry studies of wolverines across western North America (starvation accounted for 29%) (Krebs et al. 2004). These researchers stated that trapping appeared to be an *additive* cause of mortality (not compensatory) and cautioned that high annual survival (≥0.85) of adult female wolverines is requisite to sustaining populations. Trapping accounted for 21 (88%) of 24 wolverine mortalities recorded during 1972-1977 in the South Fork of the Flathead River basin (Hornocker and Hash 1981). More recently, researchers working in western Montana reported that licensed trapping accounted for 9 (64%) of 14 recorded mortalities of instrumented wolverines during 2002-2005 (Squires et al. 2007). They estimated that this additive mortality from trapping reduced annual survivorship from 0.80 down to 0.57 and determined that population stability was most sensitive to adult survival.

Numerous wolverine researchers have cautioned that trapped populations will likely decline in the absence of immigration from un-trapped populations (Krebs et al. 2004, Squires et al. 2007). Small populations in isolated mountain ranges are especially vulnerable to over-harvest and local extirpation (Squires et al. 2007). In an assessment of the sustainability of the wolverine harvest in B.C., researchers estimated that the Flathead population unit were over-harvested during 1985-2004 by 162%; they urged particular attention and precautionary approach be focused on this unit (Lofroth and Ott 2007).

Numerous wolverine researchers have recommended refugia – such as those created by restricting/eliminating trapping quotas or sanctuaries like Glacier National Park – as a crucial element in the overall conservation of wolverine (Weaver et al. 1996, Krebs et al. 2004, Squires et al. 2007). Due to the large home ranges of wolverines and their low density, these safe havens need to be managed at a regional and/or metapopulation scale (Inman 2013). Montana Department of Fish, Wildlife and Parks does not allow trapping of wolverine.

Dispersal and Connectivity: Wolverines are capable of dispersing long distances. Juvenile dispersals of between 105 mi and 236 mi (168 km and 378 km) have been reported (Magoun 1985, Gardner et al. 1986, Copeland 1996, Vangen et al. 2001, Copeland and Yates 2006, Inman et al. 2012b). Most interesting, a young male wolverine left Grand Teton National Park in northwest Wyoming, crossed expanses of atypical habitat the Red Desert and Interstate Highway 80 in southern Wyoming, and pulled up in Rocky Mountain National Park in northern Colorado – an astounding distance of 563 mi (900 km) (R. Inman, WCS, *unpublished data*). Young wolverines also make extensive exploratory movements >100 miles, which usually precede actual dispersal (Vangen et al. 2001, Inman et al. 2004). Both males and females make long-distance movements, typically during their second year prior to reaching sexual maturity (Vangen et al. 2001, Dalerum et al. 2007, Inman et al. 2012b). If the territory of a resident adult female becomes vacant, often her daughter will take over that space (Vangen et al. 2001). Using both mitochondrial DNA (maternal-only) and nuclear microsatellite DNA, researchers reported that male gene flow predominated and female gene flow was restricted at the southern portion of their range (Cegelski et al. 2006).

The genetically-effective population size (the number of individuals actually involved in breeding, in contrast to the total number of animals) for wolverines in the northern U.S. Rocky Mountains has been estimated at only 35 individuals (range 28-52) (Schwartz et al. 2009). Due to such low effective population size and the patchy, 'island-like' distribution of suitable wolverine habitat in the Rocky Mountains, maintaining landscape connectivity that facilitates demographic and genetic interchange among sub-populations will be crucial to ensuring the viability of the larger meta-population (Schwartz et al. 2009, Inman 2013). Researchers have found that areas with persistent snow cover during late spring and sparse human footprint (housing density) characterize the least-cost pathways for successful gene flow among sub-populations of wolverines across the northern U.S. Rocky Mountains (Balkenhol et al. 2009, Schwartz et al. 2009, Rainey et al. 2012, Inman 2013).

Sensitivity to Human Disturbance: Wolverines are vulnerable to human disturbance in several ways.

Maternal female wolverines appear sensitive to human activity near maternal dens and rendezvous sites, which are used February through June (Magoun and Copeland 1998). With the advent of more powerful snow machines as well as heli-skiing, one concern is that such motorized access could disturb maternal females and young during the critical late winter and spring period.

Major highways can have a significant impact on wolverine movements, too. In winter, wolverines avoided areas within 100 m of the Trans Canada Highway between Yoho and Banff National Parks and preferred areas 0.7 mi (>1.1 km) away from the highway (Austin 1998). Wolverines made repeated approaches and retreats and only crossed 3 of 6 times. In the Greater Yellowstone Ecosystem, Packila et al. (2007) documented 43 crossings of U.S. or State highways by 12 wolverines. Subadults making dispersal or exploratory movements comprised the majority (76%) of road crossings, most of which were made during January–March. On a Wyoming highway where traffic volume commonly exceeded 4,000 vehicles per day, four different wolverines (2F, 2 M) crossed the highway 16 times. At least 3 crossings occurred within a 4-km section where forest cover bordered close to the highway, about 4 km from the nearest human settlement.

Response to Climate Change: Wolverines may be especially sensitive to climate change. As noted, the broad distribution of wolverines, their foraging and reproductive ecology, and travel routes associated with successful dispersal seem strongly linked to areas characterized by persistent snow cover during spring (Aubry et al. 2007, Schwartz et al. 2009, Copeland et al. 2010, McKelvey et al. 2011, Inman et al. 2012a). Moreover, 90% of 1474 wolverine locations during summer in the northern U.S. Rocky Mountains occurred in areas with average maximum temperatures during August <73° F (22.8° C) (calculated from data in Copeland et al. 2010). This is consistent with the hypothesis that wolverines select cooler habitats at higher elevations during hot summer months in the southern sector of their range. Warming climate could impact the ecology and populations of wolverines' alpine prey such as hoary marmots (Lofroth et al. 2007) and reduce the abundance of ungulate carrion due to milder winter conditions (Wilmers and Post 2006). Some of the biggest changes wrought by global warming may be alterations to mountain snowpack. Recent warming has already led to substantial reductions in spring snow cover in the mountains of western North America (Mote et al. 2005, Pederson et al. 2010). Future projections under various scenarios through the year 2040 suggest this trend will continue, notably at low to mid-elevations (Pederson et al. 2011). Some researchers estimate that the extent of persistent snow cover in spring could decrease by 23% in Montana by year 2045 (McKelvey et al. 2011). Wolverines will be quite vulnerable to such changes, with likely reductions in the size of suitable habitat patches, loss of connectivity, and reduced effectiveness of its caching strategy to extend food availability.

Conclusion: Wolverines exhibit **high vulnerability** due to low resiliency. Although they have a broad foraging niche, their selection for reproductive habitat, summer habitat, and dispersal routes is closely linked to areas characterized by persistence of snow cover during spring. Wolverines have extremely low reproductive rates. Consequently, they cannot sustain high mortality rates, which can be exacerbated by trapping pressure – especially in areas of disjunct habitat patches. Trapping also may obviate the likelihood of successful dispersal by juvenile wolverines, which could be important to the viability of regional populations. Wolverines appear sensitive to human disturbance near natal den sites, and major highways may impede movements leading to fragmentation. Due to their multi-faceted adaptation to snow environments, wolverines appear particularly vulnerable to reductions in suitable habitat as a result of projected climate change.

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Mountain Goat Vulnerability Profile

Mountain goats are managed as a trophy big game species in Montana.

Niche Flexibility: Mountain goats have broad flexibility in their diet (Côté and Festa-Bianchet 2003). They will feed on grasses, sedges, lichens, herbs, mountain shrubs, and conifer needles – all on the same cliff. Indeed, they are masters of the opportunistic foraging microniche (Chadwick 1983). In contrast, mountain goats have very stringent habitat preferences based upon topography. Simply put, they select cliff faces usually ≥40° – the steeper, the better because steep cliffs shed snow that buries the rest of the high country (Chadwick 1983, Gross et al. 2002, Poole et al. 2009). Most of the time, mountain goats are found on or within 250-400 m of cliffs that serve as escape terrain (Gross et al. 2002, Poole and Heard 2003); females with kids often stay closer to cliffs to minimize risk of predation (Hamel and Côté 2007).

Winter is a critical season for mountain goats due to the energetic costs of moving through deep snow (Côté and Festa-Bianchet 2003). Mountain goats adopt two winter-coping strategies: (1) remain on high-elevation windswept slopes with nearby escape terrain, or (2) in areas with deeper snow, move to bands of cliffs at lower elevations (Chadwick 1983, Rice 2008, Poole et al. 2009). In areas with dry, shallow snow conditions, mountain goats may winter on the same mountain top where they spent the summer. In areas where summer temperatures and solar radiation becomes intense, goats may select for cooler aspects or sites. Thus, the broad foraging niche of mountain goats may have evolved to compensate for their narrow habitat preference for safety among the cliffs (Geist 1971). Because their alpine plant foods contain low sodium and high potassium levels, mountain goats may travel considerable distance (up to 24 km) even through forests to obtain supplemental minerals (sodium, magnesium, and carbonates) (Hebert and Cowan 1971, Singer 1975, Ayotte et al. 2008, Poole et al. 2010, Jokinen et al. 2013).

Reproductive Capacity and Mortality Risk: Compared to other ungulates, native populations of mountain goats have very low reproductive potential (Côté and Festa-Bianchet 2003). Young goats grow more slowly than juvenile bighorn sheep, and female goats may delay age of first reproduction until 4 or 5 years, or even older (Festa-Bianchet and Côté 2008). Prime reproductive age for female mountain goats is from 6 to 12 years of age. A nanny typically carries only a single kid, but up to a 1/3 of adult females (>3 years old) may not produce offspring in a given year (Côté and Festa-Bianchet 2003). These parameters may improve *initially* for females in introduced populations (Swenson 1985), but others have urged caution in assuming compensatory reproduction in harvested populations (Cote et al. 2001). The longer a female goat lives, the more offspring she is likely to produce. Hence, longevity of female mountain goats is paramount to their lifetime reproductive success (Festa-Bianchet and Côté 2008). Native populations of mountain goats have extremely limited capacity to compensate for excessive mortality – especially of adult females.

The history of mountain goat populations harvested by hunters is strewn with case studies of excessive kill rates – particularly of adult females who can be difficult to distinguish (Côté et al. 2001, Hamel et al. 2006 and references therein). Excessive harvest is often facilitated by new road access (Chadwick 1983). Fortunately, many contemporary wildlife managers have embraced this realization and reduced harvest quotas for mountain goats. Some mountain goats, of course, also die from a variety of natural factors such as falls, avalanches, starvation, and predation (Côté and Festa-Bianchet 2003).

Dispersal and Connectivity: Young mountain goats appear to disperse more commonly and further distance than do bighorn sheep (Festa-Bianchet and Côté 2008). In the population of goats introduced to the Olympic National Park, young individuals of both genders (but mostly 2-3 year-old males) dispersed an average of 25 mi (40 km) (maximum >55 mi) (Stevens 1983). Thus, goats appear to have moderate capacity for re-colonization through dispersal.

Sensitivity to Human Disturbance: Mountain goats appear particularly sensitive to disturbance from certain human activities (Joslin 1986, Côté and Festa-Bianchet 2003, B.C. MGMT 2010). Several studies have documented behavioral responses of goats to helicopters ranging from short movements (<100 m) and short bouts of nervous activity to panicked goats running at full speed over precipitous terrain resulting in at least 1 case of a broken leg (Côté 1996, Goldstein et al. 2005). The closer the helicopter, the stronger the behavioral reaction by goats. Nor does it appear that mountain goats habituate over time to helicopter activity (Côté et al. 2013). Goats likely would be vulnerable to disturbance to a variety of helicopter-supported activities: including backcountry skiing, fishing, biking and hiking, sightseeing, exploration for minerals/ oil and gas, and wildlife research. Consequences of helicopter harassment could include abandonment of critical habitat, which could result in a decline in local goat populations (Festa-Bianchet and Côté 2008). Researchers have recommended no-fly buffer zones ranging in size from 0.6 mi (1.0 km) (Goldstein et al. 2005) to 1.2 mi (2.0 km) (Foster and Rahs 1983, Côté 1996).

From the long-term study of mountains goats at Caw Ridge, Alberta, researchers reported that goats were moderately to strongly disturbed by All-Terrain-Vehicles (ATVs) on 44% of occasions, particularly during direct and rapid approaches (St-Louis et al. 2013). They recommended regulating use of ATVs in areas with mountain goats. Mountain goats likely are susceptible to mechanized industrial activities in alpine areas or on winter range such as seismic exploration, mountain-top removal mining of coal, or commercial logging (B.C. MGMT 2010).

Response to Climate Change: Vulnerability of mountain goats to climate change is not well understood at present (Festa-Bianchet and Côté 2008). Projected warming of +2° C over the next 40-50 years in the region could be even warmer at higher elevations in the alpine. With such warming, subalpine forests could shift several hundred feet or higher in elevation resulting in considerable shrinkage of lower alpine areas. Conceivably, warmer daytime temperatures and more intense solar radiation in the alpine during summer could force a reduction in foraging time for mountain goats, whose tolerance for heat does not seem high. Adequate foraging in summer is important for female ungulates that must bear and nurse young and acquire good body condition to survive the following winter. On the other hand, warmer winters with less snow could result in milder conditions for goats during that season. In wintering sites where deep moist snow is more common, however, rain-on-snow events could create crusted snow conditions. This would be especially tough on young goats that have not reached full body size and cannot paw as well as adults (Chadwick 1983). For these mountain-top denizens, perhaps the best conservation strategy for now is to provide security from mechanized disturbance on a variety of cliff aspects and reduce other pressures such as hunting quotas (B.C. MGMT 2010).

Conclusion: Mountain goats exhibit **high vulnerability**. They are constrained to live on or very near cliffs that provide escape terrain from predators and more accessible forage in winter. Female goats have very low reproduction and cannot quickly compensate for excessive mortality (notably hunting). Goats, particularly males, do disperse modest distances which may provide connectivity among some populations. Mountain goats are especially sensitive to motorized disturbance. In terms of climate-smart conservation strategies, maintaining secure access to a variety of aspects among cliffs and reducing other pressures could provide options.

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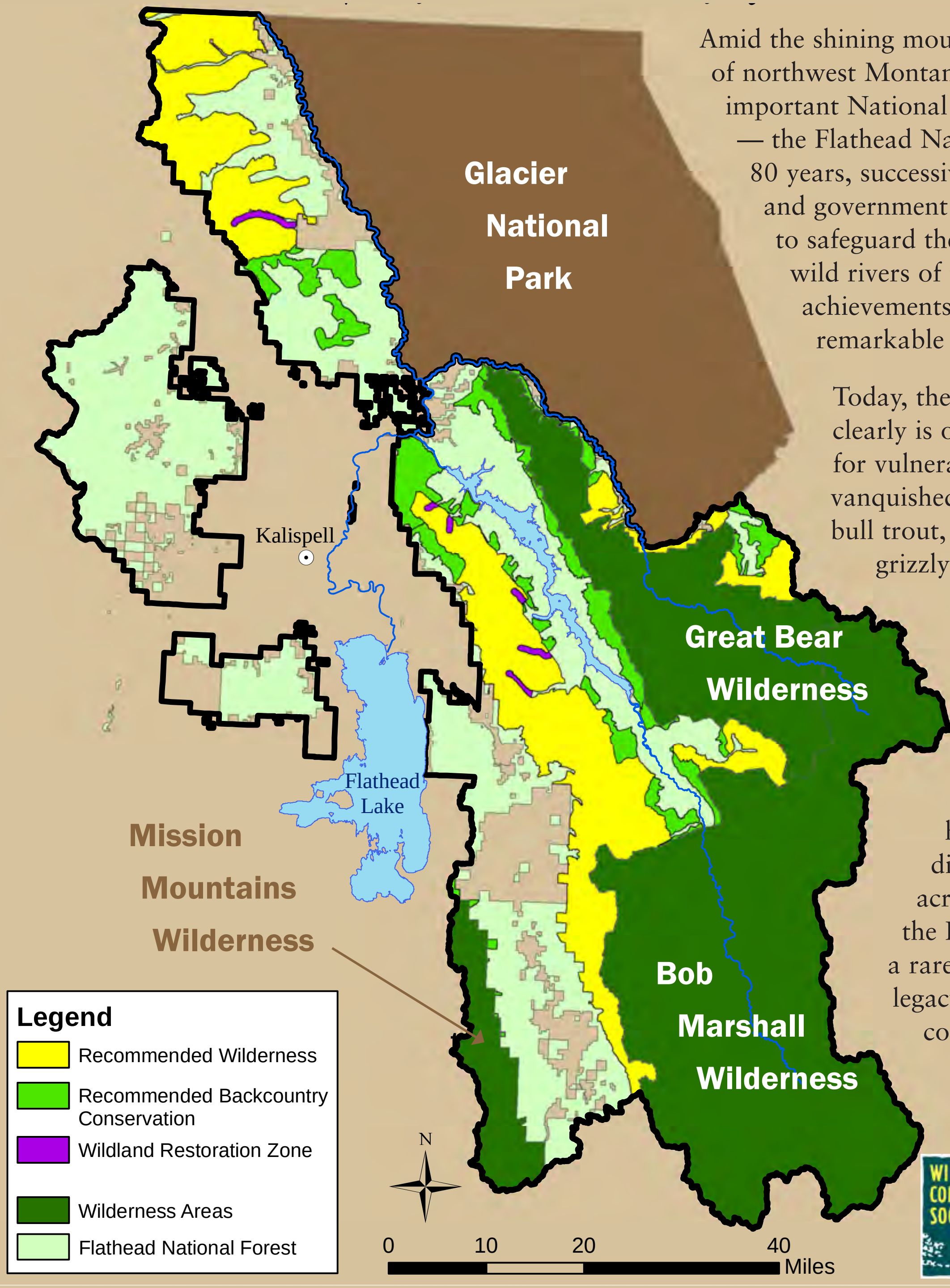
Flathead National Forest, Montana

Completeting the Conservation Legacy



Amid the shining mountains and verdant valleys of northwest Montana lies one of the most important National Forests in the United States — the Flathead National Forest. Over the past 80 years, successive generations of citizens and government leaders have worked hard to safeguard the wild life, wild lands and wild rivers of the Flathead country. Their achievements comprise a great gift and remarkable legacy.

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Wildlife Conservation Society
301 North Willson Avenue
Bozeman, Montana 59715
www.wcsnorthamerica.org