Coldwater Fish Conservation Element Package

1 Introduction

The coldwater fish assemblage for the NGB ecoregion includes redband trout, mountain whitefish, Lahontan cutthroat trout, and Yellowstone cutthroat trout. These species were selected to represent the assemblage due to their sensitivity to changes in water and habitat quality, in addition hybridization and predation pressures associated with introduced species. System level components modeled for this assemblage include habitat loss, fragmentation of current habitat, isolation of existing populations, and introduced species are primary factors that affecting coldwater fish status and distribution within this ecoregion.

The system level conceptual model (Figure 5-1) illustrates the interactions between the change agents (CAs) and the primary habitat functions for coldwater fish species in this ecoregion. Any CA that positively or negatively influences these factors has the potential to influence coldwater fish distribution and population levels in the region. The coldwater fish assemblage was selected as a fine-filter conservation element (CE) for the NGB AMT because it is a landscape-level species assemblage that is the focus of management concern in the ecoregion.

2 CE Package Review Process

2.1 Subject Matter Expert Review

Subject Matter Experts play a key role in ensuring that the REA reflects the best available data and modeling processes suitable for each conservation element and change agent. Subject Matter Experts were added to Rolling Review Teams comprised of SAIC scientists, SAIC GIS personnel, AMT member(s) and other subject matter experts from the Department of Interior or state agencies. Membership of the Rolling Review Teams is listed in Appendix A. To ensure consistency amongst the different Rolling Review Teams, the number of lead SAIC scientists was limited to only a few individuals. This ensured that there was a common approach, or framework, used among the different Rolling Review Teams and that one Rolling Review Team did not stray too far from the rest. The USGS, as peer reviewers, were invited to participate in Rolling Review Teams.

3 CE Description

The coldwater fish assemblage CE (mountain whitefish, Yellowstone cutthroat trout, Lahontan cutthroat trout, and redband trout) occurs throughout drainages in the NGB. For species such as redband trout, hybridization with other salmonids has contributed to its decline (Thurow *et al.* 2007). Many of the species in this assemblage require well–oxygenated water; clean, well–sorted gravels with minimal fine sediments for successful spawning; temperatures <21 C (<70 F), and a complexity of instream habitat structure such as large woody debris and overhanging banks for cover. In addition, a number of these species are genetically isolated by impoundments and other structures that limit connectivity between populations within a given drainage. The effects of CAs on these habitat conditions will constrict the range over which these species can occur.

A brief description of the four native fish species that comprise the coldwater fish assemblage is provided below.

3.1 Mountain Whitefish

Mountain whitefish (*Prosopium williamsoni*) are a broadly distributed, long-lived (to 11 years) salmonid native to western North America rivers, streams and lakes (Wydoski and Whitney 2003). In general their mouths are smaller than most salmonids, with prey resources primarily consisting of adult and larval aquatic insects, however larger mountain whitefish also prey on crayfish, leeches and occasionally small fish (Wydoski and Whitney 2003).

Though slightly more tolerant of warmer water temperatures and higher turbidity than cutthroat trout, mountain whitefish prefer large, deep, clear, cold rivers (Behnke 2002). The general in-stream temperature in habitats where mountain whitefish occur generally ranges from 48 to 52° F, however fall spawning can occur in waters as cool as 40 to 46°F (Wydoski and Whitney 2003). Whereas young-of-the-year fish can be found in slow moving, shallow (1.2 in mean depth) habitats (Wydoski and Whitney 2003), Meyer *et al.* (2009) found that adult mountain whitefish preferred low-gradient, main stem streams at least 50 feet wide. Within Utah streams, mountain whitefish tended to be associated with habitats having pools greater than four feet deep at base flow (Sigler 1951 as described in Wyoming State Wildlife Action Plan 2010). Whereas many other salmonid species are associated with in-stream structured habitats utilized for refuge from predators and for ambushing prey, mountain whitefish occupy more open channel habitats (Behnke 2002).

Threats to mountain whitefish include loss or alteration of habitats, including changes in water quantity and temperature, and the availability of suitable spawning gravel. In addition, water quality degradation from sources such as effluent and agricultural run-off has the potential to adversely affect mountain whitefish health. Quinn *et al.* (2010) found that mountain whitefish are more sensitive to elevated temperatures and pesticide levels than are co-occurring white suckers (*Catostomus commersoni*). Impoundments have been found to alter these habitats and reduce local populations (Wyoming State Wildlife Action Plan 2010). Disease can also have an adverse effect on mountain whitefish populations. As far back as 1975, Abernethy and Lund (1978) found that Mycobacteriosis affected as much as 8 percent of the mountain whitefish population in the Yakima River, Washington. In some Colorado systems caudal fin deformities attributed to whirling disease, caused by the parasite *Myxobolus cerebralis*, have been detected in as much as 20 percent of the outmigrant population (Schisler 2010), resulting in mortality events. These findings suggests that whether mountain whitefish are exposed to an existing parasite or some not yet introduced parasite or pathogen, disease can be an significant stressor on the occurrence and persistence of mountain whitefish populations in a given region.

3.2 Yellowstone Cutthroat Trout

The Yellowstone cutthroat trout (*Oncorhynchus clarki bouvieri*) was historically native to the Yellowstone river drainage in south-central Montana and Wyoming, and in the Snake River drainage in Wyoming, Idaho, Utah, and Nevada (Gresswell 1995), but at present 91 percent of the current range lies within the boundary of Yellowstone National Park. In addition to its native distribution, Yellowstone cutthroat have been stocked in mountain lakes on the east slope of the Rocky Mountains and in the Absaroka-Beartooth Wilderness, including areas in which westslope cutthroats are native. Westslope cutthroat trout are widespread in headwaters, lake and stream environments in Montana west of the continental divide as well as the upper Missouri River drainage, much of central and northern Idaho, and the extreme northwestern corner of Wyoming. Where they overlap, the two cutthroat subspecies hybridize with each other and with rainbow trout, with the result that pure stocks have been greatly reduced in number and geographic extent.

Native cutthroat trout subspecies have three life history patterns based on migration from spawning streams to rearing habitat: resident, fluvial and adfluvial (Gresswell 1995; McIntyre and Rieman 1995). All three life forms spawn in tributary streams, and the movements of juveniles may range from very limited to many kilometers depending on their life form, in response to water temperature, ice conditions, and food availability. Spawning and rearing streams provide cold water, riffles, and gravel substrate that is relatively free of fine sediment (Weaver and Fraley 1991; McIntyre and Rieman 1995), although some studies have demonstrated adaptation to microhabitat changes (Everest et al 1987). Resident form cutthroat trout remain in tributary streams throughout their lives, while migratory forms may travel several hundred kilometers as they move between adult and spawning habitat (AFS website 2011). Thus, loss of connectivity is a particular threat to migratory forms. In most basins within their range, currently occupied habitat is at low risk for increasing summer temperatures due to climate change, and moderate risk for drought, and risk of winter flooding and wildfire are highly variable across basins (Haak *et al.* 2010).

3.3 Lahontan Cutthroat Trout

The Lahontan cutthroat trout (*Oncorhynchus clarki henshawi*) was listed as Endangered on October 13, 1970 (35 FR 13520), and subsequently reclassified as Threatened on July 16, 1975 (40 FR 29863). On September 9, 2008, the U.S. Fish and Wildlife Service determined that delisting the Lahontan cutthroat trout is not warranted (73 FR 52257). No critical habitat has been designated for this species. A Recovery Plan was published in 1995 (U.S. Fish and Wildlife Service 1995).

The Lahontan cutthroat trout, a unique subspecies of cutthroat trout, is endemic to the Lahontan Basin of northern Nevada, eastern California, and southern Oregon, but are also found in numerous lakes and streams within the Sierra Nevada and elsewhere outside their historic range (U.S. Fish and Wildlife Service 1995). The Lahontan cutthroat trout is one subspecies of the wide-ranging cutthroat trout species (*O. clarki*) that includes at least 14 recognized forms in the western United States. Cutthroat trout have the most extensive range of any inland trout species of western North America, and occur in anadromous, non-anadromous, fluvial, and lacustrine populations (Behnke 1979). Historically, Lahontan cutthroat trout were found in a wide variety of cold-water habitats including large, terminal, alkaline lakes; alpine lakes; slow, meandering rivers; mountain rivers; and small headwater tributary streams.

Generally, Lahontan cutthroat trout occur in cool flowing water with available cover of well-vegetated and stable stream banks healthy riparian zones), in areas where there are stream velocity breaks, and in relatively silt-free, rocky riffle-run areas (U.S. Fish and Wildlife Service 1995). However, unlike most freshwater fish species, some Lahontan cutthroat trout tolerate alkalinity and total dissolved solid levels as high as 3,000 mg/L and 10,000 mg/L, respectively (Koch *et al.* 1979).

Like other cutthroat trout subspecies, Lahontan cutthroat trout is an obligatory stream spawner that spawns between April and July, depending upon stream flow, elevation, and water temperature (McAfee 1966; Lea 1968; Moyle 2002; Dunham *et al.* 2003; Wydoski and Whitney 2003). Spawning depends upon stream flow, elevation, and water temperature. Egg survival depends on well oxygenated waters that are relatively silt free.

When originally listed as endangered in 1970, the U.S. Fish and Wildlife Service identified the primary threats as habitat destruction and modification primarily due to dams and water developments and hybridization with introduced trout species (35 FR 13520). Current threats include isolation of populations, loss and degradation of suitable spawning habitat, competition and/or hybridization with nonnative fish (e.g., nonnative rainbow [*Oncorhynchus mykiss*] and brook trout [*Salvelinus fontinalis*]), decreased viability of native populations, loss of spawning habitat due to pollution from logging, mining, and urbanization, blockage of streams due to dams, channelization, de-watering due to irrigation and urban demands, and watershed degradation due to overgrazing of domestic livestock (Gerstung 1986; Coffin 1988; Wydoski 1978; U.S. Fish and Wildlife Service 1995; Dunham *et al.* 1997, 2003). In addition, drought conditions from 1987 through 1994 caused significant declines in many populations within the Great Basin, but good water years from 1995 through 1999 improved the abundance of Lahontan cutthroat trout in many streams (Sevon *et al.* 1999).

3.4 Redband Trout

Non-anadromous rainbow trout (*Oncorhynchus mykiss*) that are found primarily east of the Cascade Mountains in the U.S. are often called redband trout (*O.m. gairdneri)*. The redband trout subspecies was considered as a candidate species for listing under the federal Endangered Species Act. However, on March 20, 2000 the U.S. Fish and Wildlife Service decision not to list redband trout was announced (65 FR 14936).

The understanding of the distribution and status of redband trout across their range was greatly enhanced with the completion of the redband trout status assessment (May *et al.* 2012). Prior to completion of the status assessment, Thurow *et al.* (2007) summarized and mapped known and predicted ranges of redband trout based on existing knowledge of occurrence and habitat requirements. This effort also attempted mapping spawning and rearing differences between allopatric redband trout and sympatric redband trout, with substantial differences in results. Within the drainages of Owyhee County Idaho, small, fragmented populations of redband trout have been studied in perennial streams from 1976-1991 (Allen *et al.* 1996). However, as an indication of a poor understanding of their current and historic range and occurrence, seven of the 17 stream segments sampled in the 1995 effort contained redband trout in areas where no previous records of in-stream sampling has taken place.

Redband trout are the most prevalent indigenous salmonid in the Malheur River Subbasin (Hanson *et al.* 1990 as cited by the Malheur Watershed Council and Burns Paiute Tribe 2004). They are found in tributaries of the South Fork Malheur and the Malheur River below Warm Springs Reservoir, the mainstem and North Fork and their tributaries and above Bully Creek reservoir and its tributaries (Malheur Watershed Council and Burns Paiute Tribe 2004). Within this subbasin, redband trout populations appear healthiest in the North Fork and Upper Malheur River upstream of the reservoirs, similar to that of bull trout (Malheur Watershed Council and Burns Paiute Tribe 2004). Below the reservoirs, spawning and rearing habitat is lower in quality due to low in-stream flows, poor water quality, and between-habitat obstructions such as irrigation structures (Hanson *et al.* 1990).

Redband trout like cool temperatures in clean and clear waters. As the range over which this subspecies occurs includes reaches that become frozen over, these fish require deeper pools in which to overwinter. Mature redband trout, typically age 3 or older, prefer to spawn in riffle or end of pool tail-out habitats that provide in gravels, free of fine-grained sediment to ensure proper oxygenation of their eggs. Redband trout spawning periods and locations are influenced by in-stream temperature and flow. With some exception, spawning in Oregon systems was found to occur in April and May when in-stream temperatures exceeded a low temperature threshold of 7°C (summary review in Malheur Watershed Council and Burns Paiute Tribe 2004). Within the Malheur River Basin, some redband trout populations became isolated upstream of natural barriers, and so adopted a resident life history strategy after connectivity to marine environments was severed by the construction of dams (Bangs *et al.* 2008). Similar to that described for Lahontan cutthroat trout, drought conditions from 1987 through 1994 likely caused significant declines in many populations within the Great Basin (Allen *et al.* 1996).

Redband trout and their habitats have been affected by land use practices including; direct loss of water resources through water diversions, entrainment and impingement on screened diversions, and direct loss of fish in unscreened diversions, blockage of migration corridors, loss or conversion of riparian habitat timber harvest, mining, urbanization, wildfire, road construction, and agriculture (Meehan 1991 as cited in Bayley 2002; Thurow *et al.* 2007). Loss of habitat connectivity has loss resulted in redband trout populations becoming increasingly isolated into smaller and smaller areas of suitable habitat minimizing gene flow. Habitat connectivity allows for migration, rearing, and overwintering over a broader range than occurs in isolated stream reaches. These isolated patches face further degradation of suitable conditions should climate change alter existing in-water conditions, or further limit connectivity between available habitats. Displacement via competition, predation, and hybridization and disease introduction (e.g., whirling disease) may also represent substantial threats to redband trout populations. Within recreational regions of their range stocking of hatchery rainbow trout, and other species, may exposes native fish to loss of genetic integrity through hybridization, direct competition for available food and habitat, as well as potential increased risk from disease introduction.

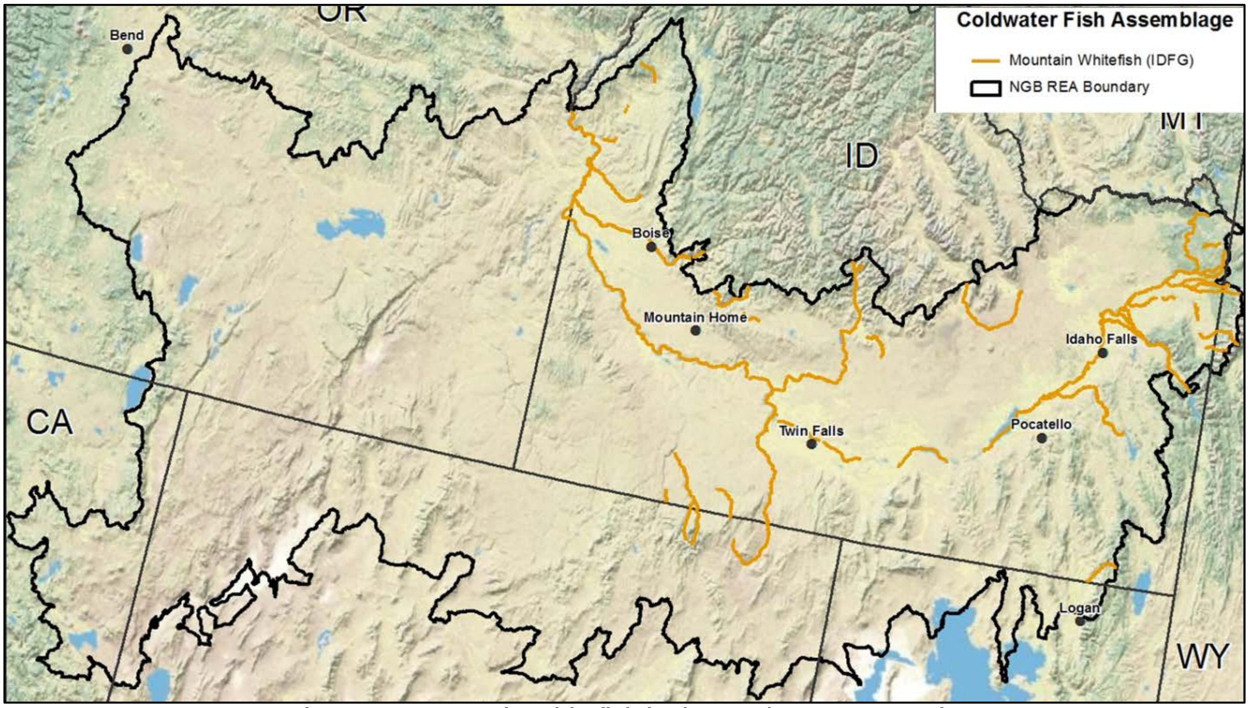


Figure 3-1. Mountain Whitefish in the Northern Great Basin

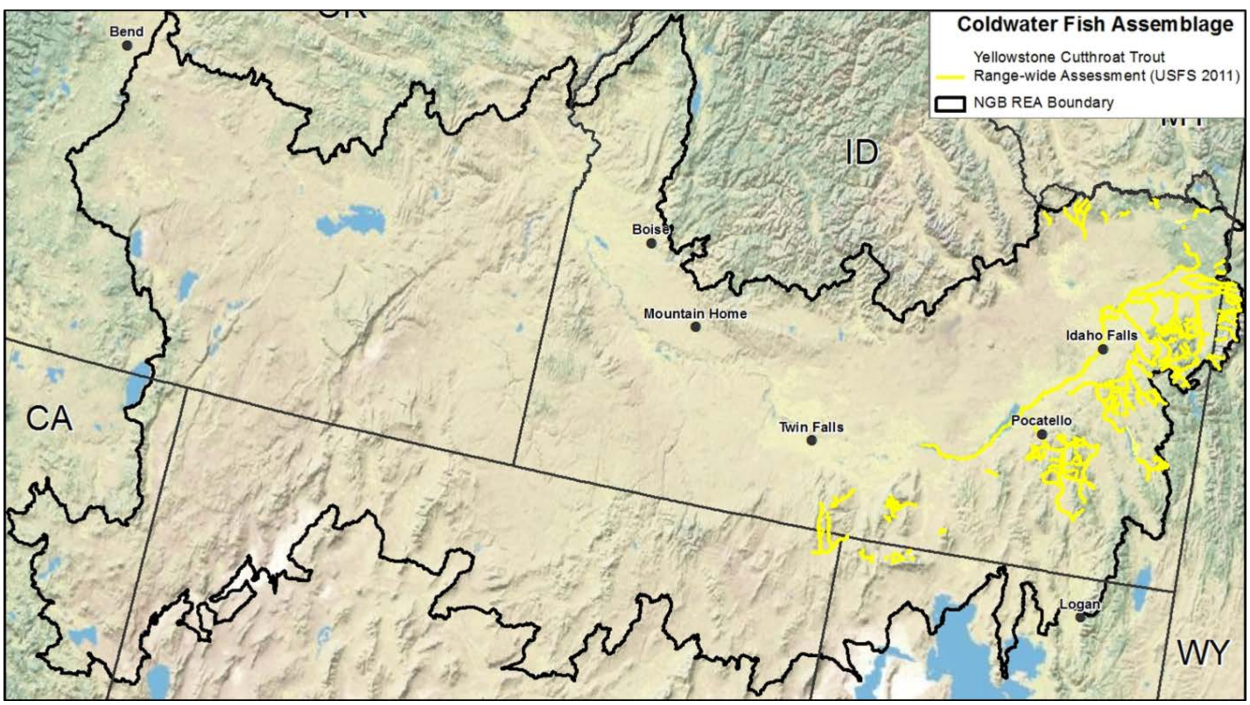


Figure 3-2. Yellowstone Cutthroat Trout in the Northern Great Basin

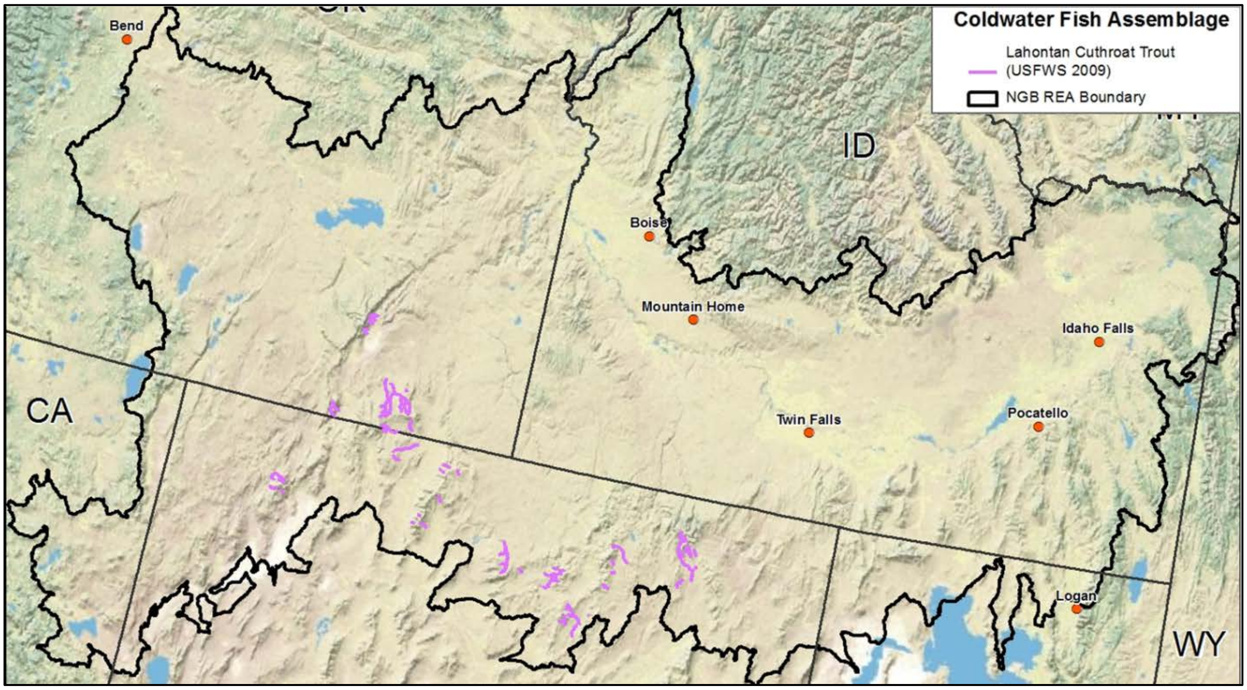


Figure 3-3. Lahontan Cutthroat Trout in the Northern Great Basin

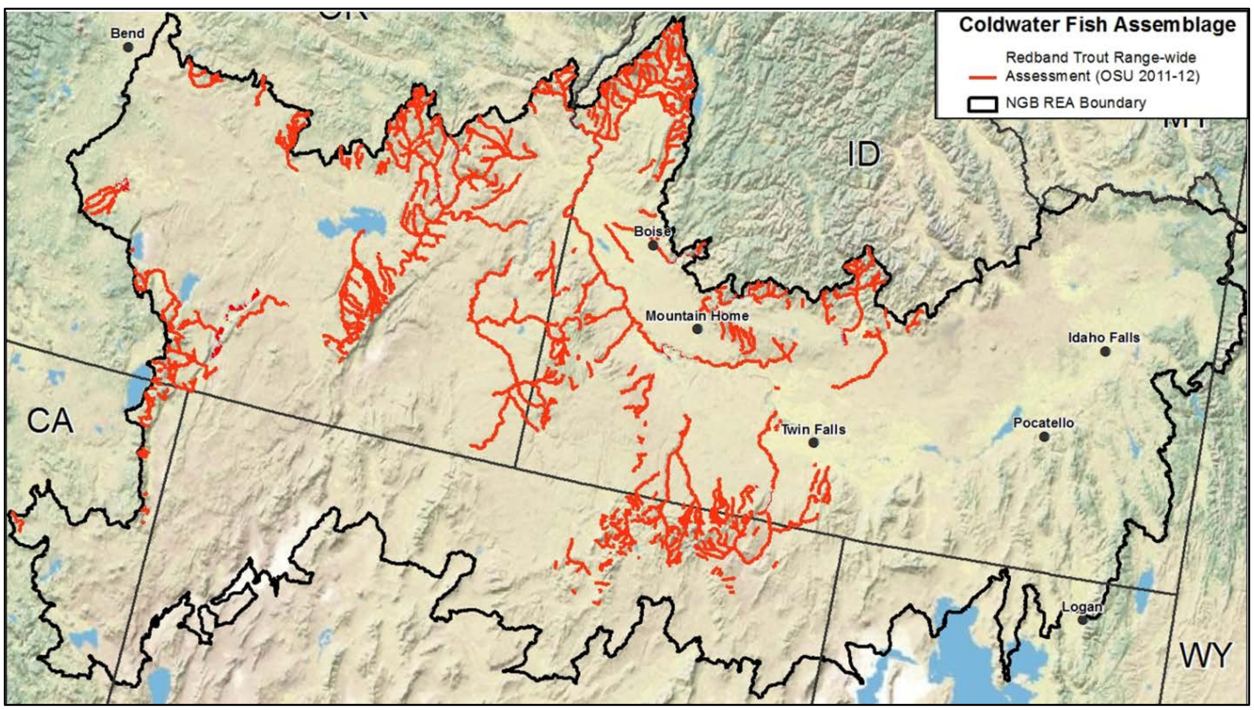


Figure 3-4. Redband Trout in the Northern Great Basin

4 CE Modeling

4.1 Data Identification

Table 4-1 provides a brief summary of potentially available data sources that may be available to document the range and occurrence of the coldwater fish assemblage within the NGB.

Table 4-1. Preliminary List of Coldwater Fish Data Sources

Data Required	Dataset Name	Source Agency	Type/Scale	Status	Use in REA
Documented Spawning Sites	TBD	NMFS, U.S. Fish and Wildlife Service, State Agencies	Point	Data Gap	No
Dams and Fish Ladders	National Inventory of Dams	USACE	Point	Data Acquired	Yes
	Fish Barriers	RBT and YCT Range-wide Assessment	Point	Data Acquired	Yes
	Fish Barriers	U.S. Fish and Wildlife Service	Point	Data Acquired	Yes
Current Distribution	StreamNet	Pacific States Marine Fisheries Commission	Polyline	Data Acquired	Yes
	Redband Trout Range wide Assessment	Oregon State University	Polyline, Polygon	Data Acquired	Yes
	Yellowstone Cutthroat Trout Range wide Assessment	USFS, various agencies	Polyline	Data Acquired	Yes
	Lahontan Cutthroat Trout 5 Year Review (2009)	U.S. Fish and Wildlife Service	Polyline, Polygon	Data Acquired	Yes
	Mountain Whitefish	Idaho Department of Fish and Game	Polyline	Data Acquired	Yes
Areas with Potential for Restoration of Habitat or Habitat Connectivity	TBD	NMFS, U.S. Fish and Wildlife Service, State Agencies	Point	Data Gap	No
Climate	PRISM 1981 – 2010	Oregon State University	Raster (800 m)	Data Acquired	Yes

4.2 Distribution Mapping Methods

The current distribution of the coldwater species assemblage can be viewed in Figure 4-1. The redband trout data is from a range-wide assessment that was conducted in 2012 and led by Oregon State University (May *et al.* 2012). Yellowstone cutthroat trout data (2011) was downloaded from StreamNet's data library. The USFS along with other agencies conducted the range-wide assessments in 2010 and 2011. The Lahontan cutthroat trout data was acquired from the U.S. Fish and Wildlife Service as part of their 5 year review that was conducted in 2009. Mountain whitefish was acquired from the Idaho Fish and Game that has species distribution in Idaho and northern Nevada.

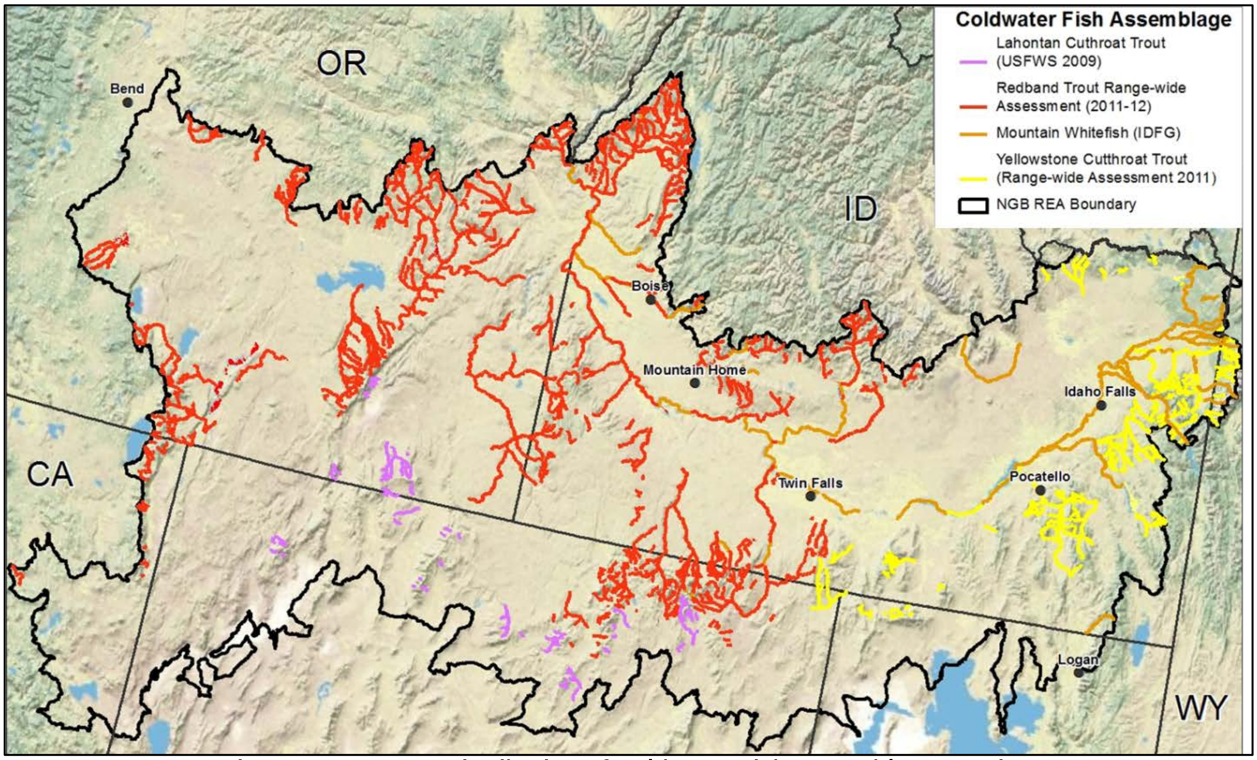


Figure 4-1. Current Distribution of Coldwater Fish Assemblage species

4.3 Data Gaps, Uncertainty, and Limitations

Data Gaps

It was difficult to acquire spatial data for mountain whitefish. Data was provided by the Nevada Department of Wildlife but only consisted of a couple of location points. Some of the Mountain whitefish streams are tributaries to the Snake River bordering Oregon and Idaho (Weiser, Payette and Boise River) so it is possible that some of the streams from Oregon may also contain populations that are tributaries to the Snake River. There is also a stream (Cub Creek) within Idaho that appears to end at the Utah border. StreamNet does have some mountain whitefish spatial data but it is out of the ecoregion within Montana.

Uncertainty

This assemblage is made up of data collected from different agencies and varying in the timeliness of the datasets. Different agencies have various thresholds for determining whether a stream is considered occupied and how it is reported and also where to the line is between a current population and historic population.

Fish barriers were collected from both the individual range-wide assessments (Yellowstone cutthroat and Redband trout) along with the U.S. Fish and Wildlife Service GeoFIN fish barrier data. Only raw coordinates of fish barriers could be acquired from the U.S. Fish and Wildlife Service due to data sharing agreements so there was no attempt to try to remove duplicates. Using fish barriers along with analysis units also added the problem of a barrier occurring within a HUC 12 or 4km analysis unit may not be located on a coldwater fish assemblage occupied stream. These barriers may still have effects on the populations if they are upstream or downstream or within the same watershed. The Aquatic Invasives dataset was provided by the USFS and all invasive detections were used in this analysis. This dataset is a presence-only dataset showing where invasives were detected not everywhere that has been surveyed.

5 System Models

The system model for the coldwater fish assemblage CE is a conceptual model that illustrates the effects of CAs on the primary habitat functions for this assemblage (see Memo 2-C). Habitat functions include biotic and abiotic processes that may occur at local and landscape-levels (Figure 5-1). The model was developed to provide a scientific framework and justification for the choice of indicators that were used in assessing CA threats for this CE. The CAs originally included in the analysis included development, climate change, wildfire, disease, and introduced species. The conceptual model depicts our current understanding of the most important habitat functions in the systems occupied by this CE without regard for data availability or suitability of a habitat function for an ecoregion-level assessment. Following sections of this appendix will explain why certain elements in the model were carried forward in the analysis and why others were not.

The primary CAs for the coldwater fish species are identified across the top of the figure in red and their effects on habitat functions important to this species are identified in gray boxes below (Figure 5-1). The habitat functions that are key to the distribution and status of this species include development, climate change, wildfire, disease, and introduced species. The features that most significantly affect the distribution of the coldwater fish are habitat suitability and physical barriers. Changes caused by human development and resource use, climate change, and altered fire regime affect coldwater fish assemblage habitats primarily by degrading water quality, effectively reducing available suitable habitats. In addition, anthropogenic effects cause direct mortality and disturbance.

5.1 Development

Past human development activities and land use have adversely affected native coldwater fish species in many ways. Habitat loss and degradation have been primary causes of depressed populations in Idaho (McIntyre and Rieman 1995; Zoellick and Cade 2006; Thurow et al 2007; Gresswell 2011). Within drainages of this ecoregion, dams, logging, grazing, urban/exurban development, road construction, and mining have resulted in streambank erosion, sedimentation, adverse changes to channel configuration, reductions in water quality, and loss of riparian habitat, which provides shading and a source of insect prey for fish. In addition to increased sedimentation, water chemistry can be degraded by contaminants and nutrients in runoff from adjacent developments and mining. Within the upper Snake River, climate change has altered snowpack timing and extent, which has corresponded into increases in acid rock drainage (ARD). ARD, which can be increased in areas of previous mining activity, dissolves metals such as zinc, copper, and iron, which have increased in some drainages with adverse effects on instream organisms, including fish and the foodwebs upon which they are dependent. In laboratory studies on cutthroat trout, dissolved metals have been shown to reduce feeding activity, and decrease kidney function, with effects likely expressed as reduced growth and survival of fish in the wild (Farag *et al.* 1999).

Dams, improperly placed culverts, irrigation diversions, and other migration barriers have negatively affected individuals and habitat and likely have interfered with metapopulation dynamics. As a result, populations have become increasingly fragmented. Surface and groundwater extraction for urban and exurban populations, agricultural irrigation, and industrial development adversely affect native coldwater fish populations. Diversion of water for hydroelectric and agriculture uses has exacerbated persistent drought conditions, and requires mitigated flow management of the dams by the US Army Corps of Engineers (USACE). Degradation of riparian vegetation negatively impacts fish habitat by reducing large woody debris, shade, available food resources, and the protection of water and sediment quality during precipitation events.

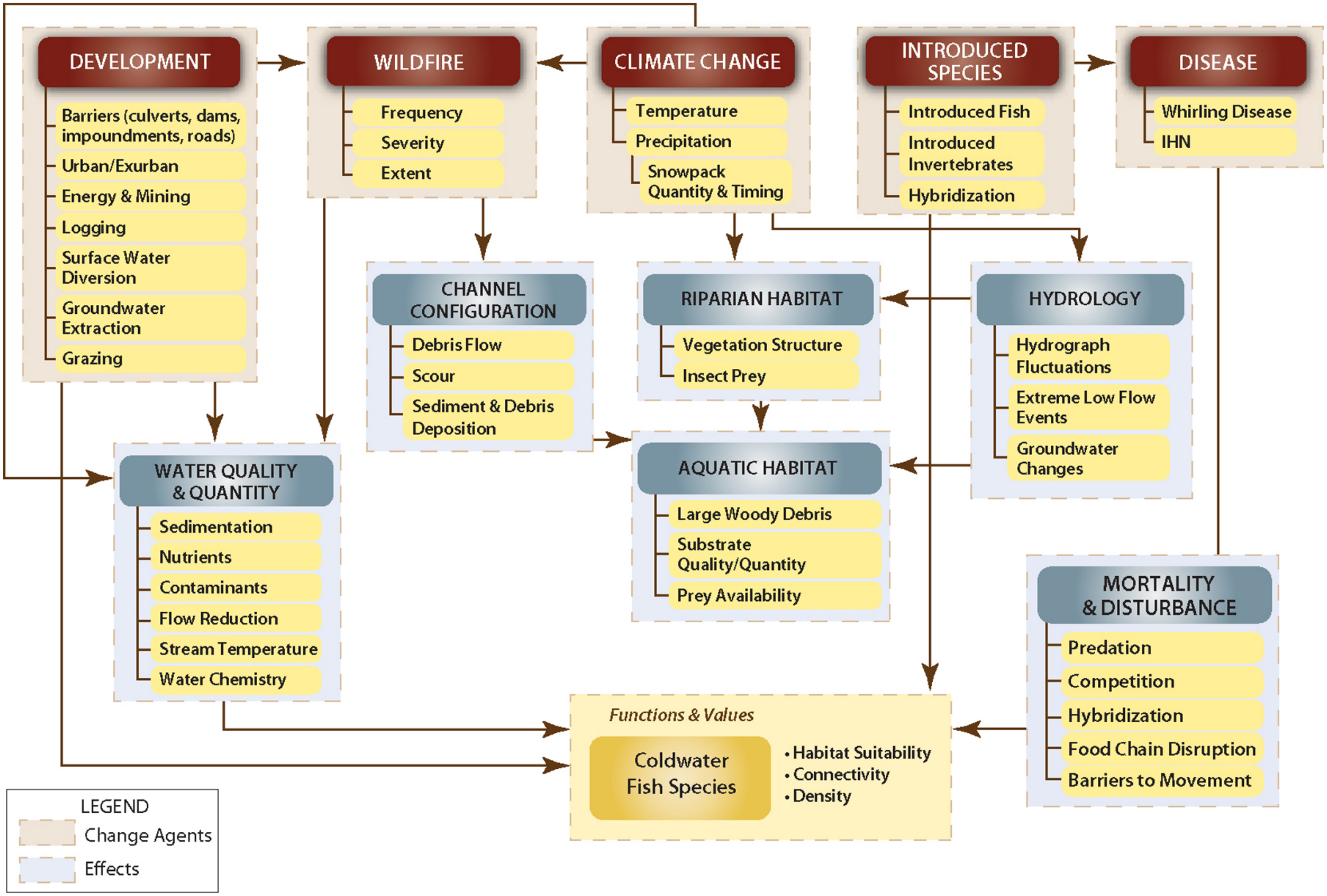


Figure 5-1. Conceptual System Model for the Coldwater Fish Assemblage in NGB Ecoregion

5.2 Climate Change

Reduced snowpack, water temperature changes, precipitation changes, and greater fluctuations in stream hydrographs will likely be significant stressors on native coldwater fish species that result from climate change. The U.S. Bureau of Reclamation (USBR 2010) suggests that future climate conditions will feature less snowfall and more rainfall, less snowpack development, and earlier snowmelt runoff. The report also suggests that warming will lead to more intense and heavy rainfall that will tend to be interspersed with longer relatively dry periods. USBR (2010) reported evaluations of potential future changes to Pacific Northwest climate relative to the ability of the Columbia River reservoir system to meet regional resource objectives. The report predicted decreased summer streamflows of up to 26 percent relative to the historic average. This reduction, if realized, would amplify competition between water users, and the required mitigation for USACE mandated flows for fish. Climate change is likely to eliminate some habitat directly through water quantity and temperature changes (USBR 2010) and indirectly through water quality changes. Water quantity issues associated with climate change include effects of persistent severe drought and impacts on recruitment due to sudden runoff events during hatching and emergence of larvae (USBR 2010). Conversely, extreme low flows during severe drought decrease survival of adults due to increased water temperatures, increased susceptibility to predation, and diminished habitat volume. Under current climatic patterns, in drought years water temperatures have surpassed lethal limits for all salmonid species; these conditions would occur more frequently under climate change.

5.3 Introduced Species

The introduction of non-native fishes in the waters occupied by native salmonid populations, hybridization between trout species such as redband trout and cutthroat trout, competition with non-native fish species, and predation by non-native fish species are among the primary concerns for persistence of native populations. The impact of hybridization of redband trout has become so problematic that it has necessitated monitoring of genetic purity within systems in which pure redband trout still occur. Introduced fish species such as channel catfish, smallmouth bass, and walleye likely contribute influence population dynamics and distribution of the coldwater fish assemblage.

5.4 Wildfire

Wildfire affects aquatic habitats and biota through water quality changes including sedimentation and debris flows. Climate change will increase the likelihood of wildfires in the presence of fuels and ignition sources in relation to the timing of snowmelt (Haak *et al.* 2010). Dunham *et al.* (2003) indicated that an increase in wildfire prevalence would likely result in a corresponding decrease of riparian habitat function and benefit to the associated stream or river system, and has been considered as a disturbance that may provide an ecological advantage for introduced fish species. Though large, severe wildfire can contribute to small increases in stream temperature attributable to riparian vegetation loss, the greatest impact to coldwater fish from wildfire comes from the influx of sediment from upland sources. In sufficient quantities, the additional sediment can degrade water quality conditions and smother spawning habitats and eggs.

5.5 Disease

All species of trout and salmon may become infected with the parasite responsible for whirling disease (*Myxobolus cerebralis*), an introduced disease agent that was first identified in the United States in 1956 and is now present in Idaho (Idaho Invasive Species Council Technical Committee 2007). The presence of the parasite does not always cause dramatic population losses, but can be a serious problem in hatcheries and has had severe impacts on some wild trout populations (Whirling Disease Initiative 2011). Infectious hematopoietic necrosis virus (IHN) and other pathogens affect salmonids, and other hosts, and require continued monitoring within hatchery systems. The significance of disease as a CA for native coldwater fishes is unknown at present but it is included in the conceptual model due to the potential for spread of pathogens from hatchery facilities into habitats of wild salmonid populations.

6 Change Agent Threat Analysis

Current status and future threat assessments for the coldwater fish CE were conducted for the NGB ecoregion using 30 m pixel, 4 km and 12-digit HUC as the analysis units. Based on the conceptual system model for the assemblage (Figure 5-1), key ecological attributes were identified for the current status and future threat analyses with an emphasis on the feasibility of measuring impacts using geospatial data.

6.1 Key Ecological Attributes

The list of key ecological attributes (Table 6-1) provides some indicators for assessing habitat size, condition, and landscape context with respect to anthropomorphic influences.

Table 6-1. List of Coldwater Fish Key Ecological Attributes and Indicators

Ecological Attribute	Indicator	Data Source
Landscape Structure	Riparian habitat condition	Development in Riparian Corridor (see Riparian CE)
Water Quality Factors	Instream temperatures	USGS Stream Gage
	Instream flow (hydrographs)	USGS Stream Gage
	Dissolved oxygen	Limited Sampling
	Contaminants, turbidity, sedimentation	303d lakes and streams (EPA)
	Alterations in reservoir operations	No Data Available
Wildfire	Wildfire	Fire SIMulation Burn Probability
Climate Change: Hydrologic Processes	Hydrograph changes	PRSIM
	Changes in average annual rainfall, extreme dry and wet water years	PRISM
Physical Barriers (Surface Water Diversion)	Fish Barriers	U.S. Fish and Wildlife Service Fish Barriers and other barriers from species specific assessments
Introduced Species	Aquatic Invasive Detections	USFS Aquatic Invasives Dataset
Disease		No Spatial Data

6.2 Current Status of the CE

6.2.1 Water Quality

6.2.1.1 Instream Flow and Temperature

Instream flow and temperature were measured using USGS stream gage data from a variety of stations located throughout the range of the coldwater fish assemblage. Since gages aren't located on all streams and can vary temporally, stream gages were chosen where there was a long history (50+ years) of recorded data up to present. The flow and temperature data was converted to raster graphs to display seasonal fluctuations and longer term patterns. Figure 6-1 shows locations of USGS stream gages used for stream flow and Figure 6-2 displays gages used for instream temperature. The raster graphs showing instream flow tend to display a peak spring runoff in March – June. The Malheur River is one of the outliers as its flow is only high during the May – September timeframe and very low outside that window.

6.2.1.2 Dissolved Oxygen

Dissolved oxygen monitoring at USGS gaging stations has been very infrequent. The USGS water sampling that includes dissolved oxygen is mostly done on larger rivers such as the Snake River and usually consists of sampling once a month and can vary from year to year. Dissolved oxygen was identified as a data gap for the coldwater fish assemblage streams in the ecoregion.

6.2.1.3 Contaminants, Turbidity and Sedimentation

Similar to dissolved oxygen, turbidity is another parameter measured at some larger rivers or during monthly water sampling at select gage sites. The 303d waters dataset from the EPA was used as a surrogate to determine the percentage of waters that were listed as 303d within the analysis unit. The main causes of 303d classification within coldwater fish assemblage waters was: arsenic, dissolved oxygen, e. coli, fecal coliform, mercury, phosphorus, sedimentation/siltation, selenium, temperature, total suspended solids (TSS)/ total dissolved solids (TDS) and zinc. Figure 6-3 and Figure 6-4 show the resulting percentage of 303d waters per analysis unit.

6.2.1.4 Alterations in Reservoir Operations

There was no information on alterations in reservoir operation and this key ecological attribute was identified as a data gap for the ecoregion.

6.2.2 Wildfire

The dataset used to analyze wildfire was the Fire SIMulation developed by the USFS and USGS. Figure 6-5 and 6-6 displays the burn probability for analysis units containing coldwater fish assemblages.

6.2.3 Physical Barriers (Surface Water Diversions)

There were three main data sources used for fish barriers for the coldwater fish assemblage. The U.S. Fish and Wildlife Service maintains an online dataset of fish barriers at their GeoFIN website http://ecos.fws.gov/geofin/. Their website contains detailed information on the location and type of barrier. Due to data sharing agreements, only the locations of the barriers (no details) were obtained for the ecoregion. The Yellowstone cutthroat trout and redband trout range-wide assessments included fish barriers that were used in conjunction with the U.S. Fish and Wildlife Service fish barriers. Some uncertainty was created by the analysis such as:

1. Since detailed information about the U.S. Fish and Wildlife Service fish barriers wasn't available some duplicate barriers may exist.
2. An analysis unit (HUC 12 or 4 km grid) may contain a barrier that isn't associated with a coldwater fish assemblage stream. When summing by the analysis unit, these would be included.

The amount of fish barriers within each analysis unit is displayed in Figure 6-7 and Figure 6-8. Nevada appears to have a concentration of fish barriers in some of the tributaries to the Owyhee and Bruneau Rivers while the rest of the ecoregion has much less density of barriers.

6.2.4 Aquatic Invasives

The main source for aquatic invasive species was the USFS aquatic invasive detections dataset. Figure 6-9 and 6-10 show the amount of detections with the analysis units (HUC 12 and 4 km grid). It appears the majority of the detections were located along the Snake River and some isolated occurrences outside that corridor. Two elements of uncertainty for aquatic invasives are:

1. All invasive detections were used. A more detailed analysis may exclude certain types of aquatic invasives that do not affect coldwater fish.
2. The USFS dataset shows locations where invasives were detected and is a presence only dataset. Locations with no detections may contain invasives but haven't been surveyed or reported.

6.2.5 Riparian Habitat Condition

The estimate of the riparian condition was based on how much development has occurred in the riparian corridor. The mapping of the riparian corridor is discussed in more detail in the Riparian CE package. Figure 6.2-11 shows the fraction of natural land cover (undeveloped) land in the riparian corridor by HUC 12 watershed.

6.2.6 Cumulative Indicator Score

Five of the metrics from the Perennial Streams CE (water quality, aquatic invasives, flow regulation, groundwater condition, and riparian condition) were combined with the two additional metrics described in this package, fish barriers and burn probability. The individual metrics were scored with a 1, 2 or 3 with 1 given to lowest quality indicator and 3 given to the highest quality indicator. The seven metrics were then added together to derive a range of cumulative scores from 7 to 21. Figure 6-12 shows the resulting high and low scoring areas by HUC12. The data for perennial rivers, such as flow regulation by dams, 303D impaired, and aquatic invasives are best analyzed at a watershed scale, since water quality impairment in a stream is a symptom of poor land management practices in the watershed. Therefore, the cumulative indicator score is presented by HUC 12 only.

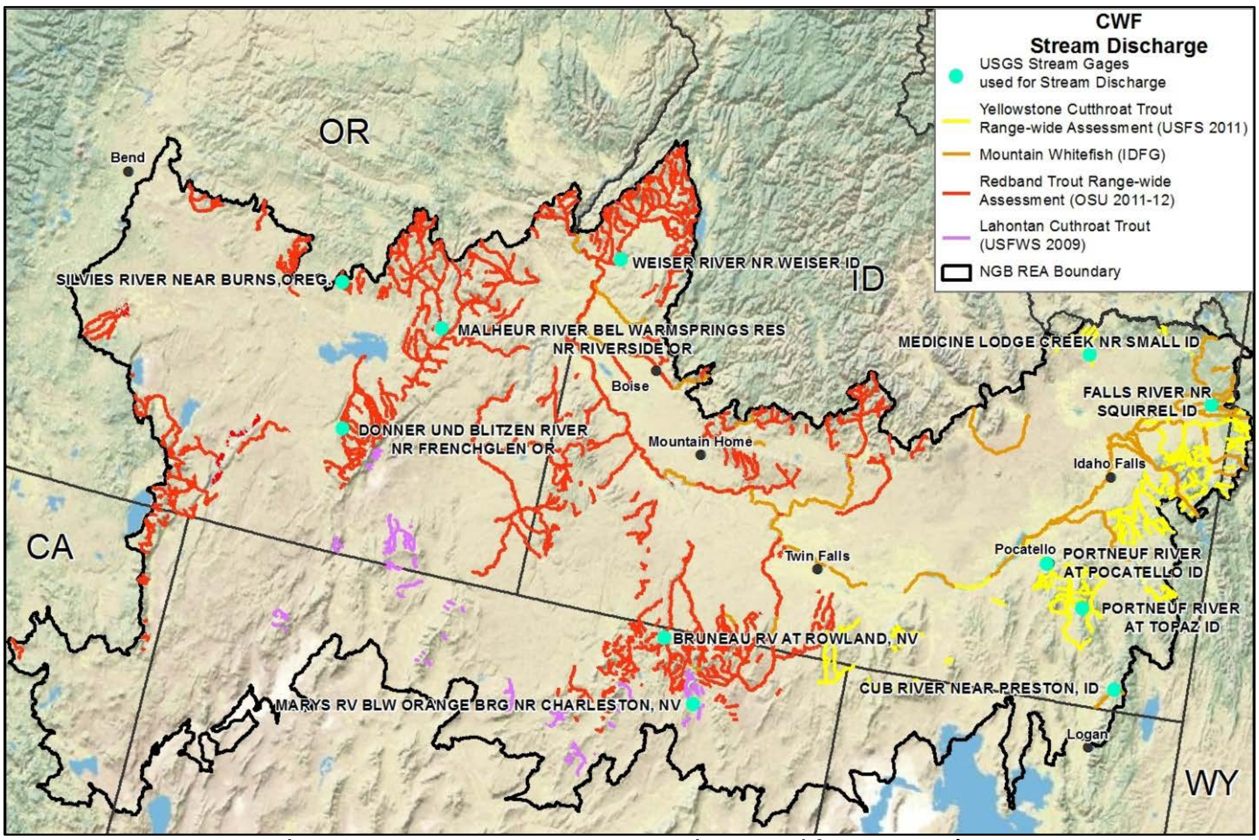


Figure 6-1. USGS Stream Gage Locations used for Stream Flow

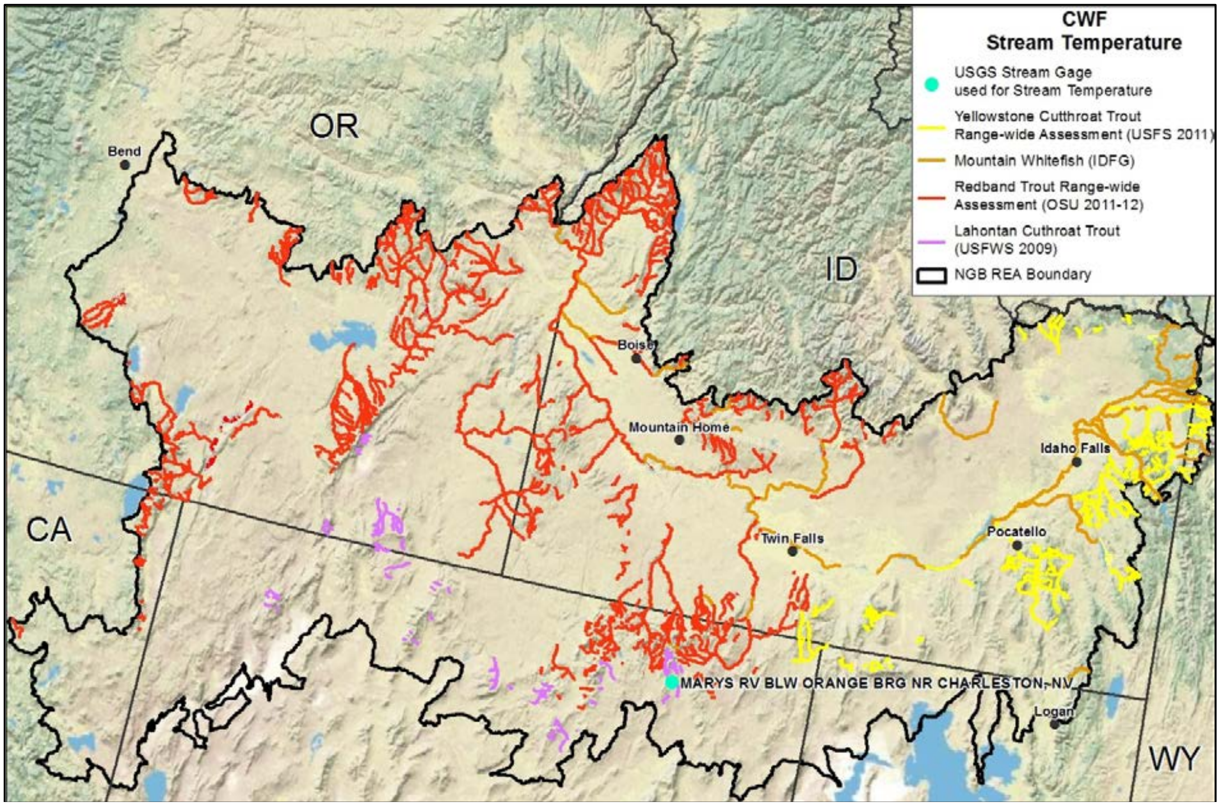


Figure 6-2. USGS Stream Gages used for Instream Temperature.

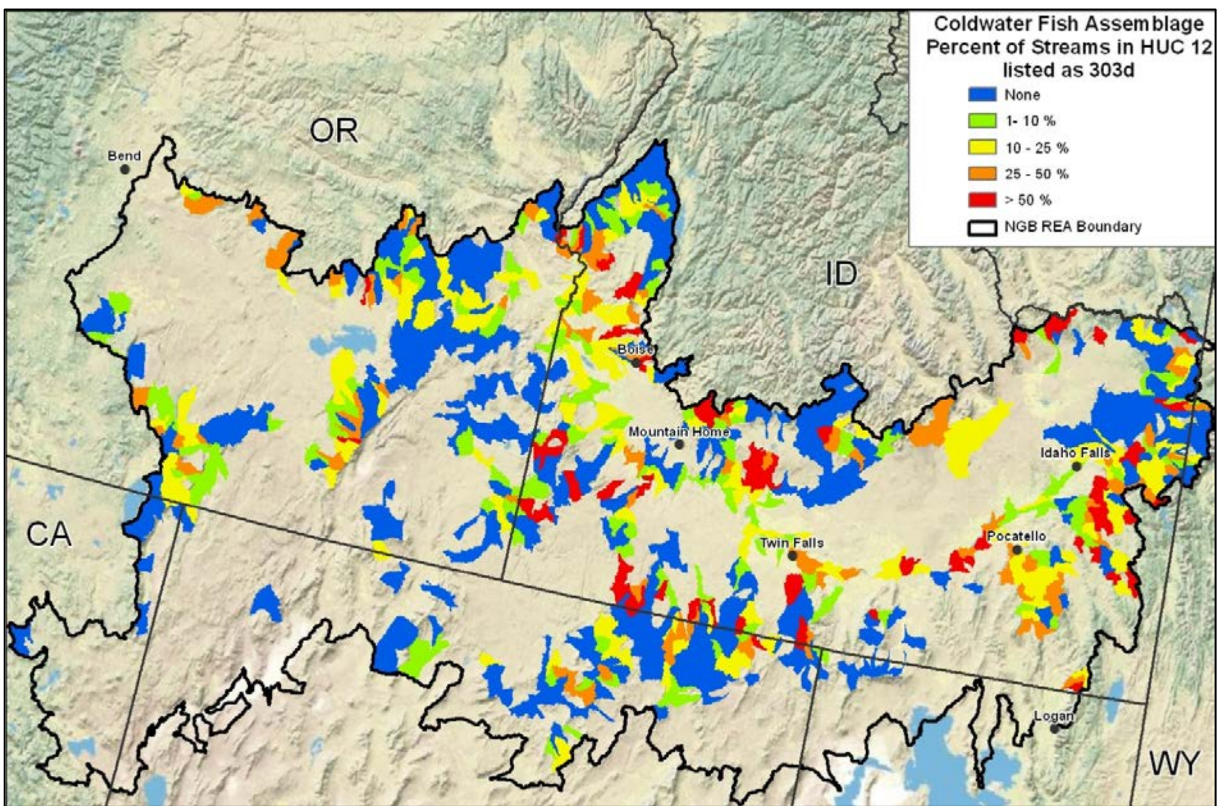


Figure 6-3.Percent of HUC12 with Waters Listed as 303(d)

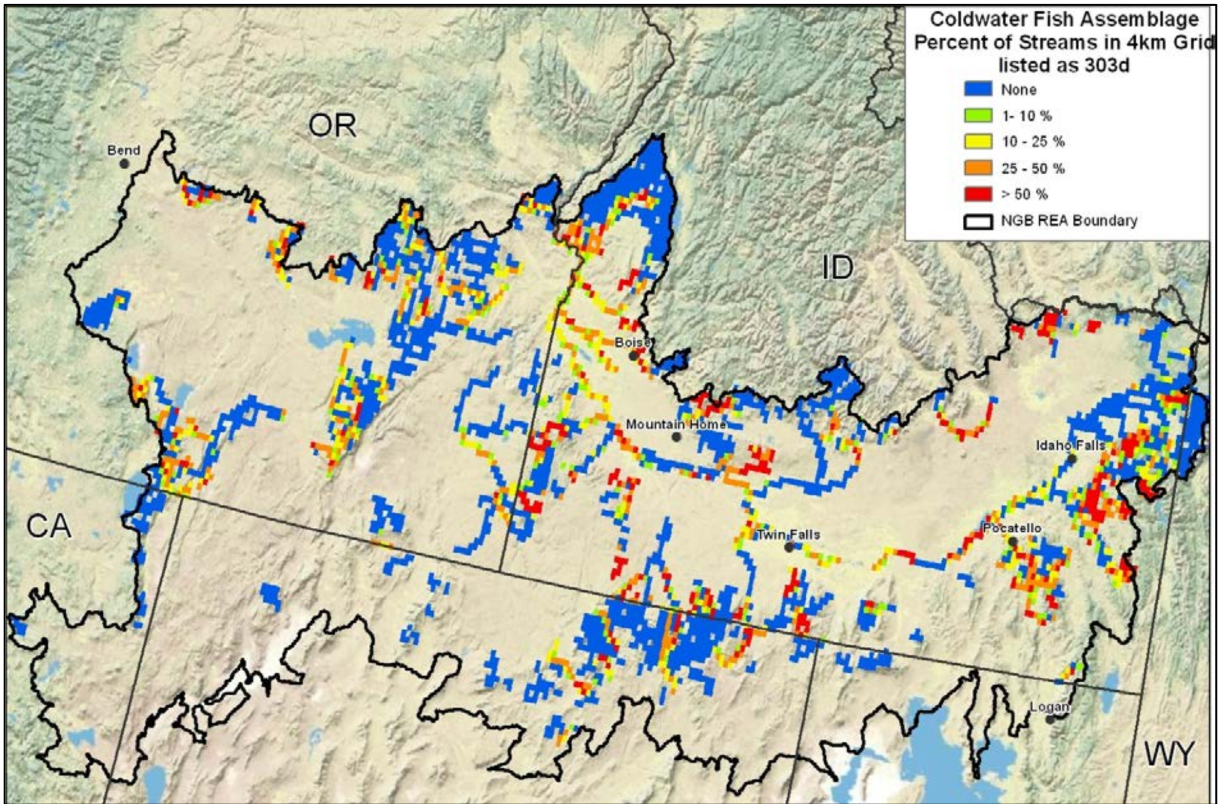


Figure 6-4 Percent of 4 km Grid with Waters Listed as 303(d)

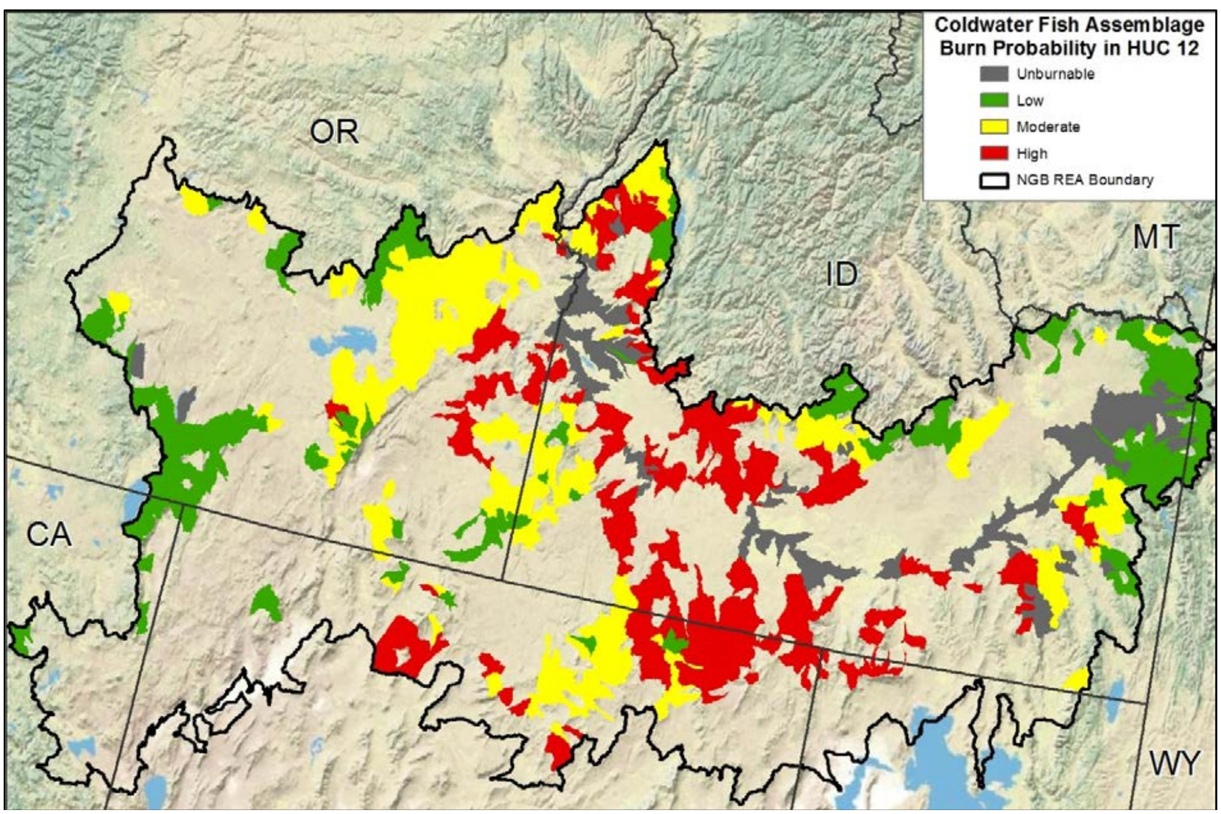


Figure 6-5 Burn Probability by HUC 12 for Coldwater Fish Assemblage

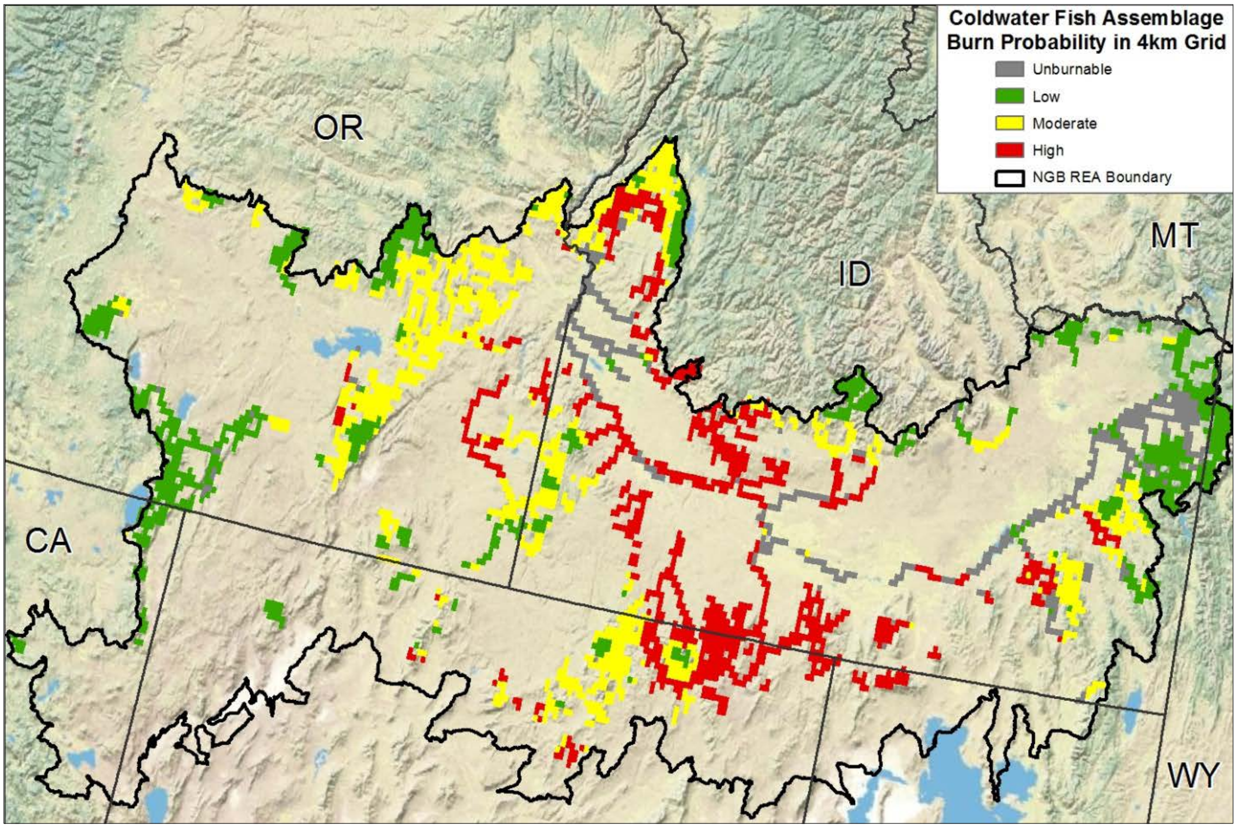


Figure 6-6 Burn Probability by 4 km Grid for Coldwater Fish Assemblage

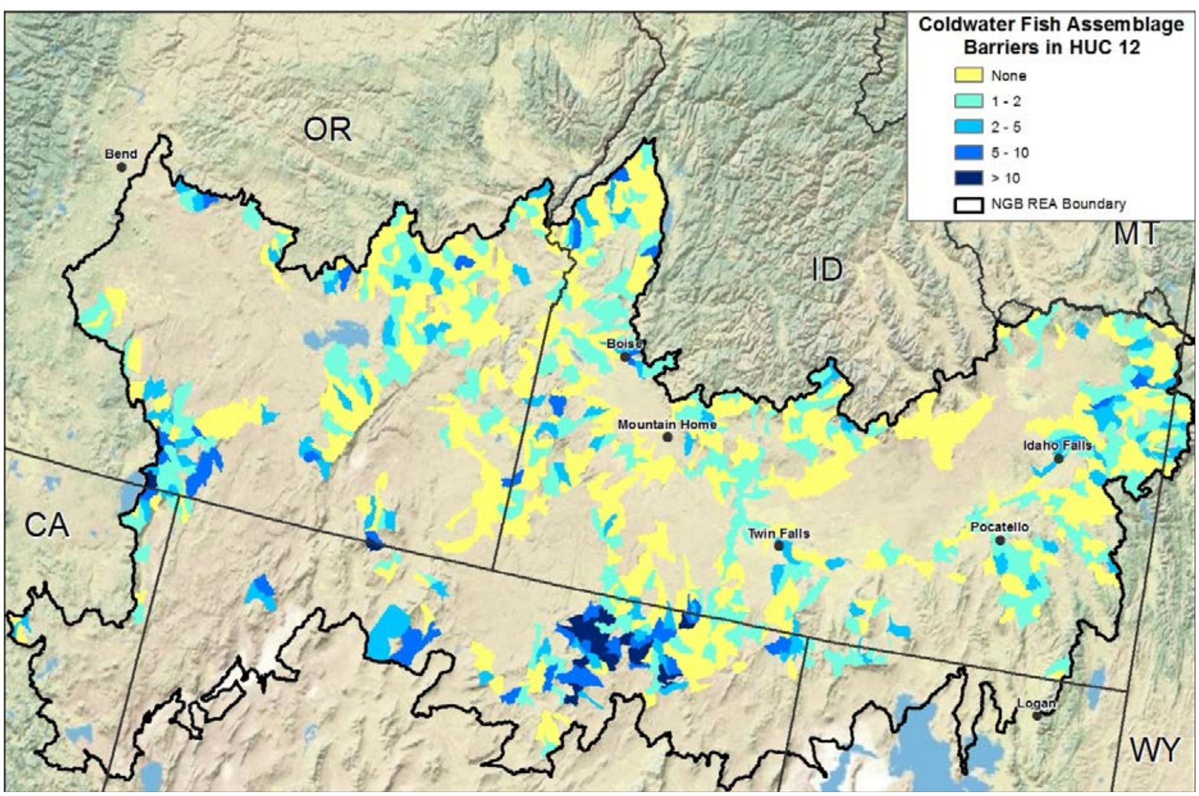


Figure 6-7 Fish Barriers by HUC 12 for Coldwater Fish Assemblage

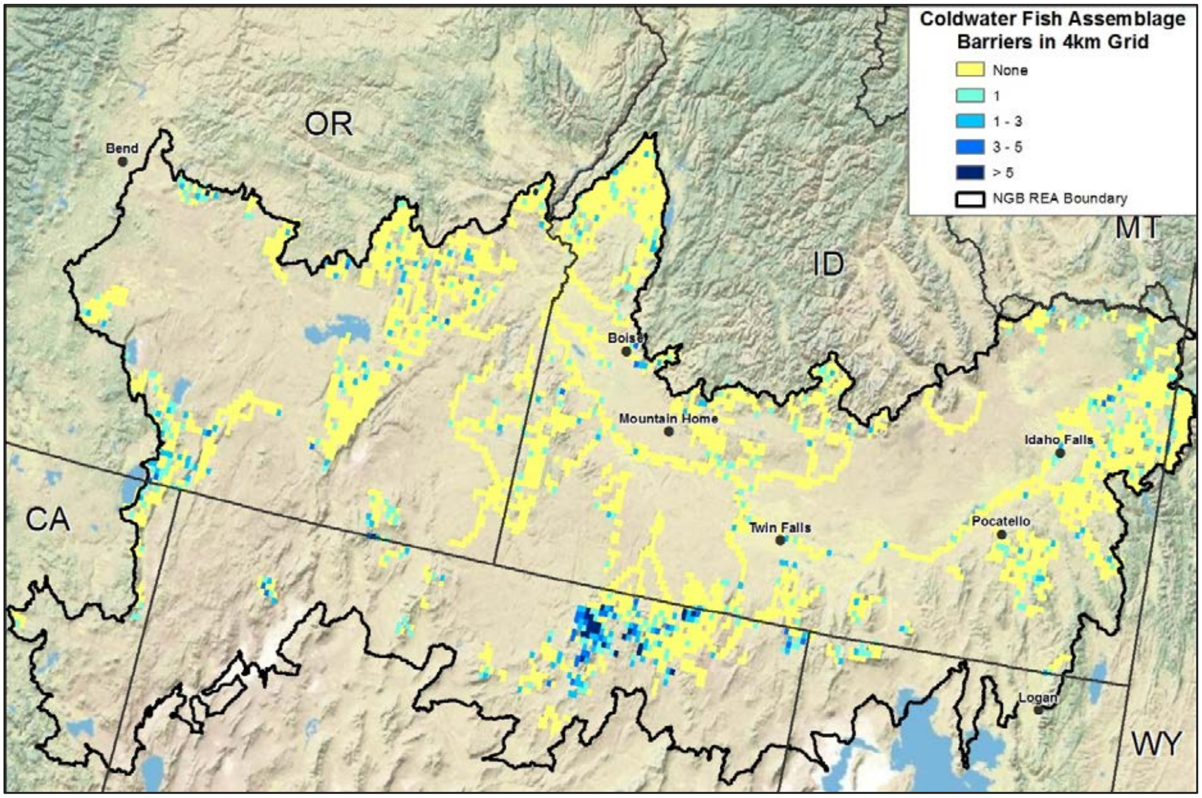


Figure 6-8 Fish Barriers by 4 km Grid for Coldwater Fish Assemblage

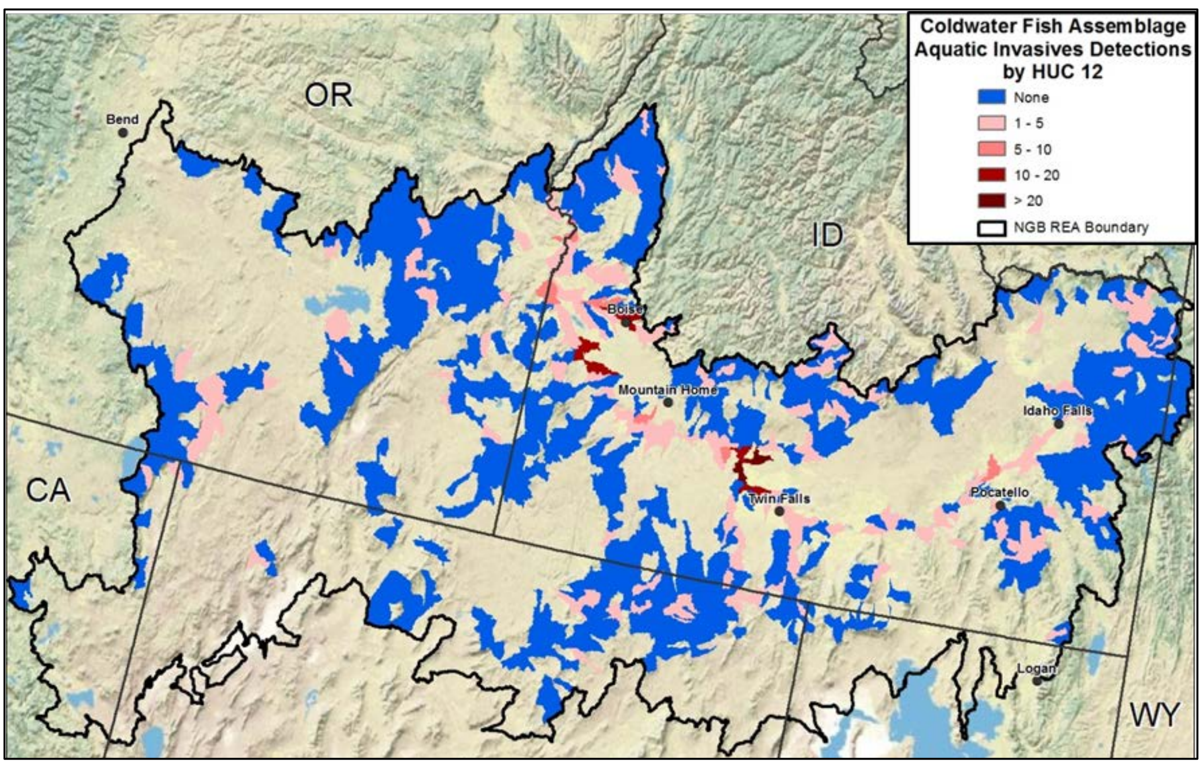


Figure 6-9 Aquatic Invasive Detections in HUC 12 for Coldwater Fish Assemblage.

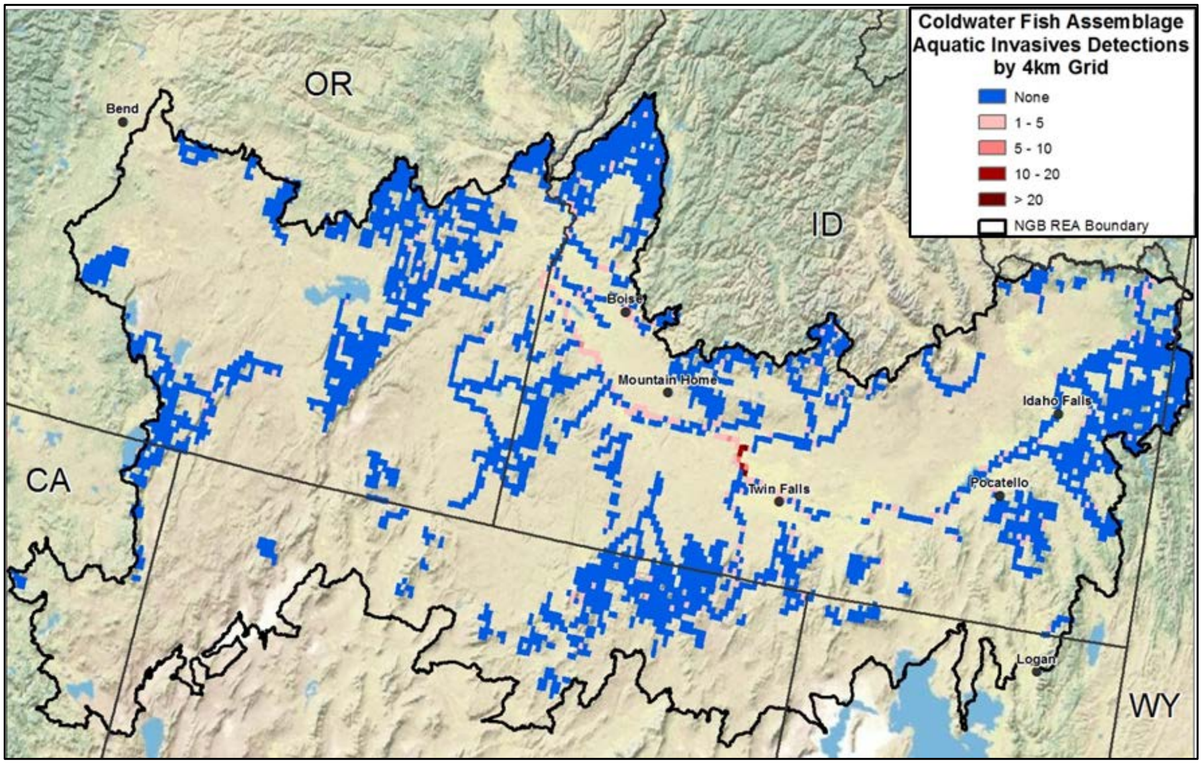


Figure 6-10 Aquatic Invasive Detections in 4 km Grid for Coldwater Fish Assemblage

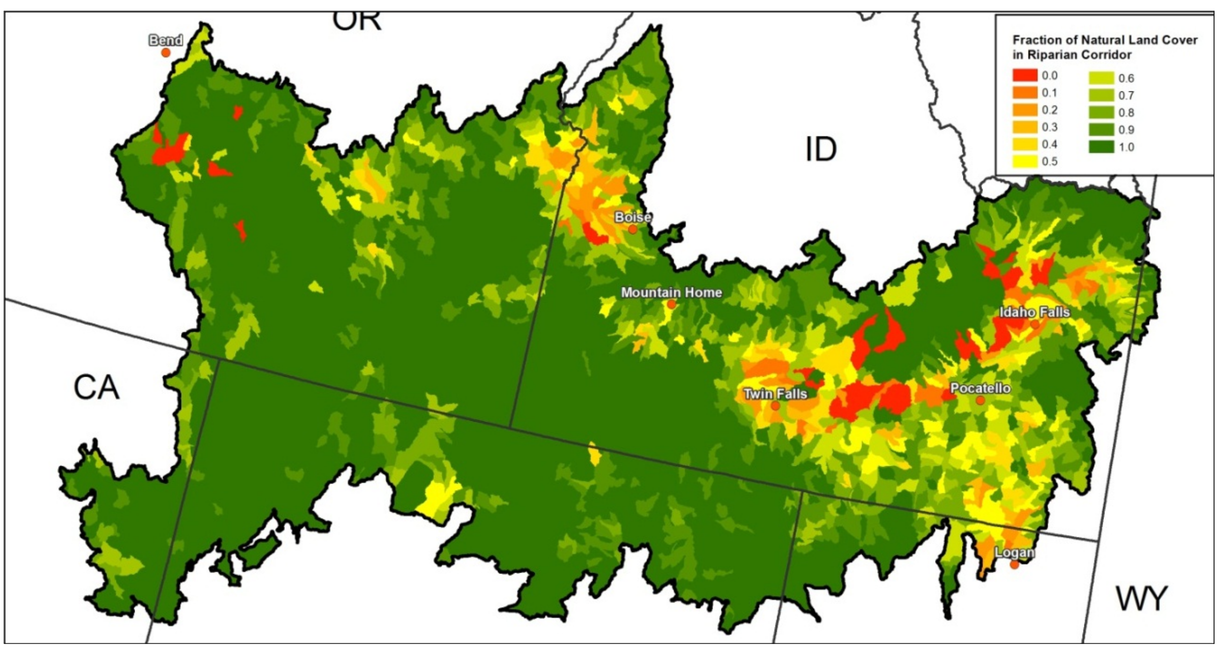


Figure 6-11. Fraction of Natural or Undeveloped Land Cover in the Riparian Corridor

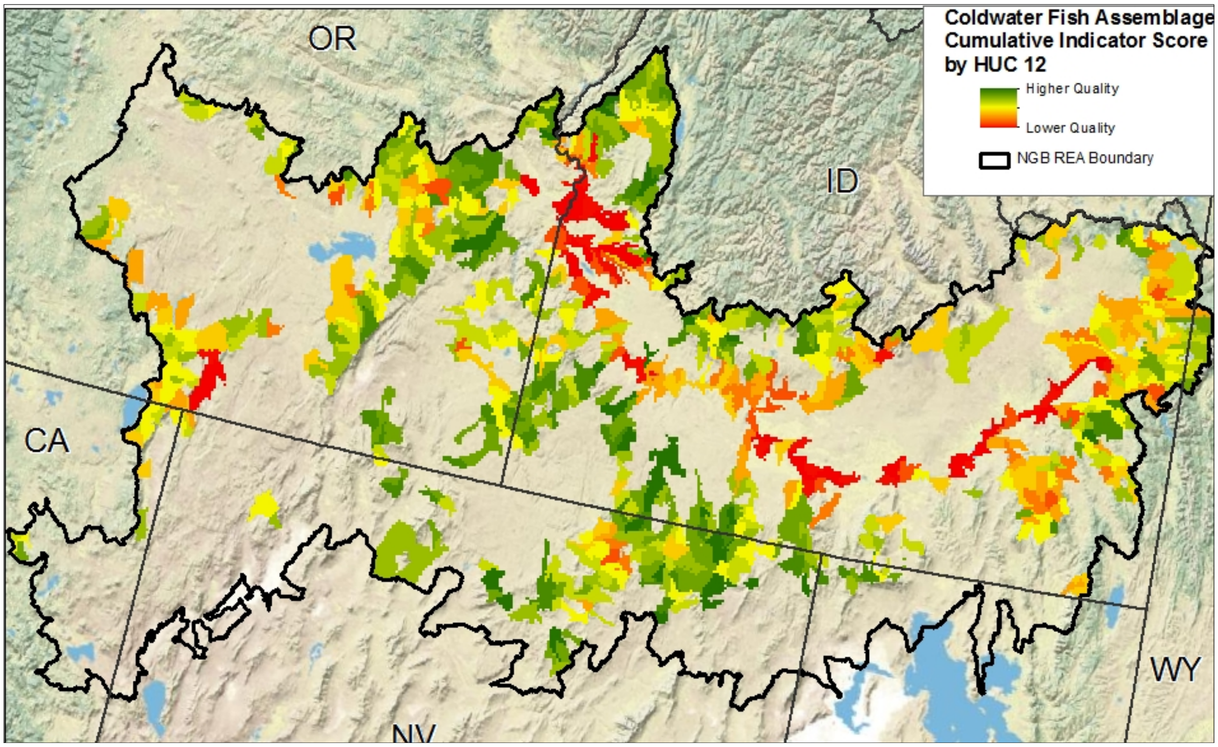


Figure 6-12. Coldwater Fish Cumulative Indicator Score

6.3 Future Threat Analysis

Many of the future threats described in the Perennial Streams and Rivers CE are applicable to coldwater fish.

6.3.1 Climate Change

6.3.1.1 Instream Temperature Change Modeling

Modeling instream water temperature based on air temperature was used by Haak *et al.* 2010 to determine future risk of climate change impacting salmonids. Their model uses PRISM climate data to determine the average July temperature for current range of the species and then increases the temperature 3 degrees Celsius to simulate a future climate change scenario. Using the elevated temperature it would then determine which areas would remain suitable (based on current range) and which areas could become marginal or unsuitable.

The PRISM dataset used was 1981-2010 which was released this summer, Haak had previously used the 1971-2000 PRISM dataset. The PRISM data represents a 30 year averaged data at an 800 m raster cell size resolution. July was chosen as the hottest month by Haak *et al.* 2010 and reviewing PRISM climate maps for June, July and August appears to also be the hottest month for the Northern Great Basin.

Since the coldwater fish assemblage is made up of four different species, these were modeled separately since individual species may have different thermal thresholds. Extracting the temperature for July using the ranges shown in Figure 4-1 resulted in the following mean air temperature, maximum air temperature and the mean air temperature plus one standard deviation (Table 6-2).

Table 6-2. Air Temperatures for July for Each Species within the Coldwater Fish Assemblage

Species	Mean Temp (°C)	Mean + 1 SD (°C)	Max Temp (°C)
Redband Trout	30	32.2	35.6
Mountain Whitefish	30.2	32.8	35.6
Lahontan Cutthroat trout	28.4	30.3	31.6
Yellowstone Cutthroat trout	27.4	29.0	32.3

The current (1981 – 2010) PRISM July air temperature was then raised three degrees (geospatial operation) to simulate a future climate change (Haak *et al.* 2010). The air temperature was then analyzed using the HUC 12 and 4 km analysis units. Table 6-3 shows the future air temperature ranges of what was determined suitable, marginal and unsuitable based on Haak *et al.* 2010 methodology.

Table 6-3. Modeled Future Temperature Suitability (Haak et al. 2010)

Modeled Future Temperature Range Determination as Listed Below	
Suitable	<= Mean July Air Temperature + 1 Standard Deviation
Marginal	Mean July Air Temp (+ 1SD) to Max July Air Temperature
Unsuitable	> Max July Air Temperature

Based on the air temperatures in Table 6-2 and the methodology of determining future suitability in Table 6-3, the resulting modeled suitability ranges are displayed in Table 6-4.

Table 6-4. Modeled Future Air Temperature Suitability

Species	Modeled Future Suitable Range (°C)	Modeled Future Marginal Range (°C)	Modeled Future Unsuitable Range (°C)
Redband Trout	<= 32.2	32.2 – 35.6	> 35.6
Mountain Whitefish	<= 32.8	32.8 – 35.6	> 35.6
LCT	<= 30.3	30.3 – 31.6	> 31.6
YCT	<= 29.0	29.0 – 32.3	> 32.3

Figures 6-13 to 6-20 display the resulting modeled future suitability of the current range for each species using the HUC 12 and 4 km grid analysis units. With a three degree temperature change, much of the currently occupied reaches in the Snake River system may become marginal or unsuitable for redband trout, mountain whitefish, and Yellowstone cutthroat trout. Scattered Lahontan cutthroat trout populations in Nevada and southeastern Oregon may experience shifts to marginal or unsuitable temperatures.

6.3.1.2 Winter Flood Risk

Winter flood risk due to climate change (increase of three degrees Celsius) was another aspect of climate change on salmonids that Haak *et al.* 2010 analyzed. The focus of this model is to determine the threat of change of winter precipitation type (e.g. snow to rain) not change in the amount of precipitation. Based on their methodology, the first step was to identify areas with low winter precipitation and remove those areas from analysis. This was done by using PRISM 1981-2010 thirty year average precipitation data for the months of November, December, January, February and March.

The climate data was extracted from the range of the combined coldwater fish assemblage and then binned into ten classes using Jenk's Natural Breaks option with ArcView. The value of the lowest class (of the ten) was determined by Haak *et al.* 2010 to have low enough precipitation to not warrant further analysis. The results of this analysis are displayed in Figure 6-21 and 6-22 for the HUC 12 and 4 km analysis units.

To determine winter flood risk, Haak *et al.* 2010 used the maximum mean air temperature for the months of January, February, and March. After excluding areas of low winter precipitation, the temperature was increased three degrees Celsius to simulate a future climate change scenario. Based on the current air temperature for January, February and March and the future climate scenario each analysis unit was analyzed to determine whether there is a change in the type of winter precipitation. Table 6-5 shows the temperatures used to classify analysis units into the three winter precipitation types.

Table 6-5. Type of Winter Precipitation

Type of Winter Precipitation	Mean Winter Temperature
Snow Dominant	< -1 degrees Celsius
Transitional Dominant	> -1 to < 1 degrees Celsius
Rain Dominant	> 1 degrees Celsius

Table 6-6 displays how Haak *et al.* 2010 displays the threats to flood risk based on the temperature change from current to a future climate change scenario.

Table 6-6. Flood Risk from Change in Type of Winter Precipitation

Type of Winter Precipitation	Winter Flood Risk
Snow to Transitional	High
Snow to Rain	High
Transitional to Rain	Moderate
Stays Snow	Low
Stays Transitional	Low
Stays Rain	Low
Low Winter Precipitation	Low

The results of the classification of the HUC 12 and 4km analysis units based on the change in the type of winter precipitation is displayed in Figures 6-23 and 6-24. Based on the analysis, most of the ecoregion will continue to be dominated by rain or be in a low winter precipitation area. The areas at risk are located primarily in the eastern portion of the ecoregion in Idaho and Wyoming (in the Greater Yellowstone Ecosystem). Using the 4 km grid analysis, there are some locations in Nevada and one 4 km grid in Utah that may be at risk.

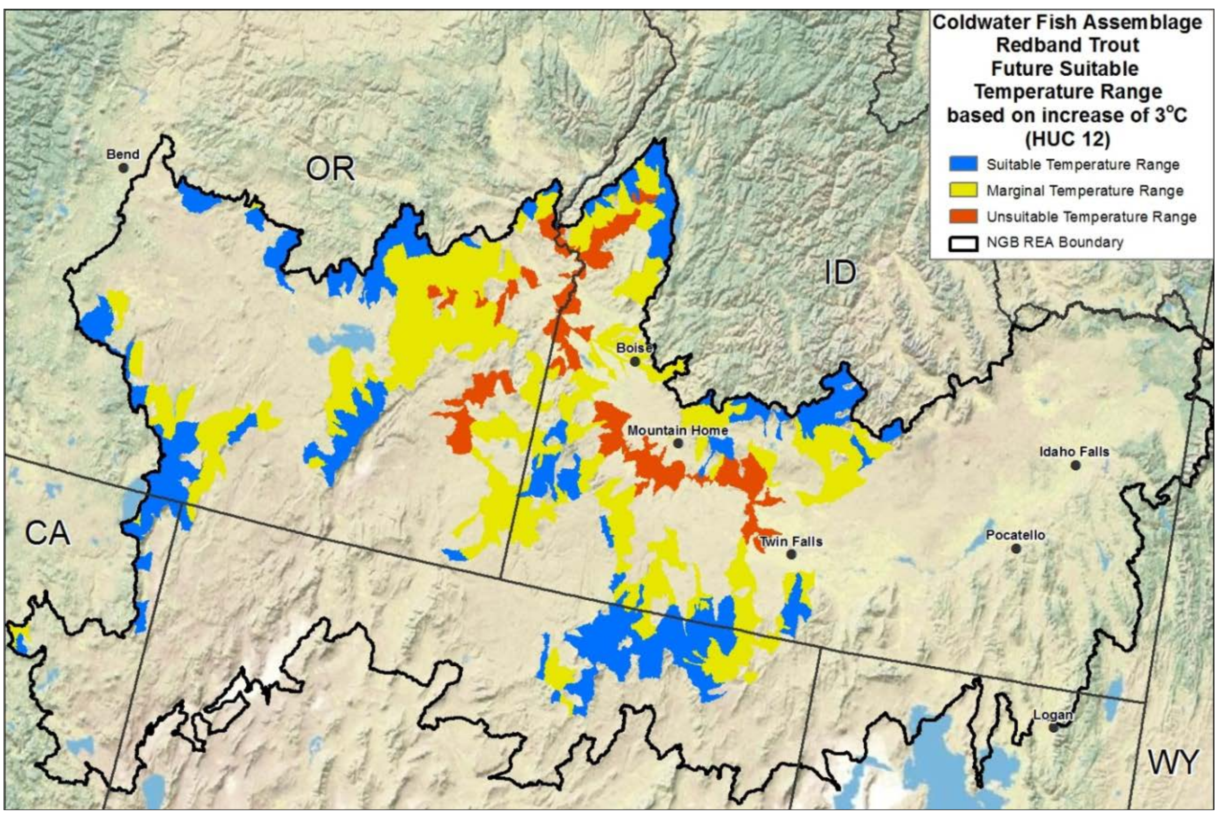


Figure 6-13. Redband trout Future Temperature Risk by HUC 12

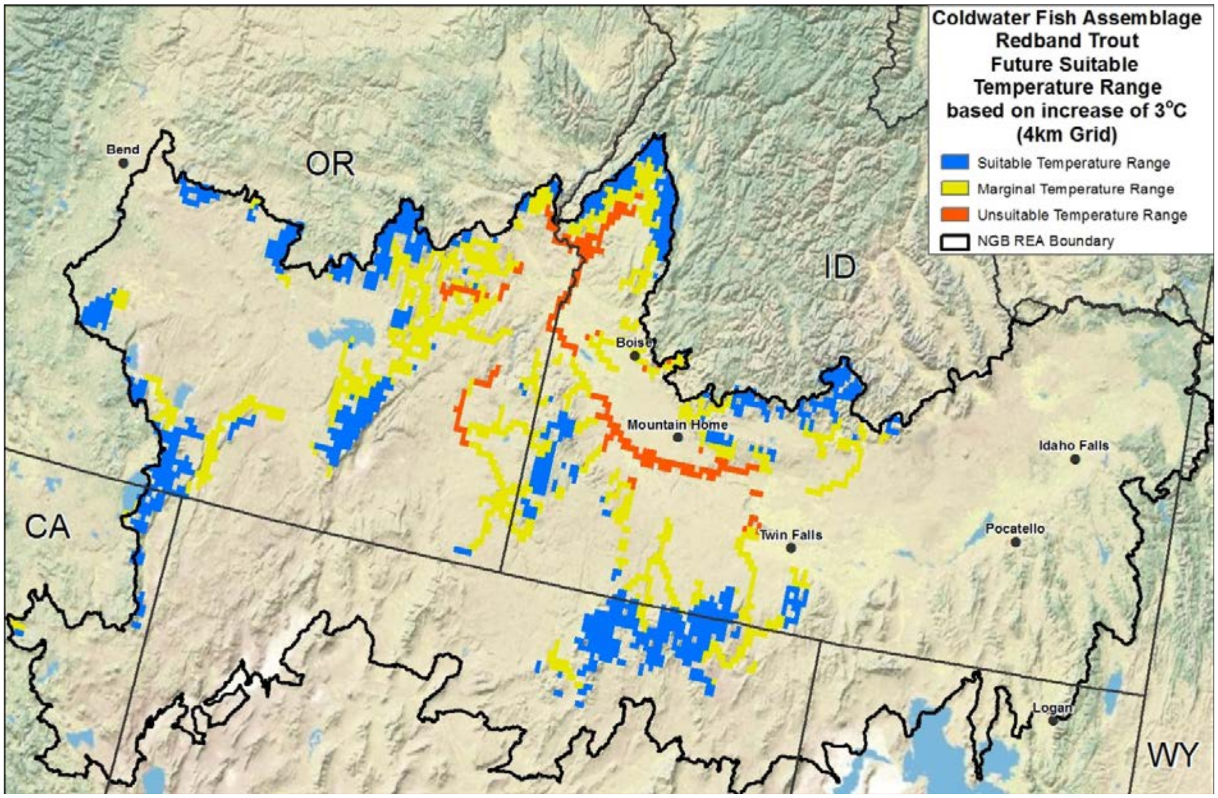


Figure 6-14. Redband Trout Future Temperature Risk by 4 km Grid

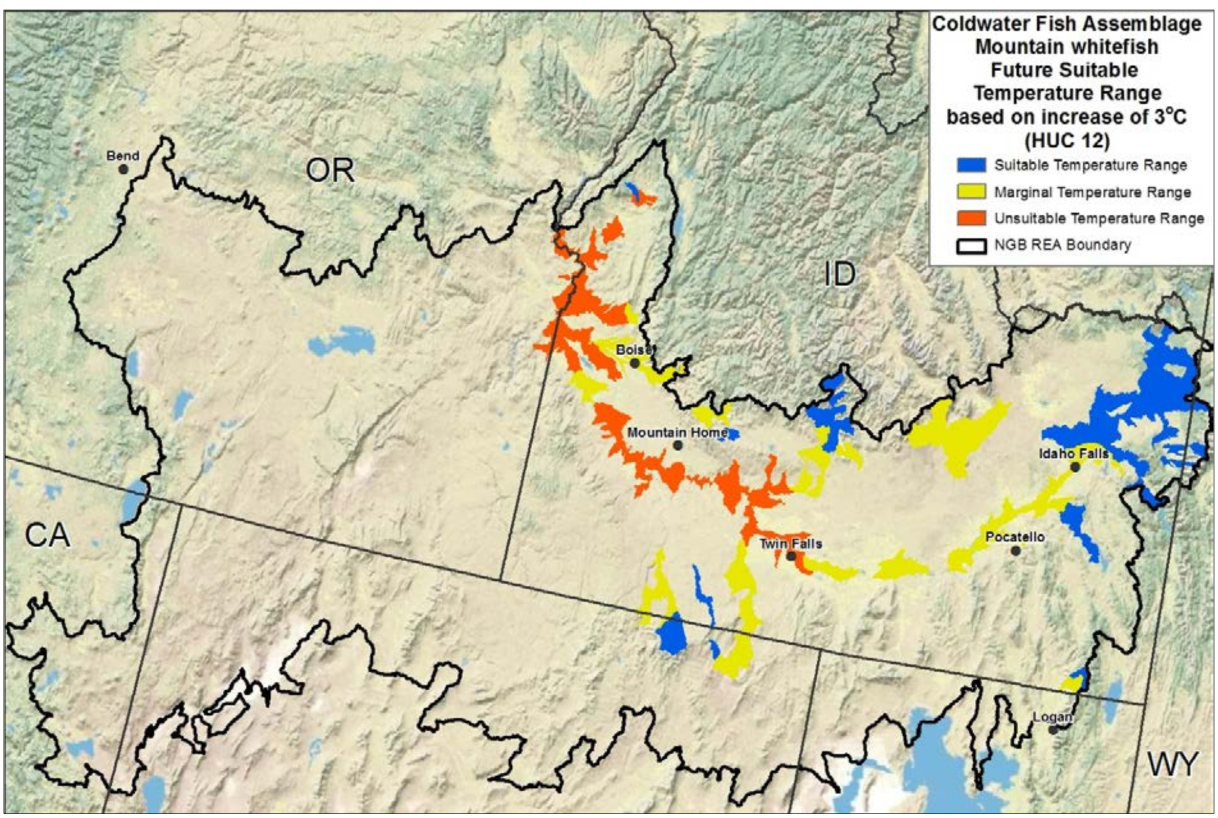


Figure 6-15. Mountain Whitefish Future Temperature Risk by HUC 12

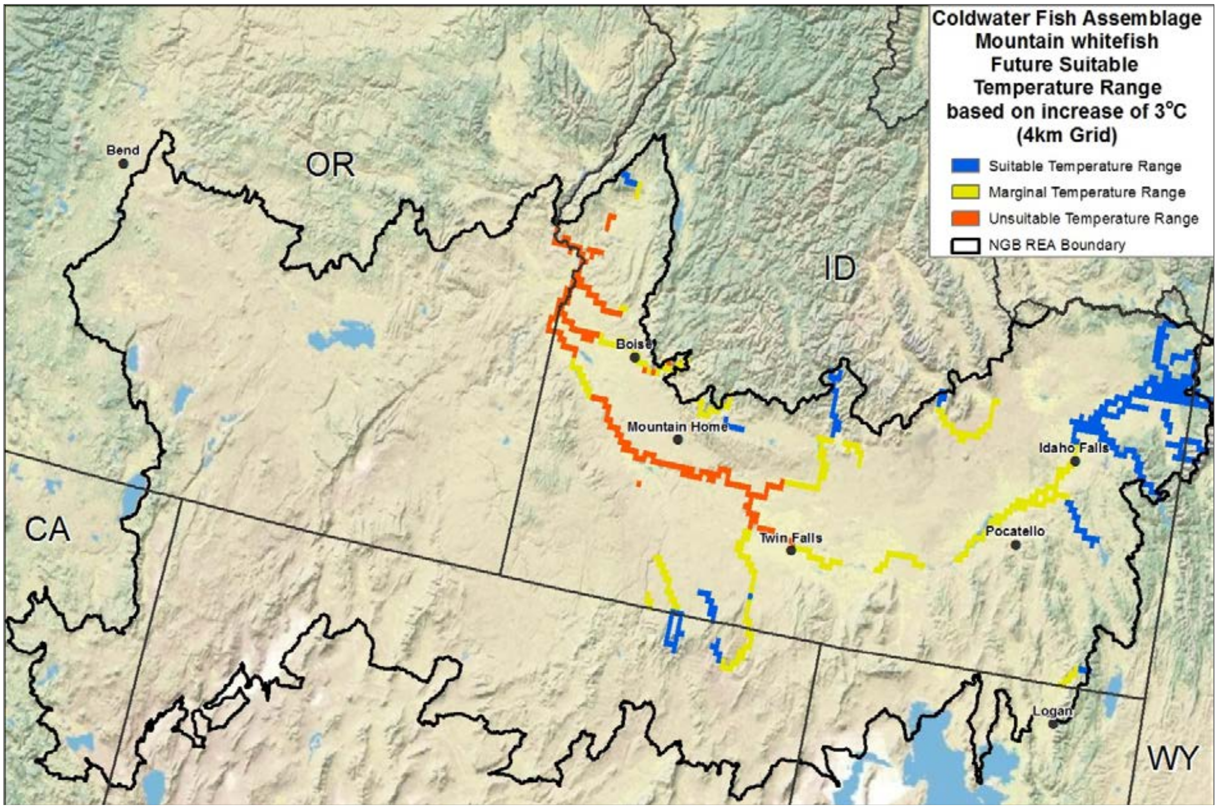


Figure 6-16. Mountain Whitefish Future Temperature Risk by 4 km Grid

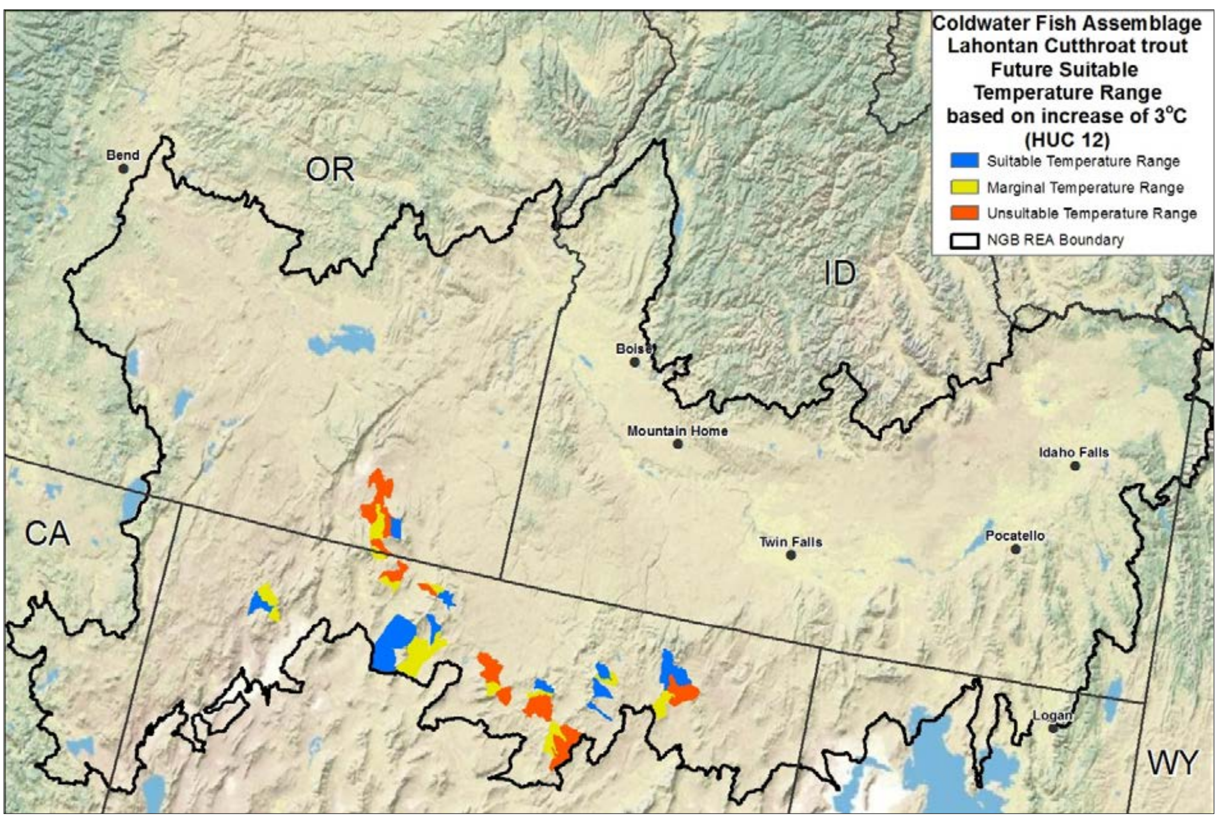


Figure 6-17. Lahontan Cutthroat Trout Future Temperature Risk by HUC 12

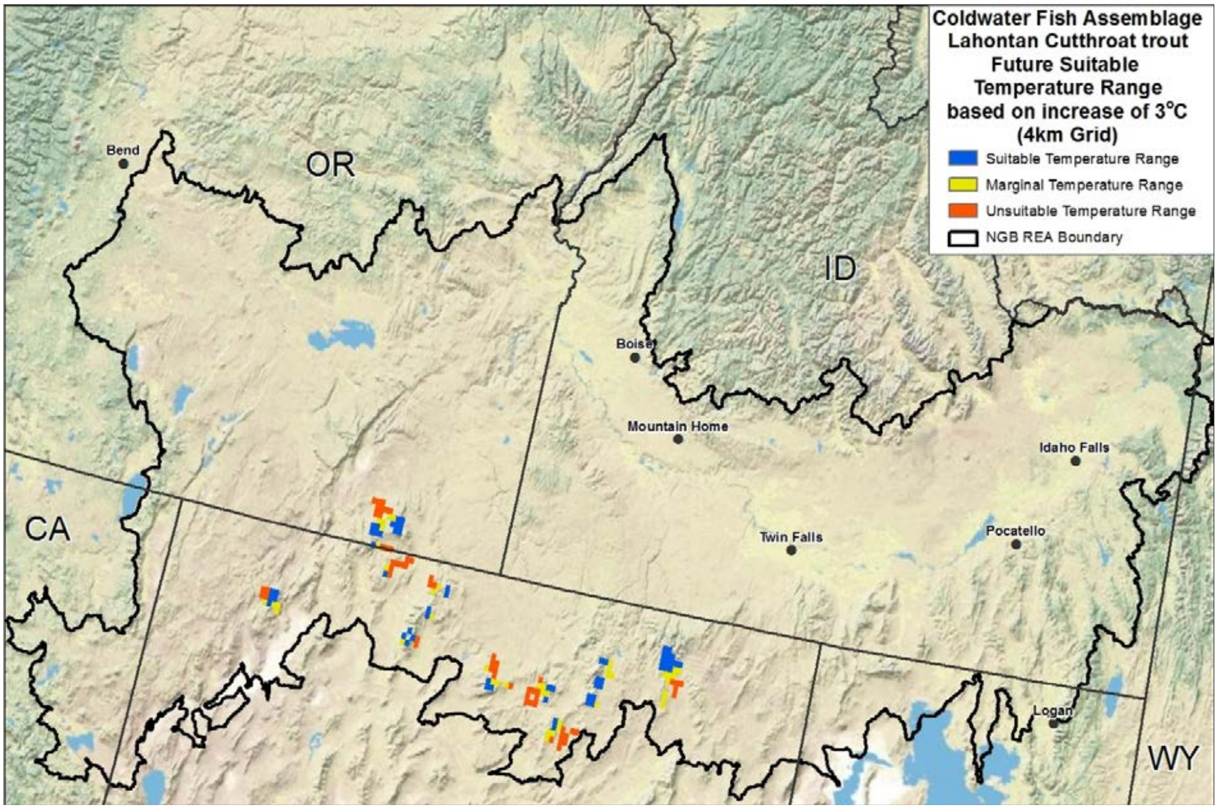


Figure 6-18. Lahontan Cutthroat Trout Future Temperature Risk by 4 km Grid

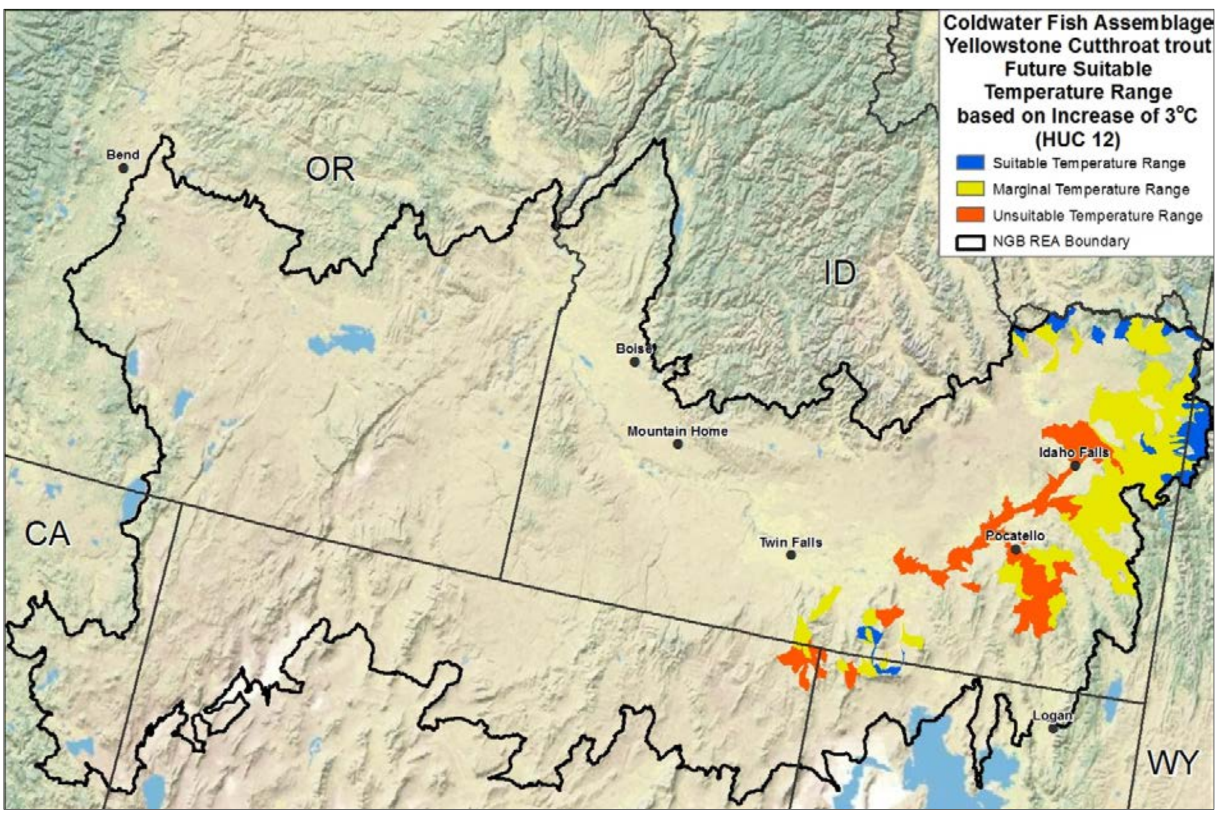


Figure 6-19. Yellowstone Cutthroat Trout Future Temperature Risk by HUC 12

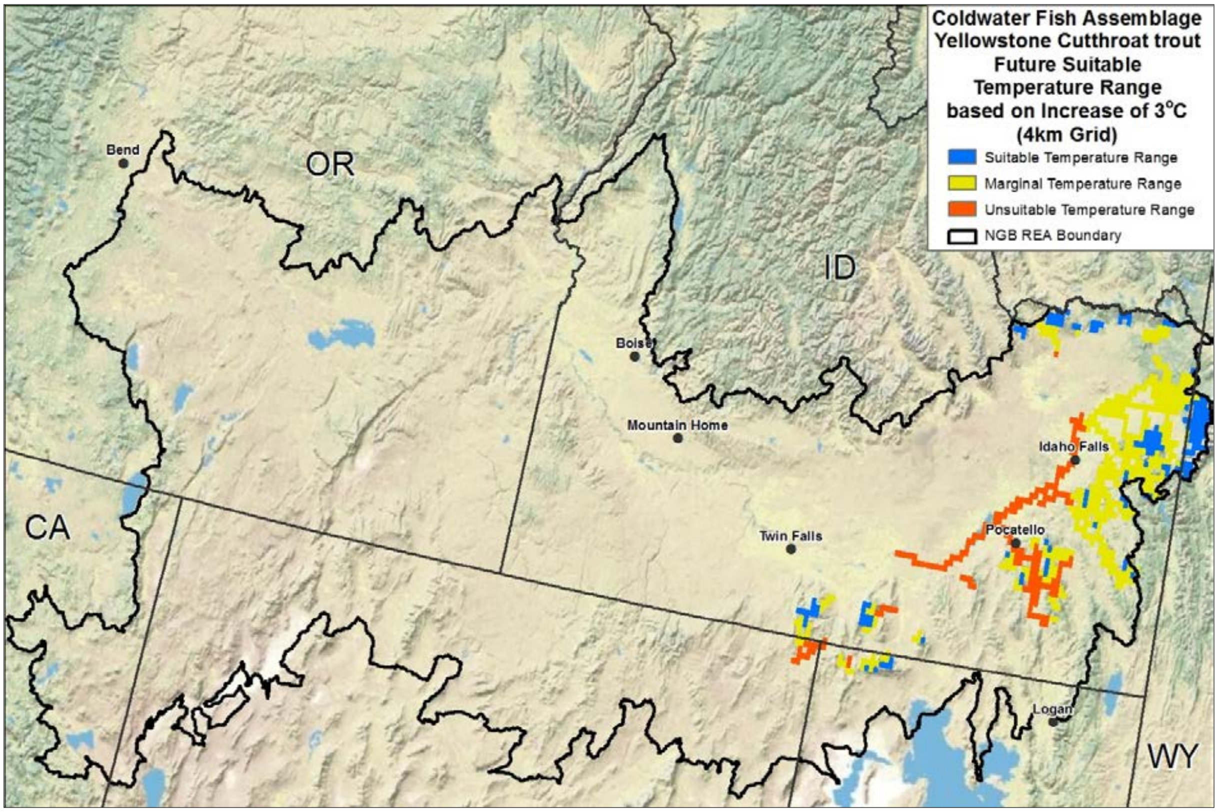


Figure 6-20. Yellowstone Cutthroat Trout Future Temperature Risk by 4 km Grid

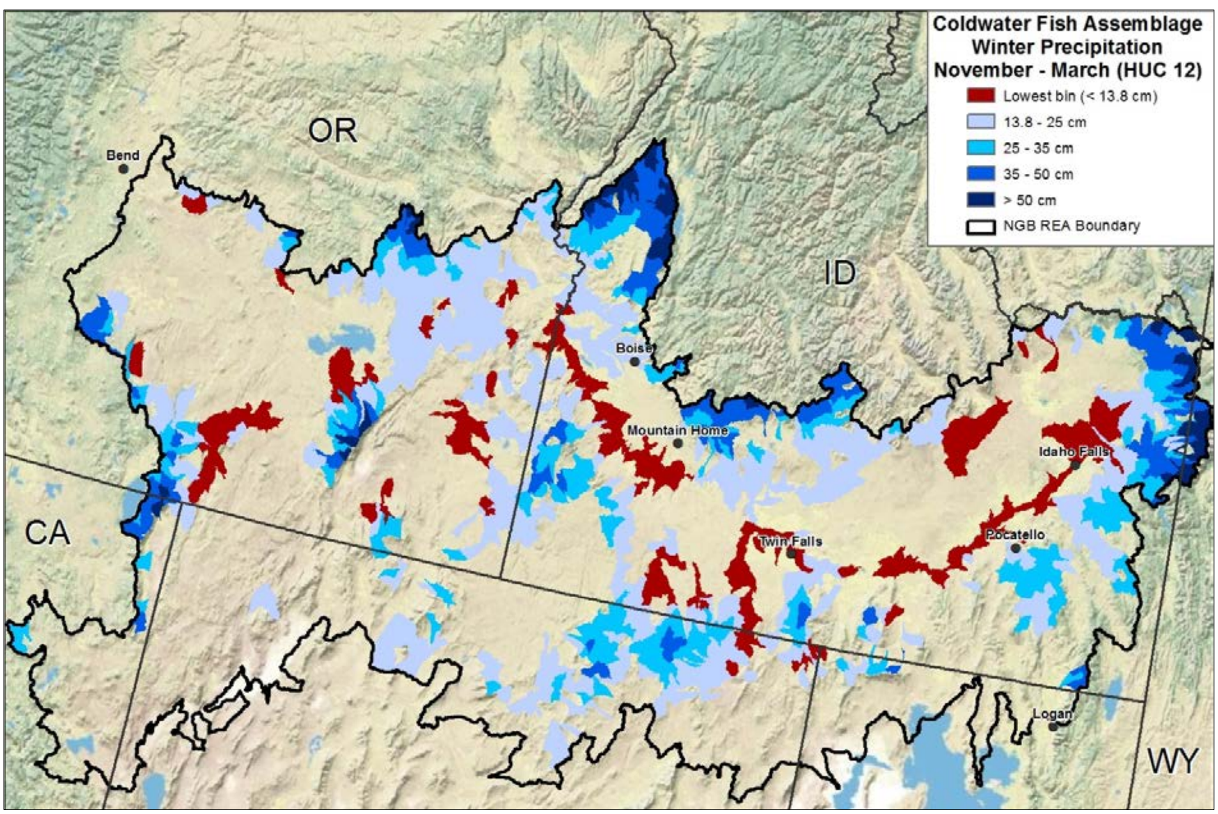


Figure 6-21. Winter Precipitation for Coldwater Fish Assemblage Range by HUC 12

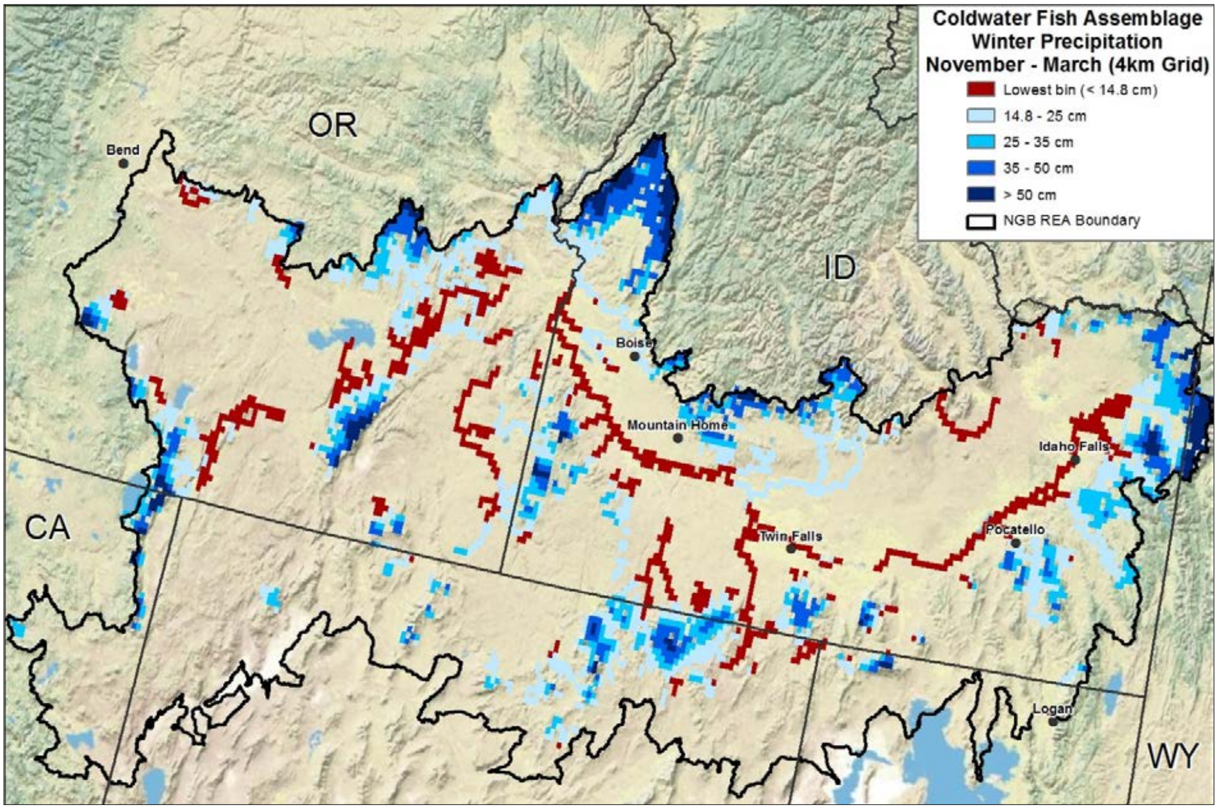


Figure 6-22. Winter Precipitation for Coldwater Fish Assemblage Range by 4 km Grid

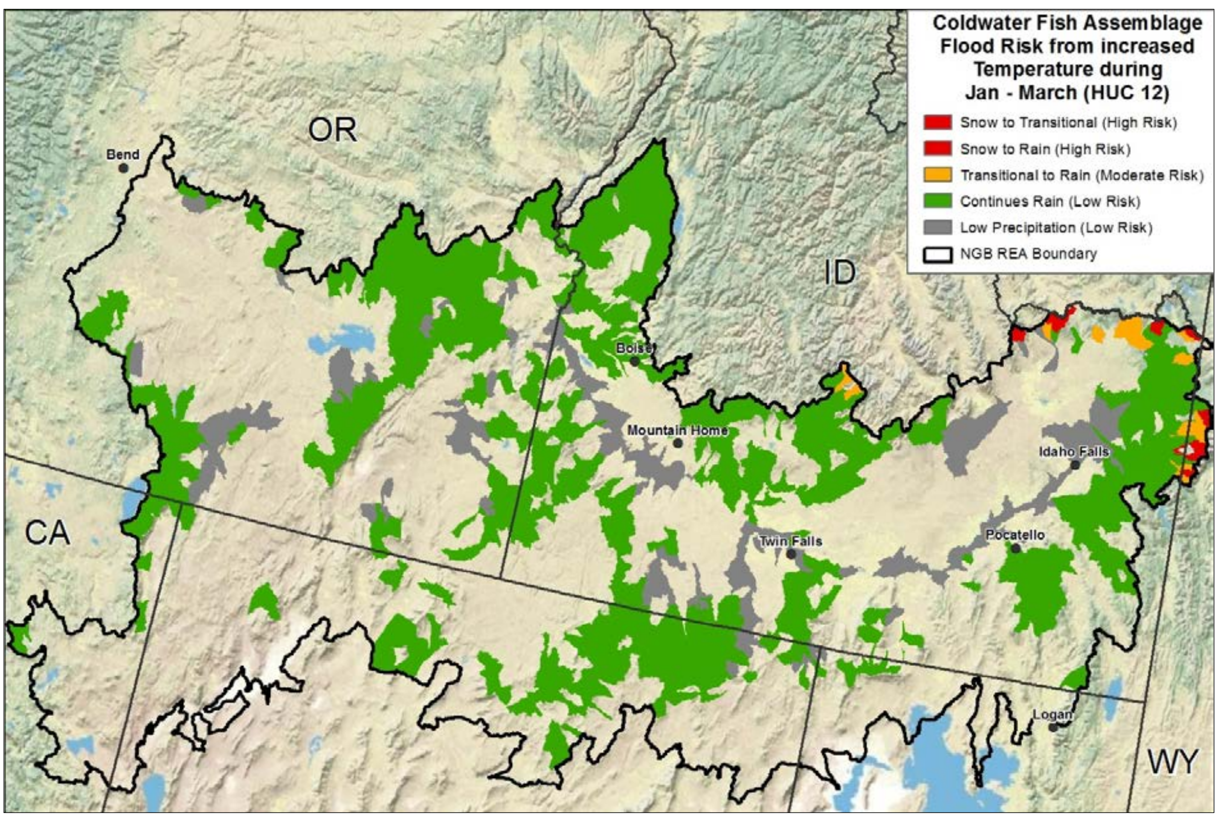


Figure 6-23. Winter Flood Risk for Coldwater Fish Assemblage Range by HUC 12

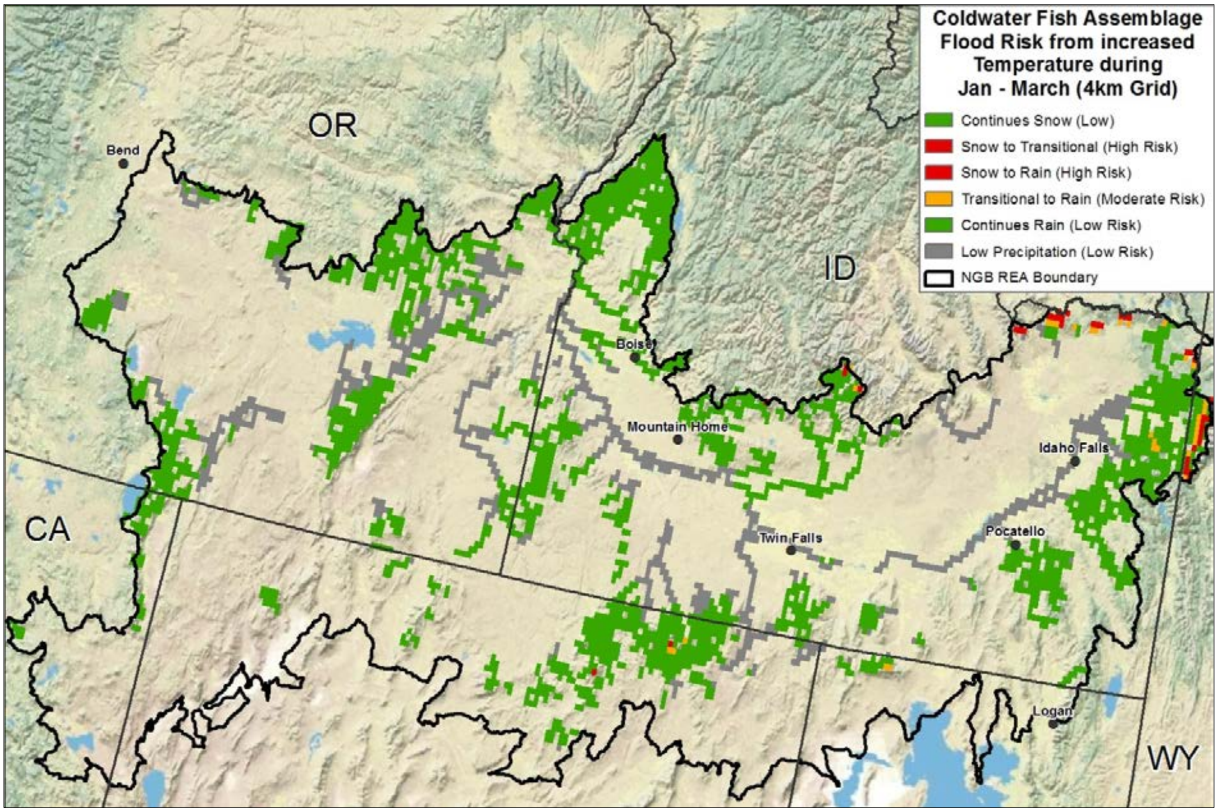


Figure 6-24. Winter Flood Risk for Coldwater Fish Assemblage Range by 4km Grid

6.3.2 Development

Agricultural development in the ecoregion has resulted in widespread construction of dams or diversion structures for surface water withdrawals that have reduced flow. Dams, improperly placed culverts, irrigation diversions, and other migration barriers have negatively affected individuals and habitat and likely have interfered with metapopulation dynamics. As a result, populations have become increasingly fragmented. Surface and groundwater extraction for urban and exurban populations, agricultural irrigation, and industrial development adversely affect native coldwater fish populations. Diversion of water for hydroelectric and agriculture uses has exacerbated persistent drought conditions, and requires mitigated flow management of the dams by the US Army Corps of Engineers (USACE). Degradation of riparian vegetation can negatively impacted fish habitat through reductions in large woody debris contribution, shade, available food resources with this vegetation (e.g., insects), and the protection of water and sediment quality during precipitation events.

Agriculture water use has been stable from 2000 to 2005, indicating that the future growth of agriculture may have reached limitations in prime agricultural land and water supply. The future threat from agricultural is the reduced dependence on surface water irrigation and an increase in groundwater withdrawals by 20 percent from 2000 to 2005. This will likely lead to a lowering of the water tables in some areas which could have an impact on the groundwater component of baseflow in perennial streams and rivers that support coldwater fish.

6.3.3 Wildfire

Forest fires accelerate sediment transport from mountain drainage basins. Transport processes range from sediment-charged floods to debris flows (Meyer *et al.* 2001). These erosion events following fires can have short-term, detrimental effects but long-term importance for land and stream form development

(Benda *et al.* 2003). Intense fire can result in the temporary loss of riparian vegetation, sedimentation, loss of shading and water temperature increases. However, low to moderate intensity fires release nutrients into the water and bring down timber into water bodies. These submerged trees provide important shelter for fish and other aquatic animals (Idaho Department of Fish and Game 2012).

Larger, more catastrophic fires can threaten entire fish populations in a watershed as well as the loss of riparian vegetation and alterations of channel morphology. In most aquatic systems, fish populations can recolonize quickly after a fire (Gresswell 1999). Native fish populations in the fire area that exist as isolated populations in fragmented habitats are at greater risk of localized extirpation. If the local populations are lost their former habitat cannot be recolonized naturally. Lack of connectivity among populations can lead to loss of entire populations of fish after a fire (Rinne 1996). Loss of any of these local populations may be devastating to recovery of the species as a whole due to the loss of unique genetic material.

6.3.4 Invasives and Disease

Introduced fish species such as channel catfish, smallmouth bass, and walleye likely influence population dynamics and distribution of the coldwater fish assemblage. The impact of hybridization of redband trout has become so problematic that it has necessitated monitoring of genetic purity within systems in which pure redband trout still occur.

Species of trout and salmon may become infected with the parasite responsible for whirling disease (*Myxobolus cerebralis*), an introduced disease agent that was first identified in the United States in 1956 and is now present in Idaho (Idaho Invasive Species Council Technical Committee 2007). The presence of the parasite does not always cause dramatic population losses, but can be a serious problem in hatcheries and has had severe impacts on some wild trout populations (Whirling Disease Initiative 2011). Infectious hematopoietic necrosis virus (IHN) and other pathogens affect salmonids, and other hosts, and require continued monitoring within hatchery systems. The significance of disease as a CA for native coldwater fishes is unknown at present.

6.3.5 Grazing

Grazing animals and pasture production can also negatively affect water quality through erosion due to trampling of soils, nutrients dropped by the animals, and introduction of pathogens into streams from livestock wastes (Hubbard 2004). Un-fenced riparian zones are often trampled by grazing activities (Sada and Vinyard 2002) adversely affecting shading and stream temperatures. High-density stocking, poor forage stands, and grazing in riparian zones can impact the water quality of streams and rivers that coldwater fish depend on.

7 Management Questions

Management questions for the NGB were developed by BLM managers and refined by the AMT to answer questions regarding the agency's land management responsibilities—including planning land use, developing best management practices, authorizing uses, and establishing conservation and restoration priorities. Several management questions relate to the coldwater fish CE:

1 What is the currently occupied habitat or modeled suitable habitat for this CE?

The coldwater fish assemblage currently occupied habitat is shown in Figure 4-1. Each species (mountain whitefish, Yellowstone cutthroat trout, Lahontan cutthroat trout, and redband trout) occupied habitat is shown individually in Figures 3-1 to 3-4.

2 Where are the areas of greatest and least collective impact of existing CAs on occupied habitat or modeled suitable habitats of this CE?

The coldwater fish cumulative indicator score is provided in Figure 6-12 by HUC 12 watershed. The highest scoring areas are along the Owyhee and Bruneau Rivers. Low-scoring areas are located near developed areas and include much of the Snake and Boise rivers.

3 What is the current distribution of suitable habitat, including seasonal habitat and movement corridors, for each landscape species and species assemblage CE?

The suitable habitat with barriers to movement are provided in Figures 6-7 and 6-8.

4 Where are existing CAs potentially affecting this current habitat and/or movement corridors, for landscape species and species assemblage CEs?

The coldwater fish cumulative indictor score is provided in Figure 6-12 by HUC 12 watershed. This shows where existing CAs are affecting the current habitat.

5 Where are current locations of this CE likely to overlap with the potential future distribution of CAs (other than climate change)?

Coldwater fish habitat overlaps areas with high burn probability in much of Idaho and northwestern Nevada (see Figures 6-5 and 6-6). Most growth in development is modeled to occur in existing population centers along the Snake River corridor where coldwater fish habitat is low scoring.

6 Given current and anticipated future locations of CAs, which habitat areas remain as opportunities for habitat enhancement/restoration for this CE?

The cumulative indicator scores for coldwater fish habitat under current conditions (Figure 6-12) should be useful in identifying the areas most in need of preservation (high quality but unprotected) or the best restoration opportunities (low scoring habitat areas. Coldwater fish downstream of reservoirs are highly dependent on reservoir releases to maintain proper flow and temperature. This ecoregional evaluation did not examine the specific flow regimes and how flows in different portion of the ecoregion could be improved to make rivers more suitable for coldwater fish. In addition, invasive fish species can be an important limiting factor in native fish restoration. Figures 6-9 and 6-10 provide the aquatic invasive detections, however, local managers should consider invasive species type and abundance in river reaches considered for reintroduction or habitat enhancement.

7 Where are potential areas to restore connectivity for this CE, based on current locations of CAs?

The fish barriers database (Figures 6-7 and 6-8) provides locations where barriers could be removed and connectivity could be restored for the coldwater fish assemblage. Local managers should consider barrier ownership, type, and removal feasibility when considering which rivers reaches are most suitable to restore connectivity.

68 Where will aquatic CEs experience significant deviations from historic climate variation that potentially could affect the hydrologic and temperature regimes of these aquatic CEs?

RegCM3 (Hostetler *et al.* 2011) climate modeling predicts a slight increase precipitation in the basins, valleys, and uplands, and large increases in precipitation in the mountains by 2060. Perennial river flow would be expected to slightly increase in the majority of the ecoregion.

Water temperature changes due to climate change could potentially make habitat unsuitable in the low elevation areas of the ecoregion. Based on the analysis of winter flooding risk, most of the ecoregion will mostly continue as rain-dominated or be in a low winter precipitation area. The areas at risk are located in the northwestern parts of the ecoregion in Idaho and Wyoming (Greater Yellowstone Ecosystem).

34 What is the condition (ecological integrity) of aquatic CEs?

See answer to management question #2.

40 Focusing on the distributions of terrestrial and aquatic CEs that are significantly affected by invasive species, which areas have restoration potential?

See answer to management question #6.

8 References

Abernethy, C.S, and J.E. Lund. 1978. Mycobacteriosis in mountain whitefish (*Prosopium williamsoni*) from the Yakima River, Washington. Journal of Wildlife Disease 14: 333-336.

Allen, D.B., B.J. Faltter, and K. Fite. 1996. Redband trout (Oncorhynchus mykiss gairdneri) population and habitat surveys in southern Owyhee County, Idaho. Prepared by the Idaho Dept. of Fish and Game for the Bureau of Land Management, Boise, ID office. February 1996. 48 pp.

American Fisheries Society. 2011. Website accessed March 1, 2011.

Bangs, B., S. Gunkel, and S. Jacobs. 2008. Distribution and abundance of redband trout Oncorhynchus mykiss in the Malheur River Basin, 2007. OR Dept. of Fish and Wildlife, Native Fish Investigations Project. June 2008. 15 pp.

Bayley, P.B. 2002. A review of studies on responses of salmon and trout to habitat change, with potential for application in the Pacific Northwest. Prepared by the Department of Fisheries and Wildlife, Oregon State University for the Washington State Independent Science Panel. May 2002. 38 pp. Behnke, R. J. 2002. Trout and salmon of North America. Free Press, New York. 359 pp.

Behnke, R.J. 1992. Native trout of Western North America. Am. Fish. Soc. Monog. 6.

Benda, L., Miller, D., Bigelow, P., and Andras, K. 2003. Effects of post-wildfire erosion on channel environments, Boise River, Idaho. Forest Ecology and Management 178 (2003) 105–119.

Bottom, D.L., P.J. Howell, and J.D. Rodgers. 1985. The effects of stream alterations on salmon and trout habitat in Oregon. Oregon Department of Fish and Wildlife, Portland.

Coffin, P.D. 1988. Nevada's native salmonid program:status, distribution, and management. Nevada Dept. of Wildlife. Reno, NV. 17pp.

Dunham, J., R. Schroeter, and B. Rieman. 2003. Influence of maximum water temperature on occurrence of Lahontan cutthroat trout within streams. North American Fisheries Management 23: 1042-1049.

Dunham, J.B., M.K. Young, R.E. Greswell, and B.E. Rieman. 2003. Effects of fire on fish populations: landscape perspectives on persistence of native fishes and nonnative fishes invasions. *Forest Ecology and Management* 178(2003): 183-196.

Everest, F.H., R.L. Beschta, J.S. Scrivener, K.V. Koski, J.R. Sedell, and C.J. Cederholm. 1987. Fine sediment and salmonid production: a paradox. In E.O. Salo and T.W., Cundy, eds. Streamside management: forestry and fishery interactions. Institute of Forest Resources, University of Washington, Seattle. Contribution 57.

Farag, M., D. F. Woodward, W. Brumbaugh, J. N. Goldstein, E. MacConnell, C. Hogstrand, and F. T. Barrows. 1999. Dietary Effects of Metals-Contaminated Invertebrates from the Coeur d'Alene River, Idaho, on Cutthroat Trout. *Transactions of the American Fisheries Society* 128(4): 578-592.

Gerstung, E.R. 1986. Draft fishery management plan for Lahontan cutthroat trout (Salmo clarki henshawi) in California and western Nevada waters. California Dept. of Fish and Game. Inland Fisheries Admin. Rept. No. 86. Fed Aid Proj. No. F33-R-11. 53pp.

Gresswell, R.E. 1995. Yellowstone cutthroat trout. RM_GTR 256., pp. 36-54. Accessed online at http://www.fs.fed.us/rm/pubs_rm/rm_gtr256/rm_gtr256_036_054.pdf

Gresswell, R.E. 1999. Fire and aquatic ecosystems in forested biomes of North America. Transactions of the American Fisheries Society 128: 193-221.

Gresswell, R.E. 2011. Biology, status, and management of the Yellowstone cutthroat trout. North American Journal of fisheries Management 31:782-812.

Haak, A.L., Williams, J.E., Isaak, D., Todd, A., Muhlfeld, C., Kershner, J.L., Gresswell, R., Hostetler, S., and Neville, H.M. 2010. The potential influence of changing climate on the persistence of salmonids of the inland west: U.S. Geological Survey Open-File Report 2010–1236, 74 pp.

Hanson, M.L., R.C. Buckman, and W.E. Hosford. 1990. Malheur River Basin fish management plan. Oregon Department of Fish and Wildlife, Portland, OR.

Hubbard, R.K., Newton, G.L., and Hill, G.M. 2004. Water Quality and the Grazing Animal. USDA-ARS.

Idaho Fish and Game Department. 2012. Wildfire: Nature's Wildlife Habitat Renewal. Idaho Fish and Game News October 2012.

Idaho Invasive Species Council Technical Committee. 2007. Idaho Aquatic Nuisance Species Plan, A Supplement to Idaho's Strategic Action Plan for Invasive Species. 145 pp.

LaRivers, I. 1962. Fishes and fisheries of Nevada. Nevada State Fish and Game Commission, Reno, Nevada. 782 pp.

Lea, T.N. 1968. Ecology of Lahontan cutthroat trout, Salmo clarkii henshawi, in Independence Lake, California. M.S. Thesis. University of California, Berkeley, California. 95 pp. [In U.S. Fish and Wildlife Service. 1995 Lahontan cutthroat trout (Oncorhynchus clarkii henshawi) recovery plan. Portland, Oregon.]

Li, H.W., G.A. Lamberti, T.N. Pearsons, C.K. Tait, J.L. Li, and J.C. Buckhouse. 1994. Cumulative effects of riparian disturbances along High Desert trout streams of the John Day Basin, Oregon. Transactions of the American Fisheries Society 123:627–640.

Malheur Watershed Council and Burns Paiute Tribe. 2004. Malheur River Subbasin Assessment and Management Plan for Fish and Wildlife Mitigation Management Plan. May 2004. 121 pp. http://www.nwcouncil.org/fw/subbasinplanning/malheur/plan/MgmtPlan.pdf

May, B.E., J. Writer, and S. Albeke. 2012. Redband Trout Status Update Summary. Wild Trout Enterprises, LLC, Bozeman, Montana. 36 pages.

McAfee, W.R. 1966. Lahontan cutthroat trout. In A. Calhoun, editor. Inland fisheries management. California Department of Fish and Game, Sacramento, California. pp. 225-231. [In U.S. Fish and Wildlife Service. 1995 Lahontan cutthroat trout (Oncorhynchus clarkii henshawi) recovery plan. Portland, Oregon.]

McIntyre, J.D. and B.E. Rieman. 1995. Westslope Cutthroat Trout IN Conservation Assessment for Inland Cutthroat Trout. General Technical Report RM-256. US Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. M.K. Young, tech. ed. Pages 1-15.

Meehan, W.R., and T.C. Bjornn. 1991. Salmonid distributions and life histories. American Fisheries Society Special Publication 19:47-82.

Meyer, G. A., Pierce, J. L., Wood,S. H. and Jull, A. J. T. 2001. Fire, storms, and erosional events in the Idaho batholith. Hydrol. Process. 15, 3025–3038 (2001).

Meyer, K.A., F.S. Elle, and J.A. Lamansky, Jr. 2009. Environmental factors related to the distribution, abundance, and life history characteristics of mountain whitefish in Idaho. North American Journal of Fisheries Management 29:753-767.

Moyle, PB. 2002. 2002. Inland fishes of California. University of California Press, Berkeley, CA. 502 pp.

Rinne, J. N. 1996. Short-term effects of wildfire on fishes and aquatic macroinvertebrates in the southwestern United States. North American Journal of Fisheries management 16:653-658.

Schisler, G.J. 2010. Effects of whirling disease (Myxobolus cerebralis) exposure on juvenile mountain whitefish (Prosopium williamsoni). Prepared for the Colorado Division of Wildlife, Fort Collins, CO. September, 2010. 33 pp.

Schlosser, I.J. 1982. Trophic structure, reproductive success, and growth rate of fishes in a natural and modified headwater stream. Canadian Journal of Fisheries and Aquatic Sciences 39: 968–978.

Sevon, M., J. French, J. Curran, and R. Phenix. 1999. Lahontan cutthroat trout species management plan for the Quinn River/Black Rock Basins and North Fork Little Humboldt River Sub-basin. Nevada Division of Wildlife, Reno, Nevada. 65 pp.

Sigler, W.F. 1951. The life history and management of *Prosopium williamsoni* in the Logan River, Utah. State Agricultural College, Bulletin 374, Logan.

Tait, C.K., J.L. Li, G.A. Lamberti, T.N. Pearsons, and H.W. Li. 1994. Relationships between riparian cover and the community structure of high desert streams. Journal of the North American Benthological Society 13:45–56.

Thurow, R.F., B.E. Rieman, D.C. Lee, P.J. Howell, and R.D. Perkinson. 2007. Distribution and status of redband trout in the interior Columbia River basin and portions of the Klamath River and great basins. Pages 1-19, In J. Hall (Ed), Inland rainbow trout. Oregon Chapter of the American Fisheries Society.

U.S. Bureau of Reclamation (USBR). 2010. Literature Synthesis on Climate Change Implications for Water and Environmental Resources, Second Edition. Technical Memorandum 86-68210-2010-03. Prepared by: Technical Service Center, Water Resources Planning and Operations Support Group, Water and Environmental Resources Division. 264 pp.

U.S. Fish and Wildlife Service. 1995. Lahontan cutthroat trout, Oncorhynchus clarki henshawi, Recovery Plan. Portland, OR. 147.

Weaver, T.M. and J.J. Fraley. 1993. A method to measure emergence success of westslope cutthroat trout fry from varying substrate compositions in a natural stream channel. North American Journal of Fisheries Management 13 : 8 17-822.

Whirling Disease Initiative. 2011. Accessed online at http://whirlingdisease.montana.edu/default.asp

Williams, J.E., J.E. Johnson, D.A. Hendrickson, S. Contreras-Balderas, J.D. Williams, M. Navarro-Mendoza, D.E. McAllister, and J.E. Deacon. 1989. Fishes of North America: endangered, threatened, or of special concern: Fisheries 14(6): 2–20.

Wydoski, R.S. 1978. Responses of trout populations to alterations in aquatic environments: a review. Pages 57-92 in J.R. Moring, ed. Proceedings of the wild trout-catchable trout symposium, Eugene, OR. Feb. 15-17, 1978.

Wydoski, R.S., and Whitney, R.R. 2003. Inland Fishes of Washington, second edition, revised and expanded. University of Washington Press, Seattle. 322 pp.

Wyoming State Wildlife Action Plan. 2010. Wyoming Game and Fish Department. 890 pp.

Zoellick, B.W. and B.S. Cade. 2006. Evaluating redband trout habitat in sagebrush desert basins in southwestern Idaho. North American Journal of Fisheries Management 26:268-281.

Bull Trout Conservation Element Package

1 Introduction

This document provides the assessment of the current status and future threats due to CAs for the bull trout in the NGB ecoregion, This package includes a brief description of the biology of the bull trout in the NGB ecoregion, a description of change agents that are assessed, a conceptual model of ecosystem functions relevant to the bull trout, the data sources and analytical methods for the assessment, and a listing of relevant management questions (MQ) for this CE.

2 CE Package Review Process

2.1 Subject Matter Expert Review

Subject Matter Experts play a key role in ensuring that the REA reflects the best available data and modeling processes suitable for each conservation element and change agent. Subject Matter Experts were added to Rolling Review Teams comprised of SAIC scientists, SAIC GIS personnel, AMT member(s) and other subject matter experts from the Department of Interior or state agencies. Membership of the Rolling Review Teams is listed in Appendix A. To ensure consistency amongst the different Rolling Review Teams, the number of lead SAIC scientists was limited to only a few individuals. This ensured that there was a common approach, or framework, used among the different Rolling Review Teams and that one Rolling Review Team did not stray too far from the rest. The USGS, as peer reviewers, were invited to participate in Rolling Review Teams.

3 CE Description

Bull trout, an Endangered Species Act threatened species, currently occurs in less than half of their historic range. Of all salmonids, due to their sensitivity to environmental conditions, bull trout are considered excellent indicators of water quality. Habitat alteration/loss, habitat fragmentation, riparian condition, climate change, environmental effects of mining and hybridization with introduced trout species are also factors affecting bull trout status and distribution over its this range (Rieman and McIntyre 1993; U.S. Fish and Wildlife Service 2002; Andonaegui 2003; Dunham *et al.* 2003a). The reduction of suitable habitat conditions by CAs will further constrict the range over which bull trout can occur. Decreases in habitat connectivity also isolate individual populations and decrease the sustainability of the metapopulation. The system level conceptual model (Figure 5-1) illustrates the interactions between the CAs and the primary habitat functions for bull trout in this ecoregion.

Bull trout have the most specific habitat requirements of salmonids, including the “Four Cs”: Cold, Clean, Complex and Connected habitat. Bull trout require colder water temperature than most salmonids, very clean stream substrates for spawning and rearing, complex and connected habitats, including streams with riffles and deep pools, undercut banks and lots of large logs, for rearing and annual spawning and feeding migrations.

Bull trout are known to exhibit four distinct life history forms throughout their US range (the migratory adfluvial and fluvial, resident, and anadromous). Within this ecoregion, bull trout display migratory and resident behaviors (64 FR 58910). Resident bull trout spend their entire lives in the same stream/creek, whereas migratory bull trout move to larger bodies of water to overwinter and then migrate back to smaller waters to reproduce. Largely due to smaller range and habitat resources over which they occur, resident bull trout are generally much smaller than migratory forms.

Bull trout feed opportunistically, with diets of a similar aged fish of the same form varying widely between systems, based on the available food resource (McPhail and Baxter 1996). Juvenile bull trout eat terrestrial and aquatic insects, macrozooplankton, amphipods, mysids, and crayfish but shift to preying on other fish as they grow larger. Resident and juvenile bull trout prey on invertebrates and small fish, whereas adult migratory bull trout primarily eat fish, including whitefish, perch, sculpins and other salmonids. Large bull trout, primarily fish predators, utilize much larger prey resources (e.g., kokanee), which allows them to attain very large sizes.

Bull trout reach sexual maturity at between four and seven years of age and are known to live as long as 12 years. They spawn in the fall after temperatures drop below 46° F (8° C), with the benthic surface comprised of gravel or cobble to maximize water to flow and oxygenation of incubating eggs, embryos, and fry (Montana Bull Trout Restoration Team 2000). Many spawning areas are associated with cold water springs or areas where stream flow is influenced by groundwater. In Montana, Spawning takes place between late August and early November. Spawning tends to occur in reaches where temperature and flow conditions are somewhat consistent, such as third and fourth order streams. Bull trout eggs require a long incubation period compared to other salmon and trout (4-5 months), hatching in late winter or early spring. Fry remain in the stream bed for up to three weeks before emerging. Growth rates of juvenile migratory bull trout increase substantially as they transition from third and fourth order streams to large river and lake environments, concurrent with their diet shifting from insects to fish (Montana Bull Trout Restoration Team 2000). Juvenile fish retain their fondness for the stream bottom and are often found at or near it. Salow (2004) found that young bull trout in the North Fork of the Boise River realized their greatest growth in two to three year old fish.

Within streams, juvenile bull trout, generally bottom foragers, are tightly associated with instream cover in reaches that include deep pools, large woody debris, rocky stream beds, and undercut banks (Montana Bull Trout Restoration Team 2000). However, life history forms that occur in lakes tend to be bottom oriented, though can utilize relatively shallow zones (less than 130 ft; 40 m) if water temperatures are sufficiently cool (Montana Bull Trout Restoration Team 2000). When temperatures increase during summer months, bull trout appear to occur in the deepest regions of deep lakes, though continuing to forage opportunistically in shallower waters. In addition, bull trout seem to prefer river/lake transition zones (Montana Bull Trout Restoration Team 2000). Both migratory and stream-resident bull trout move in response to seasonal habitat conditions (flow and temperature) and foraging opportunities, however migratory individuals travel much greater distances than do resident fish, with movement largely occurring at nigh (Salow 2004).

In addition to the cool, clean cold, and connected aquatic habitats, bull trout have other needs to support a healthy population. As summarized in the bull trout Endangered Species Act listing, bull trout have specific habitat requirements that appear to influence their distribution and abundance, including water temperature, cover, channel form and stability, valley form, spawning and rearing substrates, and migratory corridors (U.S. Fish and Wildlife Service 2002; 64 FR 58910). Anthropogenic stressors that can adversely affect the prevalence or persistence of bull trout within a given region include: habitat degradation, fragmentation and alterations associated with dewatering, road construction and maintenance, mining, and grazing; the blockage of migratory corridors by dams or other diversion structures; poor water quality; incidental angler harvest; entrainment (process by which aquatic organisms are pulled through a diversion or other device) into diversion channels; and introduced non-native species (64 FR 58910).

4 CE Modeling

4.1 Data Identification

Table 4-1 provides a brief summary of potentially available data sources that may be available to document the range and occurrence of bull trout within the Northern Great Basin.

Table 4-1. Preliminary List of Bull Trout Data Sources

Data Required	Dataset Name	Source Agency	Type/Scale	Status	Use in REA
Dams and Fish Barriers	National Inventory of Dams	USACE	Point	Data Acquired	No
	Fish Barriers	ID Bull Trout Review	Point	Data Acquired	Yes
	U.S. Fish and Wildlife Service Fish Barriers	U.S. Fish and Wildlife Service	Point	Data Acquired	Yes
Current Distribution	StreamNet	Pacific States Marine Fisheries Commission	Polyline	Data Acquired	Yes
Areas with Potential for Restoration of Habitat or Habitat Connectivity		NMFS, U.S. Fish and Wildlife Service, State Agencies	Point	Data Gap	No
Critical Habitat	Bull Trout	U.S. Fish and Wildlife Service	Polyline, Polygon	Data Acquired	Yes
Climate	PRISM 1981 – 2010	Oregon State University	Raster (800 m)	Data Acquired	Yes

4.2 Distribution Mapping Methods

The current distribution of bull trout can be viewed in Figure 4-1. The two main data sources used are StreamNet and U.S. Fish and Wildlife Service critical habitat layers (last updated in 2010). Fish Barrier information came from a 2004 Idaho Department of Fish and Game bull trout review along with the U.S. Fish and Wildlife Service GeoFIN fish barriers.

4.3 Data Gaps, Uncertainty, and Limitations

4.3.1 Uncertainty

Bull trout were analyzed using two datasets, critical habitat and StreamNet. There are instances where StreamNet has populations outside of bull trout critical habitat (Cougar Creek in NV) and there are instances where critical habitat doesn't contain a StreamNet population (lower Bruneau River).

Fish barriers were collected from both the individual state assessments (Idaho Department of Fish and Game) along with the U.S. Fish and Wildlife Service GeoFIN fish barrier data. Only raw coordinates of fish barriers were available to be acquired from the U.S. Fish and Wildlife Service due to data sharing agreements so there was no attempt to try to remove duplicates. Using fish barriers along with analysis units also added the problem of a barrier occurring within a HUC 12 or 4 km analysis unit may not be located on a bull trout occupied stream. These barriers may still have effects on the populations if they are upstream or downstream or within the same watershed.

Aquatic Invasives dataset was provided by the USFS and all invasive detections were used in this analysis. This dataset is a presence only dataset showing where invasives were detected not everywhere that has been surveyed.

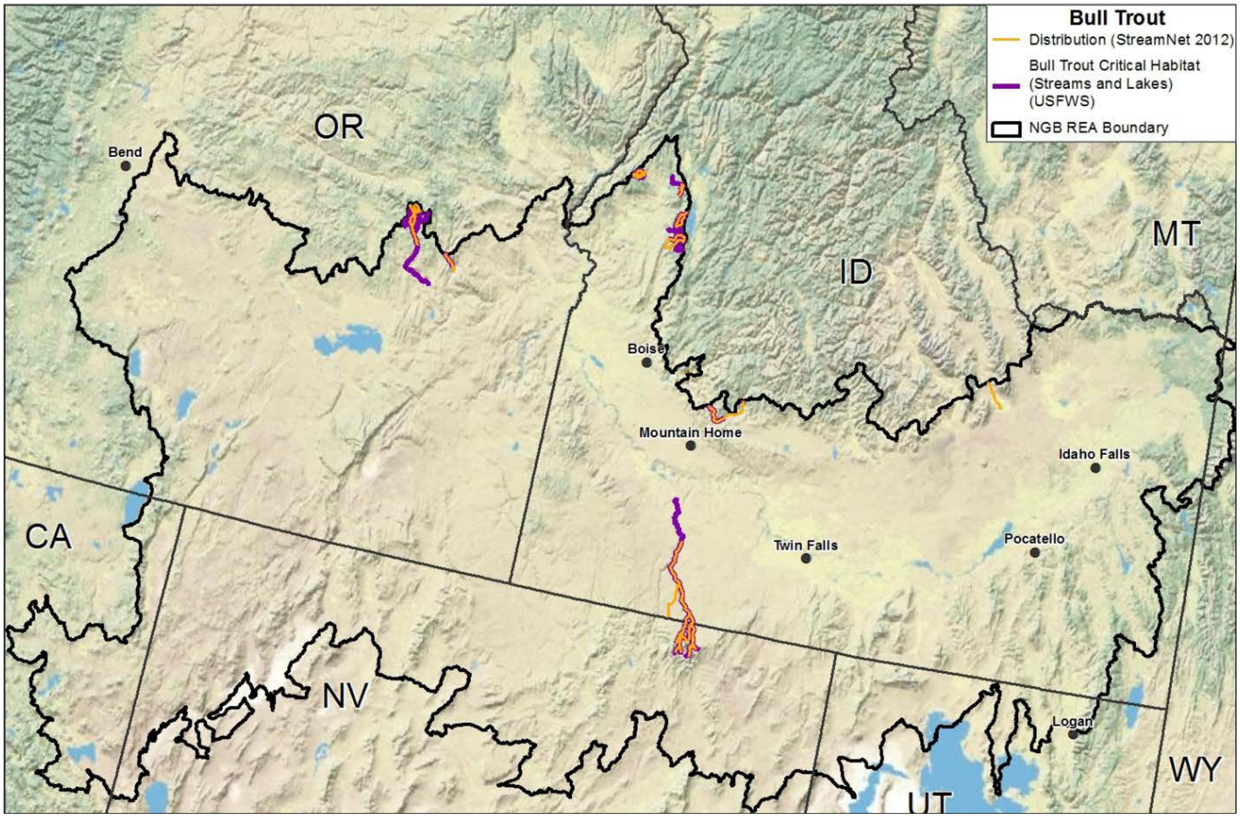


Figure 4-1. Current Distribution Based on Available Data Sources of Bull Trout

5 System Models

The conceptual model for the bull trout CE (Figure 5-1) illustrates the interactions between the change agents (CAs) and the primary habitat functions for the bull trout in this ecoregion. Any CA that positively or negatively influences these factors has the potential to influence the bull trout distribution and population levels in the region. Habitat functions include biotic and abiotic processes that may occur at local and landscape-levels (Figure 5-1). The model was developed to provide a scientific framework and justification for the choice of indicators that were used in assessing CA threats for this CE. The CAs included in the analysis are development, climate change, wildfire, disease, and introduced species. The conceptual model depicts our current understanding of the most important habitat functions in the systems occupied by this CE without regard for data availability or suitability of a habitat function for an ecoregion-level assessment. Following sections of this appendix will explain why certain elements in the model were carried forward in the analysis and why others were not.

The primary CAs for the bull trout are identified across the top of the figure in brown and their effects on habitat functions important to this species are identified in blue boxes below (Figure 5-1). The habitat functions that are key to the distribution and status of this species include availability of breeding sites with suitable substrate quality, resting sites that include woody debris, prey availability, and the effects of anthropogenic influences on habitats. The features that most significantly affect the distribution of the bull trout are habitat suitability and physical barriers. Changes caused by human development and resource use, climate change, and altered fire regime likely all affect the bull trout habitat either directly or indirectly.

5.1 Development

Past human development activities have adversely affected the Four-C's in many ways. As depicted in the model for bull trout (Figure 5-1), within drainages of this ecoregion dams, logging, urban/exurban development, road construction, and mining have resulted in streambank erosion, sedimentation, adverse changes to channel configuration, reductions in water quality, and loss of riparian habitat which provides shading and a source of insect prey for aquatic habitats. In addition to increased sedimentation, water chemistry can be degraded by contaminants and nutrients in runoff from adjacent developments and mining. As discussed in more detail for coldwater fish, in areas of past mining activity, metals such as zinc, copper, and iron have adversely affected the ecological function of these systems, and have the potential to lead to fish death.

Migrational barriers such as dams, improperly placed culverts, and irrigation diversions, among other migration barriers, have negatively affected bull trout and have interfered with metapopulation dynamics as well as spawning adult fish access to limited suitable spawning habitats within this ecoregion. Degradation of riparian vegetation in headwater streams can negatively impact bull trout habitat use through reductions in large woody debris contribution, shade, available food resources with this vegetation (e.g., insects), and the protection of water and sediment quality during precipitation events.

5.2 Climate Change

As addressed in more detail for coldwater fish, reduced snowpack, water temperature changes, precipitation changes, and greater fluctuations in stream hydrographs will likely be significant stressors on native coldwater fish species that result from climate change. Due to a greater dependence on cold water than the coldwater fish assemblage, a reduction in cold waters represents an even greater risk of reducing suitable habitat conditions for bull trout in the ecoregion. Reduced snowpack increases stream temperature variability. In addition, under climate change the snowpack will be replaced by periodic rain events as the climate gets warmer. These events would contribute to warmer instream temperatures, and increase fine sediment contribution to small tributaries. As bull trout have a narrow thermal tolerance range (Dunham *et al.* 2003a) particularly during early fall spawning periods, a reduction in snowpack will increase the range of instream temperatures, effectively decreasing the suitability of the limited number of headwater streams as bull trout spawning habitat. The input of finer-grained sediments can bury eggs and fry and reduce the oxygenation of bull trout eggs, effectively decreasing bull trout egg survivability. As populations are already isolated by migrational barriers, maintaining suitable spawning habitat is essential to avoid additional declines and local bull trout extinctions (Rieman *et al.* 1997).

5.3 Introduced Species

The introduction of non-native fishes in the waters occupied by bull trout, would result in competition with and predation by, non-native fish species, and are among the primary concerns for persistence of bull trout throughout their range. Hybridization with introduced brook trout many times leads to sterile offspring (Leary *et al.* 1993). Species of trout and salmon may become infected with the parasite responsible for bull trout appear to be somewhat resistant of the whirling disease (*Myxobolus cerbralis*) (Lorz *et al.* 2002). Although bull trout require colder water temperatures than many introduced fish species, such as channel catfish, smallmouth bass, and walleye, should they co-occur, non-native fish species could influence population dynamics and distribution of bull trout.

5.4 Wildfire

Wildfire effects on bull trout and their habitat are anticipated to be similar to those described for the coldwater fish assemblage, and are not repeated here.

5.5 Disease

Although all species of trout and salmon may become infected with the parasite responsible for whirling disease (*Myxobolus cerebralis*), an introduced disease agent that was first identified in the United States in 1956 and is now present in Idaho (Idaho Invasive Species Council Technical Committee 2007), bull trout appear to be somewhat resistant to the disease (Lorz *et al.* 2002).

Infectious hematopoietic necrosis virus (IHN) and other pathogens affect salmonids, and other hosts, and require continued monitoring within hatchery systems. The significance of disease as a CA for native coldwater fishes, including bull trout is unknown at present but it is included in the conceptual model due to the potential for spread of pathogens from hatchery facilities into habitats of wild salmonid populations.

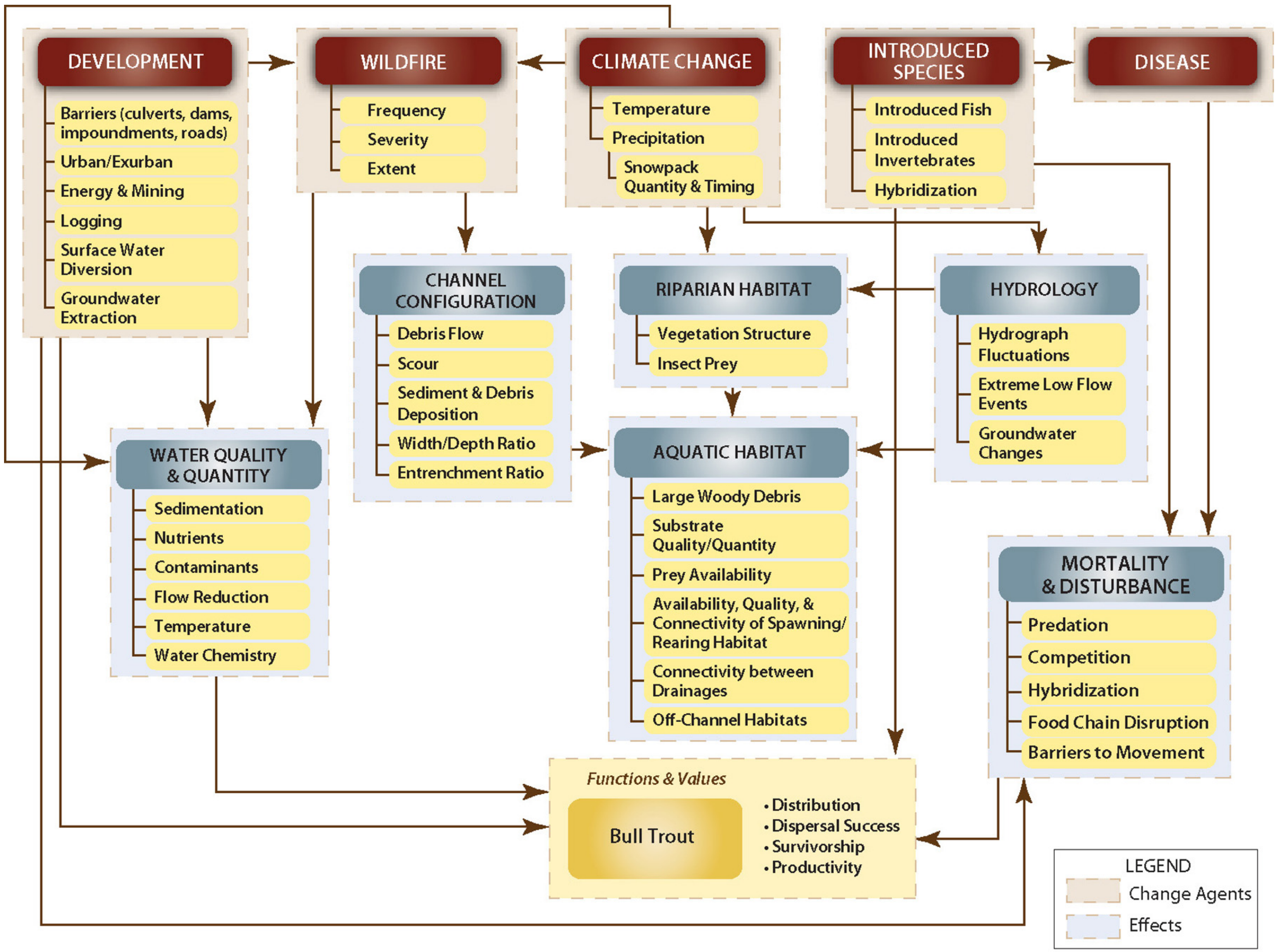


Figure 5-1. Bull Trout Conceptual Model

6 Change Agent Threat Analysis

Current status and future threat assessments for the bull trout CE were conducted for the NGB ecoregion using 30 m pixel, 4 km and 12-digit HUC as the analysis units. Based on the conceptual system model for the assemblage (Figure 5-1), key ecological attributes were identified for the current status and future threat analyses with an emphasis on the feasibility of measuring impacts using geospatial data (Table 6-1). The CAs evaluated for current status will include development, wildfire, climate change, introduced species, and disease.

6.1 Key Ecological Attributes

The list of key ecological attributes (Table 6-1) suggests some indicators for assessing habitat size, condition, and landscape context with respect to anthropomorphic influences.

Table 6-1. Preliminary List of Bull Trout Key Ecological Attributes and Indicators

Ecological Attribute	Indicator	Data Source
Landscape Structure	Riparian habitat condition	No Geospatial Data
Water Quality Factors	Instream temperatures	USGS Stream Gage
	Instream flow (hydrographs)	USGS Stream Gage
	Dissolved oxygen	Limited Sampling
	Contaminants, turbidity, sedimentation	303d lakes and streams (EPA)
	Alterations in reservoir operations	No Data Available
Wildfire	Wildfire	Fire SIMulation Burn Probability
Climate Change: Hydrologic Processes	Hydrograph changes	PRSIM
	Changes in average annual rainfall, extreme dry and wet water years	PRISM
Physical Barriers (Surface Water Diversion)	Fish Barriers	U.S. Fish and Wildlife Service Fish Barriers and other barriers from species specific assessments
Introduced Species	Aquatic Invasive Detections	USFS Aquatic Invasives Dataset
Disease		No Spatial Data

6.2 Current Status of the CE

6.2.1 Water Quality

6.2.1.1 Instream Flow and Temperature

Instream flow and temperature were measured using USGS stream gage data from a variety of stations located throughout the range of the bull trout. Since gages aren't located on all streams and can vary temporally, stream gages were chosen where there was a long history (50+ years) of recorded data up to present. The flow and temperature data was converted to raster graphs to display seasonal fluctuations and longer term patterns. Figure 6-1 shows locations of USGS stream gages used for stream flow. The raster graphs showing instream flow tend to display a peak spring runoff in March – June. The Malheur River is one of the outliers as its flow is only high during the May – September timeframe and very low outside that window.

6.2.1.2 Dissolved Oxygen

Dissolved oxygen monitoring at USGS gaging stations was very infrequent. The USGS water sampling that includes dissolved oxygen is mostly done on larger rivers such as the Snake River and usually consists of sampling once a month and can vary from year to year. Dissolved oxygen was identified as a data gap for the bull trout streams in the ecoregion.

6.2.1.3 Contaminants, Turbidity and Sedimentation

Similar to dissolved oxygen, turbidity is another parameter measured at some larger rivers or during monthly water sampling at select gage sites. The 303d waters dataset from the EPA was used as a surrogate to determine the percentage of waters that were listed as 303d within the analysis unit. The main causes of 303d classification within bull trout waters was: dissolved oxygen, mercury, phosphorus, sedimentation / siltation, temperature and zinc. Figure 6-3 and Figure 6-4 show the resulting percentage of 303d waters per analysis unit.

6.2.1.4 Alterations in Reservoir Operations

There was no information on alterations in reservoir operation as was identified as a data gap for the ecoregion.

6.2.2 Wildfire

The dataset used to analyze wildfire was the Fire SIMulation (FSIM) developed by the USFS and USGS. Figures 6-5 and 6-6 displays the burn probability for analysis units containing bull trout. Most of the Jarbidge region (Bruneau River) is in a high burn probability area except for its uppermost range in Nevada.

6.2.3 Physical Barriers (Surface Water Diversions)

There were two main data sources used for fish barriers for bull trout. The U.S. Fish and Wildlife Service maintains an online dataset of fish barriers at their GeoFIN website http://ecos.fws.gov/geofin/. Their website contains detailed information on the location and type of barrier. Due to data sharing agreements, only the locations of the barriers (no details) was able to be obtained for the ecoregion. Idaho Fish and Game did a range-wide assessment in 2004 that included fish barriers which were used in conjunction with the U.S. Fish and Wildlife Service fish barriers. Some uncertainty was created by the analysis such as:

1. Since detailed information about the U.S. Fish and Wildlife Service fish barriers wasn't available some duplicate barriers may exist.
2. An analysis unit (HUC 12 or 4 km grid) may also contain a barrier that isn't associated with a bull trout stream. When summing by the analysis unit, these would be included.

The amount of fish barriers within each analysis unit is displayed in Figures 6-7 and 6-8.

6.2.4 Aquatic Invasives

The main source for aquatic invasive species was the USFS aquatic invasive detections dataset. Figures 6-9 and 6-10 show the amount of detections with the analysis units (HUC 12 and 4 km grid). It appears the majority of the detections were located along the Snake River and some isolated occurrences outside that corridor. Two elements of uncertainty for aquatic invasives are:

1. All invasive detections were used. A more detailed analysis may want to not include certain types of aquatic invasives.
2. The USFS dataset shows locations where invasives were detected and is a presence only dataset. Locations with no detections may contain invasives but haven't been surveyed or reported.

6.2.5 Riparian Habitat Condition

The estimate of the riparian condition was based on how much development has occurred in the riparian corridor. The mapping of the riparian corridor is discussed in more detail in the Riparian CE package. Figure 6-11 shows the fraction of natural land cover (undeveloped) land in the riparian corridor by HUC 12 watershed.

6.2.6 Cumulative Indicator Score

Five of the metrics from the Perennial Streams CE (water quality, aquatic invasives, flow regulation, groundwater condition, and riparian condition) were combined with the two additional metrics described in this package, fish barriers and burn probability. The individual metrics were scored with a 1, 2 or 3 with 1 given to lowest quality indicator and 3 given to the highest quality indicator. The seven metrics were then added together to derive a range of cumulative scores from 7 to 21. Figure 6-12 shows the resulting high and low scoring areas by HUC12. The data for perennial rivers, such as flow regulation by dams, 303d impaired, and aquatic invasives are best analyzed using a watershed unit, since water quality impairment in a stream is a symptom of poor land management practices in the watershed. Therefore the cumulative indicator score is presented by HUC 12 only.

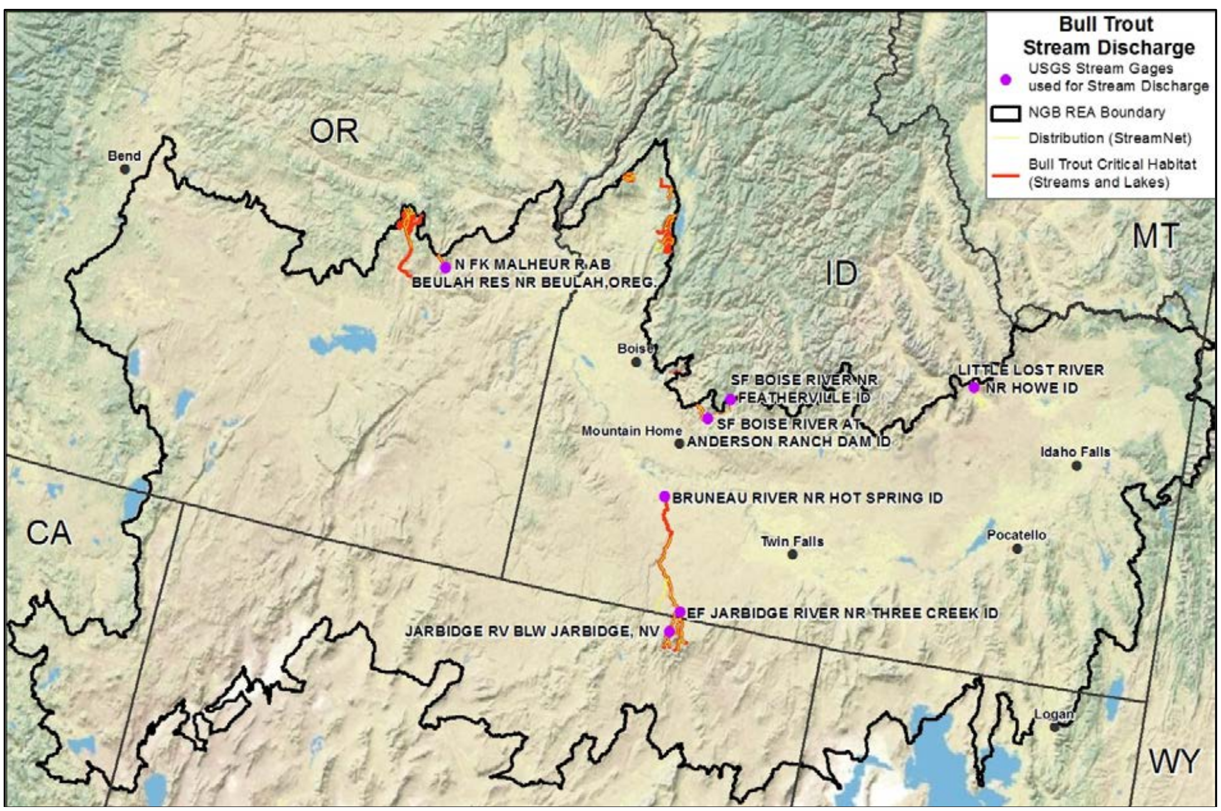


Figure 6-1. USGS Stream Gage Locations used for Stream Flow

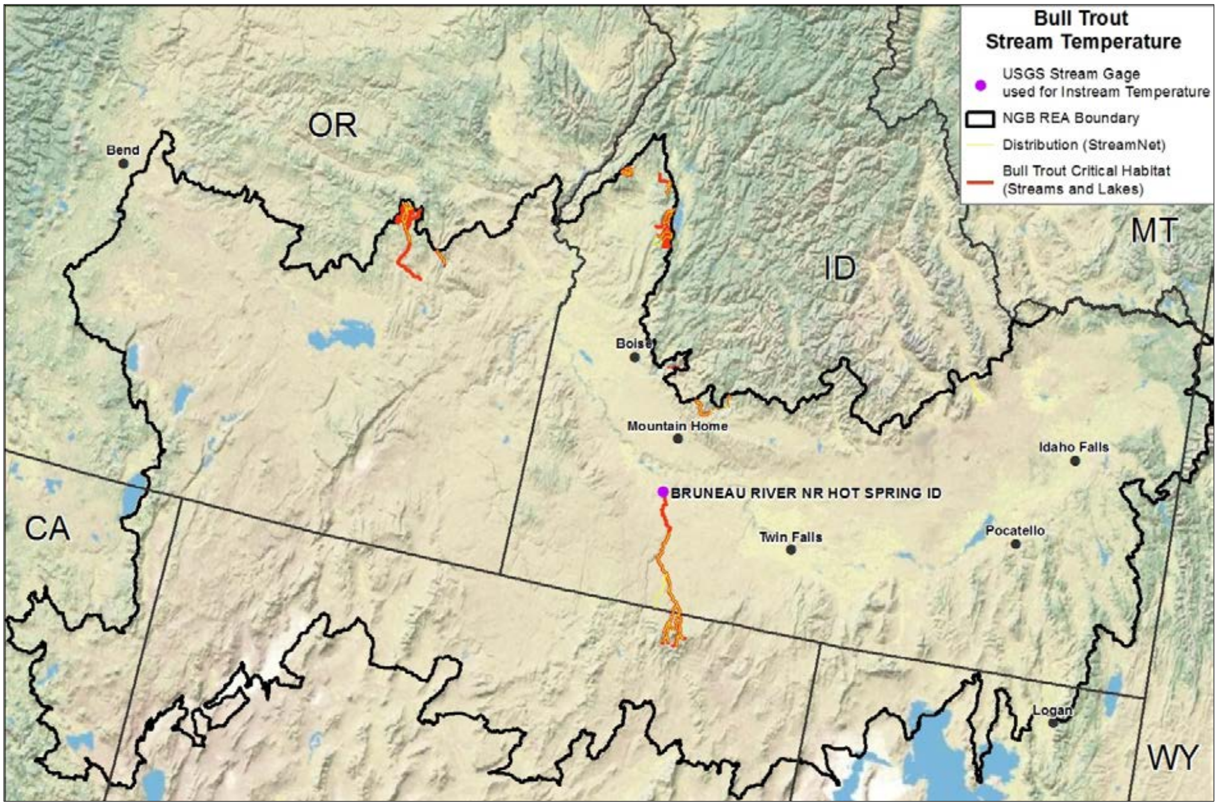


Figure 6-2. USGS Stream Gages used for Instream Temperature.

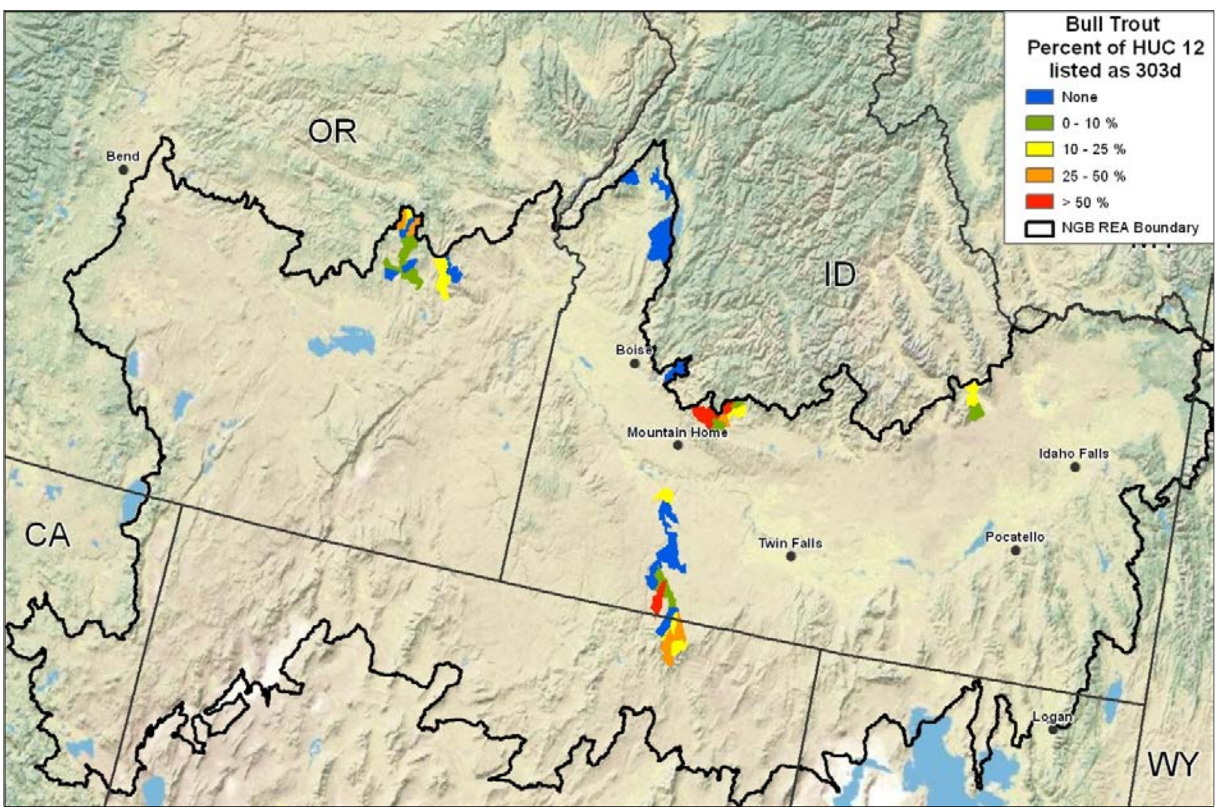


Figure 6-3. Percent of HUC12 with Waters Listed as 303(d)

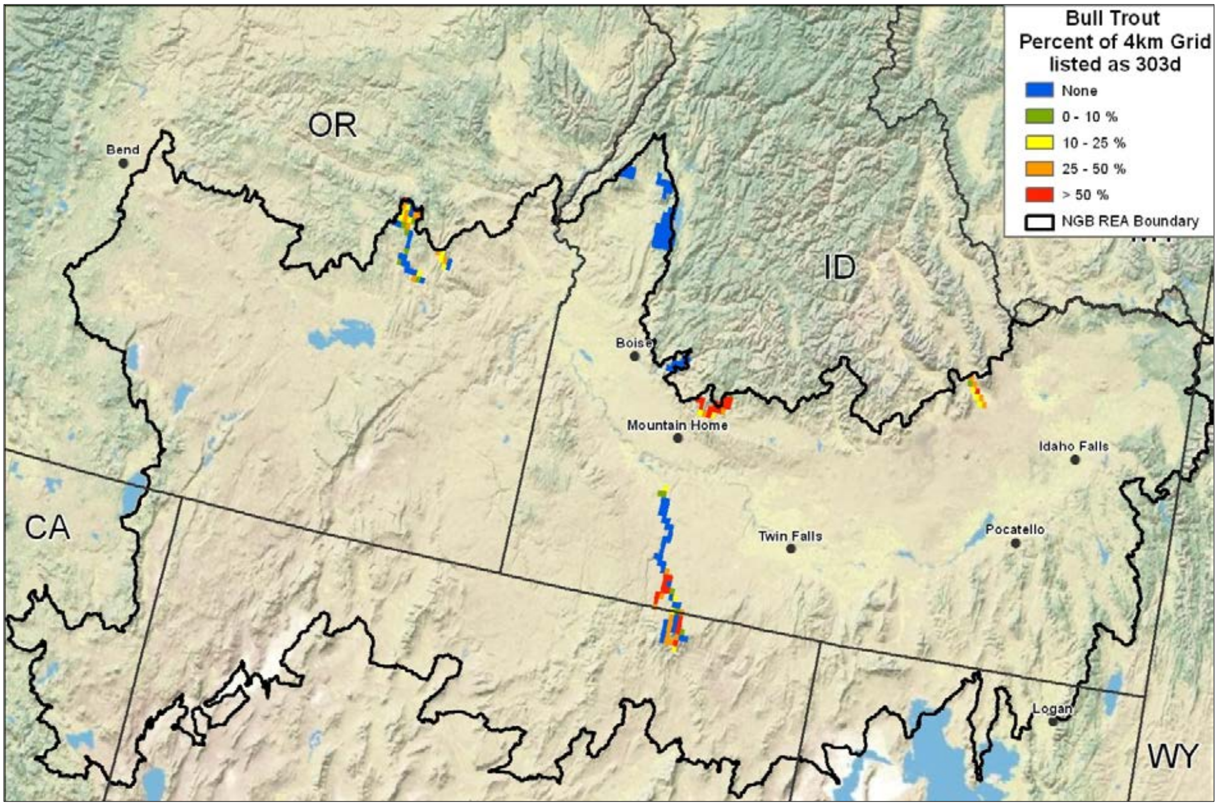


Figure 6-4. Percent of 4 km Grid with Waters Listed as 303(d)

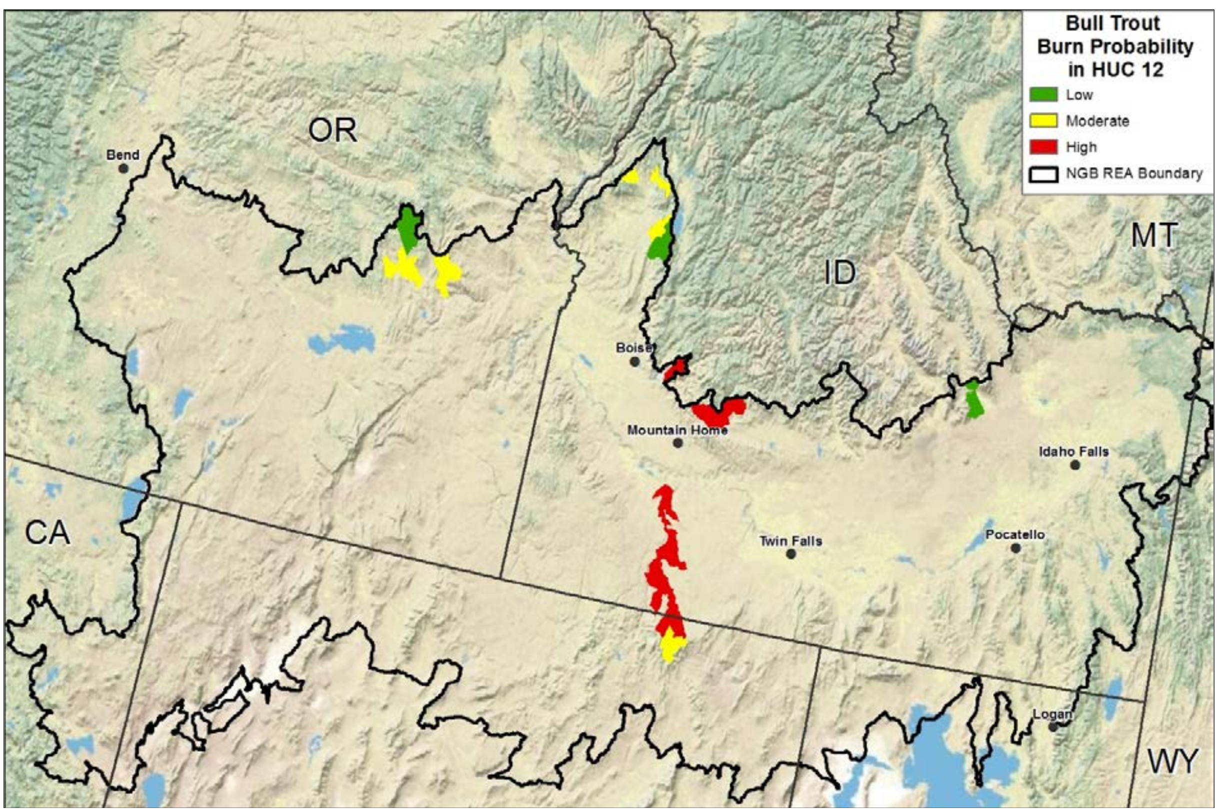


Figure 6-5. Burn Probability by HUC 12 for Bull Trout

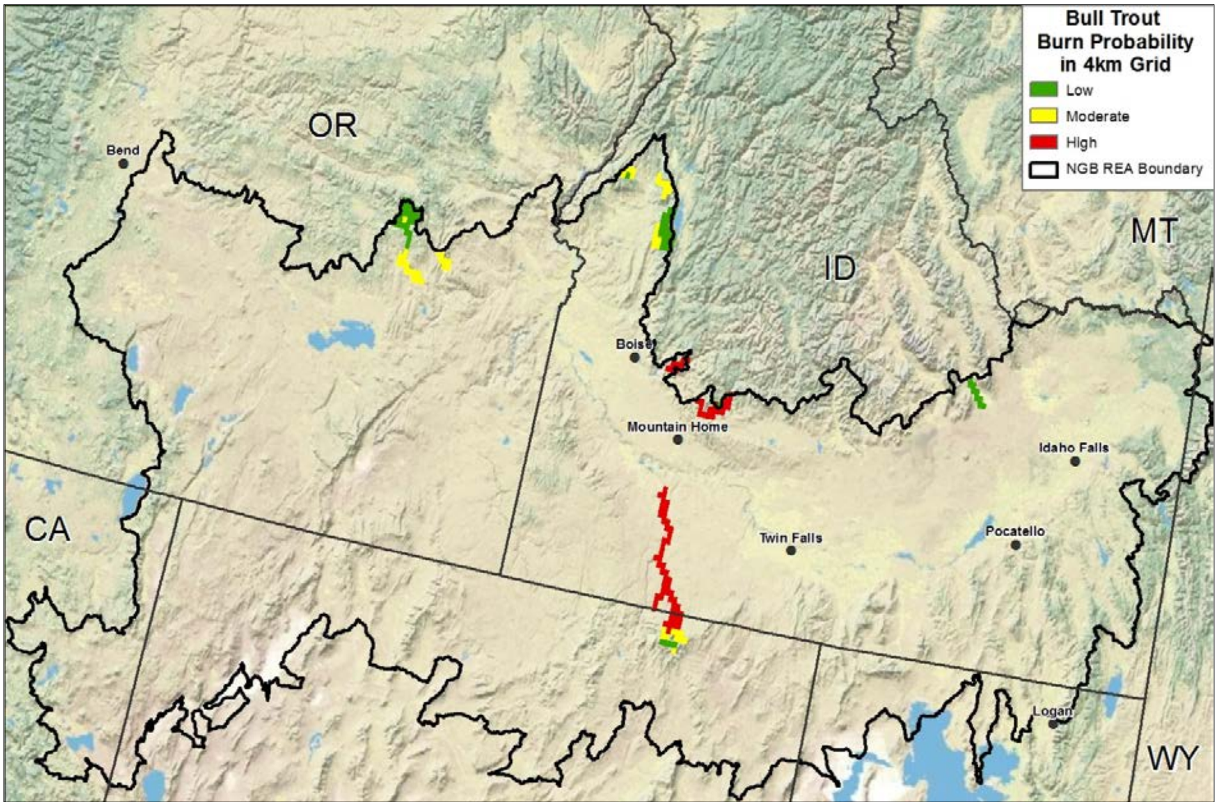


Figure 6-6. Burn Probability by 4 km Grid for Bull Trout

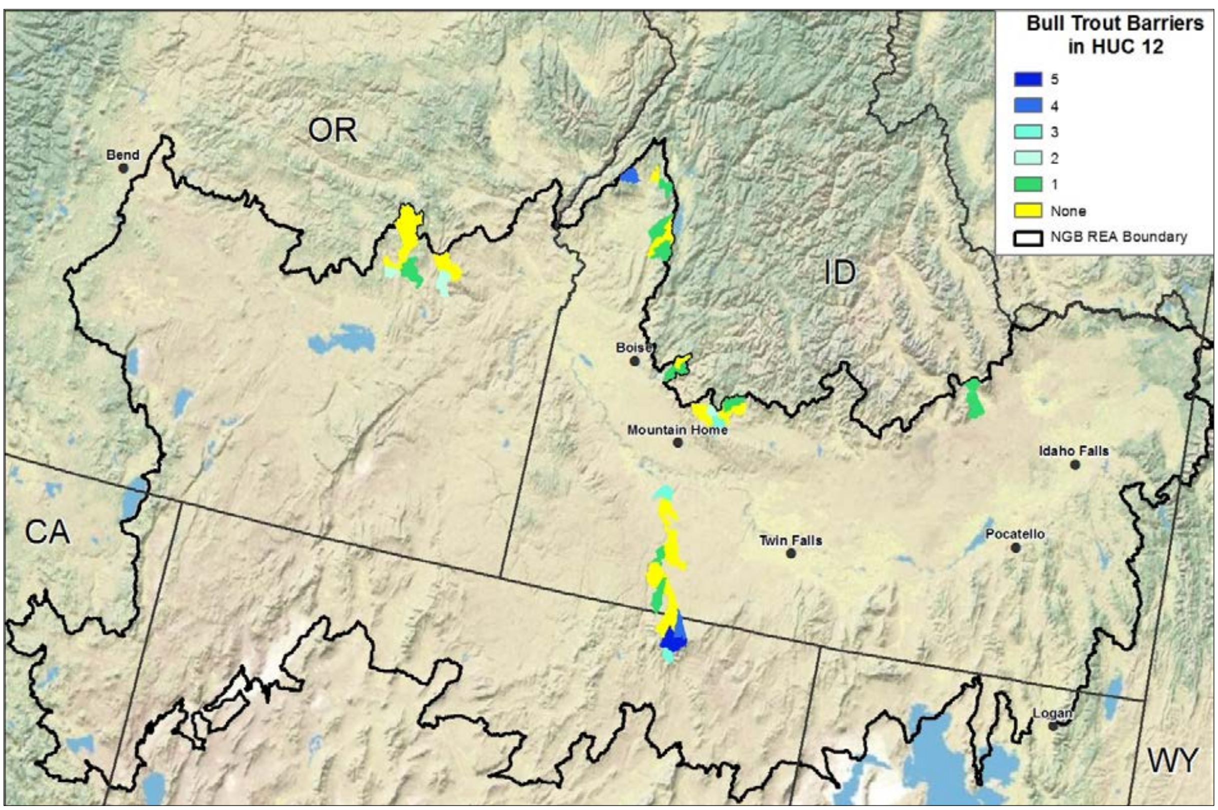


Figure 6-7. Fish Barriers by HUC 12 for Bull Trout

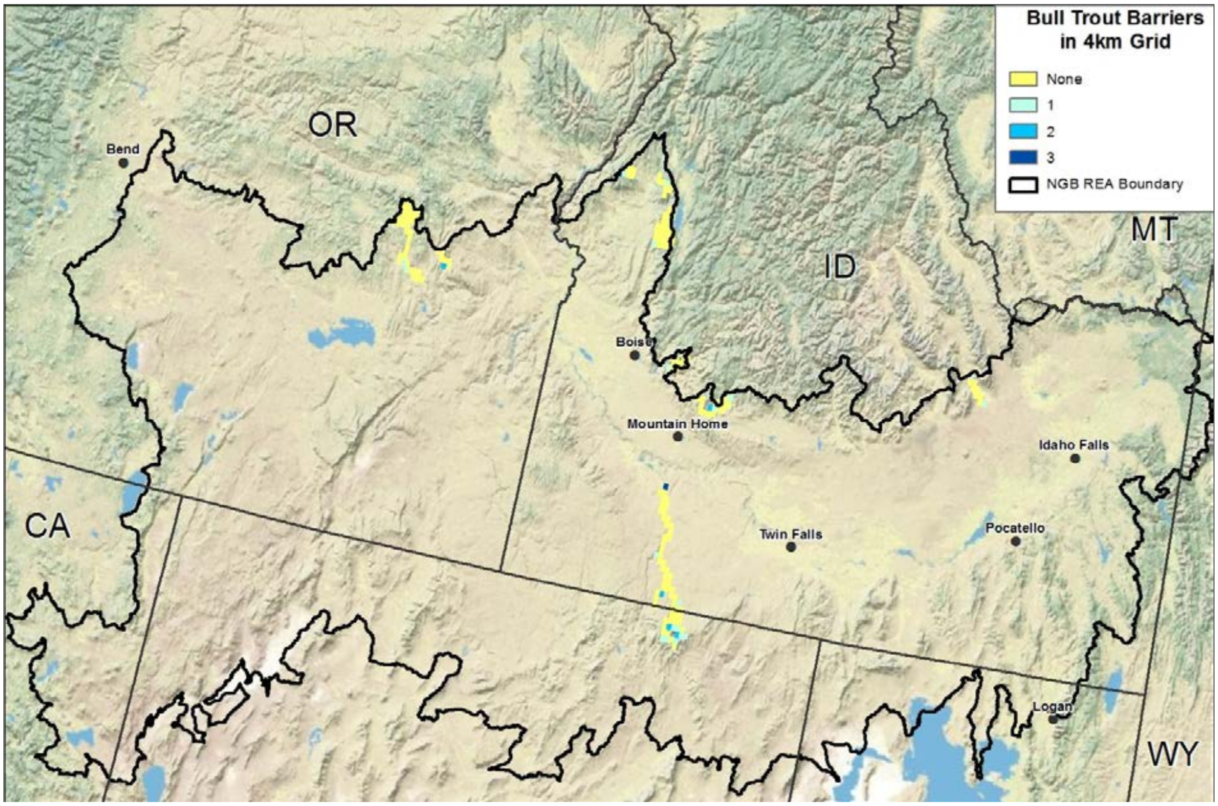


Figure 6-8. Fish Barriers by 4 km Grid for Bull Trout

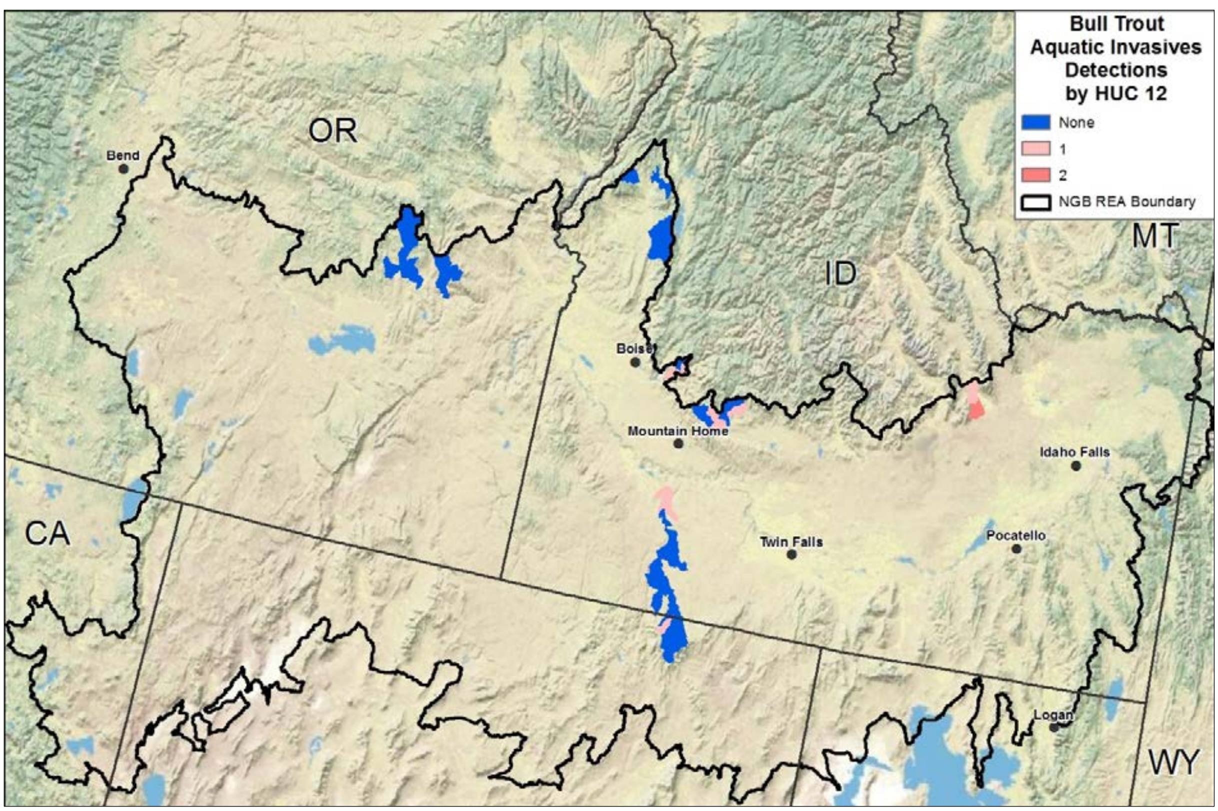


Figure 6-9. Aquatic Invasive Detections by HUC 12 for Bull Trout.

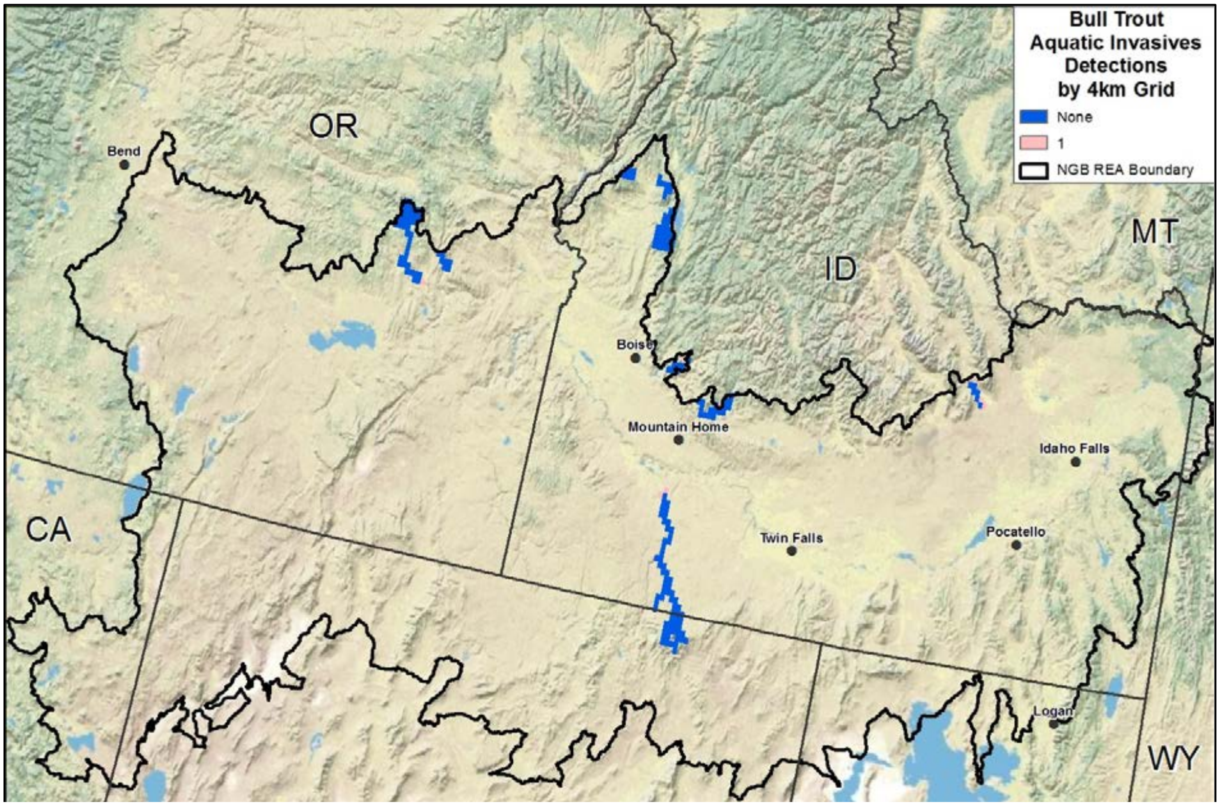


Figure 6-10. Aquatic Invasive Detections in 4 km Grid for Bull Trout

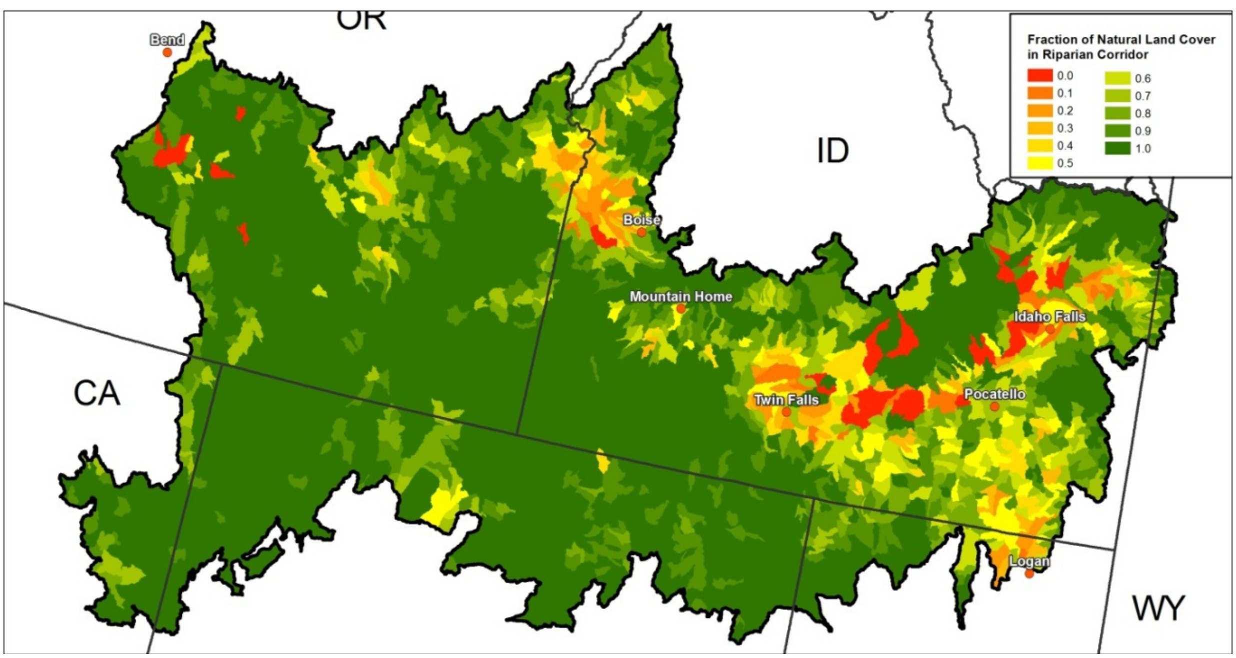


Figure 6-11. Fraction of Natural or Undeveloped Land Cover in the Riparian Corridor

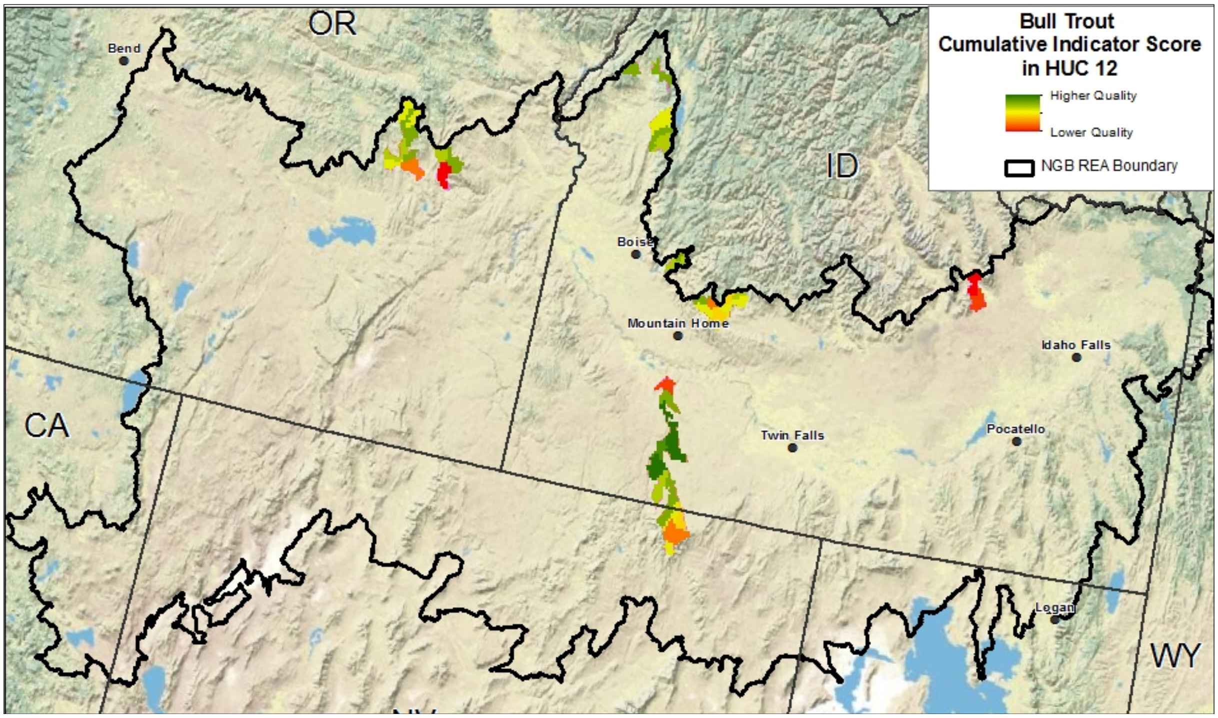


Figure 6-12. Bull Trout Cumulative Indicator Score

6.3 Future Threat Analysis

6.3.1 Climate Change

6.3.1.1 Instream Temperature Change Modeling

Modeling instream water temperature based on air temperature was used by Haak *et al.* 2010 to determine future risk of climate change impacting salmonids. Their model uses PRISM climate data to determine the average July temperature for current range of the species and then increases the temperature 3 degrees Celsius to simulate a future climate change scenario. Using the elevated temperature it would then determine which areas would remain suitable (based on current range) and which areas could become marginal or unsuitable.

The PRISM dataset used was 1981-2010 which was released this summer, Haak had previously used the 1971-2000 PRISM dataset. The PRISM data represents a 30 year averaged data at an 800 m raster cell size resolution. July was chosen as the hottest month by Haak *et al.* 2010 and reviewing PRSIM climate maps for June, July and August appears to also be the hottest month for the Northern Great Basin.

Extracting the temperature for July using the ranges shown in Figure 4-1 resulted in the following mean air temperature, maximum air temperature and the mean air temperature plus one standard deviation (Table 6-2).

Table 6-2. Air Temperatures for July for Bull Trout

Species	Mean Temp (°C)	Mean + 1 SD (°C)	Max Temp (°C)
Bull Trout	29.6	32.4	33.9

The current (1981–2010) PRISM July air temperature was then raised three degrees (geospatial operation) to simulate a future climate change (Haak *et al.* 2010). The air temperature was then analyzed using the

HUC 12 and 4 km analysis units. Table 6-3 shows the future air temperature ranges of what was determined suitable, marginal and unsuitable based on Haak *et al.* 2010 methodology.

Table 6-3. Modeled Future Temperature Suitability (Haak et al. 2010)

Modeled Future Temperature Range Determination as Listed Below	
Suitable	<= Mean July Air Temperature + 1 Standard Deviation
Marginal	Mean July Air Temp (+ 1SD) to Max July Air Temperature
Unsuitable	> Max July Air Temperature

Based on the air temperatures in Table 6-2 and the methodology of determining future suitability in Table 6-3, the resulting modeled suitability ranges are displayed in Table 6-4.

Table 6-4 Modeled Future Air Temperature Suitability

Species	Modeled Future Suitable Range (°C)	Modeled Future Marginal Range (°C)	Modeled Future Unsuitable Range (°C)
Bull Trout	<= 32.4	32.4 – 33.9	> 33.9

Figures 6-13 and 6-14 display the resulting modeled future suitability of the current range for each species using the HUC 12 and 4 km grid analysis units. It appears that if the temperature were to rise the modeled 3°C (Haak *et al.* 2010) large portion of the ecoregion's critical habitat would become unsuitable or marginal. One item that wasn't factored into this model would be coldwater from springs and seeps that may help keep water temperatures lower and within a suitable range.

6.3.1.2 Winter Flood Risk

Winter flood risk due to climate change (increase of three degrees Celsius) was another aspect of climate change on salmonids that Haak *et al.* 2010 analyzed. The focus of this model is to determine the threat of change of winter precipitation type (e.g. snow to rain) not change in the amount of precipitation. Based on their methodology, the first step was to identify areas with low winter precipitation and remove those areas from analysis. This was done by using PRISM 1981-2010 thirty year average precipitation data for the months of November, December, January, February, and March.

The climate data was extracted from the range of the combined coldwater fish assemblage and then binned into ten classes using Jenk's Natural Breaks option with ArcView. The value of the lowest class (of the ten) was determined by Haak *et al.* 2010 to have low enough precipitation to not warrant further analysis. The results of this analysis are displayed in Figures 6-15 and 6-16 for the HUC 12 and 4 km analysis units.

To determine winter flood risk, Haak *et al.* 2010 used the maximum mean air temperature for the months of January, February and March. After excluding areas of low winter precipitation, the temperature was increased three degrees Celsius to simulate a future climate change scenario. Based on the current air temperature for January, February and March and the future climate scenario each analysis unit was analyzed to determine whether there is a change in the type of winter precipitation. Table 6-5 shows the temperatures used to classify analysis units into the three winter precipitation types.

Table 6-5. Type of Winter Precipitation

Type of Winter Precipitation	Mean Winter Temperature
Snow Dominant	< -1 degrees Celsius
Transitional Dominant	> -1 to < 1 degrees Celsius
Rain Dominant	> 1 degrees Celsius

Table 6-6 displays how Haak *et al.* 2010 displays the threats to flood risk based on the temperature change from current to a future climate change scenario.

Table 6-6. Flood Risk from Change in Type of Winter Precipitation

Type of Winter Precipitation	Winter Flood Risk
Snow to Transitional	High
Snow to Rain	High
Transitional to Rain	Moderate
Stays Snow	Low
Stays Transitional	Low
Stays Rain	Low
Low Winter Precipitation	Low

The results of the classification of the HUC 12 and 4km analysis units based on the change in the type of winter precipitation is displayed in Figures 6-17 and 6-18. Based on the analysis, most of the ecoregion will remain mostly continue as rain or be in a low winter precipitation area. The areas at risk are located in the highest reaches of the Bruneau River in the Jarbidge region). These areas are only evident when looking at the results at a 4km grid analysis unit (Figure 6-19)

6.3.2 Development

Agricultural development in the ecoregion has resulted in widespread construction of dams or diversion structures for surface water withdrawals that have reduce flow. Migrational barriers such as dams, improperly placed culverts, and irrigation diversions, among other migration barriers, have negatively affected bull trout and have interfered with metapopulation dynamics as well as spawning adult fish access to limited suitable spawning habitats within this ecoregion. As a result, populations have become increasingly fragmented. Surface and groundwater extraction for urban and exurban populations, agricultural irrigation, and industrial development adversely affect native coldwater fish populations. Diversion of water for hydroelectric and agriculture uses has exacerbated persistent drought conditions, and requires mitigated flow management of the dams by the US Army Corps of Engineers (USACE). Degradation of riparian vegetation can negatively impacted fish habitat through reductions in large woody debris contribution, shade, available food resources with this vegetation (e.g., insects), and the protection of water and sediment quality during precipitation events.

6.3.3 Wildfire

Forest fires accelerate sediment transport from mountain drainage basins. Transport processes range from sediment-charged floods to debris flows (Meyer *et al.* 2001). These erosion events following fires can have short-term, detrimental effects but long-term importance for land and stream form development (Benda *et al.* 2003). Intense fire can result in the temporary loss of riparian vegetation, sedimentation, loss of shading and water temperature increases. However, low to moderate intensity fires release nutrients into the water and bring down timber into water bodies. These submerged trees provide important shelter for fish and other aquatic animals (Idaho Department of Fish and Game 2012).

Larger, more catastrophic fires can threaten entire fish populations in a watershed. In most aquatic systems, fish populations can recolonize quickly after a fire (Gresswell 1999). Native fish populations in the fire area that exist as isolated populations in fragmented habitats are at greater risk of localized extirpation. If the local populations are lost their former habitat cannot be recolonized naturally. Lack of connectivity among populations can lead to loss of entire populations of fish after a fire (Rinne 1996). Loss of any of these local populations may be devastating to recovery of the species as a whole due to the loss of unique genetic material.

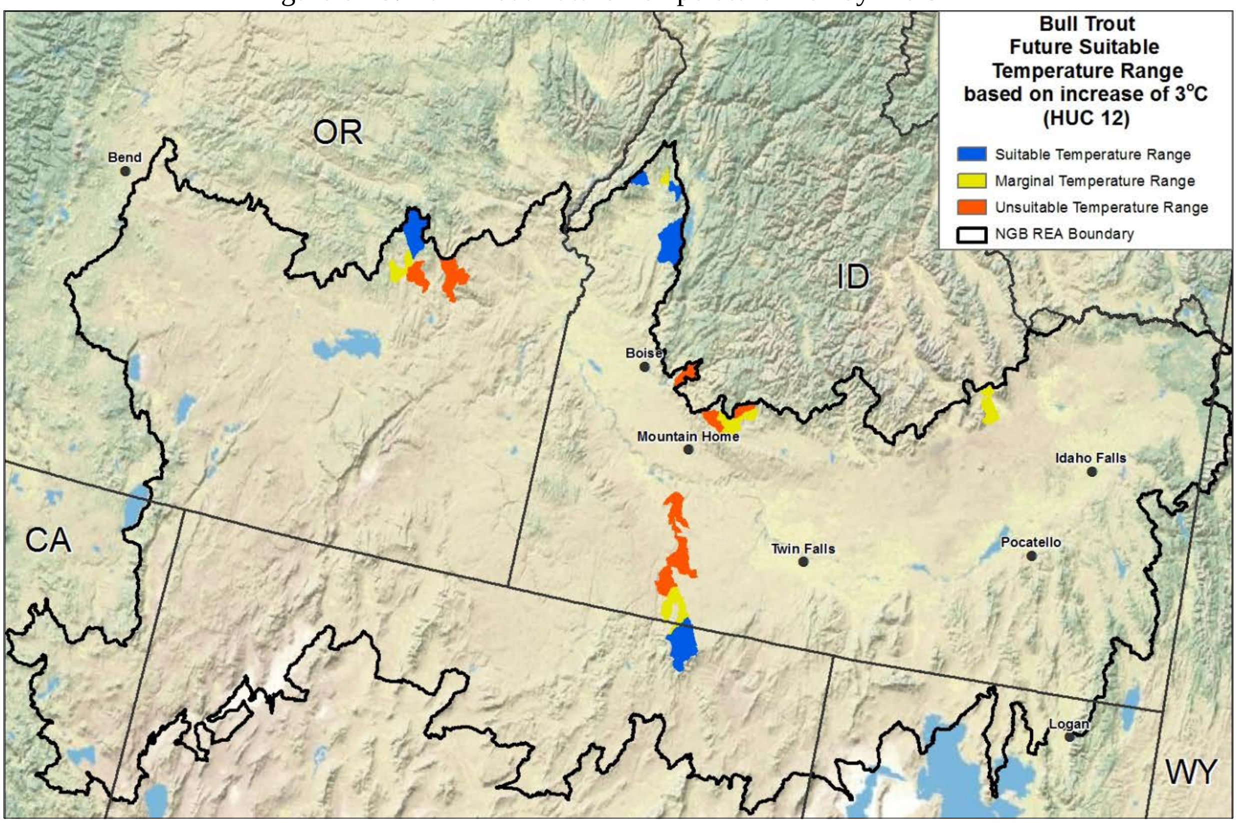
6.3.4 Invasives and Disease

Hybridization with introduced brook trout many times leads to sterile offspring (Leary *et al.* 1993). Introduced fish species such as channel catfish, smallmouth bass, and walleye likely influence population dynamics and distribution of bull trout. Species of trout and salmon may become infected with the parasite responsible for whirling disease (*Myxobolus cerebralis*). Bull trout appear to be somewhat resistant of the disease (Lorz *et al.* 2002).

6.3.5 Grazing

Grazing animals and pasture production can also negatively affect water quality through erosion, through nutrients dropped by the animals and through pathogens from the wastes (Hubbard 2004). Un-fenced riparian zones are often trampled by grazing activities (Sada and Vinyard 2002). High-density stocking, poor forage stands, and grazing in riparian zones can impact the water quality of streams and rivers that bull trout depend on.

Figure 6-13. Bull Trout Future Temperature Risk by HUC 12



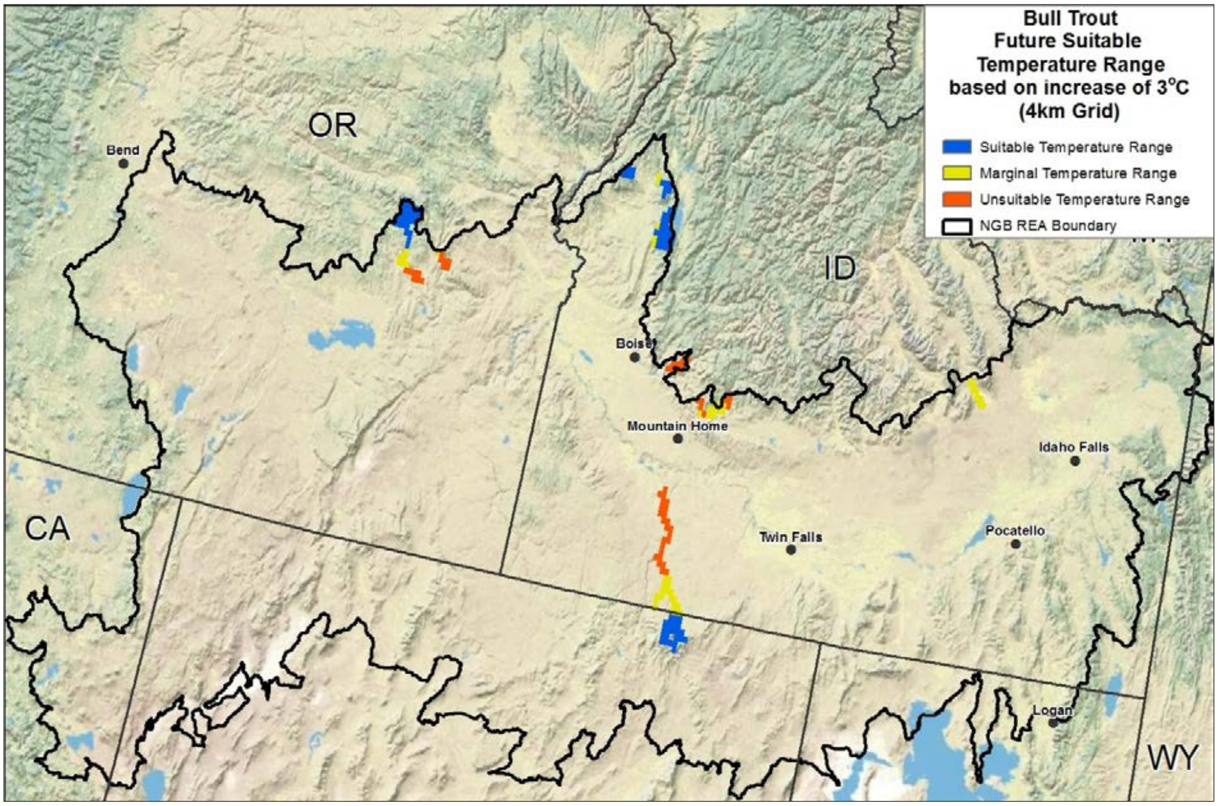


Figure 6-14. Bull Trout Future Temperature Risk by 4 km Grid

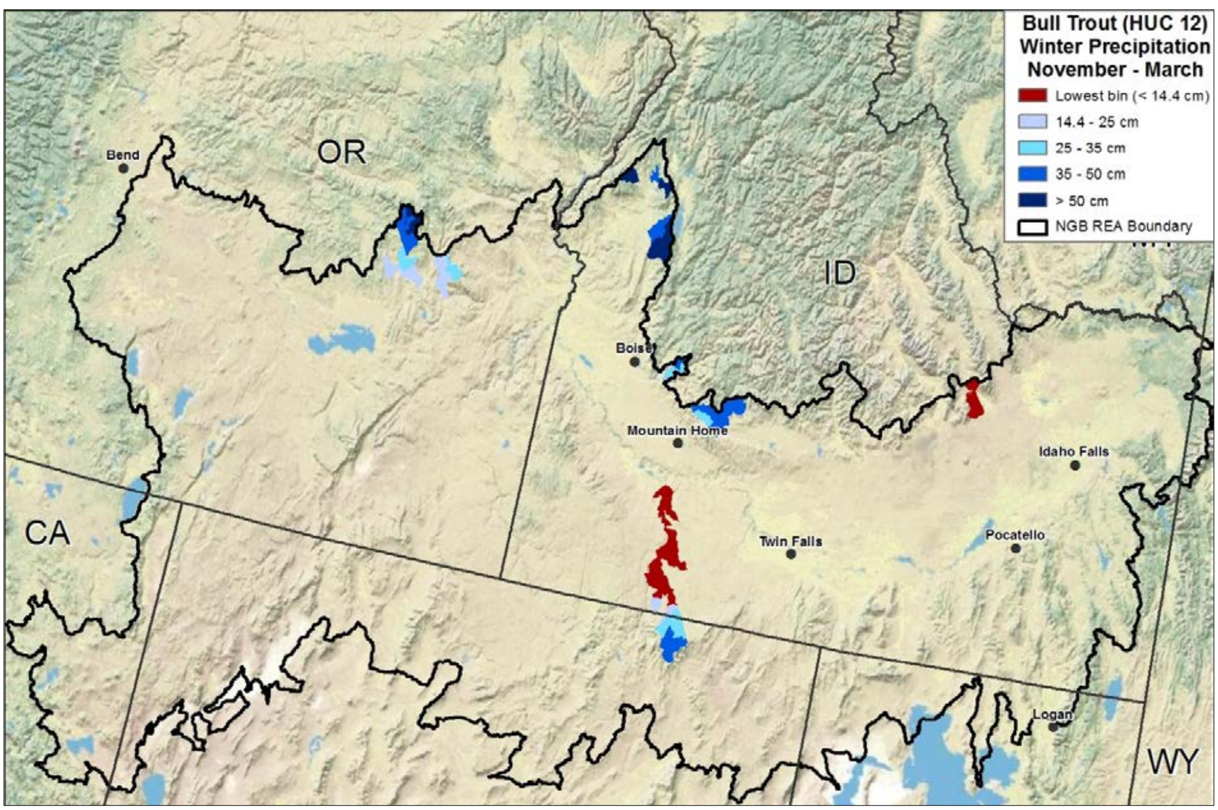


Figure 6-15. Winter Precipitation for Bull Trout Range by HUC 12

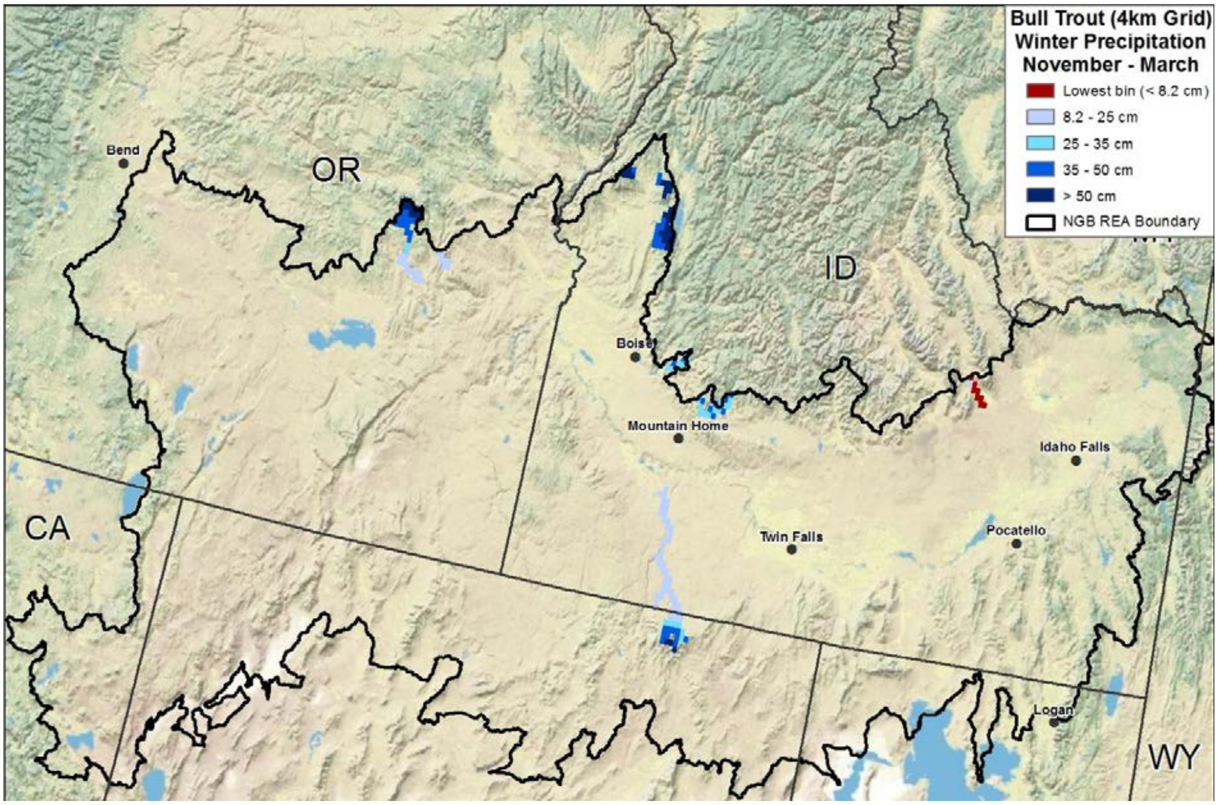


Figure 6-16. Winter Precipitation for Bull Trout Range by 4 km Grid

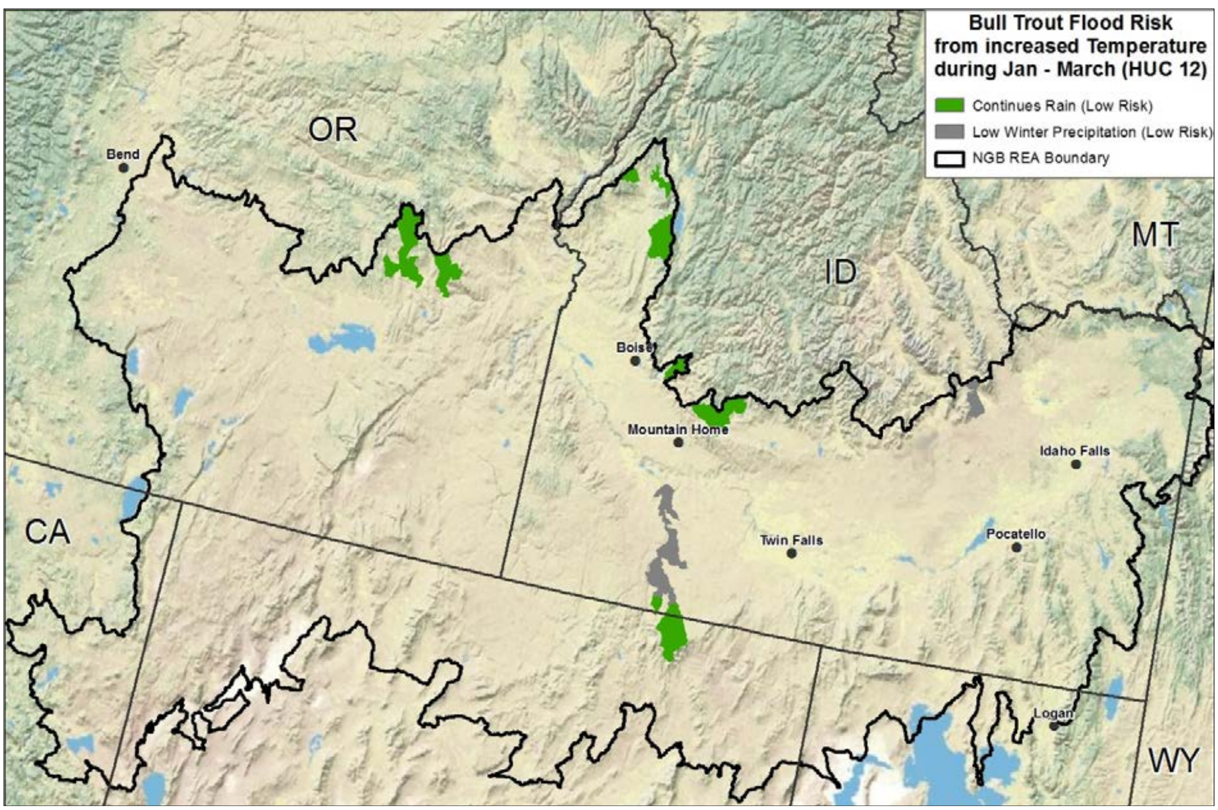


Figure 6-17. Winter Flood Risk for Bull Trout by HUC 12

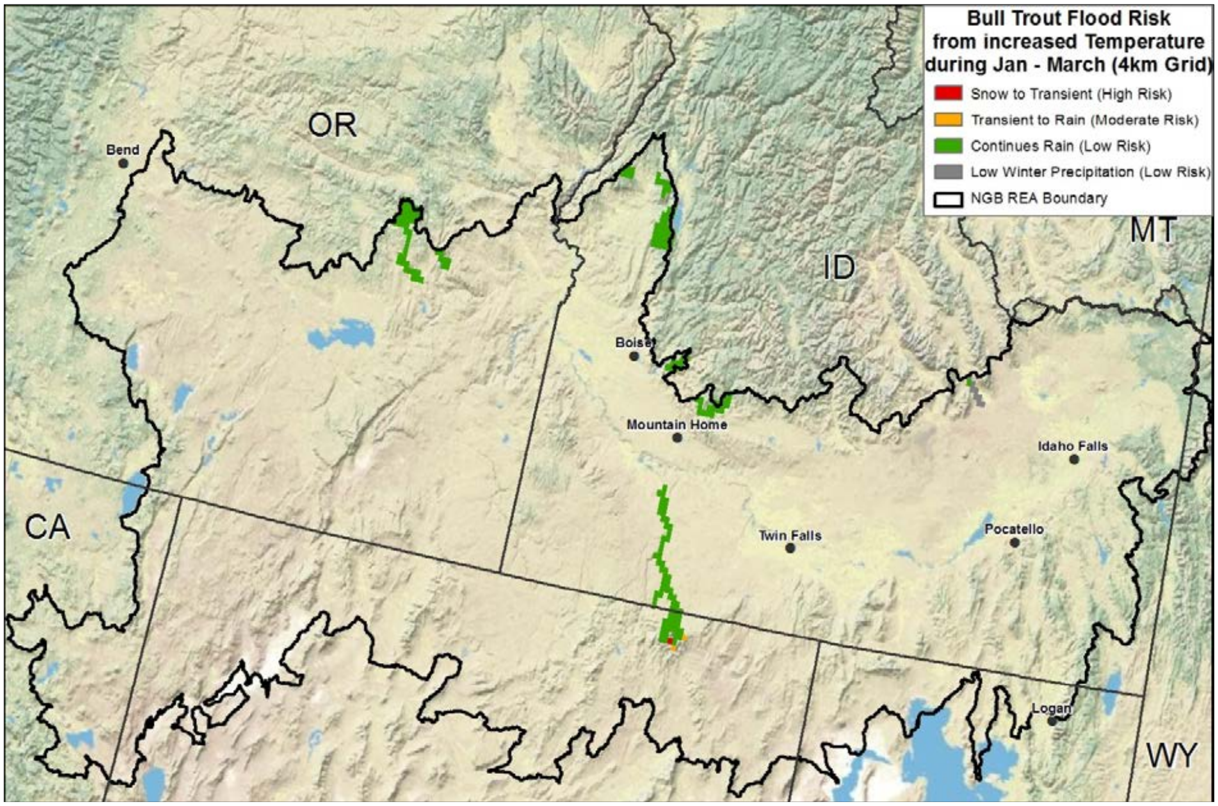


Figure 6-18. Winter Flood Risk for Bull Trout by 4 km Grid

7 Management Questions

Management questions for the NGB were developed by BLM managers and refined by the AMT to answer questions regarding the agency's land management responsibilities—including planning land use, developing best management practices, authorizing uses, and establishing conservation and restoration priorities. Several management questions relate to the bull trout CE:

1 What is the currently occupied habitat or modeled suitable habitat for this CE?

The bull trout current occupied habitat is shown in Figure 4-1.

2 Where are the areas of greatest and least collective impact of existing CAs on occupied habitat or modeled suitable habitats of this CE?

The bull trout cumulative indicator score is provided in Figure 6-12 by HUC 12 watershed. The highest scoring areas are along the Jarbidge and Bruneau Rivers. Lower scoring areas are along the Malheur River.

3 What is the current distribution of suitable habitat, including seasonal habitat and movement corridors, for each landscape species and species assemblage CE?

The suitable habitat with barriers to movement are provided in Figures 6-7 and 6-8

4 Where are existing CAs potentially affecting this current habitat and/or movement corridors, for landscape species and species assemblage CEs?

The bull trout cumulative indictor score is provided in Figure 6-12 by HUC 12 watershed. This shows where existing CAs are affecting the current habitat.

5 Where are current locations of this CE likely to overlap with the potential future distribution of CAs (other than climate change)?

Bull trout habitat overlaps areas with high burn probability in the Bruneau and Jarbidge rivers (Figures 6-5 and 6-6). Most growth in development is modeled to occur in existing population centers along the Snake River corridor where bull trout habitat does not currently exist.

6 Given current and anticipated future locations of CAs, which habitat areas remain as opportunities for habitat enhancement/restoration for this CE?

The cumulative indicator scores for bull trout under current conditions (Figure 6-12) identifies the Bruneau and Jarbidge rivers as key habitat that should be preserved and the best restoration opportunities to improve existing habitat may be along the Malheur River. This ecoregional evaluation did not examine the specific flow regimes and how flows in different portion of the ecoregion could be improved to make rivers more suitable for coldwater fish. In addition, invasive fish species can be an important limiting factor in native fish restoration. Figures 6-9 and 6-10 provide the aquatic invasive detections, however, local managers should consider invasive species type and abundance in river reaches considered for reintroduction or habitat enhancement.

7 Where are potential areas to restore connectivity for this CE, based on current locations of CAs?

The fish barriers database (Figures 6-7 and 6-8) provides locations where barriers exist and could be removed. Local managers should consider barrier ownership, type, and removal feasibility when considering which rivers reaches are most suitable to restore connectivity.

68 Where will aquatic CEs experience significant deviations from historic climate variation that potentially could affect the hydrologic and temperature regimes of these aquatic CEs?

RegCM3 (Hostetler *et al.* 2011) climate modeling predicts a slight increase precipitation in the basins, valleys, and uplands, and large increases in precipitation in the mountains by 2060. Perennial river flow would be expected to slightly increase in the majority of the ecoregion.

Water temperature changes due to climate change could potentially make habitat unsuitable in the low elevation areas of the ecoregion. Based on the analysis of winter flooding risk, most of the precipitation in the bull trout habitat will mostly continue as rain-dominated or be in a low winter precipitation area.

34 What is the condition (ecological integrity) of aquatic CEs?

See answer to management question #2.

40 Focusing on the distributions of terrestrial and aquatic CEs that are significantly affected by invasive species, which areas have restoration potential?

See answer to management question #6.

8 References

Andonaegui, C. 2003. Bull Trout Habitat Limiting Factors For Water Resource Inventory Area (WRIA) 62 (Pend Oreille County, Northeast Washington State). WA State Conservation Commission, Olympia, Washington 98504-7721. 477 pp.

Dunham, J., B. Rieman, and G. Chandler. 2003a. Influences of Temperature and Environmental Variables on the Distribution of Bull Trout within Streams at the Southern Margin of Its Range. *North American Journal of Fisheries Management* 23:894-904.

Idaho Invasive Species Council Technical Committee. 2007. Idaho Aquatic Nuisance Species Plan, A Supplement to Idaho's Strategic Action Plan for Invasive Species. 145 pp.

Leary, R.F., Allendorf, F.W., and Forbes, S.H. 1993. Conservation genetics of bull trout in the Columbia and Klamath river drainages. Conserv. Biol. **7**(4): 856–865.

Lorz, H.V., S.A. Sollid, D.G. Stevens, and J.L. Bartholomew. 2002. Comparative susceptibility of juvenile and yearling bull trout (*Salvelinus confluentus*) from the Deschutes River, OR, to different levels and durations of exposure to *Myxobolus cerebralis triactinomyxons.* 2002 Whirling Disease Symposium. http://whirlingdisease.montana.edu/biblio/pdfs/Symposia/ LorzWDS2002.pdf

McPhail, J.D., and J.S. Baxter. 1996. A review of bull trout (Salvelinus confluentus) life history and habitat use in relation to compensation and improvement opportunities (Fisheries management report, ISSN 0705-5390 ; no. 104)

Montana Bull Trout Restoration Team. 2000. Restoration Plan for Bull Trout in the Clark Fork River Basin and Kootenai River Basin Montana. Helena, Montana: Montana Bull Trout Restoration Team.

Rieman, B.E, D.C. Lee, and R.F Thurow. 1997. Distribution, status, and likely future trends of bull trout within the Columbia River and Klamath Basins. North American Journal of Fisheries Management 17: 1111-1125.

Rieman, B.E, and J.D. McIntyre. 1993. Demographic and habitat requirements for conservation of bull trout. General Technical Report INT-302. U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Ogden, Utah. 42 pp.

Salow, T. 2004. Population Structure and Movement Patterns of Adfluvial Bull Trout (Salvelinus confluentus) in the North Fork Boise River Basin, Idaho. MS Thesis functioning as a Technical Report for Upper Snake River Biological Opinion# 1009.2700. September, 2004. 132 pp.

U.S. Fish and Wildlife Service. 2002. Chapter 18, Southwest Idaho Recovery Unit, Idaho. 110 p. In: U.S. Fish and Wildlife Service. Bull Trout (*Salvelinus confluentus*) Draft Recovery Plan. Portland, Oregon. 121

White Sturgeon Conservation Element Package

1 Introduction

The white sturgeon, sensitive to changes in environmental conditions, are dependent on cold, clean waters of suitable depth and flow to allow reproductive-sized adult fish access to suitable spawning habitats (Idaho Department of Fish and Game 2008; Israel *et al.* 2009). Eggs and larvae require clean substrates, and cool waters to ensure healthy egg survival and larval development (Israel *et al.* 2009). Introduced species have been shown to limit their survival through alteration in foodwebs, and direct predations on larval and juvenile white sturgeon. Other factors that have limited white sturgeon abundance in the NGB ecoregions and prompted its inclusion as a CE are harvest, regional population isolation, loss of habitat connectivity, and loss of flowing water habitats by dams.

This CE package provides the assessment of the current status and future threats due to CAs for the white sturgeon in the NGB ecoregion. Information in this CE package includes a brief description of the biology of the white sturgeon in the NGB ecoregion, a description of CAs that were assessed, a conceptual model of ecosystem functions relevant to the white sturgeon, some information on potential data sources and analytical methods for the assessment, and a listing of relevant management questions (MQ) for this CE.

2 CE Package Review Process

2.1 Subject Matter Expert Review

Subject Matter Experts play a key role in ensuring that the REA reflects the best available data and modeling processes suitable for each conservation element and change agent. Subject Matter Experts were added to Rolling Review Teams comprised of SAIC scientists, SAIC GIS personnel, AMT member(s) and other subject matter experts from the Department of Interior or state agencies. Membership of the Rolling Review Teams is listed in Appendix A. To ensure consistency amongst the different Rolling Review Teams, the number of lead SAIC scientists was limited to only a few individuals. This ensured that there was a common approach, or framework, used among the different Rolling Review Teams and that one Rolling Review Team did not stray too far from the rest. The USGS, as peer reviewers, were invited to participate in Rolling Review Teams.

3 CE Description

Natural reproduction and occurrence of white sturgeon populations throughout the NGB may not be sustainable under current conditions. Their current distribution and abundance is dependent upon the intervention of resource managers. Therefore, as white sturgeon require hatchery production for their continued presence in the NGB, white sturgeon recruitment may not be as responsive to outside CAs as species that are not dependent on resource management for sustainability. Due to poor recruitment of naturally-spawned white sturgeon within the NGB, these populations may require ongoing aquaculture of and reach-specific releases of juveniles and the translocation of adults (Idaho Department of Fish and Game 2008).

3.1 White Sturgeon Life History Requirements

White sturgeon (*Acipenser transmontanus*) are a broadly distributed, long-lived (to 100 years) fish native to western north American rivers, streams, and some lakes (Emmett *et al.* 1991). In open systems adults are anadromous; however, they can also persist in closed, or isolated systems (e.g., upstream of impoundments). White sturgeon generally do not use fish ladders, so bypass measures are largely unsuccessful. The Idaho Fish and Game web site for white sturgeon states: “The healthiest populations of white sturgeon remaining in Idaho are found in the free-flowing stretch of the Snake River between the Bliss Dam and the upper end of C.J. Strike Reservoir in southern Idaho, and in the free-flowing Snake River from Lewiston upstream to Hell's Canyon Dam. Smaller numbers of sturgeon are also found in the Snake River below American Falls and C.J. Strike dams.” However, the Snake River Conservation Plan (Idaho Power Company 2005) indicates that “of the nine subpopulations in the Snake River in Idaho, only the Hells Canyon-Lower Granite and the Bliss-CJ strike reaches support viable populations.”

Adult white sturgeon have been documented to reach lengths approaching 20 feet (6 m) and weights of 1,400 lbs (635 kg) or more (Moyle 2002). As a long-lived species, they are slow in maturing. Studies in the warmer Sacramento-San Joaquin river systems have indicated that the youngest mature male was 6 years old, and female was 9 years, though more typical ages are 10 and 12 years of age, respectively (review in Israel et. al. 2009). Within the cooler Columbia River system, DeVore *et al.* (1995) found that the median age of first sexual maturity for females was 24 years of age. Within the Snake River, data suggest an average size of 5.4 ft (1.65 m) and 16 years of age before female sturgeon reach maturity (Idaho Power Company 2005).

White sturgeon are extremely fecund. In a review by Israel *et al.* (2009), this point was supported by the findings of Skinner (1962), who described a 9.2 ft (2.8-m), 460 lbs (206 kg) female white sturgeon that was estimated to yield 4.7 million eggs. Though not an annual spawner, they are repeat spawners over their lifetime and prefer spawning habitats with clean, fast-moving areas of rivers, downstream of rapids, with suitable gravel or larger rocks along the bottom. However, in a given year, only an estimated 10 percent are reproductively active (review in Idaho Power Company 2005). Spawning in the Snake River can occur from March to June (Idaho Power Company 2005). Eggs are adhesive; they sink toward the benthos, where they adhere to bottom gravels and hatch in 1-2 weeks.

Following emergence, yolk-feeding larvae can occur in the water column, which facilitates downstream dispersal (Brannon *et al.* 1984; McCabe and Tracy 1994). However, as larvae mature over their first few weeks, they adopt a demersal, or benthic, life strategy, becoming benthic foragers of available invertebrate prey resources. Brannon *et al.* (1984) found that as these young-of-the-year (YOY) reached the 40 days post-hatching point, and water temperatures increased (e.g. from 14.8° to 19.2°C), juvenile sturgeon biomass doubled every 2-3 weeks. As juveniles reach 2-3 years of age and older, their diet still includes benthic invertebrates, but also includes the eggs and fry of other fish, as well as dead fish (review in Israel *et al.* 2009; review in Idaho Power Company 2005). Once reaching adulthood, their diet includes these same items, but is primarily composed of fish (dead or alive), crustaceans, and mollusks.

Though predation can be a limiting factor, such as egg and larval predation by cottids (sculpin sp.) (review in Israel *et al.* 2009), generally within their first 1-2 years juvenile white sturgeon reach a size that limits natural predation pressures (McCabe and Tracy 1994; Israel *et al.* 2009). Dams have isolated populations and can limit gene exchange. In addition, the presence of dams can adversely affect the quality of spawning habitats and can result in altered water quality both above and below the dam. Temperature tolerance of this species varies with age (review in Israel *et al.* 2009), but is particularly limiting for egg survival, larval development, juvenile rearing, and adult spawning. Reduced flows are also associated with adverse effects on white sturgeon due to its association with a reduction in water quality. Reduced flows increase stream temperatures and can result in localized decreased dissolved oxygen levels, creating unsuitable habitat and a non-physical barrier for fish movement. In addition, alterations in seasonal flows can mask migrational cues for white sturgeon.

As a long-lived and benthic-associated fish species, white sturgeon can be more susceptible to the bioaccumulation of contaminants than shorter-lived species. Metals and PCBs (polychlorinated biphenyls) can lead to decreases in survival and increased deformities in white sturgeon eggs, larvae, and juveniles (Parsley *et al.* 1989; review in Israel *et al.* 2009). Lastly, due to the fecundity of large female sturgeon, both legal and illegal fishing, that results in the removal of late-maturing reproductive adults can severely limit future year class strength and long-term persistence within a given system.

4 CE Modeling

4.1 Data Identification

Table 4-1 provides a brief summary of potentially available data sources that may be available to document the range and occurrence of white sturgeon within the NGB&R.

Table 4-1. Preliminary List of White Sturgeon Data Sources

Data Required	Dataset Name	Source Agency	Type/Scale	Status	Use in REA
Modeled Rearing Suitable Habitat	TBD	State agencies	Polygon	Data Gap	No
Modeled Suitable Spawning Habitat	TBD	State Fish & Game agency data	Polygon	Data Gap	No
Documented Spawning Sites	TBD	NMFS, U.S. Fish and Wildlife Service, State Agencies	Point?	Data Gap	No
Dams and Fish Ladders	National Inventory of Dams	USACE	Point	Data Gap	No
	Fish Barriers	U.S. Fish and Wildlife Service	Point	Data Acquired	Yes
Current Distribution	StreamNet	Pacific States Marine Fisheries Commission	Polygons	Data Acquired	Yes

4.2 Distribution Mapping Methods

Currently the only data source for white sturgeon in the ecoregion is Streamnet data. The current distribution data can be viewed in Figure 4-1. Since this species upstream movement is blocked by dams and downstream movement is only available over spillways, populations can become locked into defined reaches of the Snake River. This was expanded upon in Section 6 under the discussion of barriers to movement.

4.3 Data Gaps, Uncertainty, and Limitations

4.3.1 Data Gaps

The main data gap was the USACE National Inventory of Dams, but the National Atlas Dams layer was able to locate the fish barriers since they are large dams along the Snake River. Detailed mapping of these individual stretches (free flowing vs. artificial [reservoir]) and suitable habitats within these stretches was a data gap.

4.3.2 Uncertainty

The StreamNet distribution extends beyond Shoshone Falls all the way to Twin Falls. The Idaho Department of Fish and Game 2008 document, Management Plan for the Conservation of Snake River White Sturgeon in Idaho, only gives detailed information on the sub ranges up to Shoshone Falls and nothing above it. The length of stream between the two dams is 4.2 km and there was no additional information as to whether it was free flowing.

Information is available on the amount of free-flowing and impounded habitat within each of the Snake River reaches occupied by white sturgeon (Idaho Department of Fish and Game 2008). However, the geospatial locations of suitable habitat within these reaches were not available for the ecoregional analysis; this uncertainty limits our ability to evaluate key ecological attributes by 4 km analysis unit in actual suitable habitat. This type of analysis may be more properly the focus of a drill-down effort.

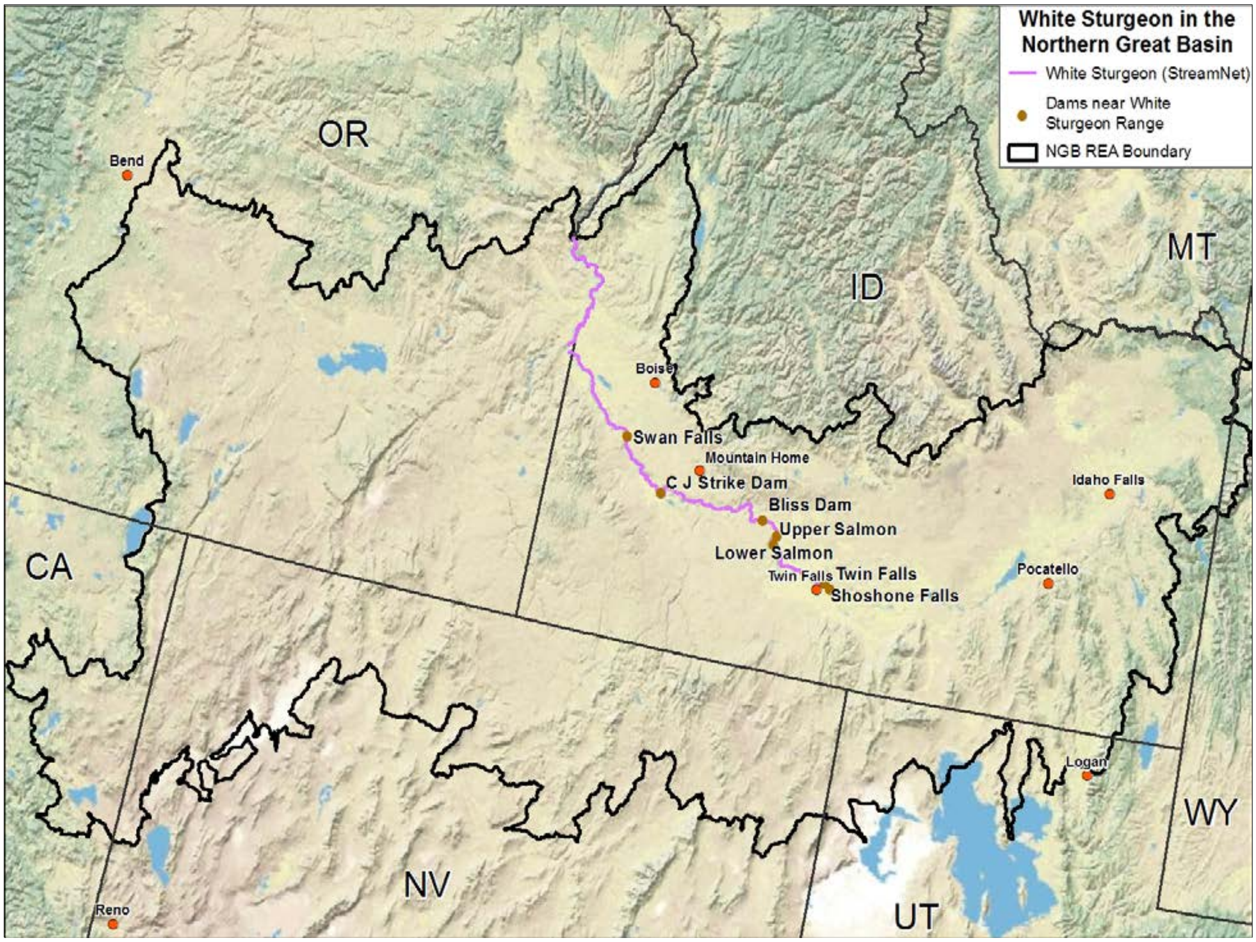


Figure 4-1. White Sturgeon Location within the Ecoregion (StreamNet)

5 System Models

The system level conceptual model (Figure 5-1) illustrates the interactions between the CAs and the primary habitat functions for white sturgeon. The most important CAs for white sturgeon are climate change, development, and introduced species, but wildfire and disease are also included in the model due to their potential to affect water quality and habitat. Although white sturgeon have not experienced regional population impacts comparable to whirling disease in salmonids, the effects that introduced diseases have had on other fish species highlight the potential regional effects introduced diseases could have on white sturgeon populations.

The conceptual model (Figure 5-1) illustrates the interactions between the CAs and the primary habitat functions for white sturgeon in this ecoregion. Any CA that positively or negatively influences these factors has the potential to influence white sturgeon distribution and population levels in the region. Habitat functions include biotic and abiotic processes that may occur at local and landscape-levels (Figure 5-1). The model was developed to provide a scientific framework and justification for the choice of indicators that were used in assessing CA threats for this CE. The CAs included in the analysis are development, climate change, wildfire, disease, and introduced species. The conceptual model depicts our current understanding of the most important habitat functions in the systems occupied by this CE without regard for data availability or suitability of a habitat function for an ecoregion-level assessment. Following sections of this appendix will explain why certain elements in the model were carried forward in the analysis and why others were not.

5.1 Development

A variety of human development projects affect white sturgeon and the habitats upon which they are dependent. Within the NGB, these include roads, mining, logging, dams, culverts, diversions, impoundments and reservoirs. Development projects such as dams have also necessitated associated development projects such as fish hatcheries, roads, and transmission lines.

Logging, mining, roads, water diversions and impoundments, and urban/exurban development can result in sedimentation, adverse changes to channel configuration, loss of riparian habitats, reductions in large woody debris, shade, available food resources, and adverse impacts to water and sediment quality associated with precipitation events and reservoir needs (review in Johnson *et al.* 1995; Israel *et al.* 2009). In addition, human population growth and development can lead to degradation of water quality from roads and agricultural runoff, mining, and municipal wastes.

Impoundments, such as those along the Snake River (Hell's Canyon Dam and upstream), alter and fragment riverine habitats, and limit fish movements between upstream and downstream reaches (Lepla *et al.* 2003). Within river systems impeded by dams, the reservoir levels and associated flows require seasonal adjustment by the USACE, which is mandated to facilitate fish access to and use of habitats, as well as maintaining suitable instream temperatures during critical life history periods of these fish (Lepla *et al.* 2003; Rust and Wakkinen 2008).

5.2 Climate Change

As with other regions where the species is distributed, potential threats to white sturgeon attributable to climate change include the decrease of flows due to changing precipitation regimes and the potential increase of riverine and reservoir water temperatures (Lepla *et al.* 2003; Israel *et al.* 2009). In general, white sturgeon favor moderate to fast water and can be found in deeper mid-channel areas. Sufficient seasonal flows are required for successful spawning. Within highly studied systems, successful white sturgeon spawning is tightly correlated with wetter water years (Israel *et al.* 2009). A reduction in these events reduces the number of years in which conditions are favorable for successful spawning and recruitment events. In addition, drier water years can amplify the water quality degradation from agricultural runoff and municipal wastes. Increases in nutrient loads can reduce dissolved oxygen, which can lead direct mortality or decreased fitness due to a reduction and feeding activity (Lepla *et al.* 2003; Israel *et al.* 2009). Reductions in flow not only reduce velocity, but alter sediment distribution, island development, water depth and channel morphology, as well as increase the risk of colonization of riparian habitats by non-native riparian vegetation (Johnson *et al.* 1995).

5.3 Introduced Species

The establishment and introduction of non-native fishes in waters occupied by white sturgeon likely affects this species by increasing competition with and predation by these species. Within the Snake River above Hell's Canyon Dam, there is very poor recruitment of new year classes of white sturgeon, even though older, reproductive-aged fish are present (Lepla *et al.* 2003). Poor survival of younger age classes within this portion of the Snake River may be due to predation by other fish, including non-native species. Along the Pacific coast, a number of white sturgeon populations have shown indications that younger age class survivability may be limited due to predation by non-indigenous fish species (Israel *et al.* 2009). Non-native species generally prey on eggs, larvae and younger juveniles (< year 2-3) before juvenile sturgeon growth is sufficient to provide them a size refuge from fish predation pressures (Israel *et al.* 2009). A number of non-native species introduced into Snake River systems, such as channel catfish, smallmouth bass, and walleye, may play a role in limiting the survivability and recruitment of naturally-spawned white sturgeon. With repeated recruitment failures, this species appears to be nearing complete dependence on artificial propagation to sustain their existence in this portion of the Snake River system.

5.4 Wildfire

Wildfire affects aquatic habitats and associated biota through a reduction in riparian vegetation. Climate change has the potential to increase the prevalence of wildfires in the presence of fuels and ignition source in relation to the timing of snowmelt (Haak *et al.* 2010). An increase in wildfire prevalence would likely result in a corresponding decrease of riparian habitat function and benefit to the associated stream or river system, and has been considered as a disturbance that may provide an ecological advantage for non-native species introductions of fish species (Dunham *et al.* 2003).

5.5 Disease

White sturgeon appear to be resistant to whirling disease and also to other salmonid diseases including infectious pancreatic necrosis virus (IPNV) and IHN, and do not appear to be carriers of these diseases (Canadian Columbia River Inter-Tribal Fisheries Commission 2005; LaPatra *et al.* 2011). However, white sturgeon are at risk for other diseases, including white sturgeon iridovirus disease (WSID). Wild populations may be susceptible to due to their occurring in dense populations and often being dependent on aquaculture and hatchery transplants to maintain adequate breeding populations with recent failing natural recruitment (LaPatra *et al.* 1996). These risks are likely greater than would occur in natural populations as white sturgeon iridovirus disease is more prevalent in dense populations, and can spread rampantly in hatcheries (LaPatra *et al.* 1996; Drennan *et al.* 2005).

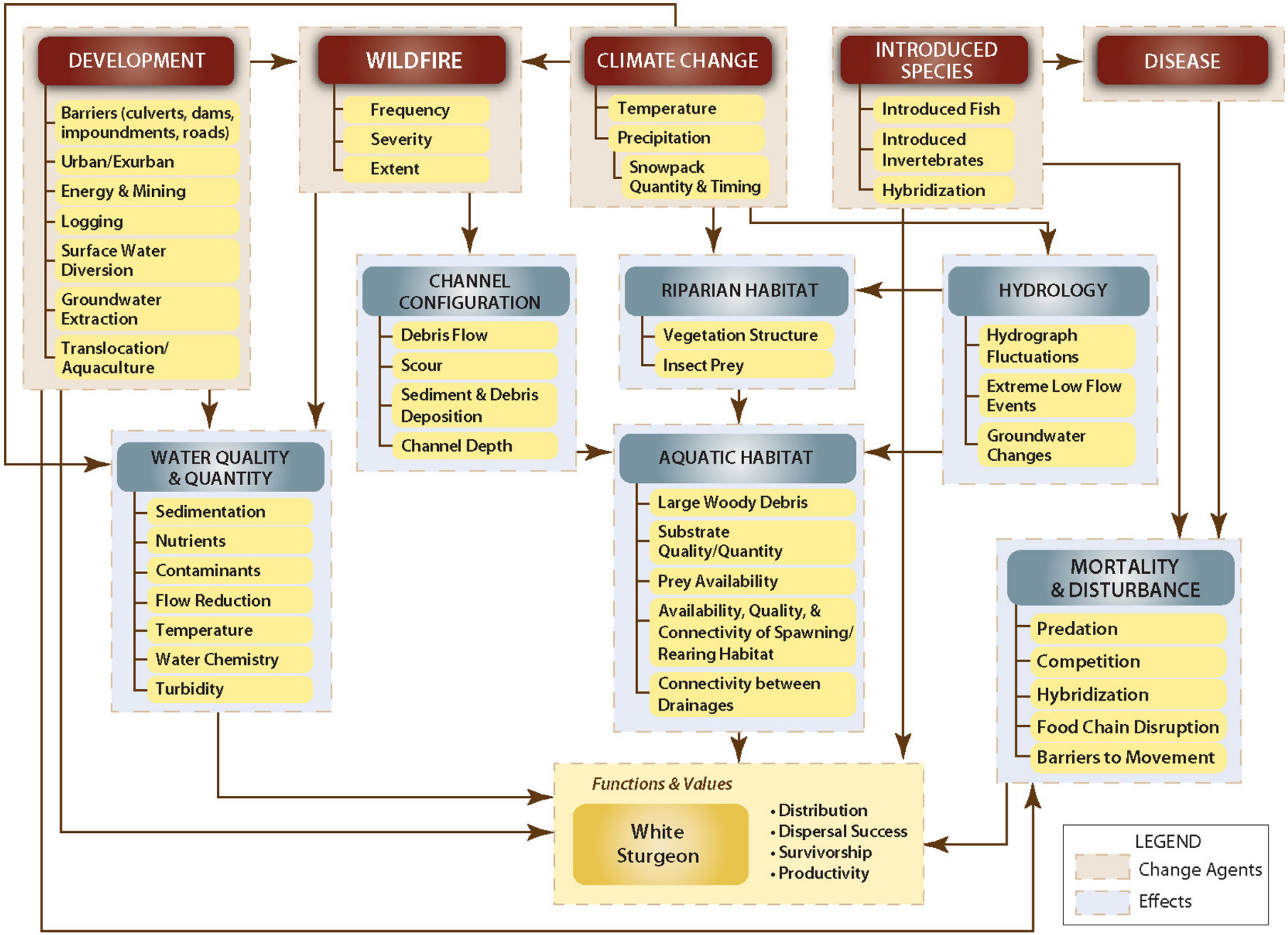


Figure 5-1. White Sturgeon Conceptual Model

6 Change Agent Threat Analysis

Current status and future threat assessments for the white sturgeon CE was conducted for the NGB ecoregion using 30 m pixel, 4 km and 12-digit HUC as the analysis units. Based on the conceptual system model for the assemblage (Figure 5-1), key ecological attributes were identified for the current status and future threat analyses with an emphasis on the feasibility of measuring impacts using geospatial data. The CAs evaluated for current status will initially include development, wildfire, climate change, introduced species, and disease.

6.1 Key Ecological Attributes

The preliminary list of key ecological attributes (Table 6-1) suggests some indicators for assessing habitat size, condition, and landscape context with respect to anthropomorphic influences. In some cases, we may need to suggest surrogate indicators for measuring potential effects as indicted in the conceptual model. For example, to establish a metric for water quality of habitat for white sturgeon occurrence, spawning, and rearing, we may need to measure distance to potential sources of pollution such as agricultural operations (feedlots, croplands) or energy developments.

Table 6-1. Preliminary List of White Sturgeon Key Ecological Attributes and Indicators

Ecological Attribute	Indicator	Data Source	Reference
Landscape Structure	Riparian habitat condition	No Geospatial Data	Need citations
Water Quality Factors	Instream temperatures	USGS Stream Gage	Need citations Lepla *et al.* 2003; Rust and Wakkinen 2008; Israel *et al.* 2009
	Instream flow (hydrographs)	USGS Stream Gage	Israel *et al.* 2009
	Dissolved oxygen	Limited Sampling	Israel *et al.* 2009
	Contaminants, turbidity, sedimentation	303d lakes and streams (EPA)	Parsley *et al.* 1989; review in Israel *et al.* 2009
	Alterations in reservoir operations	No Data Available	Israel *et al.* 2009
Wildfire	Wildfire	Fire SIMulation Burn Probability	Need citations
Physical Barriers (Surface Water Diversion)	Fish Barriers	Idaho Department of Fish and Game	Lepla *et al.* 2003
Introduced Species	Aquatic Invasive Detections	USFS Aquatic Invasives	Israel *et al.* 2009
Disease		No Spatial Data	LaPatra *et al.* 1996; Drennan *et al.* 2005

6.2 Current Status of the CE

This section will document the CA analysis under current conditions, i.e. the current extent of the CE's distribution and locations of the CAs. For each of the key ecological attributes listed in Table 6-1 and used in the CA analysis, a discussion of the indicator, metrics, metric rank and value, data source(s), and references were provided. The analysis was based on spatially available attributes affecting the CE at the ecoregion level.

6.2.1 Water Quality

6.2.1.1 Instream Temperature

There were two stream gages that contained a long (25-50 years) record of instream temperature measurements as displayed in Figure 6-1. Both stream gages show some data gaps where the gage may have been not maintained or where it may have only been used seasonally. One of the gages is in the lower Snake River between Swan Falls and where the Snake River leaves the ecoregion towards Brownlee Dam. This part of the Snake River is one of the poorest sections for white sturgeon with only the first 22 km below Swan Falls suitable for white sturgeon (Idaho Department of Fish and Game 2008). The raster graph shows very elevated water temperatures in July and August annually. The other stream gage is further upstream below the Bliss Dam and shows a similar pattern of increased temperatures in July and August but much lower temperatures and shorter duration.

6.2.1.2 Instream Flow

There were five stream gages that contained a long (50+ years) record of instream flow measurements as displayed in Figure 6-2. The raster graphs appear to show July through September seem to be the lowest flow months with a variety of average flows depending on the section of the Snake River. The Lower Salmon Falls Dam gage station is reporting fairly low flows year round with some variation on an annual basis.

6.2.1.3 Dissolved Oxygen

There were three gage stations along the Snake River (Figure 6-3) with a good amount of dissolved oxygen monthly sampling. The state of Idaho uses 6 mg/l to be the standard for the minimum acceptable level. Viewing the charts of dissolved oxygen there were very few years that fell below the 6 mg/l.

6.2.1.4 Contaminants, Turbidity and Sedimentation

Similar to dissolved oxygen, turbidity is another parameter measured at some larger rivers or during monthly water sampling at select gage sites. The 303d waters dataset from the EPA was used as a surrogate to determine the percentage of waters that were listed as 303d within the analysis unit. The main causes of 303d classification within white sturgeon waters were: fecal coliform, mercury, sedimentation / siltation and temperature. Figures 6-4 and 6-5 show the resulting percentage of 303d waters per analysis unit.

6.2.1.5 Alterations in Reservoir Operations

There was no information on alterations in reservoir operation and this key ecological attribute was identified as a data gap for the ecoregion.

6.2.2 Wildfire

The dataset used to analyze wildfire was the Fire SIMulation developed by the USFS and USGS. Figures 6-6 and 6-7 displays the burn probability for analysis units containing white sturgeon. Most of the white sturgeon range in the ecoregion falls into the high burn probability or classified as unburnable. The most northern part of the white sturgeon range as it leaves the ecoregion has the lower burn probability.

6.2.3 Barriers to Movement

The upstream movement of the white sturgeon in the Snake River is restricted by seven to eight dams within the ecoregion (Figure 6-8). There are no fish ladders suitable for white sturgeon so the only mobility for sturgeon is downstream over the spillway or through a turbine (Idaho Department of Fish and Game 2008). Table 6-2 lists the reaches between dams, the amount of free flowing river and the estimate of white sturgeon population size.

Table 6-2. White Sturgeon Habitat between Barriers in the Snake River

Reach	Free Flowing River (km)	Reservoir (km)	Sturgeon Rearing Habitat (km)	Population Estimate
Shoshone Falls to Twin Falls	*StreamNet shows White Sturgeon presence, report from IDFG 2008 doesn't.*			
Shoshone Falls to Upper Salmon	47	7	44	777
Upper Salmon Falls to Lower Salmon Falls	1	10	11	21
Lower Salmon Falls to Bliss Dam	13	8	21	83
Bliss Dam to C.J. Strike Dam	67	38	90	3013
C.J. Strike Dam to Swan Falls Dam	40	17	42	556
Swan Falls Dam to Brownlee Dam	189	84	222	155
Source: Management Plan for the Conservation of Snake River White Sturgeon in Idaho (IDFG 2008) http://fishandgame.idaho.gov/public/fish/planSnakeWhiteSturgeon.pdf				

6.2.4 Aquatic Invasives

The main source for aquatic invasive species was the USFS aquatic invasive detections dataset. Figures 6-9 and 6-10 show the amount of detections with the analysis units (HUC 12 and 4 km grid). Two elements of uncertainty for aquatic invasives are:

1. All invasive detections were used. A more detailed analysis may exclude certain types of aquatic invasives that do not impact white sturgeon.
2. The USFS dataset shows locations where invasives were detected and is a presence-only dataset. Locations with no detections may contain invasives but haven't been surveyed or reported.

6.2.5 Cumulative Indicator Score

The metrics for water quality, aquatic invasives, burn probability and fish barriers were used to estimate the cumulative score. The individual metrics were scored with a 1, 2 or 3 with 1 given to lowest quality indicator and 3 given to the highest quality indicator. The metrics were then added together to derive a range of cumulative scores. Figures 6-11 and 6-12 shows the resulting high and low scoring areas by HUC 12 and 4 km grid respectively.

6.3 Future Threat Analysis

6.3.1 Development

Agricultural development in the ecoregion has resulted in widespread construction of dams or diversion structures for surface water withdrawals that have reduce flow. Impoundments along the Snake River (Hell's Canyon Dam and upstream) alter and fragment riverine habitats and limit fish movements between upstream and downstream reaches (Lepla *et al.* 2003). Within river systems impeded by dams, the reservoir levels and associated flows require seasonal adjustment by the USACE, which is mandated to facilitate fish access to and use of habitats, as well as maintaining suitable instream temperatures during critical life history periods of these fish (Lepla *et al.* 2003; Rust and Wakkinen 2008).

6.3.2 Climate Change

As with other regions where the species is distributed, potential threats to white sturgeon attributable to climate change include the decrease of flows due to changing precipitation regimes and the potential increase of riverine and reservoir water temperatures (Lepla *et al.* 2003; Israel *et al.* 2009). Based on the Hostetler predictive models of climate change, the mountains within the NGB REA will experience a slight to moderate increase in snow water equivalent while snow water equivalent in the basins, lower elevations of the Owyhee Uplands, and Snake River Plains will remain the same. Precipitation during the March to May period will also increase in the mountains and the average temperature across the NGB REA will decrease by about -0.5 degree C during this period which suggests an increase in snowfall. Therefore, with slight to moderate increases in snow water equivalent, the spring runoff would be expected to slightly increase.

The gains in spring runoff may be offset by summer temperature changes and associated irrigation withdrawals. White sturgeon are sensitive to instream temperature (Haak *et al.* 2010). The Hostetler model forecast predicts no change in annual temperature across the entire NGB REA. However, temperatures are expected to increase by one degree in July and August. Agricultural irrigation demands are highest in the summer (July and August) and the slight increase in temperature may require additional surface water diversion for irrigation during the summer months.

6.3.3 Wildfire

Forest fires accelerate sediment transport from mountain drainage basins. Transport processes range from sediment-charged floods to debris flows (Meyer *et al.* 2001). These erosion events following fires can have short-term, detrimental effects but long-term importance for land and stream form development (Benda *et al.* 2003). Intense fire can result in the temporary loss of riparian vegetation, sedimentation, loss of shading and water temperature increases. However, since the white sturgeon habitat is limited to the Snake River, fire impacts will be muted by the large watershed contribution area and numerous dams along the river.

6.3.4 Invasives and Disease

Non-native species generally prey on eggs, larvae and younger juveniles (< year 2-3) before juvenile sturgeon growth is sufficient to provide them a size refuge from fish predation pressures (Israel *et al.* 2009). A number of non-native species introduced into Snake River systems, such as channel catfish, smallmouth bass, and walleye, may play a role in limiting the survivability and recruitment of naturally-spawned white sturgeon. With repeated recruitment failures, white sturgeon appear to be nearing complete dependence on artificial propagation to sustain their existence in this portion of the Snake River system.

White sturgeon are at risk for other diseases, including white sturgeon iridovirus disease. Wild populations may be susceptible to due to their occurring in dense populations and often being dependent on aquaculture and hatchery transplants to maintain adequate breeding populations with recent failing natural recruitment (LaPatra *et al.* 1996). These risks are likely greater than would occur in natural populations as white sturgeon iridovirus disease is more prevalent in dense populations, and can spread rampantly in hatcheries (LaPatra *et al.* 1996; Drennan *et al.* 2005).

6.3.5 Grazing

Grazing animals and pasture production can also negatively affect water quality through erosion due to trampling of soils, nutrients dropped by the animals, and introduction of pathogens into streams from livestock wastes (Hubbard 2004). Un-fenced riparian zones are often trampled by grazing activities (Sada and Vinyard 2002) adversely affecting shading and stream temperatures. High-density stocking and grazing in riparian zones can impact the water quality of streams and rivers that fish depend on.

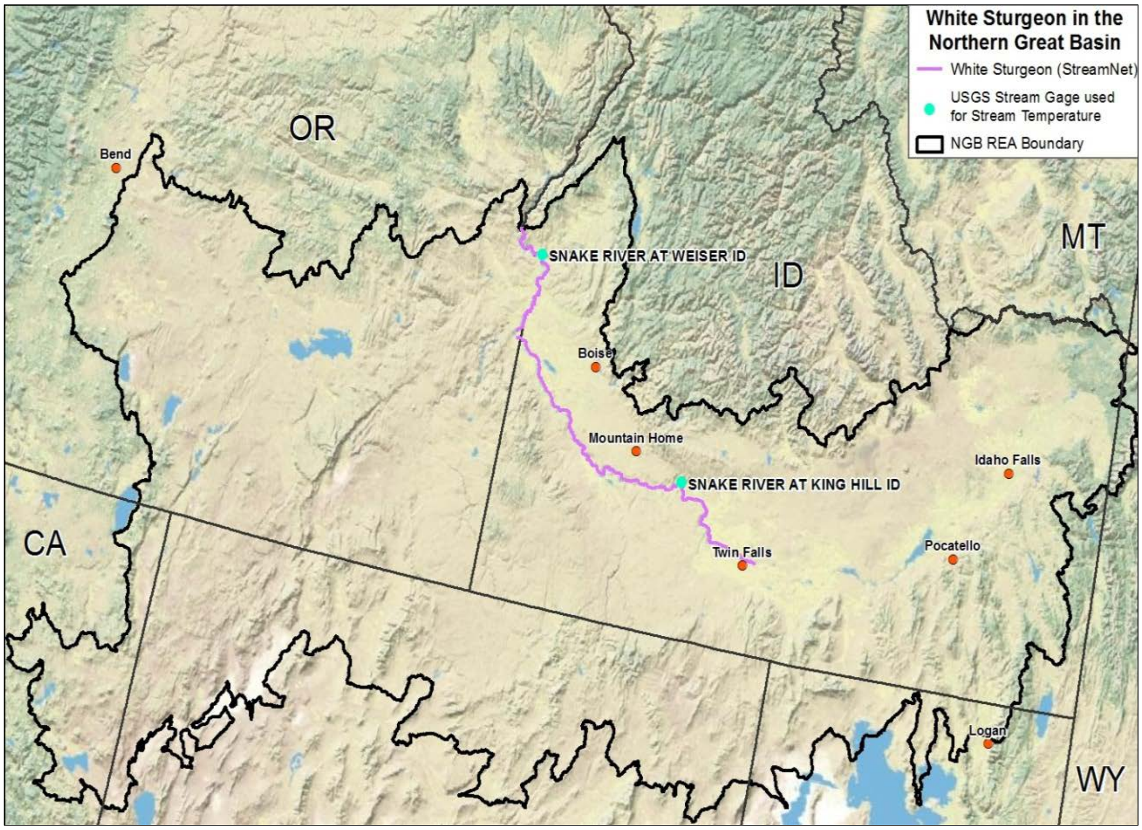


Figure 6-1. Instream Temperature Stream Gage Sites

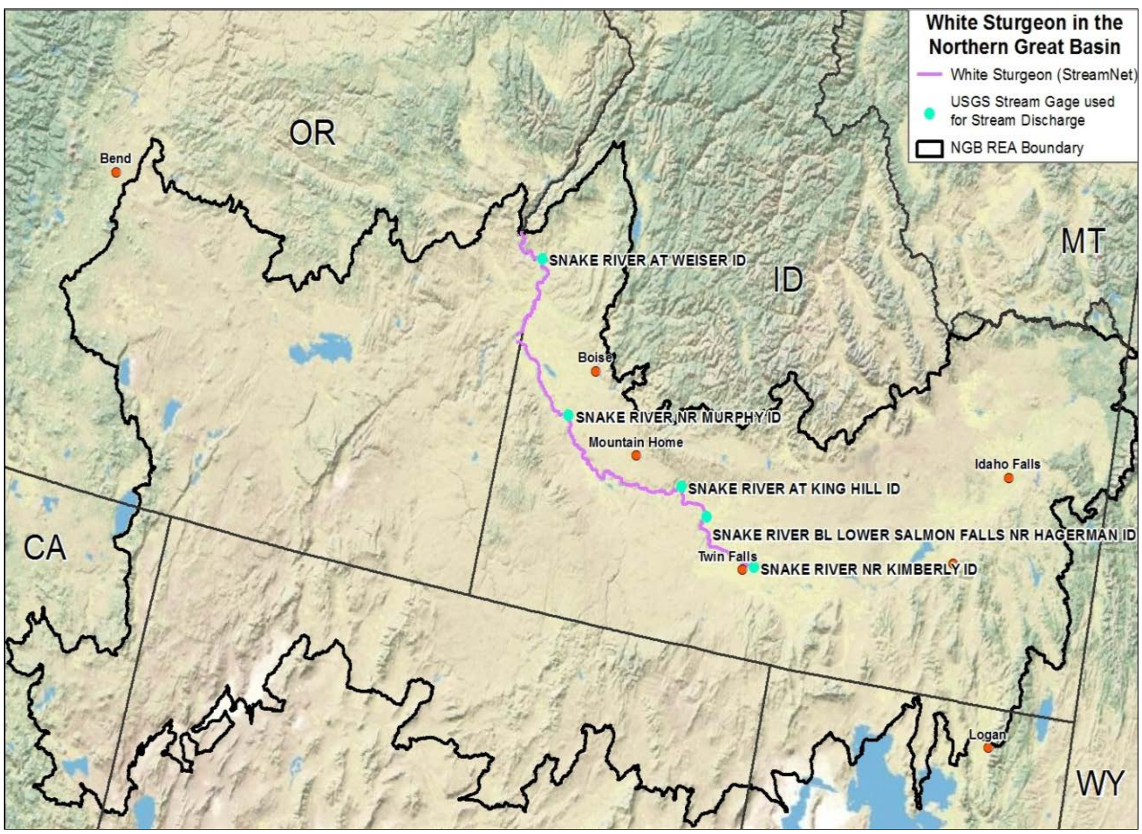


Figure 6-2. Instream Flow Stream Gage Sites

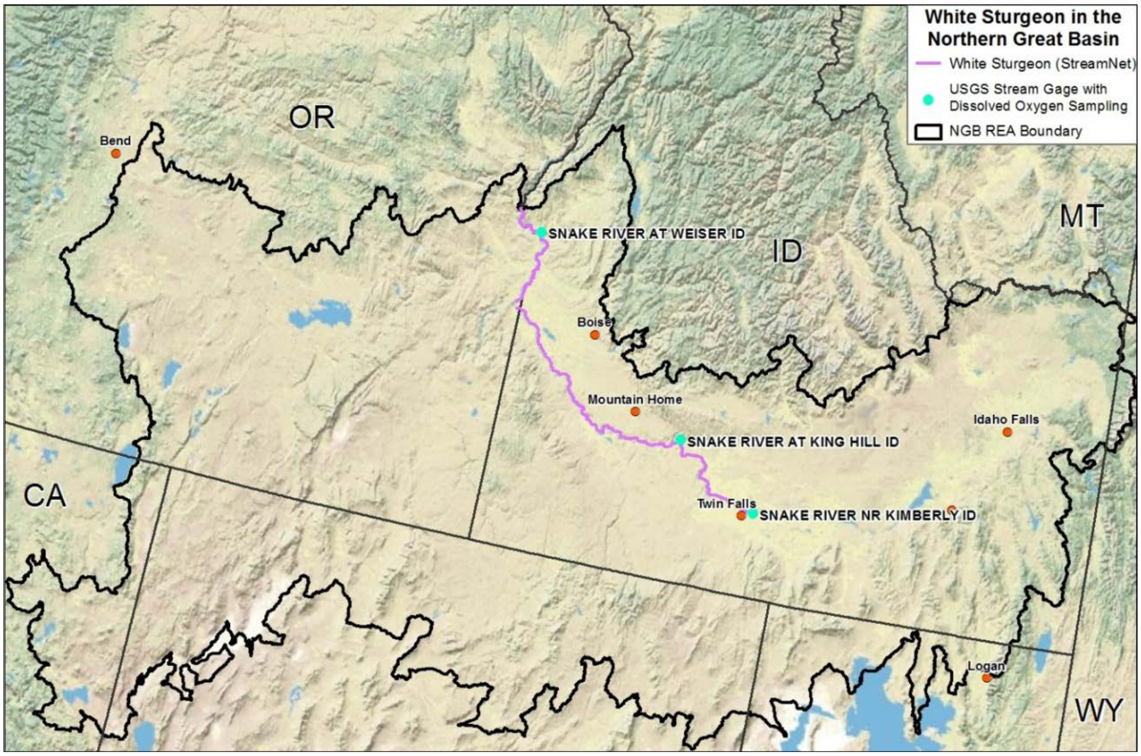


Figure 6-3. Instream Dissolved Oxygen Stream Gage Sites

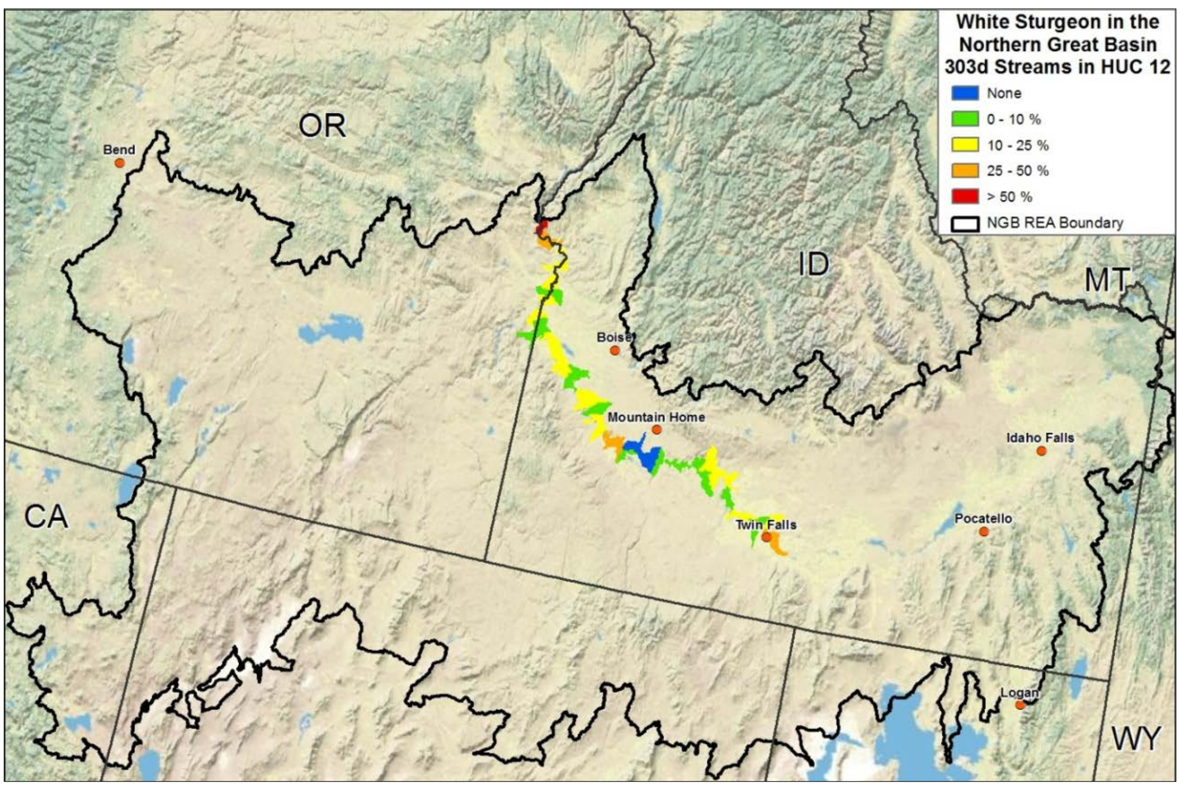


Figure 6-4. Percent of HUC12 with Waters Listed as 303(d)

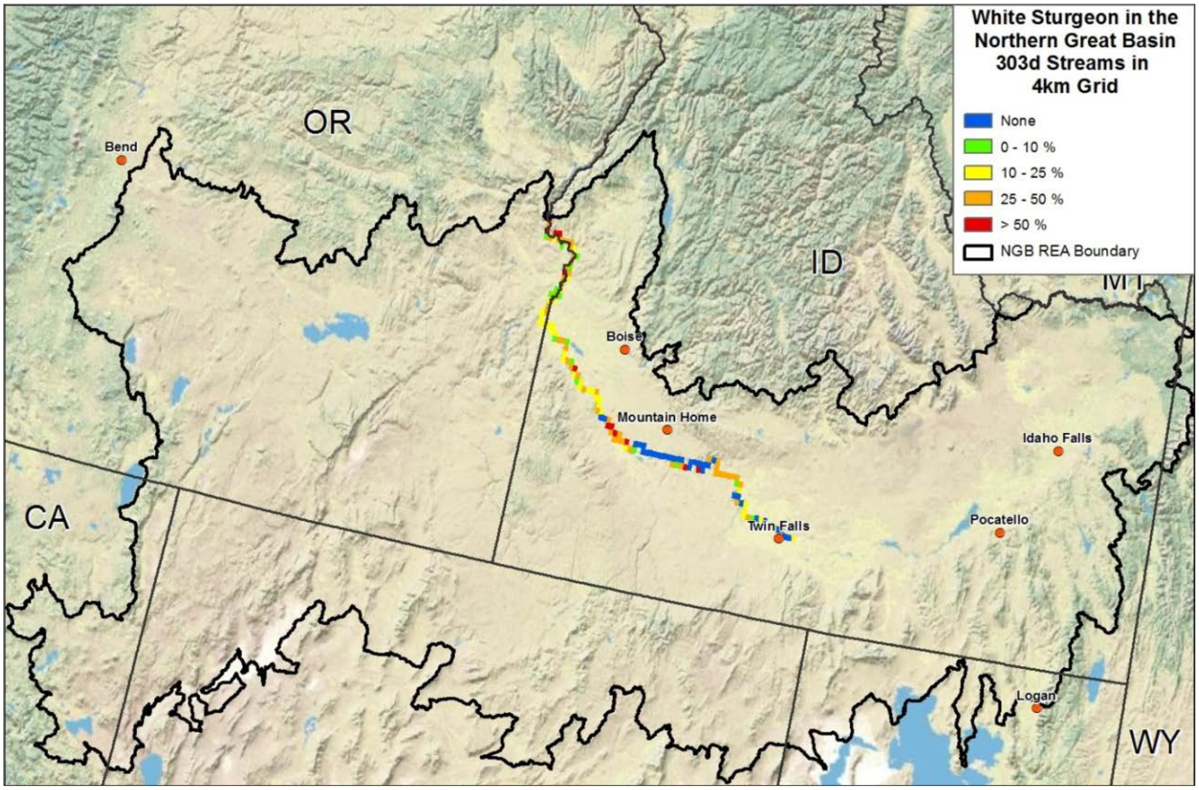


Figure 6-5. Percent of 4 km Grid with Waters Listed as 303(d)

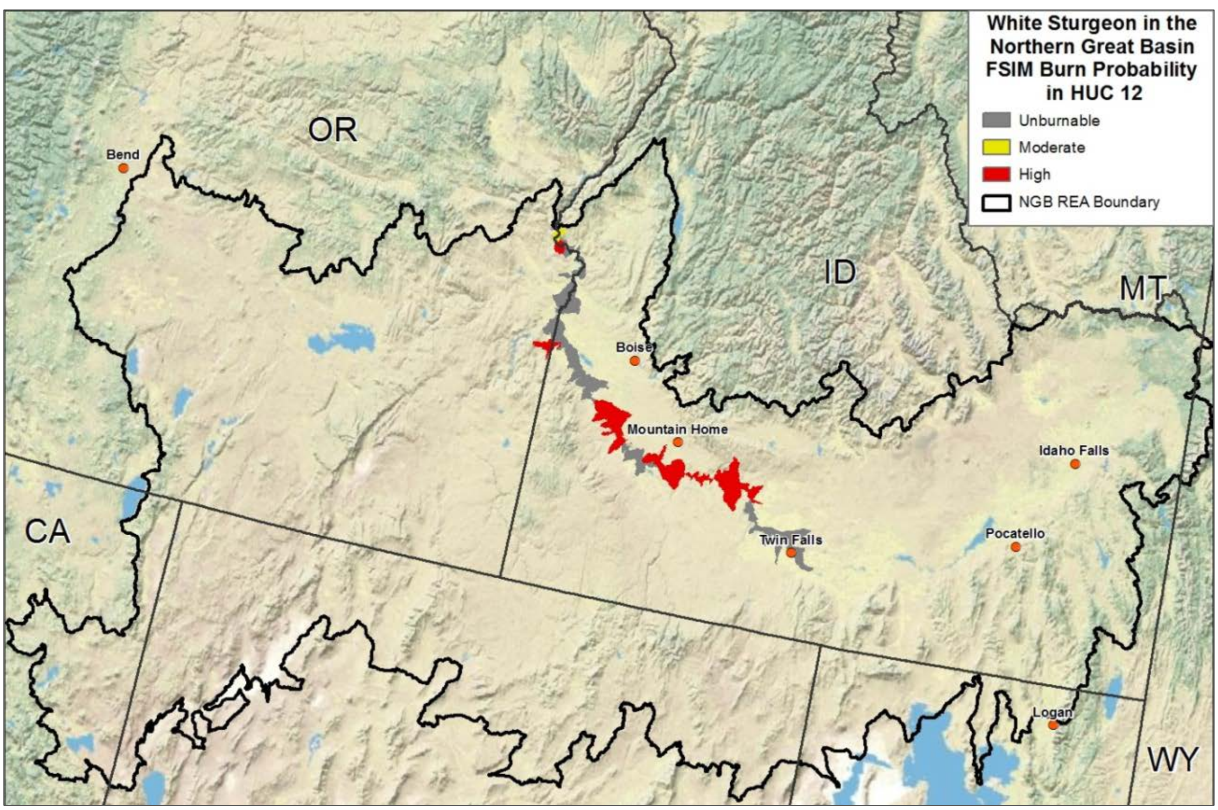


Figure 6-6. Burn Probability by HUC 12 for Grid for White Sturgeon

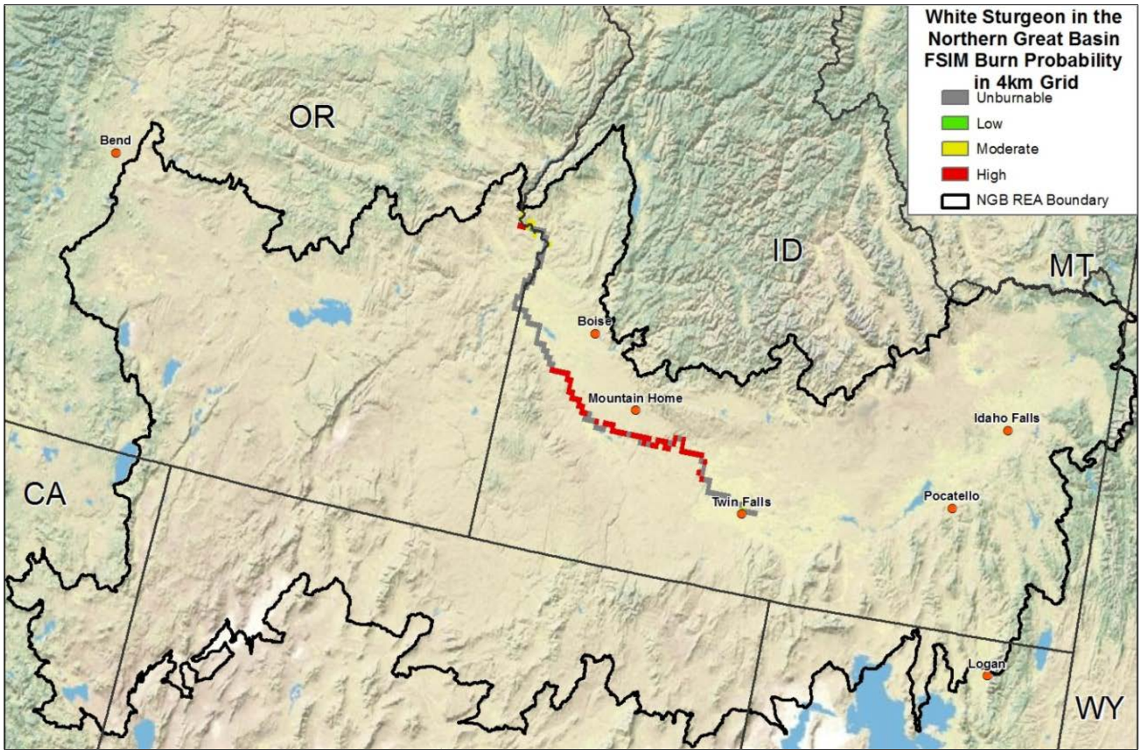
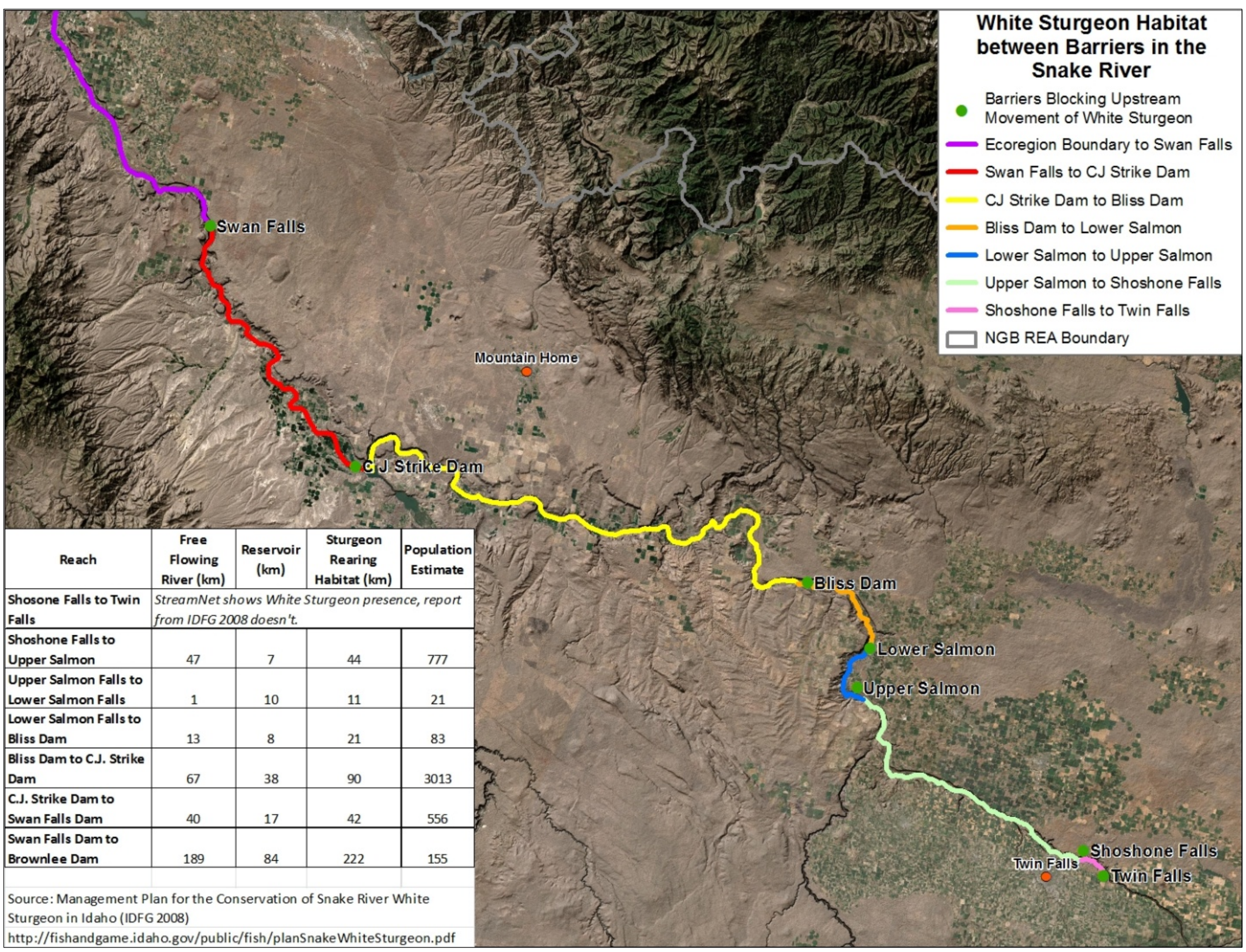


Figure 6-7. Burn Probability by 4 km Grid for White Sturgeon



Reach	Free Flowing River (km)	Reservoir (km)	Sturgeon Rearing Habitat (km)	Population Estimate
Shosone Falls to Twin Falls	*StreamNet shows White Sturgeon presence, report from IDFG 2008 doesn't.*			
Shoshone Falls to Upper Salmon	47	7	44	777
Upper Salmon Falls to Lower Salmon Falls	1	10	11	21
Lower Salmon Falls to Bliss Dam	13	8	21	83
Bliss Dam to C.J. Strike Dam	67	38	90	3013
C.J. Strike Dam to Swan Falls Dam	40	17	42	556
Swan Falls Dam to Brownlee Dam	189	84	222	155

Source: Management Plan for the Conservation of Snake River White Sturgeon in Idaho (IDFG 2008)
http://fishandgame.idaho.gov/public/fish/planSnakeWhiteSturgeon.pdf

Figure 6-8. White Sturgeon Habitat between Barriers in the Snake River

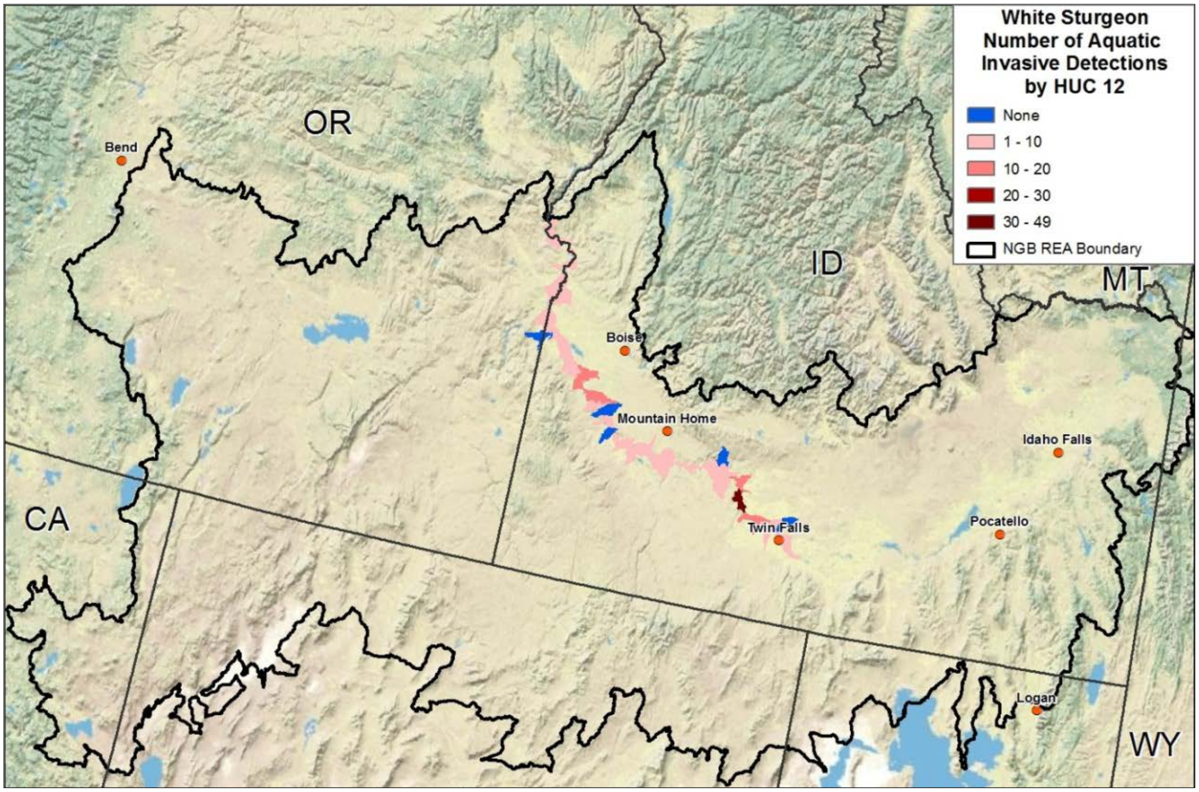


Figure 6-9. Aquatic Invasive Detections by HUC 12 for White Sturgeon

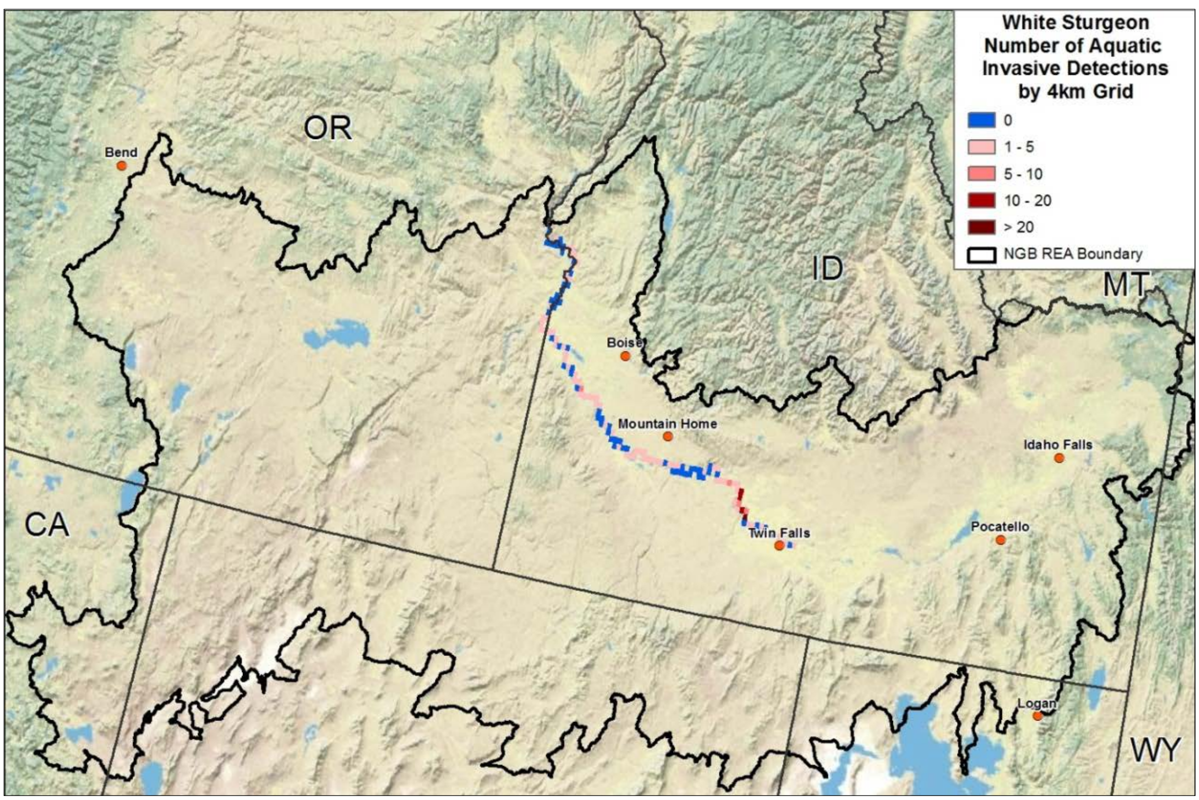


Figure 6-10. Aquatic Invasive Detections by 4 km Grid for White Sturgeon

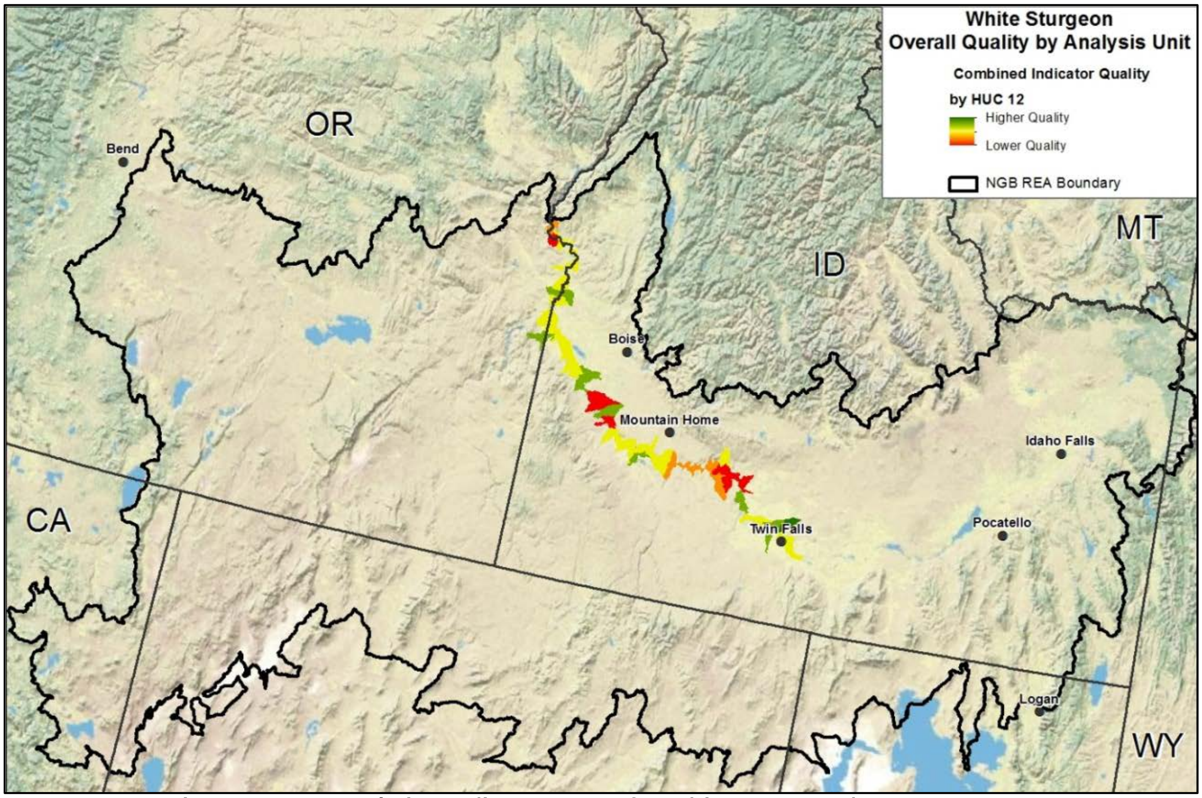


Figure 6-11. Cumulative Indicator Score for White Sturgeon by HUC 12

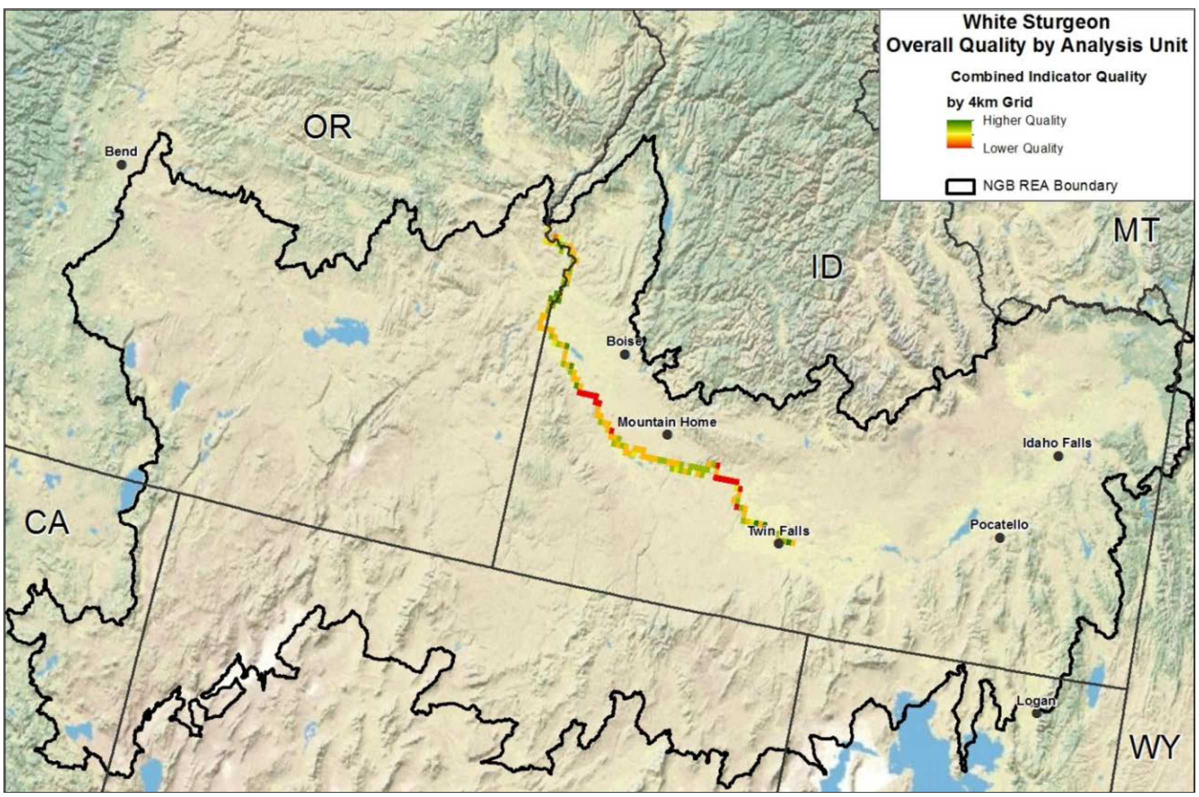


Figure 6-12. Cumulative Indicator Score for White Sturgeon by 4 km Grid

7 Management Questions

Management questions for the NGB were developed by BLM managers and refined by the AMT to answer questions regarding the agency's land management responsibilities—including planning land use, developing best management practices, authorizing uses, and establishing conservation and restoration priorities. Several management questions relate to the white sturgeon CE:

1 What is the currently occupied habitat or modeled suitable habitat for this CE?

The white sturgeon currently occupied habitat is shown in Figure 4-1.

2 Where are the areas of greatest and least collective impact of existing CAs on occupied habitat or modeled suitable habitats of this CE?

The white sturgeon cumulative indicator score is provided in Figure 6-12 by HUC 12 watershed.

3 What is the current distribution of suitable habitat, including seasonal habitat and movement corridors, for each landscape species and species assemblage CE?

The suitable habitat with barriers to movement are provided in Figure 6-7.

4 Where are existing CAs potentially affecting this current habitat and/or movement corridors, for landscape species and species assemblage CEs?

The white sturgeon cumulative indictor score is provided in Figure 6-12 by HUC 12 watershed. This shows where existing CAs are affecting the current habitat.

5 Where are current locations of this CE likely to overlap with the potential future distribution of CAs (other than climate change)?

Most growth in development is modeled to occur in existing population centers along the Snake River corridor where white sturgeon habitat is low scoring.

6 Given current and anticipated future locations of CAs, which habitat areas remain as opportunities for habitat enhancement/restoration for this CE?

The cumulative indicator scores for white sturgeon habitat under current conditions (Figure 6-12) should be useful in identifying the areas most in need of preservation or the best restoration opportunities. This ecoregional evaluation did not examine the specific flow regimes and how flows in different portion of the ecoregion could be improved to make rivers more suitable for white sturgeon. In addition, invasive fish species can be an important limiting factor in native fish restoration. Figures 6-8 and 6-9 provide the aquatic invasive detections, however, local managers should consider invasive species type and abundance in river reaches considered for reintroduction or habitat enhancement.

7 Where are potential areas to restore connectivity for this CE, based on current locations of CAs?

The fish barriers database (Figures 6-7 and 6-8) provides locations where barriers could be removed and connectivity could be restored for the white sturgeon. Local managers should consider barrier ownership, type, and removal feasibility when considering which rivers reaches are most suitable to restore connectivity.

68 Where will aquatic CEs experience significant deviations from historic climate variation that potentially could affect the hydrologic and temperature regimes of these aquatic CEs?

RegCM3 (Hostetler *et al.* 2011) climate modeling predicts a slight increase precipitation in the basins, valleys, and uplands, and large increases in precipitation in the mountains by 2060. Perennial river flow would be expected to slightly increase in the majority of the ecoregion.

The gains in spring runoff may be offset by summer temperature changes and associated irrigation withdrawals. White sturgeon are sensitive to instream temperature (Haak *et al.* 2010). The Hostetler model forecast predicts no change in annual temperature across the entire NGB REA. However, temperatures are expected to increase by one degree in July and August. Agricultural irrigation demands are highest in the summer (July and August) and the slight increase in temperature may require additional surface water diversion for irrigation during the summer months.

34 What is the condition (ecological integrity) of aquatic CEs?

See answer to management question #2.

40 Focusing on the distributions of terrestrial and aquatic CEs that are significantly affected by invasive species, which areas have restoration potential?

See answer to management question #6.

8 References

Brannon, E., S. Brewer, C. Melby. 1984. Columbia River White Sturgeon (Acipenser transmontanus) Enhancement. Project No. 1983-31600, 52 electronic pages, (BPA Report DOE/BP-363). 52 pp.

Canadian Columbia River Inter-Tribal Fisheries Commission (CCRIFC). 2005. Kinbasket – Upper Columbia sturgeon re-colonization risk assessment pathogen and local knowledge sections. Report prepared for the Upper Columbia White Sturgeon Recovery Initiative c/o Ministry of Water, Land and Air Protection, Nelson, B.C. 24 pp.

DeVore, J.D., B.W. James, C.A. Tracy, and D.A. Hale. 1995. Dynamics and Potential Production of White Sturgeon in the Unimpounded Lower Columbia River. Transactions of the American Fisheries Society 124: 845-856.

Drennan, J.D., S. Ireland, S.E. LaPatra, L. Grabowski, T.K. Carrothers, and K.D. Cain. 2005. High-density rearing of white sturgeon *Acipenser transmontanus* (Richardson) induces white sturgeon iridovirus disease among asymptomatic carriers. Aquaculture Research 36: 824-827.

Dunham, J.B., M.K. Young, R.E. Greswell, and B.E. Rieman. 2003b. Effects of fire on fish populations: landscape perspectives on persistence of native fishes and nonnative fishes invasions. Forest Ecology and *Management* 178(2003): 183-196.

Emmett, R.L., S.A. Hinton, S.L. Stone, and M.E. Monaco. 1991. Distribution and abundance of fishes and invertebrates in west coast estuaries, Volume II: Species life history summaries. ELMR Rep. No. 8 NOAA/NOS Strategic Environmental Assessments Division, Rockville, MD, 329 pp.

Haak, A.L., Williams, J.E., Isaak, D., Todd, A., Muhlfeld, C., Kershner, J.L., Gresswell, R., Hostetler, S., and Neville, H.M. 2010. The potential influence of changing climate on the persistence of salmonids of the inland west: U.S. Geological Survey Open-File Report 2010–1236, 74 pp.

Idaho Power Company. 2005. Snake River White Sturgeon Conservation Plan. August 2005. 222 pp.

Israel, J., A. Drauch, and M. Gingras. 2009. Life History Conceptual Model for White Sturgeon (*Acipenser transmontanus*). California Department of Fish and Game Delta Regional Ecosystem Restoration and Implementation Program (DRERIP). 54 pp.

Johnson W.C., M.D. Dixon, R. Simmons, S. Jenson, and K. Larson. 1995. Mapping the response of riparian vegetation to possible flow reductions in the Snake River, Idaho. Geomorphology 13(1995): 159-173.

LaPatra, S.E., G.R. Jones, K.A. Lauda, T.S. McDowell, R. Schneider, and R.P. Hedrick. 2011. White sturgeon as a potential vector of infectious hematopoietic virus. Journal of Aquatic Animal Health 7(3): 225-230.

LaPatra S.E., J.M. Groff, T.L. Patterson, W.D. Shewmaker, M. Casten, J. Siple, and A.K. Hauck. 1996. Preliminary Evidence of Sturgeon Density and Other Stressors on Manifestation of White Sturgeon Iridovirus Disease. Journal of Applied Aquaculture, Vol. 6(3).

Lepla, K. B., J. A. Chandler, and P. Bates. 2003. Status of Snake River white sturgeon associated with the Hells Canyon Complex. Chapter 1 in K. Lepla, editor. Idaho Power Company, Technical Report, Appendix E.3.1-6, Boise. Originally submitted November, 2001, revised July, 2003.

McCabe, G.T. Jr., and C.A. Tracy 1994. Spawning and early life history of white sturgeon, Acipenser transmontanus, in the lower Columbia River. Fishery Bulletin 92: 760-772.

Moyle, P. B. 2002. Inland Fishes of California. Berkeley: University of California Press. 502 pp.

Rust, P. J., and V. D. Wakkinen. 2008. Kootenai River white sturgeon spawning and recruitment evaluation. Annual Progress Report for the period May 1, 2007 - April 30, 2008. Idaho Department of Fish and Game. Prepared for Bonneville Power Administration. Idaho Department of Fish and Game Report Number 08-16, Boise, Idaho. December.

Skinner, J. E. 1962. An historical review of the fish and wildlife resources of the San Francisco Bay area. California Department of Fish and Game, Water Projects Branch Report 1. 226 pp.

Columbia Spotted Frog Conservation Element Package

1 Introduction

The range-wide distribution of the Columbia spotted frog incorporates four populations: the northern population that extends from Alaska to central Idaho and western Wyoming, the Wasatch and West Desert small, isolated populations that occur in central and western Utah, the Great Basin population that occurs in eastern Washington and Oregon, southern Idaho and northern and central Nevada. The spotted frog conservation element (CE) includes all these populations. The Columbia spotted frog subspecies (*Rana luteiventris*) that comprises the Great Basin Distinct Population Segment (DPS) is a candidate Endangered Species Act species. The Great Basin Distinct Population Segment represents the southernmost extent of the species' range and is geographically separate and genetically distinct from the remainder of the species (Engle and Munger 2003). These populations are small, exhibit low genetic variation, and are highly vulnerable to the threats faced by most small isolated populations: susceptibility to stochastic events, reduced genetic diversity, inbreeding effects, and high probability of local extinction (Funk *et al.* 2008). There are documented losses of historically known occupied sites, reduced numbers of individuals within local populations, and declines in the reproduction of those individuals (U.S. Fish and Wildlife Service 2011b). Sites at which frogs become locally extinct have a small probability of reoccupation due to overall low levels of migration. Thus, major concerns for this widely-distributed landscape species are isolation of populations and whether local populations can persist (U.S. Fish and Wildlife Service 2011a).

A large percentage of spotted frog populations occur on lands managed by the Forest Service (primarily the Humboldt-Toiyabe National Forest in Nevada) and Bureau of Land Management (BLM). The Malheur National Wildlife Refuge in south-central Oregon also has a small population (U.S. Fish and Wildlife Service 2011a).

2 CE Package Review Process

2.1 Subject Matter Expert Review

Subject Matter Experts play a key role in ensuring that the REA reflects the best available data and modeling processes suitable for each conservation element and change agent. Subject Matter Experts were added to Rolling Review Teams comprised of SAIC scientists, SAIC GIS personnel, AMT member(s) and other subject matter experts from the Department of Interior or state agencies. Membership of the Rolling Review Teams is listed in Appendix A. To ensure consistency amongst the different Rolling Review Teams, the number of lead SAIC scientists was limited to only a few individuals. This ensured that there was a common approach, or framework, used among the different Rolling Review Teams and that one Rolling Review Team did not stray too far from the rest. The USGS, as peer reviewers, were invited to participate in Rolling Review Teams.

3 CE Description

The Columbia spotted frog is strongly associated with clear, slow-moving or ponded surface waters with little shade, and relatively constant water temperatures (Munger *et al.* 1996; Reaser and Pilliod 2005; Bull 2005; Wilson 2006). Selected breeding/larval rearing sites provide a variety of herbaceous emergent, floating, and submergent vegetation (Bull 2005; Pearl *et al.* 2007). Although they are known to use temporary bodies of water for breeding in more mesic parts of their range, in more arid portions of the ecoregion breeding sites are predominantly associated with springs or other permanent water sources such as shallow ponds, and shorelines of streams and lakes (Pearl *et al.* 2007; Wilson 2006). A variety of change agents, discussed below, affect the availability and condition of spotted frog habitats.

Anuran habitats must provide the major resources for the annual cycle: reproduction, foraging, hibernation/estivation (Sinisch 1990). These life cycle stages are central in the system model (Figure 5-1). In some circumstances, these resources may be located in the same habitat patch (e.g., a breeding pond with adequate summer and winter habitat) but for many Columbia spotted frogs, some or all of these resources are spatially separated, requiring seasonal migrations among different, sometimes distant, water bodies (Pilliod *et al.* 2002). For example, up to 50 percent of adult female Columbia spotted frogs migrated between aquatic breeding and summer habitats separated by 500 m or more of dry coniferous forests in high elevation montane sites (Pilliod *et al.* 2002). Bull and Hayes (2001) found that pond size, proximity to other permanent water, and water temperature were associated with frog movements. Presence of predators and food supply are important elements of breeding and summer habitats (Bull and Hayes 2001; Pilliod *et al.* 2010). Post-breeding travel frequently follows streams and riparian corridors (Turner 1960), but movement across dry, grazed grasslands and sagebrush uplands has been documented (Reaser and Pilliod 2005, Bull and Hayes 2001). Spotted frog migrations often appear to follow shortest-distance travel routes through dry open forest even when stream corridors were available nearby (Pilliod *et al.* 2002). Columbia spotted frog overwintering habitats are different from breeding and summer habitats, and are primarily related to availability of a silt or muck layer for hibernation and sufficient oxygen levels beneath frozen pond surfaces (Bull and Hayes 2002; Pilliod *et al.* 2002, Bull 2005; Reaser and Pilliod 2005). Thus, conservation concerns include protecting not only suitable aquatic habitats for breeding/larval rearing, summer, and winter life cycle stages but also the stream, riparian, and overland corridors that connect these habitats. Pilliod *et al.* (2002) recommended protecting diverse water bodies and surrounding uplands within 1 km of breeding ponds in high elevation sites. Bull and Hayes (2001) recommended protecting permanent ponds and river and stream habitat within at least 500 m of breeding ponds in northeastern Oregon.

4 CE Modeling

4.1 Data Identification

Table 4-1 lists the types of data and data sources that were originally proposed for use in the REA as part of the pre-assessment data identification effort. This table lists the need for the data, the general name of the dataset, if the dataset was acquired and if the data was used.

The BLM's Riparian-Wetland Initiative for the 1990's contained a strategy to focus management on the entire watershed by developing a system to categorize riparian and wetlands areas. Knowing the condition of the watershed is an important component in assessing whether a riparian or wetland area is functioning properly, or achieving proper functioning condition (BLM 1994). They have since developed a database containing this information, which was explored for its usefulness to identify high quality areas that may be occupied by spotted frogs. Similarly, the USGS land health database and a GAP- interagency species habitat modeling working group were explored for data on spotted frogs.

Table 4-1. Preliminary Columbia Spotted Frog Data Sources

Data Required	Dataset Name	Source Agency	Type/Scale	Status	Use in REA
Modeled Suitable Habitat	Maxent Suitable Habitat	Based on USFS Model	Polygon	Acquired	Yes
Occupied range	Point Occurrences	Oregon (GeoBOB), Nevada Department of Wildlife, Idaho Department of Fish and Game	Points	Acquired	Yes
Habitat Condition	proper functioning conditions for Riparian Areas	BLM		Data Gap	No
Protected Areas	Conservation easements; TNC and other private	PADS	Polygon	Acquired	Yes

4.2 Distribution Mapping Methods

The subject matter expert involved with the Rolling Review Team recommend using a previously created maxent model for mapping suitable habitat from Columbia spotted frog. This previous maxent model was developed by the Umpqua National Forest focusing on south eastern Oregon. For the NGB REA, a similar suite of environmental layers were used along with Columbia spotted frog occurrences from across the ecoregion. Figure 4-1 gives a brief overview of the maxent modeling process. The environmental layers being used in this model consisted of:

- LANDFIRE Existing Vegetation Type and Succession Class
- National Elevation Dataset (Elevation, Slope, Aspect)
- Buffered NHD water features (flowlines and open water),
- STATSGO Soil,
- Tasseled Cap Transformed Remotely Sensed Imagery (Greeness, Wetness, Brightness),
- WorldClim's Diurnal Temperature and Annual Precipitation, and
- Solar Radiation (Sumer Solstice, Winter Solstice, Equinox)

Occurrence data was acquired from Oregon's GeoBOB database, Nevada Department of Wildlife and Idaho Fish Game and Parks. Utah's observations were generalized so they weren't included in the model. The Columbia spotted frog observations and modeled suitable habitat is shown in Figure 4-2.

4.3 Data Gaps, Uncertainty, and Limitations

4.3.1 Data Gaps

The main data gap was a lack of observation data from California. Maxent was still able to run without it and identify potential suitable habitat but the model may have been better with some points.

4.3.2 Uncertainty

Maxent models potential suitable habitat based on the supplied occurrence data. Accuracy of those spatial data is difficult to rectify since the observation data is supplied from multiple state agencies. Some states may provide an accuracy measurement while others may not. The potential suitable habitat doesn't mean that Columbia spotted frog occurs there just that based on the model there potential is suitable habitat. The Columbia spotted frog population below the Snake River is most threatened. Some occurrence data was used for Columbia spotted frog that came from populations north of the Snake River (within the ecoregion).

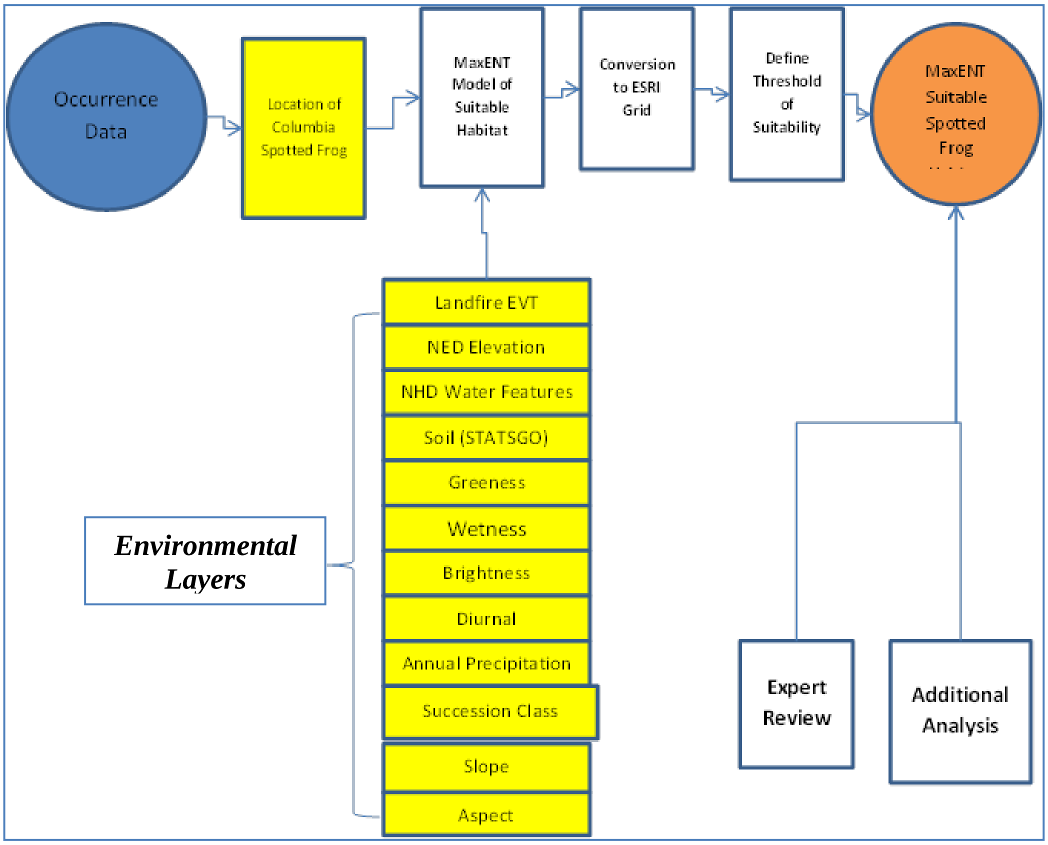


Figure 4-1. Maxent Model Process for Columbia Spotted Frog

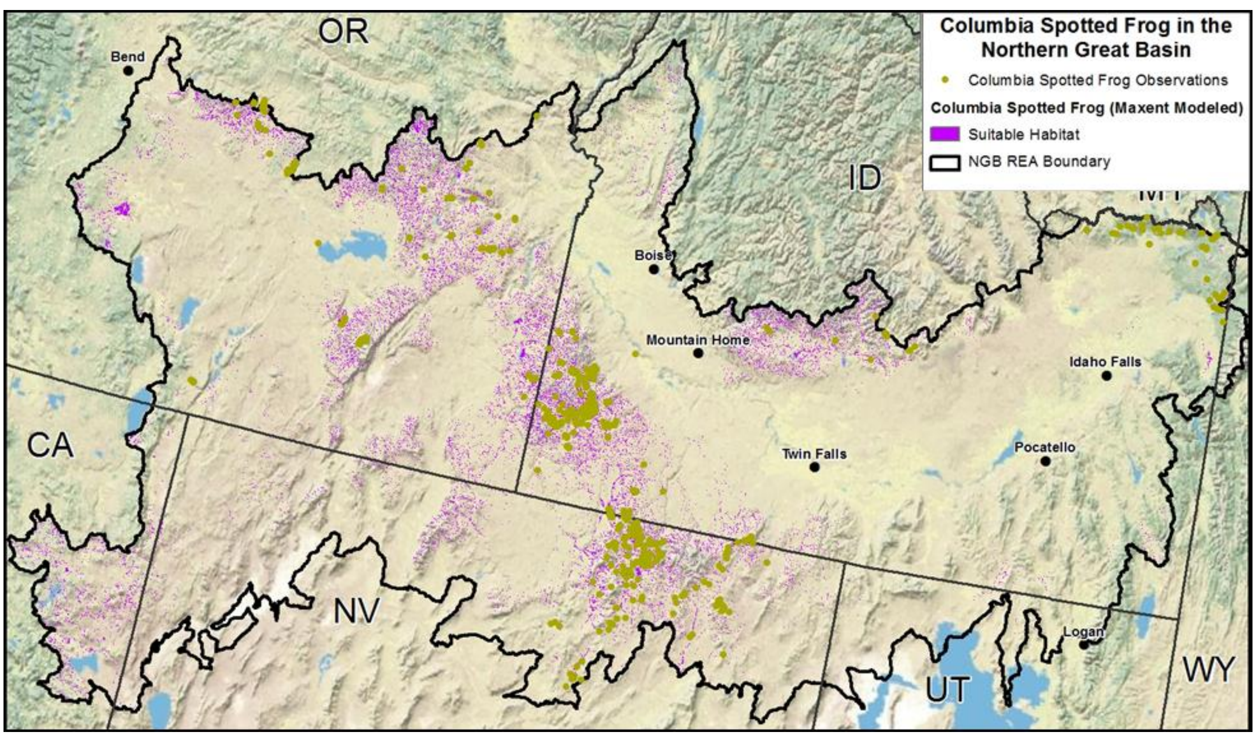


Figure 4-2. Columbia Spotted Frog Modeled Suitable Habitat

5 System Models

Conceptual system models were developed as part of the pre-assessment phase to assist with the determination of the key factors that are important to Columbia spotted frog in the NGB ecoregion. The model was developed to provide an ecological framework and justification for the choice of indicators that were used in assessing CA threats for this CE. This model begins with depicting the important habitat components for the Columbia spotted frog (or functions and values) required throughout the year and incorporates the identified CAs, as well as potential effects from the actions of the CAs on a landscape and local level (Figure 5-1). Being conceptual in nature, all potential important stressors and effects were included regardless of availability of data at this point in the REA. Those elements that could not be carried forward for analysis will be discussed.

5.1 Change Agents

The CAs considered for this CE analysis include development, climate change, invasive species, and disease, depicted in brown boxes across the top of the model (Figure 5-1). As mentioned in Section 3, suitable Columbia spotted frog habitat depends upon presence of healthy shallow aquatic sites for egg deposition, wetland riparian zones for adult foraging and overland movement, and suitable overwintering sites that remain above freezing temperatures. The conceptual model shows the pathway of CAs that affect spotted frog landscape and local habitat requirements and thereby, the frog functions and values, depicted in the lower box. The predicted results of CA effects are presented in blue boxes.

5.1.1 Development

Many anthropogenic and natural change agent effects determine the availability and condition of suitable spotted frog habitats and the distribution and persistence of spotted frog populations. Habitat loss, degradation, and fragmentation is a combined result of past and current human development influences related to agriculture, livestock grazing, hydrologic diversions, urbanization, mining, and climate change (U.S. Fish and Wildlife Service 2005). Most of the development change agents depicted in the system model (Figure 5-1) affect hydrology and water quality in spotted frogs' habitats. Urbanizing areas, for example, tend to increase impervious surface, putting increased demands on existing wetlands and streams to carry runoff. Stream dredging and straightening lead to floodwaters rising and falling at an increased rate. Spotted frog breeding habitat at the margins of shallow wetlands and ponds can be affected by more pronounced and rapid water level fluctuations: eggs laid during or immediately following late winter rains are often left exposed to freezing and desiccation by rapidly dropping water levels (Richter and Azous 1995). Water diversions and impoundments for agriculture, urban/exurban development, and rangeland management are included in the system model to indicate many other direct and indirect effects on spotted frog habitat, including lost or reduced surface and groundwater flow, flooding of desirable shallow-water habitat, changes in water temperatures, and increased habitat for predatory fish.

In semi-arid areas, springs represent a stable permanent source of water for breeding, feeding, and overwintering frogs (Patla and Peterson 1996; Munger 2003); diversion of springs for livestock watering can lead to a the loss of associated riparian habitats and wetlands. Livestock grazing affects riparian and stream ecosystems throughout the range of the Columbia spotted frog (Minshall *et al.* 1989; Munger *et al.* 1996; Reaser 1997; Engle 2002), but the magnitude of this threat in terms of frogs' reproductive success and survival is uncertain in the literature (reviews in U.S. Fish and Wildlife Service 2005; Patla and Keinath 2005).

Management of beaver populations is an important element affecting the availability of suitable spotted frog habitat (Reaser 1997; Nevada Department of Wildlife 2006; Oregon Department and Fish and Wildlife 2006), and past beaver and beaver dam removal practices have negatively affected spotted frog habitat (U.S. Fish and Wildlife Service 2005). The effects of mining on water quality and quantity in general, and amphibians in particular include addition of toxic substances into streams (such as methylmercury and other trace metals), altered stream morphology, and effects on groundwater and aquifers (Nelson *et al.* 1991; U.S. Fish and Wildlife Service 2008; Nevada Department of Wildlife 2010). Aquatic habitat loss and degradation have had both local and landscape-level effects on Columbia spotted frogs, as shown in the system model. Loss of connectivity between aquatic habitats and fragmentation of habitat patches have contributed to the isolation of remaining spotted frog populations with implications for the long-term persistence of populations.

5.1.2 Climate Change

Spotted frogs are highly vulnerable to natural drought events which sometimes cause local extirpations of populations (Turner 1962; Munger *et al.* 2002; Wilson 2006). The role of climate change beyond historic variations in temperature and precipitation has been considered in the amphibian literature but measurable effects have not been well documented. In the western states, documented warming trends will produce large hydrological changes due to reduced snowpack and earlier melting. Direct effects on spotted frogs may include loss of some ponds due to higher summer temperatures with reduced survival during overland migration, earlier reproduction and more rapid larval development, and shorter hibernation periods, (Corn 2003; Corn 2005; Patla and Keinath 2005), but the net effect is currently difficult to predict.

5.1.3 Invasive Species and Disease

At the level of effects on individual survival and reproductive success, shown as mortality and disturbance in the system model, the primary change agents are invasive predatory fish species (salmonids and bass) and bullfrogs (Monello and Wright 1999; Pilliod and Peterson 2001; Munger *et al.* 1996) and disease (chrytridiomycosis [chytrid] and ranavirus). Chytrid has not been associated with any large die-off of Columbia spotted frogs (Rollins-Smith *et al.* 2005; Adams *et al.* 2010) but monitoring of its occurrence and a better understanding of how it affects this species is needed (Russell *et al.* 2010). Malformations of frogs, which generally lead to higher mortality rates, are a common problem in Columbia spotted frog populations outside the Great Basin Distinct Population Segment (Johnson *et al.* 2002). These malformations are associated with the presence and abundance of trematodes (*Ribeiroia*) and parasitic snails (*Planorbella*) in anthropogenic wetlands and stock ponds. The level of malformations in the Great Basin Distinct Population Segment of Columbia spotted frogs is currently not significant but the range extension of *Planorbella* into the ecoregion may result in a greater threat.

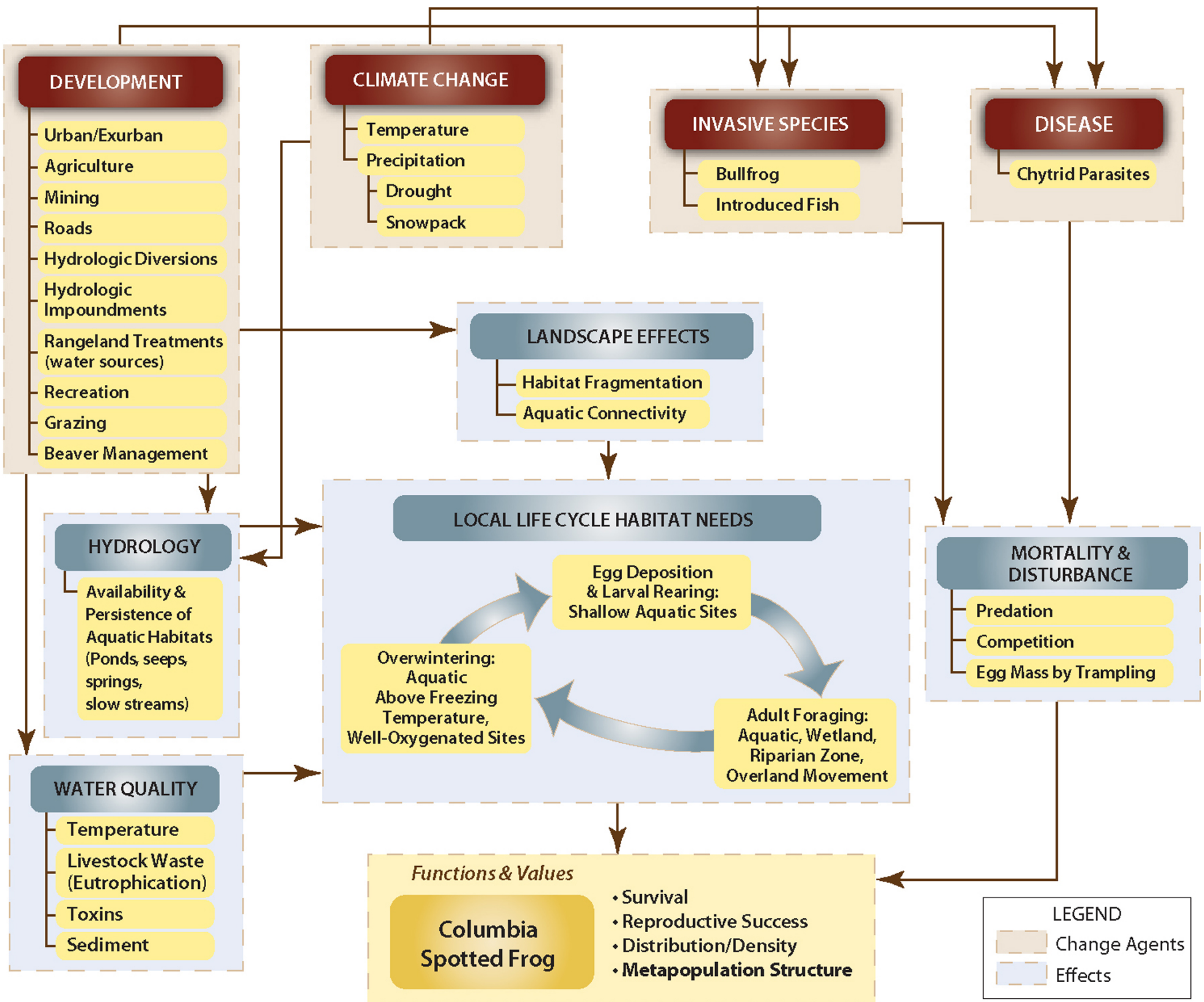


Figure 5-1. Columbia Spotted Frog Conceptual Model

6 CA Threat Analysis

Current status and future threat assessments for Columbia spotted frog was conducted for the NGB using both 30 m pixels and the 12-digit HUCs as the analysis units. Once the ecological model was developed, indicators or key ecological attributes need to be identified with a specific emphasis on the ability to measure indicators and predict future scenarios for the key ecological attributes that result from application of CAs using existing geospatial data. The indicators will assist with answering the MQs that relate to what is happening to the CE across the ecoregion. The CAs evaluated for current status include development, wildfire, climate change, invasive species, and disease.

6.1 Key Ecological Attributes

The preliminary list of key ecological attributes (Table 6-1) suggests some indicators for assessing habitat size, condition, and landscape context with respect to anthropomorphic influences. In some cases, we may need to suggest surrogate indicators for measuring potential effects as indicted in the conceptual model. For example, to establish a metric for water quality we may need to measure distance to potential sources of pollution such as agricultural operations (feedlots, croplands) or energy developments

Table 6-1. Preliminary Key Ecological Attributes for Columbia Spotted Frog CE

Category	Key Ecological Attribute	Indicator	Metric	GIS Source	Reference
Size	Barriers to movement	Number of dams in HUC10	≤5 = good 6 -9 = fair ≥ 10 = poor	National Inventory of Dams	Stagliano 2007
	Population Stability	Occupied sites per (decide area unit size)		Data Gap	
Condition	Water source permanence	Number of non-dam diversions in HUC 10	<50 = good 50-100 = fair >100 = poor	Data Gap	Stagliano 2007
		Protected ponds and wetlands (Percent of HUC12 in GAP Status 1 or 2)	>60% = good 25-60% = fair <25% = poor	PADS	Stagliano 2007 Professional judgment
	Water quality	Percent of riparian corridor with natural land cover	>80% = good 25-80% = fair <25% = poor	National Land Cover Dataset	USFS 2011
		Percent of streams that are 303d listed	0% = good 1 – 9% = fair >9% = poor	NHD Plus Streams EPA 303d List	USFS 2011
		Number of toxic release inventory (TRI) sites in HUC	0 = good >=1 = poor	EPA Envirofacts Data – toxic release inventory class	Data quantiles? Professional judgment?
		Number of mines in HUC12	0= good >=1 = poor	USGS Mineral Resources Data System	Data quantiles

Table 6-1. Preliminary Key Ecological Attributes for Columbia Spotted Frog CE

Category	Key Ecological Attribute	Indicator	Metric	GIS Source	Reference
Context	Anthropomorphic Influence	Percent of streams/pond shorelines that are within 40 meters of road	<1% = good 1 – 2.5% = fair >2.5 % = poor	NHD Plus Streams, Water bodies, area, TIGER roads (all roads)	Stagliano 2007
		Percent of HUC in ag use (cropland)	<30% = good 30-60% = fair >60% = poor	national land cover dataset	Allan 2004 Sheeder and Evans 2004
		Percent of 2-km radius buffer around modeled habitat patches in ag use	<3% = good 3 – 6% = fair >6% = poor	national land cover dataset	Pearl *et al.* 2008
		Percent of HUC in impervious surface	<6% = good 6-10% = fair >10% = poor	national land cover dataset	Allan 2004 Table 1 from Appendix E p. 142 of Annis *et al.* 2010 Wang *et al.* 2008
		Percent of riparian corridor in impervious surface	<5% = good 5-10% = fair >10% = poor	national land cover dataset	Wang *et al.* 2008 Joubert and Loomis 2005
		Human Footprint score within 2-km radius of modeled habitat patches (range 1 – 10)	<3.5 = good 3.5 – 4.5 = fair >4.5 = poor	Leu et al 2008	Pearl *et al.* 2008
	Connectivity (Seasonal migration and juvenile dispersal)	Distance between suitable habitat patches (m) without barriers to movement (high traffic roads, developed sites, mountain ridges/ elevation differences>800 m)	< 400 m = Good 400 – 1200 m = Fair >1200 m =Poor	Modeled habitat TIGER Human Footprint Elevation	Turner 1960; Engle and Munter 2003; Pilliod et al 2002; Bull and Hayes 2001; Funk *et al.* 2005

As in other REA processes, it may become apparent through discussion with the Rolling Review Team that some of these key ecological attributes were dropped from analysis because either the attribute or indicator was not suitable for a landscape level analysis, the data are not available to support the analysis, or it was duplicative.

6.2 Current Status of the CE

This section will document the CA analysis under current conditions, i.e. the current extent of the CE's distribution and locations of the CAs. For each of the key ecological attributes listed in Table 6-1 and used in the CA analysis, a discussion of the indicator, metrics, metric rank and value, data source(s), and references were provided. The analysis was based on spatially available attributes affecting the CE at the ecoregion level.

6.2.1 Size

6.2.1.1 Dams in HUC 10

This key ecological attribute wasn't used since the USACE dams layer was a data gap and the analysis unit that the metric was using was much larger than the HUC 12 and 4km grid being used in this REA.

6.2.1.2 Population Stability

This key ecological attribute wasn't carried forward since there were currently no metrics identified to define it.

6.2.2 Condition

6.2.2.1 Number of Non Dam Diversions in HUC 10

This key ecological attribute wasn't carried forward as the metrics were based on an analysis unit much larger than the HUC 12 and 4km grid being used in the key ecological attribute.

6.2.2.2 Protected Areas (GAP 1 or 2)

This key ecological attribute was analyzed by using the USGS Protected areas database and extracting the GAP 1 or 2 classified protected areas. The maxent suitable habitat was then intersected against the protected areas to determine how much of each analysis unit (4 km grid) was within a protected area. Areas scoring high were deemed to have greater than 60 percent within a protected area, 25 – 60 percent scored moderately and less than 25 percent scored low.

The results of this analysis using the 4 km grid as the analysis unit (Figure 6-1) shows that most of the ecoregion scored low due to the fact that there are few GAP 1 and 2 status lands. The main protected areas within the ecoregion are National Wildlife Refuges such as Charles Sheldon and Hart Mountain along with wilderness areas and wilderness study areas such as Jarbidge Wildness and Owyhee Canyon Wilderness Study Area.

6.2.2.3 Percent of Riparian Corridor with Natural Land Cover

The riparian corridor that was used was the same corridor that was used to limit the results of the maxent model which was created by buffering the streams and water bodies within the National Hydrographic Dataset. The National Land Cover Dataset was used to extract natural land cover. This dataset was used since other key ecological attributes that analyze imperviousness also used the National Land Cover Dataset's impervious area layer.

Figure 6-2 shows that within the corridor most of the ecoregion scored high showing that greater than 80 percent of the analysis unit (4 km grid) contained natural land cover. Most of the areas within the ecoregion that scored low were areas with high amounts of agriculture. Some examples of these areas were north of Malheur Lake in Oregon and the areas in Idaho northeast of Idaho Falls and south of Pocatello.

6.2.2.4 Percent of Streams that are 303(d)

303d streams was downloaded from the EPA and extracted for the ecoregion. Using the 4km grid analysis unit, areas identified with the modeled maxent suitable habitat for Columbia spotted frog were analyzed for the amount of streams vs. the amount of 303(d) streams. The percentage of 303(d) streams was classified as no 303(d) streams present in the analysis unit would equal a high scoring area. Moderate scoring would be up to 9 percent of the analysis unit containing 303(d) and greater than 9 percent being a low scoring area.

As shown in Figure 6-3, the majority of the Columbia spotted from areas with a high percentage of 303d waters were in Idaho between the Nevada border the southern Snake River Plain. The northwestern part of Nevada and California has the lowest amounts of 303d streams.

6.2.2.5 Number of Toxic Release Inventory Sites

The toxic release inventory sites were downloaded from the EPA for the ecoregion. There were very few toxic release sites with the ecoregion as evident in Figure 6-4. Most of the ecoregion is scored as high without any toxic release sites within the analysis unit. Any analysis unit with a toxic release site was scored low.

6.2.2.6 Number of Mines

The USGS Mineral Resource Data System was the source of mines in the ecoregion. Since there was no metric for the number of mines to determine high and low scoring areas, if there were no mines in the analysis unit it was scored as high. If any number of mines was in the analysis unit it was score as low. Figure 6-5 shows that most concentrated about of mines in Columbia spotted modeled suitable habitat was in northwestern Nevada. There was also another concentrated area in the northern part of Idaho (within the ecoregion) near Sun Valley.

6.2.3 Context

6.2.3.1 Percent of Streams/Ponds within 40m of Roads

TIGER roads and National Hydrographic Dataset were the two main datasets used in this analysis to determine the amount of roads within 40 m of streams. The metric used for this key ecological attribute to be considered a high scoring area was less than 1 percent of the analysis unit. The TIGER roads layer for the ecoregion is very complete and contains a lot of roads. This caused most of the ecoregion to be a scored low as displayed in Figure 6-6. One of the main drivers of high scoring areas would be the proximity to roadless areas such as wilderness areas and wilderness study areas.

6.2.3.2 Percent of Analysis Unit in Agriculture

Agricultural areas were extracted from ReGAP and LANDFIRE and used in this analysis to determine the amount of agricultural land within the analysis unit (4 km grid).

The percent agriculture within an analysis unit (4 km grid) key ecological attribute yield results fairly similar to those looking at natural land cover within the riparian corridor. It appears (as shown in Figure 6-7) that north of Malheur Lake in Oregon, northeast of Idaho Falls and south of Pocatello towards the Utah border appear to be the main agricultural areas within the modeled suitable habitat for the Columbia spotted frog.

6.2.3.3 Percent of 2 km Radius Buffer around Habitat within Agriculture

The percent agriculture within 2 km of modeled suitable habitat yielded results similar to the previous key ecological attribute but more areas scored poorly mostly due to the metric classifying the lower scoring areas. If more than 6 percent of the analysis unit within 2 km of modeled suitable habitat was agriculture then that analysis unit was scored as low. Figure 6-8 shows a similar pattern of areas previously mentioned (north of Malheur Lake, etc.) except most of these areas are scored low since they have greater than 6 percent within 2 km of agriculture . Many other areas not previously recognized (using other key ecological attributes for agriculture) were also scored low such as parts of California and areas within Idaho north of the Snake River Plain.

6.2.3.4 Percent of Analysis Unit within Impervious Surface

Impervious surface was measured using the National Land Cover Dataset impervious surface layer. Reviewing the results of the key ecological attributes analysis, most of the impervious areas within the Columbia spotted from modeled suitable habitat occurs on the periphery of the ecoregion mostly due to high density of roads or built areas such as State Route 75 leading to Sun Valley Resort in Idaho. Figure 6-9 shows imperviousness key ecological attributes score by analysis unit (4 km grid) for areas within modeled suitable habitat. One area on uncertainty for the impervious layer was that certain areas had what appear to be dirt roads being classified as 25-35 percent impervious. When clusters of these roads were classified high in a close proximity would yield an analysis unit that scored low. One area where this pattern occurred was in the Deschutes Great Sandy Desert. Perhaps the landscape and compaction of dirt roads was being included in the impervious calculation.

6.2.3.5 Percent of Riparian Corridor in Impervious Surface

Figure 6-10 shows a similar pattern to the previous key ecological attributes dealing with impervious areas but more areas as scored moderately or low based on a lower metric of 5 percent rather than 6 percent used previously for each analysis unit.

6.2.3.6 Human Footprint Score within 2km of Habitat Patches

The human footprint was downloaded from Sagemap and used as the base data for this key ecological attribute. The human footprint was modeled by the USGS (Leu *et al.* 2008) to analyze the effects of anthropogenic influences on the landscape (http://sagemap.wr.usgs.gov/HumanFootprint.aspx). The final human footprint layer ranks the anthropogenic influence from one to ten with ten being the most anthropogenic influenced. Using the metrics based on Pearl *et al.* 2008, values of less than 3.5 were to be scored as high, 3.5 – 4.5 were scored as moderate and anything over 4.5 scored low.

Figure 6-11 shows the results of the analysis using the 4 km grid analysis unit. A similar pattern that has been displayed in earlier key ecological attributes also appears here as agricultural areas and urbanized corridors such as State Route 75 leading to Sun Valley tend to dominate the low scoring areas.

6.2.4 Connectivity

Connectivity was modeled using barriers to movement (high traffic roads, developed/urban cover types, elevation differences) to fragment the modeled suitable habitat.

6.2.5 Cumulative Indicator Score

Cumulative indicator scores (Figure 6-12) reflect the importance of human footprint elements and percent of the analysis unit within 40 m of roads. Much of the modeled habitat in the ecoregion outside of the Owyhee Mountain region, portions of northeastern and northwestern Nevada, and scattered smaller portions of southeastern Oregon, received low scores. The scattered patches of high-scoring analysis units among larger areas of lower-scoring units raises management concerns over isolated small populations.

6.3 Future Threat Analysis

The presence of modeled suitable habitat or known occurrences of Columbia spotted frogs may be an indicator for managers to carefully consider future development and potential sites for habitat restoration in the ecoregion. The cumulative indicator scores for spotted frog occupied and modeled habitat under current conditions should be useful in identifying the areas most in need of preservation or the best restoration opportunities in local area drill-down evaluations.

6.3.1 Climate Change

Climate change leading to more prolonged drought events and the loss of some ponds, slow-moving streams, and other aquatic habitats is a concern for amphibians in the western states general, but measurable effects have not been well documented in the literature.

Overall, climate change is predicted to produce a slight precipitation increase in the basins, valleys, and uplands and large increases in the mountains. No changes are predicted in the basins or the lower elevations of the Owyhee Uplands. The western half of the NGB REA is predicted to become slightly warmer during June so the slight increase in precipitation may offset some of the increased evapotranspiration demand, making the net effect on Columbia spotted frogs difficult to predict.

However, the timing of precipitation changes may adversely affect spotted frog persistence in the ecoregion. The U.S. Bureau of Reclamation (USBR 2010) suggests that future climate conditions will feature less snowfall and more rainfall, less snowpack development, and earlier snowmelt runoff. The report also suggests that warming will lead to more intense and heavy rainfall that will tend to be interspersed with longer relatively dry periods. The report predicted decreased summer streamflows relative to the historic average. Climate change may eliminate some habitat directly through water quantity changes such as more persistent drought (USBR 2010), and indirectly through water quality changes such as increased water temperature and dissolved oxygen.

6.3.2 Development

Surface and groundwater extraction for urban and exurban populations, agricultural irrigation, and industrial development adversely affect spotted frog populations. Agricultural development in the ecoregion has resulted in widespread construction of dams or diversion structures for surface water withdrawals that have reduced flow from springs and streams. Diversion of water for hydroelectric and agriculture uses has exacerbated persistent drought conditions in the ecoregion. These changes have interfered with metapopulation dynamics and, as a result, populations have become increasingly fragmented. Additionally, degradation of riparian vegetation can negatively impact amphibian habitats through reductions in large woody debris contribution, shade, available food resources with this vegetation (e.g., insects), and the protection of water and sediment quality during precipitation events.

Agriculture water use has been stable from 2000 to 2005, indicating that the future growth of agriculture may have reached limitations in prime agricultural land and water supply. The future threat from agricultural is the reduced dependence on surface water irrigation and an increase in groundwater withdrawals by 20 percent from 2000 to 2005. This will likely lead to a lowering of the water tables in some areas which could have an impact on the groundwater component of baseflow in perennial streams.

6.3.3 Wildfire

Forest fires accelerate sediment transport from mountain drainage basins. Transport processes range from sediment-charged floods to debris flows (Meyer *et al.* 2001). These erosion events following fires can have short-term, detrimental effects but long-term importance for land and stream form development (Benda *et al.* 2003). Intense fire can result in the temporary loss of riparian vegetation, sedimentation, loss of shading and water temperature increases. However, low to moderate intensity fires release nutrients into the water (Idaho Department of Fish and Game 2012).

Larger, more catastrophic fires can threaten entire amphibian populations in a watershed. Small isolated populations in fragmented habitats are at greater risk of localized extirpation. If the local populations are lost their former habitat will likely not be quickly recolonized. Loss of any of these local populations may be devastating to recovery of the species as a whole due to the loss of unique genetic material.

6.3.4 Invasives and Disease

Invasive predatory fish (salmonids and bass) will likely remain as important mortality agents for spotted frogs. Disease agents (chytrids, trematodes and parasitic snails) have been identified in the ecoregion, and monitoring will be required to identify whether expansion of these disease agents will pose a significant threat in the future.

6.3.5 Grazing

Current and future impacts of grazing in unfenced riparian zones, springs, ponds, and streams within spotted frog habitat include water quality degradation, introduction of disease agents, and trampling of riparian vegetation and spotted frog egg masses. The magnitude of these effects is related to livestock density and rangeland improvements such as developing water sources for livestock.

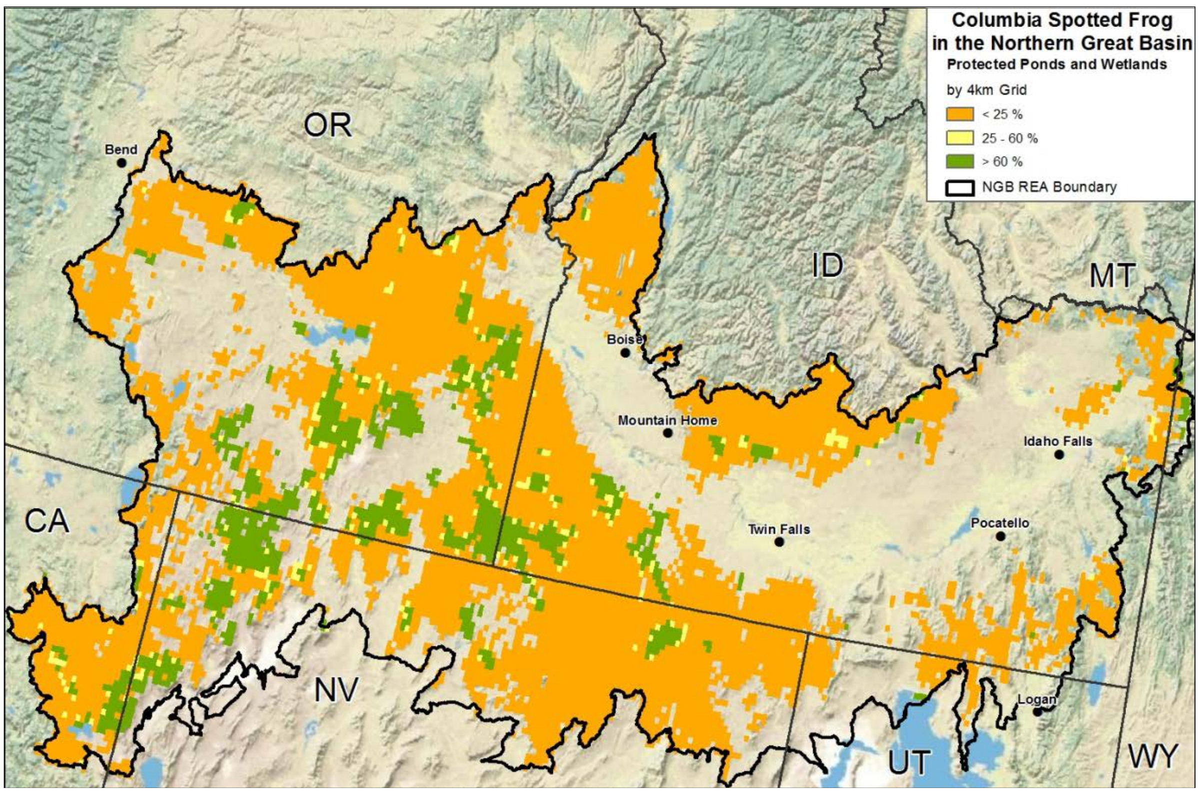


Figure 6-1. Columbia Spotted Frog Modeled Habitat in Protected Areas

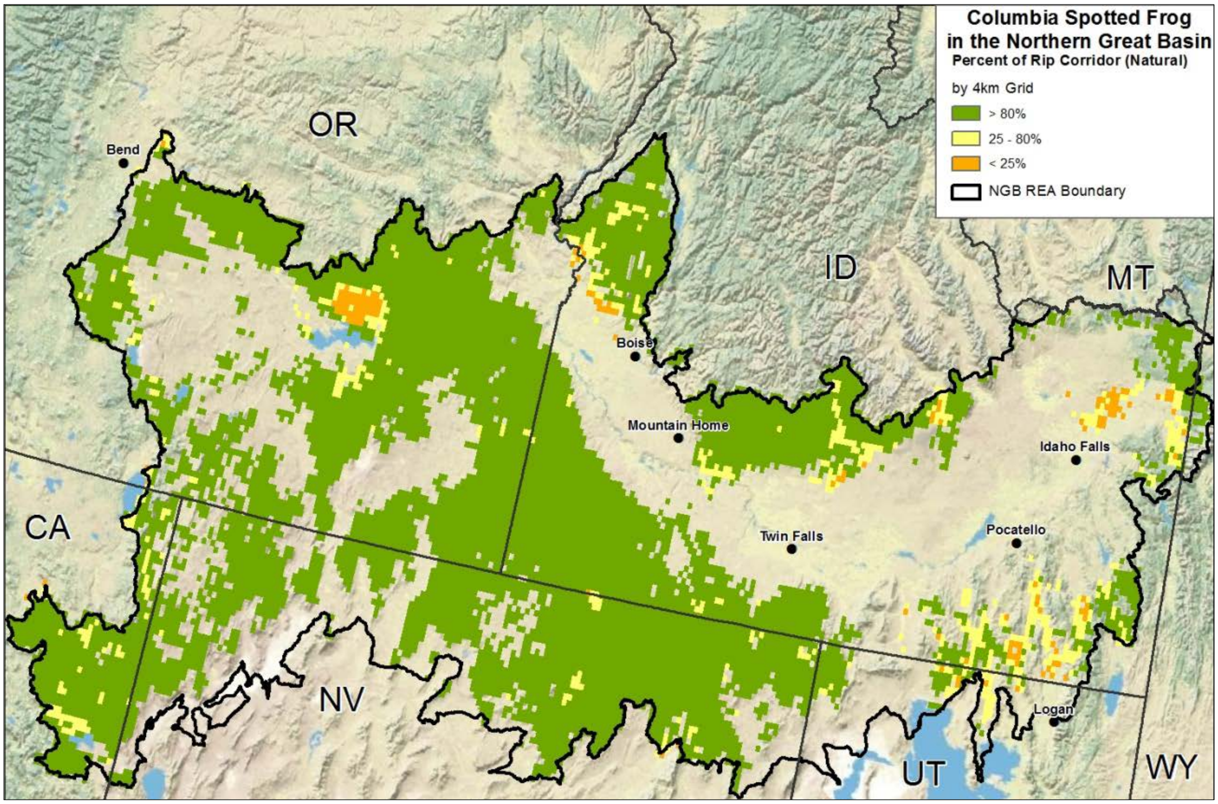


Figure 6-2. Percent of Modeled Suitable Habitat in Riparian Corridor with Natural Land Cover

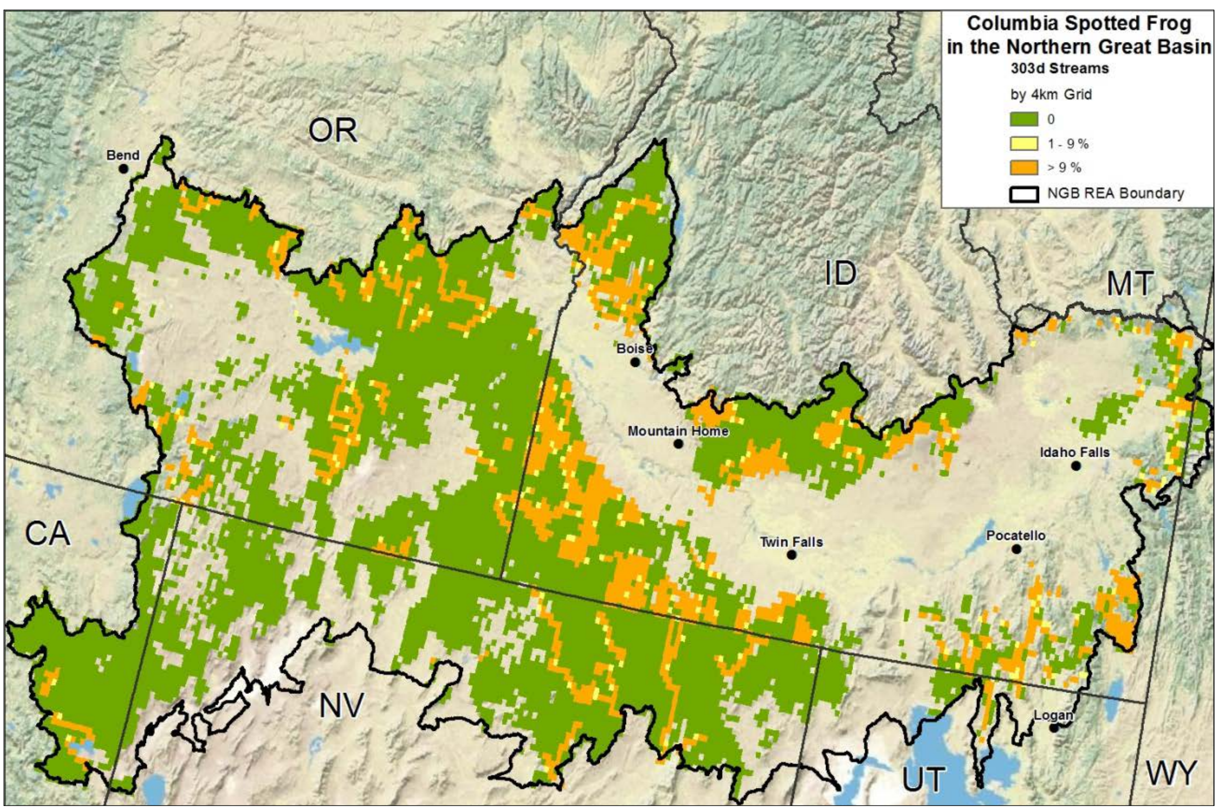


Figure 6-3. Percent of Modeled Habitat listed as 303(d) Impaired

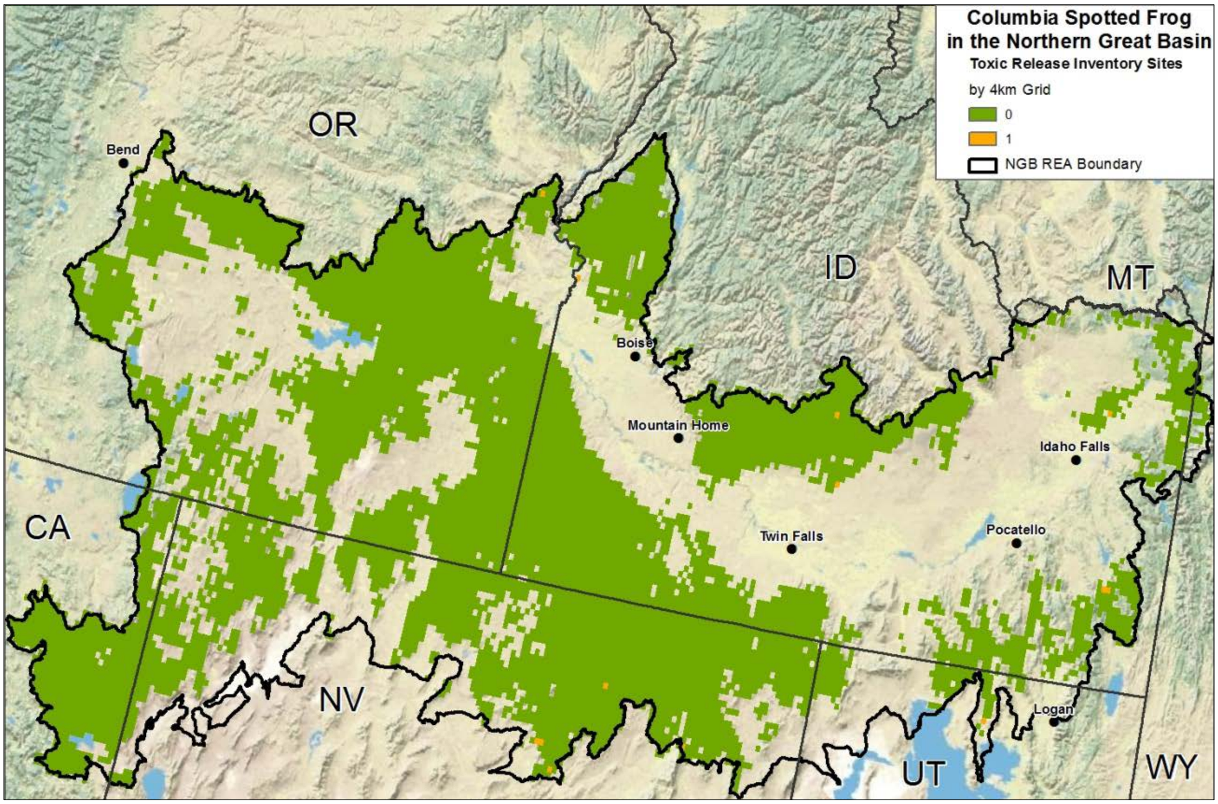


Figure 6-4. Location of Toxic Release Inventory Sites within Modeled Suitable Habitat

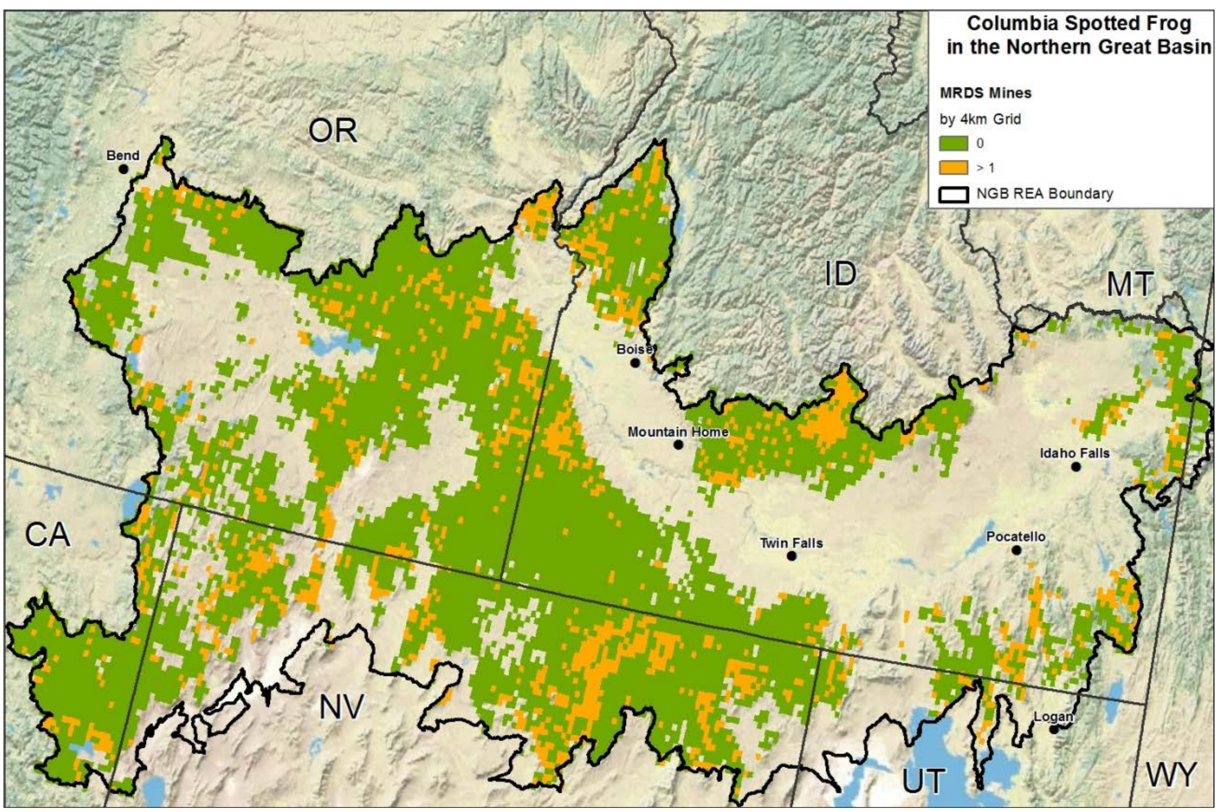


Figure 6-5. Mines within Modeled Suitable Habitat

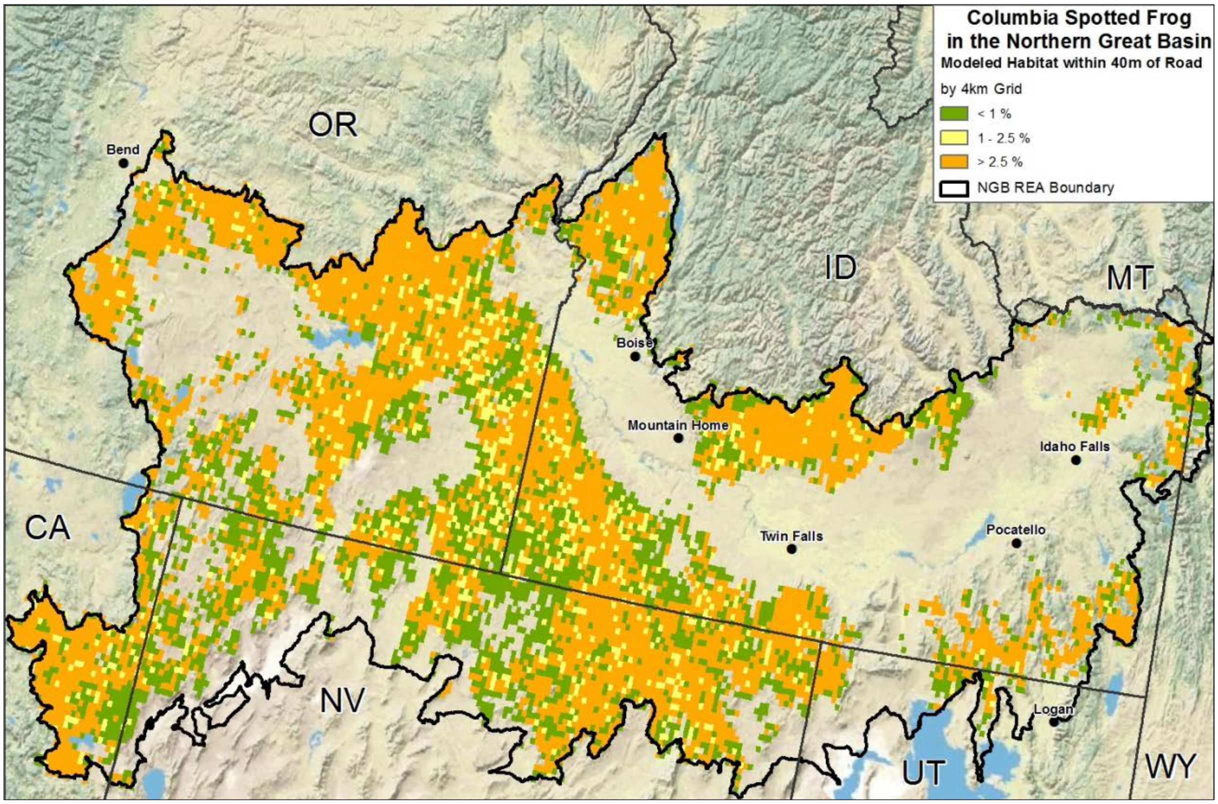


Figure 6-6. Percent of Modeled Suitable Habitat within 40m of a Road

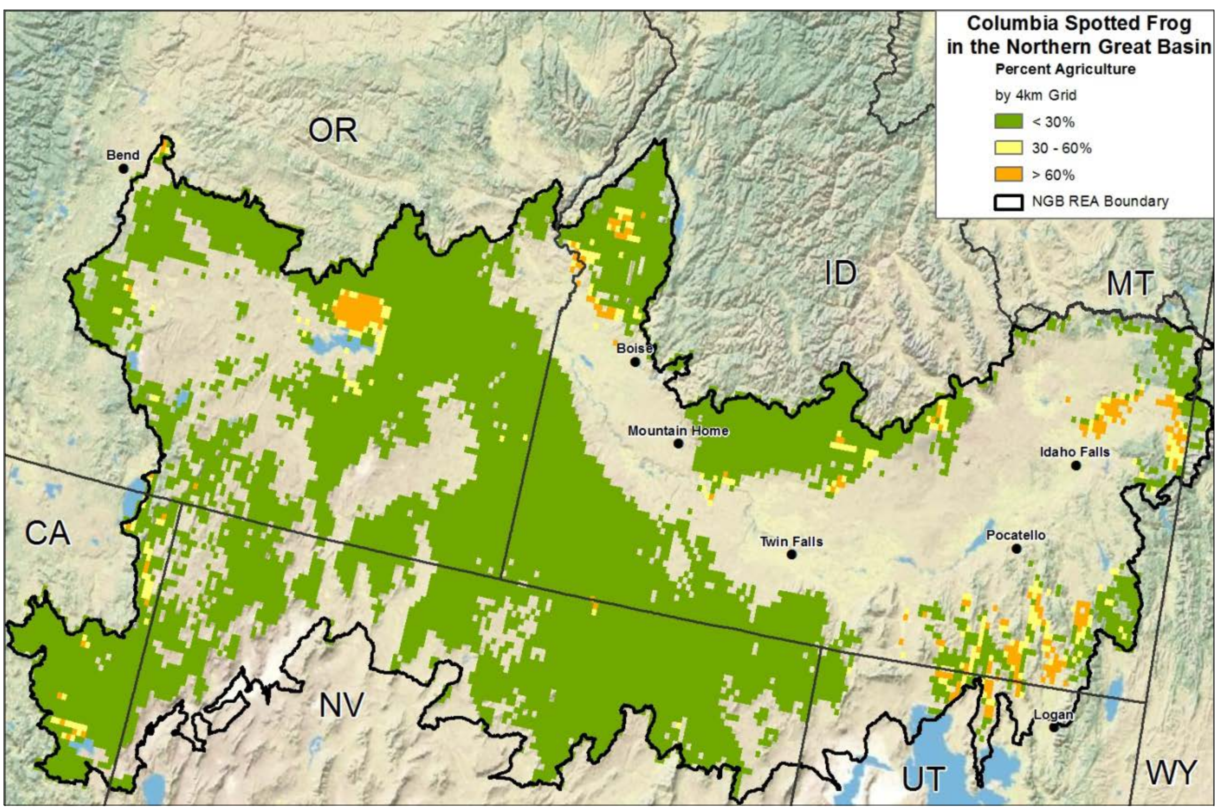


Figure 6-7. Percent Agriculture within Modeled Suitable Habitat

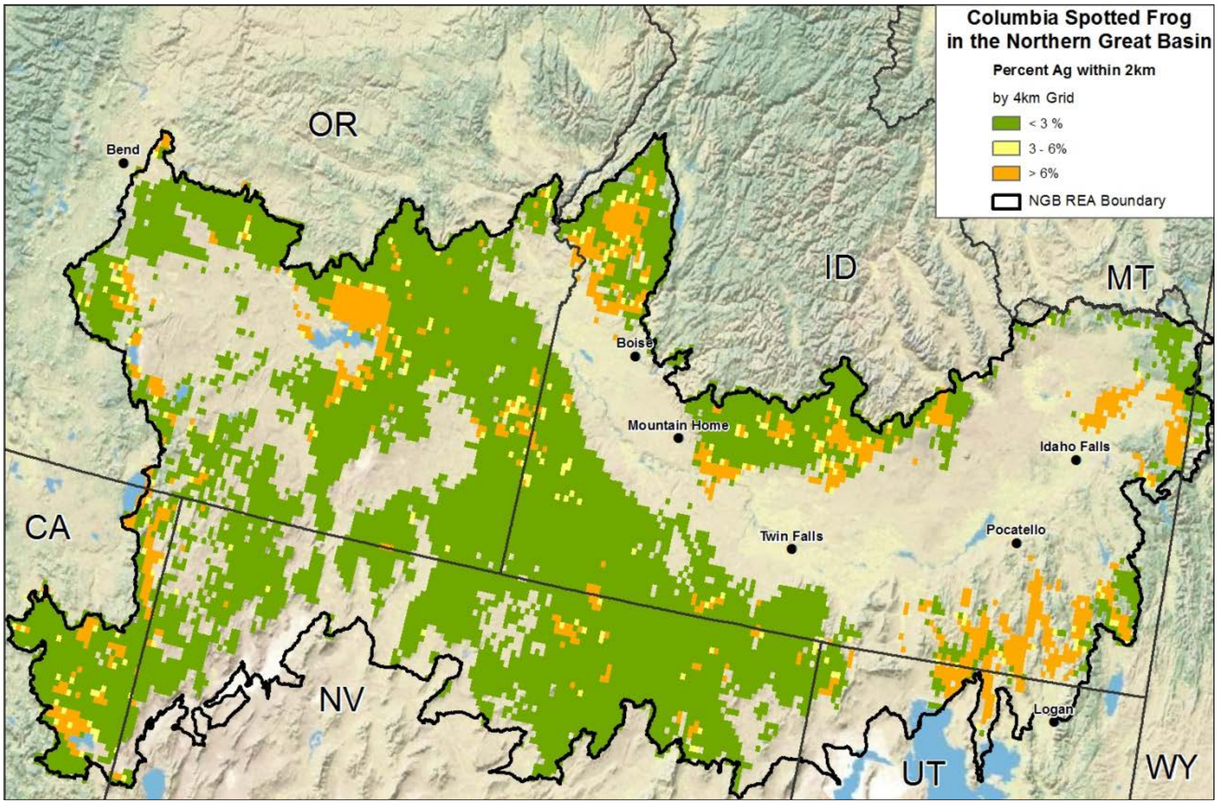


Figure 6-8. Percent Agriculture within 2km of Modeled Suitable Habitat

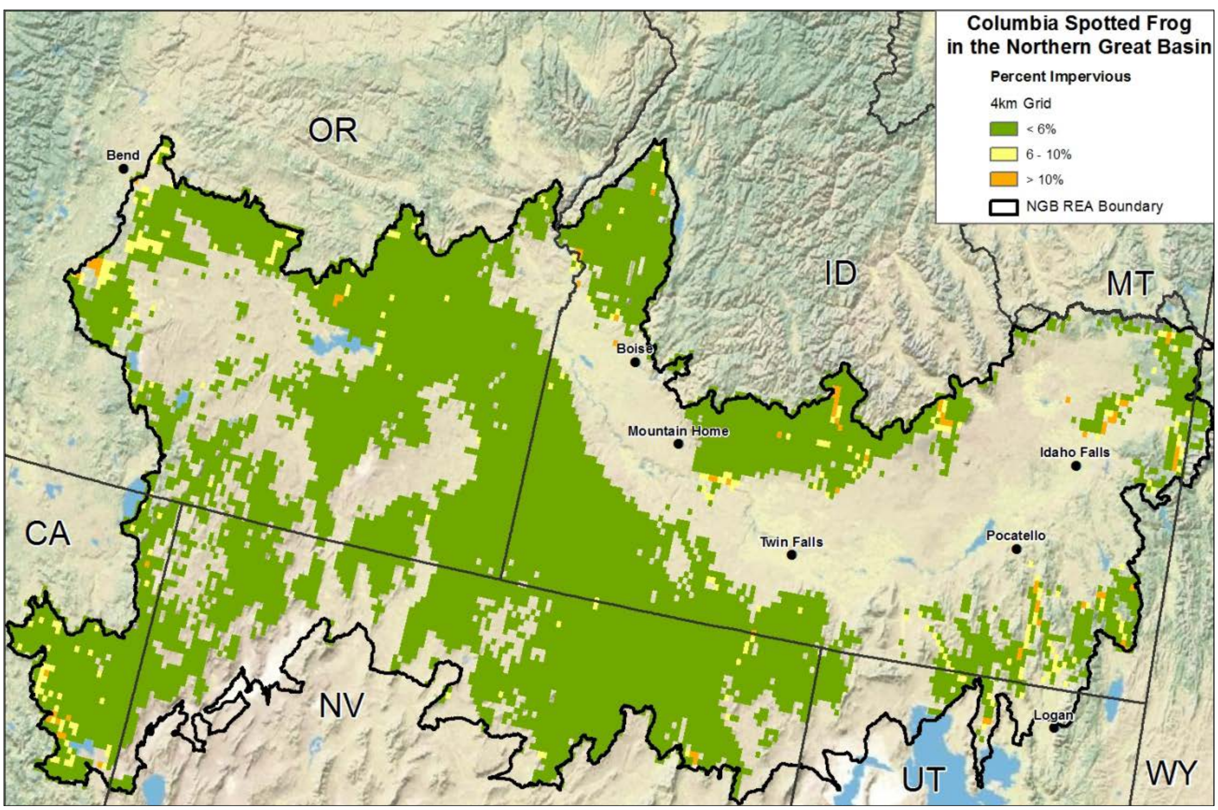


Figure 6-9. Percent Impervious of Modeled Suitable Habitat

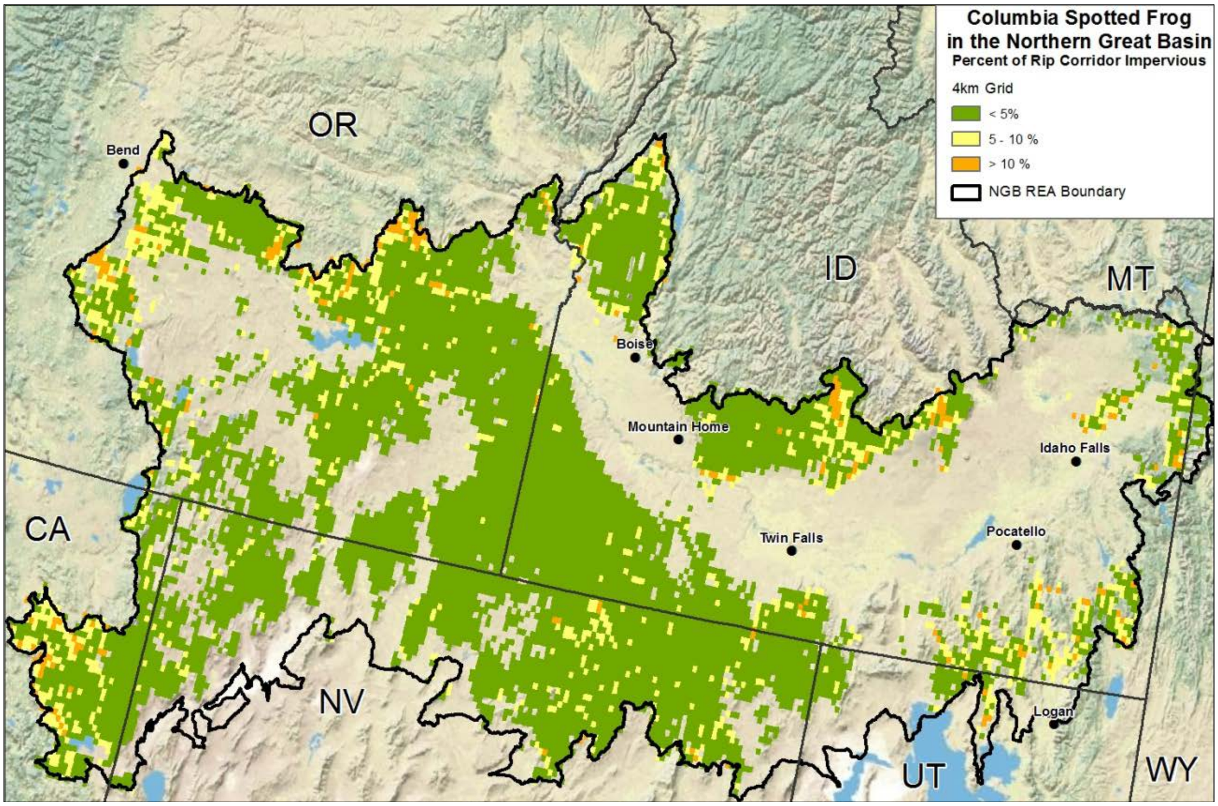


Figure 6-10. Percent of Riparian Corridor Impervious within Modeled Suitable Habitat

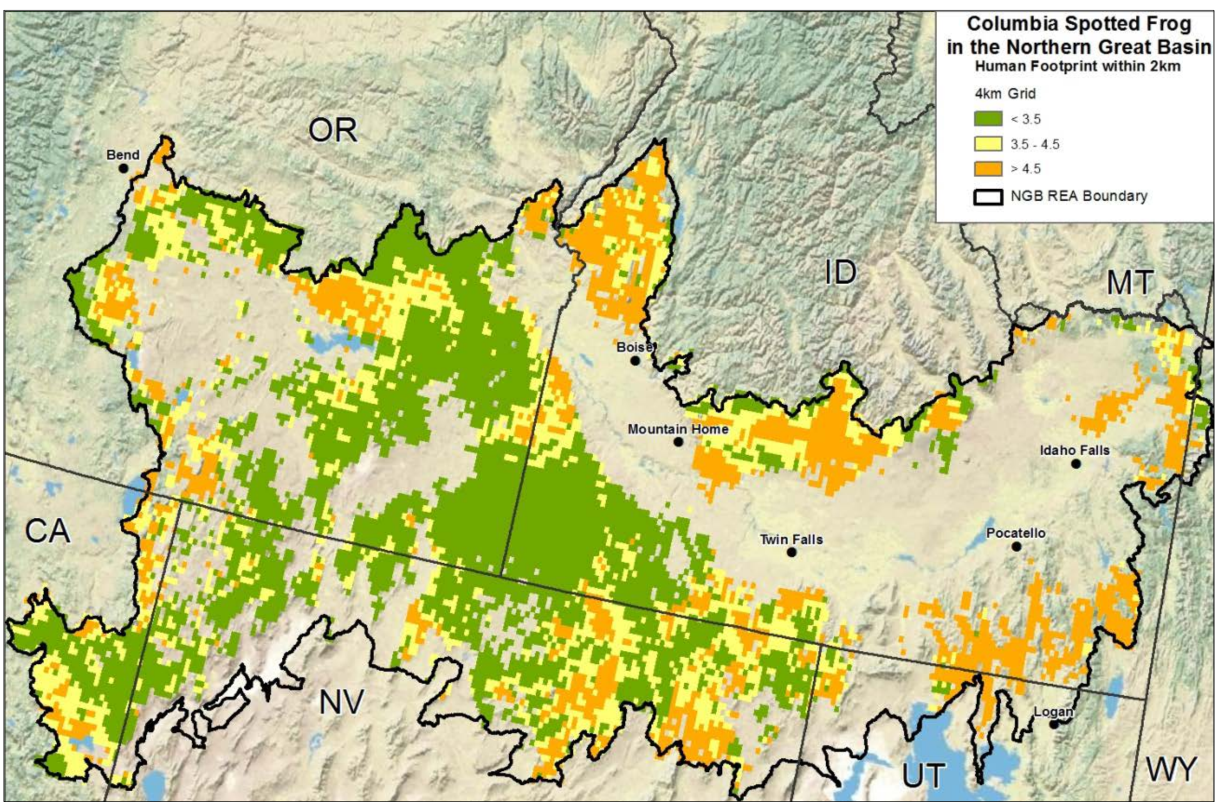


Figure 6-11. Human Footprint within 2 km of Modeled Suitable Habitat

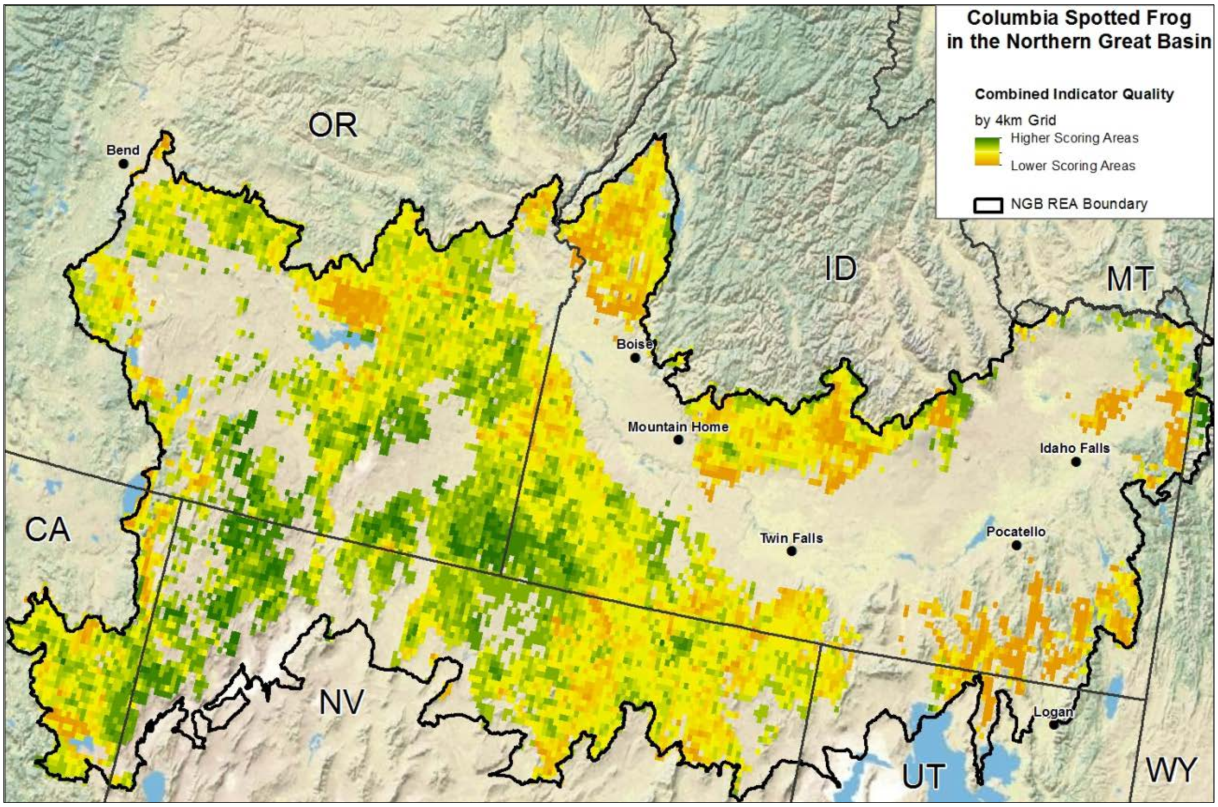


Figure 6-12. Cumulative Indicator Score for Columbia Spotted Frog Modeled Suitable Habitat

7 Management Questions

Management questions for the NGB were developed by BLM managers and refined by the AMT to answer questions regarding the agency's land management responsibilities—including planning land use, developing best management practices, authorizing uses, and establishing conservation and restoration priorities. Several management questions relate to this CE (with original numbering):

1 What is the currently occupied habitat or modeled suitable habitat for this CE?

The Columbia spotted frog observations and modeled suitable habitat is shown in Figure 4-2.

2 Where are the areas of greatest and least collective impact of existing CAs on occupied habitat or modeled suitable habitats of this CE?

Cumulative indicator scores (Figure 6-12) reflects the importance of human footprint elements and percent of the analysis unit within 40 m of roads. Much of the modeled habitat in the ecoregion outside of the Owyhee Mountain region, portions of northeastern and northwestern Nevada, and scattered smaller portions of southeastern Oregon, received low scores. The scattered patches of high-scoring analysis units among larger areas of lower-scoring units raises management concerns over isolated small populations.

5 Where are current locations of this CE likely to overlap with the potential future distribution of CAs (other than climate change)?

Potential future distribution of CEs was only modeled for wildfire and development. Wildfire may have temporary impacts on spotted frog habitat. Large, catastrophic fires can lead to major sedimentation events like debris flows, which may locally extirpate spotted frog population. Columbia spotted frog habitat overlaps areas with high burn probability in much of Idaho and northwestern Nevada. Most growth in development is modeled to occur in existing population centers along the Snake River corridor where Columbia spotted frog habitat is non-existent or low scoring.

6 Given current and anticipated future locations of CAs, which habitat areas remain as opportunities for habitat enhancement/restoration for this CE?

The cumulative indicator scores for Columbia spotted frog habitat under current conditions (Figure 6-12) should be useful in identifying the areas most in need of preservation or the best restoration opportunities in the drill-down evaluations. Areas that were modeled as suitable Columbia spotted frog habitat should be examined in detail by local managers for opportunities for habitat restoration and reintroduction.

7 Where are potential areas to restore connectivity for this CE, based on current locations of CAs?

Connectivity was modeled using barriers to movement (high traffic roads, developed/urban cover types, elevation differences) to fragment the modeled suitable habitat. Most modeled areas had a high score for connectivity < 1 km. Therefore connectivity is not a major factor in most of the modeled suitable habitat.

8 Where will this CE experience climate outside their current climate envelope? Or: Where will this CE experience significant deviations from normal climate variation?

Climate change leading to more prolonged drought events and the loss of some ponds, slow-moving streams, and other aquatic habitats is a concern for amphibians in the western states general, but measurable effects have not been well documented in the literature.

Overall, climate change is predicted to produce a slight precipitation increase in the basins, valleys, and uplands and large increases in the mountains. No changes are predicted in the basins or the lower elevations of the Owyhee Uplands. The western half of the NGB REA is predicted to become slightly warmer during June so the slight increase in precipitation may offset some of the increased evapotranspiration demand, making the net effect on Columbia spotted frogs difficult to predict.

8 References

Adams, M.J., N.D. Chelgren, D. Reinitz, R.A. Cole, L.J. Rachowicz, S. Galvan, B. McCreary, C.A. Pearl, L.L. Bailey, J. Bettaso, E.L. Bull, and M. Leu. 2010. Using occupancy models to understand the distribution of an amphibian pathogen, Batrachochytrium dendrobatidis. Ecological Applications 20:289-302.

Bull, E.L. 2005. Ecology of the Columbia spotted frog in northeastern Oregon. General Technical Report PNW-GTR-640. Pacific Northwest Research Station. USDA Forest Service. Portland, OR.

Bull, E.L. and M.P. Hayes. 2002. Overwintering of Columbia spotted frogs in northeastern Oregon. Northwest Science 76:141-147.

Bull, E.L. and M.P. Hayes. 2001. Post-breeding season movements of Columbia spotted frogs (Rana luteiventris) in northeastern Oregon. Western North American Naturalists 61:119-12.

Bureau of Land Management (BLM). 1994. Riparian Area Management, Process for Assessing Proper Functioning Condition for Lentic Riparian-Wetland Areas. Technical Reference 1737-11, Revised 1998. Lentic Riparian-Wetland Area Proper Functioning Condition Work Group. BLM Service Center, Denver, Colorado.

Corn, P.S. 2005. Climate change and amphibians. Animal Biodiversity and Conservation 28:59-67.

_____. 2003. Amphibian breeding and climate change: the importance of snow in the mountains., Conservation Biology 17:622-625.

Engle, J.C. 2002. Columbia spotted frog Great Basin population (Owyhee subpopulation) long-term monitoring plan. Year 2001 results. Idaho Department of fish and Game Report. Boise, Idaho.

_____. 2001. Columbia spotted frog Great Basin population (Owyhee subpopulation) long-term monitoring plan. Year 2000 results. Idaho Department of Fish and Game Report. Boise, Idaho.

Engle, J.C. and J.C. Munger. 2003. Population fragmentation of spotted frogs in the Owyhee Mountains. Bureau of Land Management Technical Bulletin No. 03-98. Boise, Idaho.

Johnson P.T.J., K.B. Lunde, E.M. Thurman, E.G. Ritchie, S.N. Wray, D.R. Sutherland, J.M. Kapfer, T.J. Frest, J. Bowerman, and A.R. Blaustein. 2002. Parasite (*Ribeiroia ondatrae*) infection linked to amphibian malformations in the western United States. Ecological Monographs 72:151-168.

Minshall, G.W., S.E. Jensen and W.S. Platts. 1989. The ecology of stream and riparian habitats of the Great Basin Region: A community profiles. U.S. Fish and Wildlife Service Biological Report 85(7.24)

Monello, R.J. and R.G. Wright. 1999. Amphibian habitat preferences among artificial ponds in the Palouse Region of Northern Idaho. Journal of Herpetology 33:298-303.

Munger, J.C. 2003. Critical habitat elements for Columbia spotted frogs in the Owyhee Mountains. Report on a challenge cost share agreement between Boise State University and the Bureau of Land Management. Boise, Idaho.

Munger, J.C., C.R. Peterson, M. McDonald, and T. Carrigan. 2002. Habitat conservation assessment for the Columbia spotted frog (*Rana luteiventris*) in Idaho. Report to the Idaho State Conservation Effort.

Munger, J.C., M. Gerber, M. Carroll, K. Madric, and C. Peterson. 1996. Status and habitat associations of the spotted frog (Rana pretiosa) in southwestern Idaho. Bureau of Land Management Technical Bulletin No. 96-1. Boise, Idaho.

Nelson, R.L., M.L. McHenry, and W.S. Platts. 1991. Mining. Pp. 425-457 In W.R. Meehan (ed.) Influences of forest and rangeland management on salmonid fishes and their habitats. Special publication 19. American Fisheries Society, Bethesda, MD.

Nevada Department of Wildlife. 2010. Great Basin population of Columbia spotted frog, Northeastern subpopulations: Conservation agreement and strategy implementation 2010 annual report. Eastern Region, Elko, Nevada.

______. 2006. Nevada Wildlife Action Plan. Reno, NV. June 23, 2006. 546 pp. + appendices.

Oregon Department and Fish and Wildlife. 2006. The Oregon Conservation Strategy. Salem, Oregon.

Patla, D.A. and D.Keinath. 2005. Columbia spotted frog (*Rana luteiventris* formerly *R. pretiosa*): A technical conservation assessment. Prepared for the USDA Forest Service, rocky Mountain Region, Species conservation Project.

Patla, D.A. and C.R. Peterson. 1996. The effects of habitat modification on a spotted frog population in Yellowstone national Park. Pp 16-17 in E.D. Koch, G. Wood, C.R. Peterson, and P.S. Corn, editors. Conference on declining and sensitive amphibians in the Rocky Mountains and Pacific Northwest. Idaho Herpetological Society and U.S. Fish and Wildlife Service, Snake River Basin Office Report. Boise, Idaho.

Pearl, C.A., M.J. Adams, and W.H. Wente. 2007. Characteristics of Columbia spotted frog (Rana luteiventris) oviposition sites in northeastern Oregon, USA. Western North American Naturalist 67(1):86-91.

Pilliod, D.S., B.R. Hossack, P.F. Bahls, E.L. Bull, and P.S. Corn. 2010. Non-native salmonids affect amphibian occupancy at multiple scales. Diversity and Distributions 16:959-974.

Pilliod, D.S., C.R. Peterson, and P.I. Rison. 2002. Seasonal migration of Columbia spotted frogs (Rana luteiventris) among complementary resources in a high mountain basin. Canadian Journal of Zoology 80:1849-1862.

_______. 2001. Local and landscape effects of introduced trout on amphibians in historically fishless watershed. Ecosystems 4:322-333.

Reaser, J.K. 1997. Conservation of the spotted frog (*Rana pretiosa*) in Nevada: multi-scale population status and trends assessment. Pages 21-22 in E.D. Koch, G. Wood, C.R. Peterson, and P.S. Corn, editors. Conference on declining and sensitive amphibians in the Rocky Mountains and Pacific Northwest. Idaho Herpetological Society and U.S. Fish and Wildlife Service, Snake River Basin Office Report, Boise, Idaho.

Reaser, J.K. and D.S. Pilliod. 2005. *Rana luteiventris*, Columbia spotted frog. Pp. 559-563 in M.J. Lannoo, (ed.). Amphibian Declines: the conservation status of United States species. University of California Press, Berkeley, CA

Richter, K.O. and A.L. Azous. 1995. Amphibian occurrence and wetland characteristics in the Puget Sound Basin. Wetlands 15(3):305-315.

Rollins-Smith, L.A., L.K. Reinert, C.J. O'Leary, L.E. Houston, and D.C. Woodhams. 2005. Antimicrobial peptide defenses in amphibian skin. Integrative and Comparative Biology 45:137-142.

Russell, D.M., C.S. Goldeberg, L.P. Waits, E.B. Rosenblum. 2010. *Batrachochytium dendobatidis* infection dynamics in the Columbia spotted frog *Rana luteiventris* in north Idaho, USA. Diseases of Aquatic Organisms 92:223-230.

Sinisch, U. 1990. Migration and orientation in anuran populations. Ethology Ecology and Evolution 2:65-79.

Turner, F.B. 1962. An analysis of geographic variation and distribution of *Rana pretiosa*. American Philosophical Society Yearbook 1962:325-328.

_____. 1960. Population structure and dynamics of the western spotted frog, *Rana pretiosa* Baird & Girard, in Yellowstone national Park, Wyoming. Ecological Monographs 30:251-278.

U.S. Fish and Wildlife Service. 2011a. U.S. Fish and Wildlife Service Species Assessment and Listing Priority Assignment Form. Region 8 (California/Nevada Region). Available at: http://ecos.fws.gov/docs/candidate/assessments/2012/r8/D027_V01.pdf. April 15.

_____. 2011b. Federal Register 27122 Endangered and Threatened Wildlife and Plants; Review of Native Species That Are Candidates for Listing as Endangered or Threatened; Annual Notice of Findings on Resubmitted Petitions; Annual Description of Progress on Listing Actions; Proposed Rule 76 (207): 66397. October 26

_____. 2008. Final Report: Preliminary assessment of Trace-metal exposures to aquatic biota from historical mine sites in the Western Great Basin. Project ID:1130-1F41. Nevada Fish and Wildlife Office, Reno, Nevada U.S. Fish and Wildlife Service. 2005. Columbia spotted frog. U.S. Fish and Wildlife Service species assessment and listing priority assignment form. Region 8.

Wilson, K.W. 2006. Columbia spotted frog and least chub status, distribution, habitat requirements, conservation agreements and strategies, Utah's role in conservation of the species and potential groundwater withdrawal impacts to wetland dependent species. Unpublished report. Utah Division of Wildlife Resources.

Greater Sage-grouse Conservation Element Package

1 Introduction

The greater sage-grouse was approved by the Assessment Management Team (AMT) as a conservation element (CE) because of the bird's ecoregional importance. The greater sage-grouse is considered an umbrella species for sagebrush-associated vertebrates (Rowland *et al.* 2006; Hanser and Knick 2011). Indirect effects of sagebrush habitat loss, fragmentation, and degradation are thought to have caused the extirpation of the greater sage-grouse from approximately 50 percent of its original range (Connelly and Braun 1997; Connelly *et al.* 2004; Schroeder *et al.* 2004) in 2010, the U.S. Fish and Wildlife Service determined that greater sage-grouse warranted listing under the Endangered Species Act; however, listing was precluded and greater sage-grouse remains a candidate for listing.

The Western Association of Fish and Wildlife Agencies (WAFWA) has recognized the greater sage-grouse as an indicator of overall health of sagebrush ecosystems in western North America and are working to maintain and enhance populations and distribution of greater sage-grouse by protecting and improving sagebrush habitats and ecosystems that sustain them.

Management questions (MQs) that apply to greater sage-grouse can be summarized into three primary questions: 1) where are the important areas for this species; 2) where are healthy habitats protected or those that can be restored and/or protected; and 3) what is happening to those areas?

This CE package provides the assessment of the current status and future threats due to the applicable change agents (CAs) for the greater sage-grouse in the NGB ecoregion. This CE package includes a brief description of the biology of the greater sage-grouse in the NGB ecoregion, a description of CAs that were assessed, a conceptual model of ecosystem functions relevant to the greater sage-grouse including life cycle components, information on potential data sources and analytical methods for the assessment, and a full listing of relevant management questions for this CE. The primary CAs that were identified for greater sage-grouse include development, climate change, invasive species, wildfire, and disease.

2 CE Package Review Process

2.1 Subject Matter Expert Review

Subject Matter Experts play a key role in ensuring that the REA reflects the best available data and modeling processes suitable for each conservation element and change agent. Subject Matter Experts were added to Rolling Review Teams comprised of SAIC scientists, SAIC GIS personnel, AMT member(s) and other subject matter experts from the Department of Interior or state agencies. Membership of the Rolling Review Teams is listed in Appendix A. To ensure consistency amongst the different Rolling Review Teams, the number of lead SAIC scientists was limited to only a few individuals. This ensured that there was a common approach, or framework, used among the different Rolling Review Teams and that one Rolling Review Team did not stray too far from the rest. The USGS, as peer reviewers, were invited to participate in Rolling Review Teams.

3 CE Description

The greater sage-grouse is a widespread sagebrush-obligate species whose populations have experienced long-term declines and are now absent much of their former range (Schroeder *et al.* 2004). At the landscape scale, greater sage-grouse require large, interconnected expanses of sagebrush ecosystems, with varying densities and heights of sagebrush cover, ages, and moisture regimes (Doherty *et al.* 2008).

Greater sage-grouse are most closely linked to systems dominated by three subspecies of big sagebrush, little sagebrush, black sagebrush, and silver sagebrush (Miller *et al.* 2011). Sagebrush steppe vegetation types vary in resilience to disturbance depending on the species or subspecies and site characteristics but sagebrush systems as a whole are generally not considered resilient to frequent and large-scale disturbance (Davies *et al.* 2009). Silver sagebrush may resprout after fire but the other species that are important to greater sage-grouse are killed by fire and must regenerate from seed. Sagebrush species occurring on certain types on productive sites (e.g., mountain big sagebrush) have greater ability to recover from disturbance than species or subspecies growing on less productive sites (e.g., Wyoming big sagebrush). Many semiarid systems are characterized by alternate stable states (vegetation conditions) resulting from different disturbance events, as described in greater detail in the coarse-filter vegetation models. Altering a native disturbance regime (e.g., fire frequency or grazing intensity) may drive a sagebrush community across a threshold to another stable state (e.g., grassland, woodland) that is not suitable for greater sage-grouse.

There is considerable variation among greater sage-grouse populations with respect to migration distances, but some migratory populations move relatively large distances (often >20 kilometers [km]) between different seasonal habitats, and occupy large home ranges (>600 square kilometers [km^2]). Life cycle components related to habitat (Connelly *et al.* 2011b) include:

1 Lek sites are typically located in sparse to short grassland or man-made openings within sagebrush communities. Sagebrush immediately surrounding lek sites is used for feeding, resting and cover from weather and security from predators when the birds are not on leks;

2 Nesting habitat, usually within 11 miles of the lek, which requires a sagebrush canopy that provides cover from predation during the growing season and a healthy grass understory;

3 Early brood-rearing habitat, which is characterized by the chicks' requirements for escape cover (sagebrush canopy) and food resources (primarily arthropods and forbs);

4 Summer into fall late brood-rearing, during which greater sage-grouse may shift to areas that support green vegetation, such as riparian habitats, springs and seeps, and agricultural croplands, irrigated hayfields, sagebrush uplands and high elevation meadows; and

5 Winter habitat, in which the primary requirement is sagebrush exposed above the snow. Exposed sagebrush is used for feed and cover; greater sage-grouse feed almost exclusively on sagebrush in the winter.

4 CE Modeling

4.1 Data Identification

Table 4-1 lists the types of data and data sources that were originally proposed for use in the REA as part of the pre-assessment data identification effort. This table lists the need for the data, the general name of the dataset, and if the dataset was acquired.

Table 4-1. Preliminary Key Greater Sage-Grouse Data Sources

Data Required	Dataset Name	Source Agency	Type/Scale	Status	Use in REA
Modeled Suitable Habitat	Currently Occupied Habitat	BLM Spatial Lab	Polygon	Acquired	No
	Breeding Bird Density	BLM (Doherty 2010)	Polygon	Acquired	Yes
Preliminary Priority Habitat	PPH	State Datasets	Polygon/Raster	Acquired	Yes
Preliminary General Habitat	PGH	State Datasets	Polygon/Raster	Acquired	No
Leks	USGS data compilation Natural Heritage databases State data	Natural Heritage Programs, USGS, State Fish and Game agencies	Point with buffers or polygon	Limited Data	No

4.2 Distribution Mapping Methods

The AMT decided that the state Preliminary Priority Habitat (PPH) data was the best source of important greater sage-grouse habitat. Each state provided their latest PPH data which was merged together to form one dataset. Most states provided vector polygon data while Nevada uses a raster with varying levels of importance. One area of uncertainty was that each state has its own methodology for determining PPH (see Figure 4-1). For example, Oregon appears to have a lek based method of delineating PPH while Idaho uses a sagebrush habitat approach. Breeding Bird Density data (at the 75 percent level, Figure 4-2) was used for some key ecological attributes that focused on lek quality rather than administrative boundary such as PPH. Breeding Bird Density polygons of 75 percent represents 75 percent of the known breeding population. The polygons are based on leks buffered at a distance of 8.5 kilometers to provide and estimate of the area required to support breeding populations in low abundance or fragmented landscapes (Doherty *et al.* 2010)

4.3 Data Gaps, Uncertainty, and Limitations

4.3.1 Data Gaps

All states provided PPH data based on their state methodology, and thus is best evaluated at the ecoregion scale and not for comparison between states or regions. The PPH dataset is the best representation of priority habitat for greater sage-grouse at the ecoregional scale.

4.3.2 Uncertainty

Merging state based datasets caused some uncertainty where PPH data crossed state lines and was only present on one side of the state boundary. This is primarily due to the fact that each state has its own methodology for determining priority habitat for greater sage-grouse. Further, the PPH dataset was not developed as modeled suitable habitat patches, but rather indicates each individual state's identification of priority areas for the species. Many of the mapped areas can include unsuitable habitat, or otherwise represent an accumulation of characteristics that may help capture "priority" areas for the species but may not consistently represent current habitat patches. As a result, suitable habitat "patch size" cannot be analyzed in a meaningful way using the PPH dataset and therefore the cumulative indicator score for sage-grouse habitat does not reflect this key ecological attribute. This limitation should be factored into any consideration of the modeling results presented below. More discussion on this limitation is included in Section 6.1 below.

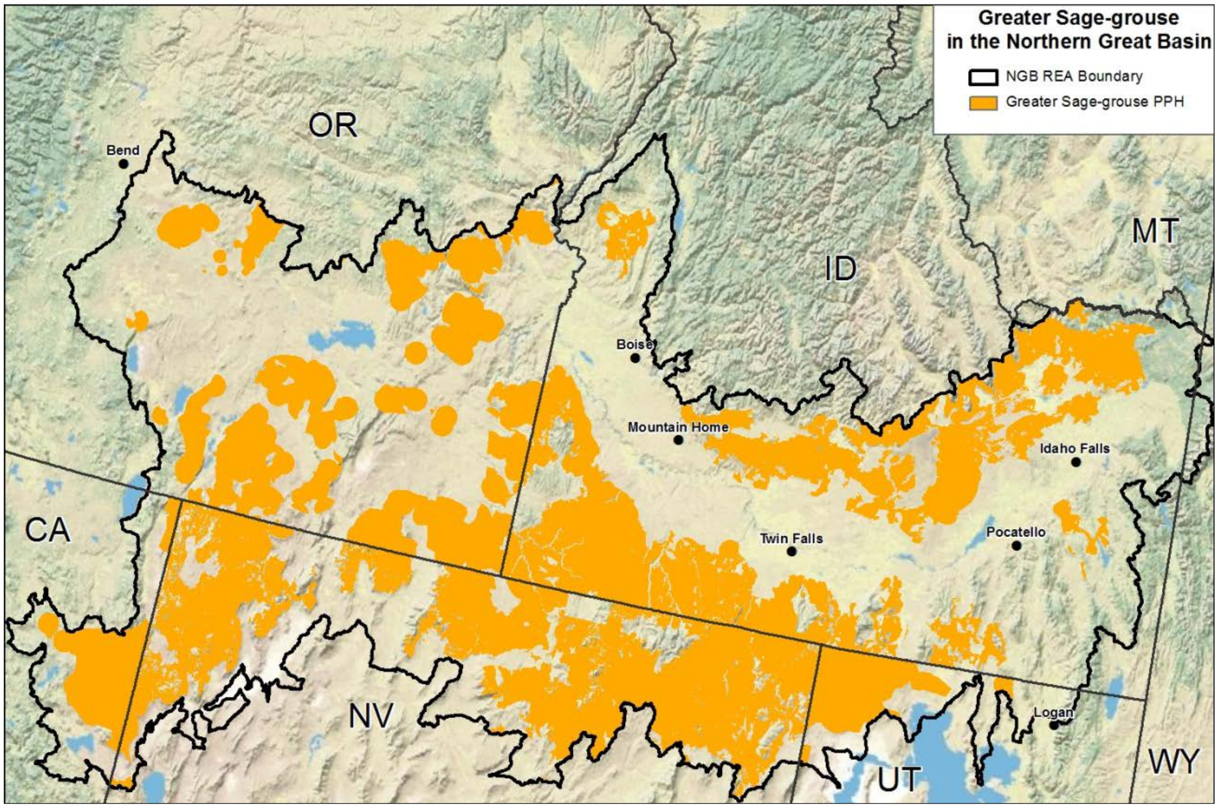


Figure 4-1. Greater Sage-Grouse Preliminary Priority Habitat

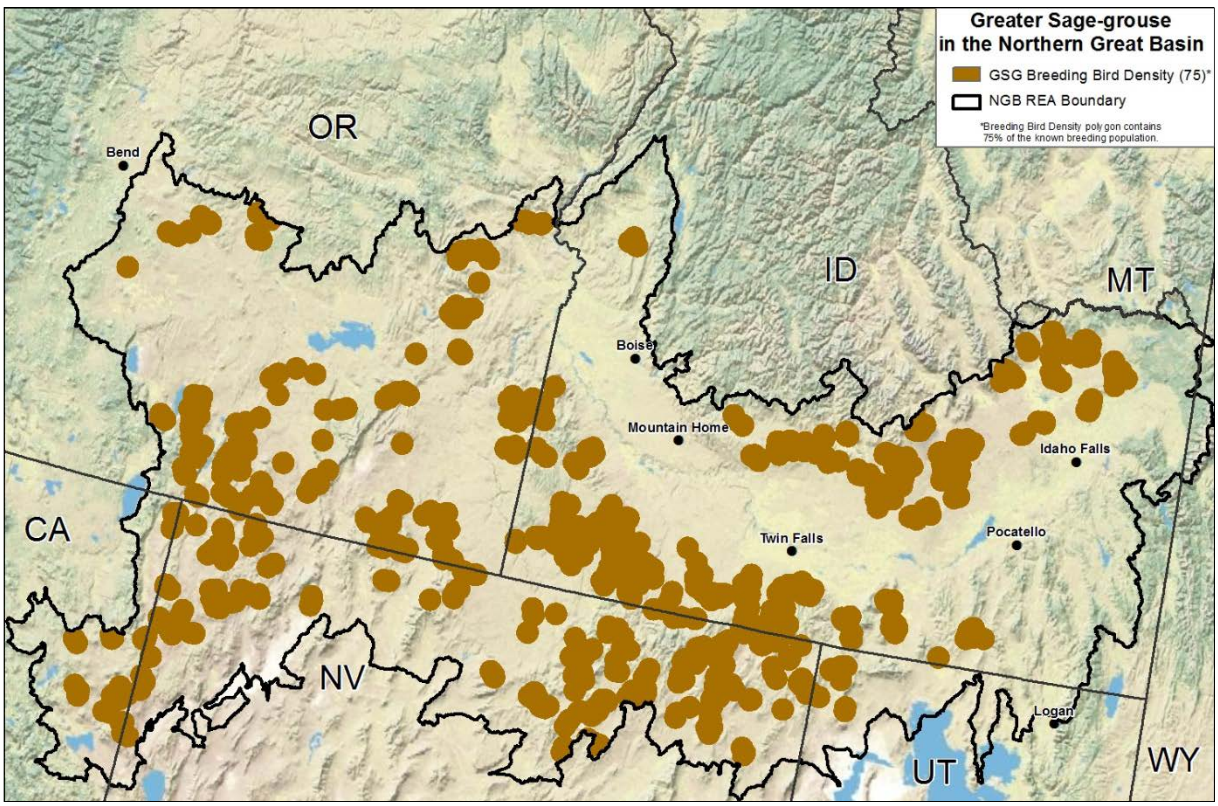


Figure 4-2. Greater Sage-Grouse Breeding Bird Density (75 percent) (Doherty et al. 2010) System Models

Conceptual system models were developed as part of the pre-assessment phase to assist with the determination of the key factors that are important to the life cycles of the greater sage-grouse in the NGB ecoregion. The model was developed to provide an ecological framework and justification for the choice of indicators that were used in assessing CA threats for this CE. This model begins with depicting the important habitat components of the greater sage-grouse life cycle required throughout the year and incorporates the identified CAs, as well as potential effects from the actions of the CAs on both the landscape and local habitat levels (Figure 5-1). Being conceptual in nature, all potential important stressors and effects were included regardless of availability of data at this point in the REA. Those elements that could not be carried forward for analysis will be discussed.

4.4 Change Agents

The CAs considered for this CE analysis include development, climate change, invasive species, wildfire, and disease, depicted in brown boxes across the top of the figure (Figure 5-1). As mentioned in Section 3, suitable greater sage-grouse habitat depends upon the stability of healthy sagebrush ecosystems. Because the details of transitions between sagebrush vegetation states are presented in a later (Coarse Filter) section, they are not repeated in the greater sage-grouse model. However, the greater sage-grouse system model does indicate the relationships between the CAs that act upon the greater sage-grouse habitat needs and thereby, on the greater sage-grouse functions and values, depicted in the lower box. The predicted results of CA effects are presented in blue boxes.

4.4.1 Development

In the last few decades, developments including infrastructure expansion (roads, pipelines, and transmission lines), , mining, and establishment of wind farms in proximity to greater sage-grouse leks and in winter habitat have directly reduced the amount of suitable habitat available for greater sage-grouse and have introduced noise and human presence that may also have adverse effects (Hollaran 2005; Kaiser 2006; Aldridge and Boyce 2007; Doherty *et al.* 2008; Naugle *et al.* 2009; Harju *et al.* 2010). Historic conversion of sagebrush to pasture, cropland or irrigated hayfields has been widely recognized as a dominant factor in the early declines of greater sage-grouse populations. Rangeland vegetation treatment practices are analyzed as a type of land development primarily because of land conversions conducted to improve forage quality, affects greater sage-grouse habitat quality. These practices removed sagebrush to promote more grazing lands, with adverse effects on greater sage-grouse habitat, but current practices attempt to maintain adequate shrub cover while rejuvenating the understory component. Knick *et al.* 2013 analyzed the differences between active leks and historic (currently extant) leks locations based on their relation to land use and anthropogenic influences. Knick *et al.* 2013 found that in a 5km area surrounding the leks:

- Sagebrush cover near active leks average 78.8 percent while historic leks averaged 34.9 percent.
- Agricultural land near active leks averaged 2.1 percent while historic leks averaged 26.6 percent
- Developed land near active leks averaged 0.3 percent while historic leks averaged 8.7 percent
- Secondary road density near active leks averaged 0.6 (km/km^2) while historic leks averaged 1.65 km/km^2
- Highway density near active leks averaged 0.02 (km/km^2) while historic leks averaged 0.11 km/km^2
- Interstate density near active leks averaged 0.001 (km/km^2) while historic leks averaged 0.038 km/km^2
- Power line density near active leks averaged 0.025 (km/km^2) while historic leks averaged 0.144 km/km^2
- Pipeline density near active leks averaged 0.014 (km/km^2) while historic leks averaged 0.086 km/km^2

- Communication tower density near active leks averaged 0.001 (towers/km^2) while historic leks averaged 0.183 towers/km^2

Conflicts between land use changes and greater sage-grouse-occupied habitat remain high across the species' range and population expansion may only be possible on large protected areas such as public lands unaffected by development and private land conservation easements of sufficient size.

Other development types included in the model include transmission lines or towers, which can both present strike hazards to flying greater sage-grouse and provide perches from which avian predators can hunt (Ellis 1987; Hall and Haney 1997; Braun 1998; Gilmer and Weihe 1977; Steenhof *et al.* 1993; Beck *et al.* 2006). Greater sage-grouse collisions with rangeland fences have also been documented (Christiansen 2009; Gruver 2009). Hydrological diversions and impoundments change the local hydrology and may affect the brood-rearing and/or summer/fall habitat required. Human urban/exurban development can introduce pet predators into the environment, as well as noise and disturbance not tolerated by greater sage-grouse. CAs affect greater sage-grouse directly through increased mortality or indirectly by increasing local noise and disturbance into occupied habitats, as depicted by a blue box in the model (Figure 5-1).

4.5 Climate Change, Wildfire, and Invasive Species

Climate change that alters vegetation growing conditions has the potential to directly change greater sage-grouse habitat availability and quality. This is in addition to potential indirect climate change effects on local precipitation and temperatures, which is turn has effects on snow pack, fire frequency, and local conditions for invasive species, insect outbreaks, and disease. Locations of habitats suitable for greater sage-grouse may change under future climate change scenarios. Predictions seem to be clearer for habitats at the extremes, such as those at highest elevations and northern latitudes. Climate effects are expressed primarily as a range of suitable precipitation (Wisdom *et al.* 2011) and the frequency and duration of drought (Aldridge *et al.* 2008). Evers (2010) suggested that under projected climate change, cooler and moister sagebrush communities (i.e., nesting and brood rearing habitat) would decrease substantially. Greater sage-grouse may have the ability to redistribute to areas that are currently cooler and wetter as long at the new regions are suitable and available for sagebrush expansion (Knick *et al*. 2013)

Under natural conditions, moderate fire return intervals and low intensity fires promoted the mixed composition of sagebrush communities required by greater sage-grouse for lekking, nesting and brood rearing. However, the ecological role of fire has changed significantly. In conjunction with climate change and the expansion of invasive annual species, wildfire now covers larger areas more frequently, reducing habitat quality and quantity for greater sage-grouse (Connelly and Braun 1997; Connelly *et al.* 2000b, Nelle *et al.* 2000; Fischer *et al.* 1996). On lower elevation drier sites more frequent wildfire covering a larger extent has contributed to vegetation type conversion from sagebrush to invasive grass monocultures. Elsewhere fire suppression has promoted expansion of juniper woodland into sagebrush sites. The predominant impacts of wildfire are expected to occur at the vegetation community level, as sagebrush sites shift from one state to another with changes in disturbance regimes.

Invasive species occurrences and fire history are often linked, as shown in the coarse filter sagebrush model, and have been estimated to contribute to an increase in pinyon-juniper woodlands in the Intermountain West (Miller and Tausch 2001), which are avoided by greater sage-grouse. Tree establishment within sagebrush communities generally decreases forb availability due to moisture depletion (Bates *et al.* 2000). In Wyoming big sage communities, invasion by annual grasses or weeds (e.g., cheatgrass, medusahead) is the greatest threat, because these fuels increase the fire frequency from greater than 100 years to less than 10 years (Whisenant 1990).

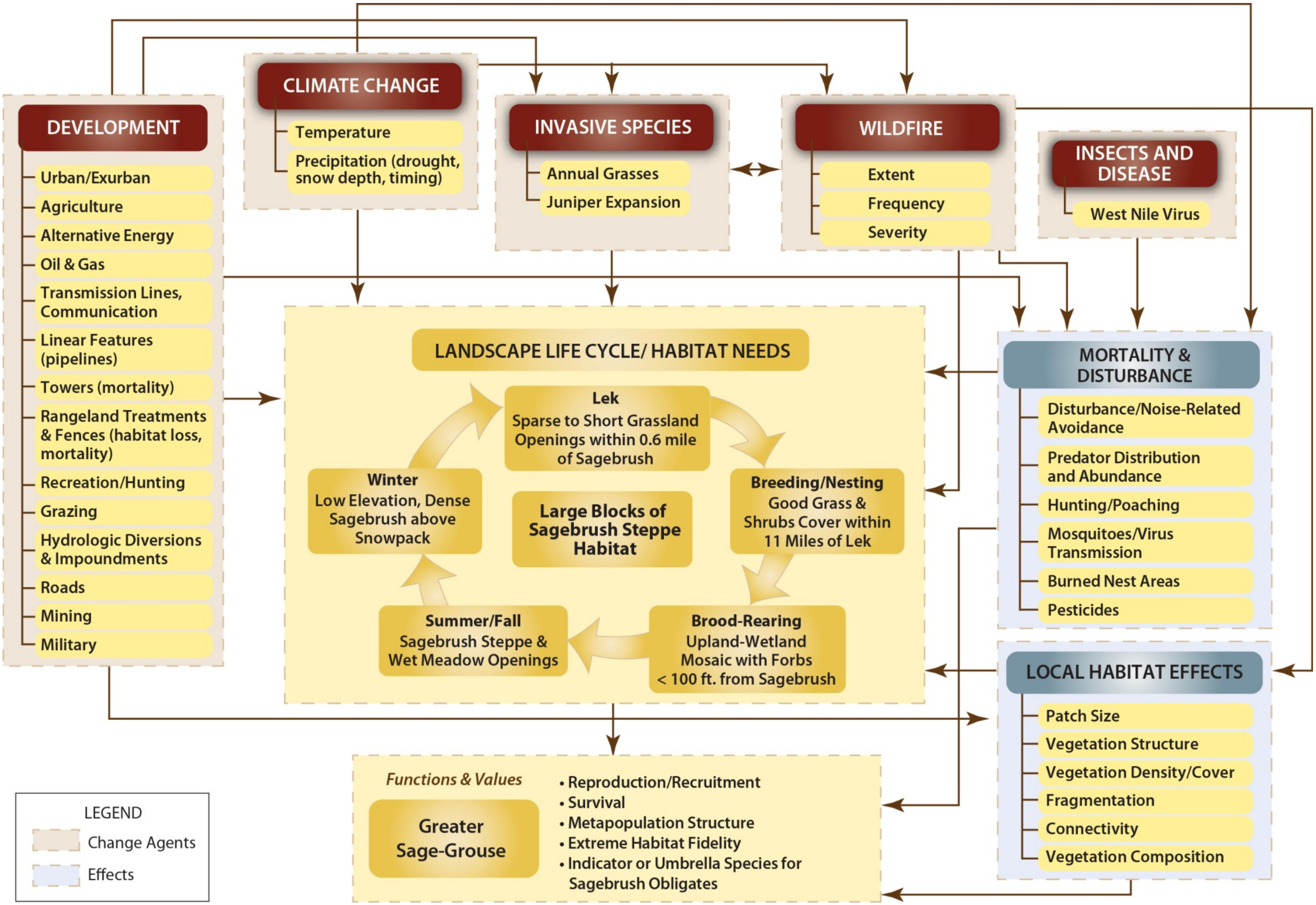


Figure 5-1. Greater Sage-grouse System Model

4.6 Disease

West Nile virus (WNV), an important new source of mortality in greater sage-grouse since its introduction in 1999, has the greatest potential for population-level effects among all parasites and infectious diseases identified in greater sage-grouse (Christiansen and Tate 2011). WNV has been identified in greater sage-grouse populations in 10 states and may result in persistent low-level mortality and possibly severe outbreaks leading to local extinctions and/or regional population declines (Walker and Naugle 2011). Small, isolated populations would be most affected (eastern California) on the fringe of the greater sage-grouse range as an outbreak could reduce populations below a recoverable size. Larger low to mid elevation populations of greater sage-grouse which are annually inflicted with WNV in northern Nevada and southern Idaho may absorb the impacts if population growth is still supported by quality habitat (Walker and Naugle 2011). WNV incidence is probably related to the increase in available surface water (breeding sites for the WNV mosquito vector) associated with irrigated agriculture (usually not on BLM lands) and livestock tanks and ponds.

5 CA Threat Analysis

Current status and future threat assessments for the greater sage-grouse were conducted for the NGB using both 30m pixels and the 12-digit HUCs as the analysis units. The CAs evaluated for current status of greater sage-grouse in the NGB include development, invasive species, wildfire, and disease. Once the ecological model was developed, indicators or key ecological attributes need to be identified with a specific emphasis on the ability to measure indicators and predict future scenarios for the key ecological attributes using existing geospatial data. The indicators will assist with answering the MQs that relate to what is happening to the CE across the ecoregion. The CAs evaluated for current status include development, wildfire, climate change, invasive species, and disease. Future revisions of this CE package will incorporate input from the Rolling Review Team and explain any key ecological attributes and CAs that were revised or dropped from the analysis.

Given the uncertainties associated with the impact of climate change on sagebrush habitats, as well as increased energy extraction activities in sagebrush ecosystems, management actions that increase and enhance the number, quality and connectivity of sagebrush habitats, while limiting fragmentation from anthropogenic sources, will be particularly important for maintaining viable sage-grouse populations (Aldridge *et al.* 2008). Theses authors recommend that using model outputs to spatially identify two conservation practices is most important: (1) mitigation of negative effects in areas where populations are most at risk, and (2) identification of areas best suited for possible recolonization. For the latter, establishing connectivity to core populations or increasing patch size through restoration efforts, together with possible reintroduction programs, may provide a strategy for reversing historical greater sage-grouse population declines (Aldridge *et al.* 2008).

The realism and applicability of geospatial modeling is contingent upon availability and quality of reference data layers included in the ecoregion. These intermediate CA layers are then combined to form a single layer outlining areas that may negatively affect suitable greater sage-grouse habitat. As indicated above, the greater sage-grouse distribution layer consists of the BLM breeding density layer and the individual states' core areas. Landscape context features (habitat connectivity, etc.) was incorporated into a GIS dataset for overlay analysis and comparison with the greater sage-grouse distribution layer.

5.1 Key Ecological Attributes

The list of key ecological attributes (Table 6-1) includes indicators for assessing habitat size, condition, and landscape context with respect to anthropomorphic influences that are known to affect greater sage-grouse habitat. Indicators and metrics for key ecological attributes listed in Table 6-1 were evaluated on their suitability to be evaluated using geospatial data. Scoring metrics used to evaluate the CE's habitat across the ecoregion were derived from the literature where possible. Similar efforts of developing ecological attribute tables have been provided by Barker *et al*. 2008; Oliver 2006; the Uinta Basin Adaptive Resource Management Local Working Group (UBARM 2006); and O'Brien 2007. Definitions for rankings of indicators were adapted from UBARM (2006) as follows:

- Poor: Allowing the indicator to remain in this condition for an extended period will make restoration or prevention of extirpation of greater sage-grouse practically impossible (e.g., it will be too complicated, costly, and/or uncertain to reverse the alteration);
- Fair: The indicator lies outside of its range of acceptable variation and requires human intervention for maintenance and if unchecked, greater sage-grouse will be vulnerable to serious degradation;
- Good: The indicator is functioning within its range of variation, although it may require some human intervention for maintenance.

During the course of the analysis, data availability and consistency concerns caused the elimination of several of these preliminary key ecological attributes with concurrence by Rolling Review Team and Subject Matter Experts. The following key ecological attributes were eliminated:

- PPH Patch Size: The PPH dataset was not developed as modeled suitable habitat patches, but rather indicate each individual state's identification of priority areas for the species. Many of the mapped areas can include unsuitable habitat, or otherwise represent an accumulation of characteristics that may help capture "priority" areas for the species but may not consistently represent current habitat patches. Further, the ecoregion-wide dataset represents a merging of each state's effort, which as stated above, do not necessarily follow a consistent methodology. Because of the ecoregional scale of this effort, a patch size analysis would require breaking down PPH into smaller critical habitat elements, and the associated development of assumptions to make data between efforts consistent. As a result, the AMT determined that a patch size analysis on the PPH dataset would not provide meaningful results. There are other major research and study efforts underway evaluating this important species in the region.
- The AMT determined that an analysis of patch fragmentation based on the PPH dataset was not appropriate for the same reasons presented above.

5.2 Current Status of the CE

This section documents the current extent of the CE's distribution and locations of the CAs. For each of the key ecological attributes used in the CA analysis, a discussion of the indicator, metrics, metric rank and value, data source(s), and references is provided. The analysis was based on spatially available attributes affecting the CE at the ecoregion level. For key ecological attributes that focus on PPH, a recommendation by the AMT was to include the breeding bird density (BBD) (75 percent) areas on the maps. The BBD data intersected with threats identified within the PPH indicates where threats could be magnified.

5.2.1 Size

5.2.1.1 Lek Quality – Sagebrush Cover

The amount of sagebrush cover within the breeding bird density was calculated by using the sagebrush vegetative coarse filter extracted from ReGAP and LANDFIRE. The amount of sagebrush within a breeding bird density patch was calculated using zonal statistics to derive the total sagebrush and total count of cells in the patch. The percentage was calculated from these two values and symbolized on the Figure 6-1 based on the metrics in the key ecological attributes table (Table 6-1).

Table 6-1. Preliminary Key Ecological Attributes for Greater Sage-grouse

Category	Key Ecological Attribute	Indicator	Metric	GIS Source	Reference
Size	Lek Quality/ Stability	Sagebrush cover (% cover of *Artemisia* spp.)	>65% = high 20-65% = moderate <20% = low	GAP/ national land cover dataset	Aldridge *et al.* 2008
		Agriculture (% cropland)	<16% = high 16-32% = moderate >32% = low	GAP/ national land cover dataset	Aldridge *et al.* 2008
	Habitat Suitability	PPH patch size	>4,000ha = high 500-4,000 ha = moderate <500 ha = low	States	Wisdom *et al.* 2011
Condition	Habitat Quality/ Community Composition/ Landscape Structure	Cover type	Revise to level 3 categories	GAP/ national land cover dataset	Crawford *et al.* 2004
	Connectivity	Fragmentation (edge density – ratio of edge to interior)	1.5-2.5 = high 2.5-4 = moderate >4 = low	GAP/ national land cover dataset	Wisdom *et al.*2011
		Fragmentation (patch density – no. of patches per 101,704 ha)	>79 = high 62-79 = moderate <62 = low	GAP/ national land cover dataset	Wisdom *et al.*2011
	Land Use Stability	Percentage of combined leks and PPH on protected lands	>64% = high 26-64% = moderate <26% = low	States, PADS	Wisdom *et al.* 2011
Context	Anthropomorphic Influences	Road density (km/km2)	<0.087 = high 0.087 – 0.112 = moderate >0.112 = low	TIGER	Wisdom *et al.* 2011
		Distance to highway	>9 mi from lek and outside PPH = high 5-9 mi from lek or within PPH = moderate <5 mi from lek = low	TIGER	Wisdom *et al.* 2011
		Distance to cell towers	>21 mi from lek and outside PPH = high 12-21 mi from lek or within PPH = moderate <12 mi from lek = low	Tower structures	Wisdom *et al.* 2011
		Distance to electric transmission lines	>15 km from lek and outside PPH = high 6-15 km from lek or within PPH = moderate <6 km from lek = low	States, Linear features	Wisdom *et al.* 2011
		Percentage of combined leks and PPH in agriculture	<9% = high 9-25% = moderate >25% = low	GAP/LANDFIRE, States	Wisdom *et al.* 2011
		Human density (persons/km2) within combined leks and PPH in agriculture	<2 = high 2-27 = moderate >27 = low	Census TIGER, States	Wisdom *et al.* 2011

5.2.1.2 Lek Quality – Agriculture (Percent Cropland)

The amount of cropland within breeding bird density was calculated by using the zonal statistics spatial operation. Only southeastern Idaho had some breeding bird density areas that were in the moderate range comprised of more than 16 percent cropland.

5.2.2 Condition

5.2.2.1 PPH in Protected Areas

Protected areas provide some level of protection from development change agents. Protected areas are classified as GAP status one and two areas within the protected areas database maintained by the USGS. The amount of PPH in protected areas was determined by intersecting the PPH and the protected areas. The resulting map (Figure 6-3) shows the intersection of PPH and these protected areas. The Sheldon National Wildlife Refuge is the largest protected area within the greater sage-grouse PPH. Utah and eastern Nevada also stand out as having very low amounts of PPH within protected areas.

5.2.3 Context

5.2.3.1 Road Density

The road density key ecological attribute was calculated using a linear density spatial operation using all TIGER roads within the NGB ecoregion. Using the metrics provided by Wisdom *et al.* 2011 the results of the density analysis didn't match up. There may be a disconnect between the scale of the road spatial layer used in the two studies.

5.2.3.2 Distance to Highway

The distance to highways or primary roads was measured using the Euclidean distance spatial operation. TIGER roads were used (class 1100 and 1200) as the primary roads for the analysis which cover interstates, US and major state highways. The average distance within each analysis unit (4km Grid) to a primary road is displayed in Figure 6-4. This figure shows some of the main road corridors within the NGB ecoregion.

5.2.3.3 Distance to Towers

The distance to towers key ecological attributes was determined by using the Euclidean distance spatial operation to determine the distance from towers. The metric used by Wisdom *et al.* 2011 gave very high distances from towers which resulted in Figure 6-5 that shows most of the NGB ecoregion with low distances to towers within the PPH. Only some small areas within Nevada and Oregon had some areas of PPH with the highest distance from towers.

5.2.3.4 Distance to Transmission Lines

The distance to transmission lines was determined using the Euclidean distance spatial operation. The source of the transmission lines was the Global Energy 115 kV (or greater) dataset along with the TIGER 2000 transmission lines. The average distance within each analysis unit (4km Grid) to a transmission line is displayed in Figure 6-6. The resulting figure looks similar to the distance to primary roads as most roads will have transmission lines or be along transmission corridors.

5.2.3.5 Percentage of PPH in Agriculture

The amount of agriculture within the PPH was measured by using the agricultural extracted from ReGAP and LANDFIRE. Zonal statistics was then used to determine the amount of agricultural within each analysis unit within the PPH. Figure 6-7 shows the results of the 4km analysis unit mostly highlighting one area in the northern part of the ecoregion within Idaho. The rest of the ecoregion has low and isolated amounts of agriculture within the PPH.

5.2.3.6 Human Density

The population density within the PPH was measured by using the 2010 census data. Zonal statistics was then used to determine the population density within each analysis unit within the PPH. Figure 6-8 shows the results of the 4km grid analysis unit mostly highlighting the area north and south of Twin Falls in Idaho along the State Route 75 as being moderately high population density within PPH. There were no areas within the PPH that were in the highest population density category.

5.2.4 Cumulative Indicator Score

Key ecological attributes were used to create a cumulative indicator score for greater sage-grouse PPH (PPH in protected areas, distance to highways, distance to towers, distance to transmission lines, percentage of PPH in agriculture and human population density within PPH). The individual metrics for the key ecological attributes were scored with a 1, 2 or 3 with 1 given to lowest quality indicator and 3 given to the highest quality indicator. The six key ecological attributes were then added together using raster calculator to derive a range of cumulative scores from six (lowest possible score) to eighteen (highest possible score). Figure 6-9 shows the resulting high and low scoring areas with a stretched raster based on the 4km grid analysis unit. The stretched raster was used to show the gradient from low scoring to high scoring which allows for the visual separation of the highest scoring areas, the lowest scoring areas, and blends in the areas in the middle.

The analysis has identified greater sage-grouse stronghold in Northwestern Nevada, Southeastern Oregon and the tri-state region where Idaho, Nevada and Oregon meet. Focusing conservation and management efforts into these regions may be necessary to prevent further deterioration of habitat.

5.3 Future Threat Assessment

5.3.1 Climate Change

Invasive plant species, wildfire, weather, and climate change are important influences on sagebrush habitats throughout range of the greater sage-grouse (Miller *et al.* 2011). Cheatgrass, an invasive annual grass, is currently present throughout the NGB (Wisdom *et al.* 2005; Meinke *et al.* 2009), with deleterious effects on many of the more xeric sagebrush vegetation types. Cheatgrass competes successfully against native grasses especially in response to disturbance (Klemmedson and Smith 1964). The cheatgrass invasion of the Great Basin has occurred in concert with increased disturbance from human land use actions and increased frequency and extent of wildfires. In the context of short-term, large-term habitat changes, repeated fires that eliminate or reduce shrubs, native grasses, and forbs, and native species' seed banks, have allowed cheatgrass to become dominant in many sagebrush communities (d'Antonio and Vitousek 1992, d'Antonio 2000; Brooks *et al.* 2004). The risk of wildfire increases with the presence of continuous cheatgrass ground cover, resulting in a synergistic feedback that increases the probability of cheatgrass spread and dominance across the landscape (Link *et al.* 2006). A large proportion of existing sagebrush cover types in the NGB are thought to be at moderate or high risk of elimination from continued invasion of cheatgrass over the next 30 years (Suring *et al.* 2005). When shrub cover is eliminated, and forbs and green plant material become scarce during summer months, habitat quality and forage availability for greater sage-grouse are degraded (Miller and Eddleman 2001).

Longer-term climate change has the additional potential to exacerbate the spread of annual invasive plants, as well as woody plants such as juniper, displacing native sagebrush communities (d"Antonio and Vitousek 1991; Neilson *et al.* 2005). Climate change models indicate less precipitation may occur in July-August in many lower-elevation sites, which may favor cheatgrass, which becomes dormant in summer months, over native perennials, which depend more on summer moisture for growth. Thus, sagebrush sites at higher risk include lower elevation sites, as these conditions generally present the warmest driest sites on which cheatgrass has the most competitive advantage and has displaced big sagebrush communities in the past (Suring *et al.* 2005). Elevated temperatures due to climate change may increase the competitive ability of cheatgrass at higher elevations, expanding its range into sites where it currently is not widespread. Climate change may increase the spread of woody plants such as juniper at higher elevations due to increased precipitation in winter and spring and warmer temperatures (Neilson *et al.* 2005), which may increase fire risk. Current trajectories of habitat loss must be viewed in light of the many uncertainties over future climate change, such as predicted changes in atmospheric carbon dioxide, and seasonal temperature and precipitation changes (Miller *et al.* 2011).

5.3.2 Development

Increasing size of human populations near greater sage-grouse habitat (people/km2) tends to cause declining greater sage-grouse persistence (Alldrege et al 2008). As roads, development, transmission lines and other infrastructure continues to fragment sage grouse habitat in the ecoregion, the species can be expected to suffer from additional habitat loss and reduced landscape integrity. As roads, development, transmission lines and other infrastructure continues to fragment sage grouse habitat in the ecoregion, the species can be expected to suffer from additional habitat loss and reduced landscape integrity. Transmission lines and tall structures further restrict the suitability of greater sage-grouse nesting and brood rearing habitat, and leks are increasingly affected by increasing traffic and other disturbances on existing and new roads.

5.3.3 Wildfire and Invasive Species

Under natural conditions, moderate fire return intervals and low intensity fires promoted the mixed composition of sagebrush communities that sustain the lifecycle of greater sage-grouse. Increasing cheatgrass cover is predicted for northwestern Nevada with significant risk of invasion into some of the best and least-fragmented greater sage-grouse habitat that is remaining in the ecoregion. Wildfires now are larger and occur more frequently, reducing habitat quality and quantity of sagebrush communities. Figure 6-10 shows the Fire SIMulation burn probability for the ecoregion along with fire perimeters from the last two years. With an increasing number of fires exceeding 100,000 acres in 2012 (see Table 6-2) and during the last decade , fire is currently the major contributing factor to the transition of many shrubsteppe ecological states to grass dominated conditions (especially when coupled with cheatgrass invasions).

Table 6-2. Selected Large 2012 Wildfires Impacting PPH

Fire Name	State(s)	Size of Fire (ac)	PPH in Fire Perimeter (ac)
Long Draw	OR	597,000	233,000
Holloway	OR/NV	468,000	384, 000
Rush	CA/NV	328,000	301,000
Miller Homestead	OR	172,000	153,000

5.3.4 Grazing

Historically, uncontrolled livestock grazing affected sage-grouse habitat quality at the site level, primarily through unsustainable utilization levels of forbs and grasses needed by sage-grouse for food and nesting cover. Grazing management on BLM lands has steadily improved in recent decades, and currently must conform to Standards and Guidelines, which include wildlife habitat requirements. However, recovery times can be protracted, especially in more arid environments. The 2013 USFWS Conservation Objectives report stresses sound grazing management, which continues to be a focus of the BLM range management program (USFWS 2013):

1. Ensure that allotments meet ecological potential and wildlife habitat requirements and, ensure that the health and diversity of the native perennial grass community is consistent with the ecological site.
2. Inform and educate affected grazing permittees regarding sage-grouse habitat needs and conservation measures.
3. Incorporate sage-grouse habitat needs or habitat characteristics into relevant resource and allotment management plans, including the desired conditions with the understanding that these desired conditions may not be fully achievable: (a) due to the existing ecological condition, ecological potential or the existing vegetation; or (b) due to causal events unrelated to existing livestock grazing.
4. Incorporate sage-grouse habitat needs or habitat characteristics into relevant resource and allotment management plans, including the desired conditions with the understanding that these desired conditions may not be fully achievable: (a) due to the existing ecological condition, ecological potential or the existing vegetation; or (b) due to causal events unrelated to existing livestock grazing.
5. Given limited agency resources, priority should be given to Priority Areas of Conservation and then sage-grouse habitats adjacent to them.

5.3.5 Disease

WNV is the predominant disease threat to greater sage-grouse. Mosquito and bird infections have been detected throughout the ecoregion. Current status of WNV can be viewed on the USGS Disease Map website by county for infections by bird, human, mosquito, sentinel and veterinary (http://diseasemaps.usgs.gov/wnv_us_human.html), WNV incidence is probably related to the increase in available surface water (breeding sites for the WNV mosquito vector) associated with irrigated agriculture (usually not on BLM lands) and livestock tanks and ponds. The risk of WNV is expected to increase as temperatures increase with predicted climate change.

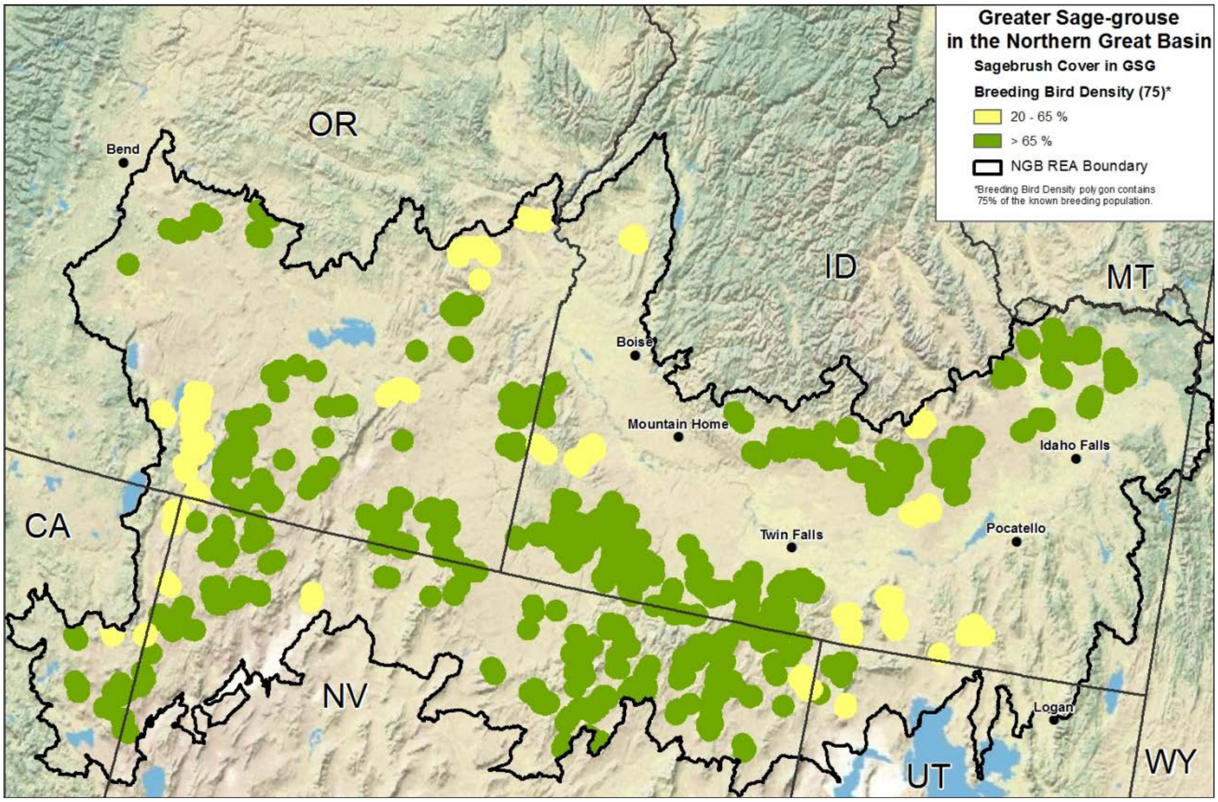


Figure 6-1. Percent Sagebrush Cover within Breeding Bird Density

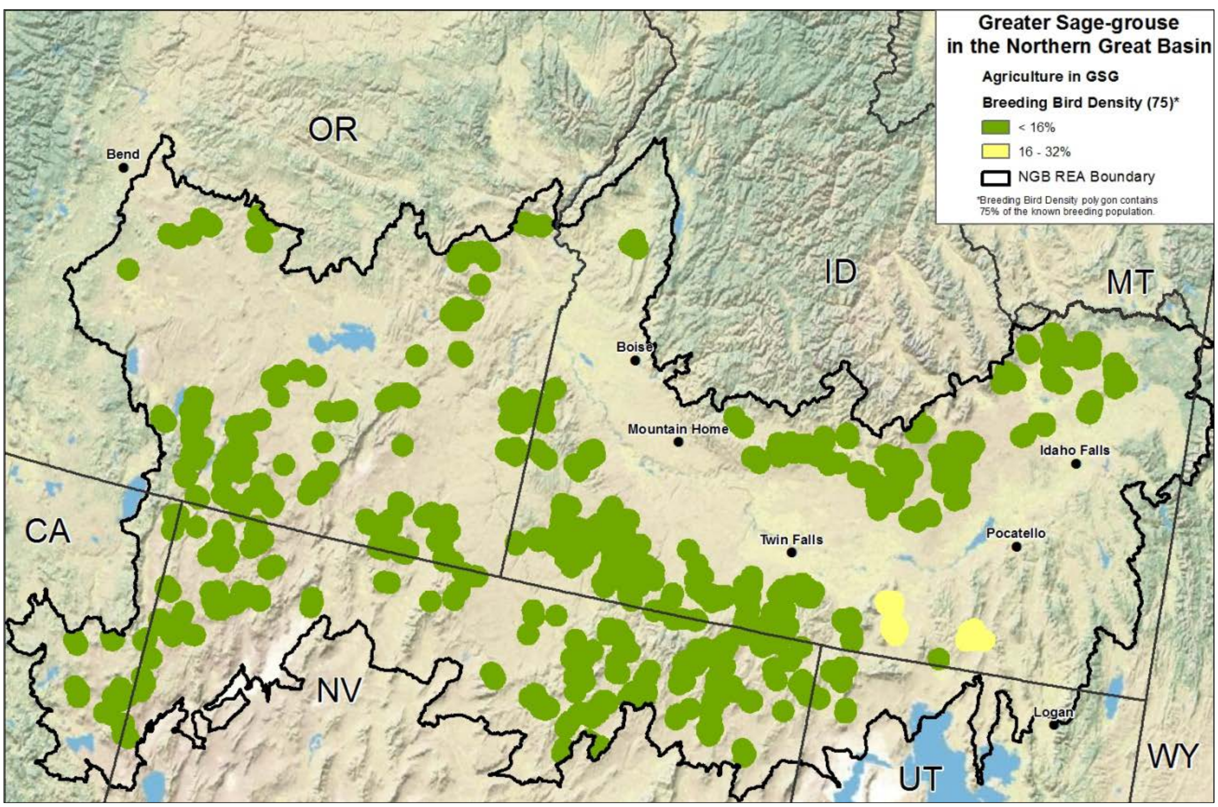


Figure 6-2. Percent Agriculture within Breeding Bird Density

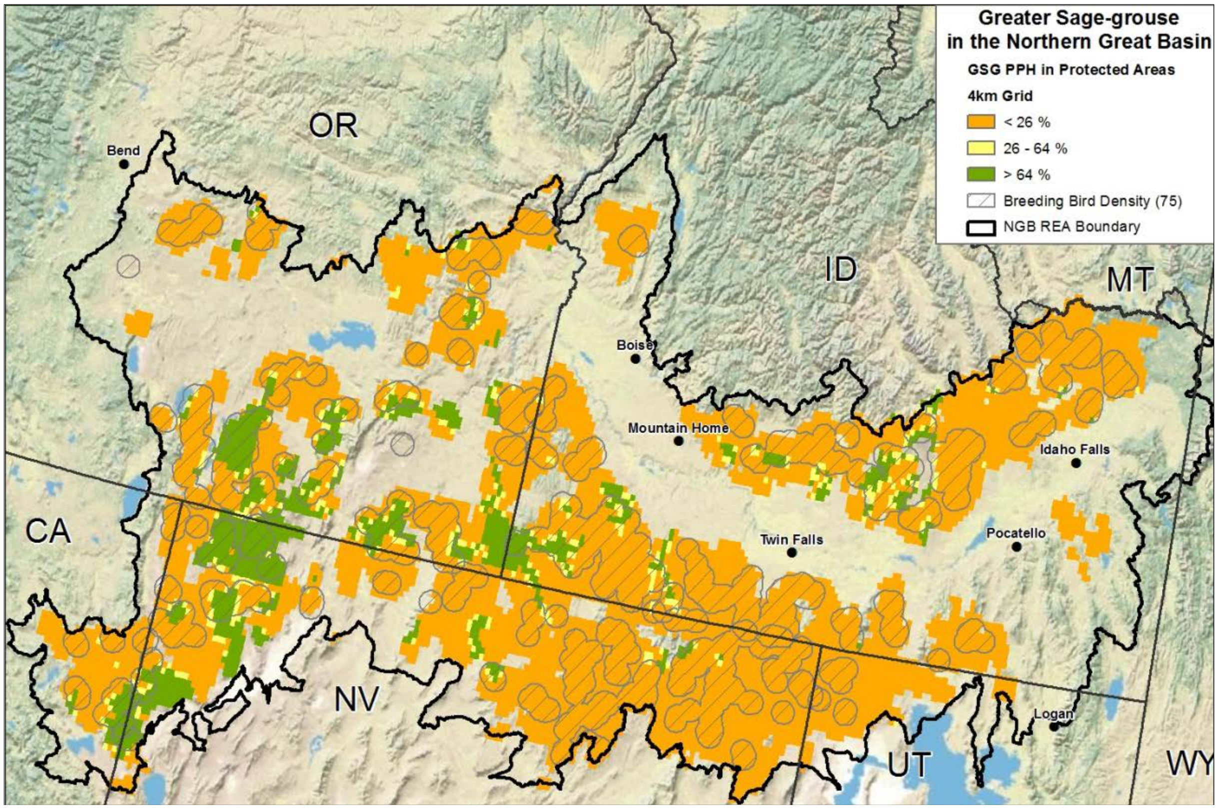


Figure 6-3. Percent of Greater Sage-Grouse PPH within Protected Areas

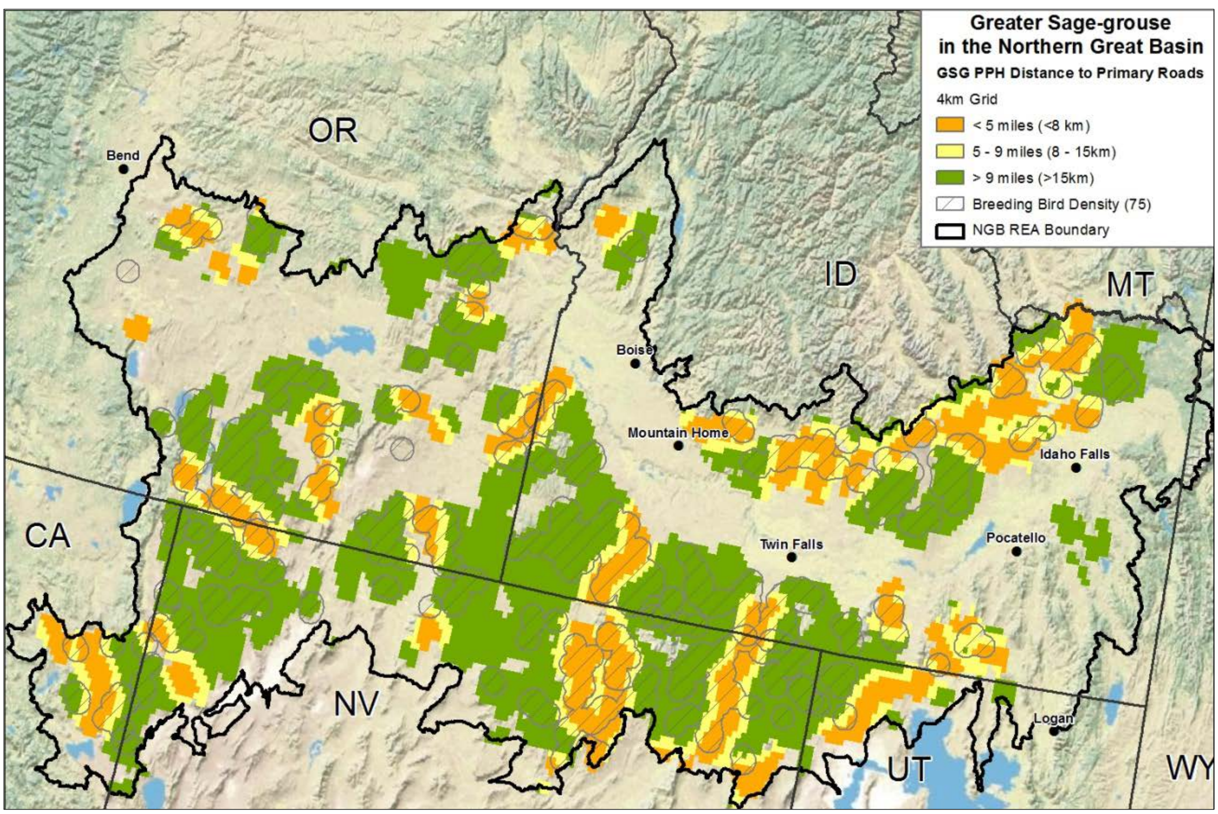


Figure 6-4. Distance to Primary Roads within Greater Sage-Grouse PPH

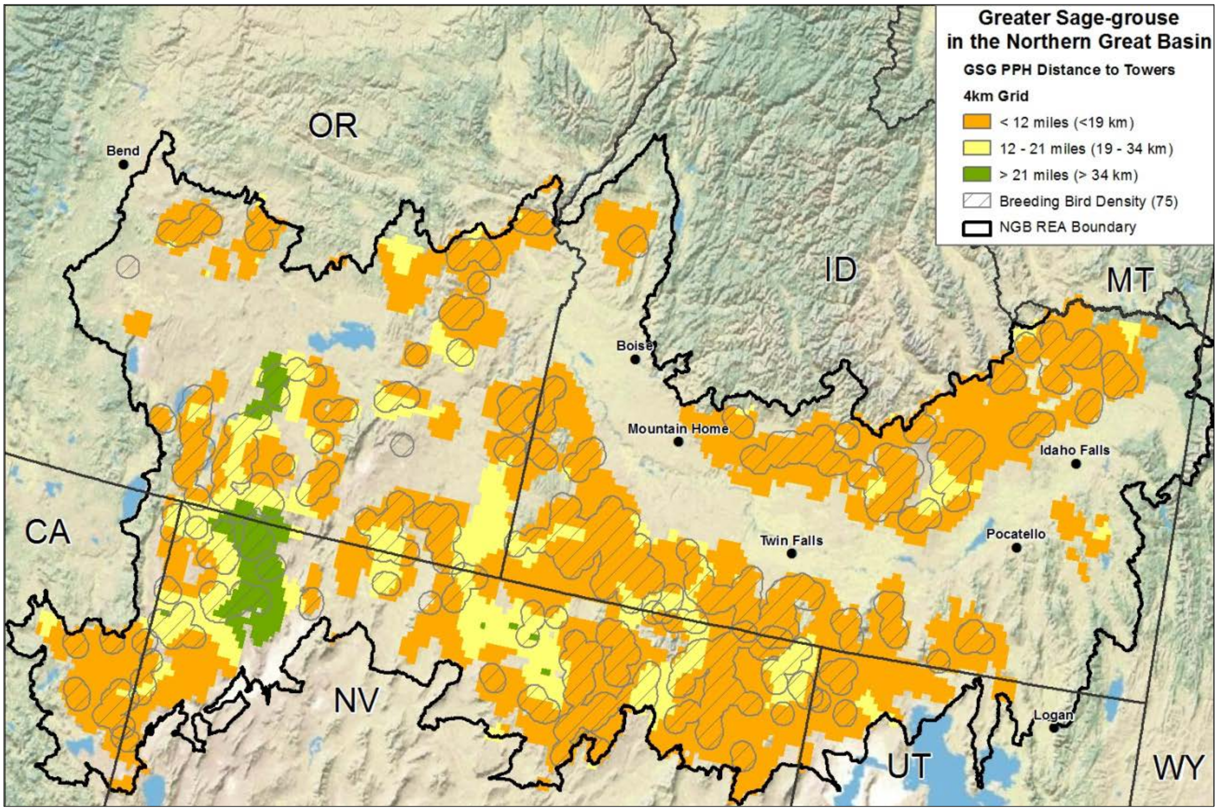


Figure 6-5. Distance to Towers within Greater Sage-Grouse PPH

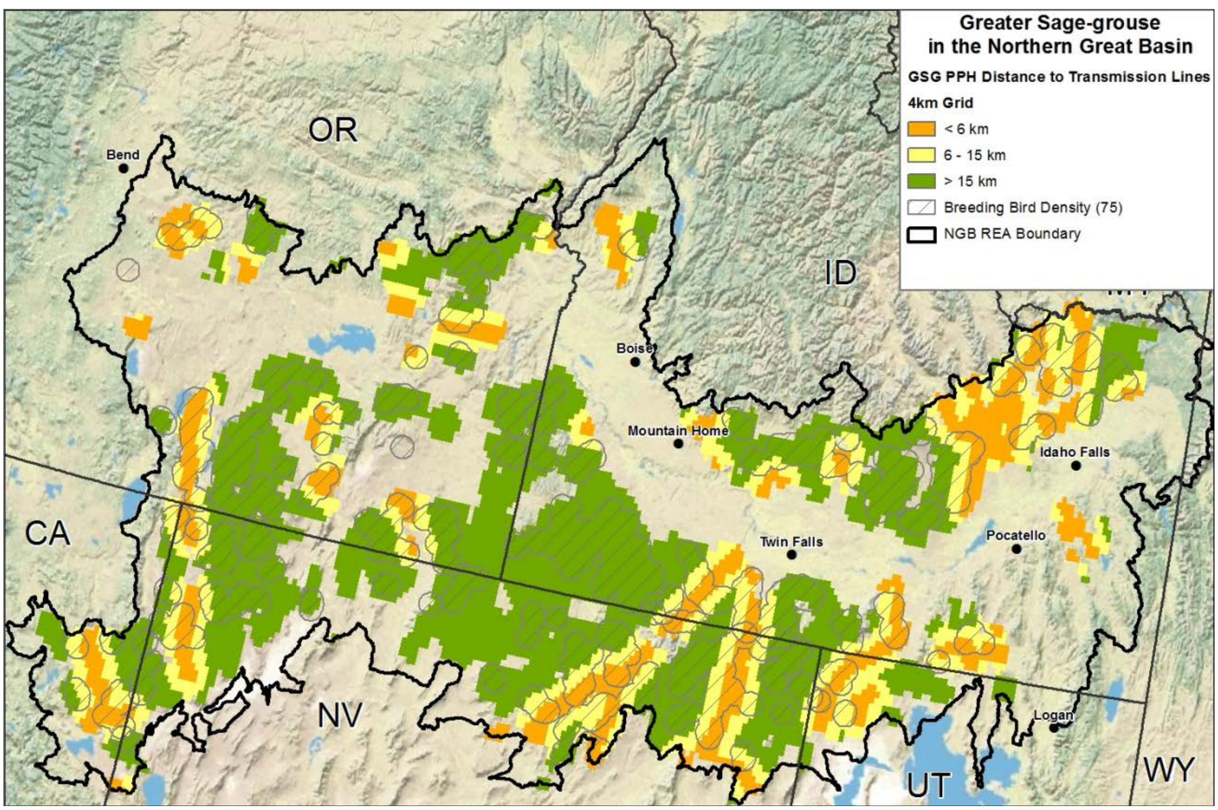


Figure 6-6. Distance to Transmission Lines within Greater Sage-Grouse PPH

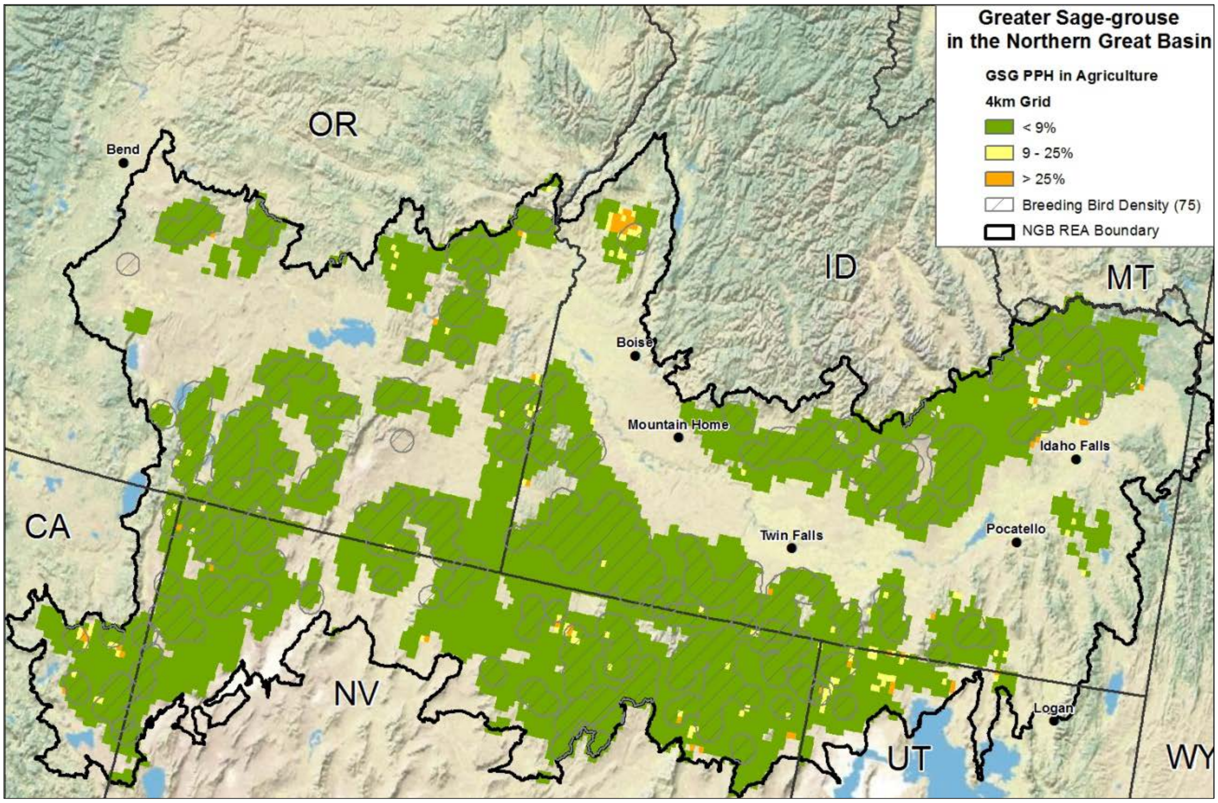


Figure 6-7. Percent of Greater Sage-Grouse PPH within Agricultural Area

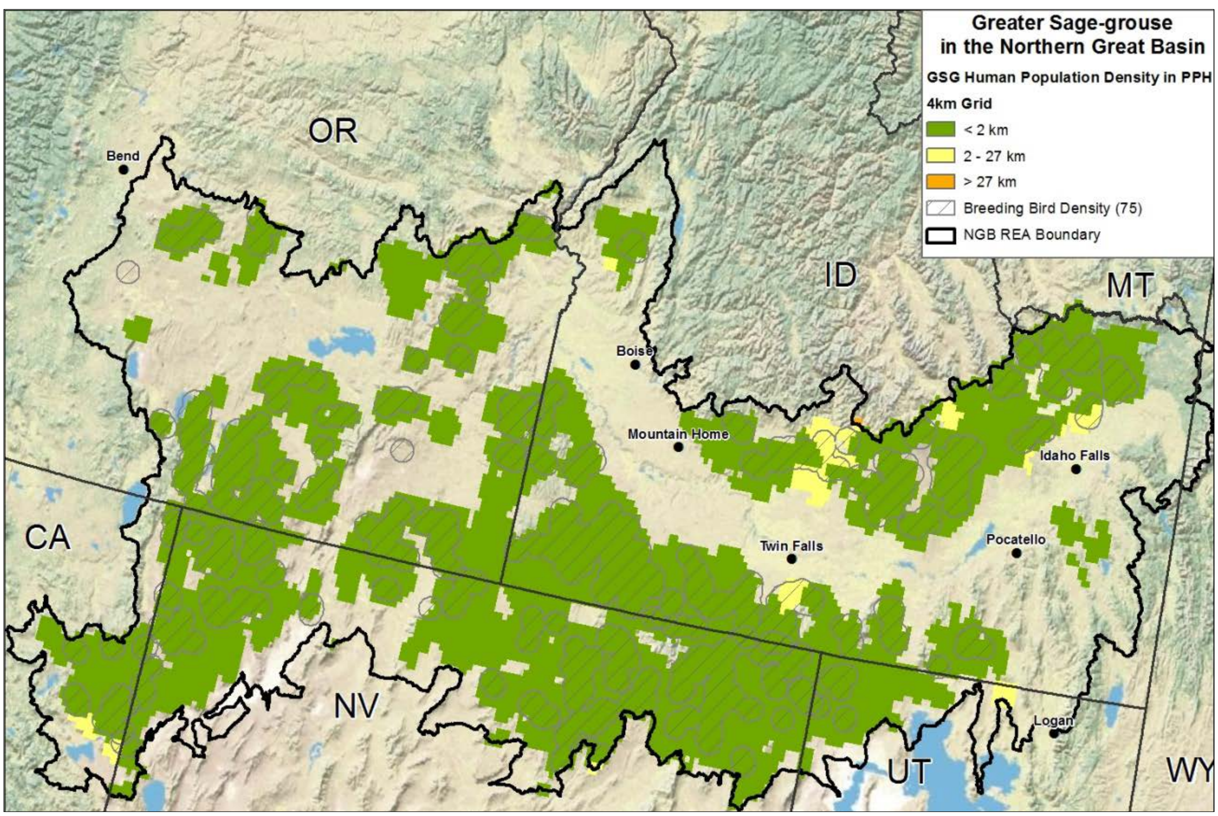


Figure 6-8. Population Density within Greater Sage-Grouse PPH

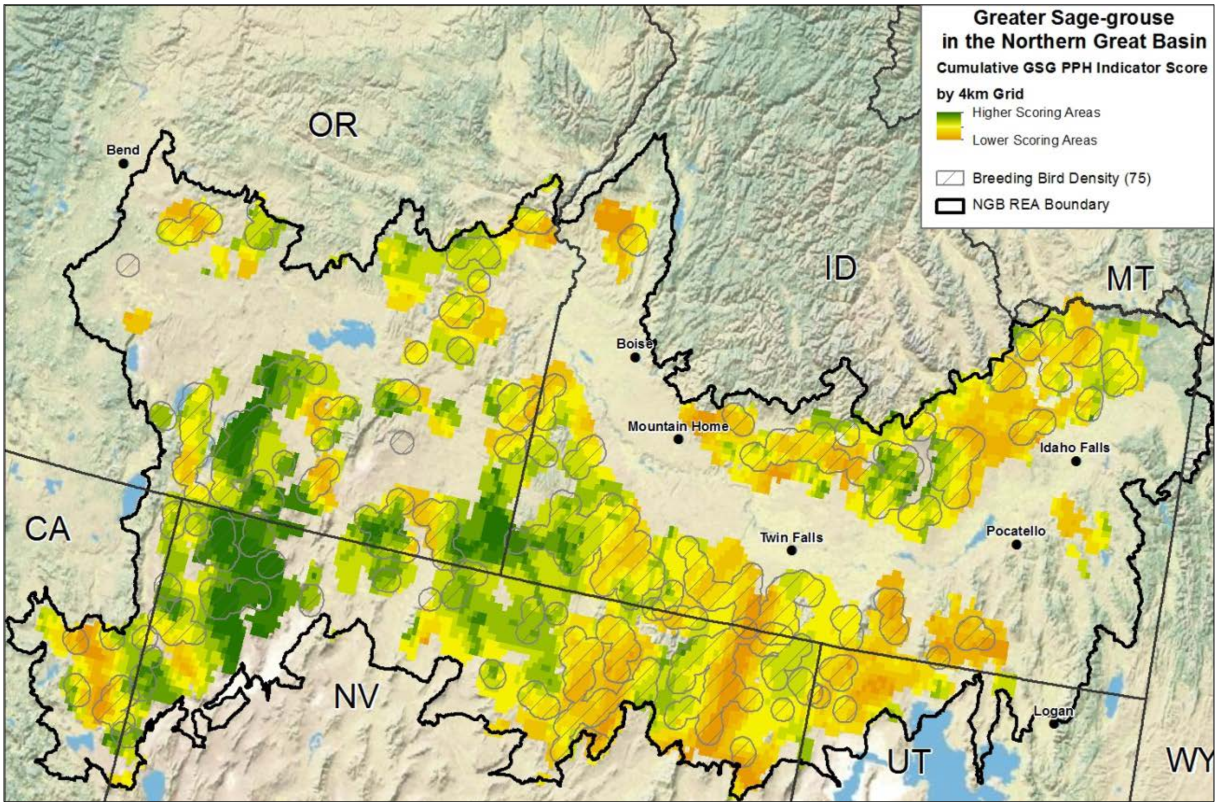


Figure 6-9. Cumulative Indicator Score for Greater Sage-Grouse PPH

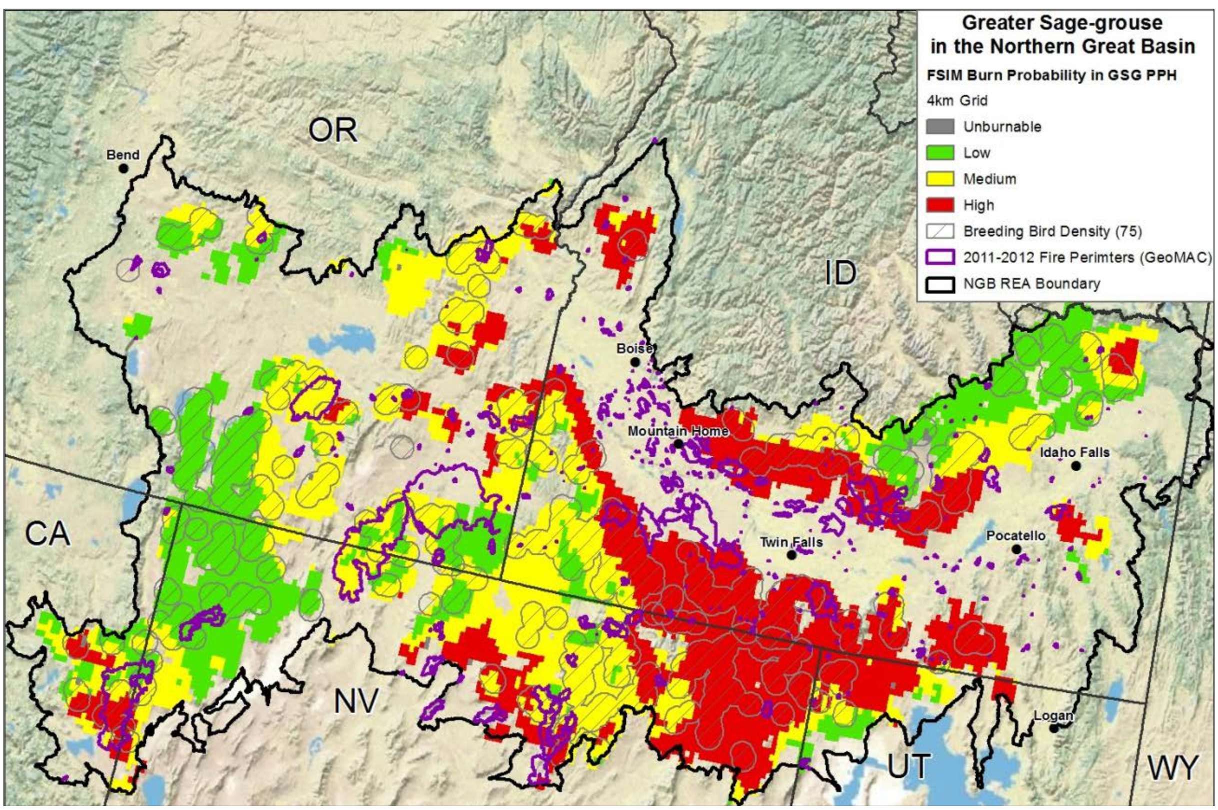


Figure 6-10. Burn Probability within Greater Sage-Grouse PPH with Recent Fire Perimeters

6 Management Questions

Management questions for the NGB were developed by BLM managers and refined by the AMT to answer questions regarding the agency's land management responsibilities—including planning land use, developing best management practices, authorizing uses, and establishing conservation and restoration priorities. Several management questions relate to this CE (with original numbering):

1 What is the currently occupied habitat or modeled suitable habitat for this CE?

Greater sage-grouse PPH areas and breeding bird density are shown in Figures 4-1 and 4-2.

2 Where are the areas of greatest and least collective impact of existing CAs on occupied habitat or modeled suitable habitats of this CE?

Figure 6-9 shows the cumulative indicator score for the pygmy rabbit. Higher scoring areas include northwestern Nevada and southern Oregon. Most of Idaho and northeast Nevada was lower scoring.

5 Where are current locations of this CE likely to overlap with the potential future distribution of CAs (other than climate change)?

Greater sage-grouse PPH overlaps areas with high burn probability in much of Idaho and northwestern Nevada (Figure 6-4). Sagebrush in high burn probability areas may be vulnerable to type conversion to cheatgrass dominated grasslands, which could reduce available habitat for greater sage-grouse. Most growth in development is modeled to occur in existing population centers along the Snake River corridor where greater sage-grouse PPH is low scoring.

6 Given current and anticipated future locations of CAs, which habitat areas remain as opportunities for habitat enhancement/restoration for this CE?

The cumulative indicator scores for greater sage-grouse PPH under current conditions (Figure 6-9) should be useful in identifying the areas most in need of preservation (high scoring, unprotected) or the best restoration opportunities (low scoring). Modeled priority habitat areas that have burned in recent years may, for example, deserve closer evaluation as potential habitat restoration sites.

7 Where are potential areas to restore connectivity for this CE, based on current locations of CAs?

Patch size and connectivity were not analyzed for greater sage-grouse, due to limitations with the PPH areas, see discussion in Section 6.1.

8 Where will this CE experience climate outside their current climate envelope? Or: Where will this CE experience significant deviations from normal climate variation?

Longer-term climate change has the additional potential to exacerbate the spread of annual invasive plants, as well as woody plants such as juniper, displacing native sagebrush communities (d"Antonio and Vitousek 1991; Neilson *et al.* 2005). Climate change models indicate less precipitation may occur in July-August in many lower-elevation sites, which may favor cheatgrass, which becomes dormant in summer months, over native perennials, which depend more on summer moisture for growth. Thus, sagebrush sites at higher risk include lower elevation sites, as these conditions generally present the warmest driest sites on which cheatgrass has the most competitive advantage and has displaced big sagebrush communities in the past (Suring *et al.* 2005). Elevated temperatures due to climate change may increase the competitive ability of cheatgrass at higher elevations, expanding its range into sites where it currently is not widespread. Climate change may increase the spread of woody plants such as juniper at higher elevations due to increased precipitation in winter and spring and warmer temperatures

(Neilson *et al.* 2005), which may increase fire risk. Current trajectories of habitat loss must be viewed in light of the many uncertainties over future climate change, such as predicted changes in atmospheric carbon dioxide, and seasonal temperature and precipitation changes (Miller *et al.* 2011).

7 Reference

Aldridge, C.L., and M.S. Boyce. 2007. Linking occurrence and fitness to persistence: a habitat-based approach for Greater Sage-Grouse. Ecological Applications 17:508-526.

Aldridge, C.L., S.E. Nielsen, H.L. Beyer, M.S. Boyce, J.W. Connelly, S.T. Knick, and M.A. Schroeder. 2008. Range-wide patterns of greater sage-grouse persistence. Diversity and Distributions 14: 983-994.

Barker, J., J. Robb, R. Stage, and N. Roster. Modeling approach to identify prime sage-grouse and pygmy rabbit habitats along the Ruby Pipeline. Unpublished report, available on internet at: http://www.rubypipeline.com/docs/rr/rr3_docs/modelingapproach.pdf. Accessed November 26, 2012. Bates, J.D., R.F. Miller, and T. Svejcar. 2000. Understory vegetation response and nitrogen cycling following cutting of western juniper. J. Range Manage. 53:119-126.

Beck, J.L., and D.L. Mitchell. 2000. Influences of livestock grazing on sage grouse habitat. Wildlife Society Bulletin 28(4):993-1002.

Beck, J.L., K.P. Reese, J.W. Connelly, and M.B. Lucia. 2006. Movements and survival of juvenile greater sage-grouse in southeastern Idaho. Wildlife Society Bulletin 34:1070–1078.

Braun, C.E. 2006. Sage-grouse Habitat Conservation Strategies: A Blueprint for Conservation and Recovery. Grouse Inc., Tucson, AZ.

Braun, C.E. 1998. Sage grouse declines in western North America: what are the problems? Proceedings of the Western Association of State Fish and Wildlife Agencies 78:139-156.

Brooks, M.L., C.M. d'Antonio, D.M. Richardson, J.B. Grace, J.E. Keeley, J.M. DiTomaso, R.J. Hobbs, M. Pelland, and D. Pyke. 2004 Effects of invasive alien plants on fire regimes. BioScience 54:677-688.

Christiansen and Tate. 2011. Chapter 8: Greater Sage-Grouse Ecology and Conservation of a Landscape Species and Its Habitats. Published for the Cooper Ornithological Society. Steven T. Knick and John W. Connelly (eds.). May.

Christiansen, T. 2009. Fence Marking to Reduce Greater Sage-grouse (*Centrocercus urophasianus*) Collisions and Mortality near Farson, Wyoming – Summary of Interim Results. Wyoming Game & Fish Department report published online at: http://gf.state.wy.us/downloads/pdf/ FenceMarkingInterimReport10-26-09corrected.pdf. October.

Connelly, J.W., C.A. Hagen, and M.A. Schroeder. 2011a. Characteristics and dynamics of greater sage-grouse populations. Pp. 53-68In S.T. Knick and J.W. Connelly (eds.). Greater Sage-Grouse: ecology and conservation of a landscape species and its habitats. Studies in Avian Biology (vol. 38), University of California Press, Berkeley, CA.

Connelly, J.W., E.T. Rinkes, and C.E. Braun. 2011b. Characteristics of greater sage-grouse habitats: a landscape species at micro and macroscales. Pp. 69-83 In S.T. Knick and J.W. Connelly (eds.). Greater Sage-Grouse: ecology and conservation of a landscape species and its habitats. Studies in Avian Biology (vol. 38), University of California Press, Berkeley, CA.

Connelly, J.W., S.T. Knick, M.A. Schroeder, and S.J. Stiver. 2004. Conservation assessment of greater sage-grouse and sagebrush habitats. Western Association of Fish and Wildlife Agencies. Unpublished Report. Cheyenne, WY, USA.

Connelly, J.W., A.D. Apa, R.B. Smith, and K.P. Reese. 2000a. Effects of predation and hunting on adult sage grouse *Centrocercus urophasianus* in Idaho. Wildlife Biology 6:227-232.

Connelly, J.W., M.A. Schroeder, A.R. Sands, and C.E. Braun. 2000b. Guidelines to manage sage grouse populations and their habitats. Wildlife Society Bulletin 28(4):967-985.

Connelly, J.W., M.W. Gratson, and K.P. Reese. 1998. Sharp-tailed grouse (*Tympanuchus phasianellus*).In A. Poole and F. Gill, editors. The birds of North America, No. 354. The Birds of North America, Inc., Philadelphia, Pennsylvania, USA.

Connelly, J.W. and C.E. Braun. 1997. Long-term changes in sage grouse *Centrocercus urophasianus* populations in western North America. Wildlife Biology 3/4:123-128.

Connelly, J.W., W.L. Wakkinen, A.D. Apa, and K.P. Reese. 1991. Sage grouse use of nest sites in southeastern Idaho. Journal of Wildlife Management 55(3):521-524.

Connelly, J.W., W.J. Arthur, and O.D. Markham. 1981. Sage grouse leks on recently disturbed sites. Journal of Range Management 34(2):153-154.

Crawford, J.A. R.A. Olson, N.E. West, J.C. Mosley, M.A. Schroeder, T.D. Whitson, R.F. Miller, M.A. Gregg, and C.S. Boyd. 2004. Ecology and management of sage-grouse and sage-grouse habitat. J. Range Manage. 57: 2-19.

d'Antonio, C.M. 2000. Fire, plant invasions, and global changes. Pp. 65-93 In Mooney, H.A. and R.J. Hobbs (editors). Invasive species in a changing world. Island Press, Washington, D.C.

d'Antonio, C.M. and P.M. Vitousek. 1992. Biological invasions by exotic grasses, the grass/fire cycle, and global change. Annual Review of Ecology and Systematics 23:63-87.

Davies, K.W., J.D. Bates, D.D. Johnson, and A.M. Nafus. 2009. Influences of mowing *Artemisia tridentata* ssp. *wyomingensis* on winter habitat for wildlife. Environmental Management. http://www.springerlink.com/content/5j4017t2024612p1/(20 December 2009).

Doherty, K.E., D.E. Naugle, B.L. Walker, and J.M. Graham. 2008. Greater sage-grouse winter habitat selection and energy development. Journal of Wildlife Management 72:187-195.

Doherty, K.E., D.E. Naugle, and B.L. Walker. 2010. Greater sage-grouse nesting habitat: the importance of managing at multiple Scales. Journal of Wildlife Management 74(7):1544–1553.

Ellis, K.L. 1984. Behavior of lekking sage grouse in response to a perched golden eagle. Western Birds 15:37-38.

Ellis, K.L. 1987. Effects of a new transmission line on breeding sage grouse at a lek in northwestern Utah. In J. Roberson, chairman. Fifteenth Sage Grouse Workshop Transactions of the Western States Sage Grouse Committee, Western Association of Fish and Game Agencies.

Eng, R.L., E.J. Pitcher, S.J. Scott, and R.J. Greene. 1979. Minimizing the effect of surface coal mining on sage grouse populations by a directed shift of breeding activities. The Mitigation Symposium, National Workshop on Mitigating Losses of Fish and Wildlife Habitats. Fort Collins, CO. July 16-20.

Evers, L. 2010. Modeling sage grouse habitat using a state and transition model Ph.D. Disertation, Oregon State University, Corvallis, OR.

Fischer, R.A., K.P. Reese, and J.W. Connelly. 1996. An investigation on fire effects within xeric sage grouse brood habitat. Journal of Range Management 49(3):194-198.

Gilmer, D.S. and J.M. Wiehe. 1977. Nesting by ferruginous hawks and other raptors on high voltage powerline towers. Prairie Naturalist 9(1):1-10.

Gruver, M. 2009. BLM: Mark fences for sage-grouse. In Trib.com, Wyoming's Online News Source. Available at: http://trib.com/news/state-and-regional/article_8456313a-99d3-56dd-84af-2b04b6f7fa05.html.

Hall, F. and E. Haney. 1997. Distribution and trend of sage grouse (*Centrocercus urophasianus*) in relation to overhead transmission lines in northeastern California. Draft. California Department of Fish and Game.

Hanser, S.E. and S. T. Knick. 2011. Greater sage-grouse as an umbrella species for shrubland passerine birds: a multiscale assessment. P. 475-487. In S.T. Knick and J.W. Connelly (eds.). Greater Sage-Grouse: ecology and conservation of a landscape species and its habitats. Studies in Avian Biology (vol. 38), University of California Press, Berkeley, CA.

Harju, S.M., M.R. Dzialak, R.C. Taylor, L.D. Hayden-Wing, and J.B. Winstead. 2010. Thresholds and Time Lags in Effects of Energy Development on Greater Sage-Grouse Populations. Journal of Wildlife Management 74(3):437-448.

Hartzler, J.E. 1974. Predation and the daily timing of sage grouse leks. Auk 91:532-536.

Holloran, M.J. 2005. Greater Sage-Grouse (*Centrocercus urophasianus*) Population Response to Natural Gas Field Development in Western Wyoming. Doctoral Dissertation, University of Wyoming, Laramie, WY.

Kaiser R.C. 2006. Recruitment by Greater Sage-Grouse in Association with Natural Gas Development in Western Wyoming. Masters thesis, Department of Zoology and Physiology, University of Wyoming, Laramie.

Klemmedson, J.O. and J.G. Smith. 1964. Cheatgrass *Bromus tectorum* L.) Botanical Review 30:226-262.

Knick, S.T., S.E. Hanser, K.L. Preston. 2013. Modeling ecological minimum requirements for distribution of greater sage-grouse leks: implications for population connectivity across their western range, U.S.A. http://pubs.er.usgs.gov/publication/70045558

Miller, R.F., and R.J. Tausch. 2001. The role of fire in pinyon and juniper woodlands: A descriptive analysis. In: Galley, K.E.M., Wilson, T.P., eds. Proceedings of the invasive species workshop: The role of fire in the control and spread of invasive species. Misc. Pub. 11. Tallahassee, FL: Tall Timbers Research Station: 15-30.

Miller, R.F., S.T. Knick, D.A. Pyke, C.W. Meinke, S.E. Hanser, M.J. Wisdom, and A.L. Hild. 2011. Characteristics of sagebrush habitats and limitations to long-term conservation. P. 145-184. In S.T. Knick and J.W. Connelly (eds.). Greater Sage-Grouse: ecology and conservation of a landscape species and its habitats. Studies in Avian Biology (vol. 38), University of California Press, Berkeley, CA.

Miller, R.F. and L. Eddleman. 2001.Spatial and temporal changes of Sage Grouse habitat in the sagebrush biome. Technical Bulletin 151. Oregon State University Agricultural Experiment Station. Corvallis, OR.

Naugle, D.E., B.L. Walker, and K.E. Doherty. 2006. Sage-Grouse Population Response to Coal-Bed Natural Gas Development in the Powder River Basin: Interim Progress Report on Region-wide Lek-Count Analysis. University of Montana, Bozeman, MT.

Naugle, D.E., K.E. Doherty, B.L. Walker, M.J. Holloran, and H.E. Copeland. 2009. Energy development and greater sage-grouse. Studies in Avian Biology. Available at: http://sagemap.wr.usgs.gov/Docs/SAB/Chapter21.pdf

Neilson, R.P., J.M. Lenihan, D. Bachelet, and R.J. Drapek. 2005. Climate change implications for sagebrush ecosystems. Transactions of the North American Wildlife and Natural Resources Conference 70:145-159.

Nelle, P.J., K.P. Reese, and J.W. Connelly. 2000. Long-term effects of fire on sage grouse habitat. Journal of Range Management 53:586-591.

O'Brien, M. 2007. Home Is Where Sagebrush Is (And Bugs, Green Forbs, and Tall Grass): An Assessment of Six Areas in Utah Where Greater Sage Grouse Live. Adapted from "O'Brien, Mary. 2007. A Survey of Greater Sage Grouse (*Centrocercus urophasianus*): Early Brood-rearing, Summer-Late Brood-rearing, and Winter Habitat Integrity in Six Utah Greater Sage Grouse Use Areas." Grand Canyon Trust, Flagstaff, AZ. March.

Oliver, G.V. 2006. Greater sage-grouse (*Centrocercus urophasianus*) ecological integrity table. Utah Division of Wildlife Resources, Salt Lake City, Utah. 22 pp.

Rowland, Mary M., Wisdom, M.J., Suring, L.H.,and Meinke, C.W. 2006. Greater sage-grouse as an umbrella species for sage-brush associated vertebrates. Biological Conservation. 129: 323-335.

Schroeder, M.A., C.L. Aldridge, A.D. Apa, J.R. Bohne, C.E. Braun, S.D. Bunnell, J.W. Connelly, P.A. Deibert, S.C. Gardner, M.A. Hilliard, G.D. Kobriger, S.M. McAdam, C.W. McCarthy, J.J. McCarthy, D.L. Mitchell, E.V. Rickerson, and S.J. Stiver. 2004. Distribution of sage-grouse in North America. Condor 106:363-376.

Schroeder, M.A., J.R. Young, and C.E. Braun. 1999. Sage grouse (*Centrocercus urophasianus*). *In:* A. Poole and F. Gill, editors. The birds of North America, No. 425.The Birds of North America, Inc., Philadelphia, Pennsylvania, USA.

Steenhof, K., M. N. Kochert, and J. A. Roppe. 1993. Nesting by raptors and common ravens on electrical transmission line towers. Journal of Wildlife Management 57(2):271-281.

Suring, L.H., M.J. Wisdom, R.J. Tausch, R.F. Miller, M.M. Rowland, L. Schueck, and C.W. Meinke. 2005. Modeling threats to sagebrush and other shrubland communities. Pp. 114-149 in J.J. Wisdom, M.M. Rowland, L.H. Suring (editors) Habitat threats in the sagebrush ecosystem: methods of regional assessment and applications in the Great Basin. Alliance Communications Group. Lawrence, KS

Uinta Basin Adaptive Resource Management Local Working Group (UBARM). 2006. Uinta Basin Greater Sage-grouse (Centrocercus urophasianus) Local Conservation Plan. Utah State University Extension, Jack H. Berryman Institute, and Utah Division of Wildlife Resources. Salt Lake City, Utah. Unpublished Report.

USFWS. 2013. Greater sage-grouse Conservation Objectives: Final Report

Walker, B.L. and D.E. Naugle. 2011. West Nile virus ecology in sagebrush habitat and impacts on greater sage-grouse populations. Pp. 127 -143 In S.T. Knick and J.W. Connelly (eds.). Greater Sage-Grouse: ecology and conservation of a landscape species and its habitats. Studies in Avian Biology (vol. 38), University of California Press, Berkeley, CA.

Whisenant, S.G. 1990. Changing fire frequencies on Idaho's Snake River Plains: ecological and management implications. Pages 4-10 in E.D. McArthur, E.M. Romney, S.D. Smith, and P.T. Tueller, compilers, Proceedings-Symposium on cheatgrass invasion, shrub die-off, and other aspects of shrub biology and management. USDA Forest Service General Technical Report INT-276. Intermountain Research Station, Ogden, UT. 351 pp.

Wisdom, M.J., M.M. Rowland, L.H. Suring (editors). 2005. Habitat threats in the sagebrush ecosystem: methods of regional assessment and applications in the Great Basin. Alliance Communications Groups. Lawrence, KS

Wisdom, M.J., C.W. Meinke, S.T. Knick, and M.A Schroeder. 2011. Factors associated with extirpation of sage-grouse. Page 451-472 in S.T. Knick and J.W. Connelly (editors). Greater sage-grouse: ecology and conservation of a landscape species and its habitats. Studies in Avian Biology 38. University of California Press, Berkeley, California, USA.

Golden Eagle Conservation Element Package

1 Introduction

The golden eagle is one of the most widely distributed of raptor species, but western U.S. populations are believed to be in decline (Kochert and Steenhof 2002). The status of golden eagles in the Northern Great Basin (NGB) reflects local factors determining breeding territory occupancy, nesting success, and survival. Any agent of change (CA) that positively or negatively influences these factors has the potential to influence golden eagle distribution and population levels in the region. The golden eagle was selected as a fine-filter conservation element (CE) for the NGB by the AMT because it is a landscape-level species that is the focus of management concern in the ecoregion.

This CE package provides the assessment of the current status and future threats due to CAs for the golden eagle in the NGB ecoregion. Information in this CE package includes a brief description of the biology of the golden eagle in the NGB ecoregion, a description of change agents that were assessed, a conceptual model of ecosystem functions relevant to the golden eagle, some information on potential data sources and analytical methods for the assessment, and a listing of relevant management questions (MQ) for this CE. The primary CA that was identified for the golden eagle was development.

2 CE Package Review Process

2.1 Subject Matter Expert Review

Subject Matter Experts play a key role in ensuring that the REA reflects the best available data and modeling processes suitable for each conservation element and change agent. Subject Matter Experts were added to Rolling Review Teams comprised of SAIC scientists, SAIC GIS personnel, AMT member(s) and other subject matter experts from the Department of Interior or state agencies. Membership of the Rolling Review Teams is listed in Appendix A. To ensure consistency amongst the different Rolling Review Teams, the number of lead SAIC scientists was limited to only a few individuals. This ensured that there was a common approach, or framework, used among the different Rolling Review Teams and that one Rolling Review Team did not stray too far from the rest. The USGS, as peer reviewers, were invited to participate in Rolling Review Teams.

3 CE Description

The golden eagle occurs primarily in association with open habitats including shrublands and grasslands, although hunting may be conducted also over open woodlands (Kochert *et al.* 2002; Stahlecker *et al.* 2010). The eagles avoid heavily forested areas (Poole and Bromley 1988). During the breeding season most golden eagles are found where cliffs, canyon walls, and rock outcrops provide nest sites. Less often, golden eagles will nest in tall trees or man-made structures such as telecommunication towers. In eastern Utah, Bates and Moretti (1994) found active eagle nests in four habitat types: in trees on saltbush flats or low elevation riparian areas, on cliffs and escarpments in pinyon-juniper and talus, and in prominent trees in the aspen-conifer zone. The golden eagle has a broad prey base, though it relies primarily on mammals including rabbits and ground squirrels (Olendorf 1976; Kochert *et al.* 2002). Prey species are closely associated with open vegetation types.

4 CE Modeling

4.1 Data Identification

Table 4-1. Preliminary List of Golden Eagle Data Sources

Data Required	Dataset Name	Source Agency	Type/Scale	Status	Use in REA
Modeled Suitable Habitat	Maxent		Raster	Developed for REA	Yes
Point Occurrence and Nests	Observations	Natural Heritage databases, State Fish and Game (ID, NV, OR, UT)	Point	Acquired	Yes
	China Mountain GE Nest Survey	U.S. Fish and Wildlife Service	Point	Acquired	Yes
	Cotterel Mountain GE Nest Survey	U.S. Fish and Wildlife Service	Point	Acquired	Yes

4.2 Distribution Mapping Methods

The Maxent modeling program was used to determine the distribution of the golden eagle in the Northern Great Basin. This model uses various geospatial environmental variables (i.e., climate variables, elevation, vegetation layer, etc) and species occurrence data to determine the distribution of a species within a given area. The Maxent distribution layer was required for use in the threat assessment as a boundary to limit the output to those areas where golden eagles were currently nesting.

Table 4-1 lists the types of data and data sources that were proposed for use in the REA as part of the pre-assessment data identification effort. Suitable habitat models, point occurrence data, and nest sites were proposed for use in defining distribution of the golden eagle in the NGB ecoregion.

The BLM determined that nest site location data was the preferential data type to be assessed in the distribution model. Nest site location data was obtained from the states for use in a Maxent distribution model. Data attributes varied widely from nest data to mortality data (i.e., road kills), and was inconsistent both on an interstate and intrastate basis. In several cases states only provided nest location data with no further attributes associated with the data. Additionally, the data varied greatly in accuracy with some data providing an estimate of the spatial quality of the data collection method. This attribute information was used to further remove data that appeared to show poor spatial accuracy.

The intent of the REA modeling effort was to determine the current distribution of breeding golden eagles within the ecoregion. In order to reflect this properly we determined that the nest location data should be limited to 1990 – present nest site locations. This dramatically limited our data, but increased the likelihood of capturing active or recently-active nest site locations. Furthermore, because of the potential for multiple counting of a given nest site within the Maxent model, duplicate records (based on coordinates), or records within 30m of another record were removed from the input data set.

The raster output from the Maxent provides cell values that provide information regarding the probability of species occurrence. Several iterations of the model were run to determine the best fit for golden eagles. The WYNDD model (Maxent-derived) provided an output based on very low probability, low probability, moderate probability, and optimal probability of distribution. The most conservative model was preferred by the BLM (very low probability to optimal probability) as the Maxent model layer depicting the distribution of the golden eagle. This model insured that all known breeding eagles were included in the data layer.

The Maxent output distribution model was overlain with the nest site location points to visually inspect the relative accuracy of the model. Knowledge of the species natural history and the nest location data was used to infer the initial quality of the modeled output. The output was further inspected by the Rolling Review Team based on what is known of the currently occupied nests. In this way, a synthesized field check was performed to confirm the relative accuracy of the species distribution model. Maxent also provides data outputs that include information regarding the accuracy of the modeled output and which environmental variables affected the model the most. Threat analysis outputs were correlated to reporting units that spatially contained distribution data.

4.3 Data Gaps, Uncertainty, and Limitations

4.3.1 Data Gaps

The generalist nature of the golden eagle allows the CE analysis to some leeway in spatial data availability, however certain key ecological attributes were sought specifically to identify the key factors that affect either the distribution or threats associated with the species. With regard to distribution, preferred datasets across the ecoregion were not readily available. The nest site location for the state of California was not included in the Maxent model. This data would have helped the model performance for the small portion of California within the ecoregion.

The use of key ecological attributes in this analysis was an important factor in determining potential threats or identifying preferable attributes across the golden eagle range. In instance where the preferred data were not available for use in the analysis, a surrogate dataset was used. For the analysis for proximity to electric distribution lines (as a surrogate for electrocution hazards), proximity to urban areas was used as a surrogate. Although this analysis is still meaningful, future assessments of this key ecological attribute would be improved greatly if electric distribution line data were available. Similarly, pesticide contamination data was lacking at the ecoregional scale, so proximity to agriculture was used in the analysis.

The vegetation condition class (VCC) presented a different data gap issue. Although the data was available, the quality of the data was questioned by numerous Rolling Review Team experts for use in this analysis. The issues arose as a result of confidence in the spatial and temporal accuracy of the data in this ecoregion. It was expressed that VCC values do not necessarily reflect the current departure from vegetation.

Although foraging habitat based on vegetation type is a suitable descriptor of habitat, primary prey species distribution data would have greatly improved upon the key ecological attributes identified in this analysis. The jackrabbit, rabbit, and ground squirrel make up the bulk of prey for the golden eagle in the NGB. An accurate species distribution layer for these species would have made an excellent indicator of golden eagle foraging habitat.

4.3.2 Uncertainty

The golden eagle distribution model is made up of data collected from different agencies and states and varied in the timeliness of the datasets. Every effort was made to create a relevant nest site location dataset that could be implemented into the model. Of course, additional species occurrence data would have improved upon the quality of the model.

In both instances (electric distribution lines and pesticide contaminants) in which surrogate data were used, uncertainty exists simply because of the use of surrogate data. The results of the analyses are only as good as the data input layers, and in this case the preferred datasets were not available. The level of uncertainty attributed to this analysis might not be too important due to the reporting units used in the analysis.

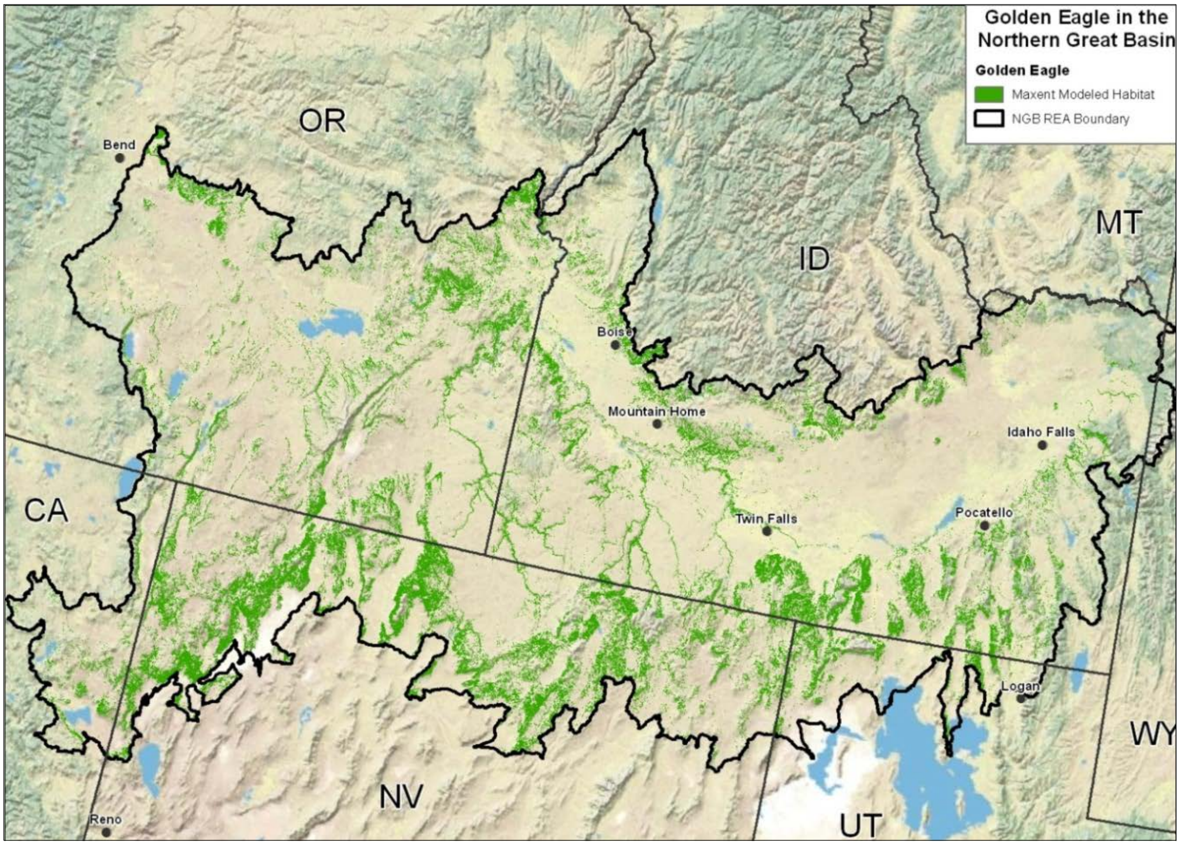


Figure 4-1. Maxent Modeled Golden Eagle Suitable Habitat

5 System Models

The system model for the Golden Eagle CE is a conceptual model that illustrates the effects of CAs on the primary habitat functions for this species (see Memo 2-c). Habitat functions include biotic and abiotic processes that may occur at local and landscape-levels (Figure 5-1). The model was developed to provide a scientific framework and justification for the choice of indicators that were used in assessing CA threats for this CE. The CAs originally included in the analysis included development, climate change, wildfire, disease, and invasive species. The conceptual model depicts our current understanding of the most important habitat functions in the systems occupied by this CE without regard for data availability or suitability of a habitat function for an ecoregion-level assessment.

The primary CAs for golden eagles are identified across the top of the figure in red and their effects on habitat functions important to this species are identified in gray boxes below (Figure 5-1). The habitat functions that are key to the distribution and status of this species include availability of nest sites and foraging perches, habitats that support its terrestrial prey, and the effects of anthropogenic influences on survival of individuals. The feature that most significantly affects the distribution of the golden eagle is vegetation type because suitable vegetation supports prey species availability and abundance; thus, vegetation type and condition indirectly drive the distribution, productivity, and survival of golden eagles. Changes caused by human development and resource use, climate change, and altered fire regime affect eagle habitat primarily through their effects on prey habitats. In addition, anthropogenic effects cause direct mortality and disturbance.

5.1 Development

The golden eagle system model depicts the change agents that were evaluated in this REA, of which habitat destruction through human development and direct mortality are the most important. The golden eagle is threatened by development on a variety of levels. Large-scale population declines have followed urban growth, and agricultural activities (Kochert and Steenhoff 2002). Land use change and agriculture affect golden eagle distribution via affecting the prey base, as described above (Marzluff *et al.* 1997; Beecham and Kochert 1975; Smith and Murphy 1973; McGahan 1968). The primary prey species of the golden eagle inhabit predominantly natural areas of shrub-steppe and other open vegetation types. Agricultural conversion of these lands severely reduces prey species habitat quality, and thus indirectly reduces use by golden eagles. Vegetation degradation from shrub-steppe to annual grass and forb-dominated types also reduces habitat value for prey species.

With regard to direct mortality, there are a number of development-related threats to golden eagles. Collision with vehicles (as eagles feed on road-kill), overhead transmission lines and other structures, and electrocution at power poles are major causes of mortality of golden eagles (Franson *et al.* 1995, Harness and Wilson 2001). Fatalities due to collision with wind turbines also contribute significantly to eagle mortality in areas where wind farms are situated in corridors used by golden eagles (Smallwood and Thelander 2007; Hunt 2002; Stahlecker *et al.* 2010). Siting of wind farms is a significant issue in the NGB ecoregion because of the substantial number of migrant golden eagles during winter months (Kochert *et al.* 2002; McIntyre *et al.* 2008). Golden eagles are killed by secondary poisoning after consuming prey that have ingested rodenticides and herbicides, or that may be contaminated by lead shot.

The effect of human disturbance on golden eagle nesting remains largely understudied. Coal mining activities have been found to affect breeding populations of golden eagles (Platt 1984), and other types of mining activities could potentially affect breeding behavior and distribution of the species. Roads lead to collisions of eagles with vehicles but affect eagle distribution because golden eagles avoid nesting in areas with high densities of roads.

5.2 Climate Change

The role that climate change will play in golden eagle distribution is also unclear. Potentially climate change may affect shrub-dominated habitats through altered fire regimes and increased occupation by invasive plants, leading to reduced small mammal populations. Also, temperature affects golden eagle reproduction in concert with prey abundance (Steenhof *et al.* 1993). In a long-term study in southwestern Idaho, the percentage of eagle pairs that laid eggs was limited by black-tailed jackrabbit abundance and winter severity influenced how much eagle reproduction declined. In addition, brood size at fledging was positively affected by rabbit abundance and inversely related to the number of hot days in spring. Although these results show a relationship between weather factors and reproductive success, the long-term implications with respect to the effects of climate change on golden eagle distribution are unclear.

5.3 Invasive Species and Fire

The relationship of fire with golden eagles is complex under the historic ranges of variability in frequency, extent, and severity, in part because this is a generalist species that occupies a wide range of vegetation types. Wildfires in the western states reduce the shrub layer and can promote vegetation types dominated by invasive annual grasses, affecting prey populations such as the black-tailed jackrabbit. For example, the loss of shrub habitat due to wildfires in southwestern Idaho reduced golden eagle reproductive success for several years (Kochert *et al.* 1999). However, fire in forested areas may create clearings that promote the prey base and improve hunting efficiency of eagles. Although fire plays a part in short-term effects on breeding populations, there is no clear correlation between fire and long-term effects on golden eagles.

5.4 Disease

West Nile virus was introduced into the United States in 1999 and has been confirmed as the cause of death of bald eagles in several regions; however, the extent of the problem in golden eagles is unknown (North American Golden Eagle Science Meeting 2010), and no large-scale mortality event has been recorded in any wild eagle population.

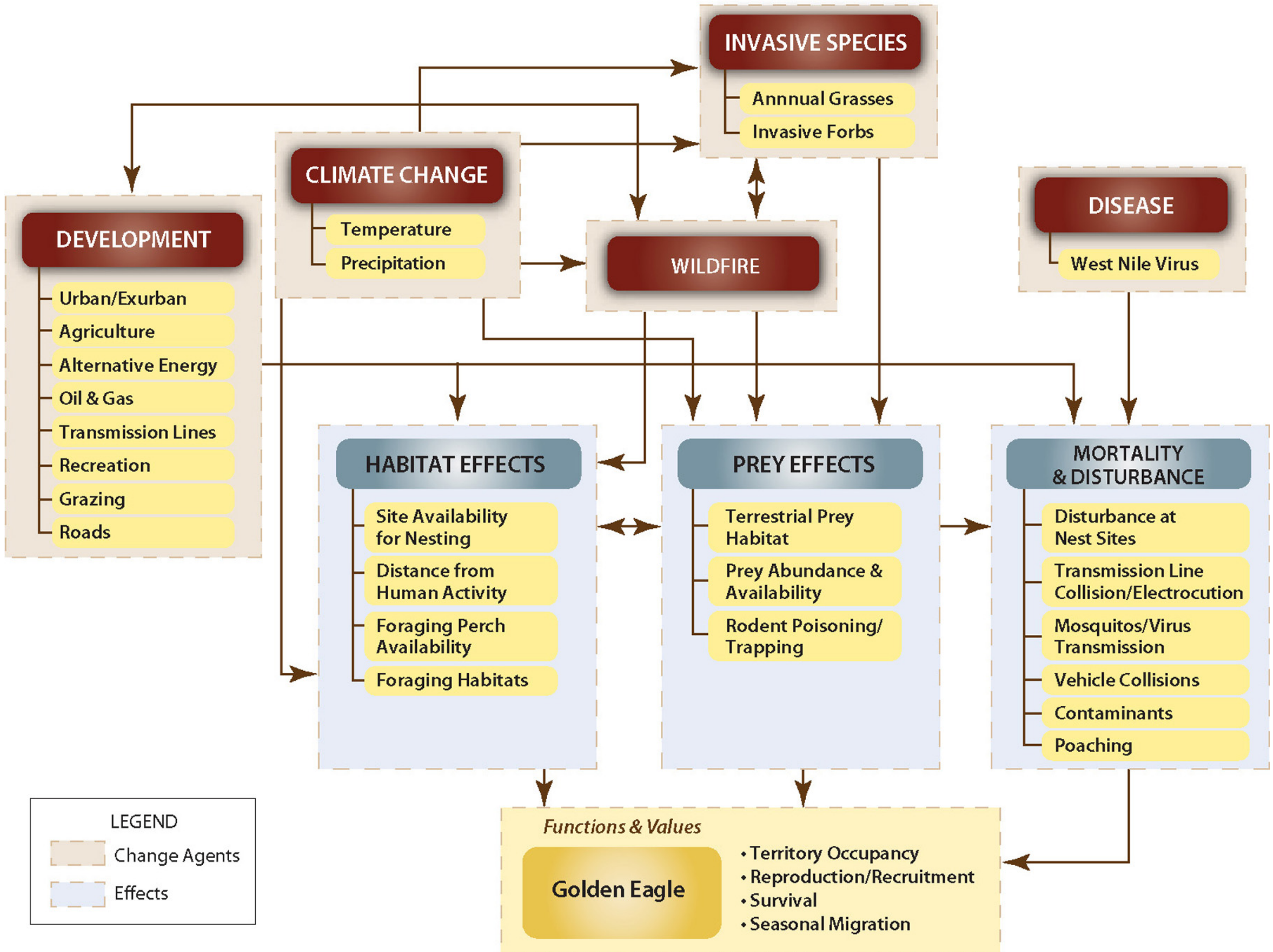


Figure 5-1. Conceptual Model for Golden Eagle

6 Change Agent Threat Analysis

Current status and future threat assessments for the Golden Eagle CE were conducted for the NGB ecoregion using 30 m pixel, 4 km and 12-digit HUC as the analysis units. Based on the conceptual system model for the species (Figure 5-1), key ecological attributes were identified for the current status and future threat analyses with an emphasis on the feasibility of measuring impacts using geospatial data (Table 6-1). The CAs evaluated for current status initially included development, wildfire, climate change, invasive species, and disease. The final version of the key ecological attributes table was limited to development, due to a lack of suitable data sources for other potential CAs.

Table 6-1. Key Ecological Attributes for Golden Eagle

Category	Ecological Attribute	Indicator/Unit of Measure	Metric			Data Source	Reference
			Low = 1	Moderate= 2	High = 3		
Size/Condition	Foraging Habitat	Extent of suitable habitat (Percent by HUC or 4km Grid)	HUC = 0-37% Grid = 0-32%	HUC = 37-70% Grid = 32-72%	HUC = 70-100% Grid = 72-100%	Existing vegetation type	Marzluff *et al.* 1997; Bates & Moretti 1994; Beecham and Kochert 1975; Smith and Murphy 1973; McGahan 1968
		VCC class	3	2	1	LANDFIRE	Not used
Landscape Context	Mortality/ Disturbance Risk	Proximity to urban/exurban development (km) (surrogate for proximity to electric distribution lines)	<6 km	6-15 km	>15 km		Delong 2004; Professional judgment
		Proximity to agriculture (km) (surrogate for pesticide contaminants	<1 km	1-5 km	>5 km	Cropland Layer	Delong 2004; professional judgment
		Road Density (km roads/km sq)	>10 km/km^2	5-10 km/km2	<5 km/km^2	TIGER	Professional judgment
		Proximity to Wind Turbines (km)	<10 km	10-16 km	>16 km	Wind Turbine Towers	Hunt *et al.* 1998; U.S. Fish and Wildlife Service Eagle Conservation Plan Guidelines (U.S. Fish and Wildlife Service 2011)

6.1 Key Ecological Attributes

The list of key ecological attributes (Table 6-1) shows the indicators used to assess habitat size; habitat condition, including risk of mortality and disturbance; and landscape structure with respect to migration and dispersal. In some cases, we suggested surrogate indicators for habitat functions listed in the conceptual model. For example, foraging habitat extent and condition is suggested as a key indicator of prey availability for golden eagles because reliable ecoregion-wide prey distribution data were not available.

Table 6-2 lists Landfire Existing Vegetation Type (EVT) natural land cover types that are considered suitable golden eagle habitat.

Table 6-2. Landfire Existing Vegetation Type Codes and Descriptions for the Golden Eagle Foraging Habitat Layer

EVT Value	EVT Name	EVT Value	EVT Name
2017	Columbia Plateau Western Juniper Woodland and Savanna	2114	California Lower Montane Blue Oak-Foothill Pine Woodland and Savanna
2031	California Montane Jeffrey Pine(-Ponderosa Pine) Woodland	2115	Inter-Mountain Basins Juniper Savanna
2053	Northern Rocky Mountain Ponderosa Pine Woodland and Savanna	2124	Columbia Plateau Low Sagebrush Steppe
2054	Southern Rocky Mountain Ponderosa Pine Woodland	2125	Inter-Mountain Basins Big Sagebrush Steppe
2062	Inter-Mountain Basins Curl-leaf Mountain Mahogany Woodland and Shrubland	2126	Inter-Mountain Basins Montane Sagebrush Steppe
2063	North Pacific Broadleaf Landslide Forest and Shrubland	2127	Inter-Mountain Basins Semi-Desert Shrub-Steppe
2064	Colorado Plateau Mixed Low Sagebrush Shrubland	2152	California Montane Riparian Systems
2065	Columbia Plateau Scabland Shrubland	2153	Inter-Mountain Basins Greasewood Flat
2068	North Pacific Dry and Mesic Alpine Dwarf-Shrubland or Fell-field or Meadow	2154	Inter-Mountain Basins Montane Riparian Systems
2070	Rocky Mountain Alpine Dwarf-Shrubland	2158	North Pacific Montane Riparian Woodland and Shrubland
2071	Sierra Nevada Alpine Dwarf-Shrubland	2159	Rocky Mountain Montane Riparian Systems
2072	Wyoming Basins Dwarf Sagebrush Shrubland and Steppe	2160	Rocky Mountain Subalpine/Upper Montane Riparian Systems
2079	Great Basin Xeric Mixed Sagebrush Shrubland	2162	Western Great Plains Floodplain Systems
2080	Inter-Mountain Basins Big Sagebrush Shrubland	2168	Northern Rocky Mountain Avalanche Chute Shrubland
2081	Inter-Mountain Basins Mixed Salt Desert Scrub	2169	Northern Rocky Mountain Subalpine Deciduous Shrubland
2082	Mojave Mid-Elevation Mixed Desert Scrub	2202	Juniperus occidentalis Wooded Herbaceous Alliance
2083	North Pacific Avalanche Chute Shrubland	2203	Juniperus occidentalis Woodland Alliance
2084	North Pacific Montane Shrubland	2210	Coleogyne ramosissima Shrubland Alliance
2086	Rocky Mountain Lower Montane-Foothill Shrubland	2217	Quercus gambelii Shrubland Alliance
2106	Northern Rocky Mountain Montane-Foothill Deciduous Shrubland	2220	Artemisia tridentata ssp. vaseyana Shrubland Alliance
2107	Rocky Mountain Gambel Oak-Mixed Montane Shrubland		

6.2 Current Status of the CE

This section documents the CA analysis under current conditions, i.e. the current extent of the CE's distribution and locations of the CAs. For each of the key ecological attributes listed in Table 6-1 and used in the CA analysis, a discussion of the indicator, metrics, metric rank and value, data source(s), and references are provided. The analyses were based on spatially available attributes affecting the CE at the ecoregion level.

6.2.1 Size

Habitat size was assessed in terms of the extent of suitable habitat as a percent of the reporting unit (4 km grid or 12-digit HUC). The habitat types used in this analysis are listed in Table 6-2 and were derived from the Landfire existing vegetation type data layer. A region group analysis was run on the extracted habitat layer type to develop a layer that showed the connectivity and extent of habitat. This layer was subsequently categorized into three groups based on their values. This was accomplished in ArcGIS, using geometric intervals for statistical grouping. The outputs were derived from the percent of cover for each category within the reporting units.

The output from the analysis (Figure 6-1) indicates a general trend that is apparent in most of the analyses for the golden eagle. A corridor of major cities within the ecoregion is responsible for a trend in lower quality habitat extent. This is indicative of the major concentrations of urban activity and development. Additionally, most agricultural activity in the ecoregion is centered along these corridors. Therefore, it is reasonable to assume that the extent of habitat will be greater in areas that are far removed from urban settings.

In Nevada Humboldt National Forest is clearly defined by a large portion of intact forested habitat. In Northwestern Nevada one of the largest extents of golden eagle foraging habitat is present in the foothills and plateaus surrounding Sheldon National Antelope Refuge. This large intact habitat area extends into Oregon near the Hart Mountain National Antelope Refuge. Other large intact areas exist along the eastern edge of Oregon’s Fremont National Forest. In Idaho the western portion of the Snake River Plain contains a large extent of foraging habitat.

The most important factor affecting the extent of foraging habitat for golden eagles is probably accessibility. All of the areas identified in this analysis indicate that remote or isolated areas provide the largest extent of foraging habitat. Due to the migratory abilities of the golden eagle, and minimal impediments to eagle distribution within the ecoregion, these isolated areas exist as refuges for the species.

6.2.2 Condition

Habitat condition was assessed in terms of the departure from natural vegetation. We used the Landfire vegetation condition class (VCC) to determine the values for this attribute. VCC is categorized as 1 (Low Departure), 2 (Medium Departure), and 3 (High Departure) vegetation ranking. These values were calculated as mean values by reporting unit and categorized in terms of quality using the natural breaks statistical method.

Figure 6-2 displays the varying levels of vegetation condition within the golden eagle distribution area in the NGB. Most of the ecoregion is limited to a medium departure from natural vegetation with only smaller areas remaining completely intact. Humboldt National Forest in Nevada, the eastern edge of Modoc National Forest in California, northwestern Nevada, and Boise National Forest and the western Snake River Plain in Idaho are the few low departure areas within the ecoregion.

Golden eagles are highly adaptable and can thrive in areas where prey abundance and suitable nest sites exist. The prevalence of fire and weed infestation in the ecoregion will determine the departure from vegetation, but with their adaptability, golden eagles are likely to remain unaffected by small changes in vegetation. The extent of foraging habitat (Figure 6-1) indicates that despite a high departure from natural vegetation, eagles continue to persist in these areas.

6.2.3 Mortality/Disturbance Risk

6.2.3.1 Urban Development

Development is potentially the single most important risk factor affecting golden eagles. Because of the potential effect of this CA on golden eagles, several attributes were assessed to determine the potential overall effect from development. Proximity to urban areas was analyzed by identifying areas within the golden eagle distribution area that were less than 6 km, 6-15 km, and greater than 15 km from urban areas. Urban areas were identified using an urban development layer that was derived from ReGAP/Landfire urban data layers. A distance raster analysis was applied to the urban dataset using the parameters outlined above, and the values were categorized accordingly.

In Figure 6-3 the urban areas and associated corridors are evident throughout the ecoregion. The main city centers and interstates are identified as lower quality areas and the more remote areas are identified as preferred. Northern Nevada and Northeastern California are primarily devoid of urban activity. In Oregon Hart Mountain National Antelope Refuge, Malheur National Forest, Umatilla National Forest, and Whitman National Forest are also unaffected by urban areas.

Urban growth is the most important development CA, because it is responsible for the increase in all other development CAs. Despite the overwhelming nature of urban sprawl that seems apparent in the NGB, other indicators have shown that golden eagles are only somewhat affected by this attribute. It is possible that despite the literature (Delong 2004) indicating that these distance values impact golden eagle populations, the species distribution and habitat analysis indicate that they are capable of adapting to slow changes related to urban growth in the Northwest.

6.2.3.2 Agricultural Development

Agricultural development is closely associated with urban development for the simple reason that increased human population results in increased demand for agriculture. This is coupled with the requirement for distribution of agricultural products. The agricultural analysis was completed using a cropland layer that was derived from the ReGAP/Landfire data layers. Proximity to agricultural areas was analyzed by identifying areas within the golden eagle distribution area that were less than 1 km, 1-5 km, and greater than 5 km from agricultural areas. A distance raster analysis was applied to the agriculture dataset using the parameters outlined above, and the values were categorized accordingly.

The output from the analysis (Figure 6-4) is similar to the output from the urban areas analysis (Figure 6-3). The difference in the overall output is primarily observed in the level of spatial accuracy on a 4 km reporting unit scale. Because lower proximity values were used in the agricultural analysis, the values are more diverse in their ranges across the ecoregion. However, the overall results of this analysis indicate that the main city centers and areas surrounding interstates are identified as lower quality areas and the more remote areas are identified as preferred. In Nevada the foothills and plateaus surrounding the Sheldon National Antelope refuge and Humboldt National Forest, the western Snake River Plain in Idaho, and the Hart Mountain National Antelope Refuge, Malheur National Forest, Umatilla National Forest, and Whitman National Forest in Oregon are areas identified as high quality non-agricultural areas.

Large portions of the ecoregion are characterized as either moderate or preferred quality in relation to proximity to agriculture. This indicates that agricultural land is a factor that affects golden eagles in the NGB, but it also indicates the ability of the species to adapt to these changes when suitable prey and nest site locations exist. As a result limited agricultural growth would likely have little effect on eagle populations within the NGB.

6.2.3.3 Road Development

The road analysis is important because of its direct correlation to mortality for golden eagles. The road analysis was performed using the TIGER roads (all roads) data layer for the NGB. Road density was calculated using the raster density analysis, which characterizes density as the number of road kilometers per kilometer. The metrics assigned to the categories of quality for the road analysis were less than 5 km/km^2, 5-10 km/km^2, and greater than 10 km/km^2. Lower road density was preferred and higher density was considered lower quality.

Due to the relatively low populations of the NGB ecoregion and therefore lower road densities, the majority of the ecoregion was considered to be of higher quality with regard to road density. The lower quality areas were related to the primary city centers of Boise, Mountain Home, Twin Falls, Pocatello, and Idaho Falls.

The current road densities as a result of overall limited human populations indicate that overall golden eagle populations are not currently at risk from roads in the NGB. Local mortality will remain a factor in areas where road densities remain at higher levels.

6.2.3.4 Wind Energy Development

The wind energy development analysis is important because of the increased mortality rates for golden eagles as a result of collision. The U.S. Fish and Wildlife Service Eagle Conservation Plan provides direction for agencies studying the effects of wind turbine facilities on golden eagles. The metrics used in the analysis were obtained from the Eagle Conservation Plan and applied to the FAA and U.S. Fish and Wildlife Service wind turbine data layer and are as follows: less than 10 km, 10-16 km, and greater than 16 km proximities. Close proximity to wind turbines was characterized as lower quality and distant proximity was characterized as preferred. A distance raster analysis was applied to the wind turbine dataset using the parameters outlined above, and the values were categorized accordingly.

The majority of the ecoregion is characterized as preferred for golden eagles with relation to wind turbine locations (Figure 6-6). Most of the lower potential wind turbine locations exist in close proximity to the population and transportation corridors in Idaho. In Oregon the area to the southwest of the Ochoco National Forest and the Malheur National Forest and the vicinity of Goose Lake and Summer Lake (South Central Oregon) are considered to be of lower quality. In Nevada the eastern edge of Humboldt National Forest and in Utah the western edge of the Bonneville Salt Flats are impacted by wind turbine activity.

Although wind turbines are present at some level in every state within the ecoregion, their overall effect is limited due to the low prevalence of wind turbines. Localized mortality of golden eagles is expected across the ecoregion in these areas, especially in areas of higher golden eagle population densities. Another factor that isn't considered in this analysis is the size of individual wind turbines and wind farms. Wind turbine spacing, blade speed, and height are all factors that affect golden eagle mortality at wind farm locations. Therefore this analysis can only identify potential threat regions within the NGB.

6.2.4 Cumulative Risk

The cumulative risk assessment was performed using a combination of all attributes and metrics listed in the key ecological attributes table. The cumulative risk score was obtained by combining all of the output layers used in the analysis and evaluating the mean value across the ecoregion. This enables the user to obtain an overall "risk from CA" value for the golden eagle in the NGB that can be applied to BLM field office-level management. The spatial scale of this analysis limits this dataset to be used as a guide to determine the best use of tools available for the management of the species, rather than to draw specific correlations from the analysis values provided in Figure 6-7.

The cumulative score figure follows the same trends observed in the key ecological attribute analyses. There is a general lower quality corridor associated with the urban areas in Idaho. The area north of the Snake River Plain, which is historically considered one of the best raptor habitats in the United States appears to be at threat from the CAs described in this CE assessment. Southeastern Idaho and the area surrounding Malheur Lake in Oregon appear to score low based on cumulative threats (agriculture being the one of the major factors for low scores). This corresponds with the lack of golden eagle distribution in the immediate vicinity of Malheur Lake. Also in Oregon, the area east of Fremont National Forest running north to Bend appears to contain large areas of with low cumulative scores interspersed with areas of high scores. All of the ecoregion that is encompassed in California and the vast majority of Nevada scored moderate to high values. Despite large areas of higher risk for golden eagles, the overall ecoregion scored values ranging from medium to high.

In general the risk from CAs across the NGB appears to remain low for the golden eagle. Species adaptability and prey abundance indicate an overall relative stable ecoregional ecosystem for the golden eagle. Development in the form of urban growth is the most likely factor to have a broad effect on the species. Throughout the majority of the ecoregion lack of accessibility to human activity remains an important factor with regard to risk. Because of the mobility of golden eagles large areas within the ecoregion act as natural refuges for the species. Localized mortality risks increase in areas where wind turbine activity and high-traffic roadways exist within specific ranges of golden eagle habitat. The overall risk to the species within the NGB is probably low overall.

Although the analyses performed in this REA attempt to characterize the CAs that most likely affect the golden eagle, the assessment could be improved as newer and better datasets become available. The quality of the analysis through use of surrogate data in this REA would be better served by data sources that reflected the actual threats (i.e., prey distribution layer, electric distribution lines, pesticides). Increased nest site location data would improve upon the Maxent distribution model, which would also provide important information to field managers.

6.3 Future Threat Analysis

6.3.1 Development

Development along major urban corridors in Idaho most greatly affects the population of golden eagles. Habitat is threatened by future urban/exurban expansion, agriculture (especially when land conversion occurs), and alternative energy development. Wind farm development is a significant concern because it can be a major source of mortality.

6.3.2 Wildfire

The increase in fire frequency in the West poses potential short-term threats to bald eagles. Nesting habitat destruction through wildfire results in temporary extirpation (<10 years) of breeding golden eagles. More frequent fires than occurred historically reduces the time between burns required for sagebrush to fully mature limiting the availability of prey species habitat.

6.3.3 Invasives and Disease

The increase in cheatgrass (invasive grass) cover reduces prey species occupancy. In addition, increasing dominance of invasive annuals produces fuel for wildfire and facilitates short fire return intervals.

6.3.4 Grazing

Golden eagle foraging habitat is affected by livestock grazing when grazing intensity is severe enough to alter sagebrush cover or the nutritional quality of forage for prey species. Golden eagles are highly adaptable and may alter foraging locations or switch to alternative prey species**.** However, if grazing intensity increases in the future, net degradation of local foraging habitat quality may result.

6.3.5 Climate Change

The role of climate change in golden eagle distribution and abundance is unclear and is likely associated with vegetation and temperature changes affecting prey populations. Vegetation habitat models (i.e., sagebrush and salt desert scrub CEs) assess climate change in these systems and their effects on prey populations.

6.3.6 CE Summary

The presence of priority habitat or a potential site for habitat restoration may be an indicator for managers to carefully consider future development in the more remote regions of the Great Basin, particularly in the western and southwestern portions. The cumulative indicator scores for golden eagle priority habitat under current conditions should be useful in identifying the areas most in need of preservation or the best restoration opportunities in these drill-down evaluations.

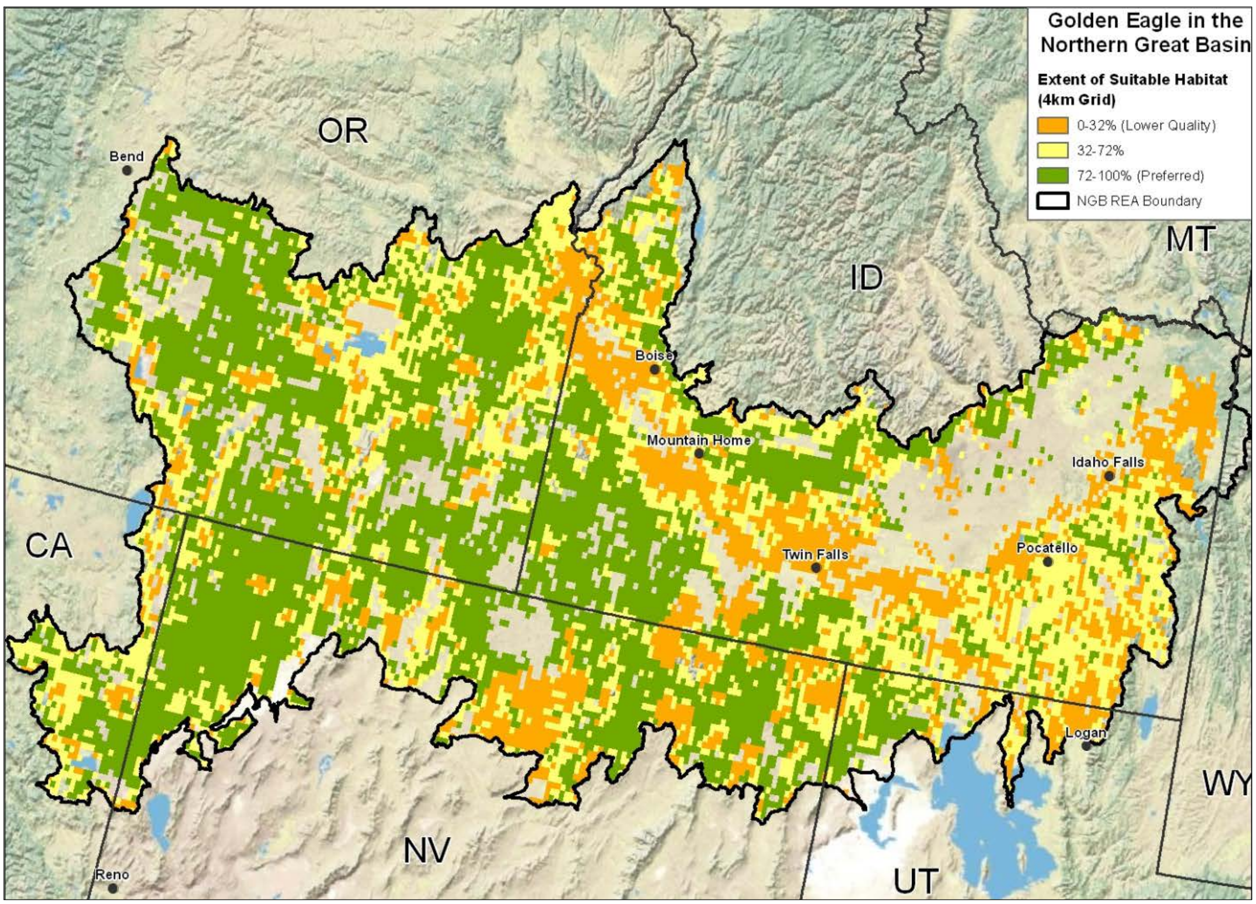


Figure 6-1. Extent of Suitable Habitat Described as Percent per 4 km Grid Area

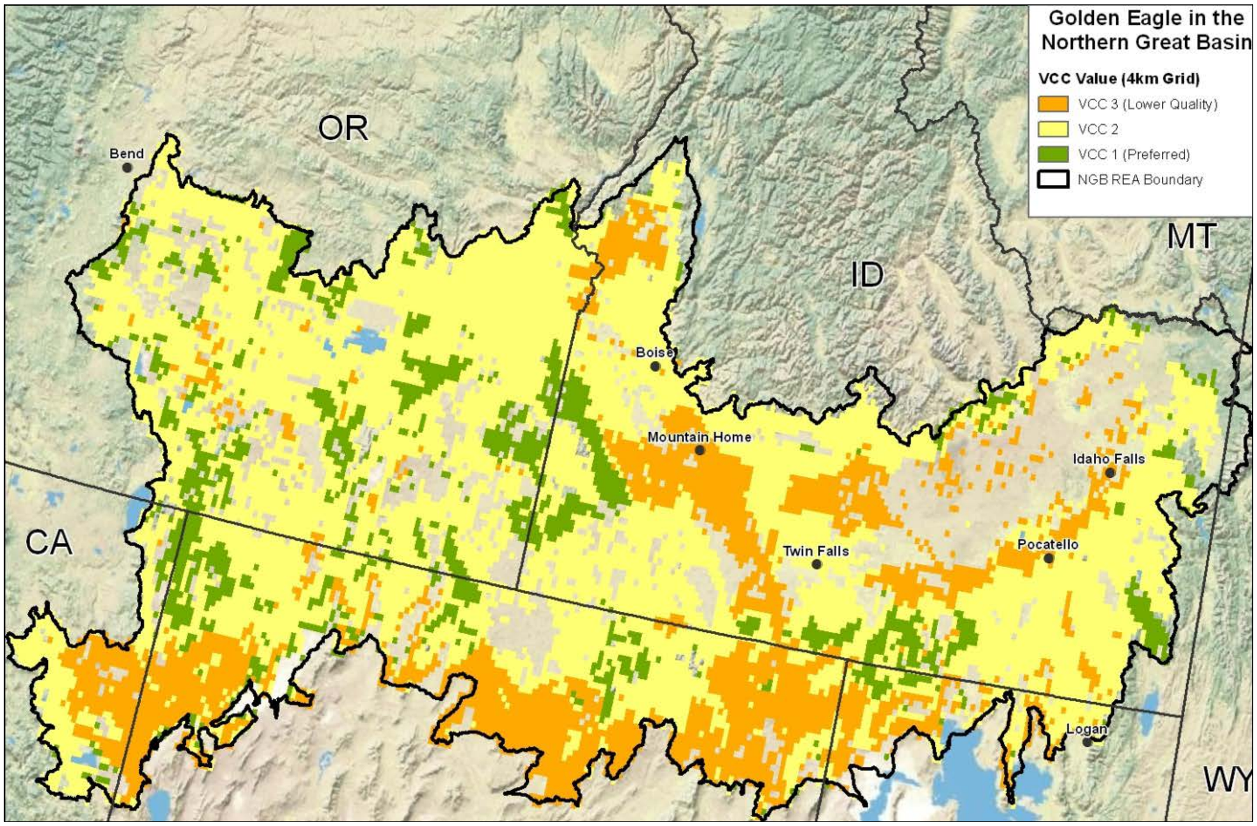


Figure 6-2. Vegetation Condition Class Rating within the 4 km Grid Reporting Unit

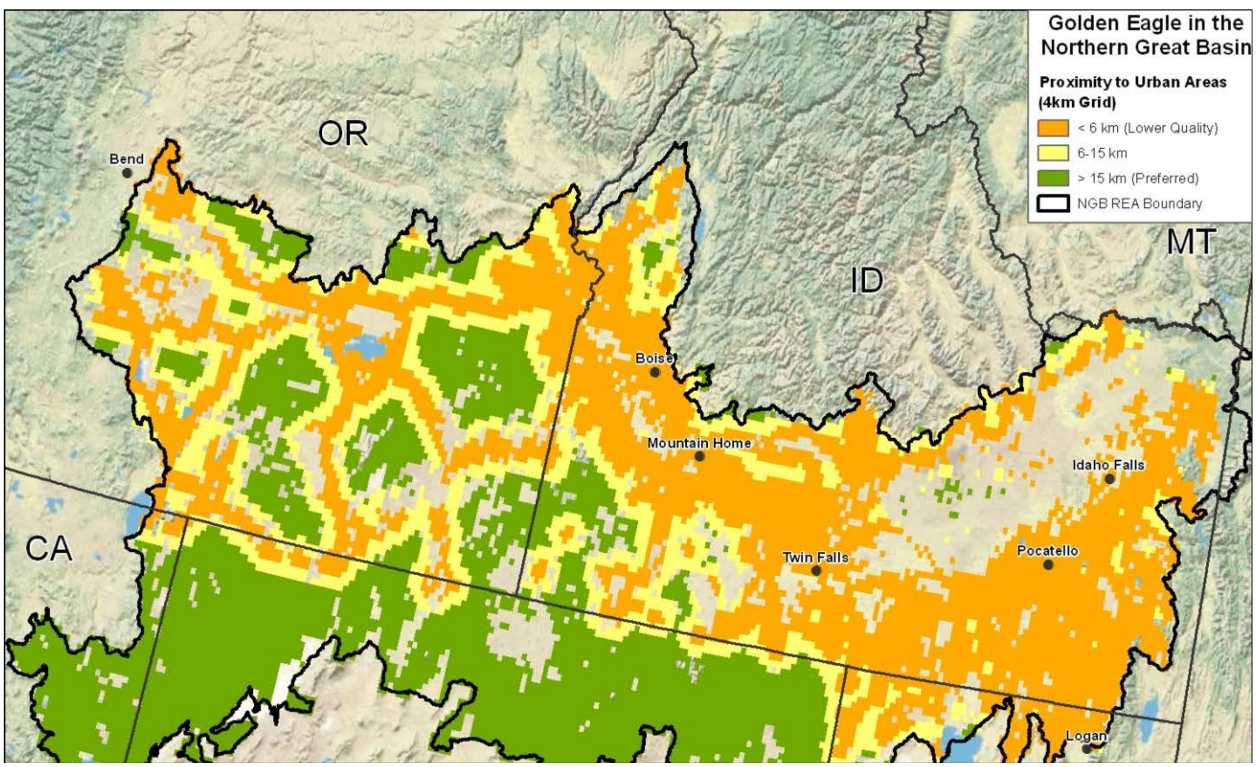


Figure 6-3. Proximity to Urban/Exurban Development

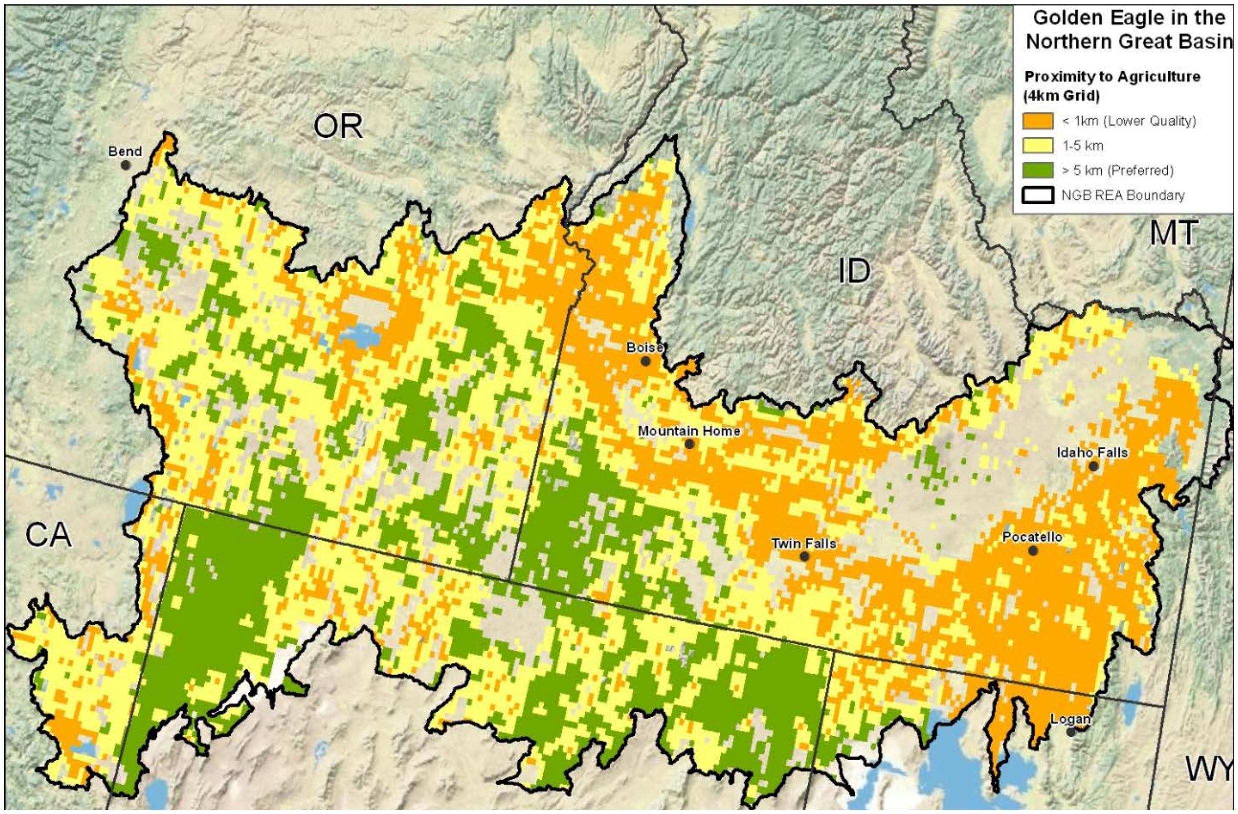


Figure 6-4. Proximity to Agriculture

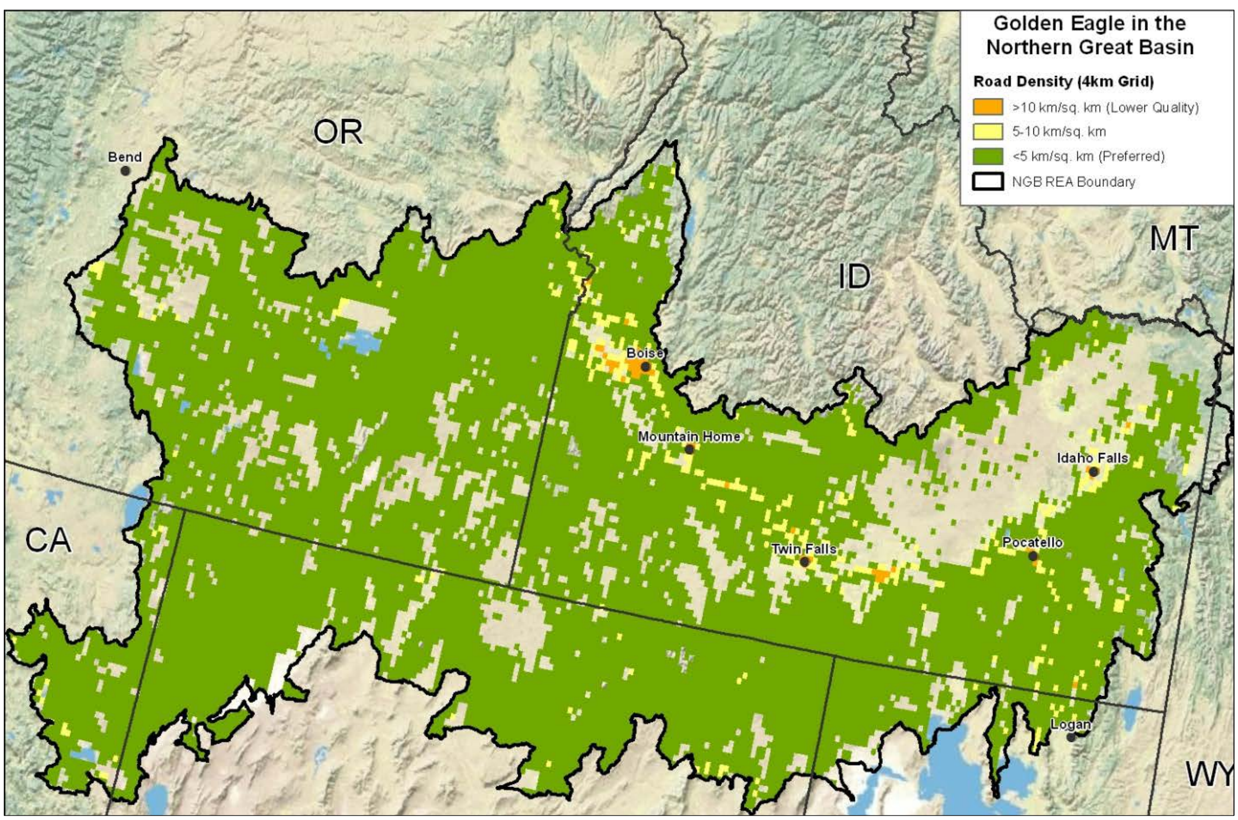


Figure 6-5. Road Density

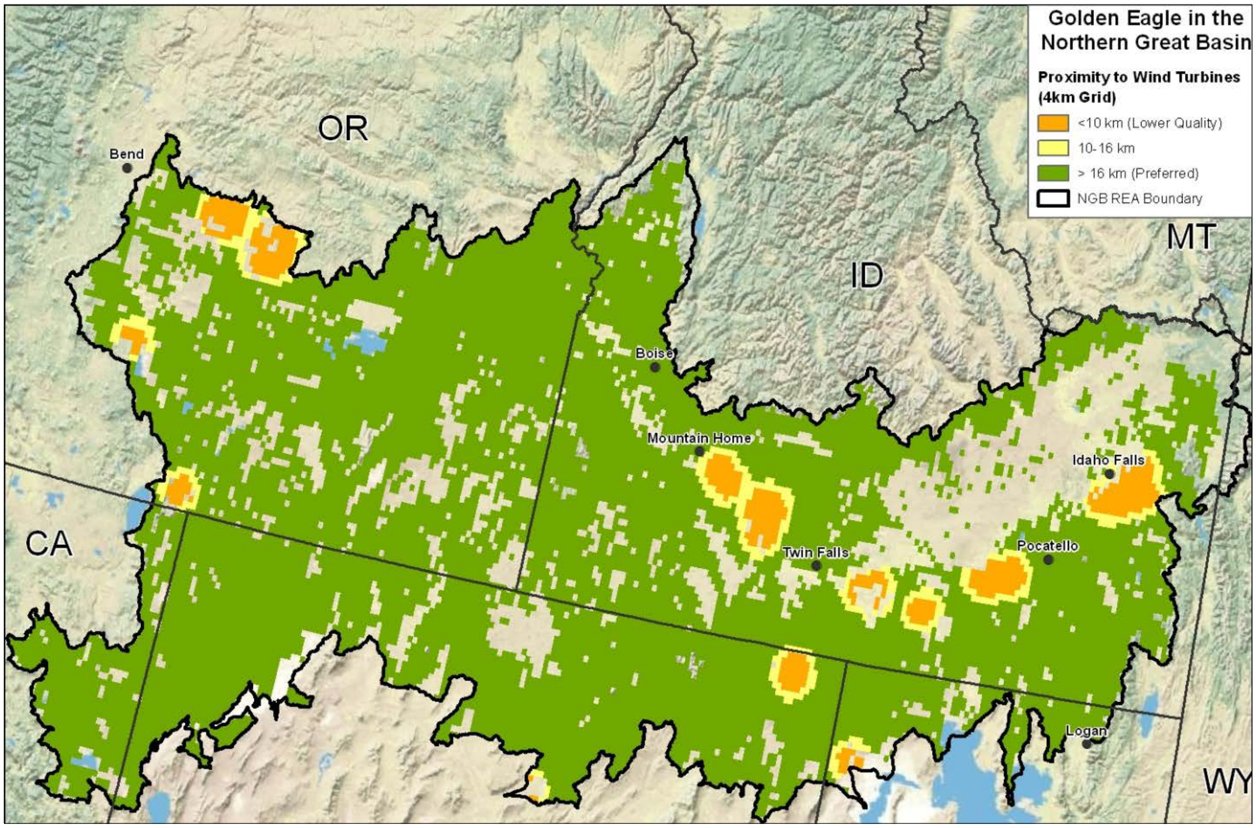


Figure 6-6. Proximity to Wind Turbines

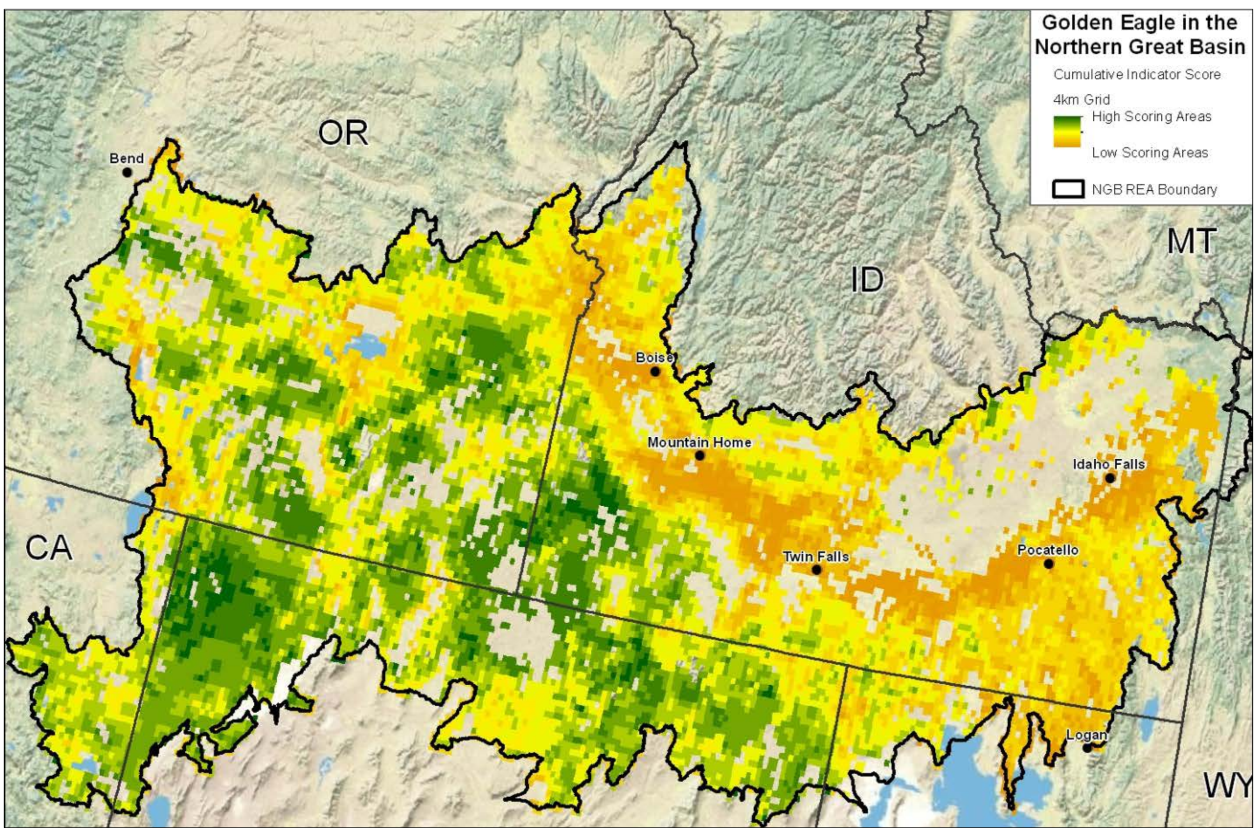


Figure 6-7. Cumulative Score for all Key Ecological Attributes

7 Management Questions

Management questions for the NGB were developed by BLM managers and refined by the AMT to answer questions regarding the agency's land management responsibilities—including planning land use, developing best management practices, authorizing uses, and establishing conservation and restoration priorities. Several management questions relate to the golden eagle CE:

1 What is the currently occupied habitat or modeled suitable habitat for this CE?

The golden eagle habitat was modeled using Maxent (Maximum Entropy Model). This model incorporated nest site location and physical spatial data to derive the distribution layer shown in Figure 4-1.

2 Where are the areas of greatest and least collective impact of existing CAs on occupied habitat or modeled suitable habitats of this CE?

Within the NGB the areas of greatest impact from CAs are the urban and transportation corridors in Idaho (Boise, Mountain Home, Twin Falls, Pocatello, and Idaho Falls), southeastern Idaho, Malheur Lake in Oregon, and the western edge of the ecoregion boundary in Oregon. The majority of the ecoregion aside from these areas exhibits the least collective impact (Figure 6-7).

5 Where are current locations of this CE likely to overlap with the potential future distribution of CAs (other than climate change)?

The areas most susceptible to threat are the golden eagle habitats that are adjacent to urban activity and growth in Idaho (Boise, Mountain Home, Twin Falls, Pocatello, and Idaho Falls). In addition a large section of southeastern Idaho appears to be potentially at risk (Figure 6-7).

6 Given current and anticipated future locations of CAs, which habitat areas remain as opportunities for habitat enhancement/restoration for this CE?

There appear to be multiple remote "natural refuges" that exist in areas that do not appear at high risk from CAs. The areas that present opportunities for habitat enhancement are the western portion of the Snake River Plain in Idaho, northern Nevada (specifically in the northwest), all of California that is encompassed in this ecoregion, and the areas south and east of Malheur Lake in Oregon (Figure 6-7).

7 Where are potential areas to restore connectivity for this CE, based on current locations of CAs?

Although connectivity does not greatly affect the golden eagle, because of its mobility, its prey species are affected by connectivity. Figure 6-1 describes the extent of suitable foraging habitat. The areas of great habitat connectivity are the western Snake River Basin in Idaho, most of Oregon (that is contained within the ecoregion boundary) excepting the vicinity surrounding Lake Malheur, and northwestern Nevada.

8 Where will this CE experience climate outside their current climate envelope? Or: Where will this CE experience significant deviations from normal climate variation?

The role of climate change in golden eagle distribution and abundance is unclear and was not evaluated in depth for this CE.

56 Where do current locations of CEs overlap with areas of potential future locations of renewable energy development (MQ 65)?

Figure 6-6 identifies the occurrence and proximity of wind turbines in relation to golden eagle habitat. Most of the wind turbine locations exist in close proximity to the population and transportation corridors in Idaho. In Oregon the area to the southwest of the Ochoco National Forest and the Malheur National Forest and the vicinity of Goose Lake and Summer Lake (South Central Oregon) are considered to be of lower quality. In Nevada the eastern edge of Humboldt National Forest and in Utah the western edge of the Bonneville Salt Flats are impacted by wind turbine activity.

8 References

Bates, J. W., and M. O. Moretti. 1994. Golden Eagle (*Aquila chrysaetos*) population ecology in eastern Utah. Great Basin Nat. 54:248-255.

Beecham, J. J., and M. N. Kochert. 1975. Breeding biology of the Golden Eagle in southwestern Idaho. Wilson Bulletin 87:506-513.

Franson, J. C., L. Sileo, and N. J. Thomas. 1995. Causes of eagle deaths. *in* E. T. LaRoe, G. S. Farris, C. E. Puckett, P. D. Doran, and M. J. Mac, editors. Our living resources: a report to the nation on the distribution, abundance and health of U.S. plants, animals and ecosystems. United States Department of the Interior, National Biological Service, Washington, DC, USA.

Hunt G. 2002. Golden eagles in a perilous landscape: predicting the effects of mitigation for wind turbine blade-strike mortality. Predatory Bird Research Group, University of California, Santa Cruz. Retrieved from: http://www.energy.ca.gov/reports/2002-11-04_500-02-043F.PDF

Kochert, M. N., K. Steenhof, C. L. McIntyre, and E. H. Craig. 2002. Golden Eagle (*Aquila chrysaetos*). *In* A. Poole and F. Gill (eds.), The Birds of North America, No. 684. The Birds of North America, Inc., Philadelphia, Pennsylvania.

Kochert, M. N., K. Steenhof, L. B. Carpenter, and J. M. Marzluff. 1999. Effects of fire on golden eagle territory occupancy and reproductive success. Journal of Wildlife Management 63: 773-780.

Marzluff, J.M., S.T. Knick, M.S. Vekasy, L.S. Schueck, and T.J. Zarriello. 1997. Spatial use and habitat selection of Golden Eagles in southwestern Idaho. Auk 114:673-687.

McGahan, J. 1968. Ecology of the golden eagle. Auk 85:1-12.

McIntyre C.L., Douglas D.C., Collopy M.W. 2008. Movements of golden eagles (*Aquila chrysaetos*) from interior Alaska during their first year of independence. The Auk 125(1):214-224.

North American Golden Eagle Science Meeting. 2010. A collaborative critique of the golden eagle's uncertain future in North America. Minutes and Notes. USGS Science Center, Fort Collins, CO. 21 September 2010. Accessed online at: http://www.dfg.ca.gov/wildlife/nongame/raptors/goldeneagle/docs/NAGoldenEagleScienceMeeting-2010-09-21.pdf

Olendorf, R. R. 1976. The food habits of North American Golden Eagles. American Midland Naturalist 95:231–236.

Platt, S. W. 1984. Energy development and raptor populations on and adjacent to the Black Butte Coal Company mine permit area. Unpublished progress report. Black Butte Coal Company, Point of Rocks, Wyoming. 71 pages.

Poole, K. G., and R. G. Bromley. 1988. Interrelationships within a raptor guild in the central Canadian Arctic. Canadian Journal of Zoology 66:2275–2282.

Smallwood, K. S., C. G. Thelander, M. L. Morrison, and L. M. Rugge. 2007. Burrowing owl mortality in the Altamont Pass Wind Resource Area. Journal of Wildlife Management 71:1513–1524.

Smith, D. G., and J. R. Murphy. 1973. Breeding ecology of raptors in the eastern Great Basin of Utah. Brigham Young Univ., Provo. Sci. Bull. Biol. Ser. 18, No. 3. 76pp

Stahlecker, Dale W., Cartron, Jean-Luc E., Mikesic, and David G. 2010. Golden Eagle (Aquila chrysaetos). In: Cartron, Jean-Luc, ed. Raptors of New Mexico. Albuquerque, NM: University of New Mexico Press. p. 371-391.

Steenhof, K., M. N. Kochert, and J. A. Roppe. 1993. Nesting by raptors and common ravens on electrical transmission line towers. Journal of Wildlife Management 57(2):271-281.

Steenhof, K., S.S. Berlinger and L.Hl. Fredrickson. 1980. Habitat use by wintering bald eagles in South Dakota. Journal of Wildlife Management 44:798-805.

Bald Eagle Conservation Element Package

1 Introduction

The bald eagle is widely distributed in western states; population increases, habitat protection, management actions, and reduction in persistent organochlorine pesticides in the environment led to its delisting under the Endangered Species Act in 2007. The distribution and status of bald eagles in the Northern Great Basin (NGB) reflects local factors related to availability of nesting sites and suitable wintering habitat (Swenson *et al.* 1986; Buehler 2000). Any agent of change that positively or negatively influences these factors has the potential to influence bald eagle distribution and population levels in the region. The bald eagle was selected as a fine-filter conservation element (CE) for the NGB AMT because it is a landscape-level species that is the focus of management concern in the ecoregion.

This CE was evaluated under the following set of assumptions:

1. Assessment of the CE will focus on broad landscape factors and not on small-scale habitat features that may be important primarily at the local level.

2. Not every feature of bald eagle habitat was identified through this analysis.

3. The primary drivers of distribution and status of this CE are risk of direct mortality and habitat condition.

This CE package provides the assessment of the current status and future threats due to CAs for the bald eagle in the NGB ecoregion. Information in this CE package includes a brief description of the biology of the bald eagle in the NGB ecoregion, a description of change agents that were assessed, a conceptual model of ecosystem functions relevant to the bald eagle, some information on potential data sources and analytical methods for the assessment, and a listing of relevant management questions for this CE.

2 CE Package Review Process

2.1 Subject Matter Expert Review

Subject Matter Experts play a key role in ensuring that the REA reflects the best available data and modeling processes suitable for each conservation element and change agent. Subject Matter Experts were added to Rolling Review Teams comprised of SAIC scientists, SAIC GIS personnel, AMT member(s) and other subject matter experts from the Department of Interior or state agencies. Membership of the Rolling Review Teams is listed in Appendix A. To ensure consistency amongst the different Rolling Review Teams, the number of lead SAIC scientists was limited to only a few individuals. This ensured that there was a common approach, or framework, used among the different Rolling Review Teams and that one Rolling Review Team did not stray too far from the rest. The USGS, as peer reviewers, were invited to participate in Rolling Review Teams.

3 CE Description

Bald eagles are widespread in North America in association with marine shorelines and large bodies of water where there is significant forest cover nearby to provide nesting, roosting, and foraging perch sites. The number of resident pairs in the Snake River Plain is largest in the upper river above Idaho Falls (Greater Yellowstone Ecosystem /Idaho Bald Eagle Research Project 2004). Bald eagle numbers increase greatly along the Snake River system in winter due to an influx of migrants coming into the region from Canada, northern Idaho and Montana (Buehler 2000). The distribution and numbers of bald eagles in this ecoregion reflect a complex pattern of migration dependent on age of the individual (immature or adult), location of breeding sites (north vs. south, interior vs. coastal), severity of climate at breeding sites during winter, and food availability. Most immatures migrate and may move nomadically, presumably because they are not tied to defense of a nest site, but it is difficult to distinguish between true migration (seasonal movements between breeding and wintering grounds) in immatures and dispersal. Adult birds, in contrast, migrate as needed when food becomes unavailable (Buehler 2000).

Factors related to availability of nesting sites and suitable wintering habitat play a major role in determining the distribution and abundance of the species (Swenson *et al.* 1986, Buehler 2000). Nest sites are limited to forest stands with suitable large nest trees. Vegetation types that offer the best nesting opportunities include forest stands located in proximity to lakes or reservoirs that are dominated by Douglas-fir and/or lodgepole pine, and occasionally cottonwood-dominated gallery forests. A stable food source (most often fish) that is available from early spring through the end of the nesting period in late summer is an important factor in breeding area selection (Swenson *et al.* 1986). Overwintering bald eagles exploit available food supply, following salmon runs (Swenson *et al.* 1986; McClelland *et al.* 1994) and concentrating near dams along the Snake River where open water and fish are available (Steenhof *et al.* 1980; Brown *et al.* 1989; Kaltenecker *et al.* 1998). Adults in some northern populations may not migrate but instead move locally to food sources such as mammalian carrion or waterfowl during winter (e.g., Greater Yellowstone Ecosystem) (Swenson *et al.* 1986). Wintering bald eagles congregate at communal roosts located in conifer forest stands in close proximity to foraging areas (Stalmaster 1987; Buehler *et al.* 1991).

Factors related to reproductive success and survival of immature and adult bald eagles are also important in determining distribution and abundance of bald eagles (Swenson *et al.* 1986). Productivity of bald eagle populations is regulated by the percentage of adults that breed and the relative success of those attempts (Buehler 2000). The percentage of adults that are able to breed is determined in part by competition for limited supply of suitable breeding sites (Swenson *et al.* 1986). The success of breeding attempts is limited by food availability and weather, among other factors. For example, weather effects explained 63 percent of variation in reproductive output in Greater Yellowstone Ecosystem, with reduced output in cold, wet springs (Swenson *et al.* 1986). However, in terms of long-term population dynamics, survival rates of bald eagles have a greater effect than reproductive rates (Grier 1980; Harmata *et al.* 1999). Lifespan, rather than clutch size and number of young fledged, often accounts for most of the variance of lifetime reproduction in long-lived birds (Newton 1979) such as the bald eagle. Thus, factors related to availability of nesting sites, reproductive success, and survival of immature and adult bald eagles play a major role in determining the distribution and abundance of the species.

4 CE Modeling

4.1 Data Identification

Table 4-1. Preliminary List of Bald Eagle Data Sources

Data Required	Dataset Name	Source Agency	Type/Scale	Status
Modeled Suitable Habitat	GAP Suitable Habitat	USGS	Raster	Acquired
Point Occurrence and Nests	Observations	Natural Heritage	Point	Limited Data
	eBird	eBird	Point	Not Used
	Breeding Bird Survey	USGS compilation?	Point	Not Used
	Midwinter Bald Eagle Count	USGS, NBII	Point	Limited Data
	State agency surveys	Oregon Department and Fish and Wildlife	Point	Limited Data
Sensitive Areas	Audubon Important Bird Areas	Audubon Society	Polygon	Not Used
	Bird Conservation Areas	Partners in Flight	Polygon	Not Used

4.2 Distribution Mapping Methods

After consultation with the Rolling Review Team, the GAP summer and winter Bald Eagle suitable habitat data models were used. The distribution based on these models is provided in Figure 4-1.

4.3 Data Gaps, Uncertainty, and Limitations

4.3.1 Data Gaps

The bald eagle is less-studied in this region of the United States than the golden eagle. As a result data gaps existed at several levels in this REA. The primary data gap was the availability of a good species distribution model. In other instances in this REA in the absence of a good existing distribution model, Maxent was used in coordination with nest site location or point occurrence data. For the bald eagle we were not able to obtain adequate data of this type for use in a model. As a result, we used the existing GAP distribution model for the bald eagle. Although this model is adequate, a more relevant model would have been preferred.

The use of key ecological attributes in this analysis was an important factor in determining potential threats or identifying preferable attributes across the bald eagle range. In instances where the preferred data were not available for use in the analysis, a surrogate dataset was used. The prey base condition analysis used a surrogate to determine the potential health of the prey base. Since actual fish data was not available at the required scale, water quality data for streams and open water within the bald eagle habitat range were used instead. This attribute was examined separately for the winter analysis. This analysis focused on areas of high waterfowl concentrations, but due to a lack of available waterfowl wintering data, National Wildlife Refuges were used as surrogates. For the analysis for proximity to electric distribution lines (as a surrogate for electrocution hazards), proximity to urban areas was used. Although this analysis is still meaningful, future assessments of this key ecological attribute would be improved greatly if electric distribution line data were available. Similarly, pesticide contamination data was lacking at the ecoregional scale, so proximity to agriculture was used in the analysis. The Rolling Review Team discussed the use of potential lead poisoning data, but this also was a data gap since lead poisoning is not related to a specific area within the ecoregion.

4.3.2 Uncertainty

The lack of a good species distribution model lends this analysis some level of uncertainty. The analysis is intended to be a rapid ecological assessment, and is therefore limited to the use of available data or simplified modeling techniques. In the case of the distribution model, it is important to be able to accurately identify the extent of the inhabited areas to apply all of the attributes appropriately.

In all instances (prey base condition, electric distribution lines and pesticide contaminants) in which surrogate data were used, uncertainty exists simply because of the use of surrogate data. The results of the analyses are only as good as the data input layers, and in this case the preferred datasets were not available. The level of uncertainty attributed to this analysis might not be too important due to the reporting units used in the analysis.

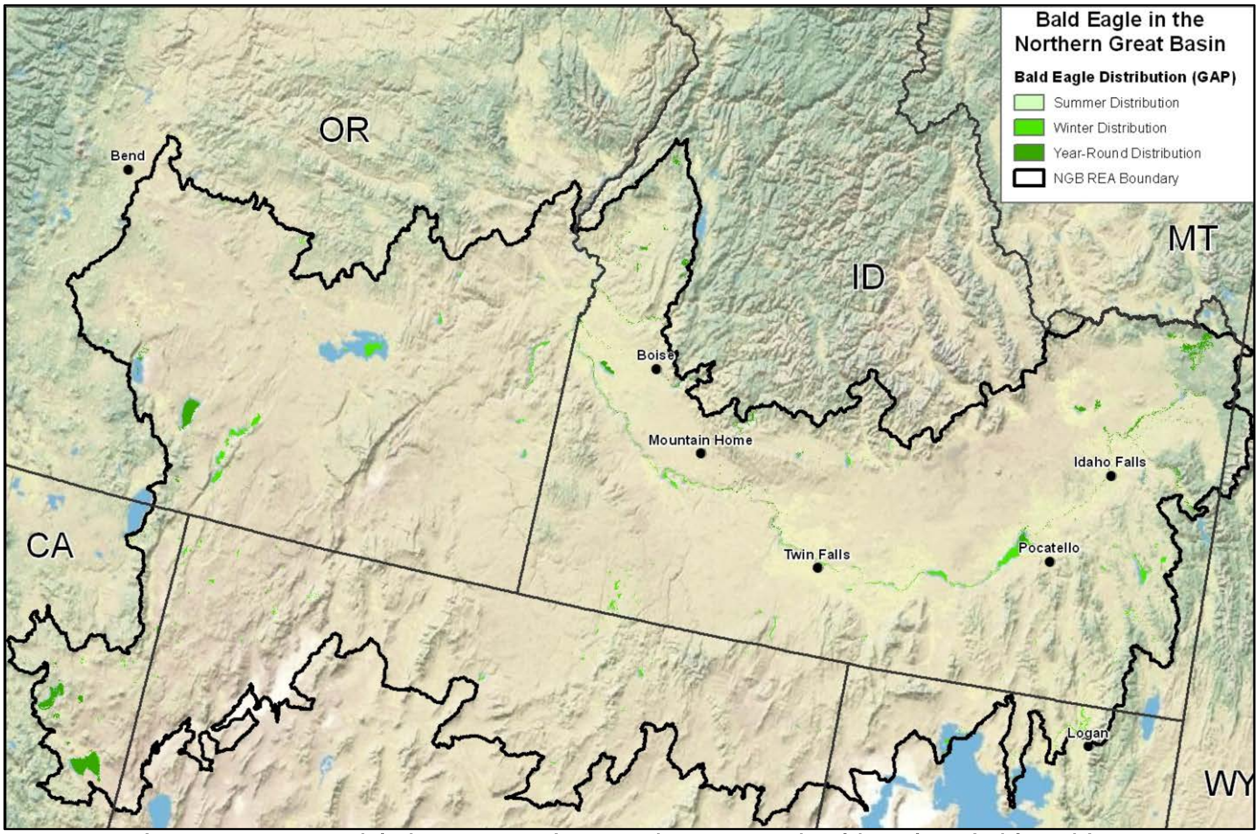


Figure 4-1. GAP Modeled Summer, Winter, and Year-Round Bald Eagle Suitable Habitat

5 System Models

The system model for the Bald Eagle CE is a conceptual model that illustrates the effects of CAs on the primary habitat functions for this species. Habitat functions include biotic and abiotic processes that may occur at local and landscape-levels (Figure 5-1). The model was developed to provide a scientific framework and justification for the choice of indicators that were used in assessing CA threats for this CE. The CAs originally included in the analysis included development, climate change, wildfire, disease, and invasive species. The conceptual model depicts our current understanding of the most important habitat functions in the systems occupied by this CE without regard for data availability or suitability of a habitat function for an ecoregion-level assessment

The primary CAs for bald eagles are identified across the top of the figure in red and their effects on habitat functions important to this species are identified in gray boxes below (Figure 5-1). The habitat functions that are key to the distribution and status of this species include availability of nest sites, winter roost sites, foraging perches, aquatic and terrestrial habitats that support its prey, and the effects of mostly anthropogenic influences on mortality and disturbance of individual bald eagles. The features that most significantly affect the distribution of the bald eagle are suitable nesting sites, foraging sites where prey are accessible to eagles, and habitats (most of which are aquatic) that support prey species abundance; thus, the condition of these habitats indirectly drive the distribution, productivity, and survival of bald eagles. In addition, anthropogenic effects cause direct mortality and disturbance. . The bald eagle system model depicts the change agents that were evaluated in this REA, of which habitat alteration through human development and direct mortality are the most important. Changes caused by climate change, altered fire regime, and invasive species affect eagle habitat primarily through their effects on prey habitats

5.1 Development

The bald eagle system model depicts the change agents that were evaluated in this REA, of which habitat alteration through human development and direct mortality are the most important. Bald eagles are threatened by human development on a variety of levels.

Human development in the vicinity of nesting and feeding areas along streams, lakes, and reservoirs affects habitat condition for bald eagles. Shorelines of the major water bodies in the region offer a variety of feeding perch types including trees and gravel bars but are subject to extensive human modification due to logging, firewood cutting, livestock grazing, water projects, agricultural, residential, recreational, and highway development (Fielder and Starkey 1986). Many water impoundments have a beneficial effect on bald eagles if they offer habitat for prey and foraging perches. However, most land use changes tend to remove foraging perch sites. Conifer stands in areas occupied by overwintering bald eagles, which are generally in the vicinity of feeding areas and isolated from human activities, offer thermal cover and are used as communal night roosts (Isaacs *et al.* 1993). Some development activities remove these stands, affecting habitat condition and the distribution of bald eagles.

Development-related change agents may involve hydrologic changes that create foraging opportunities, such as impoundments on the Snake River and its tributaries with natural or stocked fish populations and winter waterfowl concentration, water withdrawals and diversions that affect seasonal flow, and runoff of sediments and contaminants into aquatic habitat. All of these CAs may affect the fish and waterfowl prey base for bald eagles.

Development change agents also affect bald eagles by disturbing them at nest sites, foraging sites and communal roosts and interfering with the reproductive cycle and survival. Causes of mortality associated with human development and activities include collisions with power lines and vehicles, electrocution at power poles, and illegal shooting (Buehler 2000). Other anthropogenic mortality agents include contaminants in the environment and prey species such as lead shot. Bald eagles ingest lead pellets from waterfowl carcasses and deer carcasses, leading to lead poisoning (Neumann 2009). Henny *et al.* (1987) found secondary poisoning of bald eagles due to ingestion of organophosphorus insecticides used in feedlots where the eagles fed on cow carcasses.

In addition, human development and presence on shorelines in feeding areas increases the likelihood of behavioral disturbance, especially of foraging eagles, or mortality due to illegal shooting. Proximity of transmission lines to areas occupied by bald eagles increases the likelihood of collisions and electrocutions.

5.2 Climate Change and Wildfire

The role of climate change and wildfire in bald eagle distribution and abundance is unclear and is likely associated with hydrologic, water quality, and temperature changes affecting prey populations. Some of these effects, including direct effects on fish species reproduction and survival as well as effects on aquatic habitats, are described in other CE packages and are not repeated here. Effects of climate change and wildfire on coldwater fish species CEs in the ecoregion was described in the relevant system models. Although many of the preferred prey species of bald eagles, including fish and waterfowl, are not included in the CEs for this assessment, aquatic habitat models (i.e., perennial streams, wetlands, and open water habitat CEs) will assess climate change and wildfire effects in these systems. Riparian habitats CE package will assess these CAs in this system.

5.3 Invasive Species and Disease

Similar to climate change and wildfire, terrestrial and aquatic invasive species may have indirect effects on bald eagle distribution and abundance associated with prey species' distribution and abundance.

Avian cholera is the most important infectious disease affecting wild North American waterfowl (USGS 2002); outbreaks may recur in certain sites like the Klamath Basin National Wildlife Refuge, providing easily-available prey for bald eagles and leading to winter concentrations. Eagles may be subject to infection from contact with affected waterfowl. However, literature review has not indicated similar issues in the adjacent NGB ecoregion. West Nile virus was introduced into the United States in 1999 and has been confirmed as the cause of death of bald eagles in several regions; however, no large-scale mortality event has been recorded in any wild eagle population.

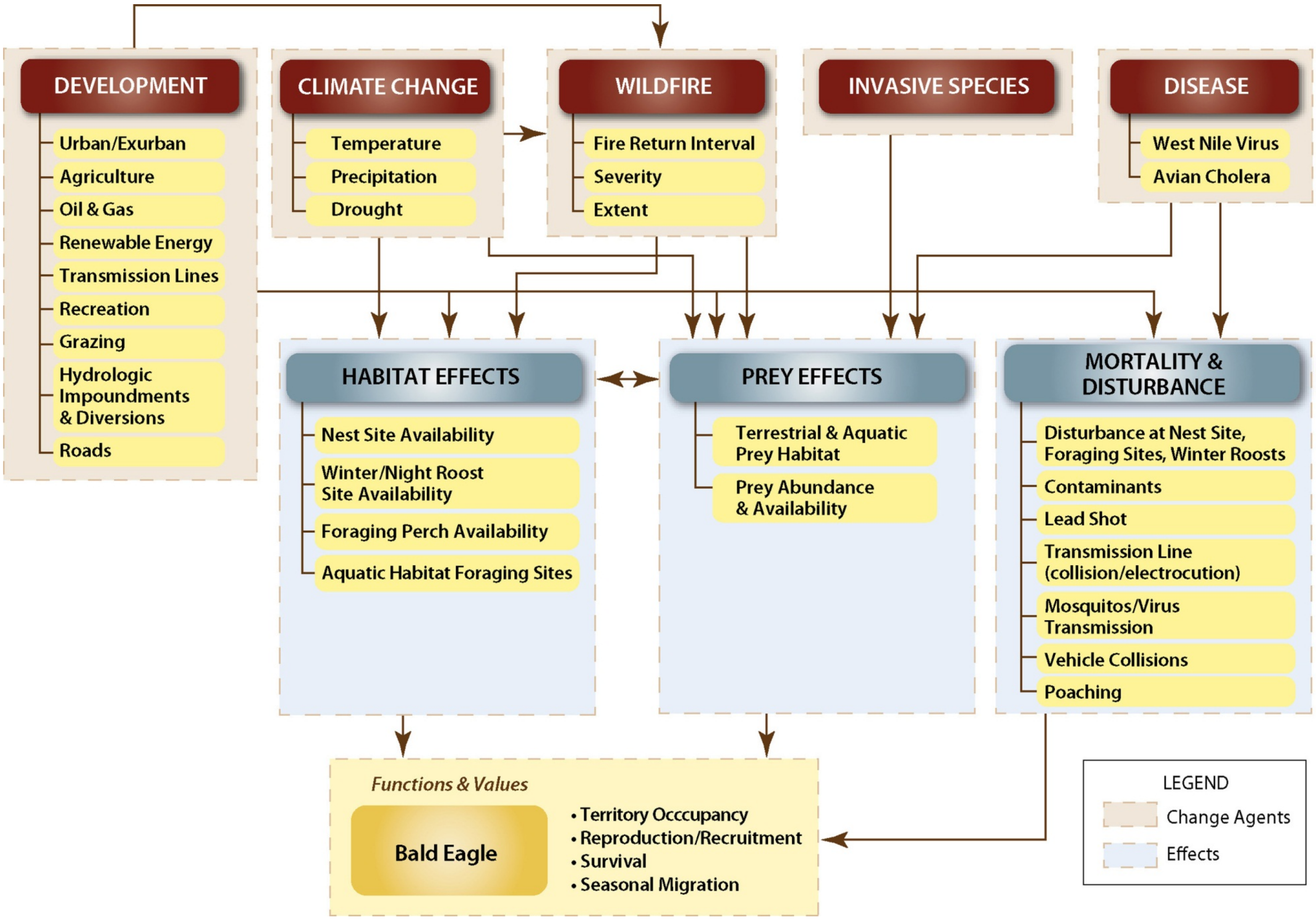


Figure 5-1. Conceptual System Model for Bald Eagle in NGB Ecoregion

6 Change Agent Threat Analysis

Current status and future threat assessments for the Bald Eagle CE were conducted for the NGB ecoregion using 30 m pixel, 4 km and 12-digit HUC as the analysis units. Based on the conceptual system model for the species (Figure 5-1), key ecological attributes were identified for the current status and threat analyses with an emphasis on the feasibility of measuring impacts using geospatial data (Tables 6-1 and 6-2). Current status of bald eagles was evaluated for development CAs. The key ecological attributes assessed for the bald eagle included separate summer and winter attributes as directed by the Rolling Review Team.

Table 6-1. Preliminary List of Bald Eagle Key Ecological Attributes and Indicators (Summer)

Category	Ecological Attribute	Indicator/ Unit of Measure	Metric			Data Source	Reference
			Low = 1	Moderate = 2	High = 3		
Size/ Condition	Foraging Habitat	Availability of suitable foraging habitat Suitable foraging habitat (percent per HUC/4km Grid)	Other	Other aquatic feature (high gradient stream, wetland, spring; non-perennial stream)	Open water edge (lake, reservoir); low-gradient perennial stream	NHD	Steenhof 1978; Steenhof et al 1980, Isaacs *et al.* 1993 1996; Kaltenecker & Bechard 1995; Holthuijzen 1999.
	Nest Site and foraging perch availability	Proximity of all forested cover types to foraging habitat (km) Foraging Habitat = (moderate & high)	>2	0.2 - 2	< 0.2	national land cover dataset, NHD	Swenson 1986; Buehler 2000
	Prey base condition	Use overall perennial streams/open water CE condition as surrogate indicator/metric (Low to High Mean Values by HUC12/4 km Grid)				NHD, 303d	
Landscape Context	Mortality/ Disturbance Risk	Proximity to urban/exurban development (km) (surrogate for proximity to electric distribution lines)	<6 km	6 – 15 km	>15 km		Delong 2004; Professional judgment
		Proximity to agriculture (km) (surrogate for pesticide contaminants	<1 km	1 – 5 km	>5 km	GAP, LANDFIRE, States	Delong 2004; professional judgment
		Road Density (km roads/km sq)	>10 km/km^2	1 – 5km/ km^2	<5 km/km^2	TIGER	Professional judgment

Table 6-2. Preliminary List of Bald Eagle Key Ecological Attributes and Indicators (Winter)

Category	Ecological Attribute	Indicator/Unit of Measure	Metric			Data Source	Reference
			Low = 1	Moderate =2	High = 3		
Size/ Condition	Foraging Habitat (mammalian carrion, fish, and waterfowl)	Availability of suitable foraging habitat Suitable foraging habitat (percent per HUC/4km Grid)	Other	Other aquatic feature (high gradient stream, wetland, spring; non-perennial stream)	Open water edge (lake, reservoir); low-gradient perennial stream	NHD	Steenhof 1978; Steenhof et al 1980, Isaacs *et al.* 1993 1996; Kaltenecker & Bechard 1995; Holthuijzen 1999.
	Night Roost availability	Proximity of coniferous forested cover types to foraging habitat (km)	> 15	2 -15	>2	national land cover dataset, NHD	Keister and Anthonyt 1983; Isaacs et al 1993, Watson & Pierce 1998
	Prey base condition	Use overall perennial streams/open water CE condition as surrogate indicator/metric (Low to High Mean Values by HUC12/4 km Grid)				NHD, 303d	
		Wildlife Refuge present within 2 km of HUC (waterfowl concentrations)	No		Yes	NHD, PAD	Professional judgment; Rolling Review Team
Landscape Context	Mortality/ Disturbance Risk	Proximity to urban/exurban development (km) (surrogate for proximity to electric distribution lines)	<6 km	6 – 15 km	>15 km		Buehler 2000; ;Lehman *et al.* 2007; Professional judgment
		Proximity to agriculture (km) (surrogate for pesticide contaminants	<1 km	1 – 5 km	>5 km	GAP, LANDFIRE, States	Professional judgment
		Road Density (km roads/km sq)	>10 km/km^2	5 – 10 km/km^2	<5 km/km^2	TIGER	Professional judgment

6.1 Key Ecological Attributes

The preliminary list of key ecological attributes (Tables 6-1 and 6-2) shows some indicators for assessing habitat size; habitat condition, including risk of mortality and disturbance; and landscape structure with respect to migration and dispersal. In some cases, we suggested surrogate indicators for habitat functions listed in the conceptual model. For example, foraging habitat extent and condition is suggested as a key indicator of prey availability for bald eagles because reliable ecoregion-wide prey distribution data was not available. Suitable ReGAP land cover types such as open water, floodplain and riparian, and forested marsh cover types, in addition to streams, lakes, and reservoirs identified in the National Hydrology Dataset were used to create a foraging habitat layer.

6.2 Current Status of the CE

This section documents the CA analysis under current conditions, i.e. the current extent of the CE's distribution and locations of the CAs. For each of the key ecological attributes listed in Tables 6-1 and 6-2 and used in the CA analysis, a discussion of the indicator, metrics, metric rank and value, data source(s), and references are provided. The analyses were based on spatially available attributes affecting the CE at the ecoregion level.

6.2.1 Size

6.2.1.1 Summer Foraging Habitat

Summer foraging habitat was assessed in terms of the availability of suitable foraging habitat as a percent of the reporting unit (4 km grid or 12-digit HUC). The habitat types used in this analysis are listed in Table 6-1 and were derived from the NHD data layer. The NHD layer was characterized by a value of 1-3 (low to high) based on the preferred foraging areas utilized by bald eagles. Open water edge was characterized as high, other aquatic features were characterized as moderate, and non-aquatic features were characterized as low. These values were subsequently applied to the reporting units and the outputs were derived from the percent of each category within the reporting units.

The output from the analysis (Figure 6-1) indicates a general trend that is apparent in most of the analyses for the bald eagle. A corridor of major cities within the ecoregion is responsible for a trend in lower quality habitat extent. This is indicative of the major concentrations of urban activity and development. However, some areas along these corridors contain large areas of open water that provide suitable foraging habitat.

Idaho contains the largest summer distribution of the bald eagle, but also contains a large area that is affected by urban areas. American Falls Reservoir is the only urban area reservoir that received a preferred rating near an urban area. Areas north of Boise and east of Mountain Home also provide good foraging habitat areas. The other preferred areas within Idaho are on the outlying northern edges of the ecoregion. Western Oregon provides multiple foraging habitat locations at Lake Abert and several lakes along the western extent of the Hart Mountain National Antelope Refuge. In California the areas around Eagle Lake and Honey Lake provide suitable foraging habitat.

The most important factor affecting the extent of summer foraging habitat for bald eagles is water body size. Large bodies of water and their tributaries provide the resources for summer eagle foraging. The majority of these areas tend to be located in areas away from larger urban centers and transportation corridors.

6.2.1.2 Winter Foraging Habitat

Winter foraging habitat was assessed in identical format to the summer foraging habitat, however the winter distribution mask was applied to the output.

The output from the analysis (Figure 6-1) indicates the general trend that is apparent in most of the analyses for the bald eagle. A corridor of major cities within the ecoregion is responsible for a lower quality habitat extent.

The winter foraging habitat and distribution of the bald eagle is much more widespread than in the summer period. In Idaho Anderson Ranch Reservoir, CJ Strike Reservoir, American Falls Reservoir and Minidoka National Wildlife Refuge are urban area water bodies that received a preferred rating. The other preferred areas within Idaho are major rural reservoirs and lakes such as Lake Cascade, Brownee

Reservoir, Crane Creek Reservoir, Payette Lake and numerous reservoirs along the eastern edge of the ecoregion. The western edge of the ecoregion in Oregon provides multiple foraging habitat locations at Lake Abert and several lakes along the western extent of the Hart Mountain National Antelope Refuge. In Eastern Oregon Lake Owyhee provides a large higher quality foraging area for bald eagles. In California the areas around Eagle Lake and Honey Lake provide suitable foraging habitat.

6.2.2 Condition

6.2.2.1 Nest Site and Foraging Site Summer

Summer nest site and foraging habitat was assessed in terms of the availability of suitable foraging habitat in close proximity to nesting tree locations (4km grid or 12-digit HUC). The habitat types used in this analysis are listed in Table 6-1 and were derived from the national land cover dataset data layer. All tree types (conifers and deciduous) were included in the summer analysis. The national land cover dataset layer was characterized by the proximity of forested areas to foraging areas (those used in Figure 6-1) for bald eagles. The proximity values were assessed as >2 km (low), 0.2 -2 km (moderate) and <0.2 km (high).

Similar to many of the other analyses outputs, the urban corridor contained mostly lower scoring areas for proximity of forested areas to foraging habitat. In Idaho the reservoirs around Sawtooth National Forest (near Boise), Wallowa National Forest, Targhee National Forest and Bridger National Forest received the highest ratings. The western edge of the ecoregion in Oregon provides multiple foraging habitat locations at Lake Abert and several lakes along the western extent of the Hart Mountain National Antelope Refuge. In California the areas around Eagle Lake and Honey Lake also received higher ratings.

The National Forest system in the NGB appears to be a significant factor in defining potential bald eagle nest site locations in close proximity to large reservoirs. Since a large portion of the ecoregion is not forested, these areas exist as important areas for bald eagle nesting.

6.2.2.2 Night Roost Availability Winter

Winter roost locations and foraging habitat was assessed in terms of the availability of suitable foraging habitat in close proximity to roosting tree locations within the reporting units (4 km grid or 12-digit HUC). The habitat types used in this analysis are listed in Table 6-2 and were derived from the national land cover dataset data layer. Only conifers were included in the winter roost location analysis. The national land cover dataset layer was characterized by the proximity of conifer forested areas to foraging areas (those used in Figure 6-2) for bald eagles. The proximity values were assessed as >15 km (low), 2-15 km (moderate) and <2 km (high).

The outputs for the winter roost location analysis follow the summer nest site to foraging habitat analysis very closely despite the expanded spatial area. See the Nest Site and Foraging Site Summer analysis section for a detailed description.

6.2.2.3 Prey Base Condition Summer

Summer prey base condition was assessed in terms of the EPA water quality rating (303d listing) based on the reporting units (4km grid or 12-digit HUC). The 303d list was applied to the NHD waterbody and polyline datasets. The datasets were characterized by values of 1 (303d listed) or 3 (non-listed) bodies of water. The mean values were calculated at the reporting unit levels and ranked from lower quality to preferred, using the natural breaks method. This provided an output consistent with the ranges applied to the other key ecological attributes.

The results of this analysis indicate high overall ratings across the ecoregion. Near some urban areas, the availability of clean water bodies is lower than in rural areas (e.g. the transportation corridor in Idaho). In California the areas around Eagle Lake and Honey Lake show results that indicate lower water quality.

According to this analysis, in many of the areas in which eagles occupy habitat, the water quality is very good. The bald eagle appears to select foraging areas adjacent to clean water bodies within the NGB.

6.2.2.4 Prey Base Condition Winter

Winter prey base condition was assessed in terms of the EPA water quality rating (303d listing) based on the reporting units (4 km grid or 12-digit HUC). The 303d list was applied to the NHD waterbody and polyline datasets. The datasets were characterized by values of 1 (303d listed) or 3 (non-listed) bodies of water. The mean values were calculated at the reporting unit levels and ranked from lower quality to preferred, using the natural breaks method. This provided an output consistent with the ranges applied to the other key ecological attributes.

The results of this analysis are similar to those for the summer analysis. The winter range of the bald eagle in the NGB in comparison to the summer output indicates a great spatial distribution of higher ratings overall across the ecoregion. The lower quality areas remain around the urban transportation corridor in Idaho and Eagle Lake and Honey Lake in California.

6.2.2.5 NWR Proximity Winter

Winter prey base condition was assessed in terms of proximity of National Wildlife Refuges (NWR) within the reporting units (4 km grid or 12-digit HUC). The habitat types used in this analysis are listed in Table 6-2 and were derived from the PADS data layer. In this case the outputs were based on a binary function of proximity >2 km (Lower Quality) to a NWR or <2 km (Preferred). This analysis was completed separately for field management use, but was not included in the cumulative assessment for the bald eagle.

Within the NGB only a few areas contain National Wildlife Refuges. Therefore the results of this analysis were limited to the area surrounding Malheur Lake, Hart Mountain National Antelope Refuge, and Steens Mountain Cooperative Management and Protection Area. (Note: Modoc National Wildlife Refuge and Clear Lake National Wildlife Refuge in California and Red Rock Lakes National Wildlife Refuge in Idaho are just outside the ecoregion boundary).

Steens Mountain Cooperative Management and Protection Area is included in the data layer for Malheur Lake National Wildlife Refuge, and potentially is misrepresented as an important waterfowl refuge. However, Malheur Lake and the Warner Valley near Hart Mountain are represented in this analysis as important areas for wintering bald eagles, despite their exclusion from the cumulative assessment.

6.2.3 Mortality/Disturbance Risk

6.2.3.1 Summer Urban Development

Proximity to urban areas during the summer months was analyzed by identifying areas within the bald eagle distribution area that were less than 6 km, 6-15 km, and greater than 15 km from urban areas. Urban areas were identified using an urban development layer that was derived from ReGAP/Landfire urban data layers. A distance raster analysis was applied to the urban dataset using the parameters outlined above, and the values were categorized accordingly.

In Figure 6-8 the urban areas and associated corridors are displayed. The main city centers and interstate corridors are identified as lower quality areas and the areas adjacent to large water bodies in rural areas are preferred. In Idaho Arrowrock Reservoir near Boise, Lake Cascade, Anderson Ranch Reservoir, and Island Park Reservoir received higher ratings. Thompson Reservoir in Oregon, and nearly all of the state of California that is contained within the NGB boundary also received higher ratings.

Urban growth is the most important development CA, because it is responsible for the increase in all other development CAs. Despite the nature of urban sprawl, other indicators have shown that bald eagles are only somewhat affected by this attribute. It is possible that the species distribution and habitat analysis indicate that they are capable of adapting to slow changes related to urban growth in the Northwest.

6.2.3.2 Winter Urban Development

Proximity to urban areas during the winter months was analyzed by identifying areas within the bald eagle distribution area that were less than 6 km, 6-15 km, and greater than 15 km from urban areas. Urban areas were identified using an urban development layer that was derived from ReGAP/Landfire urban data layers. A distance raster analysis was applied to the urban dataset using the parameters outlined above, and the values were categorized accordingly.

In Figure 6-9 the urban areas and associated corridors are displayed. The main city centers and interstate corridors are identified as lower quality areas and the areas adjacent to large water bodies in rural areas are preferred. In Idaho Arrowrock Reservoir near Boise, Lake Cascade, Anderson Ranch Reservoir, and Island Park Reservoir received higher ratings. The eastern border of Oregon, the northern edge of the ecoregion (within Oregon), the northern part of Lake Albert, and nearly all of California and Nevada within the ecoregion received high ratings for this attribute.

6.2.3.3 Summer Agricultural Development

Agricultural development is closely associated with urban development for the simple reason that increased human population results in increased demand for agriculture. This is coupled with the requirement for distribution of agricultural products. The summer agricultural analysis was completed using a cropland layer that was derived from the ReGAP/Landfire data layers. Proximity to agricultural areas was analyzed by identifying areas within the bald eagle distribution area that were less than 1 km, 1-5 km, and greater than 5 km from agricultural areas. A distance raster analysis was applied to the agriculture dataset using the parameters outlined above, and the values were categorized accordingly.

The output from the analysis (Figure 6-10) indicates an overall lower quality rating for the bald eagle for this attribute. Eagle Lake in California and Lake Cascade in Idaho are the only areas in the entire ecoregion that received preferred ratings for this attribute.

The ratings for this attribute are potentially affected by the need for irrigation related to agricultural activities in the ecoregion. Therefore the data outputs are potentially being skewed by this activity.

6.2.3.4 Winter Agricultural Development

The winter agricultural analysis was completed using a cropland layer that was derived from the ReGAP/Landfire data layers. Proximity to agricultural areas was analyzed by identifying areas within the bald eagle distribution area that were less than 1 km, 1-5 km, and greater than 5 km from agricultural areas. A distance raster analysis was applied to the agriculture dataset using the parameters outlined above, and the values were categorized accordingly.

The output from the analysis (Figure 6-11) indicates an overall lower quality rating for the bald eagle for this attribute, but shows improvement over the summer analysis (Figure 6-10) with the addition of winter habitat across Nevada. Malheur Lake and Owyhee Reservoir in Oregon, and Eagle Lake in California were the only areas in those states that received higher ratings. Southwest Idaho and the vicinity of Island Park Reservoir, and nearly all of Nevada within the ecoregion also showed preferred ratings.

6.2.3.5 Summer Road Development

The road analysis is important because of its direct correlation to mortality for bald eagles. The summer road analysis was performed using the TIGER roads (all roads) data layer for the NGB. Road density was calculated using the raster density analysis, which characterizes density as the number of road kilometers per kilometer. The metrics assigned to the categories of quality for the road analysis were less than 5 km/km^2, 5-10 km/km^2, and greater than 10 km/km^2. Lower road density was preferred and higher density was considered lower quality.

Due to the relatively low populations of the NGB ecoregion and therefore lower road densities, the majority of the ecoregion was considered to be of higher quality with regard to road density. The lower quality areas were related to the primary city centers of Boise, Mountain Home, Twin Falls, Pocatello, and Idaho Falls.

The current road densities as a result of overall limited human populations indicate that overall bald eagle populations are not currently at risk from roads in the NGB. Local mortality will remain a factor in areas where road densities remain at higher levels.

6.2.3.6 Winter Road Development

The winter road analysis was performed using the TIGER roads (all roads) data layer for the NGB. Road density was calculated using the raster density analysis, which characterizes density as the number of road kilometers per kilometer. The metrics assigned to the categories of quality for the road analysis were less than 5 km/km^2, 5-10 km/km^2, and greater than 10 km/km^2. Lower road density was preferred and higher density was considered lower quality.

Due to the relatively low populations of the NGB ecoregion and therefore lower road densities, the majority of the ecoregion was considered to be of higher quality with regard to road density. The lower quality areas were related to the primary city centers of Boise, Mountain Home, Twin Falls, Pocatello, and Idaho Falls.

6.2.4 Cumulative Risk

6.2.4.1 Summer

The summer cumulative risk assessment was performed using a combination of all attributes and metrics listed in the key ecological attributes table. The cumulative risk score was obtained by combining all of the output layers used in the analysis and evaluating the mean value across the ecoregion. This enables the user to obtain an overall “risk from CA” value for the bald eagle in the NGB that can be applied to BLM field office-level management. The spatial scale of this analysis limits this dataset to be used as a guide to determine the best use of tools available for the management of the species, rather than to draw specific correlations from the analysis values provided in Figure 6-14.

The results of the cumulative assessment indicate that those areas far removed from urban areas tend to show higher ratings for all combined attributes. Since several of the attributes themselves are related to development, this is not unexpected. The areas that appear to be most suitable for bald eagles exist near large water bodies. The summer assessment indicates that the preferred areas for bald eagles are in California, southwest Oregon, Lake Cascade, Brownee Reservoir, Lost Valley Reservoir, Arrowrock Reservoir, Anderson Ranch Reservoir, and Island Park Reservoir in Idaho. A minority of the ecoregion received a moderate rating, and areas associated with urban activity received the lowest ratings.

The overall risk from CAs across the ecoregion is moderate to high for the summer range of the bald eagle. However, the areas that are most closely associated with the lower ratings are also those areas in which bald eagles may appear only rarely during the summer period. Foraging and nesting activities will most likely remain in close proximity to areas of ideal habitat. It is also important to note that the distribution layer used in the summer analysis includes the summer GAP distribution and the year-round GAP distribution. It is possible that the areas of lower quality are only being used occasionally during the summer months or are representative of dispersing juveniles, as opposed to nesting adults. The analysis would be much more complete if the summer distribution was based on nest locations.

6.2.4.2 Winter

The winter cumulative risk assessment was performed using a combination of all attributes and metrics listed in the key ecological attributes table. The cumulative risk score was obtained by combining all of the output layers used in the analysis and evaluating the mean value across the ecoregion. The output from this analysis is shown in Figure 6-15.

The results of the cumulative assessment indicate that those areas far removed from urban areas tend to show higher ratings for all combined attributes. As above, since several of the attributes themselves are related to development, this is not unexpected. The areas that appear to be most suitable for bald eagles exist near large water bodies. The winter assessment indicates that large areas in California and Nevada resulted in preferred ratings. The rest of the ecoregion is much more variable overall.

The central ecoregion, all of Oregon (excluding the area around Malheur Lake), Lake Cascade, Brownee Reservoir, Lost Valley Reservoir, Arrowrock Reservoir, Anderson Ranch Reservoir, and Island Park Reservoir in Idaho all received higher ratings than the other parts of the ecoregion. A minority of the ecoregion received a moderate rating, and areas associated with urban activity received the lowest ratings. The exception to this is southeastern Idaho which also received a lower rating.

The risk from CAs to wintering bald eagles appears very low overall. Similar to the summer cumulative assessment, the winter analysis included a distribution layer based on the wintering and year-round GAP data layer. Potentially this data layer does not well-represent the activity of wintering bald eagles in this ecoregion. A model based on winter roosts, or other point occurrence data specific to the winter months would provide a better model. This is perhaps indicative of the distribution model along urban corridors. Bald eagles are more likely to focus on areas where foraging activity is available and will therefore occupy these areas more readily than those where foraging opportunities are low (i.e., urban areas). However, in winter carrion along roadways presents an important foraging opportunity and remains a potential feature for wintering populations.

6.3 Future Threat Analysis

6.3.1 Development

Development along major urban corridors in Idaho most greatly affects the summer population of bald eagles. Nesting habitat is threatened by future urban/exurban expansion and agriculture development (especially when land conversion occurs). Large, healthy bodies of water in rural/remote areas will continue to provide preferred habitat for the species.

6.3.2 Wildfire

The increase in fire frequency in the West poses potential short-term threats to bald eagles. Nesting habitat destruction through wildfire results in temporary extirpation (<10 years) of breeding golden eagles, and could similarly affect bald eagles through the direct loss of suitable nest sites and foraging perches.

6.3.3 Invasives and Disease

Invasive species were not directly analyzed in relation to the bald eagle. However, potential aquatic invasive species that could affect bald eagles are species that could harm native fish populations (e.g. zebra mussels, snakehead fish, etc). West Nile virus was introduced into the United States in 1999 and has been confirmed as the cause of death of bald eagles in several regions; however, no large-scale mortality event has been recorded in any wild eagle population.

6.3.4 Grazing

Grazing could affect the bald eagle population through the degradation of aquatic habitats in grazing allotments where riparian zones are unfenced and woodland perch sites within or near allotments are removed. Increased grazing activity will further limit nesting habitat through removal of trees, and could impact the health of the water bodies adjacent to grazing areas through loss of water quality (e.g., eutrophication, erosion, etc.).

6.3.5 Climate Change

The role of climate change in bald eagle distribution and abundance is unclear and is likely associated with hydrologic, water quality, and temperature changes affecting prey populations. Climate change is predicted to produce a slight precipitation increase in the basins, valleys, and uplands and large increases in the mountains. No changes are predicted in the basins or the lower elevations of the Owyhee Uplands. Likewise, the climate change model predicts slight increases in the mountains and either no change or a very slight change in the basins, lower elevations of the Owyhee Uplands, and Snake River Plains. The western half of the NGB REA is predicted to become slightly warmer during June so the slight increase in precipitation may offset some of the increased evapotranspiration demand. However, the net effect on prey populations for bald eagles is currently difficult to predict. Aquatic habitat models (i.e., perennial streams, wetlands, and open water habitat CEs) assess climate change in these systems.

6.3.6 CE Summary

The presence of priority habitat or a potential site for habitat restoration may be an indicator for managers to carefully consider future development in the more rural or remote regions of the Great Basin. The cumulative indicator scores for bald eagle priority summer habitat under current conditions should be useful in identifying the areas most in need of preservation or the best restoration opportunities in these drill-down evaluations.

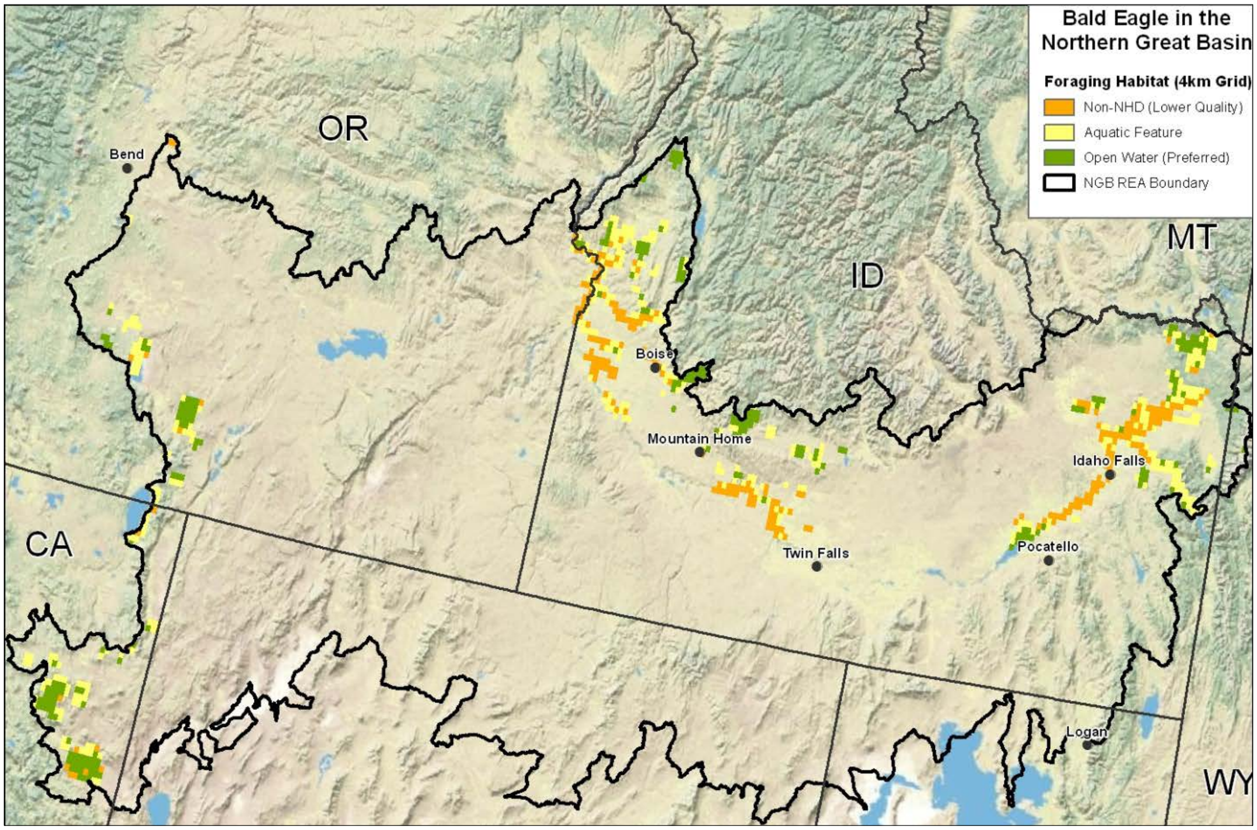


Figure 6-1. Extent of Suitable Habitat Described as Percent per 4 km Grid Area (Summer)

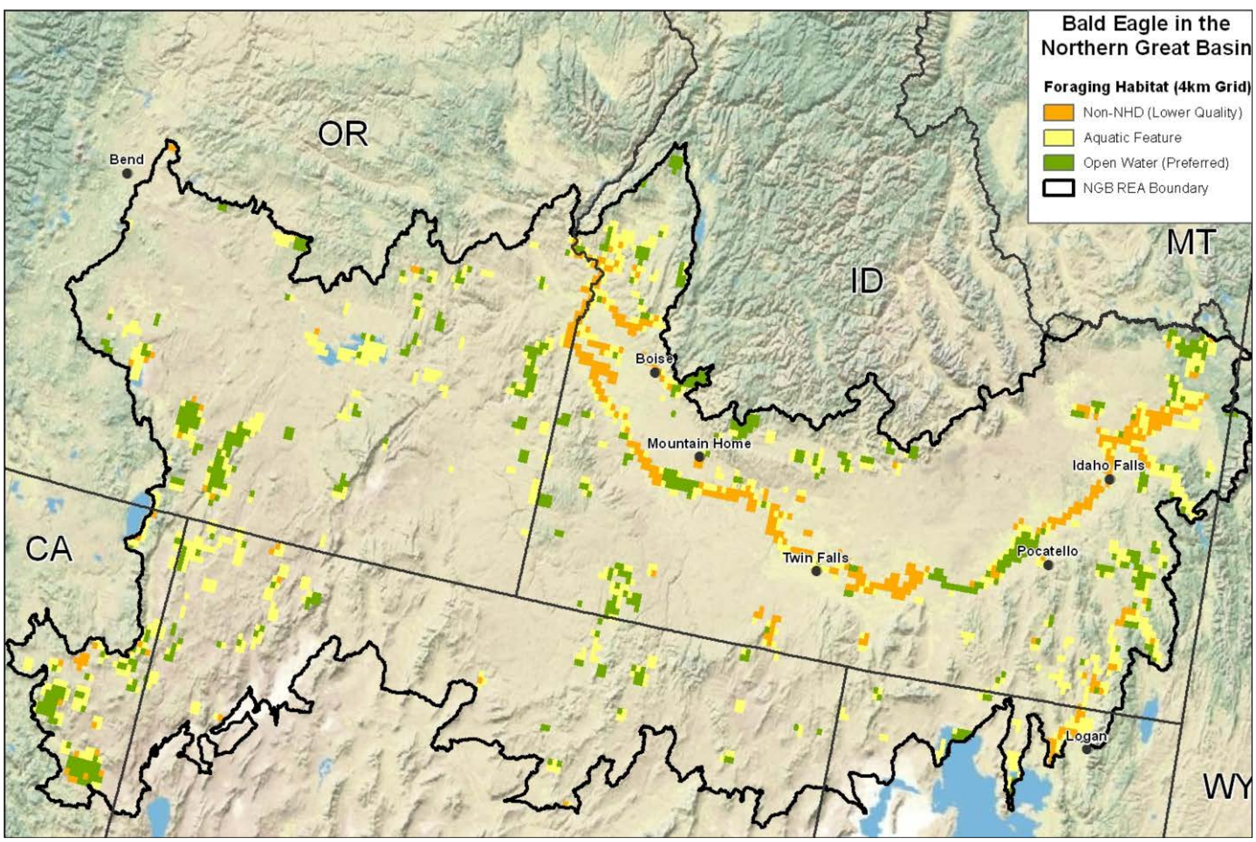


Figure 6-2. Extent of Suitable Habitat Described as Percent per 4 km Grid Area (Winter)

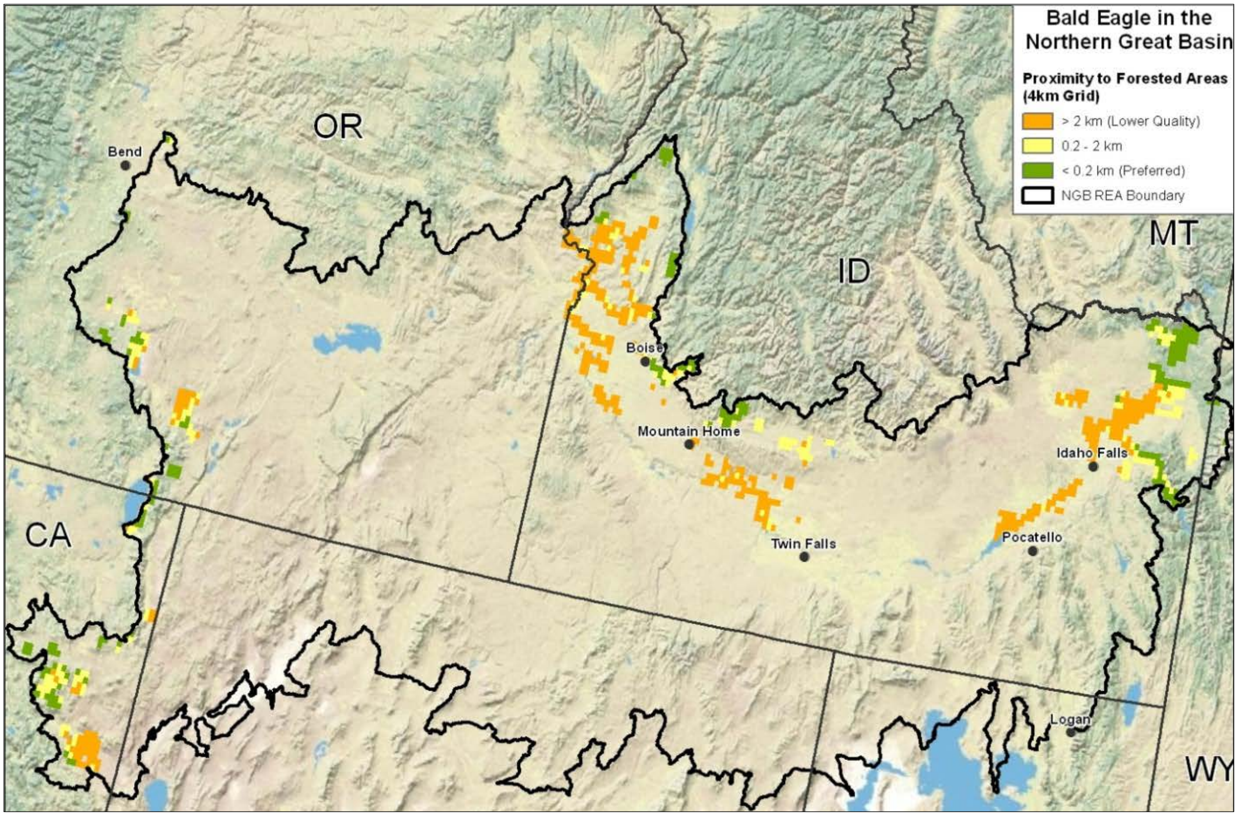


Figure 6-3. Proximity of all forested cover types to foraging habitat (Summer)

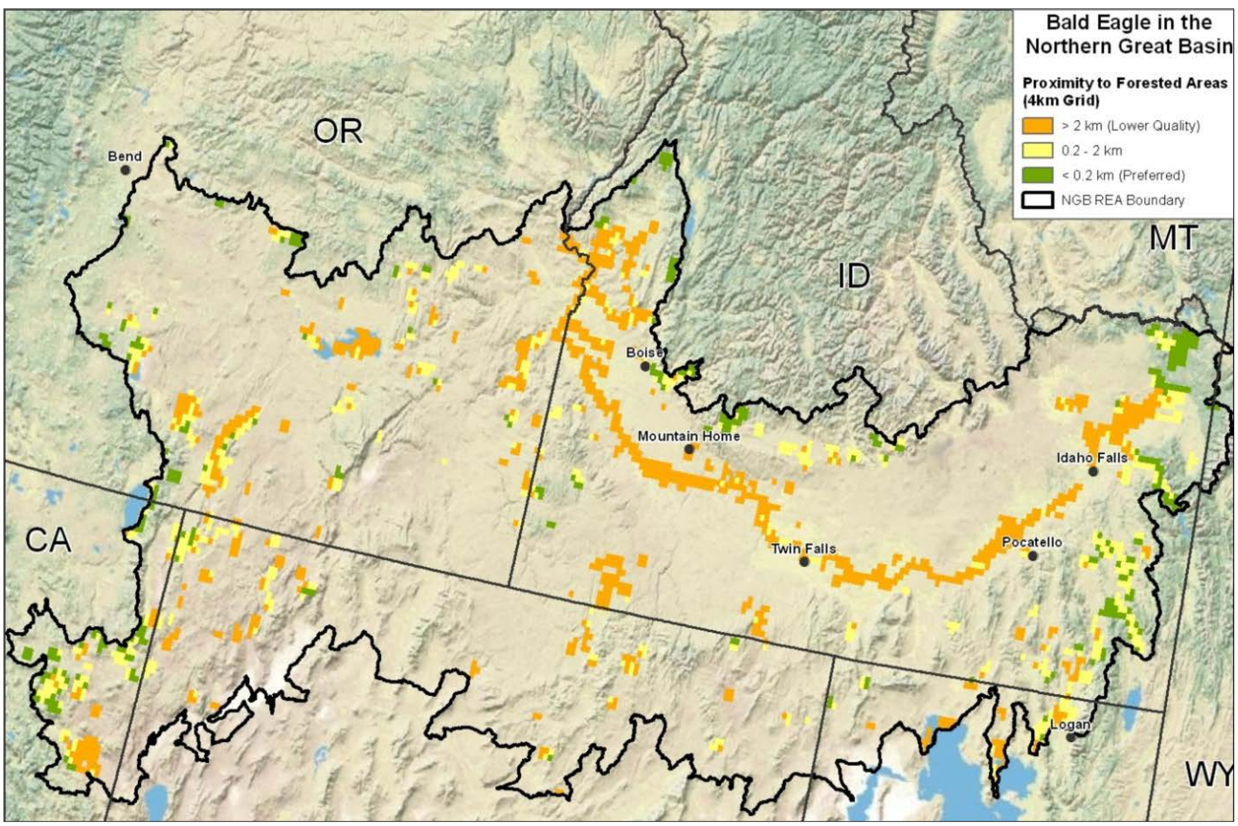


Figure 6-4. Proximity of coniferous forested cover types to foraging habitat (Winter)

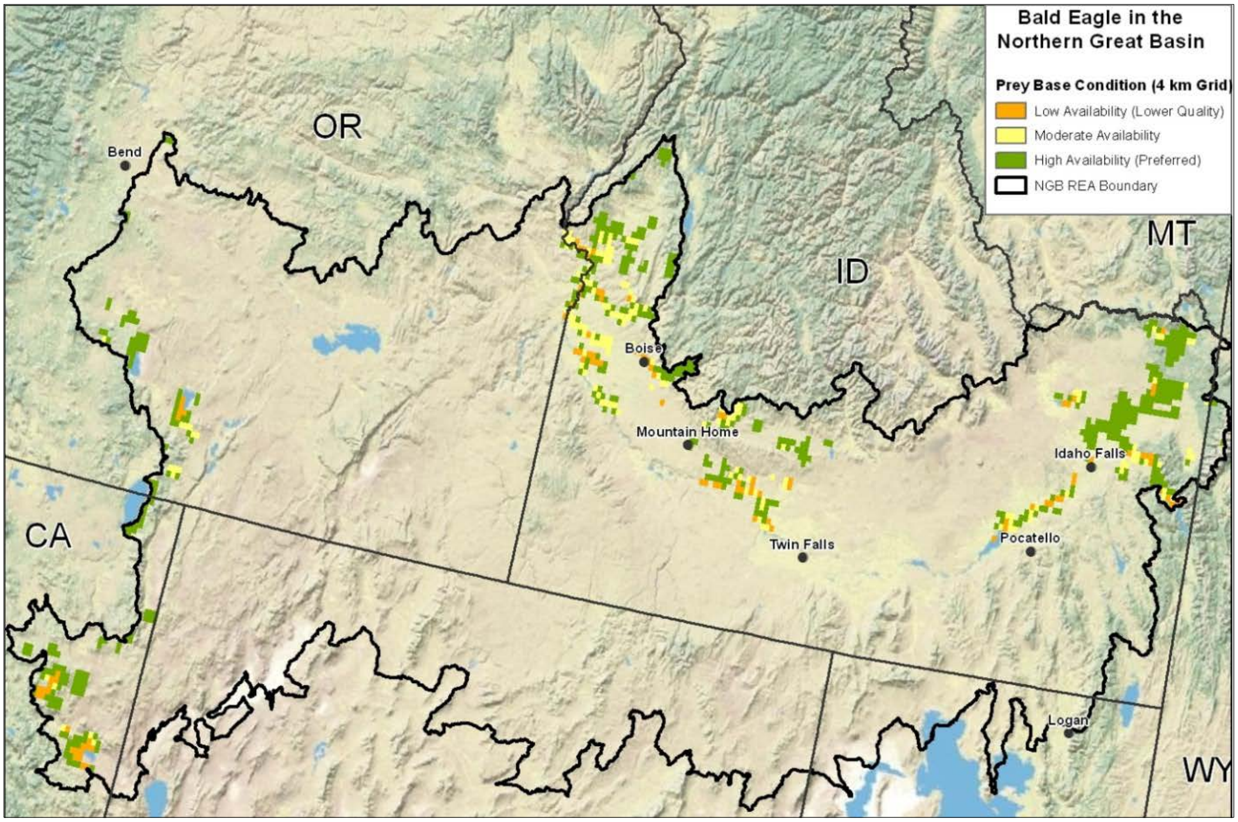


Figure 6-5. Condition of perennial streams and open water (Summer)

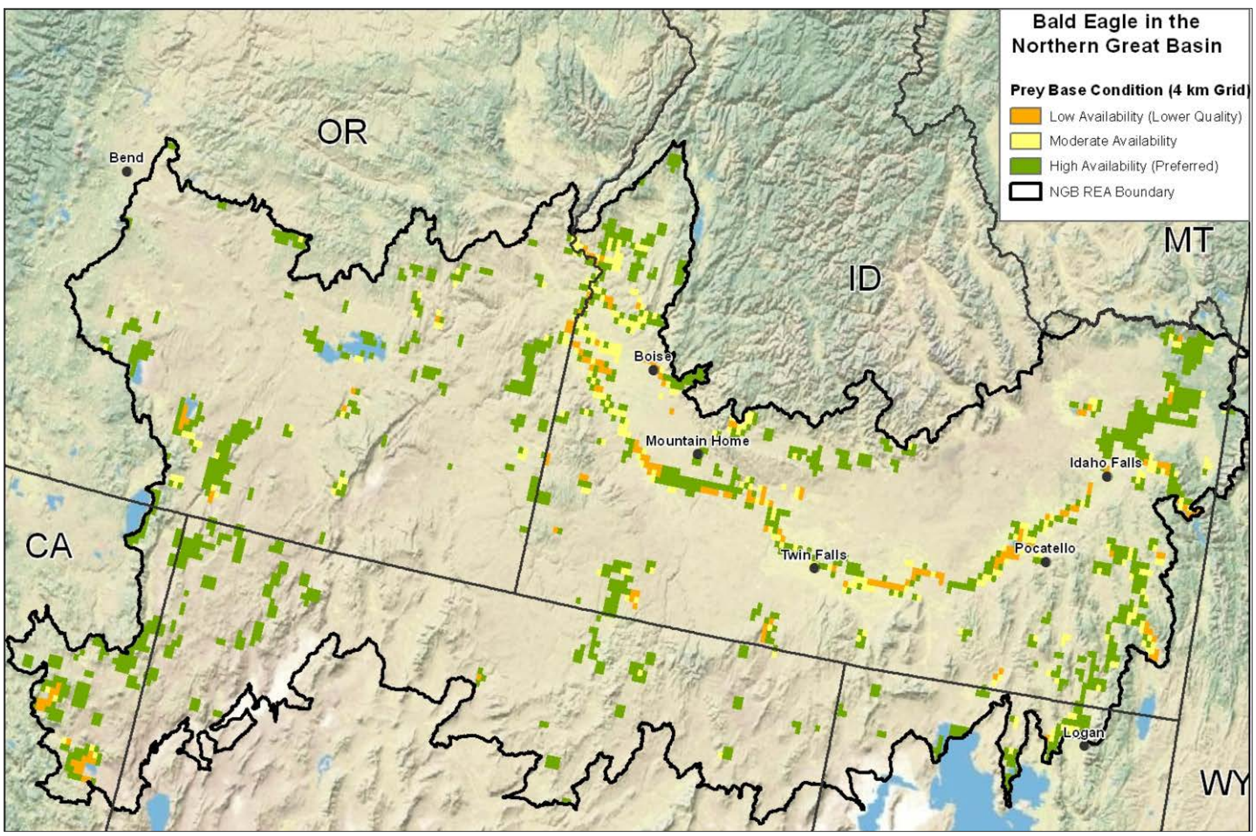


Figure 6-6. Condition of perennial streams and open water (Winter)

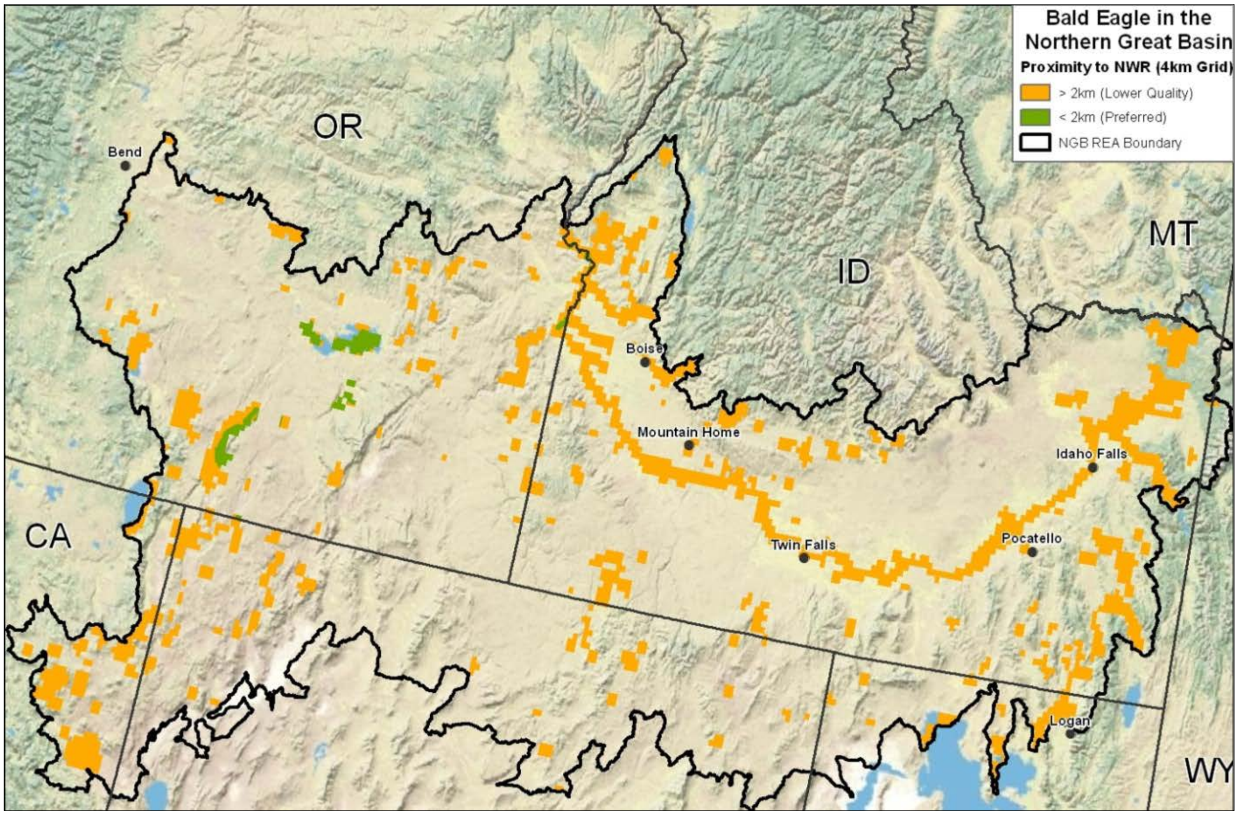


Figure 6-7. Proximity to NWR (Winter)

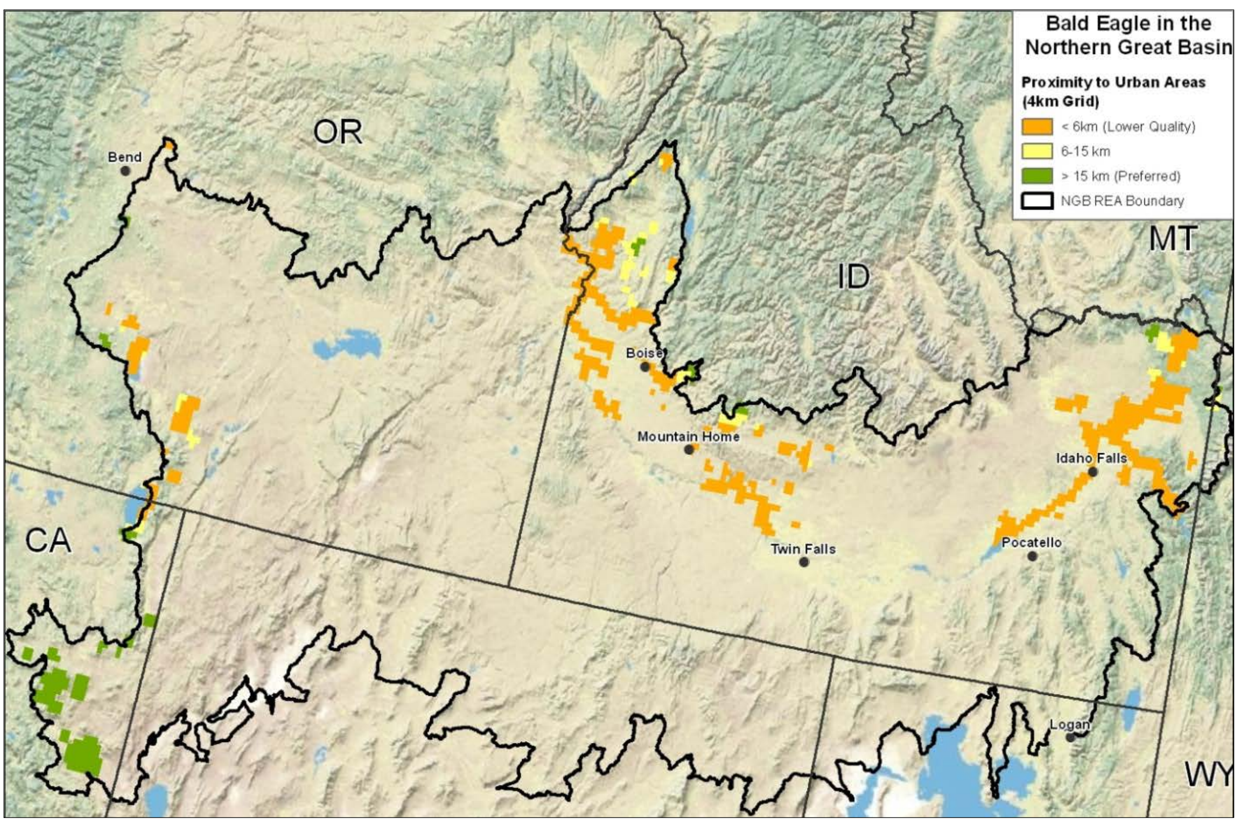


Figure 6-8. Proximity to urban/exurban development (Summer)

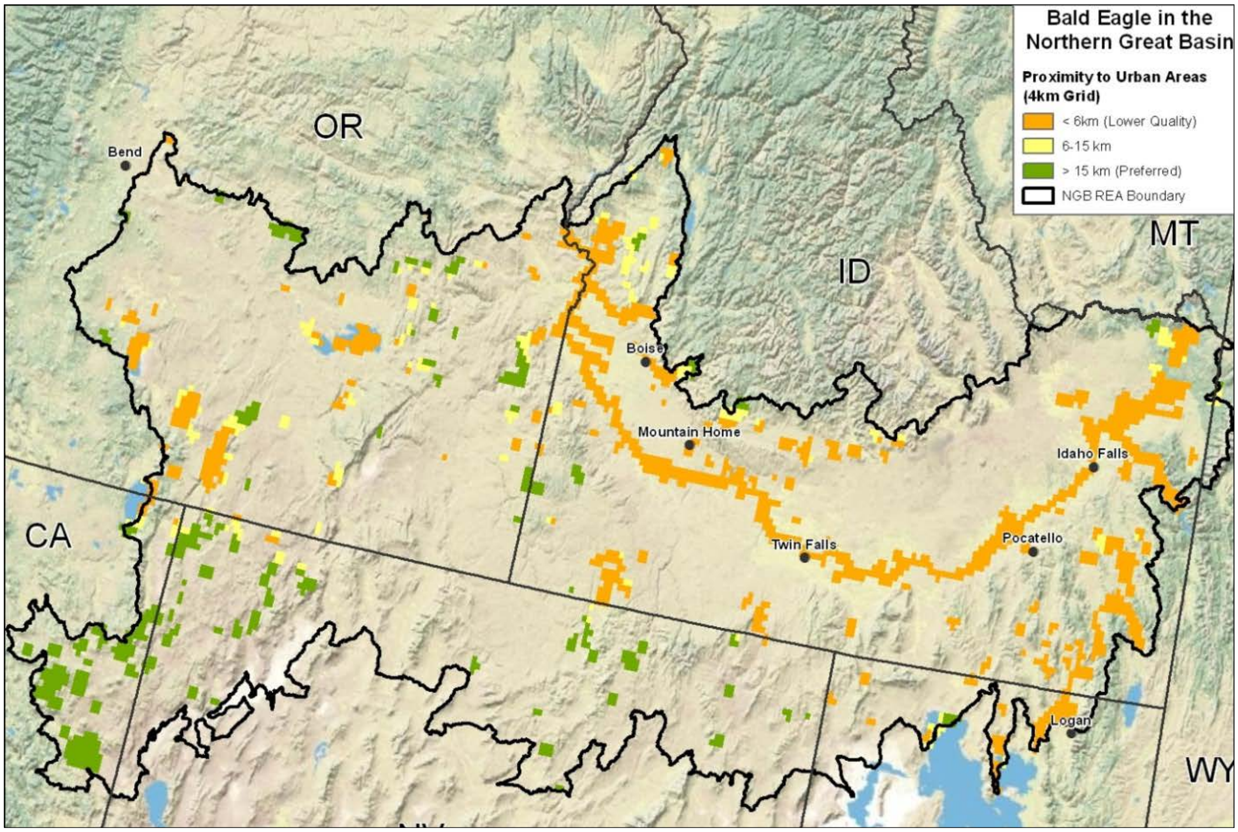


Figure 6-9. Proximity to urban/exurban development (Winter)

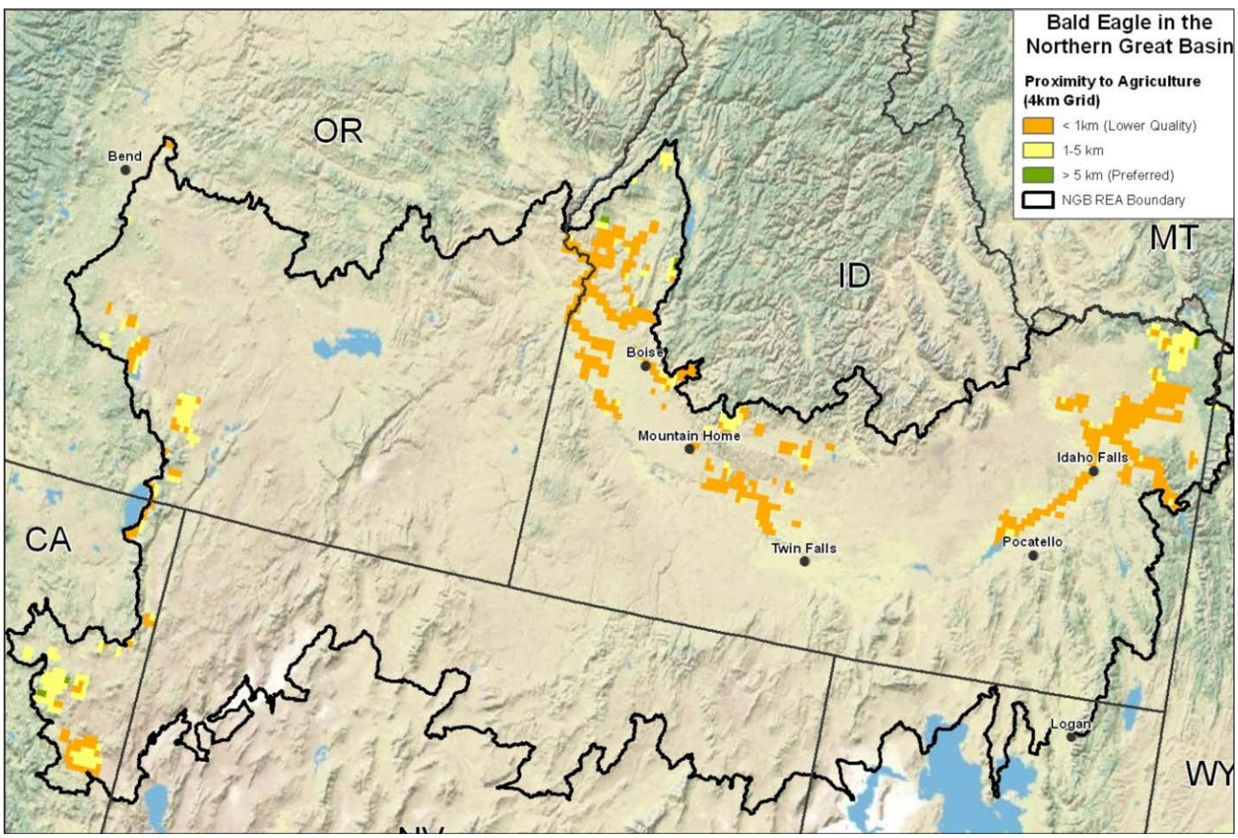


Figure 6-10. Proximity to Agriculture (Summer)

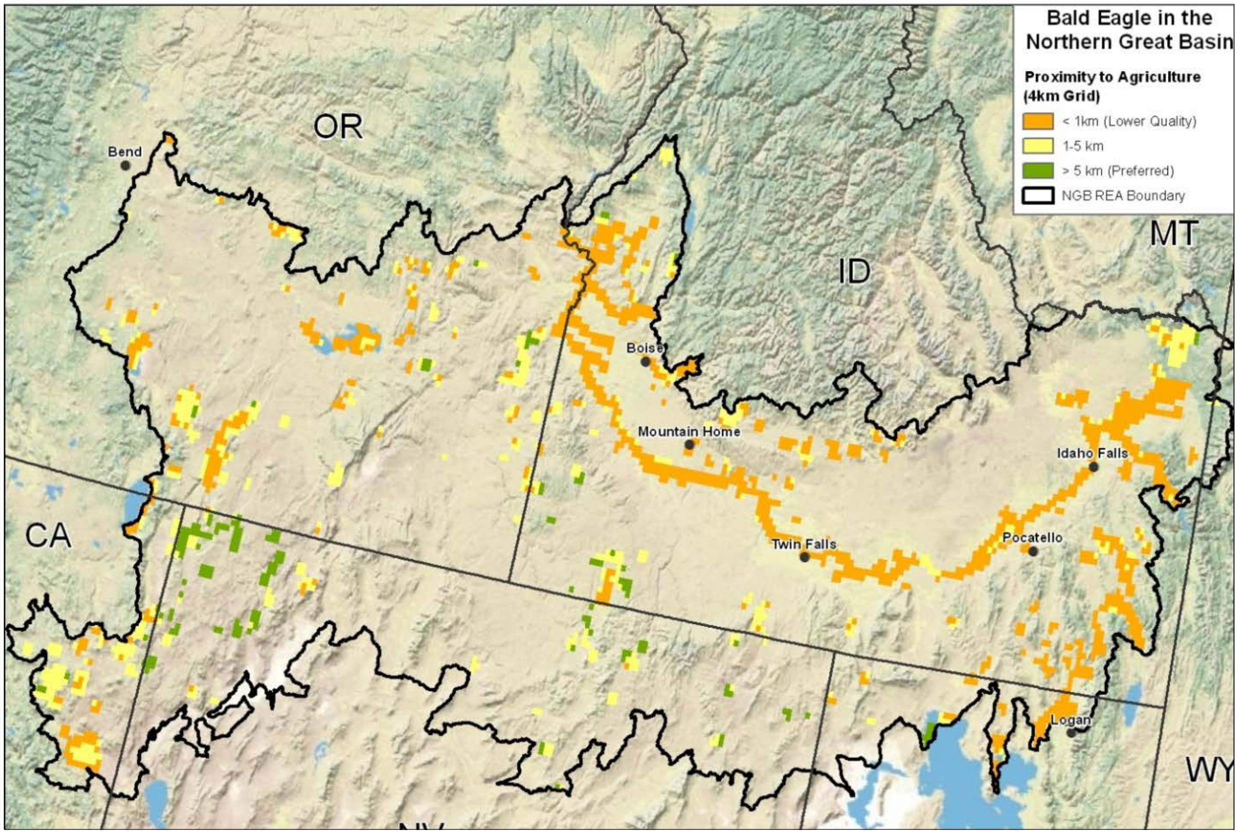


Figure 6-11. Proximity to agriculture (Winter)

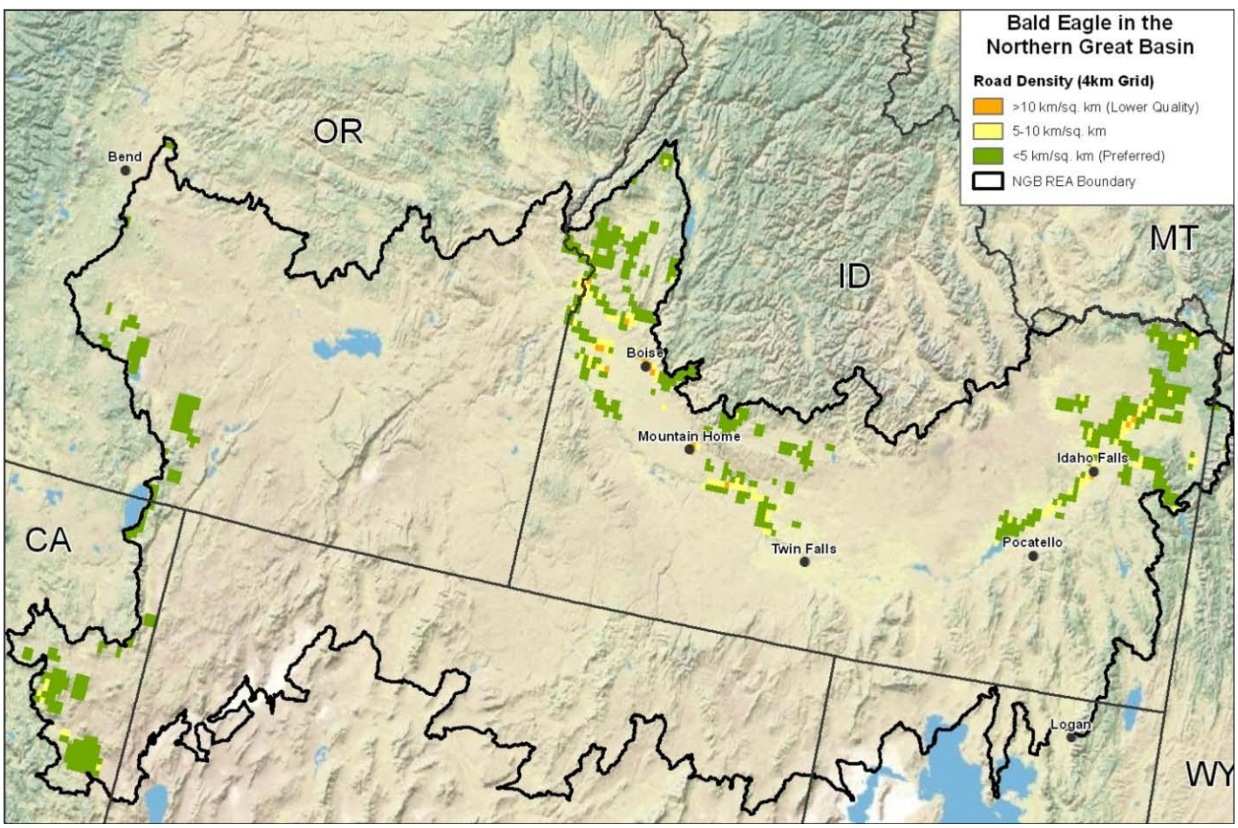


Figure 6-12. Road Density (Summer)

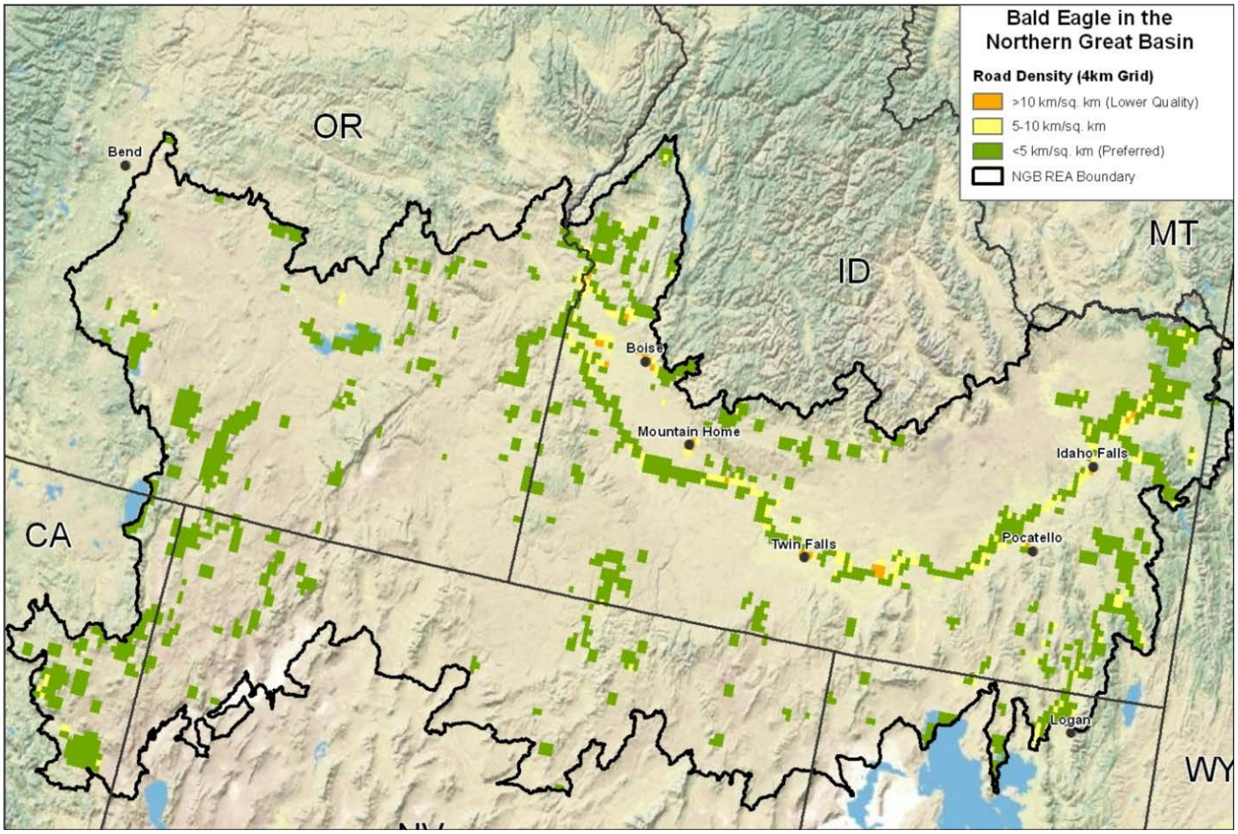


Figure 6-13. Road Density (Winter)

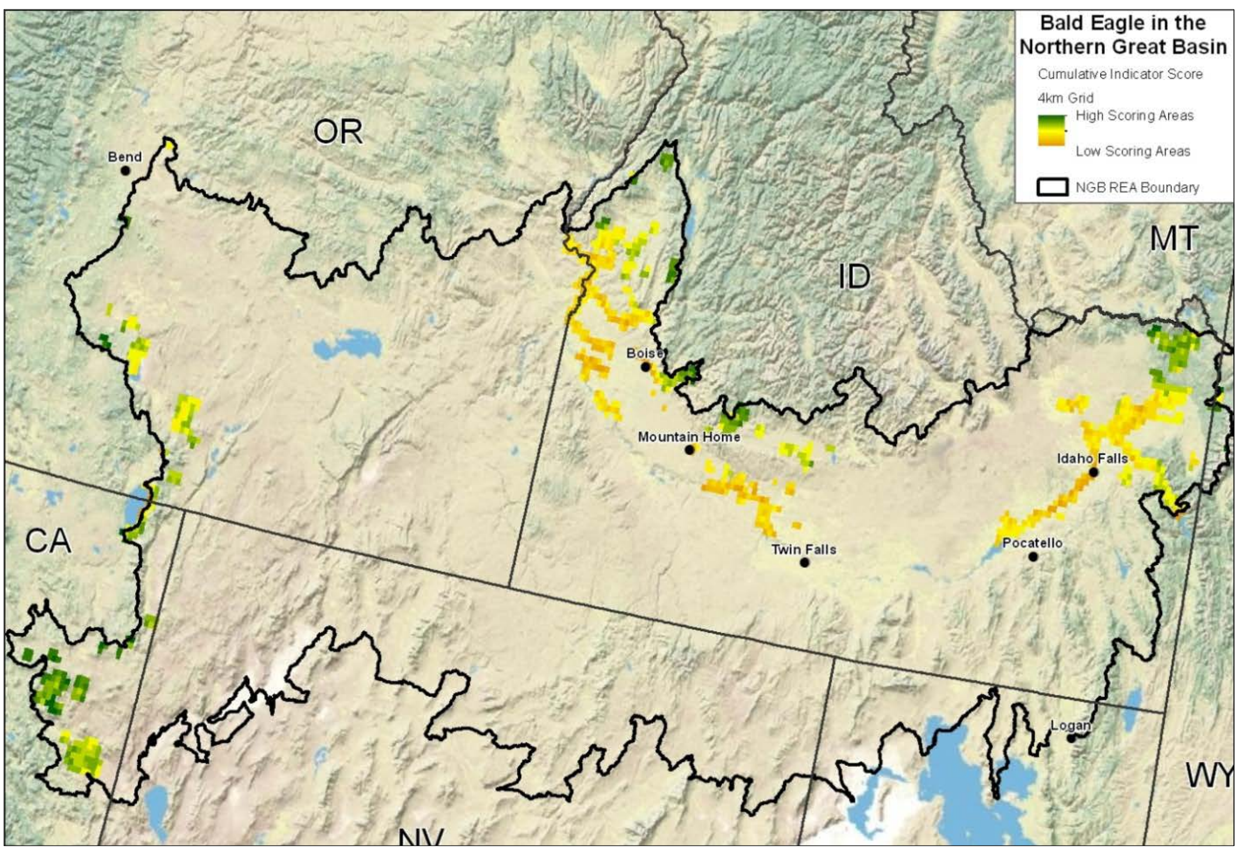


Figure 6-14. Cumulative Score for all Key Ecological Attributes (Summer)

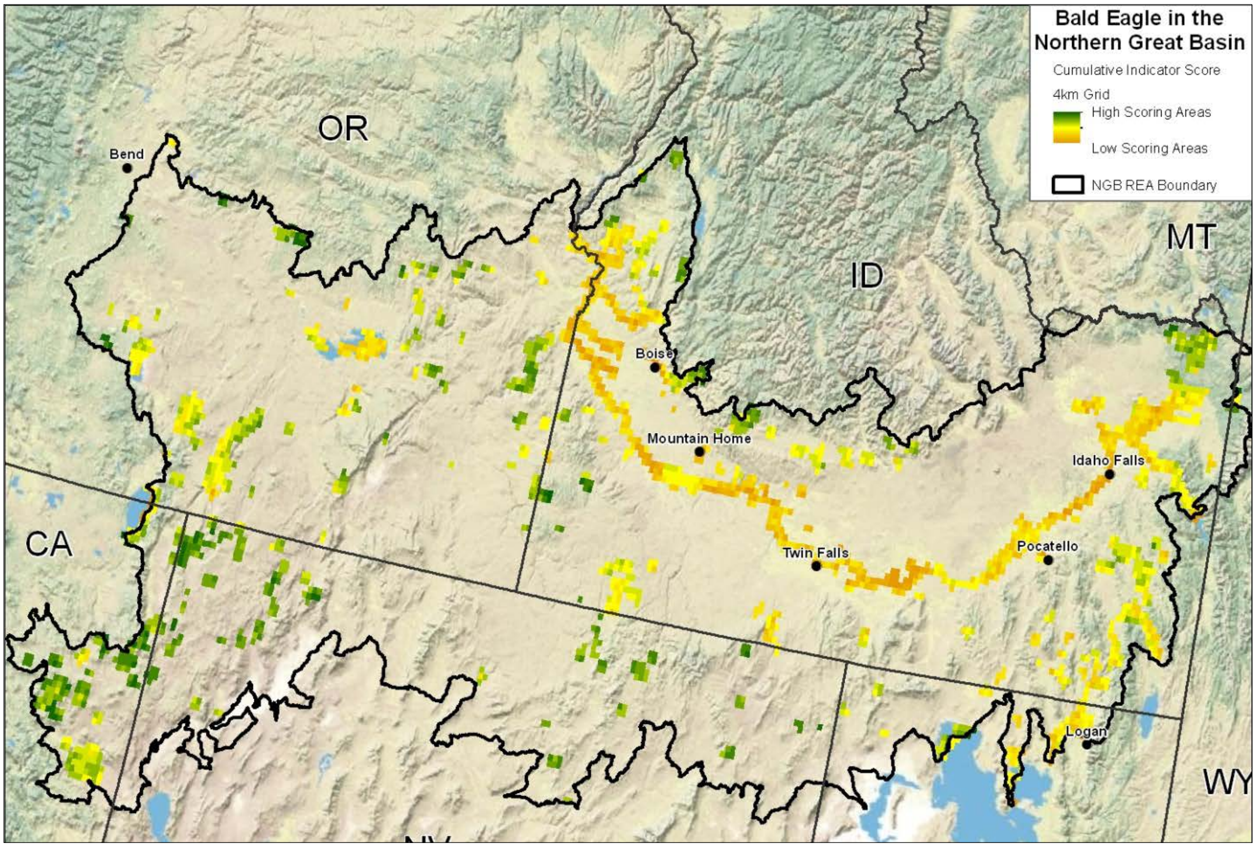


Figure 6-15. Cumulative Score for all Key Ecological Attributes (Winter)

7 Management Questions

Management questions for the NGB were developed by BLM managers and refined by the AMT to answer questions regarding the agency's land management responsibilities—including planning land use, developing best management practices, authorizing uses, and establishing conservation and restoration priorities. Several management questions relate to the bald eagle CE:

1. What is the currently occupied habitat or modeled suitable habitat for this CE?

Figure 4-1 shows the GAP modeled distribution layer for the bald eagle. Point occurrence/nest site location data for this species was difficult to obtain. The Rolling Review Team recommended the use of this model.

2. Where are the areas of greatest and least collective impact of existing CAs on occupied habitat or modeled suitable habitats of this CE?

The areas of greatest impact are located in Idaho along the urban corridor (Boise, Mountain Home, Twin Falls, Pocatello, and Idaho Falls). The areas of least impact are California, Nevada, Oregon (excluding the area around Malheur Lake), and the northern edge of the ecoregion in Idaho.

5. Where are current locations of this CE likely to overlap with the potential future distribution of CAs (other than climate change)?

The most likely areas of overlap between the CE and future CAs are located in Idaho along the urban corridor (Boise, Mountain Home, Twin Falls, Pocatello, and Idaho Falls).

6. ***Given current and anticipated future locations of CAs, which habitat areas remain as opportunities for habitat enhancement/restoration for this CE?***

The areas that remain as opportunities for habitat enhancement are California, Nevada, Oregon (excluding the area around Malheur Lake), and the northern edge of the ecoregion in Idaho.

7. ***Where are potential areas to restore connectivity for this CE, based on current locations of CAs?***

Connectivity does not significantly affect the bald eagle because of its mobility.

8. ***Where will this CE experience climate outside their current climate envelope? Or: Where will this CE experience significant deviations from normal climate variation?***

The net effect of climate change (increasing in precipitation and increase in summer temperatures) on prey populations for bald eagles is currently difficult to predict.

56. ***Where do current locations of CEs overlap with areas of potential future locations of renewable energy development (MQ 65)?***

Renewable energy was not analyzed as a CA for the bald eagle. Although the golden eagle risks significant mortality from wind turbines, the bald eagle occupies habitat that is not closely associated with this renewable energy source.

8 References

Brown, B.T., R. Mesta, L.E. Stevens and J. Weisheit. 1989. Changes in winter distribution of bald eagles along the Colorado River in Grand Canyon, Arizona. Journal of Raptor Research 23:110-113.

Buehler, D. A., T. J. Mersmann, J. D. Fraser and J. K. D. Seegar. 1991. Nonbreeding Bald Eagle communal and solitary roosting behavior and habitat use on the northern Chesapeake Bay. Journal of Wildlife Management. 55: 273–281.

Buehler, D.A. 2000. Bald Eagle (Haliaeetus leucocephalus). In A. Poole, editor. The Birds of North America Online. Cornell Laboratory of Ornithology. Ithaca, NW. http://bna.birds.cornell.edu/bna/species/506

Grier, J. W. 1980. Modeling approaches to Bald Eagle population dynamics. Wildl. Soc. Bull. 8: 316–322.

Harmata, A. R., G. J. Montopoli, B. Oakleaf, P. J. Harmata. and M. Restani. 1999. Movements and survival of Bald Eagles banded in greater Yellowstone ecosystem. J. Wildl. Manage. 63: 781–793.

Henny, C. J., E. J. Kolbe, E. F. Hill and L. J. Blus. 1987. Case histories of Bald Eagles and other raptors killed by organophosphorus insecticides topically applied to livestock. J. Wildl. Dis. 23: 292–295.

Kaltenecker, G.S., K. Steenhof, M.J. Bechard, and J.C. Munger. 1998. Winter ecology of bald eagles on a regulated river in southwest Idaho. Journal of Raptor Research 32(3):215-220.

McClelland, B.R., L.S. Young, P.T. McClelland, J.G. Crenshaw, H.L. Allen, and D.S. Shea. 1994. Migration ecology of bald eagles from autumn concentrations in Glacier National Park Montana. Wildlife Monograph 125.

Neumann, K. 2009. Bald eagle lead poisoning in winter. In R.T. Watson, M. Fuller, M. Pokras, and W.G. Hunt, editors. Ingestion of lead from spent ammunition: implications for wildlife and humans. The Peregrine Fund, Boise, Idaho. DOI 10.4080/ilsa.2009.0119

Newton, I. 1979. Population ecology of raptors. Buteo Books, Vermillion, SD.

Stalmaster, M. V. 1987. The Bald Eagle. Universe Books, New York.

Steenhof, K., M. N. Kochert, and J. A. Roppe. 1993. Nesting by raptors and common ravens on electrical transmission line towers. Journal of Wildlife Management 57(2):271-281.

Steenhof, K., S.S. Berlinger and L.Hl. Fredrickson. 1980. Habitat use by wintering bald eagles in South Dakota. Journal of Wildlife Management 44:798-805.

Swenson, J. E., K. L. Alt and R. L. Eng. 1986. Ecology of Bald Eagles in the greater Yellowstone ecosystem. Wildl. Monogr. 95.

Pygmy Rabbit Conservation Element Package

1 Introduction

The pygmy rabbit was approved by the Assessment Management Team (AMT) as a conservation element (CE) because a combination of natural factors and effects from anthropogenic causes have generated concern for the status and conservation of pygmy rabbit populations throughout most of its range. Its current distribution in the sagebrush ecoregions of the West is much reduced from historic locations. In addition, rapid declines in local isolated, small populations are possible due to a number of factors including increased habitat disturbances from fire and agricultural/ranching land use changes.

This CE package provides the assessment of the current status and future threats due to the applicable change agents (CAs) for the pygmy rabbit in the NGB ecoregion, Information in this CE package includes a brief description of the biology of the pygmy rabbit in the NGB ecoregion, a description of CAs that were assessed, a conceptual model of ecosystem functions relevant to the pygmy rabbit, some information on potential data sources and analytical methods for the assessment, and a full listing of relevant management questions for this CE. The primary CAs that were identified for pygmy rabbit include development, climate change, invasive species, and wildfire.

2 CE Package Review Process

2.1 Subject Matter Expert Review

Subject Matter Experts play a key role in ensuring that the REA reflects the best available data and modeling processes suitable for each conservation element and change agent. Subject Matter Experts were added to Rolling Review Teams comprised of SAIC scientists, SAIC GIS personnel, AMT member(s) and other subject matter experts from the Department of Interior or state agencies. Membership of the Rolling Review Teams is listed in Appendix A. To ensure consistency amongst the different Rolling Review Teams, the number of lead SAIC scientists was limited to only a few individuals. This ensured that there was a common approach, or framework, used among the different Rolling Review Teams and that one Rolling Review Team did not stray too far from the rest. The USGS, as peer reviewers, were invited to participate in Rolling Review Teams.

3 CE Description

The pygmy rabbit (*Brachylagus idahoensis*) is the smallest rabbit species in North America and occupies sagebrush-steppe communities within the Great Basin and adjacent Intermountain West. The distribution of the species is widespread but populations are disjunct within a large geographic range that roughly stretches from southwestern Oregon, through central Nevada, to western Utah, into southern Idaho. Few assessments of effects of fragmentation on pygmy rabbit habitat use and population dynamics have been done (Weiss and Verts 1984, Hagar and Lienkaemper 2007, Gabler *et al.* 2001).

The pygmy rabbit is a sagebrush obligate and relies year-round on big sagebrush (*Artemisia tridentata* spp.) for food (51–99% of the diet) and cover from thermal extremes and predators (Crawford 2008, Gabler *et al.* 2001). Several investigators have identified the presence of taller, denser stands of big sagebrush, relative to surrounding unused areas, as an essential feature of pygmy rabbit habitat (Crawford 2008, Larrucea and Brussard 2008a, Hagar and Lienkaemper 2007, Gabler *et al.* 2001). Suitable habitat selection appears to be based on a complex of vegetation and soil characteristics (Gabler *et al.* 2001). Important vegetative characteristics include composition (i.e., sagebrush), shrub cover, and shrub height (greater than 65 cm) (Hagar and Lienkaemper 2007, Weiss & Verts 1984, Larrucea &

Brussard 2008a, Roberts 2001). Deep (greater than 60 cm), friable soils are usually required for the species to dig their burrows. Soil texture is also important, usually comprised of greater sand and less clay content in an optimal balance to provide ease of burrow excavation and minimize burrow collapse (Hagar and Lienkaemper 2007).

4 CE Modeling

4.1 Data Identification

Table 4-1 lists the types of data and data sources that were originally proposed for use in the REA as part of the pre-assessment data identification effort. This table lists the need for the data, the general name of the dataset, and if the dataset was acquired.

Table 4-1. Preliminary Pygmy Rabbit Data Sources

Data Required	Dataset Name	Source Agency	Type/Scale	Status
Modeled Suitable Habitat	Rachlow and Svancara Model (2006)		Raster (30m)	Acquired
Point Occurrence	Nevada NNHP	Natural Heritage Programs,	Point	Acquired
	Oregon GeoBoB	BLM	Point	Acquired
	Idaho Conservation Data Center	ID State	Point	Acquired
	Utah NHP	Natural Heritage	Point	Acquired
Protected Areas	Conservation easements TNC and other private	PADS	Polygons	Acquired
Soils suitable for burrows	SSURGO Soils	NRCS	Polygons	Acquired

4.2 Distribution Mapping Methods

Pygmy rabbit was modeled based on previous methodology identified by Rachlow and Svancara (2006) the following variables: presence of sagebrush, soil depth to bedrock, not in a recent burned area, percent clay of soil and suitable slope to prioritize habitat. The main two variables required were sagebrush and soil with a depth to bedrock > 60 cm. These areas within the ecoregion were extracted using the sagebrush vegetation coarse filter and soil depth parameter. Using the areas with these two variables in common the three other variables were applied (Percent Clay 13-31%, Slope: 0 – 8%, not burned since 1990). Figure 4-1 shows areas with all three variables overlap within the sagebrush and deep soils. These areas were classified at suitable habitat for pygmy rabbit and used in further analysis.

Areas that have been recently burned were left out and would be considered as possible restoration or rehabilitation sites depending on when they burned, how frequently it has burned, what types of vegetation exist currently and whether reseeding of sagebrush occurred.

4.3 Data Gaps, Uncertainty, and Limitations

4.3.1 Data Gaps

The SSURGO data used for soil depth to bedrock and percent clay is incomplete in the ecoregion with large parts of eastern Oregon not available. STATSGO data was used in its place.

4.3.2 Uncertainty

The model used from Rachlow and Svancara (2006) was originally based on Idaho data, expanding it to a larger region may lower the quality accuracy of the model.

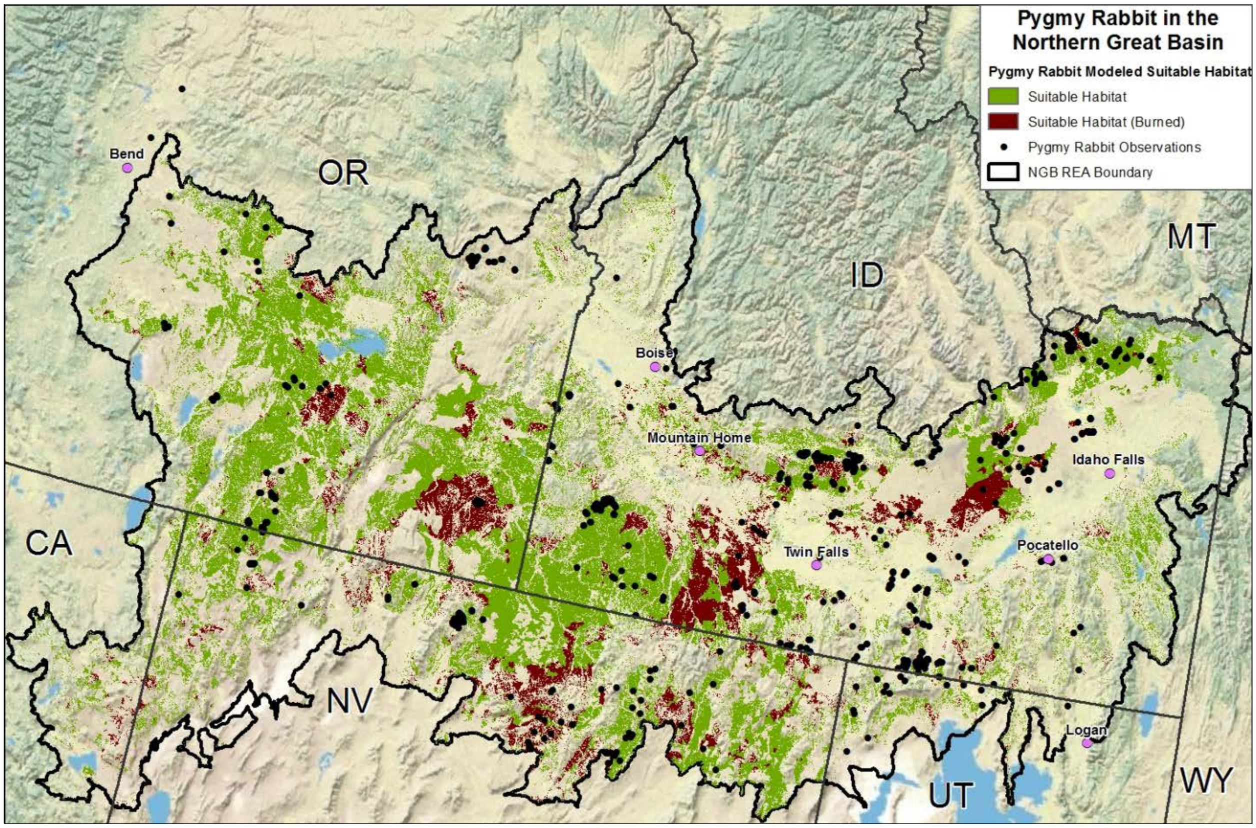


Figure 4-1. Modeled Pygmy Rabbit Suitable Habitat

5 Conceptual Model

Conceptual system models were developed as part of the pre-assessment phase to assist with the determination of the key factors that are important to the life cycles of the pygmy rabbit in the NGB ecoregion. The model was developed to provide an ecological framework and justification for the choice of indicators that were used in assessing CA threats for this CE. This model depicts the important habitat components required throughout the year for the pygmy rabbit and incorporates the identified CAs, as well as potential effects from the actions of the CAs on both the landscape and local habitat levels (Figure 5-1). Being conceptual in nature, all potential important stressors and effects were included regardless of availability of data at this point in the REA. Those elements that could not be carried forward for analysis will be discussed.

The CAs considered for this CE analysis includes development, climate change, invasive species, and wildfire, depicted in brown boxes across the top of the figure (Figure 5-1). As mentioned in Section 3, suitable pygmy rabbit habitat depends upon the stability of healthy sagebrush ecosystems. Because the details of transitions between sagebrush vegetation states are presented in a later (Coarse Filter) section, they are not repeated in the pygmy rabbit model. However, the pygmy rabbit model does indicate the relationships between the CAs that act upon the pygmy rabbit habitat needs and thereby, on the pygmy rabbit functions and values, depicted in the lower box. The predicted results of CA effects are presented in blue boxes.

Larrucea and Brussard (2008b) measured current presence at 105 previously occupied (pre-1950) pygmy rabbit sites in the Great Basin. They found occupancy down 64 percent with 14 percent of the sites showing signs of pinyon-juniper woodland encroachment, recent evidence of fires (16%), urbanization (13%), and agricultural conversion (6%). At a local scale, fire frequency reduction due to livestock grazing and fire suppression have shifted pygmy rabbit habitat to lower elevations. However, overall there was more extirpation at lower elevation sites, and the increase in mean elevation of 157 m closely corresponded to the predicted elevation increase with the rise in average global temperature seen over the last century (Larrucea and Brussard (2008b).

The various types of human development identified in the model affect important pygmy rabbit habitat requirements as indicated in the Local Habitat Effects box (Figure 5-1) including changes in patch size, vegetation density and cover, vegetation height or composition, and soil structure, and increased fragmentation of suitable habitat patches. Large, land-intensive developments especially affect the natural patchy distribution of sagebrush communities resulting in changes to pygmy rabbit behavior, movements, genetic exchange among populations, and feeding habits (Crawford 2008). As indicated by the Mortality and Disturbance box (Figure 5-1), competition with other species has been identified as an issue for pygmy rabbits, for example, suitable habitat occupancy decreased with presence of cottontails (Larrucea and Brussard 2008b). These researchers also found that an increase in cheatgrass (invasive grass) reduced pygmy rabbit occupancy.

Maintaining connectivity between patches of adequate size was found to be of great importance for pygmy rabbit populations studied in southwest Idaho (Burak 2006). Any of the CAs that fragment habitat patches and limit successful rabbit dispersal among patches would have adverse effects, potentially leading to local extirpations. However, little information is currently available, especially at the landscape level, to assess effects of fragmentation on pygmy rabbit habitat use and population dynamics, including genetic analysis of metapopulations (Hagar and Lienkaemper 2007). For this reason, the model includes several local habitat effects factors that can be evaluated to determine effects to pygmy rabbits (Figure 5-1).

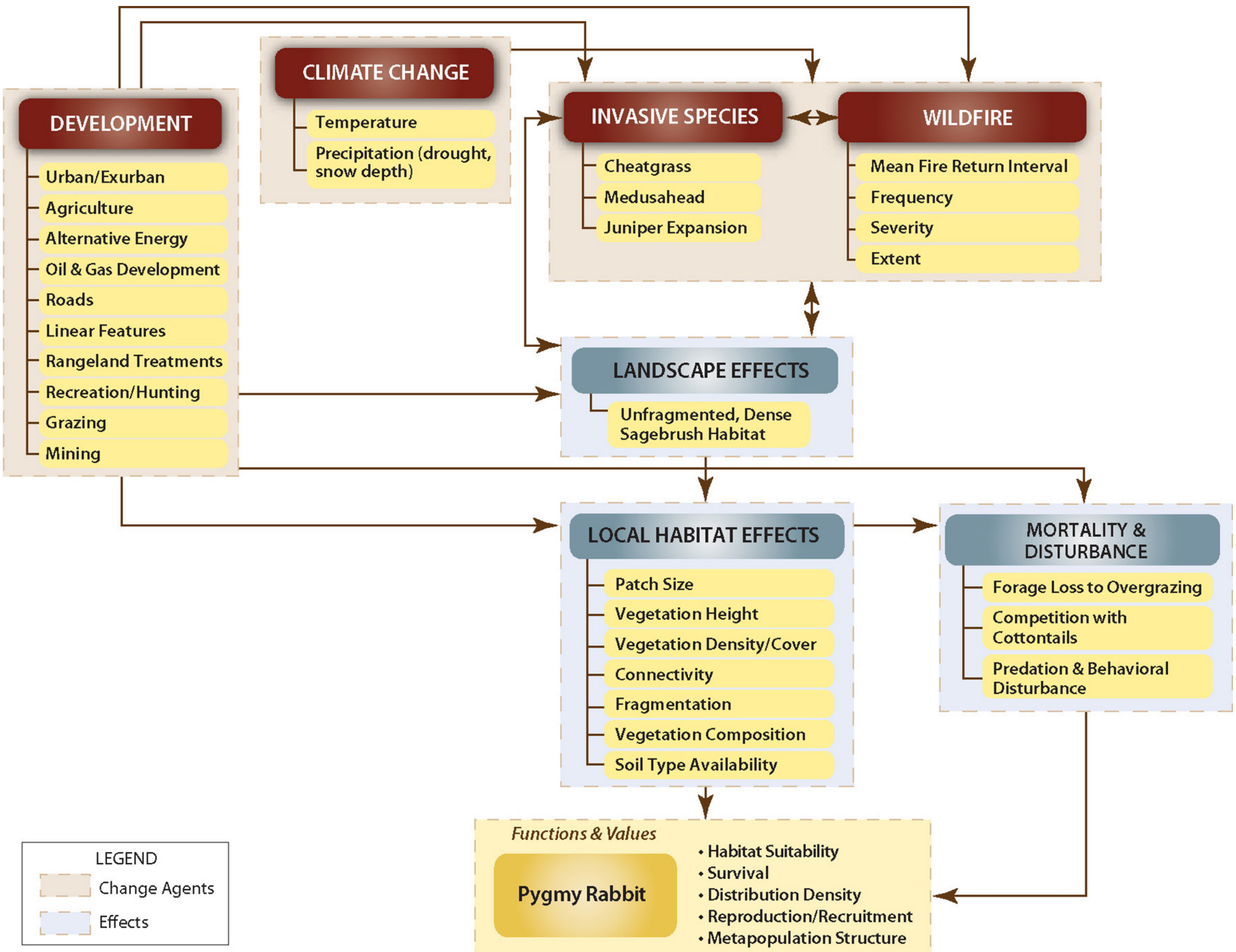


Figure 5-1. Pygmy Rabbit Conceptual Mode

6 CA Threat Analysis

Current status and future threat assessments for the pygmy rabbit were conducted for the NGB using both 30m pixels and the 12-digit HUCs as the analysis units. Once the ecological model was developed, indicators or key ecological attributes were identified with a specific emphasis on the ability to measure indicators and predict future scenarios for the key ecological attributes using existing geospatial data. The indicators assisted with answering the MQs that relate to what is happening to the CE across the ecoregion. The CAs evaluated for current status of pygmy rabbit in the NGB include development, climate change, invasive species, and wildfire.

6.1 Key Ecological Attributes

The preliminary list of key ecological attributes (Table 6-1) suggests some indicators for assessing habitat size, condition, and landscape context with respect to anthropomorphic influences. In some cases, we may need to suggest surrogate indicators for measuring potential effects as indicted in the conceptual model. For example, some of the soil indicators may have to be derived from data other than soil surveys.

Table 6-2. Preliminary Key Ecological Attributes for Pygmy Rabbit

Category	Key Ecological Attribute	Indicator/Unit of Measurement	Metric			Data Source	Reference
			Poor = 1	Fair = 2	Good =3		
Size	Suitable Habitat Patch Size	Modeled habitat patch size (ha) (based on annual fixed kernel home range size of male rabbits)	<2	2-12	>12	Modeled Priority Habitat	Sanchez & Rachlow 2008
Condition	Habitat Quality	Sagebrush cover (% cover within modeled habitat)	<20	20-40	>40	Landfire existing vegetation cover	Weiss & Verts 1984 (OR), Hagar & Lienkaemper 2007 (OR), Larrucea & Brussard 2008a (NV, CA), Roberts 2001 (ID)
	Habitat Quality	Sagebrush height within modeled habitat (cm)	<60	60-100	>100	Landfire existing vegetation height	Weiss & Verts 1984 (OR), Hagar & Lienkaemper 2007 (OR), Larrucea & Brussard 2008a (NV, CA), Roberts 2001 (ID)
	Wildfire	Fire SIMulation Burn Probability	High	Moderate	Low	USFS / USGS	
Landscape Context /Predation Risk / Barriers to	Fragmentation	Road density (km/km sq)*	>0.112	0.087-0.112	<0.087	TIGER	Professional judgment; based on Greater sage-grouse models (Wisdom 2011)

Table 6-2. Preliminary Key Ecological Attributes for Pygmy Rabbit

Category	Key Ecological Attribute	Indicator/Unit of Measurement	Metric			Data Source	Reference
			Poor = 1	Fair = 2	Good =3		
Movement	Connectivity	Natal Dispersal (distance between modeled habitat patches) (km)	>6	1 – 6	<1		Green & Flinders 1979 (se ID); Burak 2006 (sw ID), Gahr 1993 (WA); Katzner & Parker 1998 (sw WY); Estes-Zumpf and Rachlow 2009 (ID);; Crawford 2008 (se OR/nw NV)
	Anthropogenic Influences	Agriculture (% of area within 5 km of suitable habitat)	>25	9-25	<9	GAP, LANDFIRE	Professional judgment; based on Greater Sage-Grouse models (Wisdom 2011)
		Proximity to human development (including power lines, communications towers,) (km)	<6	6-15	>15	Census TIGER, States	Professional judgment; based on Greater Sage-Grouse models (Wisdom 2011)
		Or human footprint composite score	> 4.5	3.5 – 4.5	< 3.5		

6.2 Current Status of the CE

This section will document the CA analysis under current conditions, i.e. the current extent of the CE's distribution and locations of the CAs. For each of the key ecological attributes listed in Table 6-1 and used in the CA analysis, a discussion of the indicator, metrics, metric rank and value, data source(s), and references were provided. The analysis will be based on spatially available attributes affecting the CE at the ecoregion level.

6.2.1 Size – Suitable Habitat Patch

Suitable patch size was analyzed by extracting distinct patches of suitable habitat and measuring the size in pixels for each patch. The modeling process starts with expanding the size of the pixels from 30 m to 90 m. This was done to for to remain consistent with another key ecological attributes Natal Dispersal. The Region Group operation was used to connect adjacent pixels (eight directions around a pixel) to create distinct patches of habitat. The patches were then exported to excel and histograms were created to extract the amount of patches within the metrics from Sanchez and Rachlow (2008). The majority of the habitat patches, as shown in Figure 6-1, are in the largest bin or preferred patch size (greater than 12 hectares).

6.2.2 Condition

6.2.2.1 Percent Sagebrush Cover

Sagebrush cover was extracted from the LANDFIRE existing vegetation cover to identify areas that with the densest sagebrush cover. The existing vegetation cover data is then run through a zonal statistics to determine the most common vegetation cover within a 4 km grid.

The existing vegetation cover data shows the amount of vegetation cover across the pygmy rabbit suitable habitat. The southern portions tend to have the higher or preferred levels of vegetation cover. Most of Oregon and the developed regions of the Snake River plain appear to have the lower vegetation cover (below 20% cover). Figure 6-2 displays the results of the existing vegetation cover by 4km analysis unit for the pygmy rabbit suitable habitat.

6.2.2.2 Vegetation Height

Sagebrush height was extracted from the LANDFIRE existing vegetation type to identify areas that with the tallest sagebrush. The existing vegetation type data is then run through a zonal statistics to determine the most common vegetation cover within a 4 km grid.

Most of the western and southern parts of the ecoregion scored low while the eastern part (Idaho) scored moderately high to preferred habitat (> 100cm) (Figure 6-3).

6.2.2.3 Wildfire Burn Probability

The wildfire burn probability data was analyzed uses a moving window analysis to determine the most common value within the 5 km window. The use of the moving window allows neighboring cells within the window to add weight to the center of the window. The resulting analysis is then run through a zonal statistics to determine the most common value within the 4 km analysis unit.

The wildfire burn probability for the pygmy rabbit suitable habitat is displayed in Figure 6-4. The Fire SIMulation burn probability shows that the highest burn probability exists in the Snake River Plain and extends down into northeastern Nevada.

6.2.3 Fragmentation

Road density wasn’t measured as the metrics used from a greater sage-grouse reference didn’t match the density that was being calculated using the TIGER road density.

6.2.4 Risk / Barriers to Movement

6.2.4.1 Natal Dispersal

Fragstats was used to determine the distance between patches of pygmy rabbit suitable habitat. Since Fragstats has a maximum raster size, the pygmy rabbit habitat was resized from a 30m pixel size to a 90 m pixel size. After running the Fragstats analysis to determine distance between patches, 99.4% of the patches were within 1 km of another patch. No mapping product was created since most patches fell into the highest or preferred category.

6.2.4.2 Agriculture within 5km

Distance to agriculture was analyzed by using a 5 km moving window to search around each pixel of suitable pygmy rabbit habitat. The sum of the count of pixels of agriculture within the moving window was divided by the total number of pixels within the moving window. As displayed in Figure 6-5, agricultural areas are displayed in the darkest orange and the Snake River plain area of Idaho is the primary agricultural areas within the pygmy rabbit suitable habitat.

6.2.4.3 Human Footprint

The Human footprint was analyzed by a moving window to calculate the mean human footprint score within each pixel of pygmy rabbit suitable habitat. The results were then averaged to a 4 km grid using zonal statistics. The results of the analysis seem to expand on the Figure 6-5 (Agriculture) and adds in urban areas and roads. Figure 6-6 shows most of the Snake River plain to be in the lowest quality with the highest human footprint score.

6.2.5 Cumulative Indicator Score

Five of the key ecological attributes were used to create a cumulative indicator score (sagebrush cover, vegetation height, wildfire burn probability, agriculture within 5km and human footprint). The individual metrics for the key ecological attributes were scored with a 1, 2 or 3 with 1 given to lowest quality indicator and 3 given to the highest quality indicator. The five key ecological attributes were then added together using raster calculator to derive a range of cumulative scores from five to fifteen. Figure 6-7 shows the resulting high and low scoring areas with a stretched raster. The stretched raster was used to show the gradient from low scoring to high scoring 4km analysis units.

6.3 Future Threat Analysis

6.3.1 Climate Change

There have been few climate change studies on the pygmy rabbit. Larrucea and Brussard (2008b) speculated that pygmy rabbit occupied sites may increase in elevation with the effects of climate change.

6.3.2 Development

Large-scale habitat fragmentation through agricultural development over the last 200 years in southern Idaho has reduced what once was probably a single pygmy rabbit population by at least 20 percent into what now can be considered three separate sub-populations (Roberts 2003). These islands of habitat support continuous big sagebrush and connectivity is still rated as good. A broad belt of dry-land and irrigated farms now forms a travel barrier to rabbits along the Snake River from Ashton to Mountain Home, which separates populations existing north of the river from populations living south of the river (Roberts 2003).

Future development may affect the suitable habitat quality and availability for the pygmy rabbit. These include urban/exurban expansion, agriculture (especially when land conversion occurs), alternative and traditional energy exploration and development, and linear features (especially pipelines that disrupt vegetation and soil structure).

6.3.3 Wildfire

Wildfire now covers larger areas and occurs more frequently, reducing habitat quality and quantity of mature sagebrush communities used by pygmy rabbits. More frequent fires than occurred historically reduces the time between burns required for sagebrush to fully mature into the canopy cover pygmy rabbits occupy. The increase in fire frequency in the West within this century poses serious threats to pygmy rabbit persistence (Gabler *et al.* 2001, Roberts 2003). With a number of fires exceeding 100,000 acres having burned during the last decade, fire is currently the major contributing factor to the loss of pygmy rabbit habitat in Idaho (Roberts 2003). One of the three current sub-populations in Idaho should be considered isolated and fragmented and its future is in doubt. The occupied habitat for another sub-population has been severely burned at lower elevations but higher elevations appear to be relatively intact (Roberts 2003).

6.3.4 Invasives and Disease

Larrucea and Brussard (2008b) found that an increase in cheatgrass (invasive grass) reduced pygmy rabbit occupancy. In addition, invasive species indirectly influence pygmy rabbit habitat because an increasing dominance of invasive annuals produces fuel for wildfire and facilitates short fire return intervals. Wildfire can alter the habitat and create soil conditions vulnerable to invasive species, particularly by cheatgrass and medusahead, that will continue to alter the fire regime and reduce persistent shrubby vegetative cover.

6.3.5 Grazing

Pygmy rabbit habitat is affected by livestock grazing when it is severe enough to alter sagebrush cover or the nutritional quality of forage (Hagar and Lienkaemper 2007). Land use changes that accompany livestock operations such as shrub thinning or removal and water source manipulations can also impact pygmy rabbit habitat.

6.3.6 CE Summary

Areas that were modeled as suitable pygmy rabbit habitat may be examined in detail by local managers for potential conflicts with land use plans and management activities, identification of areas where monitoring for occurrences of the species would be justified, and opportunities for habitat restoration and reintroduction of pygmy rabbits. Modeled suitable habitat areas that have burned in recent years may, for example, deserve closer evaluation as potential habitat restoration sites. By drilling down into modeled suitable habitat and known locations of pygmy rabbit populations within their areas, managers may identify potential conflicts with range management programs and grazing allotment plans; for example, the presence of suitable habitat or a potential site for habitat restoration may be an indicator for managers to carefully consider grazing intensity. The cumulative indicator scores for pygmy rabbit suitable habitat under current conditions should be useful in identifying the areas most in need of preservation or the best restoration opportunities in these drill-down evaluations.

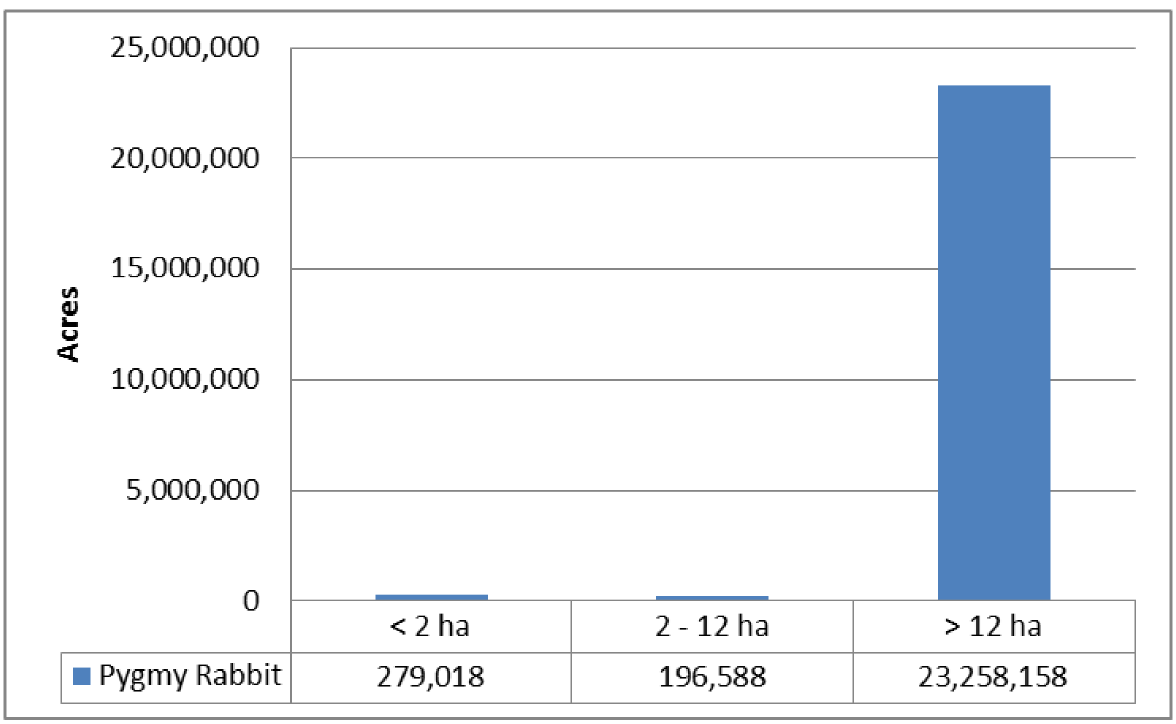


Figure 6-1. Pygmy Rabbit Suitable Habitat Patch Acres per Bin

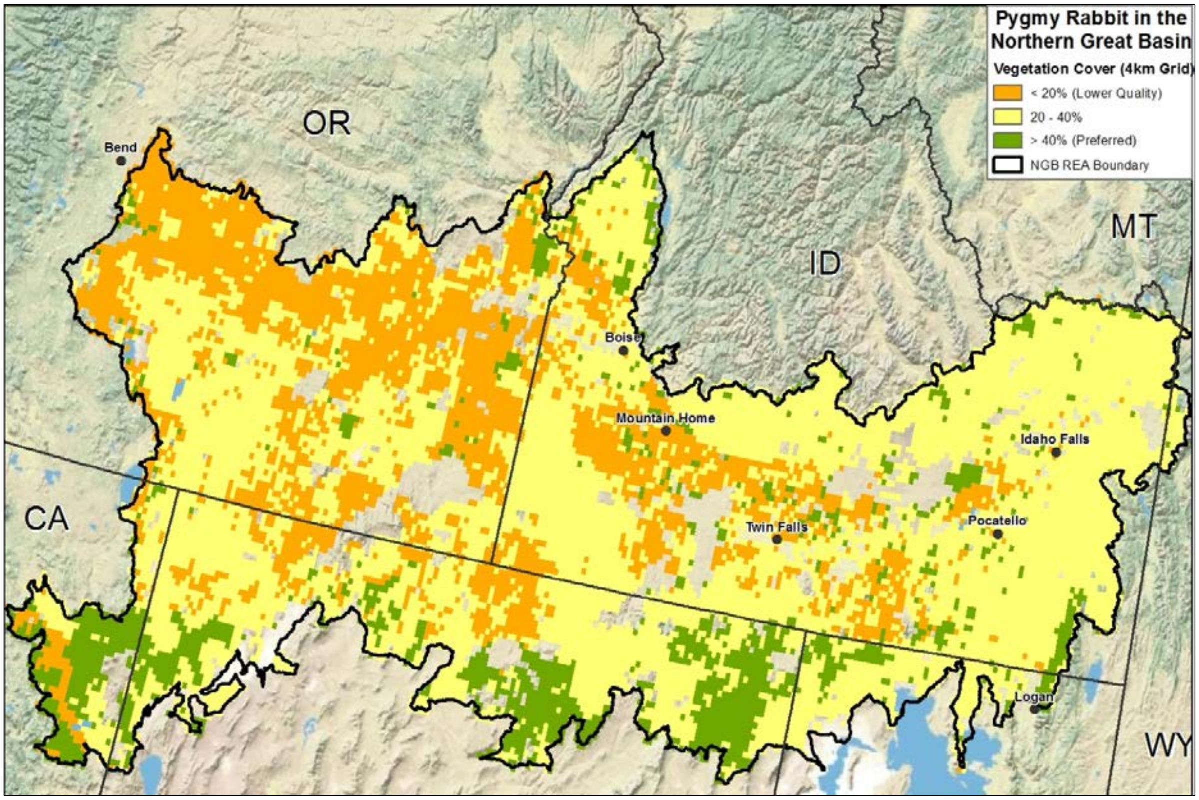


Figure 6-2. Existing Vegetation Cover in Pygmy Rabbit Suitable Habitat.

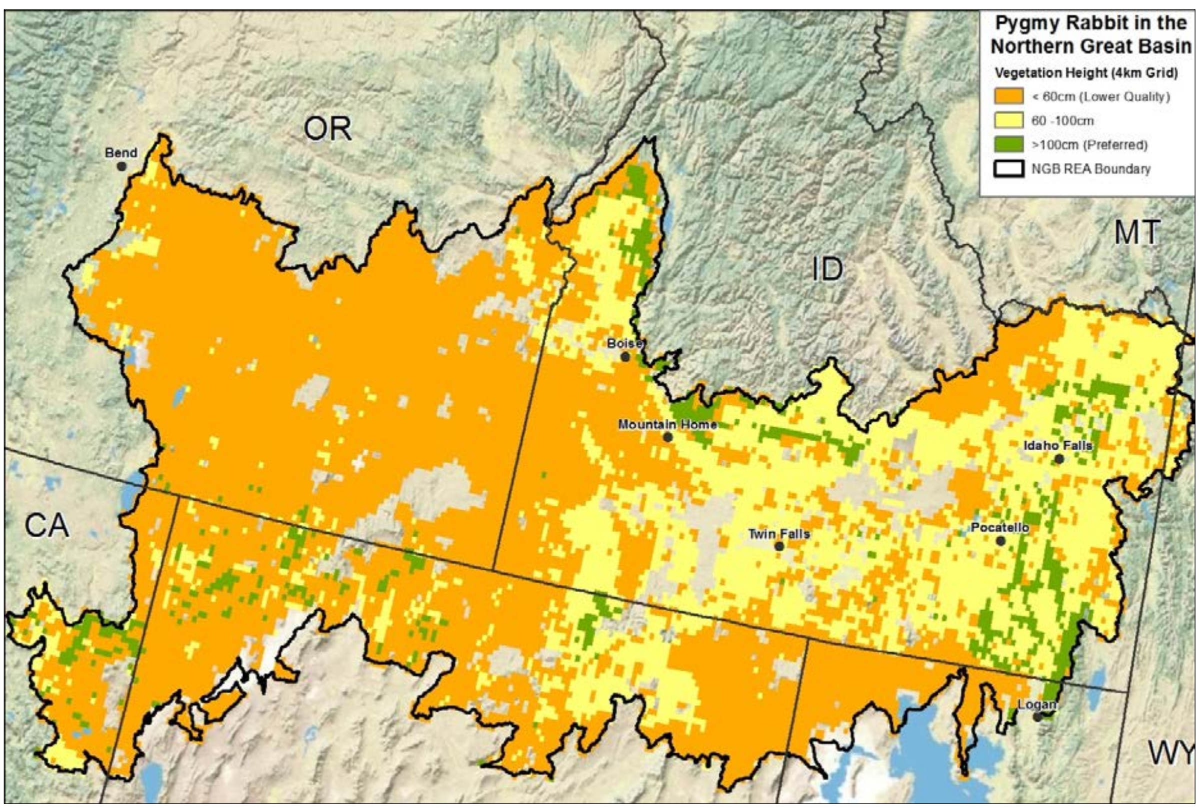


Figure 6-3. Existing Vegetation Height in Pygmy Rabbit Suitable Habitat

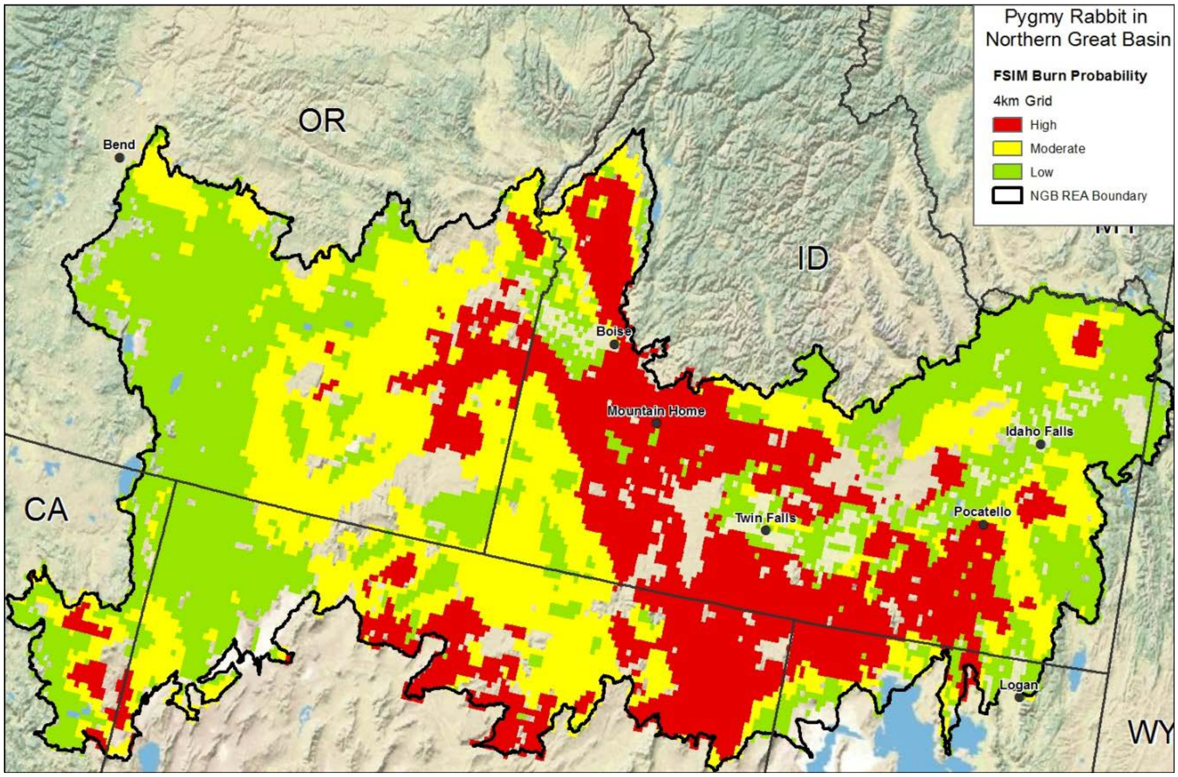


Figure 6-4. Fire SIMulation Burn Probability for Pygmy Rabbit Suitable Habitat

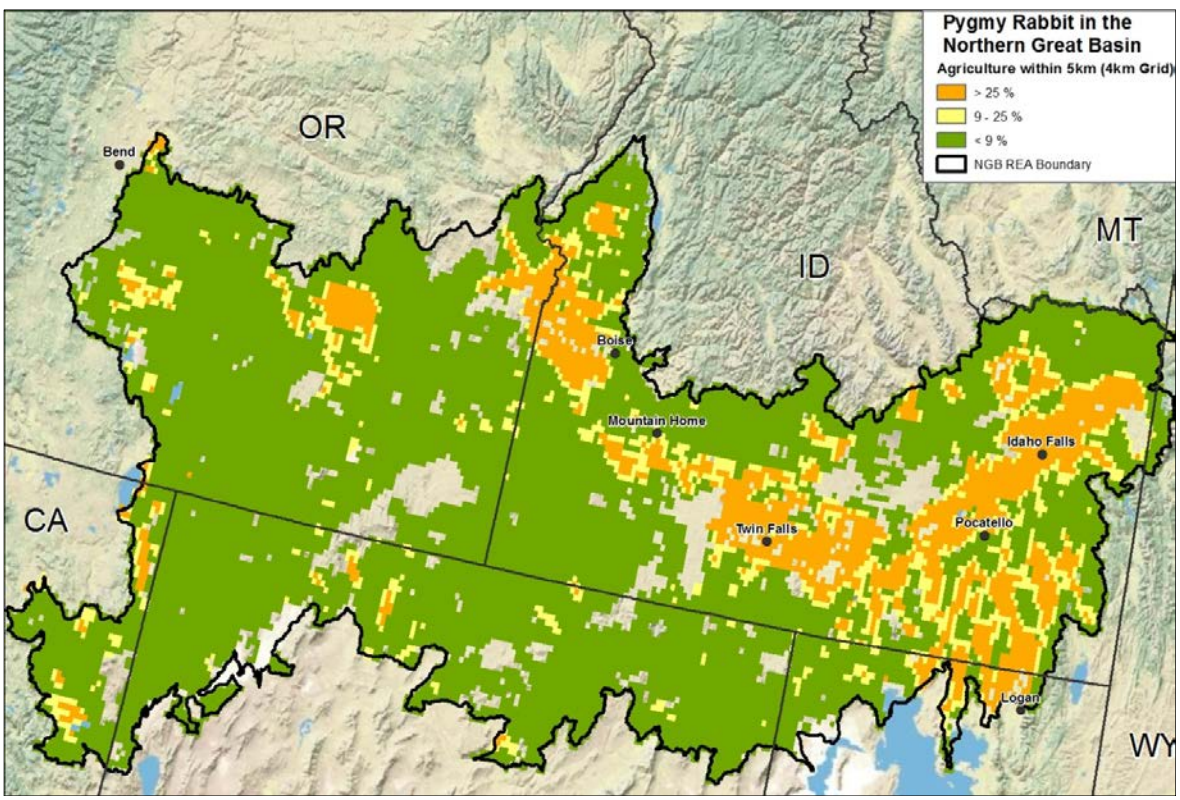


Figure 6-5. Agriculture within 5km of Pygmy Rabbit Suitable Habitat

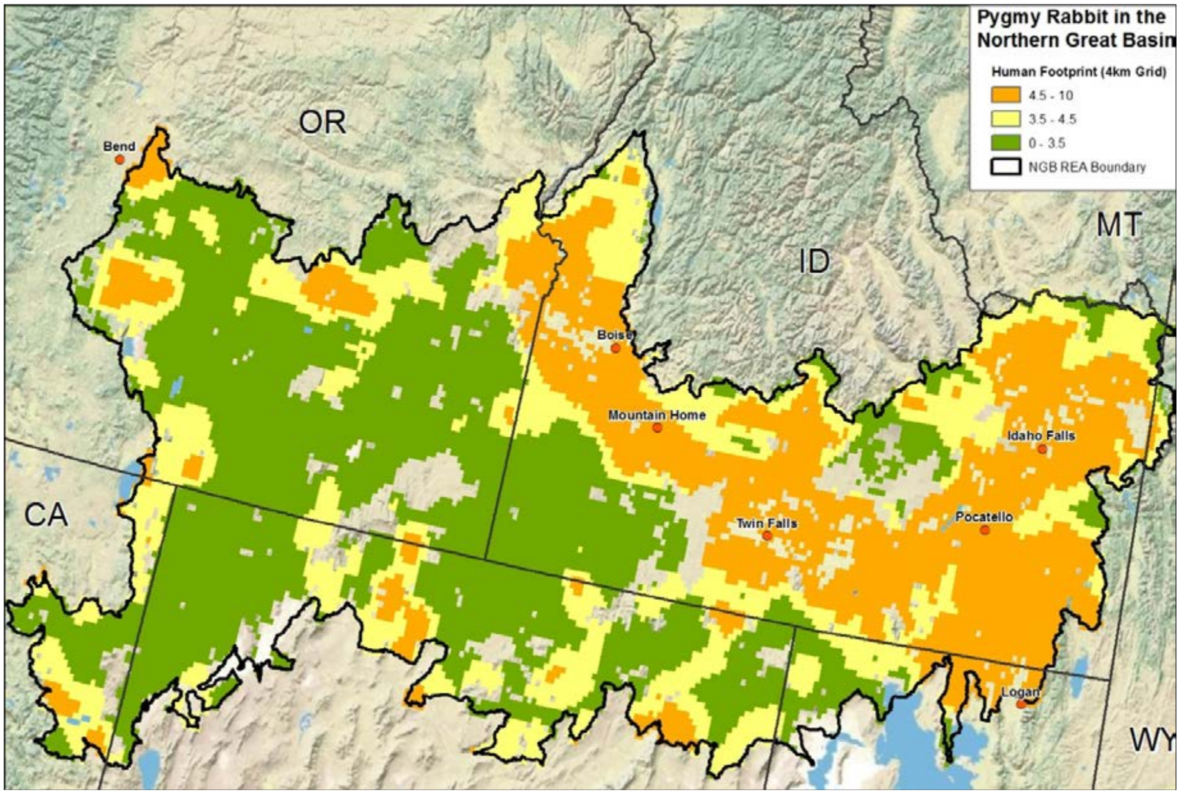


Figure 6-6. Human Footprint within the Pygmy Rabbit Suitable Habitat

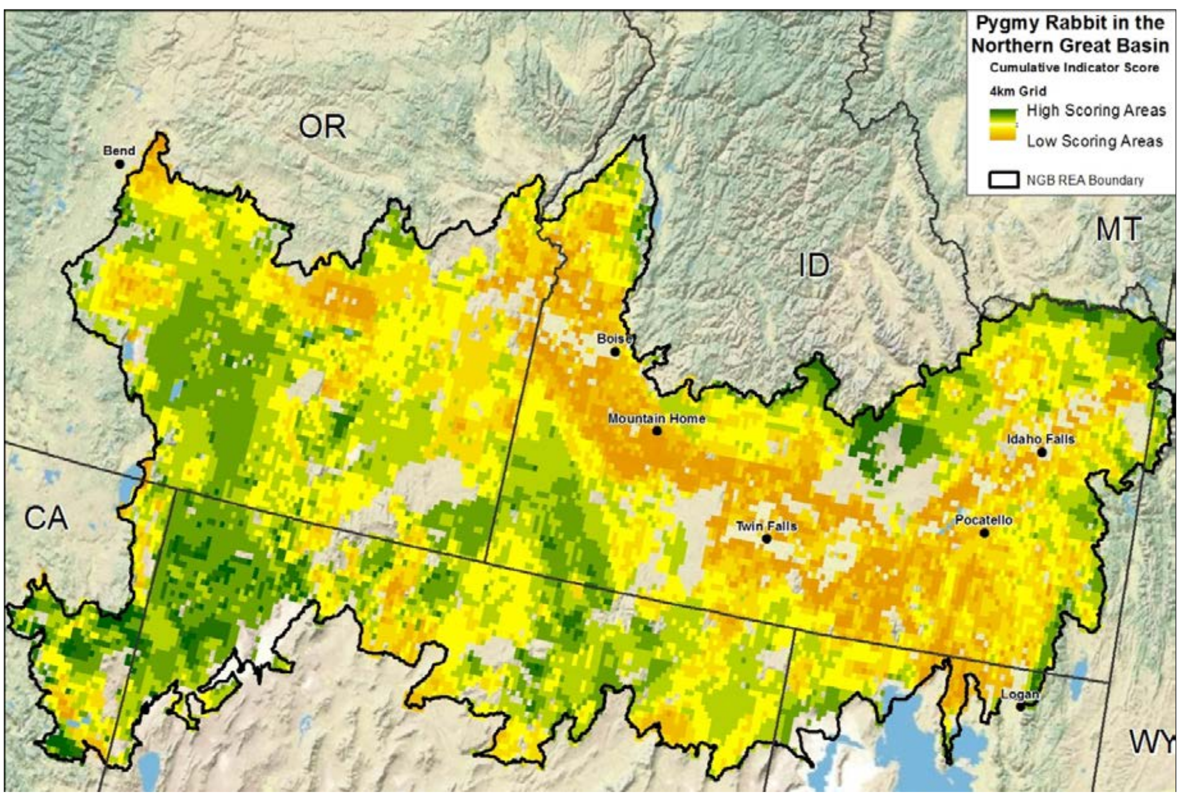


Figure 6-7. Cumulative Indicator Score for the Pygmy Rabbit Suitable Habitat

7 Management Questions

Management questions for the NGB were developed by BLM managers and refined by the AMT to answer questions regarding the agency's land management responsibilities—including planning land use, developing best management practices, authorizing uses, and establishing conservation and restoration priorities. Several management questions relate to this CE:

1 *What is the currently occupied habitat or modeled suitable habitat for this CE?*

Pygmy rabbit observations and modeled suitable pygmy rabbit habitat are shown in Figure 4-1.

2 *Where are the areas of greatest and least collective impact of existing CAs on occupied habitat or modeled suitable habitats of this CE?*

Figure 6-7 shows the cumulative indicator score for the pygmy rabbit. High scoring areas include northwestern Nevada and southwestern Idaho. The lowest scoring area is along the Snake River plain development corridor.

5 *Where are current locations of this CE likely to overlap with the potential future distribution of CAs?*

Pygmy rabbit habitat overlaps areas with high burn probability in much of Idaho and northwestern Nevada (see Figure 6-4). Sagebrush in high burn probability areas may be vulnerable to type conversion to cheatgrass dominated grasslands, which could reduce available habitat for pygmy rabbit. Most growth in development is modeled to occur in existing population centers along the Snake River corridor where pygmy rabbit habitat is low scoring.

6 *Given current and anticipated future locations of CAs, which habitat areas remain as opportunities for habitat enhancement/restoration for this CE?*

The cumulative indicator scores for pygmy rabbit suitable habitat under current conditions should be useful in identifying the areas most in need of preservation or the best restoration opportunities in these drill-down evaluations. Areas that were modeled as suitable pygmy rabbit habitat should be examined in detail by local managers opportunities for habitat restoration and reintroduction of pygmy rabbits. Modeled suitable habitat areas that have burned in recent years may, for example, deserve closer evaluation as potential habitat restoration sites. By drilling down into modeled suitable habitat and known locations of pygmy rabbit populations within their areas, managers may identify potential conflicts with range management programs and grazing allotment plans; for example, the presence of suitable habitat or a potential site for habitat restoration may be an indicator for managers to carefully consider grazing intensity.

7 *Where are potential areas to restore connectivity for this CE, based on current locations of CAs?*

Fragstats was used to determine the distance between patches of pygmy rabbit suitable habitat. Since Fragstats has a maximum raster size, the pygmy rabbit habitat was resized from a 30m pixel size to a 90m pixel size. After running the Fragstats analysis to determine distance between patches, 99.4% of the patches were within 1 km of another patch. No mapping product was created since most patches fell into the highest or preferred category, and connectivity between patches is not a major concern for the pygmy rabbit.

8 *Where will this CE experience climate outside their current climate envelope? Or: Where will this CE experience significant deviations from normal climate variation?*

The implications of these predicted changes for pygmy rabbit are not straight forward. There have been few climate change studies on the pygmy rabbit. Larrucea and Brussard (2008b) speculated that pygmy rabbit occupied sites may increase in elevation with the effects of climate change. Climate change may increase the frequency and severity of fires which would indirectly impact sagebrush and pygmy rabbit habitat.

8 References

Barker, J., J. Robb, R. Stage, and N. Roster. Modeling approach to identify prime sage-grouse and pygmy rabbit habitats along the Ruby Pipeline. Unpublished report, available on internet at: http://www.rubypipeline.com/docs/rr/rr3_docs/modelingapproach.pdf. Accessed November 26, 2012.

Burak, G.S. 2006. Home Ranges, Movements, and Multi-Scale Habitat Use of Pygmy Rabbits (*Brachylagus idahoensis*) in Southwestern Idaho. A thesis submitted to Boise State University in partial fulfillment of the requirements for the degree of Master of Science in Biology. December.

Crawford, J.A. 2008. Survival, Movements and Habitat Selection of Pygmy Rabbits (*Brachylagus idahoensis*) on the Great Basin of Southeastern Oregon and Northwestern Nevada. A thesis submitted to Oregon State University in partial fulfillment of the requirements for the degree of Master of Science. June.

Gabler, K.I., L.T. Heady, and J.W. Laundré. 2001. A Habitat Suitability Model for Pygmy Rabbits (*Brachylagus idahoensis*) in Southeastern Idaho. Western North American Naturalist 61(4), pp. 480–489.

Hagar, J. and G. Lienkaemper. 2007. Pygmy Rabbit Surveys on State Lands in Oregon. U.S. Geological Survey, Reston, Virginia. Open-File Report 2007-1015.

Larrucea, E.S. and P.F. Brussard. 2008a. Habitat selection and current distribution of the pygmy rabbit in Nevada and California, USA. Journal of Mammalogy: Vol. 89, No. 3, pp. 691-699. June.

Larrucea, E.S. and P.F. Brussard. 2008b. Shift in location of pygmy rabbit (*Brachylagus idahoensis*) in response to changing environments. Journal of Arid Environments 72 (9): 1636–1643. September.

Rachlow, J.L and L.K. Svancara. 2006. Prioritizing Habitat for Surveys of an Uncommon Mammal: A Modeling Approach Applied to Pygmy Rabbits. Journal of Mammalogy 87(5):827-833.

Roberts, H.B. 2003. Status of the Pygmy Rabbit (*Brachylagus idahoensis*) in Idaho. Technical Bulletin No. 03-6 Idaho Bureau of Land Management. April.

_____. 2001. Survey of Pygmy Rabbit Distribution, Numbers and Habitat Use in Lemhi and Custer Counties, Idaho. Prepared for Bureau of Land Management, Idaho Field Offices. February.

Weiss, N.T. and B.J. Verts. 1984. Habitat and Distribution of Pygmy Rabbits (*Sylvilagus idahoensis*) in Oregon. Great Basin Naturalist. 44(4).

Pronghorn Conservation Element Package

1 Introduction

Pronghorn are an important part of the grassland-sagebrush steppe ecosystem and iconic symbol of open spaces in the West. These ungulates require vast open landscapes to meet their life cycle requirements. Many types of anthropogenic land disturbances have interrupted, changed, reduced, or blocked pronghorn access to habitats and movement patterns, adversely affecting this species across its historic range. This is especially true of fast-growing industries such as oil and gas development, alternative energy, and suburban to exurban residential housing with their accompanying roads and utilities corridors. In addition to development pressures, pronghorn were also chosen as a CE because of their status as an important game species in all of the NGB states.

The management questions (MQs) that apply to pronghorn can be summarized into three primary questions: 1) where are the important areas for this species; 2) where are healthy habitats protected or those that can be restored and/or protected; and 3) what is happening to those areas?

This CE package provides the assessment of the current status and future threats due to the applicable change agents (CAs) for pronghorn in the NGB ecoregion. Information in the CE package includes a brief description of the biology of pronghorn in the NGB ecoregion, a description of CAs that were assessed, a conceptual model of ecosystem functions relevant to pronghorn, information on data sources and analytical methods for the assessment, and a full listing of relevant management questions for this CE. The primary CAs that were identified for pronghorn include development, climate change, invasive species, wildfire, and disease.

2 CE Package Review Process

2.1 Subject Matter Expert Review

Subject Matter Experts play a key role in ensuring that the REA reflects the best available data and modeling processes suitable for each conservation element and change agent. Subject Matter Experts were added to Rolling Review Teams comprised of SAIC scientists, SAIC GIS personnel, AMT member(s) and other subject matter experts from the Department of Interior or state agencies. Membership of the Rolling Review Teams is listed in Appendix A. To ensure consistency amongst the different Rolling Review Teams, the number of lead SAIC scientists was limited to only a few individuals. This ensured that there was a common approach, or framework, used among the different Rolling Review Teams and that one Rolling Review Team did not stray too far from the rest. The USGS, as peer reviewers, were invited to participate in Rolling Review Teams.

3 CE Description

Pronghorn are adapted to a grassland and shrub-steppe ecosystem. Characteristics of good pronghorn habitat include large areas of unbroken rangeland, relatively flat or undulating terrain with high visibility, and sufficient rainfall (12-25 inches) to support sufficient forage. They are highly selective browsers. Although they are the predominant plant class in pronghorn habitat, grasses are the least preferred forage class, while forbs are the most preferred (O'Gara and Yoakum 2004). Feeding preferences for shrubs are intermediate and may dominate winter diets (Bayless 1969). Big sagebrush (*Artemesia tridentata*), rabbitbrush (*Chrysothamnus* spp.), and bitterbrush (*Purshia tridentata*) are particularly important pronghorn forage in this ecoregion. Grasses are important cover for neonate pronghorns up to 3 weeks old. Reduced vegetation height or excessive livestock use during parturition has been linked to high predation rates on fawns (O'Gara and Yoakum 1992).

Typically, habitat for pronghorn consists of relatively flat, open native sagebrush and grassland habitats free of encroaching trees, fragmenting infrastructure (roads, fences, and oil and gas development) and other anthropogenic disturbances. Pronghorn strongly avoid forested habitats and they typically cannot jump over fences. Slope is also an important indicator of pronghorn habitat. Studies suggest that pronghorn avoid slopes of greater than 20 percent and apparently prefer areas where the slopes are less than 10 percent (Yoakum 2004a; Longshore and Lowrey 2007). Snow depth above 15 inches (38 centimeters [cm]) appears to limit pronghorn use of winter range in some areas. Beckmann *et al.* (2006) suggest that both snow depth and land fragment size explain threshold levels for use by pronghorn within or adjacent to gas fields.

Pronghorn migration distances are the longest known for terrestrial animal species in the 48 contiguous states (Feeney *et al.* 2004). Radio-telemetry studies have confirmed that pronghorn migrate as much as 274 km between the Grand Teton National Park and the Green River Basin in Wyoming (Sawyer and Lindzey 2000, Sawyer *et al.* 2005). Not all pronghorn populations migrate these distances; non-migratory individuals have been documented in other studies (Hoskinson and Tester 1980; White *et al.* 2007). Adult pronghorn in the vicinity of the Idaho National Energy Laboratory in the eastern Snake River Plain (SRP) overwinter at the lower end of valleys on the edge of the SRP, moving variable distances (up to 64 km) up the valleys during spring migration (Hoskinson and Tester 1980). Pronghorn in northeastern California may migrate between summer and winter range up to 150 km (CDFG 2000). Pronghorn summer and winter ranges have been identified in other portions in the NGB ecoregion (e.g., reported in BLM 2004, BLM 2007), and state fish and game agencies have provided additional sources of distribution data for this CE.

4 CE Modeling

4.1 Data Identification

Table 4-1 lists the types of data and data sources that were originally proposed for use in the REA as part of the pre-assessment data identification effort. This table lists the need for the data, the general name of the dataset, and if the dataset was acquired.

Table 4-1. Preliminary list of Pronghorn Data Sources

Data Required	Dataset Name	Source Agency	Type/Scale	Status	Use in REA
Modeled Suitable Habitat					
Pronghorn Seasonal Ranges	Crucial, Severe Winter, and Winter Ranges	State Fish & Game agencies	Polygon	Acquired (UT, ID, NV)	Yes
Travel Corridors	State	State Fish and Game agencies		Data Gap	No
Snow Depth	Mean Annual Snow Depth	NOAA	Polygon	Acquired	Yes

4.2 Distribution Mapping Methods

After review by the Rolling Review Team, state agency pronghorn range data was found to have too many gaps and inconsistencies of mapping scale. Some regions were mapped at fine scale providing very detailed delineations of range habitat while other areas reflected management boundaries mapped at a coarse level. Oregon did not provide pronghorn range data.

Thus it was determined to develop a habitat model based on known pronghorn-habitat relationships. A method developed for modeling pronghorn habitat in California (Penrod et al 2010) was reviewed and determined to be applicable for determining pronghorn habitat for the ecoregion. This model is a Weighted Geometric (Multiplicative) Mean GIS habitat suitability model that uses vegetation, slope, and road density as primary variables (Penrod et al 2010). Because the NGB has a greater range of elevation it was added as a fourth input factor in the model. Habitat suitability ratings for input factors were modified from Penrod et al (2010) where determined necessary. Values range from zero to one, with one being most suitable and zero being unsuitable. See Table 4-2 for all habitat suitability values.

Vegetation suitability was based on the Landfire existing vegetation height raster dataset. SAIC biological staff reviewed the landcover types and assigned suitability values based upon their knowledge of the natural history of the species. The raster was reclassified to assign suitability values to each cell based on these values and produced a new raster with values ranging from zero to one. Percent slope was derived by GIS analysis on the USGS National Elevation Dataset (NED) for the region. The slope raster was then reclassified to reflect low (0.3), medium (0.6), and high suitability (0.9) for pronghorn habitat. Elevation data was also derived from the USGS NED and reclassified in to low, medium, and high suitability values. These ranges were determined by comparing existing WAFWA datasets with the NED data and determining the elevation range of existing pronghorn habitat in the NGB. Finally, road density was calculated using Census TIGER road line data from 2000. Road density was used both as a direct variable on suitable habitat and as a proxy for fence data (Penrod et al 2010), which is not available for the entire NGB. Density data was reclassified into 8 bins and assigned suitability values from 0 to 0.9, with the higher values assigned to areas with less dense road networks. Freeways, secondary roads, and local roads were all analyzed to produce the density model.

Final habitat suitability was calculated for each 40m grid cell by weighted geometric mean. The SC Wildlands model scored the cell (Vegetation Score$^{0.35}$) * (Road Density Score$^{0.10}$) * (Topography Score$^{0.55}$) (Penrod et al 2010). The Topography Score was comprised only of the slope values. Because of the greater elevation range in the NGB an elevation score was also included in the model. This value was included in the Topography Score by splitting the weighting between slope and elevation resulting in a final equation of:

$$(\text{Vegetation Score}^{0.35}) * (\text{Road Density Score}^{0.10}) * (\text{Slope}^{0.275})*(\text{Elevation}^{0.275}) = \text{Suitable Habitat}$$

From the habitat suitability raster a final habitat map was created by reclassifying the suitability values into 5 categories using Natural Breaks (Jenks) method. The top two categories were identified as suitable pronghorn habitat (Penrod et al 2010). The final habitat layer was then compared to the available WAFWA pronghorn datasets (Figure 4.1)

Table 4-2 Habitat Suitability Values

Spatial data layers	Data Source	Factors Used	Suitability Value
Land Cover/ and Use	Landfire existing vegetation type	Arctostaphylos patula Shrubland Alliance	0.5
		Artemisia tridentata ssp. vaseyana Shrubland Alliance	0.5
		Barren	0.2
		California Montane Riparian Systems	0.2
		Coleogyne ramosissima Shrubland Alliance	0.5
		Colorado Plateau Mixed Low Sagebrush Shrubland	0.8

Table 4-2 Habitat Suitability Values

Spatial data layers	Data Source	Factors Used	Suitability Value
		Colorado Plateau Pinyon-Juniper Woodland	0.2
		Columbia Basin Foothill and Canyon Dry Grassland	0.8
		Columbia Basin Palouse Prairie	0.8
		Columbia Plateau Low Sagebrush Steppe	0.8
		Columbia Plateau Scabland Shrubland	0.8
		Columbia Plateau Steppe and Grassland	0.8
		Columbia Plateau Western Juniper Woodland and Savanna	0.2
		Developed-Upland Herbaceous	0.2
		Developed-Upland Shrubland	0.2
		Grayia spinosa Shrubland Alliance	0.5
		Great Basin Semi-Desert Chaparral	0.5
		Great Basin Xeric Mixed Sagebrush Shrubland	0.8
		Herbaceous Semi-dry	0.5
		Herbaceous Semi-wet	0.2
		Herbaceous Wetlands	0.2
		Inter-Mountain Basins Big Sagebrush Shrubland	0.8
		Inter-Mountain Basins Big Sagebrush Steppe	0.8
		Inter-Mountain Basins Greasewood Flat	0.8
		Inter-Mountain Basins Juniper Savanna	0.5
		Inter-Mountain Basins Mixed Salt Desert Scrub	0.8
		Inter-Mountain Basins Montane Riparian Systems	0.2
		Inter-Mountain Basins Montane Sagebrush Steppe	0.8
		Inter-Mountain Basins Semi-Desert Grassland	0.8
		Inter-Mountain Basins Semi-Desert Shrub-Steppe	0.8
		Inter-Mountain Basins Sparsely Vegetated Systems	0.5
		Introduced Riparian Vegetation	0.2
		Introduced Upland Vegetation-Annual and Biennial Forbland	0.8
		Introduced Upland Vegetation-Annual Grassland	0.8
		Introduced Upland Vegetation-Perennial Grassland and Forbland	0.8
		Juniperus occidentalis Wooded Herbaceous Alliance	0.2
		Juniperus occidentalis Woodland Alliance	0.2
		Mediterranean California Sparsely Vegetated Systems	0.5
		Mediterranean California Subalpine Meadow	0.5
		Mogollon Chaparral	0.5
		Mojave Mid-Elevation Mixed Desert Scrub	0.8
		North Pacific Alpine and Subalpine Dry Grassland	0.2
		North Pacific Dry and Mesic Alpine Dwarf-Shrubland or Fell-field or Meadow	0.2
		North Pacific Montane Grassland	0.5
		North Pacific Montane Riparian Woodland and Shrubland	0.2
		North Pacific Montane Shrubland	0.2
		North Pacific Sparsely Vegetated Systems	0.5
		Northern and Central California Dry-Mesic Chaparral	0.5
		Northern Rocky Mountain Foothill Conifer Wooded Steppe	0.2
		Northern Rocky Mountain Lower Montane-Foothill-Valley Grassland	0.5
		Northern Rocky Mountain Montane-Foothill Deciduous Shrubland	0.8
		Northern Rocky Mountain Subalpine Deciduous Shrubland	0.2
		Northern Rocky Mountain Subalpine-Upper Montane Grassland	0.5
		Quercus gambelii Shrubland Alliance	0.8
		Recently Burned-Herb and Grass Cover	0.8
		Recently Disturbed Developed Upland Herbaceous	0.2

Table 4-2 Habitat Suitability Values

Spatial data layers	Data Source	Factors Used	Suitability Value
		Recently Disturbed Developed Upland Shrubland	0.2
		Rocky Mountain Alpine Dwarf-Shrubland	0.2
		Rocky Mountain Alpine Fell-Field	0.2
		Rocky Mountain Alpine Turf	0.2
		Rocky Mountain Alpine/Montane Sparsely Vegetated Systems	0.5
		Rocky Mountain Gambel Oak-Mixed Montane Shrubland	0.5
		Rocky Mountain Lower Montane-Foothill Shrubland	0.5
		Rocky Mountain Montane Riparian Systems	0.2
		Rocky Mountain Subalpine/Upper Montane Riparian Systems	0.2
		Rocky Mountain Subalpine-Montane Mesic Meadow	0.5
		Sierra Nevada Alpine Dwarf-Shrubland	0.2
		Sonora-Mojave Semi-Desert Chaparral	0.5
		Southern Rocky Mountain Montane-Subalpine Grassland	0.8
		Western Great Plains Floodplain Systems	0.2
		Wyoming Basins Dwarf Sagebrush Shrubland and Steppe	0.8
		NASS-Close Grown Crop	0.2
		NASS-Fallow/Idle Cropland	0.2
		NASS-Pasture and Hayland	0.5
		Agriculture-Pasture and Hay	0.2
		Agriculture-Cultivated Crops and Irrigated Agriculture	0.2
		Recently Disturbed Pasture and Hayland	0.5
Slope	USGS National Elevation Dataset (NED)	< 5%	1.0
		5 - 20%	0.6
		> 20%	0.3
Elevation	USGS National Elevation Dataset (NED)	0 - 1700ft	1.0
		1700 - 2100ft	0.6
		> 2100 ft	0.0
Road Density	TIGER Line Roads Census 2000	0 - 0.5 km/km2	0.9
		0.5 - 1 km/km2	0.8
		1 - 2 km/km2	0.8
		2 - 4 km/km2	0.4
		4 - 6 km/km2	0.3
		6 - 8 km/km2	0.2
		8 - 10 km/km2	0.1
		10 km/km2 and above	0.0

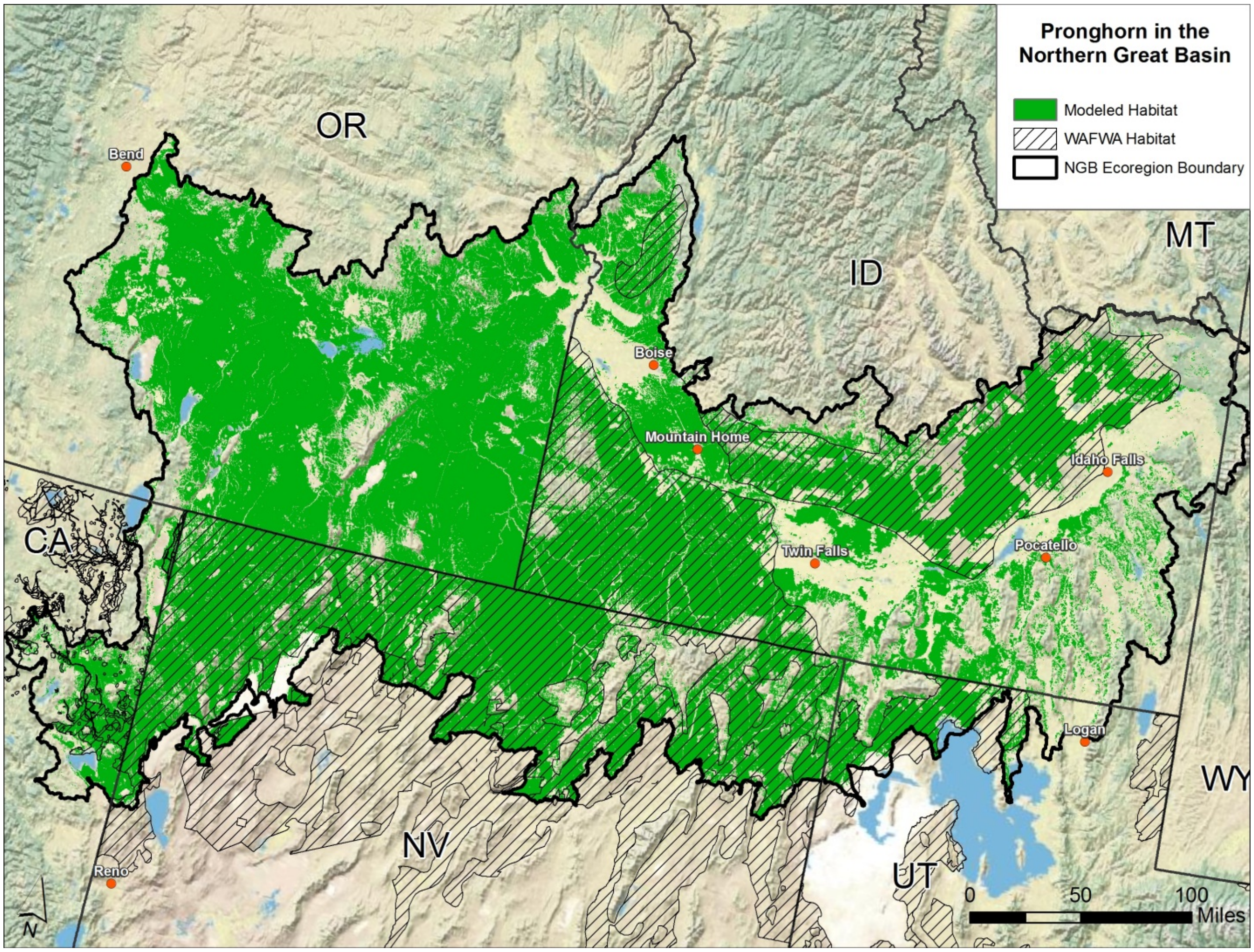


Figure 4-1. WAFWA Pronghorn Datasets

4.3 Data Gaps, Uncertainty, and Limitations

4.3.1 Data Gaps

An accurate estimation of urban/exurban development geospatial dataset was not available. After discussions with Rolling Review Team and AMT no substitute was determined. Gas/oil well data was retrieved and reviewed. After discussion with AMT and Rolling Review Team it was concluded that data represented geothermal production sites, which were assumed not to have a serious impact on pronghorn in the region. The AMT concluded that oil and gas wells were not abundant enough in the ecoregion to be considered as a key ecological attribute and were not used.

4.3.2 Uncertainty

Modeled pronghorn habitat was developed using an expert opinion modeling approach that incorporated estimated habitat suitability throughout the ecoregion without ground-truthing of modeled output. However, modeled pronghorn habitat distributions the modeled habitat outputs were compared to existing agency data and visually assessed by biological experts of the Rolling Review Team.

5 System Models

Conceptual system models were developed as part of the pre-assessment phase to assist with the determination of the key factors that are important to pronghorn in the NGB ecoregion. The model was developed to provide an ecological framework and justification for the choice of indicators that were used in assessing CA threats for this CE. This model incorporates the identified CAs, as well as potential effects from the actions of the CAs on both the landscape and local habitat/terrain levels (Figure 5-1). Being conceptual in nature, all potential important stressors and effects were included regardless of availability of data at this point in the REA. As for bighorn sheep that require large home ranges, the conceptual models depict effects on two scales, the landscape level and at the local habitat/terrain scale. This allows the model to be able to focus on site–level CA effects to certain CE habitat needs that may differ from landscape level effects. Examples of some of these critical, local terrain or habitat types recognized in the conceptual model presented in this memo include winter range, water sources, and areas with high visibility (Figure 5-1). Those elements that could not be carried forward for analysis will be discussed. Important habitat requirements depicted in the Local Habitat/Terrain blue box may include unmappable elements but were important to include as they affect habitat choices for pronghorn (Figure 5-1). These include "High Visibility" areas preferred by pronghorn to be able to watch for predators and, conversely, areas that have visual obstructions such as trees or tall shrubs are generally avoided.

5.1 Change Agents

The CAs considered for this CE analysis include development, climate change, invasive species, wildfire, and disease, depicted in brown boxes across the top of the figure (Figure 5-1). As indicated in Section 3, suitable pronghorn habitat depends upon factors including lack of cover such as trees and access to migration corridors. The system model indicates the relationships between the CAs that act upon the landscape and local pronghorn habitat needs and thereby, on the pronghorn functions and values, depicted in the lower box. The predicted results of CA effects are presented in blue boxes.

5.1.1 Development

Pronghorn evolved in open landscapes without vertical barriers. Fences often severely impede pronghorn movements (Spillet *et al.* 1967, Oakley and Riddle 1974, Mitchell 1980, Barrett 1982, Pyrah 1978, Hailey 1979); unlike deer species pronghorn rarely jump over fences. There is strong evidence that, if prevented from seasonal migration by obstacles, pronghorn may experience massive die-offs (Ryder *et al.* 1984). Other CAs included in the "Development" box that are important to analyze for effects to pronghorn include roads (Figure 5-1). Roads may also impair pronghorn access and use of winter range and seasonal movements. In southwestern Wyoming (Sheldon 2005) and in Arizona (Van Riper *et al.* 2001) unfenced roads appeared not to be a barrier to pronghorn movement, but the combination of heavy traffic volume (Buechner 1950) and fences along roads can be considerable barriers to movement (Ockenfels *et al.* 2007). Divided, interstate, and other high-volume (i.e., > 2,000 average annual daily traffic) highways are usually fenced to restrict pronghorn movements to designated crossing structures however, Yoakum (2004b) speculated that pronghorn behavior may prevent the use of under- and overpasses of high-volume highways.

The recent expansion of energy development in the West has the potential to have serious impacts to pronghorn and their long distance migration corridors (Hebblewhite 2008). Berger *et al.* (2006) showed that some pronghorn continued to use areas that were heavily developed, whereas other animals showed strong avoidance of such areas. Energy development resulted in avoidance of heavily developed areas by pronghorn and the total abandonment of the Jonah Field in Wyoming, which had previously been important winter transition range. Avoidance distances reported for pronghorn range from 0.25 miles

(0.4 km) (Autenrieth 1984) to 0.6 miles (0.96 km) (Easterly *et al.* 1991) from sources of disturbance. Pronghorn tended to avoid foraging in the habitat near well pads, even at night when human disturbance was reduced. Areas within 100 meters of gas wells were consistently avoided. Sawyer *et al.* (2002) suggested that energy development could sever migration corridors for pronghorn and could influence the distribution of pronghorn on winter ranges. In the NGB, the near-term future may likely include more alternative energy development than oil and gas, with similarly negative implications for pronghorn as oil and gas development.

5.1.2 Climate Change

Generally, changes in climatic and vegetative conditions trigger the onset and length of seasonal movements for pronghorn. If global climate change has an effect on timing of seasonal temperature changes, this may affect initiation of migration. Also, precipitation amounts and spatial distribution play a role in pronghorn fitness and reproductive success. Numerous studies have reported positive associations between pronghorn fawn survival and both the previous growing season precipitation and current season precipitation (Byers and Hogg 1995, Fairbanks 1994, Gregg *et al.* 2001). The greater the winter severity, the farther individuals and herds travel to areas with less snow (Creek 1967, Yoakum 1978, Guenzel 1986, Raper *et al.* 1989, Sawyer and Lindzey 2000) to avoid mortality that is often associated with snow depths exceeding 15 inches (38 cm) (Yoakum *et al.* 1996). Winter precipitation, specifically snow depth, also may affect recruitment (Smyser 2006).

5.1.3 Wildfire

Wildfire is considered one of the key factors affecting pronghorn migration and winter habitat. Moderate fire return intervals and low intensity fires are necessary to maintain the mixed composition of sagebrush communities that provide the forage and open migration habitat pronghorn require. The biggest threat to maintaining pronghorn habitat is fire suppression that causes “decadent” sagebrush conditions with excessive shrub heights or tree encroachment and loss of the open character of the landscape. Pronghorn generally avoid trees and woodland habitats within 100 m (Ockenfels *et al.* 1994, Yoakum 2004a).

5.1.4 Invasive Species and Disease

Hemorrhagic disease is caused by either of two closely related viruses, epizootic hemorrhagic disease (EHD) virus or bluetongue virus (SCWDS Group 2012). Because disease features produced by these viruses are indistinguishable, a general term, hemorrhagic disease, often is used when the specific virus responsible is unknown. These viruses are seasonal, transmitted by biting flies, and fatal within 24 hours after a 7 to 10-day incubation period. Domestic and wild ruminants have been infected with SCWDS Group 2012 including pronghorn, deer, and bighorn sheep. EHD was reported as severe in white-tailed deer in the central and eastern portions of Montana in 2011 (Pierce 2011). It is not certain at this point in the REA if invasive species and/or disease, which are included in the model, will play an important role in analyses for pronghorn. These types of CAs can be explored in more detail and refined as the REA process moves forward.

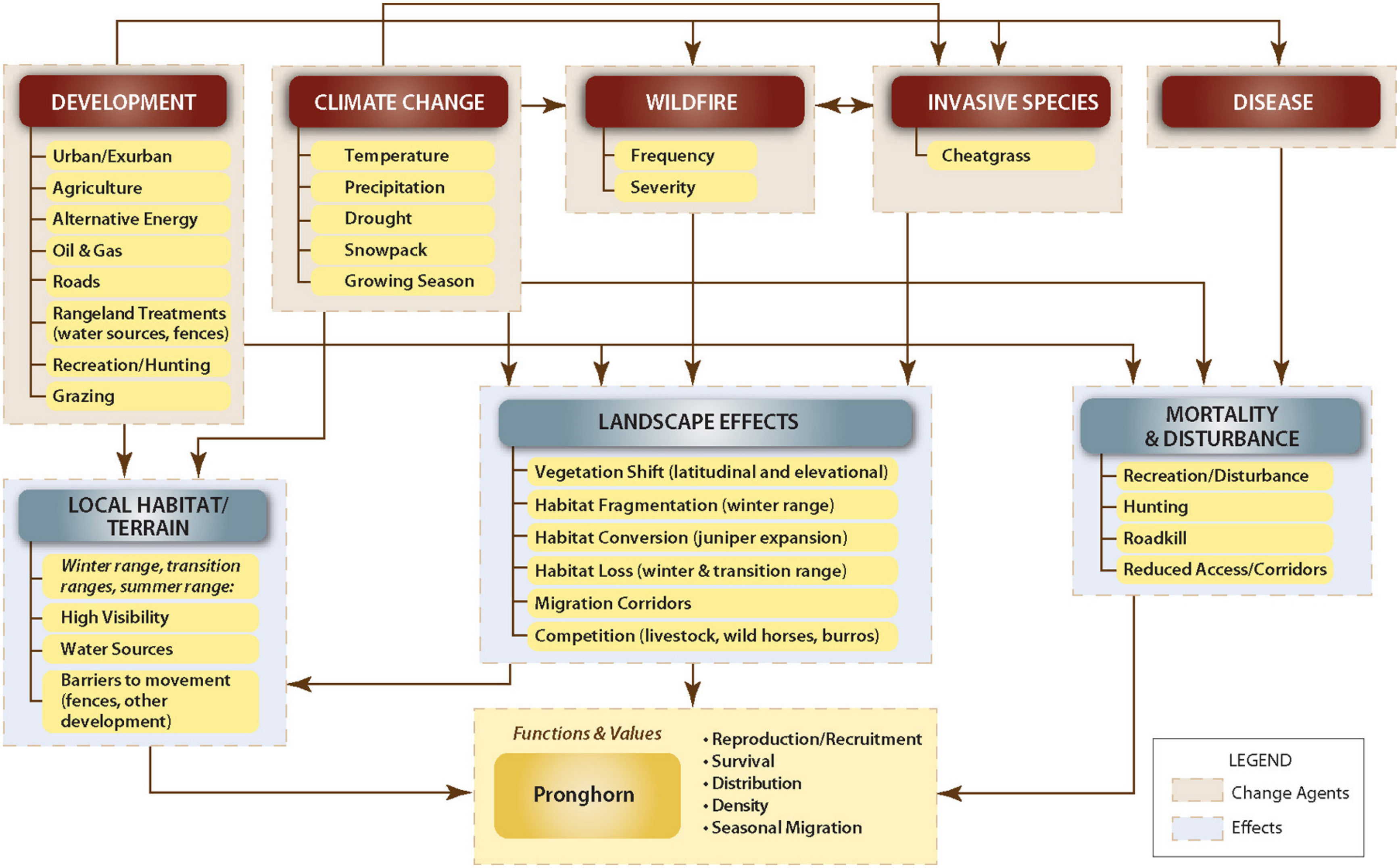


Figure 5-1. Pronghorn Conceptual Model

6 Change Agent Threat Analysis

Current status and future threat assessments for the pronghorn CE were conducted for the NGB ecoregion using 30m pixel, 4 km and 12-digit HUC as the analysis units. Based on the conceptual system model for the species (Figure 5-1), preliminary key ecological attributes were identified for the current status and future threat analyses with an emphasis on the feasibility of measuring impacts that result from application of CAs using geospatial data. The CAs evaluated for current status includes development, wildfire, climate change, invasive species, and disease. Future revisions of this CE package will incorporate input from the Rolling Review Team and explain any key ecological attributes and CAs that were revised or dropped from the analysis.

6.1 Key Ecological Attributes

The Table 6-1 provides several indicators for assessing key ecological attributes of habitat size, condition, and landscape context with emphasis on those that are mappable and measureable such as anthropomorphic influences. The metrics presented in the table were derived from the current literature, where possible. The key ecological attributes primarily include conditions that exist as specific data layers or can be inferred with reasonable precision from existing data layers. Although the Indicator "Slope" is not a CA, per se, it is a modifier to the risk imposed by CAs, such that impacts on relatively flat areas are weighted more heavily than those on steeper (> 20%) lands, which are less used by pronghorn. Slope categories were based on recommendations by Longshore and Lowrey (2008): slopes > 5% and ≤ 20% were rated as medium suitability as pronghorn habitat and slopes > 20% were rated as "poor". "Flats," ≤ 5% slope by definition, were rated as "good".

Pronghorn, unlike deer species, do not jump over fences, which present a major impediment to movement. Because many roads in the ecoregion, both paved and unpaved, are accompanied by livestock fences, and because a comprehensive fence data layer was not available, the pronghorn model considered areas with a high road density to be less suitable for pronghorn travel than less-roaded areas. Although distance to water may influence pronghorn habitat suitability, especially during summer, a complete map of water sources (including both natural and artificial water sources) was not available for the ecoregion and thus was not included in this model.

The preliminary list of key ecological attributes was compiled to provide indicators for assessing core habitat size, condition, and landscape context with respect to anthropomorphic influences. During the course of the analysis, data availability and consistency concerns caused the elimination of several of these preliminary key ecological attributes with concurrence by Rolling Review Team and Subject Matter Experts. The following key ecological attributes were eliminated:

- Corridor Width at Narrowest Point is an important aspect of the quality and utility of migration corridors for pronghorn. However, this indicator was excluded from the analysis because no conclusive and consistent data set was available that either identified migratory herds and their summer and winter ranges or migration corridors of pronghorn throughout the ecoregion.
- Fire regime data (VCC/FRCC) was reviewed and discussed with AMT and was determined to have a high level of error in shrubland and grassland cover types. Therefore, the VCC data was not evaluated because results would not be reliably indicative of conditions on the ground. Fire perimeters and frequency data were suggested as surrogates, however it was found that historical data was not reliable enough to base analysis upon.

- Edge to Perimeter Ratio: The edge to perimeter ratio of the habitat was determined to be a measure of fine-grained habitat rather than that of a landscape scale assessment. It was eliminated from the analysis because no quantitative metrics could be found in the literature.
- Energy Development: This metric essentially focuses on the density of energy development sites throughout the landscape. Similar to "Distance to other Development" the AMT and Rolling Review Team it was concluded that that the oil/gas well dataset actually represented geothermal production sites, which were assumed not to have a serious impact on pronghorn in the region; therefore this metric was not assessed
- Distance to Urban/Exurban: An accurate estimation of urban/exurban development geospatial dataset was not available. After discussions with Rolling Review Team and AMT no substitute was determined.

Table 6-1. List of Pronghorn Key Ecological Attributes and Indicators

Category	Ecological Attribute	Indicator	Metrics	Data Source	Reference
Size	Patch Size	Availability of contiguous, large native habitat patches (native grasslands, shrublands) and unfenced croplands	> 500 ha=good 300-500 ha = fair < 300 ha = poor	GAP	Berger et al 2006
	Travel Corridors/ Connectivity	Width at narrowest point	< 1000 m = poor 1000-2000 m = fair > 2000 m =good	State game agencies	Sawyer *et al.* 2005
Condition	Vegetation Condition	Fire regime condition class (FRCC)	3 = poor 2 = fair 1 = good	LANDFIRE, GAP, national land cover dataset	LANDFIRE
	Vegetation Cover	Proportion of native sagebrush and grassland habitats	< 25% = poor 25-50% = fair > 50% = good	GAP	Yoakum 2004 a
Context	Fragmentation	Edge to perimeter ratio	High = good Medium = fair Low = poor	GAP	O'Gara and Yoakum 1992
	Permeability	Predicted mean snow depth	< 15 in = good > 15 in = poor	NOAA	Sawyer et al 2005
	Landscape Preference	Slope (used as weighting factor for CAs)	< 5% = high impact (1.0) 5-20% = fair impact (0.6) >20% = low impact (0.3)	National Elevation Dataset	Longshore and Lowrey 2008
	Development	Distance to oil/gas well	< 150 m = poor 150-1000 m = medium > 1000 m = good	No Data	Poor 2010
		Density of oil and gas wells	< .10/km^2= good 0.1-0.4 wells/km^2 = fair > 0.4 wells/km^2 = poor	NoData	Hebblewhite 2008
		Distance to roads	< 300 m = poor 300-1000 m = fair > 1000 m = good	TIGER	Poor 2010
		Linear density of roads	<0.18 km/ km^2 =good 0.18-1.05 km/ km^2 =fair > 1.05 km/ km^2 = poor	TIGER	Hebblewhite 2008

6.2 Current Status of the CE

This section documents the CA analysis under current conditions, i.e. the current extent of the CE's distribution and locations of the CAs. For each of the key ecological attributes listed in Table 6-1 and used in the CA analysis, a discussion of the indicator, metrics, metric rank and value, data source(s), and references is provided. The analysis was based on spatially available attributes affecting the CE at the ecoregion level.

6.2.1 Size

6.2.1.1 Availability of Contiguous Patches

The habitat output layer was classified based on the patch acreage ranges established for this indicator and assigned associated values between 1 and 3, here a value of '1' represented 'Lower Quality" (< 300 ha) and a value of '3' represented "Preferred" (>500ha). This layer was converted to raster with assigned values. Zonal statistics were applied against the layer using the 4 km grid GIS layer to determine an overall summary score for the patches contained within each 4 km grid cell. Most of the modeled habitat (Figure 6-1) scored within the preferred range with the few exceptions being around urbanized areas and the eastern mountain ranges.

6.2.2 Condition

6.2.2.1 Proportion of Native Sagebrush and Grassland Habitats

Sagebrush and grassland cover was extracted from the LANDFIRE existing vegetation cover to identify areas that with the cover. The existing vegetation cover data is then run through a Focal Statistics to determine the mean vegetation cover over an 11x11 cell moving window within a 30m grid. The existing vegetation cover data in Figure 6-2 shows the amount of sagebrush and grassland across the pronghorn habitat. The cover is within the preferred range except in urban areas and at higher elevation ranges.

6.2.3 Context

6.2.3.1 Predicted Mean Snow Depth

NOAA total mean monthly snow depth data was obtained and represents the mean monthly total accumulation derived from 4km raster data. It does not incorporate melting, compression or sublimation. The data scoring categories were adjusted from those referenced in Table 6-1 because the snow depth data was provided in these fixed categories. The breakouts were depths less than 15 inches were preferred and over 15 inches were low quality. Snow depth data for the month of March was selected for analysis based on the importance of snowmelt and spring greenup to provide nutrition to late gestational does, and in restricting the amount of habitat and migration corridors that are available to migratory pronghorn. Most of the modeled pronghorn habitat scored as preferred with the exceptions of higher elevation mountainous regions as displayed in Figure 6-3.

6.2.3.2 Slope

Percent slope was analyzed by modeling the USGS NED raster for slope values. The slope grid was then reclassified into three categories reflecting the pronghorn's preference for flat landscapes. Slope values of 5% or less were categorized as preferred and those above 20% were low quality while 5 – 20% was deemed fair. The slope data analyzed by zonal statistics to determine the most common slope within a 4km grid.

Figure 6-4 illustrates that most of the best pronghorn habitat is on valley floors.

6.2.3.3 Distance to Roads

Roads limit connectivity through the creation of physical barriers such as right-of-way fences, increased mortalities due to collisions, and behavioral responses (avoidance of roads or high traffic volumes (WHCWG 2010). This key ecological attribute was used as an indicator to assess potential impacts from development.

Road features were identified using TIGER line data and those features mapped as freeways, secondary roads and local roads were selected. Summary zonal statistics were applied to the graded data to generate a rating for each grid cell included within the 4km grid dataset. A proximity analysis was performed and then assigned scores based on the metric values presented in Table 6-1. The distance to roads analysis for modeled pronghorn habitat is presented in Figure 6-5. Habitat located within/adjacent to urbanized or agricultural areas received lower quality ratings since these regions generally associated with a higher level of transportation networks.

6.2.3.4 Road Density

This key ecological attribute provided an additional method to assess potential impacts from development. Road features were identified using TIGER line data and those features mapped as freeways, secondary roads and local roads were selected. A moving window analysis was applied, which used a window area of a square kilometer to determine kilometers of road per square kilometer. Output from the analysis was scored based on the criteria documented in Table 6-1, where road density values less than 0.18 km/km^2 were scored as a 3 (“preferred”), densities between .18 and 1.0518 km/km^2 scored as a 2, and road density values greater than 1.0518 km/km^2 received a score of 1 (“lower quality”). Summary zonal statistics were applied to the graded data to generate a rating for each grid cell included within the 4km grid dataset. The distance to roads analysis for pronghorn habitat is presented in Figure 6-6.

The majority pronghorn habitat was rated as preferred. Habitat located within/adjacent to urbanized or agricultural areas received lower quality ratings since these regions generally associated with a higher level of transportation networks.

6.2.4 Cumulative Indicator Score

Six of the key ecological attributes were used to create a cumulative indicator score for pronghorn habitat (patch size, slope, native vegetation cover, predicted mean snow depth, distance to roads, and road density) The individual metrics for the key ecological attributes were scored with a 1, 2 or 3 with 1 given to lowest quality indicator and 3 given to the highest quality indicator. The six key ecological attributes were then added together using raster calculator to derive a range of cumulative scores from ten to eighteen. Figure 6-7 shows the resulting high and low scoring areas with a stretched raster for pronghorn habitat. The stretched raster was used to show the gradient from low scoring to high scoring 4km analysis units. Overall habitat scores were in the preferred range, but in many areas, the landscape is a heterogeneous mixture of preferred and degraded conditions, which may affect population productivity, persistence and distribution. As landscapes become more fragmented and heterogeneous in quality, pronghorn are increasingly unable to move in response to changes in habitat quality and thus become isolated, disjunct occurrences with a high potential for localized population declines.

6.3 Future Threats

6.3.1 Climate Change

Climate change effects on big game species are primarily related to changes in vegetation communities, fire regimes, plant productivity, water availability (in arid environments), and the amount and persistence of snow pack affecting winter range. The predicted changes associated with climate change for the NGB pronghorn ranges include increasing winter and spring precipitation. Where this precipitation falls as snow, it may restrict pronghorn from moving between habitats and thus seasonal migrations. Increased early season precipitation may favor the spread of cheatgrass in pronghorn habitats, which may displace native shrubsteppe communities and exacerbate fire frequency and extent by providing more abundant continuous fuel sources during the dry summer months.

6.3.2 Development

Most of the pronghorn range throughout the NGB ecoregion is already fragmented and affected by roads, agriculture and development. Increasing development, and possibly energy exploitation will cause further habitat decline and add additional stressors to an already stressed species. Like greater sage-grouse, pronghorn are a shrubsteppe obligate species, and as sagebrush communities are converted, degraded or altered, pronghorn populations are expected to decline.

6.3.3 Wildfire and invasive species

Wildfire is a major factor in the nutritional ecology and habitat dynamics for pronghorn. Pronghorn are adapted to a mosaic of age classes of sagebrush and other shrubs maintained by natural fire regimes, which tend to produce a reliable source of high quality browse and sufficient cover for fawns from predators. Due to cheatgrass invasion, poor grazing management and increasing frequency of droughts, wildfires now are larger and occur more frequently, reducing habitat quality and quantity of sagebrush communities. With an increasing number of fires exceeding 100,000 acres during the last decade, fire is currently the major contributing factor to the transition of many shrubsteppe ecological states to grass dominated conditions (especially when coupled with cheatgrass invasions). For example, increasing cheatgrass cover is predicted for northwestern Nevada and other portions of the ecoregion with significant risk of invasion into some of the best and least-fragmented pronghorn habitat that is remaining in the ecoregion.

6.3.4 Grazing

Grazing by domestic livestock has been traditionally viewed as one of the major factors affecting habitat quality for pronghorn (Yoakum 2004). Although cattle and pronghorn tend not to compete for forage directly, effects of poor grazing management have led to the deterioration of pronghorn habitat throughout the west. Fencing for livestock may also restrict pronghorn movements, and wildlife-friendly fence construction or modification are major management emphasis in pronghorn range. As grazing intensity and frequency is largely determined by climatic conditions and plant productivity, a continuation of these risks for pronghorn is to be expected.

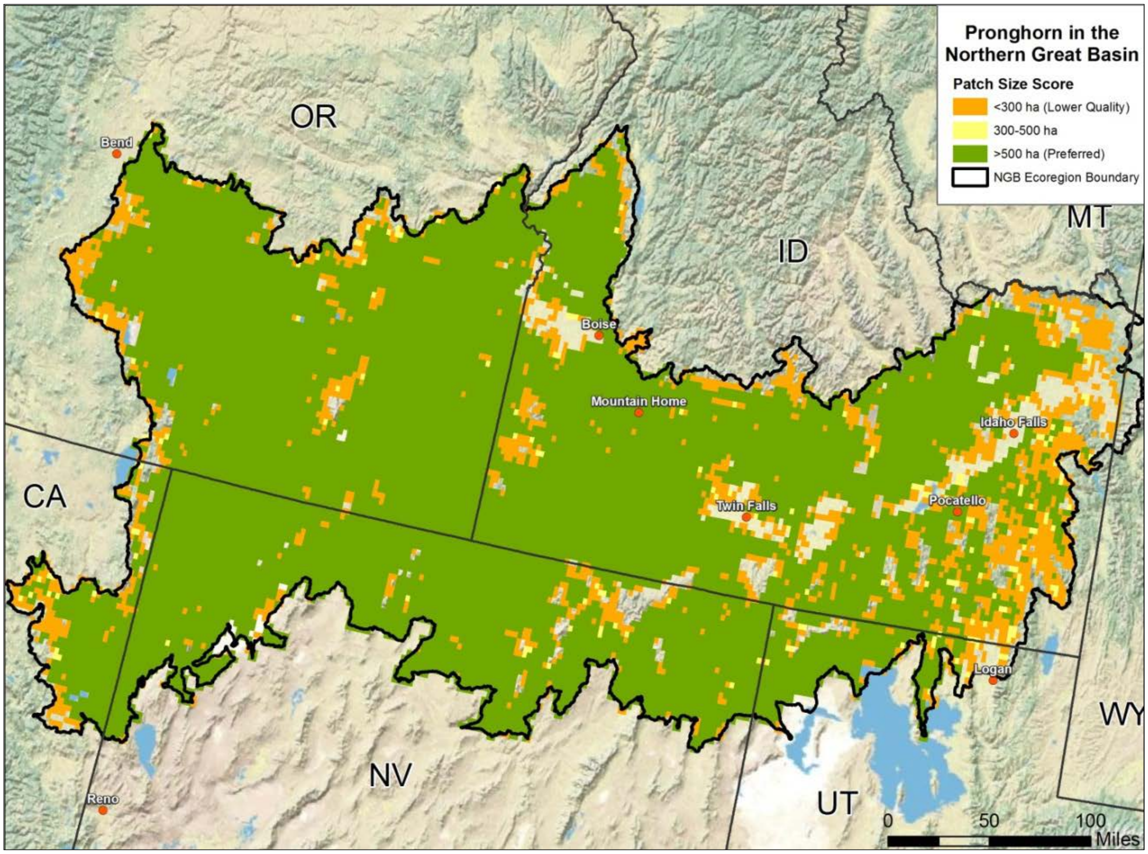


Figure 6-1. Patch Habitat Score for Modeled Pronghorn Habitat

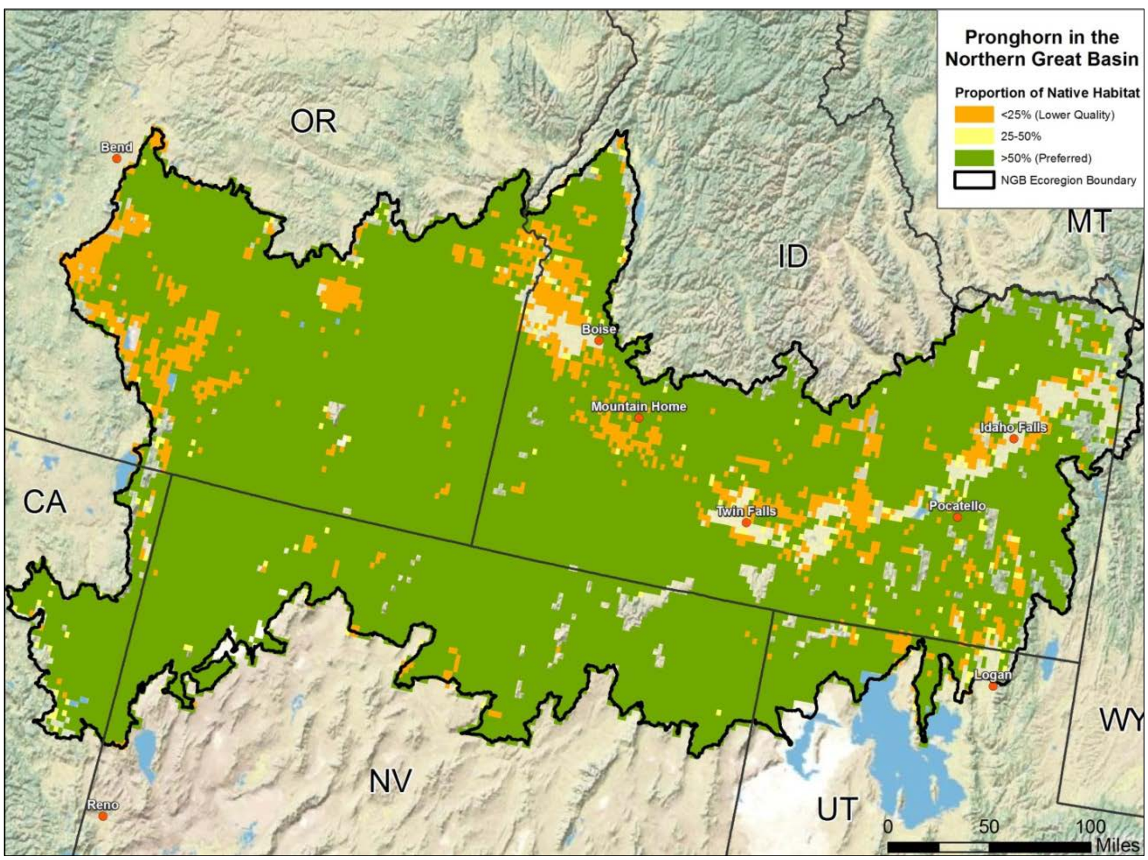


Figure 6-2. Native sagebrush and grassland Score for Modeled Pronghorn Habitat

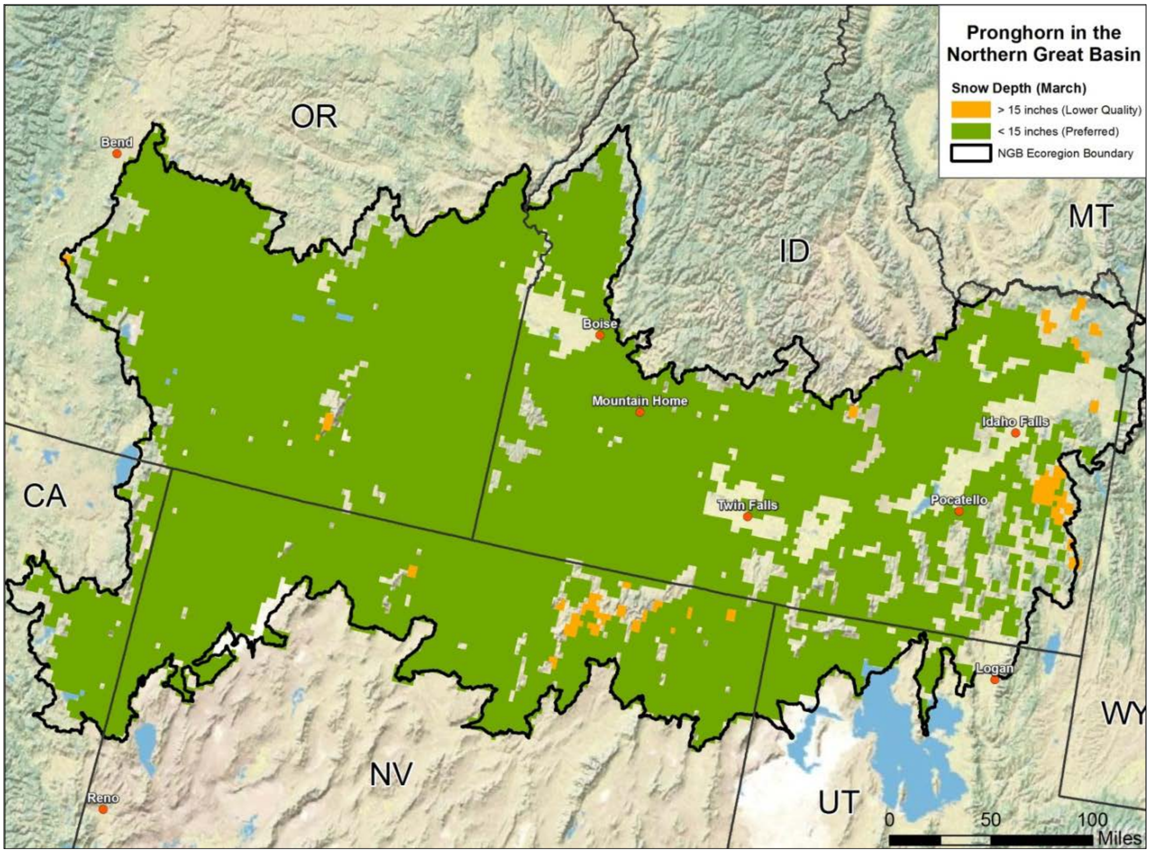


Figure 6-3. Snow Depth Score for Modeled Pronghorn Habitat

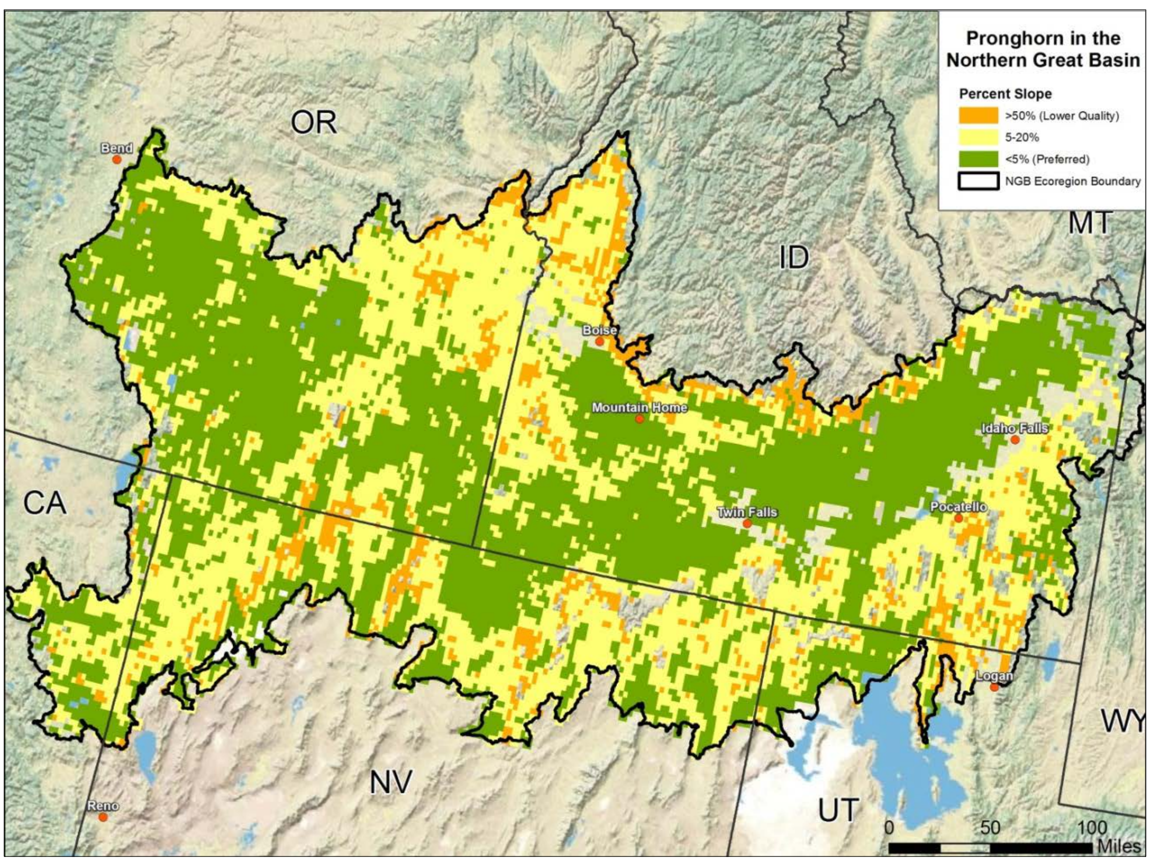


Figure 6-4. Slope Score for Modeled Pronghorn Habitat

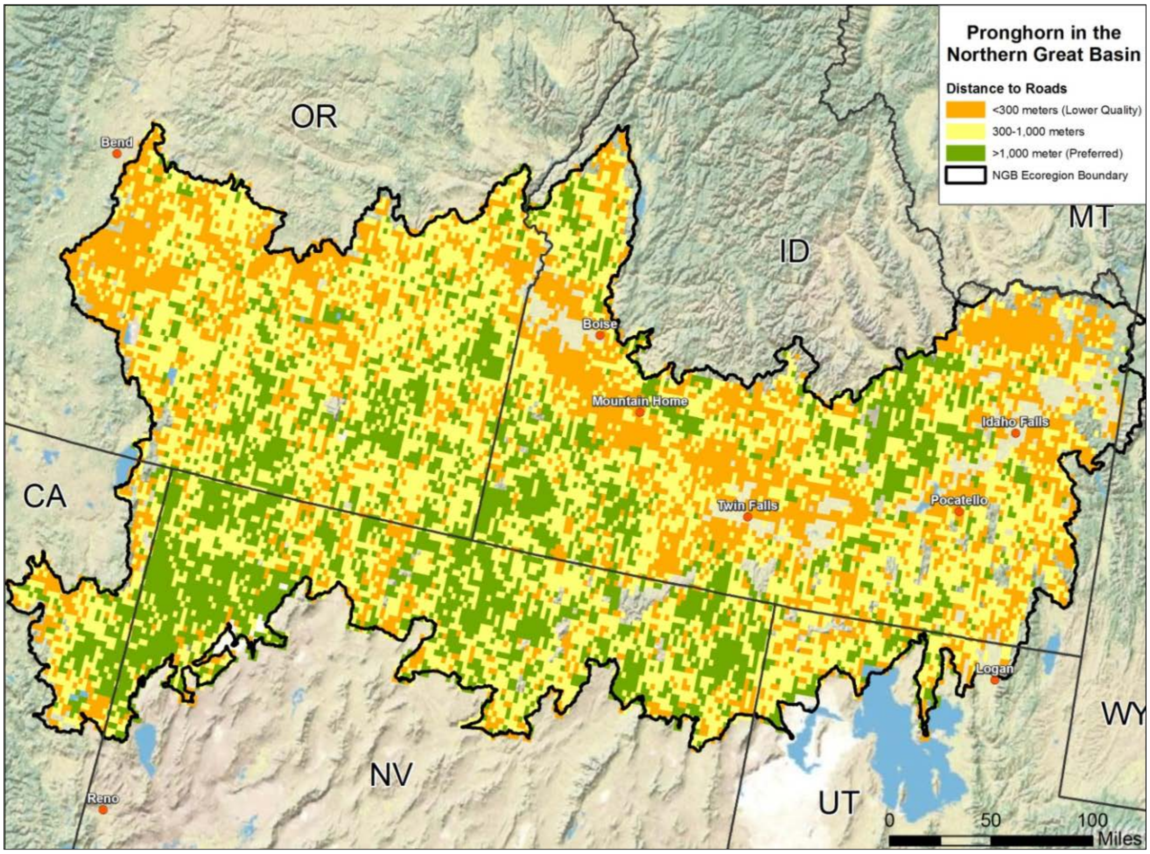


Figure 6-5. Distance to Road Score for Modeled Pronghorn Habitat

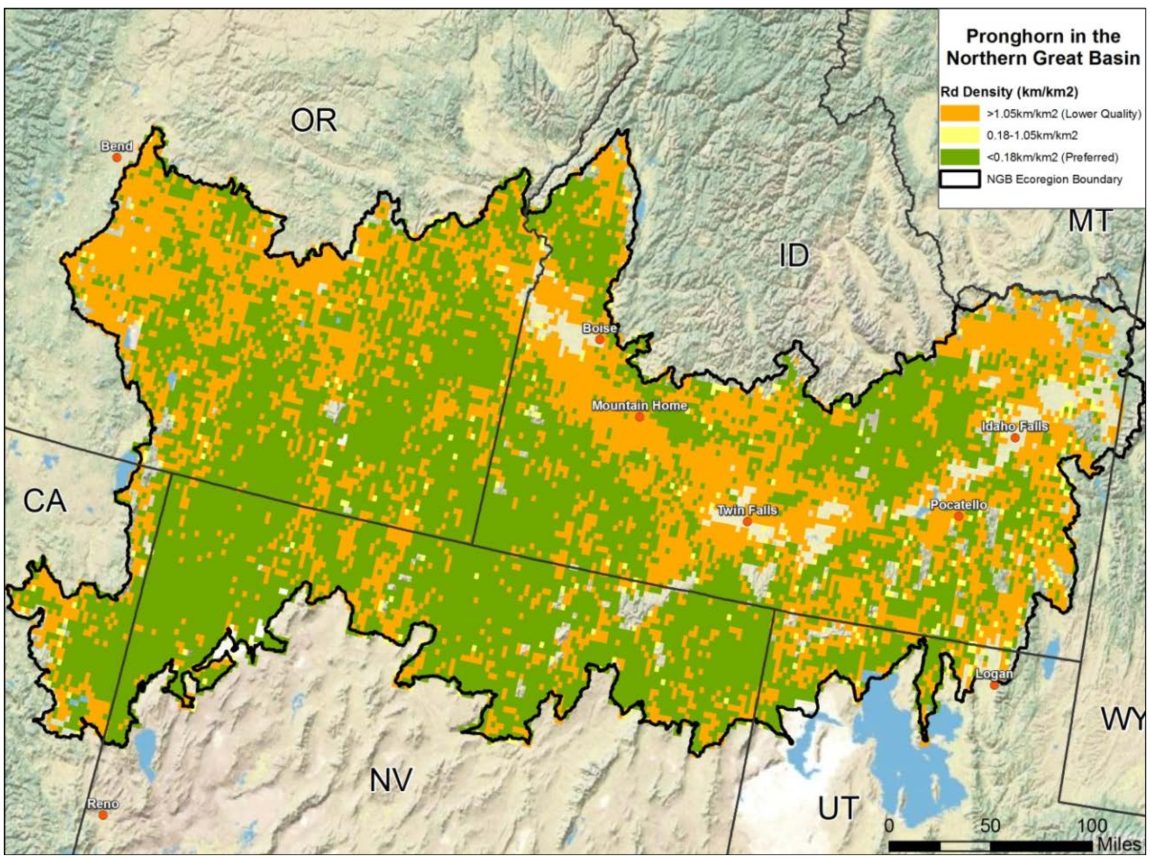


Figure 6-6. Road Density Score for Modeled Pronghorn Habitat

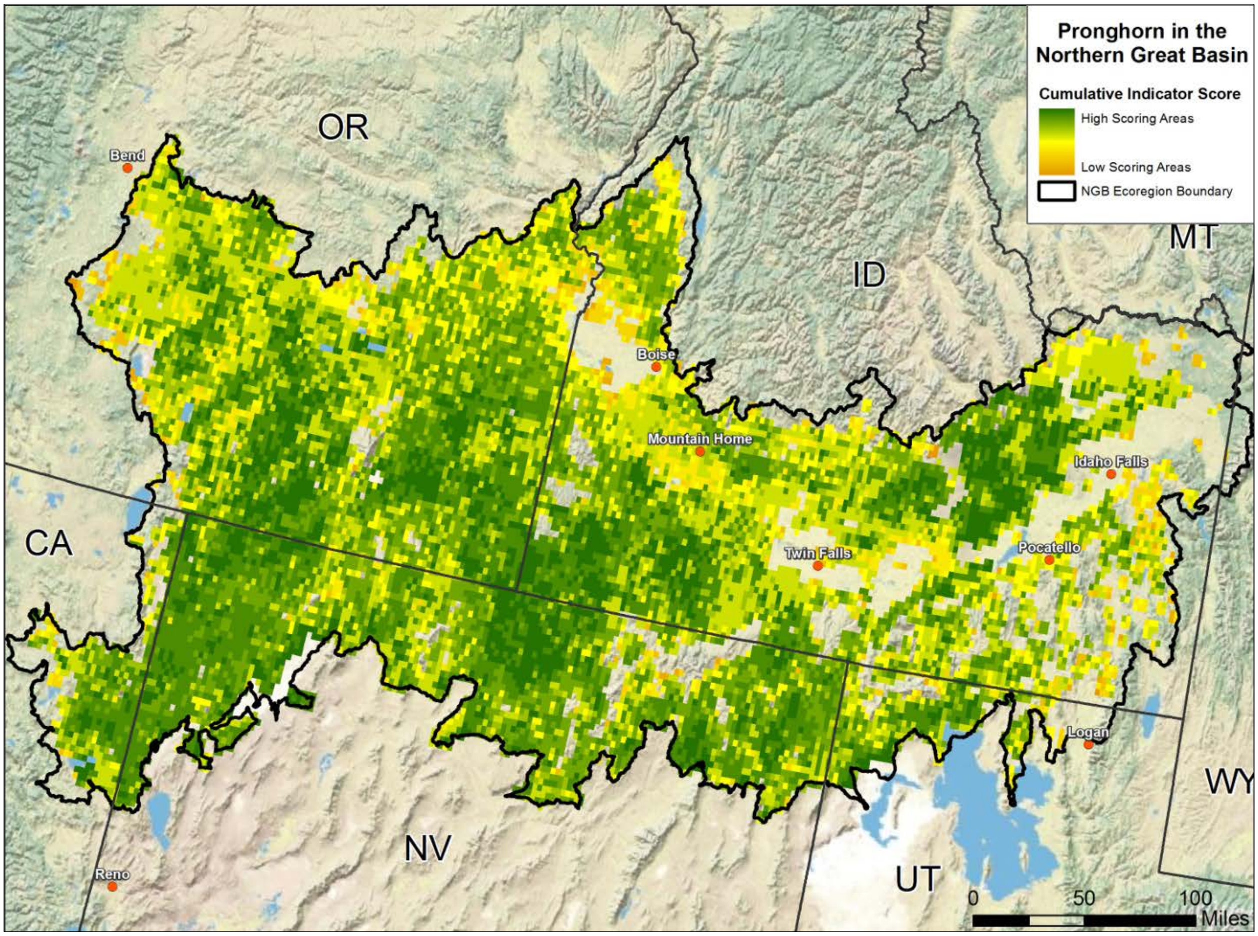


Figure 6-7. Cumulative score for Modeled Pronghorn Habitat

7 Management Questions

Management questions for the NGB were developed by BLM managers and refined by the AMT to answer questions regarding the agency's land management responsibilities—including planning land use, developing best management practices, authorizing uses, and establishing conservation and restoration priorities. Several management questions relate to this CE (with original numbering):

1 What is the currently occupied habitat or modeled suitable habitat for this CE?

The WAFWA habitat and modeled suitable habitat are shown in Figure 4-1.

2 Where are the areas of greatest and least collective impact of existing CAs on occupied habitat or modeled suitable habitats of this CE?

The cumulative indicator score for pronghorn are shown in Figure 6-7. Green areas have had the least collective impact and orange areas have had the greatest collective impact.

5 Where are current locations of this CE likely to overlap with the potential future distribution of CAs (other than climate change)?

Pronghorn have a wide distribution throughout the ecoregion and overlap with many of the future distribution in change agents. The Invasive CA package discusses the areas with potential risk for cheatgrass invasion, the wildfire CA provides the burn probability where future fires are more likely, and the development package provides the modeled future development around population centers.

6 Given current and anticipated future locations of CAs, which habitat areas remain as opportunities for habitat enhancement/restoration for this CE?

The cumulative indicator scores under current conditions (Figure 6-7) should be useful in identifying the areas most in need of preservation or the best restoration opportunities. Overall habitat scores were in the preferred range, but in many areas, the landscape is a heterogeneous mixture of preferred and degraded conditions, which may affect population productivity, persistence and distribution.

7 Where are potential areas to restore connectivity for this CE, based on current locations of CAs?

As landscapes become more fragmented and heterogeneous in quality, pronghorn are increasingly unable to move in response to changes in habitat quality and thus become isolated, disjunct occurrences with a high potential for localized population declines. Areas that are in close proximity to roads and have high road densities are shown in Figures 6-5 and 6-6, respectively. These areas are the focus of particular concern with respect to pronghorn movements because roadside fences and high volume traffic impede pronghorn movements. 8 Where will this CE experience climate outside their current climate envelope? Or: Where will this CE experience significant deviations from normal climate variation?

Climate change effects on big game species are primarily related to changes in vegetation communities, fire regimes, plant productivity, water availability (in arid environments), and the amount and persistence of snow pack affecting winter range. The predicted changes associated with climate change for the NGB pronghorn ranges include increasing winter and spring precipitation. Where this precipitation falls as snow, it may restrict pronghorn from moving between habitats and thus seasonal migrations. Increased early season precipitation may favor the spread of cheatgrass in pronghorn habitats, which may displace native shrubsteppe communities and exacerbate fire frequency and extent by providing more abundant continuous fuel sources during the dry summer months.

8 References

Allen, A.W., J.G. Cook, and M. J. Armbruster. 1984. Habitat suitability index models: Pronghorn. U.S. Fish and Wildlife Service. FWS/OBS-82/10.65. 22 pp. June.

Autenrieth, R.E. 1984. Little lost pronghorn fawn study - condition, habitat use and mortality. Proceedings Pronghorn Antelope Workshop 11:49-70.

Barrett, M.W. 1982. Distribution, behavior, and mortality of pronghorns during a severe winter in Alberta. Journal Wildlife Management 46:991–1002.

Bayless, S.R. 1969. Winter Food Habits, Range Use, and Home Range of Antelope in Montana. The Journal of Wildlife Management, 33(3): 538-551. July.

Beckmann, J. P., J. Berger, and K.M. Berger. 2006 Petroleum Development and Pronghorn: Where Are the Break Points? 22nd Biennial pronghorn workshop, P 178. Idaho Falls, Idaho.

Berger, J., K.M. Berger, and J.P. Beckmann. 2006. Wildlife and Energy Development: Pronghorn of the Upper Green River Basin – Year 1 Summary. Wildlife Conservation Society, Bronx, NY. Available at: http://www.wcs.org/media/file/Shell%20Year%201%20Progress%20REVISED%20III.pdf.

Bureau of Land Management (BLM). 2007. Surprise Proposed Resource Management Plan/Final Environmental Impact Statement. Vol. 1. Bureau of Land Management. Surprise Field Office. Cedarville, CA. Available at: http://www.blm.gov/ca/st/en/fo/surprise/propRMP-FEIS.html.

______. 2004. Andrews Management Unit/Steens Mountain Cooperative Management and Protection Area Proposed Resource Management Plan and Final Environmental Impact Statement. Vol. 1. Bureau of Land Management. Burns District Office. Hines, OR.

Buechner, H.K. 1950. Life history, ecology, and range use of the pronghorn antelope in Trans-Pecos Texas. American Midland Naturalist. 43(2): 257-354.

Byers, J.A. and J.T. Hogg. 1995. Environmental effects on prenatal growth rate in pronghorn and bighorn: further evidence for energy constraint on sex-biased maternal expenditure. Behavioral Ecology 6:451–457.

California Department of Fish and Game (CDFG). 2000. California Wildlife Habitat Relationship Database System, Version 7.0. Computer database and program. California Department of Fish and Game, Sacramento, California, USA.

Creek, D.E. 1967. A summary of pronghorn antelope investigations. Wyoming Game and Fish department, Cheyenne, Wyoming, USA.

Easterly, T.E., A.W. Wood, and T. Litchfield. 1991. “Responses of pronghorn and mule deer to petroleum development on crucial winter range in the Rattlesnake Hills.” Wyoming Game and Fish Department, Cheyenne, Wyoming. Unpublished report.

Fairbanks, W.S. 1994. Dominance, age, and aggression among female pronghorn, *Antilocapra americana* (Family: Antilocapridae). Ethology 97:278-293.

Feeney, D., D. Feeney, G. Beauvais, R. Coupal, S. Lanning, S. Lieske, N. Nibbelink, and K. Nordyke. 2004. Big Game Migration Corridors in Wyoming. University of Wyoming, Laramie Wyoming Cooperative Extension Service, Bulletin (B-1155).

Gregg, M.A., M. Bray, K.M. Kilbride, and M.R. Dunbar. 2001. Birth synchrony and survival of pronghorn fawns. Journal Wildlife Management 65:19-24.

Guenzel, R.J. 1986. Pronghorn ecology in southcentral Wyoming. Thesis, University of Wyoming, Laramie, Wyoming.

Hailey, T.L. 1979. A handbook for pronghorn antelope management in Texas. Texas Parks and Wildlife Department, Austin, Texas, USA.

Hebblewhite, M. 2008. A literature review of the effects of energy development on ungulates: Implications for central and eastern Montana. Report prepared for Montana Fish, Wildlife and Parks, Miles City, MT.

Hoskinson, R.L. and J.R. Tester. 1980. Migration behavior of pronghorn in southeastern Idaho. Jour. Wildl. Manage. 44: 132-144.

Longshore, K. and C. Lowrey. 2007. Habitat analysis and food habits of pronghorn antelope in the Carrizo Plain National Monument, California. U.S. Geological Survey, Western Ecological Research Center, Henderson, Nevada, USA.

Mitchell, G.J. 1980. The pronghorn antelope in Alberta. University of Regina, Saskatchewan, Canada. 165 pp.

Oakley, C. and P. Riddle. 1974. The impact of a severe winter and fences on antelope mortality in south-central Wyoming. Proceedings Pronghorn Antelope Workshop 6:155-173.

Ockenfels, R.A., J.C. deVos, and J.J. Hervert. 2007. Transportation corridors in Arizona and Mexico and pronghorn: Case studies. Road Ecology Center eScholarship Repository, John Muir Institute of the Environment, University California, Davis, California, accessed online at http://repositories.cdlib.org/cgi/viewcontent.cgi?article=1417&context=jmie/roadeco, July 2009.

Ockenfels, R.A., A. Alexander, C.L. Dorothy Ticer, and W.K. Carrel. 1994. Home Range Movement Patterns and Habitat Selection of Pronghorn in Central Arizona. Technical Report 13. Arizona Game and Fish Department, Phoenix, AZ.

O'Gara, B.W. and J.D. Yoakum. 1992. Pronghorn management guides. Pronghorn Antelope Workshop, Rock Springs, Wyoming, USA.

Penrod, K. W. Spencer, E. Rubin, and C. Paulman. April 2010. Habitat Connectivity Planning for ected Focal Species in the Carrizo Plain. Prepared for County of San Luis Obispo by SC Wildlands. http://www.scwildlands.org

Pierce, B. 2011. EHD outbreak takes toll on white-tailed deer. Available on internet at: populationhttp://www.bozemandailychronicle.com/sports/outdoors/article_d2064d34-0806-11e1-8695-001cc4c03286.html. Posted Sunday, November 6.

Poor, E. 2010. Modeling Pronghorn Migration Corridors in the Northern Great Plains. M.A. thesis, Nicholas School of the Environment, Duke University, Durham, NC.

Pyrah, D.B. 1978. American pronghorn antelope in the Yellow Water Triangle, Montana. Montana Department Fish, Wildlife and Parks, Helena, Montana, USA.

Raper, E., T. Christiansen, and B. Petch. 1989. Sublette antelope study: Final report. Pages 124-169 in Annual big game herd unit report. Wyoming Game and Fish Dept., Cheyenne, Wyoming.

Ryder, T.J., L.L. Irwin, and D.S. Moody. 1984. Wyoming's Red Rim pronghorn controversy: History and current status. Proc. Pronghorn Antelope Workshop. 11: 195-206.

Sawyer, H. and W. Rudd. 2005. Pronghorn roadway crossings: A review of available information and potential options. Online at http://gf.state.wy.us/downloads/pdf/pronghorn_report_final.pdf.

Sawyer, H., F. Lindzey, and D. McWhirter. 2005. Mule deer and pronghorn migration in western Wyoming. Wildlife Society Bulletin 33:1266-1273.

Sawyer, H., F. Lindzey, D. McWhirter, and K. Andrews. 2002. Potential effects of oil and gas development on mule deer and pronghorn populations in western Wyoming. Transactions North American Wildlife and Natural Resource Conference 67:350-365.

Sawyer, H. and F. Lindzey. 2000. The Jackson Hole pronghorn study. Wyoming Cooperative Fish and Wildlife Research Unit, University of Wyoming, Laramie, Wyoming. 57 pp.

Sheldon, D.P. 2005. Movement and distribution patterns of pronghorn in relation to roads and fences in southwestern Wyoming. Thesis. University of Wyoming, Laramie, Wyoming, USA.

Smyser, T.J., A.F. Reeve, and E.O. Garton. 2006. Evaluation of pronghorn population productivity relative to broad-scale habitat variables in Wyoming (1978-2003). Proceedings of Pronghorn Antelope Workshop 22.

Southeastern Cooperative Wildlife Disease Study Group (SCWDS Group). 2012. Information available on the internet at: http://www.growingdeer.tv/view/wp-content/uploads/2012/07/Epizootic-Hemorrhagic-Disease-Fact-Sheet.pdf. Accessed August 15, 2012.

Spillett, J.J., J.B. Low, and D. Sill. 1967. Livestock fences-how they influence pronghorn antelope movements. Bulletin 470, Agriculture Experiment Station. Utah State University, Logan, Utah, USA.

Van Riper III, C., J. Hart, and J. Bright. 2001. Effect of fenced transportation corridors on pronghorn antelope movements in Petrified Forest National Park, Arizona. Pages 71-74 in D. Harmon, editor. Crossing Boundaries in Park Management: Proceedings of the 11th Conference on Research and Resource Management in Parks and on Public Lands, George Wright Society, Hancock, Michigan, USA.

White, P.J., T.L. Davis, K.K. Barnowe-Meyer, R.L. Crabtree, and R.A. Garrott. 2007. Partial migration and philopatry of Yellowstone pronghorn. Biological Conservation 135:502-510.

Yoakum, J.D. 2004a Habitat characteristic and requirements. Pages 75-105 in B.W. O'Gara and J. D. Yoakum, Pronghorn: Ecology and Management. Colorado University Press, Boulder, Colorado, USA.

_____. 2004b. Foraging ecology, diet studies and nutrient values. Pages 447-502 in O'Gara B.W. and J. D. Yoakum. Pronghorn: Ecology and Management. Colorado University Press, Boulder, Colorado, USA.

_____. 2004c. Habitat Conservation. Pages 571-630 in O'Gara B.W. and J.D. Yoakum. Pronghorn: Ecology and Management. Colorado University Press, Boulder, Colorado, USA.

_____. 1978. Managing rangelands for the American pronghorn antelope. Proceedings Pronghorn Antelope Workshop 8:321-336.

Yoakum, J.D., B.W. O'Gara, and V.W. Howard. 1996. Pronghorn on western rangelands. Pages 211-226 in: Krausman, P.R. Rangeland Wildlife. Society Range Management, Denver, Colorado, USA.

Bighorn Sheep Conservation Element Package

1 Introduction

The bighorn sheep is one of the most widely recognized and iconic large mammals of the western U.S. Two subspecies of bighorn sheep, the California (*Ovis canadensis californiana*) and Rocky Mountain (*O.c. canadensis*) inhabit portions of the NGB. Westward expansion of human populations, the accompanying hunting of wildlife, use and conversion of native habitats and exposure to domestic livestock diseases led to bighorn sheep extirpation from Oregon by the mid 1940's (Oregon Department and Fish and Wildlife 2003). Land use changes have rendered much of the original wild sheep ranges unsuitable for occupancy. Present populations in Oregon are the result of reintroductions from California and occupy only a small percentage of historic ranges. Drastic population declines followed the arrival of homesteaders and other settlers in the late 1800s and early 1900s in Idaho (Idaho Department of Fish and Game 2010). Bighorn sheep remain a sought-after game species.

This CE package provides the assessment of the current status and future threats due to the applicable change agents (CAs) for bighorn sheep populations in the NGB ecoregion. Information in this CE package includes a brief description of the biology of bighorn sheep in the NGB ecoregion, a description of Change Agents (CA) that were assessed, a conceptual model of ecosystem functions relevant to bighorn sheep, information on available data sources and analytical methods for the assessment, and a full listing of relevant management questions for this CE. The primary CAs that were identified for bighorn sheep include development, climate change, invasive species, wildfire, and disease.

2 CE Package Review Process

2.1 Subject Matter Expert Review

Subject Matter Experts play a key role in ensuring that the REA reflects the best available data and modeling processes suitable for each conservation element and change agent. Subject Matter Experts were added to Rolling Review Teams comprised of SAIC scientists, SAIC GIS personnel, AMT member(s) and other subject matter experts from the Department of Interior or state agencies. Membership of the Rolling Review Teams is listed in Appendix A. To ensure consistency amongst the different Rolling Review Teams, the number of lead SAIC scientists was limited to only a few individuals. This ensured that there was a common approach, or framework, used among the different Rolling Review Teams and that one Rolling Review Team did not stray too far from the rest. The USGS, as peer reviewers, were invited to participate in Rolling Review Teams.

3 CE Description

California bighorn sheep populations are present in the steeper terrain of southeast Oregon, and the non-forested portions of the Deschutes and John Day River drainages below 8,000 feet with the forested regions of the Blue and Umatilla mountains separating them from Rocky Mountain bighorn sheep in the northeastern portion of Oregon (Oregon Department and Fish and Wildlife 2003). In Oregon, most California bighorn herds are non-migratory, preferring rugged, open habitats with high visibility of their surroundings. Survival is positively correlated with amount of cliff faces, rimrock, and rocky outcroppings, particularly important for lambing and escape from predators (Oregon Department and Fish and Wildlife 2003). Habitats used include alpine and sub-alpine, open grasslands, shrub-steppes, and canyons among low elevation steep bunchgrass slopes interspersed with rock rims.

Bighorn sheep in Nevada are reintroduced California bighorn sheep. The Rocky Mountain subspecies in Oregon and Idaho also relies on the proximity of steep, rocky escape terrain, especially when lambs are young. During the lambing season, ewes select steep inaccessible cliffs to give birth. Beyer (2008) reported that landscape ruggedness, aspect (favorable sun exposure for higher solar radiation index, more snow melt, and forage exposure) were important winter ranges habitat characteristics that affected population stability. Seasonal migrations occur in most populations, and open grasslands and shrublands typically provide winter ranges. Diets are diverse and can include grasses and sedges, browse, or forbs; forbs often contribute the greatest number of plant species eaten (Shackleton *et al.* 1999). Bighorn sheep (except young rams) avoid traversing valley bottoms and usually remain within close proximity to escape terrain.

4 CE Modeling

4.1 Data Identification

Table 4-1 lists the types of data and data sources that were originally proposed for use in the REA as part of the pre-assessment data identification effort. This table lists the need for the data, the general name of the dataset, if the dataset was acquired and if the data were used.

Table 4-1. Preliminary Bighorn Sheep Data Sources

Data Required	Dataset Name	Source Agency	Type/Scale	Status
Modeled Suitable Habitat				
Occurrence	WAFWA 2011	WAFWA	Polygon	Acquired
	Hunter groups	Northern Wild Sheep and Goat Council, Wild Sheep Working Group	Polygon	Not Acquired
Protected Areas	Conservation easements	CBI	Polygon	Acquired
	Wilderness areas	USGS, CBI	Polygon	Acquired
Lambing areas	State	State game agencies	Polygon	Data gap
Domestic Sheep/Goat Grazing Allotments	Grazing Allotments used by Domestic Sheep/ Goat	BLM	Polygon	Acquired

4.2 Distribution Mapping Methods

The AMT decided the main dataset to be used for the distribution of bighorn sheep within the ecoregion was the WAFWA 2011 dataset (Figure 4-1). This dataset is a combination of state data available with no additional information on ranges or habitats.

4.3 Data Gaps, Uncertainty, and Limitations

4.3.1 Data Gaps

The WAFWA 2011 dataset does not distinguish between the 2 subspecies of bighorn sheep with the exception of the Utah. After review by the AMT it was concluded that range extents would be assessed as one group rather two subspecies because this level of detail was not present for all states.

The WAFWA data does not distinguish between summer and winter range except in the case of Nevada. After review by the AMT it was concluded that the range data would be assessed as yearlong as opposed to breaking into seasons since this detail was not available for all states.

Disease transmission/proximity to sheep allotments is a significant management concerns. It was agreed to use BLM data on sheep allotments, and -where available- sheep trailing routes to assess the degree of separation between domestic sheep and bighorns in wild sheep habitat.

4.3.2 Uncertainty

Bighorn sheep are highly specialized ungulates requiring a narrow set of habitat conditions. Hence it is assumed that the original WAFWA data were reasonably accurate in terms of the distribution of the species in the NGB. However, the existence of bighorn sheep in each range was not verified. Bighorn sheep are prone to die-offs and local extinctions due to outbreaks of *pasteurella* infections of wild sheep. Likewise, transplanting of sheep into currently unoccupied range has become a standard management action of state agencies in the recent decades, and it is unclear how frequently the existing WAFWA data are updated to reflect such changes.

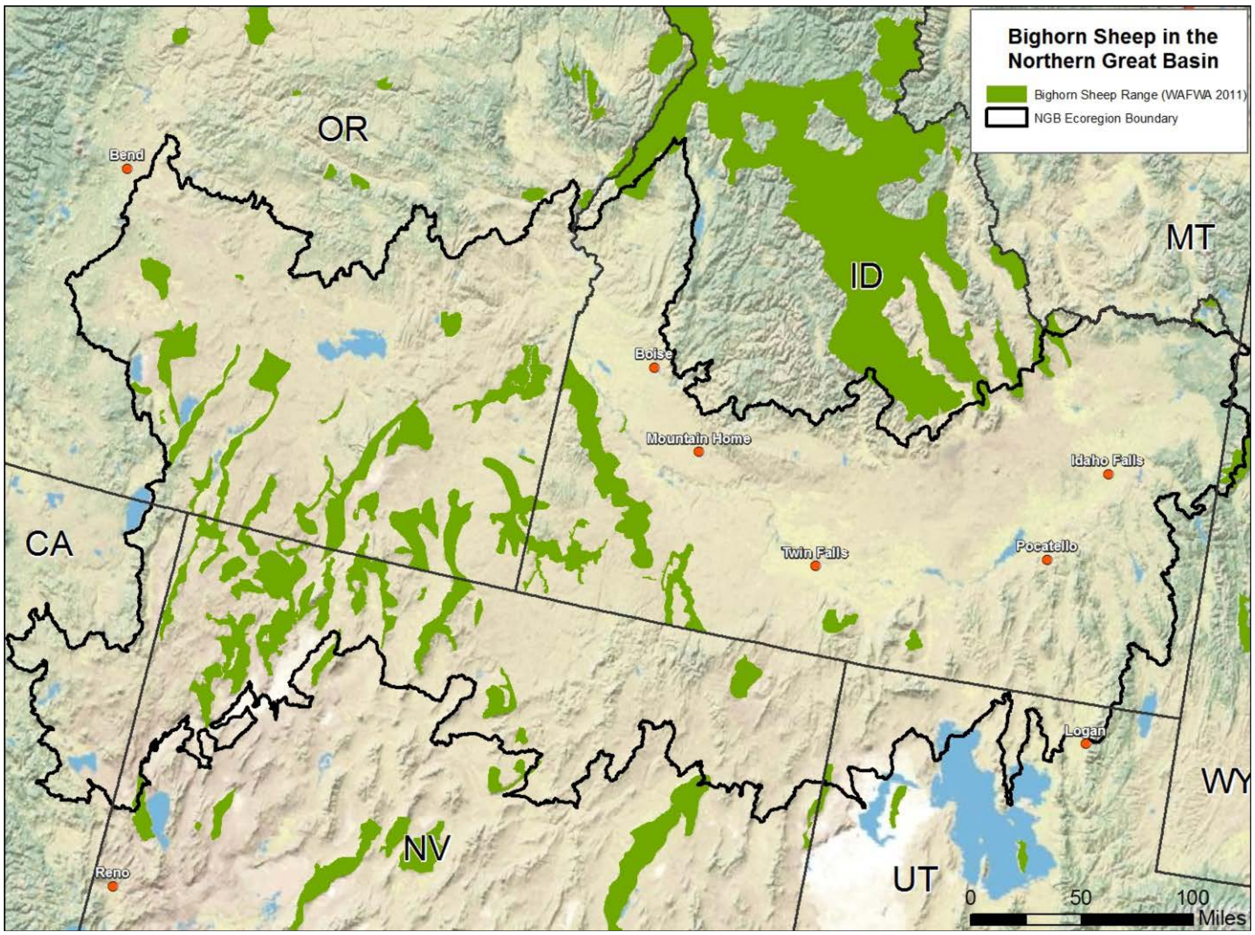


Figure 4-1. Bighorn sheep WAFWA range habitat (WAFWA 2011).

5 System Models

Conceptual system models were developed as part of the pre-assessment phase to assist with the determination of the key factors that are important to bighorn sheep in the NGB ecoregion. The model was developed to provide an ecological framework and justification for the choice of indicators that were used in assessing CA threats for this CE. This model begins with depicting the important habitat components of the bighorn sheep life cycle required throughout the year and incorporates the identified

CAs, as well as potential effects from the actions of the CAs on both the landscape and local habitat/terrain levels (Figure 5-1). The conceptual model depicts effects on two scales, the landscape level and at the local habitat/terrain scale. This allows the model to be able to focus on site–level CA effects to certain CE habitat needs that may differ from landscape level effects. Examples of some of these critical, local terrain or habitat types recognized in the conceptual model presented in this memo include winter range, slope and aspect, and areas with high visibility (Figure 5-1). Being conceptual in nature, all potential important stressors and effects were included regardless of availability of data at this point in the REA. Those elements that could not be carried forward for analysis were eliminated from further consideration and analysis. Important habitat requirements depicted in the Local Habitat/Terrain blue box may include unmappable elements but were important to include as they affect habitat choices for bighorn sheep (Figure 5-1). These include "High Visibility" areas preferred by bighorn sheep to be able to watch for predators and, conversely, areas that have visual obstructions such as trees or tall shrubs are generally avoided.

5.1 Change Agents

The CAs considered for this CE analysis include development, climate change, invasive species, wildfire, and disease, depicted in brown boxes across the top of the figure (Figure 5-1). As indicated in Section 3, suitable bighorn sheep habitat consists of factors including geology, slope, elevation, and lack of tree cover. The system model indicates the relationships between the CAs that act upon the landscape and local bighorn sheep habitat needs and thereby, on the bighorn sheep functions and values, depicted in the lower box (Figure 5-1). The predicted results of CA effects are presented in blue boxes.

5.2 Development

Specific development types that may limit bighorn health and habitat access include grazing of domestic sheep, mining, and military use of steep terrain and low level overflights. Helicopters have been shown to have an adverse effect on mountain bighorn sheep movements, habitat use, and foraging efficiency (Bleich *et al.* 1994). However, Krausman *et al.* (1993) found no long-term detrimental effects to penned desert bighorn sheep from jet overflights conducted about 125 m above ground level in Nevada.

Studies indicate that adversely impacts sheep by inducing flight (Papouchis *et al.* 2000) and stress responses (i.e. elevated heart rate) (MacArthur *et al.* 1982), and causing mortality (Cunningham and deVos 1992), Roads may impede movement between habitat patches (Cunningham 1982, Ough and deVos 1984) and may bisect traditional migration routes (Van Dyke *et al.*1983, Ough and DeVos 1984). Papouchis *et al.* (2000) reported that the average distance maintained by bighorn sheep from a road increased with frequency of traffic. Human use of a road along or through lambing, bedding, or watering areas may affect security and thus reduce overall habitat availability (Van Dyke *et al.* 1983, Jorgensen1974). Cunningham and deVos (1992) found that ewes with home ranges bisected by a state highway had a 24% probability of being killed while crossing the highway. In addition, bighorns exhibited elevated heart rates and flight responses to the presence of hikers (MacArthur 1979, Miller and Smith 1985, Papouchis *et al.* 2000).King and Workman (1986) noted that responses may be more severe in areas where bighorn have historically been exposed to relatively high levels of human activity.

5.3 Climate Change

Climate change effects on big game species are primarily related to changes in vegetation communities, fire regimes, plant productivity, water availability (in arid environments), and the amount and persistence of snow pack affecting winter range. Bighorn sheep are generally limited to areas within winter range that are snow-free, such as wind-blown ridges and steep, snow-shedding slopes. Rapid changes in climate have been documented to have adverse effects on bighorn sheep. Epps *et al.* (2004) investigated effects of climate change on bighorn sheep in southern California and concluded that increased temperature and decreased precipitation in the late 1900s was an important factor in bighorn sheep population extirpations in California. These findings may apply to understanding the direction and role of climate change on the bighorn sheep within the ecoregion.

5.4 Invasive Species and Fire

Direct effects of invasive vegetation species are concentrated on competition with bighorn sheep preferred forage and reduction of native forage species. In addition, some invasive species (especially *Bromus* spp.) can alter fire regimes and thus affect entire landscapes and their communities by increasing fire frequency, extent and severity. As for the other big game species, wildfire threats to bighorn sheep are generally related to short-term loss of forage. Depending on fire severity and the size and timing of fires, bighorn sheep may need to migrate out of affected areas. However, within one to two seasons, forage conditions are generally improved over pre-fire conditions and these effects may last for several years, depending on the vegetation community. Vegetation transitions across ecological thresholds following wildfires are often associated with loss of important habitat resources and functions for wildlife, such as foraging areas, parturition areas or winter ranges. Thus, vegetation state and fire frequency and severity are important indicators for habitat stability.

In a 2010 report, Idaho agencies listed habitat change due to noxious weed and tree encroachment on critical habitat as a major factor in affecting Rocky Mountain bighorn sheep population changes. In some cases, invasive species may follow fire, and some species such as cheatgrass can act as easily burned fuel for the next fire cycle.

Wildfire changes the suitability and availability of bighorn sheep habitat by reducing the canopy cover of shrubs and trees, which improves access and the field of vision of bighorn sheep that is important for predator detection (Holl and Bleich 2010). Bighorn sheep consume primarily forbs and grasses, thus, wildfire can remove shrubs and trees and improves forage for bighorn sheep (if land health is sufficient for recovery). In a 2010 study in the Sierra Nevada Mountain, forage biomass and high quality forage initially decreased following fire but by the second year post wildfire had recovered to be equal to areas that had not burned (Greene *et al.* 2010). Plants within the burn had a 4 percent increase in crude protein for the duration of the study. In addition forage quality in the burned areas tended to be greater than unburned areas because the forage class composition within burns was forb dominated, which bighorn sheep seemed to prefer when available. Areas outside the burn were shrub dominated.

5.5 Disease

Respiratory disease epidemics caused by *Pasteurella* [*Mannheimia*] spp and other pathogens have caused catastrophic die-offs and chronic mortality in bighorn populations throughout western North America (Cassirer and Sinclair 2007; Miller 2001). Another bacterial pathogen (*Mycoplasma ovipneumoniae*) widely found in bighorn sheep may also cause pneumonia and is thought to predispose bighorn sheep to *Pasteurella* infection (Dassanayake et al 2009).Wildlife agencies now list disease as either their first or second cause of population declines in bighorn populations (Larkins 2010). Transmission of *Pasteurella haemolytica* from domestic sheep to bighorn sheep has been established clinically and supported by field observations (Foreyt 1989; George *et al.* 2008). Therefore, the presence of domestic sheep allotments in or near active bighorn sheep habitat is considered a major risk factor due to the transmission of respiratory diseases from domestic sheep or goats to wild sheep.. Guidelines for management of domestic sheep and goats in wild sheep habitats emphasize separation of domestic livestock from wild sheep in order to minimize spread of disease (BLM 1998, WAFWA 2010).

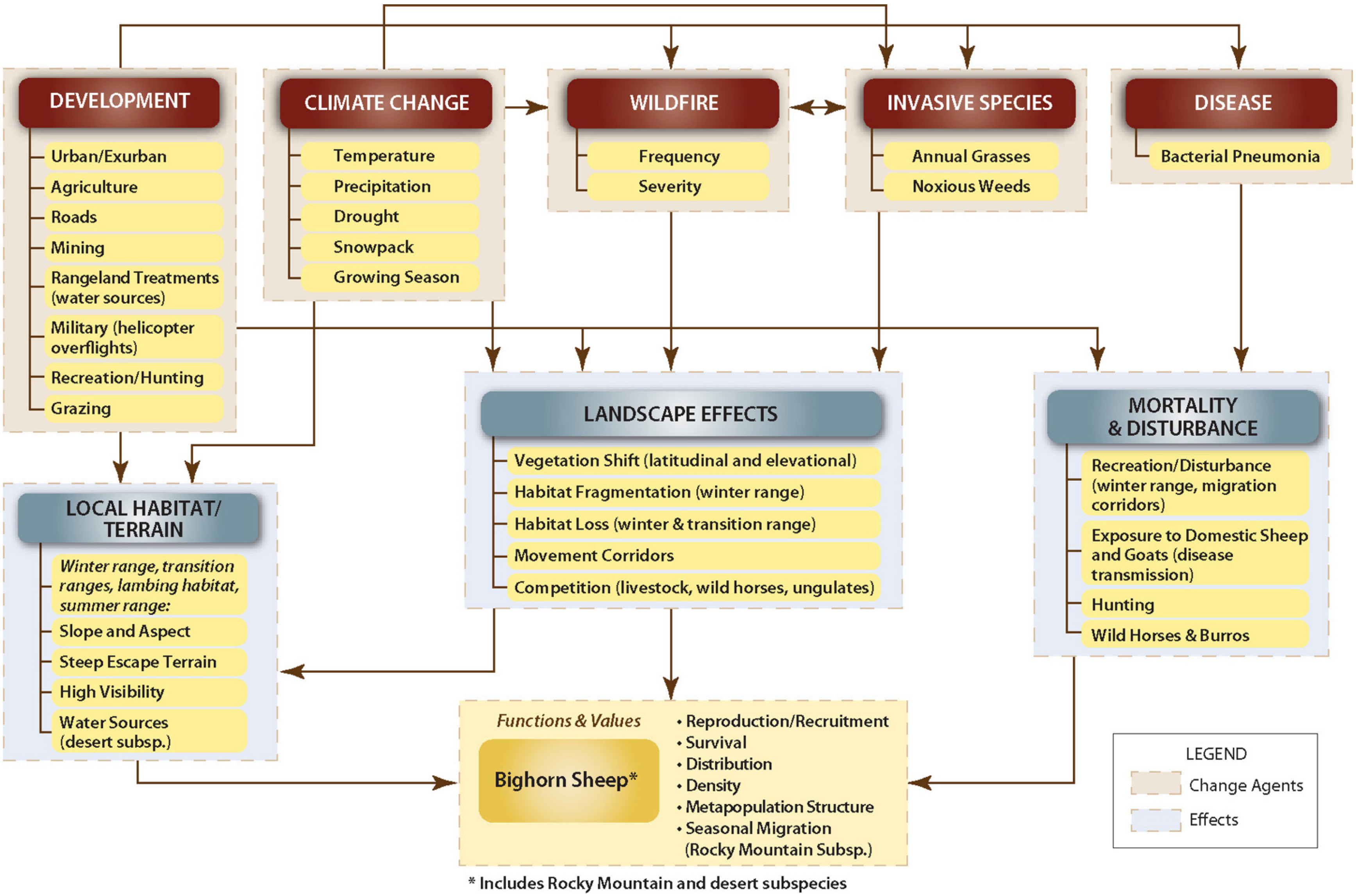


Figure 5-1. Bighorn Sheep Conceptual Model

6 Change Agent Threat Analysis

Current status and future threat assessments for bighorn sheep were conducted for the NGB using both 30m pixels, 4 km and 12-digit HUCs as the analysis units. Once the ecological model was developed, preliminary indicators or key ecological attributes were identified for the current status and future threat analyses with an emphasis on the feasibility of measuring impacts that result from application of CAs using geospatial data. The indicators were selected to assist with answering the MQs that relate to what is happening to the CE across the ecoregion. The CAs evaluated for current status include development, wildfire, climate change, invasive species, and disease. The final CE package was based on input from the Rolling Review Team; key ecological attributes and CAs that were revised or dropped from the analysis are discussed below.

6.1 Key Ecological Attributes

The preliminary list of key ecological attributes (Table 6-1) included indicators for assessing habitat size, condition, and landscape context with respect to anthropomorphic influences. During the course of the analysis, data availability and consistency concerns caused the elimination of one preliminary key ecological attribute with concurrence by Rolling Review Team and Subject Matter Experts. The following key ecological attribute was eliminated:

- Landscape structure/ cover: VCC (FRCC) data was reviewed and discussed with AMT and was determined to have a high level of error in shrubland and grassland cover types. For this reasons the VCC data was not evaluated because it was feared that results would not be indicative of conditions on the ground. Fire perimeters and frequency data was suggested to be used as a surrogate, however it was found that historical data was not reliable enough for further analysis.

Table 6-1. Preliminary List of Bighorn Sheep Key Ecological Attributes and Indicators

Ecological Attribute	Indicator	Metrics	Data Source	Reference
Size				
Habitat Size	Minimum aggregate size of adequate habitat (not necessarily contiguous but contains no barriers to movement)	>75 km^2 = good < 75 km^2 = poor	GAP/ WAFWA	Hells Canyon Bighorn Restoration Committee 2004
Escape Terrain	30 to 85% slope	> 1.6 ha = good < 1.6 ha = poor	DEM	Hells Canyon Bighorn Restoration Committee 2004
Condition				
Habitat Visibility	Horizontal visibility within upland grasslands, exposed rock, barren areas, snow fields	<10% canopy cover = good >1m shrubland height of forest cover 10-15% = fair > 15% canopy closure; agriculture, urban/ exurban = poor	GAP/ existing vegetation type	Hells Canyon Bighorn Restoration Committee 2004
	Tree encroachment distance from occupied habitat	> 300 m = good 100-300 m = fair < 100 m = poor	GAP/ existing vegetation type	Risenhoover & Bailey 1985; Etchberger *et al.* 1989; Wakelyn 1987

Table 6-1. Preliminary List of Bighorn Sheep Key Ecological Attributes and Indicators

Ecological Attribute	Indicator	Metrics	Data Source	Reference
Landscape Structure/Cover	Fire regime condition class	3 = good 2 = fair 1 = poor	LANDFIRE	
Context				
Connectivity	Distance of occupied habitat to barriers (forest, highways, rivers)	> 1,500 m = good 400-1,500 m = fair < 400 m = poor	TIGER/GAP / existing vegetation type /Linear features/NHD	Papouchis *et al.* 2001
Distance to Development	Human disturbance and presence near occupied habitat (rural, recreation, etc.)	> 1,500 m = good 400-1,500 m = fair < 400 m = poor	Human footprint	Papouchis *et al.* 2001
Disease Threats	Distance to domestic sheep allotments	>50km = good 23 – 50km = fair <23km =poor	WAFWA 2010	WAWFA Wild Sheep Working Group.

6.2 Current Status of the CE

This section documents the CA analysis under current conditions, i.e. the current extent of the CE's distribution and locations of the CAs. For each of the key ecological attributes listed in Table 6-1 and used in the CA analysis, a discussion of the indicator, metrics, metric rank and value, data source(s), and references is provided. The analysis was based on spatially available attributes affecting the CE at the ecoregion level.

6.2.1 Habitat Size

The minimum aggregate habitat size reflects the area occupied by an isolated or distinct population of bighorn sheep. The habitat within these ranges is not necessarily contiguous but must not be fragmented by barriers to sheep movement. Typically, larger herd ranges are better able to sustain populations of sheep and are less affected by chance events (severe winters, fires, disease outbreaks). Thus the size of the occupied area is an important indicator of overall population persistence and sustainability.

To assess habitat size for individual herd ranges, the 2011 WAFWA bighorn sheep range dataset was reviewed and found suitable for analysis at the ecoregion scale. Mapped range boundaries are generally based on long-term observation data, specific research projects, and professional judgment by state and federal biologists. The habitat layer was reclassified based on the total area of each individual herd range (see Table 6-1) and assigned associated values between 1 and 3, where 1 represented "Lower Quality" and 3 represented "Preferred". This layer was converted to raster layer with the assigned values. Zonal statistics were applied against the layer using the 4km grid GIS layer to determine an overall summary score for the patches contained within each grid cell. Figure 6-1 shows that the majority of bighorn sheep habitat is of preferred quality concerning area size.

6.2.2 Escape Terrain

Escape terrain for bighorn sheep was defined as habitat patches that occurred on slopes between 30-85%. Elevation data was retrieved from USGS NED website and slopes were extracted that fell within the defined elevation range. The bighorn sheep range habitat dataset was then intersected with the extracted slope data to isolate patches that had the required 30-85% slope criteria. Area calculations were completed and the data was assigned scores based on the scoring criteria listed in Table 6-1. This layer was converted to raster layer with the assigned scored values. Zonal statistics were applied against the layer using the 4km grid GIS layer to determine an overall summary score for the patches contained within each grid cell. Figure 6-2 illustrates that the majority of bighorn sheep habitat is of preferred quality based on the escape terrain assessment.

6.2.3 Habitat Visibility – Horizontal Visibility

Habitat patches were assessed and scored on the basis of horizontal visibility. Three datasets were required to support the analysis, including Landfire canopy cover, GAP/ existing vegetation type landcover data and Landfire existing vegetation height. To assess habitat that would qualify as having 'good' horizontal visibility landcover types were extracted from the GAP/ existing vegetation type landcover datasets. These landcover types included grasslands, shrublands, sparsely vegetated areas, and forest cover types that had less than 10% canopy cover. All selected areas were further constrained to areas only located within the bighorn sheep range habitat. Habitats qualifying as having 'fair' horizontal visibility were lands composed of shrublands with greater than 1 meter vegetation height and all forest cover types that had 10-15% canopy cover. The GAP/ existing vegetation type landcover datasets was used to identify shrubland and forested lands. The shrubland cover types were further limited to areas of shrublands that had greater than 1 meter height. This was accomplished by the overlay of both the selected shrubland portions of the GAP/ existing vegetation type vegetation cover and Landfire's existing vegetation height datasets. Forested types were further limited to those regions that had 10-15% canopy cover by using the Landfire canopy cover dataset to identify the appropriate cover conditions.

Finally, to delineate habitat areas considered to have 'poor' horizontal visibility forested areas with greater than 15% of canopy cover or areas mapped as agriculture or urban/exurban were delineated. Each group of habitat described above was scored based on the valuation documented in Table 6-1 and were then combined into one raster. Zonal statistics were applied to the raster output and summarized on a watershed basis using 4km grid cell unique identifiers. Figure 6-3 illustrates that the majority of bighorn sheep habitat is of preferred quality concerning horizontal visibility.

6.2.4 Connectivity

Barriers were characterized as the minimum distance from forested regions, highways and perennial rivers. Forested regions were extracted from GAP/ existing vegetation type landcover data by isolating pixels that were classed as 'forest'. Only forested regions having canopy cover of >80% were selected by using the Landfire canopy cover dataset. TIGER road data was used to identify highways. The USGS National Hydrography Dataset was used to extract perennial stream features. Proximity analyses were applied to all development datasets, outputs were combined, constrained to the bighorn sheep range boundaries and then graded based on distance criteria documented within Table 6-1. Summary zonal statistics were applied to the scored data to generate a rating for each 4km grid cell. Figure 6-4 illustrates that the majority of bighorn sheep habitat is of moderate to preferred quality concerning barriers to movement.

6.2.5 Distance to Development

Bighorn sheep are sensitive to human activity (Duncan 1960; McCutcheon 1981; MacArthur *et al.* 1982; Bleich *et al.* 1990; Krausman *et al.* 2001). Human disturbance and presence was assumed to be adequately represented by the existence and proximity of trails, roads, highways and urbanized regions. TIGER road data was used to identify trail, road and highway features. Trails captured within the TIGER dataset represent trail features that support vehicular traffic (i.e., dirt roads). Urban areas were extracted from the GAP/ existing vegetation type landcover dataset by isolating pixels that represented urban uses. Proximity analyses were applied to all development datasets, outputs were combined, constrained to the bighorn sheep range boundaries and then scored based on metrics documented within Table 6-1. Summary zonal statistics were applied to the graded data to generate a rating for each 4 km grid cell. Figure 6-5 illustrates that most of the bighorn sheep habitat is of low to moderate quality concerning the effects of human disturbance/presence. In general, the higher elevation regions (mountain and ridge tops) have fewer disturbances, because road construction and development is hampered by snow accumulation and topographical challenges to road construction.

6.2.6 Disease Threats

The risk of disease transmission from domestic sheep to bighorns was evaluated using a proximity analysis of BLM sheep allotments in relation to bighorn sheep occupied habitat. BLM allotment data were used to identify active domestic sheep grazing locations and their distance to bighorn ranges was represented by a distance buffer as defined in Table 6-1. Buffered areas were intersected with bighorn ranges and scored based on the values in Table 6-1. Summary zonal statistics were applied to the scored data to generate a rating for each 4km grid cell. Figure 6-6 illustrates that the majority of bighorn sheep habitat is of low risk to the threat of disease transmitted by domestic sheep herds, with the exception of Nevada and regions within the Snake River floodplain, where the domestic sheep industry is a significant factor.

6.2.7 Cumulative Indicator Score

Key ecological attributes used to create a cumulative indicator score for bighorn sheep habitat included habitat size, escape terrain, horizontal visibility, distance to barriers, distance to human disturbance/presence and risk of disease transmission. The individual metrics for the key ecological attributes were scored with a 1, 2 or 3 with 1 given to lowest quality indicator and 3 given to the highest quality indicator. Scores were added using a raster calculator to derive a range of cumulative scores from six to eighteen. Figure 6-7 shows the resulting high and low scoring areas with a stretched raster for each 4km analysis unit of bighorn sheep habitat.

The primary outcome of this analysis clearly identified portions of bighorn range (in yellow and orange) that are currently threatened by fragmentation and disease, and those (in green) that remain largely intact and should be viewed as strongholds of bighorn sheep habitat in the ecoregion. Bighorn habitat in western Nevada and in Oregon appears to have the highest quality, while populations occupying habitat in eastern Nevada and Idaho appear to experience significant threats, primarily from fragmentation, but domestic sheep disease threats are locally important in large portions of Nevada and Idaho. Populations in southeastern Idaho and northeastern Nevada appear especially vulnerable, with a multitude of factors affecting habitat integrity for the species.

6.3 Future Threats

6.3.1 Climate Change

The predicted changes associated with climate change throughout the NGB include increasing winter precipitation, possibly leading to more, deeper or heavier snowfall (depending on whether precipitation is rain or snow). The availability of windblown ridges, steep, snow shedding terrain and low moisture snow pack are important aspects of bighorn sheep winter habitat, as they allow the species to forage and persist in high elevations. Spring precipitation is expected to increase which may increase forage quality, but may also support further tree encroachment into grasslands. Decreased precipitation in summer months may detrimentally affect forage availability during these months. The overall outcome however, also depends on the spread of invasive annual grasses such as cheatgrass, as they displace preferred forage species and exacerbate detrimental effects of changing fire regimes, including potentially irreversible transition state changes. Development

Most bighorn sheep ranges in the ecoregion are already affected by development, such as roads, trails and exurban development. As developments increase, higher elevations are likely to receive disproportionate pressure due to the availability of water, scenery and recreational opportunities. Expansion of outdoor recreation, such as OHV traffic, hiking and skiing are expected to increasingly affect bighorn sheep in fragmented ranges. Wildlife and land managers thus must recognize the imminent threat of future development on an already stressed wildlife species and preserve and manage habitat to alleviate stressors wherever possible.

6.3.2 Wildfire

Wildfire in bighorn sheep range can have largely positive impacts on nutritional characteristics of forage plants and in suppressing or preventing tree encroachment. However, where ranges are fragmented or fires are extremely large (as can be expected under future climate and invasive weed scenarios), bighorn sheep may not be able to move to alternative habitat. Cheatgrass invasion into bighorn ranges, especially where low-elevation herds exist, tends to support short fire intervals which are detrimental to most high-quality forage species used by bighorn sheep. Wildfire regimes supported by cheatgrass are one of the most significant current and future stressors of bighorn sheep.

6.3.3 Invasives and Disease

As indicated above, cheatgrass is the primary invasive species affecting bighorn sheep. Cheatgrass expansion has dramatically changed fire regimes and plant communities over vast areas of western rangelands by creating an environment where fires are easily ignited, spread rapidly, cover large areas, and occur frequently. Bighorn sheep use green cheatgrass after a fire (Spoward and Hobbs 1985), but generally its nutritional quality is low for mature or dormant plant tissue and it is avoided by bighorn sheep. Cheatgrass tends to displace or eliminate a variety of native forbs, grasses and shrubs that are important winter an dry season forages, but it offers little replacement value. Thus habitat degradation associated with cheatgrass invasion is a significant stressor on many sheep populations in the intermountain west. Added nutritional stress may increase the susceptibility of bighorns to bacterial pneumonia pathogens, especially *Pasteurella haemolytica* (Goodson 1982; Kraabel and Miller 1997). The current close proximity of several domestic sheep allotments in Northern Nevada and Idaho are a considerable stressor and risk factor to bighorns, because these populations are already stressed by habitat fragmentation, invasive plants and altered fire regimes. Management of domestic sheep grazing allotments is an imperative element in the conservation of bighorn sheep.

6.3.4 Grazing

Bighorn sheep are relatively intolerant to poor range condition, interspecific competition, and habitat alteration (Krausman *et al.* 1996). Bighorn sheep may respond to cattle grazing by movement and spatial separation, due to social intolerance and avoidance (Krausman *et al.* 1996, King and Workman 1986). Habitat degradation by past poor grazing management has affected bighorn sheep throughout the West (Blood 1961; Geist 1971; Brown 1964, Krausman *et al.* 1996).

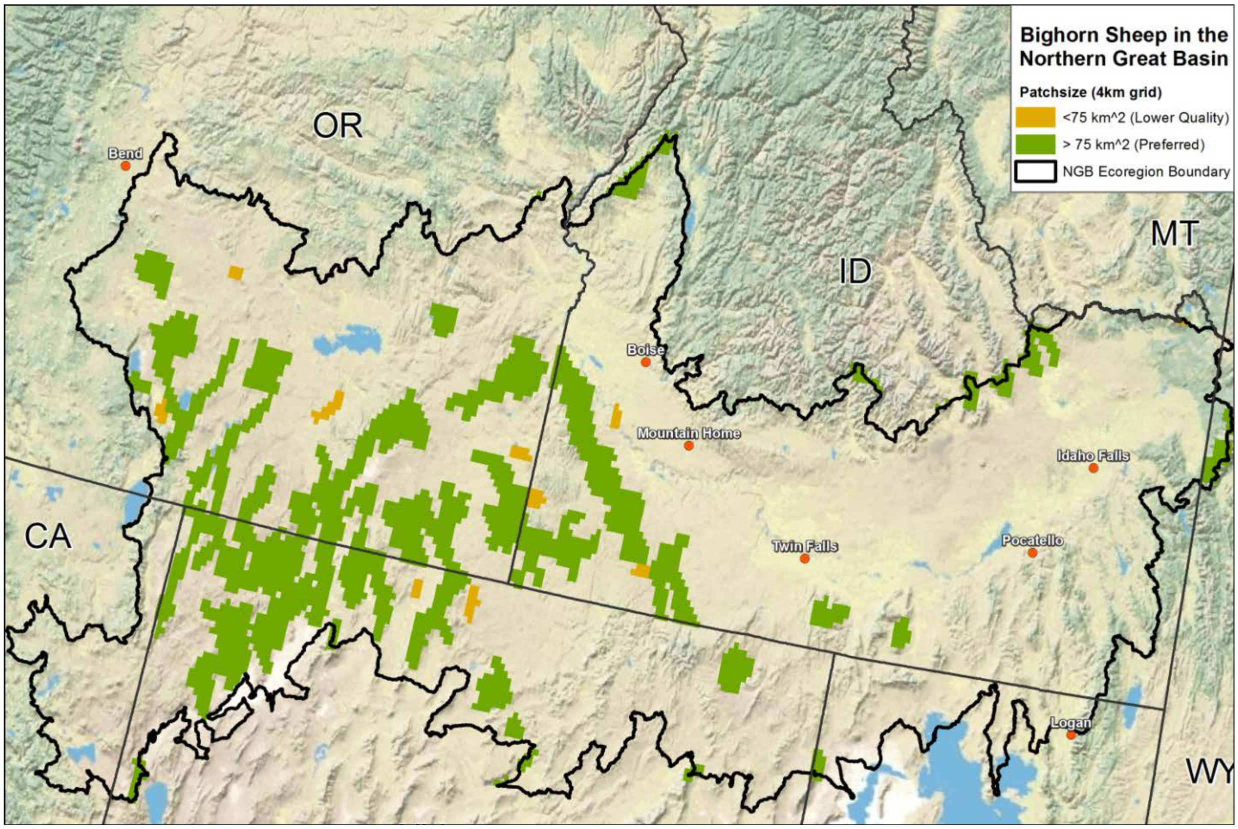


Figure 6-1. Habitat Size Assessment for Bighorn Sheep Habitat

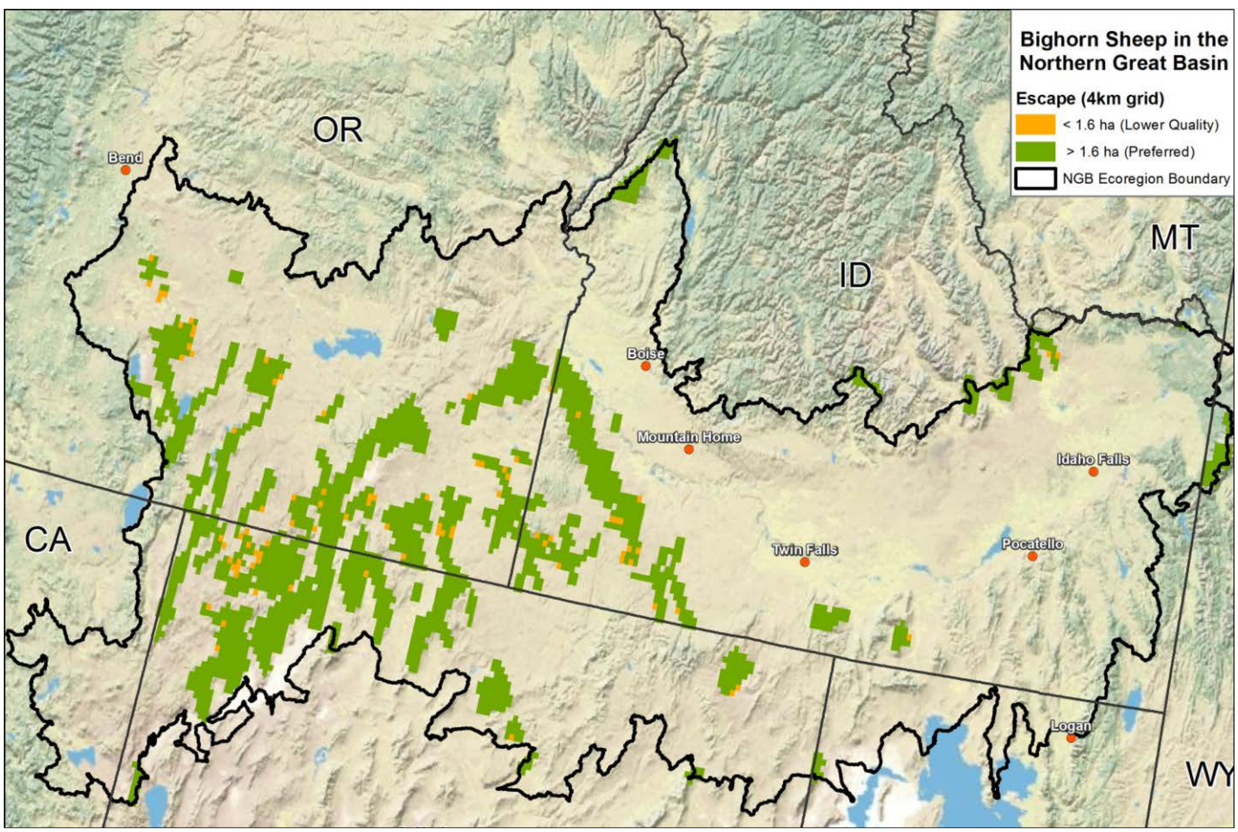


Figure 6-2. Escape Terrain Assessment for Bighorn Sheep Habitat

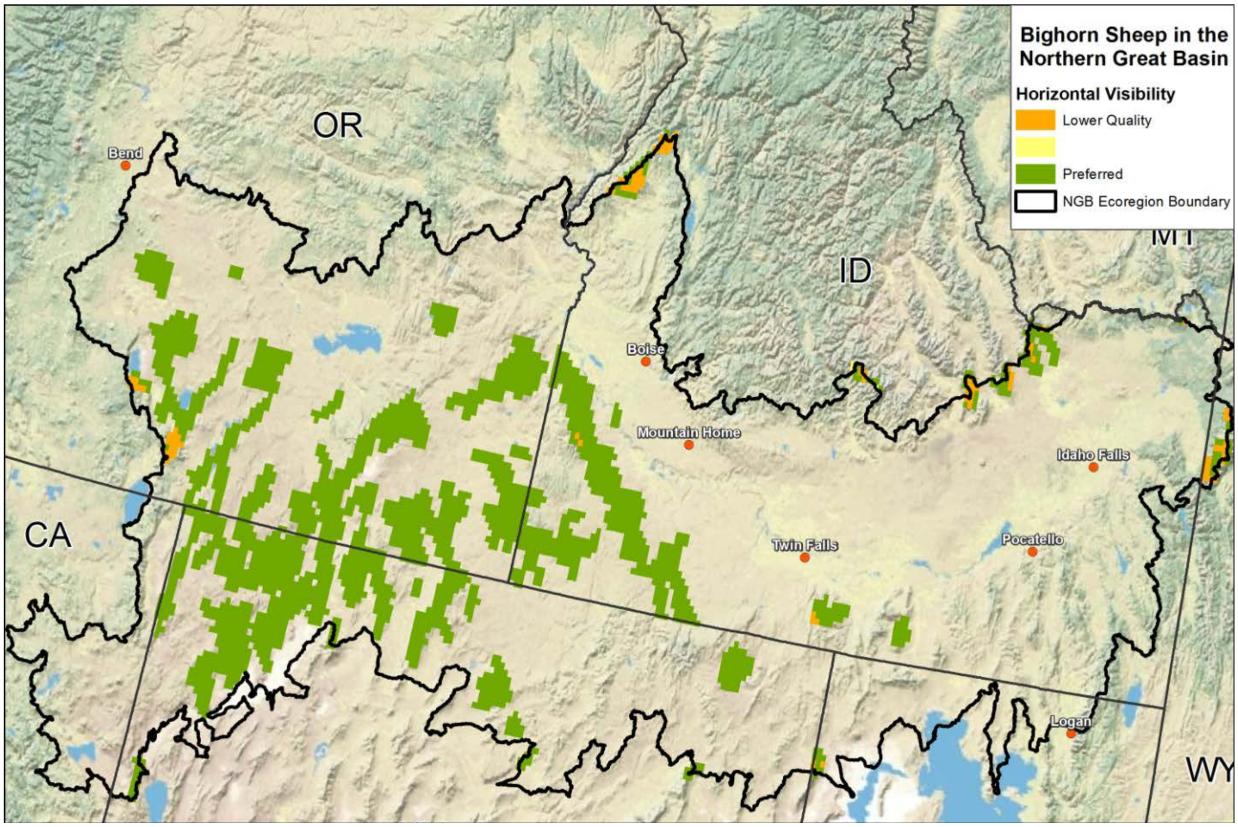


Figure 6-3. Horizontal Visibility Assessment for Bighorn Sheep Habitat

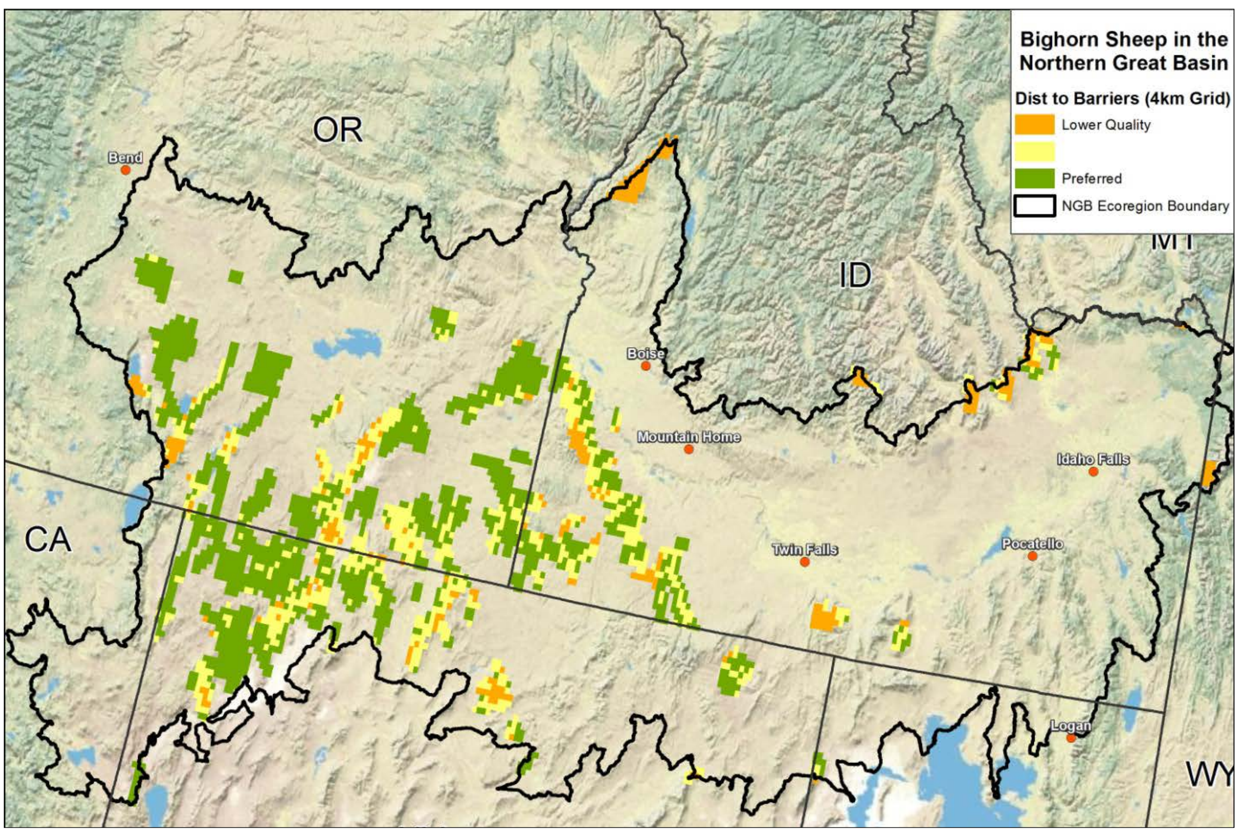


Figure 6-4. Distance to Barriers Assessment for Bighorn Sheep Habitat

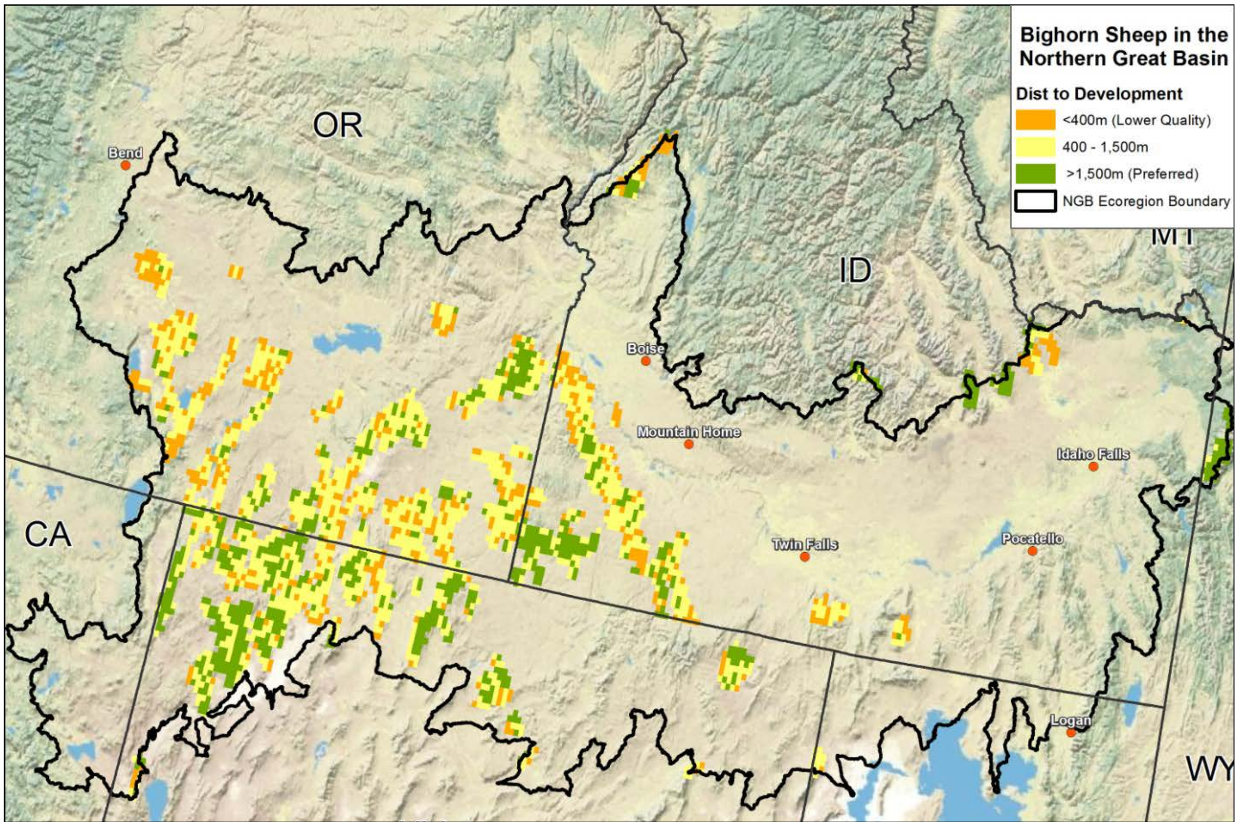


Figure 6-5. Human Disturbance and Presence Assessment for Bighorn Sheep Habitat

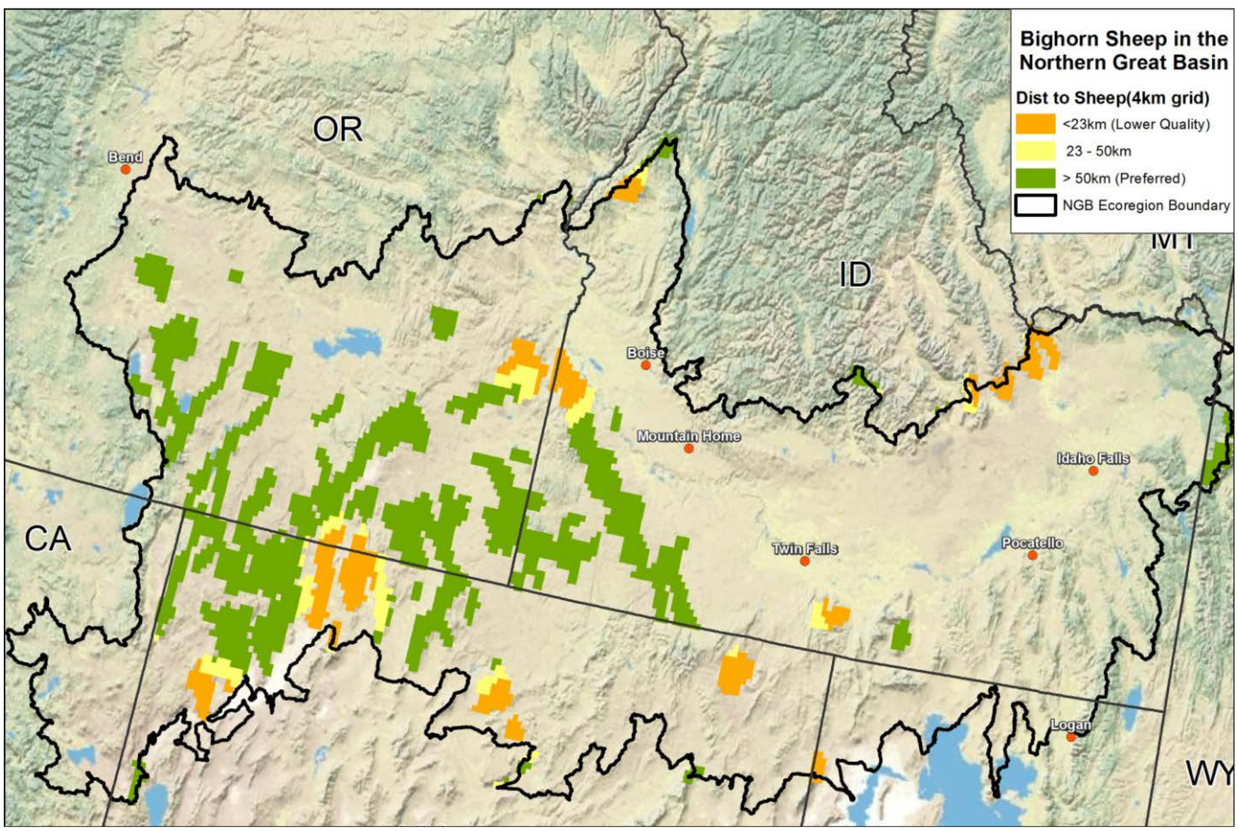


Figure 6-6. Domestic Sheep Disease Transmission Risk Assessment for Bighorn Sheep Habitat

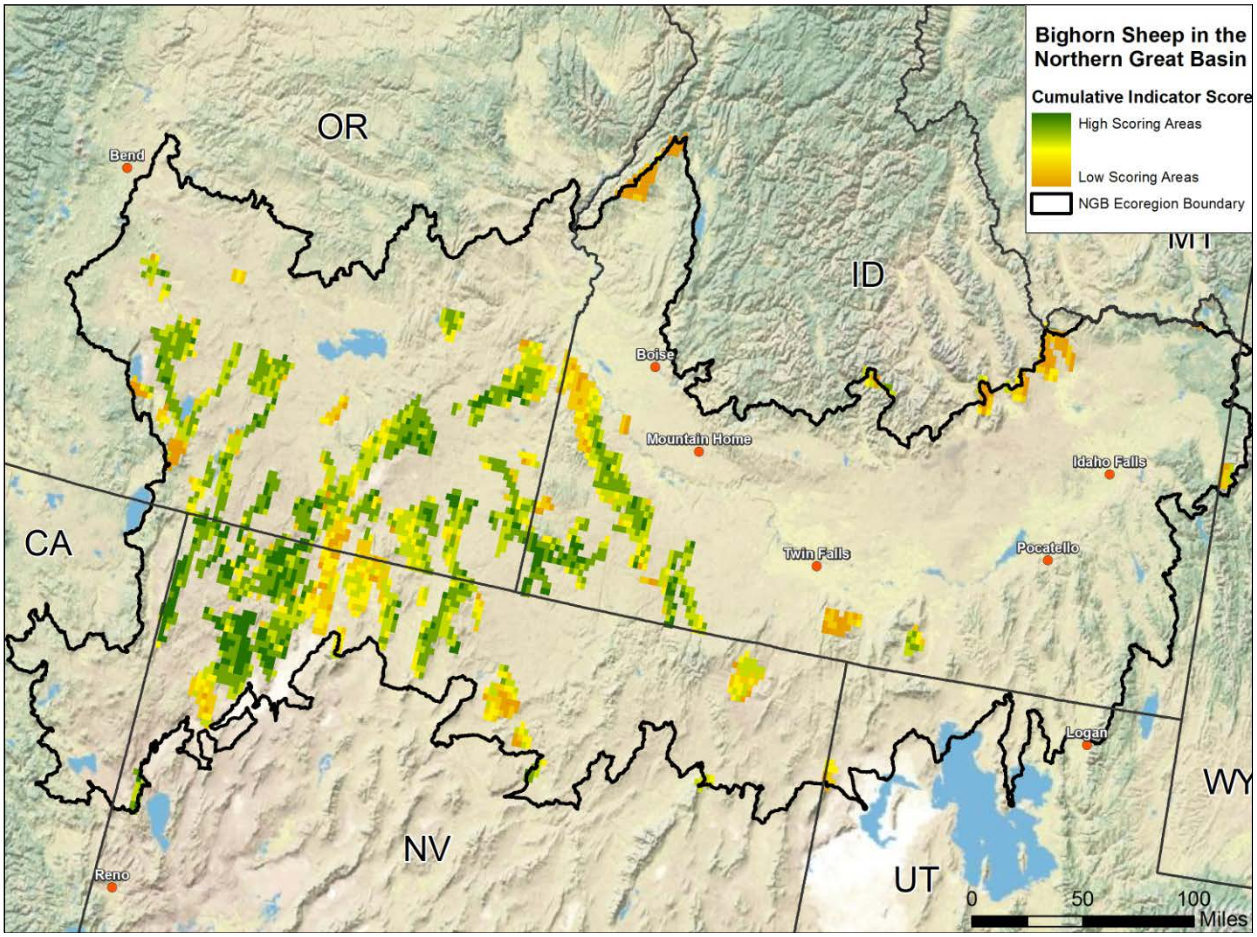


Figure 6-7. Cumulative Indicator Score for Bighorn Sheep Habitat

7 Management Questions

Management questions for the NGB were developed by BLM managers and refined by the AMT to answer questions regarding the agency's land management responsibilities—including planning land use, developing best management practices, authorizing uses, and establishing conservation and restoration priorities. Several management questions relate to this CE (with original numbering):

1. What is the currently occupied habitat or modeled suitable habitat for this CE?

The bighorn WAFWA range habitat is shown in Figure 4-1.

2. Where are the areas of greatest and least collective impact of existing CAs on occupied habitat or modeled suitable habitats of this CE?

Figure 6-7 provides the cumulative indicator score for bighorn sheep in the ecoregion. The areas least impacted are the highest scoring areas (green) and the areas with the greatest collective impact are the low scoring areas (orange).

5. Where are current locations of this CE likely to overlap with the potential future distribution of CAs (other than climate change)?

The most likely areas of overlap between the CE and future CAs are located in Idaho along the urban corridor (Boise, Mountain Home).

6. ***Given current and anticipated future locations of CAs, which habitat areas remain as opportunities for habitat enhancement/restoration for this CE?***

The areas that remain as opportunities for habitat enhancement are California, Nevada, Oregon, and the northern edge of the ecoregion in Idaho.

7. ***Where are potential areas to restore connectivity for this CE, based on current locations of CAs?***

The WAFWA habitat ranges are generally in the undeveloped southwestern portion of the ecoregion. Habitat ranges in the basin and range complex are separated by valley bottoms. Bighorn sheep avoid traversing valley bottoms and usually remain within close proximity to escape terrain. Local geology in the southwestern portion of the ecoregion may limit connectivity for bighorn sheep.

8. ***Where will this CE experience climate outside their current climate envelope? Or: Where will this CE experience significant deviations from normal climate variation?***

The predicted changes associated with climate change throughout the NGB include increasing winter precipitation, possibly leading to more, deeper or heavier snowfall (depending on whether precipitation is rain or snow). The availability of windblown ridges, steep, snow shedding terrain and low moisture snow pack are important aspects of bighorn sheep winter habitat, as they allow the species to forage and persist in high elevations. Spring precipitation is expected to increase which may increase forage quality, but may also support further tree encroachment into grasslands. Decreased precipitation in summer months may detrimentally affect forage availability during these months. The overall outcome however, also depends on the spread of invasive annual grasses such as cheatgrass, as they displace preferred forage species and exacerbate detrimental effects of changing fire regimes, including potentially irreversible transition state changes.

8 References

Beyer, A.C. 2008. Habitat Comparisons of Historically Stable and Less Stable Bighorn Sheep Populations. M.S. thesis, Montana State University Bozeman, Montana.

Bleich, V.C., R.T. Bowyer, A.M. Pauli, M.C. Nicholson, and R.W. Anthes. 1994. Mountain sheep (Ovis canadensis) and helicopter surveys: ramifications for the conservation of large mammals. Biological Conservation 70 (1-7).

BLM. 1998. Revised Guidelines for Management of Domestic Sheep and Goats in Native Wild Sheep Habitats. Instruction Memorandum No. 98-140. 6500(230/220) P. Bureau of Land Management. Washington, D.C. July 10, 1998.

Cassirer, E.F. and A.R.E. Sinclair. 2007. Dynamics of pneumonia in a bighorn sheep metapopulation. Journal of Wildlife Management 71(4):1080-1088.

Christensen, A., L. J. Lyon, and J.W. Unsworth. 1993. Elk management in the Northern Region: considerations in forest plan updates or revisions. U.S. Department of Agriculture, Forest Service, General Technical Report INT-303, Ogden, Utah.

Coe, P. K., Johnson, B. K., Wisdom, M. J., Cook, J. G., Vavra, M., and Nielson, R. M. 2011. Validation of Elk Resource Selection Models with Spatially Independent Data. Journal of Wildlife Management 75:159-170.Epps C.W., D.R. McCullough, J.D. Wehausen, V.C. Bleich, J.L.

Rechel. 2004. Effects of climate change on population persistence of desert-dwelling mountain sheep in California. Conservation Biology, 18, 102–113.

Cunningham, S. C. 1982. Aspects of the ecology of Peninsular desert bighorn sheep (Ovis canadensis cremnobates) in Carrizo Canyon, California. M. S. thesis. Arizona State University, Tempe. 76 pp.

Cunningham and J.C. deVos. 1992. Mortality of mountain sheep in the Black Canyon area of northwest Arizona. Desert Bighorn Council Transactions 36 : 27-29.

Dassanayake, R.P., S. Shanthalingam, C.N. Herndon, R. Subramaniam, P.K. Lawrence, J. Bavananthasivam, E.F. Cassiere, G.J. Haldonson, W.J. Foreyt, F.R. Rrangirwa, D.R. Knowles, T.E. Besser,a nd S. Srikumaran. 2009. Mycoplasma ovipneumoniae can predispose bighorn sheep to fatal Mannheimia haemolytica pneumonia. Veterinary Microbiology 145(3-4):354-359.

DUNCAN, G. E. 1960. Human encroachment on bighorn habitat. Desert Bighorn Council Transactions 4:35–37.

Etchberger, R.C., P.R. Krausman, and R. Mazaika. 1989. Mountain sheep habitat characteristics in the Pusch Ridge Wilderness, Arizona. Journal of Wildlife Management 53:902-907.

Epps C.W., D.R. McCullough, J.D. Wehausen, V.C. Bleich, and J.L. Rechel. 2004. Effects of climate change on population persistence of desert-dwelling mountain sheep in California. Conservation Biology, 18: 102–113.

Foreyt, W. J. 1989. Fatal *Pasteurella haemolytica* pneumonia in bighorn sheep after direct contact with clinically normal domestic sheep. Am. J. Vet. Res. 50:341-344.

George, J.L., D.J. Martin, P.M. Lukacs, and M.W. Miller. 2008. Epidemic Pasteurellosis in a bighorn sheep population coinciding with the appearance of a domestic sheep. Journal of Wildlife Diseases 44(2):388-403

Greene, L., T. Stephenson and M. Hebblewhite. 2010. The Short-Term Effects of Wildfire on Sierra Nevada Bighorn Sheep. *In:* Proceedings of the Biennial Symposium of the Northern Wild Sheep and Goat Council 17:129.

Goodson, N. J. 1982. Effects of domestic sheep grazing on bighorn sheep: a review. Biennial Symp. North American Wild Sheep and Goat Council 3: 287-313.

Hebblewhite, M. 2008. A literature review of the effects of energy development on ungulates: Implications for central and eastern Montana. Report prepared for Montana Fish, Wildlife and Parks, Miles City, MT.

Hells Canyon Bighorn Sheep Restoration Committee. 2004. The Hells Canyon Initiative: Hells Canyon bighorn sheep restoration plan. Idaho Department of Fish and Game, Lewiston, USA.

Holl, S.A. and V.C. Bleich. 2010. Responses of Bighorn Sheep and Mule Deer to Fire and Rain in the San Gabriel Mountains, California. *In*: Proceedings of the Biennial Symposium of the Northern Wild Sheep and Goat Council 17:139–157.

Hurley, K. and R. Jones. 2010. GIS mapping of North American wild sheep translocations. *In*: Proceedings of the Biennial Symposium of the Northern Wild Sheep and Goat Council 17:81.

Idaho Department of Fish and Game 2010. Bighorn sheep management plan 2010. Idaho Department of Fish and Game, Boise, USA.

_____. 2007. Interim Strategy for Managing Separation Between Bighorn Sheep and Domestic Sheep in Idaho. Prepared with Idaho State Department of Agriculture for the Governor of Idaho.

Jansen, B. D, P. R. Krausman, J. R. Heffelfinger, and J.C. de Vos Jr. Influence Of Mining On Behavior Of Bighorn Sheep. The Southwestern Naturalist 2007 52 (3), 418-423

Jorgensen, P. 1974. Vehicle use at a desert bighorn watering site. Desert Bighorn Council Transactions 18 : 18-24.

Kraabel B. J, and M. W. Miller. 1997. Effect of simulated stress on susceptibility of bighorn sheep neutrophils to *Pasteurella haemolytica* leukotoxin. J Wildl Dis. 33(3):558-66.

Krausman, P., M. Wallace, M. Zine, L. Berner, C. Hayes and D. DeYoung. 1993. The effects of low-altitude aircraft on mountain sheep heart rate behavior. Prepared for Armstrong Laboratory, Occupational and Environmental Health Directorate, Air Force Material Command. July.

Krausman, P, R. Valdez and J. Bissonette. 1996. Bighorn sheep and livestock. Pp 237 - 243 in: Krausman, P. [ed] Rangeland Wildlife. Society for Range Management, Denver.

Krausman, P. R., W. C. Dunn, L. K. Harris, W. H. Shaw, and W. M. Boyce. 2001. Can mountain sheep and humans coexist? In: R. Field, R. J. Warren, H. Okarma, and P. R. Seivert, editors. Wildlife, land, and people: priorities for the 21st century. Proceedings of the Second International Wildlife Management Congress. The Wildlife Society, Bethesda, Maryland. Pages 224–227.

King, M. M. and G. W. Workman. 1986. Response of desert bighorn sheep to human harassment: management implications. Transactions 51st North American Wildlife and Natural Reource Conference.

Larkins, A. 2010. Wild Sheep Status and Management in Western North America: Summary of State, Province, and Territory Status Report Surveys. *In*: Proceedings of the Biennial Symposium of the Northern Wild Sheep and Goat Council 17:8-28.

Macarthur, R. A., V. Geist, and R. H. Johnston. 1982. Cardiac and behavioral responses of mountain sheep to human disturbance. Journal of Wildlife Management 46:351–358.

McCutchen, H. E. 1981. Desert bighorn zoogeography and adaptation in relation to historic land use. Wildlife Society Bulletin 9:171–179.

Miller, G. D. and E. L. Smith. 1985. Human activity in desert bighorn habitat: what disturbs sheep? Desert Bighorn Council Transactions 1985 : 4-7.

Miller, M.W. 2001. Pasteurellosis. In Infectious diseases of wild mammals. 3rd Edition, E.S. Williams and I.K. Barker, editors. Iowa State University Press. Ames, Iowa.

Ough, W. D. and J. C. deVos. 1984. Intermountain travel corridors and their management implications for bighorn sheep. Desert Bighorn Council Transactions 28 : 32-36.

Oregon Department of Fish and Wildlife. 2003. Oregon's bighorn sheep and Rocky Mountain goat management plan. Salem, OR. December.

Papouchis, C.M., F.J. Singer, and W.B. Sloan. 2001. Responses of desert bighorn sheep to increased human recreation. Journal of Wildlife Management 65(3):573-582.

Risenhoover, K.L., and J.A. Bailey. 1985. Foraging ecology of mountain sheep: implications for habitat management. Journal of Wildlife Management 49: 707-804.

Shackleton, D.M., C. C. Shank, and B. M. Wikeem. 1999. Natural history of Rocky Mountain and California bighorn sheep. In: R. Valdez and P. R. Krausman, [eds.]. Mountain sheep of North America. Tucson, AZ, USA, University of Arizona Press p. 78-138.

Schoenecker, K. A., and P. R. Krausman. 2002. Human disturbance in Bighorn Sheep habitat, Pusch Ridge Wilderness, Arizona. Journal of Arizona-Nevada Academy of Science 34(1):63-08.

Van Dyke, W. A., A. Sands, J. Yoakum, A. Polenz, and J. Blaisdell. 1983. Wildlife habitats in managed rangelands - the Great Basin of southeastern Oregon: bighorn sheep. USDA Forest Service and USDI Bureau of Land Management General Technical Report PNW-159. 37pp.

WAFWA (Western Association of Fish and Wildlife Agencies). 2010. Wild Sheep Working Group. Recommendations for Domestic Sheep and Goat Management in Wild Sheep Habitat. July 21, 2010.

Wakelyn, L.A. 1987. Changing habitat conditions on bighorn sheep ranges in Colorado. Journal of Wildlife Management. 51: 904-912.

Mule Deer Conservation Element Package

1 Introduction

The mule deer is likely the most common and most recognizable large mammal in the West. Because of their popularity for hunting and wildlife viewing and wide distribution, mule deer are one of the most economically and socially important animals in western North America (Cox *et al.* 2009). Mule deer populations have fluctuated widely throughout their range over the past century; however, recent trends indicate that populations are declining. Much of this decline can be attributed to direct habitat loss (mainly winter range), a loss of browse species and deteriorating forage base, and weather extremes including large-scale droughts and severe winters (Heffelfinger and Messmer 2003). In addition to habitat loss issues, mule deer were also chosen as a CE because of their status as an important game species in all of the NGB states.

The management questions (MQs) that apply to mule deer can be summarized into three primary questions: 1) where are the important areas for this species; 2) where are healthy habitats protected or those that can be restored and/or protected; and 3) what is happening to those areas?

CE package provides the assessment of the current status and future threats due to the applicable change agents (CAs) for mule deer in the NGB ecoregion, and is included in the final REA report. Information in this CE package includes a brief description of the biology of mule deer in the NGB ecoregion, a description of Change Agents (CA) that were assessed, a conceptual model of ecosystem functions relevant to mule deer, information on available data sources and analytical methods for the assessment, and a full listing of relevant management questions for this CE. The primary CAs that were identified for mule deer include development, climate change, invasive species, wildfire, and disease.

2 CE Package Review Process

Subject Matter Experts play a key role in ensuring that the REA reflects the best available data and modeling processes suitable for each conservation element and change agent. Subject Matter Experts were added to Rolling Review Teams comprised of SAIC scientists, SAIC GIS personnel, AMT member(s) and other subject matter experts from the Department of Interior or state agencies. Membership of the Rolling Review Teams is listed in Appendix A. To ensure consistency amongst the different Rolling Review Teams, the number of lead SAIC scientists was limited to only a few individuals. This ensured that there was a common approach, or framework, used among the different Rolling Review Teams and that one Rolling Review Team did not stray too far from the rest. The USGS, as peer reviewers, were invited to participate in Rolling Review Teams.

3 CE Description

Mule deer in the Northern Great Basin ecoregion inhabit areas primarily classified as sagebrush (*Artemisia spp*.) and other shrub-steppe habitats. Riparian and woodlands are often interspersed within the shrubsteppe habitats throughout the ecoregion, providing a mosaic of habitat types across the landscape. Where water is available, agricultural production has replaced the native ecosystems with crops and hayfields. An important aspect of good mule deer habitat is the juxtaposition of browse and security habitat. The diverse environmental and climatic conditions .across the species' range result in dynamic relationships between mule deer and their habitats (Cox *et al.* 2009). Mule deer are habitat generalists, but are typically highly selective foragers (browsers) that rely on specific components of these diverse habitats (palatable shrubs and forbs) . Vegetation disturbance and subsequent renewal is a key element to maintaining high quality deer habitat; however, many natural disturbance regimes have been altered over the last several decades. These are described in detail in Section 5.1, Change Agents.

The approach taken in this analysis follows largely the definition of WAFWA (Table 3-1). These ranges are most commonly mapped by state fish and game agencies.

Table 3-1 Mule Deer Ranges

Habitat Classification	Definition of Habitat type
A. Overall Habitat	Includes habitat which is occasionally inhabited and/or contains small population of scattered mule deer. Simply stated marginal mule deer habitat limited by quality and quantity of food and or water.
B. Summer Range	That part of the overall range where 90% of the individuals are located between spring green-up and the first heavy snowfall. Summer range is not necessarily exclusive of winter range; in some areas winter range and summer range may overlap.
C. Other important habitat	Areas that are part of the overall range where higher quality habitat supports significantly higher densities than surrounding areas. These areas are typically occupied year round and not necessarily associated with a specific season. Examples include: rough break country, riparian areas, small drainages and large areas of irrigated cropland, migration corridors, highway crossings, fawning areas, etc.
D. Winter Range	That part of the overall range where 90 percent of the individuals are located during the average five winters out of ten from the first heavy snowfall to spring green-up, or during a site-specific period of winter. A subset of this definition would include a “severe winter range” definition to include areas within the winter range where 90% of the individuals are located when annual snow pack is at its maximum and/or temperatures are at a minimum in the two worst winters out of ten.
E. Winter Concentration areas	That part of the winter range where densities are at least 200% greater than the surrounding winter range density during the same period used to define winter range in the average five winters out of ten.
F. Year round population	An area that provides year-round range for a population of mule deer. The resident mule deer use all of the area all year; it cannot be subdivided into seasonal ranges although it may be included within the overall range of the larger population.

4 CE Modeling

4.1 Data Identification

Table 4-1 lists the types of data and data sources that were originally proposed for use in the REA as part of the pre-assessment data identification effort. Additional data sources were identified and –if possible-acquired (Table 6-1).

4.2 Distribution Mapping Methods

The WAFWA Mule deer range data was used as a starting point to create summer and winter range maps for this species. The original WAFWA mule deer habitat data appeared to be combinations of detailed mapping and coarse management boundaries reflective of different approaches applied by each state. The summer and winter ranges are displayed as black hatched areas in Figures 4-1 and 4-2 for each season. After review by the Rolling Review Team, the WAFWA mule deer range data was found to have too many inconsistencies of mapping scale. Some regions were mapped at fine scale providing very detailed delineations of range habitat while other areas reflected management boundaries mapped at a coarse level.

Table 4-1. Preliminary Mule Deer Data Sources

Data Required	Dataset Name	Source Agency	Type/Scale	Status	Use in REA
Modeled Habitat	Occupied ranges, especially winter and severe winter	Mule Deer Working Group (WAFWA)	Polygon	Acquired	Yes
	State data	Nevada Dept of Wildlife (2009)	Polygon	Acquired	Yes
Snow Depth	Mean Annual Snow Depth	NOAA	Polygon	Acquired	Yes

Table 4-2. Variables Used for Habitat Resistance Model for the Mule Deer

Spatial data layers	Data Source	Factors Used	Initial (WHCWG)	Winter	Summer
Landcover/land Use	GAP	Agriculture	5	2	5
		Urban/developed	100	100	100
		Water	20	20	20
		Sparsely vegetated	5	15	15
		Alpine	0	20	0
		Riparian	0	0	0
		Wetland	1	1	1
		Grass-dominated	2	5	3
		Shrub-dominated	2	1	3
		Dry forest	0	0	0
		Wet forest	0	0	0
Elevation	USGS National Elevation Dataset (NED)	0-250 meters	0	0	0
		>250-500 meters	0	0	0
		>500-600 meters	0	0	0
		>600-1500 meters	0	1	1
		>1500 - 2000 meters	0	2	2
		>2000 - 2500 meters	1	25	2
		>2500 - 3300 meters	2	25	2
		> 3300 meters	25	25	25
Slope	USGS National Elevation Dataset (NED)	0 - 20 degrees	0	0	0
		>20 - 40 degrees	0	0	0
		> 40 degrees	30	30	30
Acres/ Dwelling Unit	Housing Density 2000, Natural Resource Ecology Lab, Colorado State University,2008	>80 ac/du	0	0	0
		>40 to <80 acres/du	0	0	0
		>20 to <40 acres/du	1	1	1
		>10 to <20 acres/du	2	2	2
		<10 acres/du	10	10	10
Transportation Freeway	TIGER Line Roads Census 2000	>500-1000m	0	0	0
		>0-500m	0	0	0
		centerline	200	200	200
Transportation Secondary Highway	TIGER Line Roads Census 2000	>500-1000m	0	0	0
		>0-500m	0	0	0
		centerline	20	20	20
Transportation Local Road	TIGER Line Roads Census 2000	>500-1000m	0	0	0
		>0-500m	0	0	0
		centerline	2	2	2

The methods for generating core habitat patches developed by Washington Wildlife Habitat Connectivity Working Group (WHCWG 2010) were reviewed and determined to be applicable for determining Mule Deer habitat patches for the Mule Deer within the Northern Great Basin ecoregion. Applying the methods documented by WHCWG and adjusting parameters reflective of the study area conditions, the habitat patch layer for mule deer was developed using the Habitat Concentration Area (HCA) tool developed by the WHCWG (WHCWG 2010). The method for deriving estimates of core habitat for mule deer as developed by the Washington Connected Landscapes Project were applied with slight adjustments to reflect conditions within the Northern Great Basin Ecoregion, based on Subject Matter Experts input.

The Habitat Concentration Area model uses attributes representative of the focal species and on the distribution of natural conditions. Habitat Concentration Area toolset developed by WHCWG identifies large, contiguous areas that have retained high levels of naturalness (i.e., core areas characterized by a relatively light human footprint). The Habitat Concentration Areas are aggregations of habitat grid cells that are connected to one another by species-specific home range movement radius. These aggregations must typically meet a minimum size requirement to support multiple individuals. To implement the Habitat Concentration Area tool, two datasets were required: (1) a habitat raster and (2) a resistance raster. The habitat raster can be derived from species distribution (i.e., range) data if available and mapped consistently at an appropriate scale. In the absence of distribution data a habitat identification model is derived from the resistance raster.

For mule deer the Habitat Concentration Areas were developed by using a combination of *a priori* Subject Matter Experts and local knowledge and a habitat identification model Due to a lack of a consistently mapped habitat distribution dataset a binary habitat raster was derived from a resistance raster. The binary habitat raster was developed where a grid cell was either classed as 'habitat' (assigned a value of '1') or non-habitat (assigned a value of '0'). The WHCWG developed a binary habitat raster by using a resistance raster developed for mule deer and assigning all resistance values 3 or less as 'habitat' (i.e. 1). All values greater than 3 were assigned a 'non-habitat' value (i.e. 0). For this application a threshold resistance value of '5' was used to delineate between 'habitat' and 'non-habitat'. The threshold was increased because it allowed the model to evaluate agricultural lands that were considered important by subject matter experts. Resistance values, in the sense of this application are simply estimated values of habitat suitability with a primary focus on an animal's ability to move through the respective land cover type. Because areas with high resistance values are typically avoided by mule deer or are not used as part of the species' home range, they tend to impose filters to movement, and thus fragment the landscape into connected core habitat areas and interstitial breaks.

Resistance values were assigned based on WHCWG Statewide project values (Table 4-2). The landcover dataset was reclassified to general vegetation classes (see Attachment 1). Various scenarios were applied and compared to WAFWA winter range data. BLM wildlife ecologists and Rolling Review Team groups further examined the patch distributions to assess the whether the outputs were reasonable. For this analysis resistance parameters were adjusted from those used in the WHCWG analysis. The resistance raster output for winter and summer scenarios as presented in Table 4-2 was used to develop a habitat binary raster. The proportion of habitat within a circular moving window of a size representative of the mule deer's home range radius was calculated. For this analysis a home radius of 2,000 meters was used (Kie et al 2002). The outcome of this step generates a surface which identifies the areas where habitat is most concentrated.

The HCA tool then deletes the grid cells in areas where habitat it sparse. Habitat grid cells are removed from the habitat binary raster if the proportion of the habitat within the home range radius was less than 0.75. This prevents habitat concentrations from forming in areas where low quality habitat is predominant.

Only grid cells meeting the minimum average habitat value of home range were evaluated. The threshold habitat value was set to 0.75. Grid cells meeting the minimum average habitat value of home range were than compared to the 0.75 threshold and if greater were than classified as core habitat. Remaining habitat grid cells are joined together if they are within a home range distance. . Habitat areas were expanded outwards (from the remaining habitat grid cells after the threshold assessment has been completed) up to a total cost-weighted distance equal to the species home range movement radius (2,000 meters).This effectively joins nearby habitat grid cells together if the intervening landscape supports movements within the home-range connectivity.

While the original WHCWG Statewide application of the HCA tool removed habitat concentration areas smaller than a threshold that was meaningful to the mule deer range no threshold was established in this analysis. Instead, the final habitat patch outputs were spatially constrained to only those located within or touching the WAFWA seasonal ranges (i.e. winter/yearlong and summer/yearlong), thus ensuring that local knowledge inherent in the WAFWA data was conserved and consistently integrated across the landscape.

Figures 4-1 and 4-2 show the habitat patches used to define the summer and winter ranges of mule deer in the ecoregion for this REA compared to the WAFWA datasets, respectively.

4.3 Data Gaps, Uncertainty, and Limitations

4.3.1 Data Gaps

An accurate estimation of urban/exurban development geospatial dataset was not available. After discussions with Rolling Review Team and AMT no substitute was determined and the key ecological attribute was dropped from further analysis.

Gas/oil well data was retrieved and reviewed. After discussion with AMT and Rolling Review Team it was concluded that data represented primarily geothermal production sites, which were assumed not to have a serious impact on mule deer in the region. The AMT concluded that oil and gas wells were not abundant enough in the ecoregion to be considered as a key ecological attribute and were not used. Cheatgrass extent data was incomplete in the ecoregion with large portions not available for the northeastern and northwestern part of the ecoregion. Furthermore, there was not one individual study conducted that assessed cheatgrass presence that applied one set of methods for assessing conditions for the entire spatial extents of the study area. The key ecological attribute was dropped from further analysis until a consistently mapped data layer can be obtained.

Chronic wasting disease (CWD) data were reviewed but the disease has not been verified in any significant portion of the ecoregion. No geospatial data sets for other important mule deer diseases (e.g., epizootic hemorrhagic disease) was available.

4.3.2 Uncertainty

Modeled mule deer habitat was developed using the Washington Wildlife Habitat Connectivity Working Group (WHCWG 2010) modeling approach. Parameters were adjusted to reflect conditions within the Northern Great Basin ecoregion, however ground-truthing of modeled output was not part of the scope of this work. In lieu of ground-truthing modeled mule deer habitat distributions the modeled habitat outputs were compared to existing WAFWA data and visually assessed by biological experts of the Rolling Review Team.

Table 4-3. Crosswalk of WAFWA and Nevada Department of Wildlife habitat classifications

WAFWA	Nevada Department of Wildlife	Name Used in REA	Modeling Seasonal Category
Limited Range	Limited Use	Limited Range	Year Long Range
Other Important Habitat		Other Important Habitat	Year Long Range
Summer Range	Summer Range	Summer Range	Summer Range
	Crucial Summer	Summer Concentration	Summer Range
Winter Concentration	Crucial Winter	Winter Concentration	Winter Range
Winter Range	Winter Range	Winter Range	Winter Range
Year Round Population	Year-Round	Year Round	Year Long Range
Empty		Deleted	Deleted
	Movement Corridor	Movement Corridor	Summer Range
	Agricultural	Agricultural	Winter Range
	Fawning Range	Fawning Range	Summer Range
	Transition Range	Transition Range	Summer Range

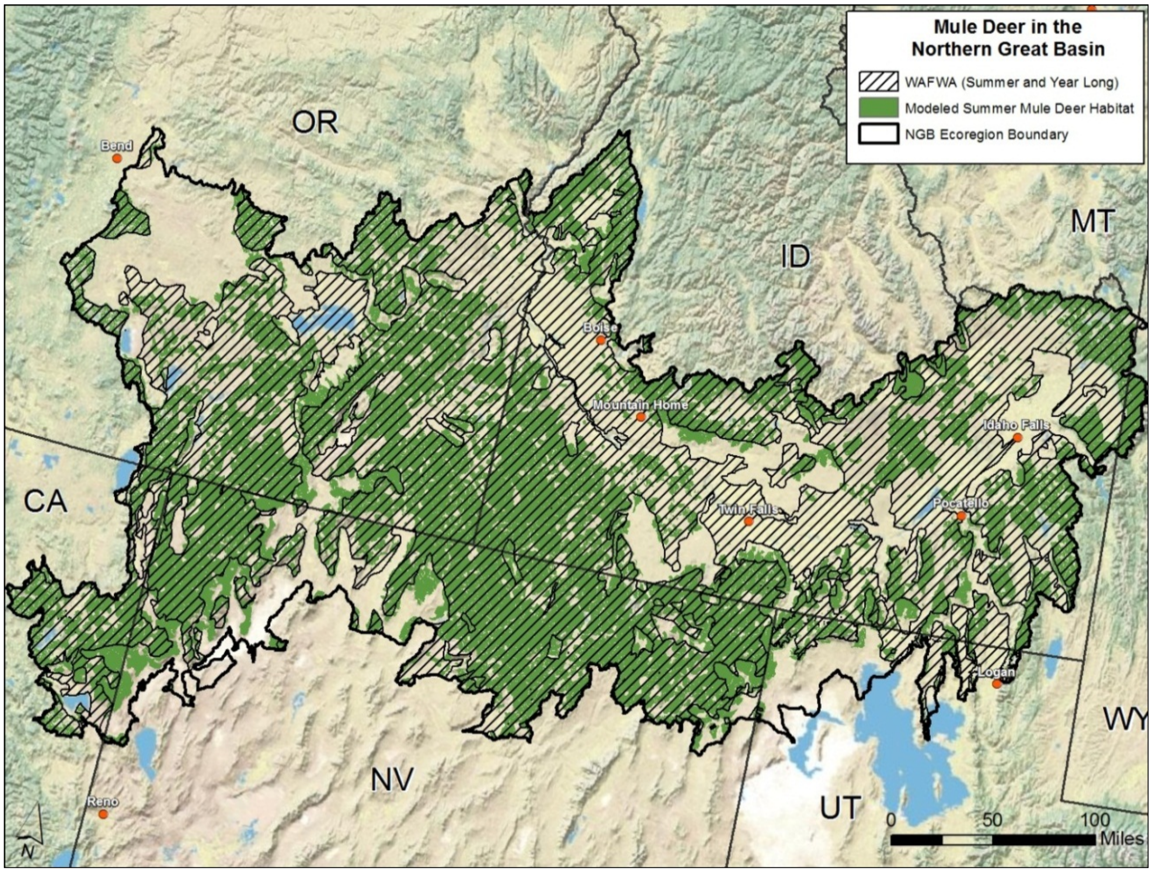


Figure 4-1. Comparison of WAFWA summer range and year-long range with modeled summer habitat for mule deer.

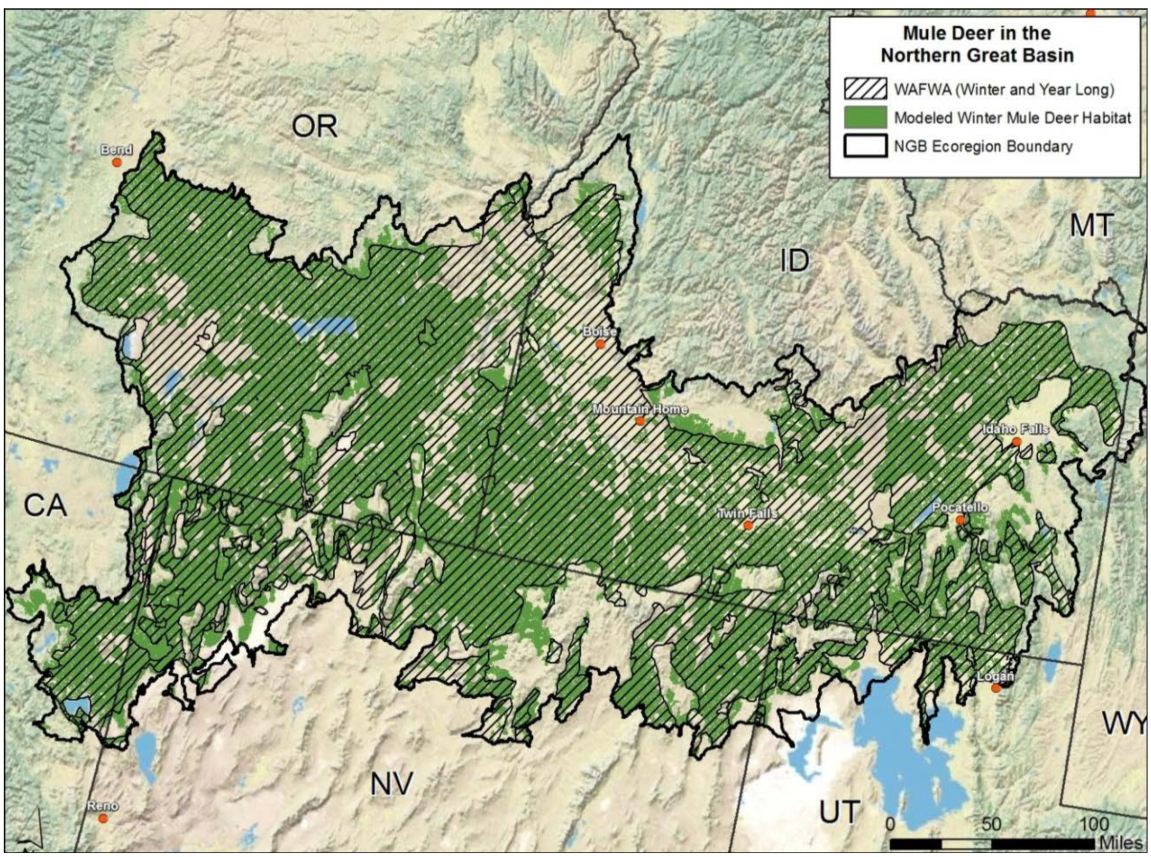


Figure 4-2. Comparison of WAFWA winter range and year-long range with modeled winter habitat for mule deer.

5 System Models

Conceptual system models were developed as part of the pre-assessment phase to assist with the determination of the key factors that are important to mule deer in the NGB ecoregion. The model was developed to provide an ecological framework and justification for the choice of indicators that were used in assessing CA threats for this CE. This model begins with depicting the important habitat components for mule deer (or functions and values) required throughout the year and incorporates the identified CAs, as well as potential effects from the actions of the CAs on a landscape level (Figure 5-1). Unlike the other fine-filter CE ungulates that require large home ranges (bighorn sheep and pronghorn), the conceptual models for mule deer did not require a local habitat/terrain scale analysis as this species is more of a foraging generalist than the other two species and remains near good cover rather than in the high visibility areas preferred by bighorn sheep and pronghorn. Being conceptual in nature, all potential important stressors and effects were included regardless of availability of data at this point in the REA.

5.1 Change Agents

The CAs considered for this analysis include development, climate change, invasive species, wildfire, and disease, depicted in brown boxes across the top of the model (Figure 5-1). As mentioned in Section 3, suitable mule deer habitat consists of a mosaic of various shrub and woodland habitats with openings offering a variety of forage sources throughout the year. The mule deer model shows the pathway of CAs that affect mule deer landscape variables and thereby, the mule deer functions and values, depicted in the lower box. The predicted results of CA effects are presented in blue boxes.

5.1.1 Development

Key management issues and threats identified by Cox *et al.* (2009) for mule deer in the Intermountain West ecoregion include loss of shrubland (sagebrush and mountain brush species) integrity, conversion of native vegetation to agriculture lands and residential developments, cumulative habitat degradation by livestock grazing and fire suppression, as well as loss of lands and fragmentation of habitats caused by urbanization expansion. Fences, road networks, and increased human disturbance associated with energy and housing developments can also influence the effectiveness of mule deer migration routes (Sawyer *et al.* 2005). Migration bottlenecks are created at those areas along historic migration routes where topography, vegetation, or other landscape features may restrict animal movements to narrow or limited regions, which is exacerbated by the addition of human influences such as development. Roads are widely recognized by the scientific community as having a range of direct, indirect, and cumulative effects on wildlife and their habitats (Trombulak and Frissell 2000, Gaines *et al.* 2003, Wisdom *et al.* 2004). Road construction often accompanies other development types listed in the model (Figure 5-1) including urban/exurban, agriculture, oil /gas and alternative energy developments. Mule deer avoid roads, depending on vehicle traffic volume and roadside cover habitat available. In a wildlife tracking study near a highway in Colorado, only about half (53%) of mule deer that approached the highway actually crossed, and mule deer comprised 77 percent of species tracked (Barnum 2001). In a Montana highway study, mule and white-tailed deer comprised the largest percentage of wildlife species killed as a result of vehicle collisions (62%; Craighead *et al.* 2001).

Energy development creates a complex network of roads, pads, pipelines, transmission lines, and other infrastructure across the landscape. Direct impacts include the loss of habitat to permanent structures and facilities, access roads and pipeline construction. Indirect impacts may include changes in population distribution, habitat access, migration routes, or other mule deer activities caused by increased human disturbances associated with energy development (e.g., traffic, noise, fencing, and human use). Sawyer and Nielsen (2010) found at the Pinedale Anticline Project Area in western Wyoming that mule deer avoided areas close to well pads, and did not habituate to presence of well pads. Lower predicted probabilities of mule deer use within 2.7 to 3.7 km of well pads, with distance increasing as development intensified, suggested indirect habitat losses may be substantially larger than direct habitat losses (Sawyer *et al.* 2006). Overall, energy development at this site reduced mule deer abundance to its lowest level since energy development began in the area (Sawyer and Nielsen 2010).

Wisdom *et al.* (2004) found that movement rates increase in response to some recreational off-road activities. Taylor and Knight (2003) noted that mule deer showed a 96 percent probability of flushing within 100 m of hikers or mountain bikers located off trails and suggested that the area around existing trails that may be affected by recreationists was a 200-m "area of influence”. These kinds of disturbances increase mule deer energy expenditures, which can be especially adverse during winter and breeding season.

Although there may be some direct competition for forage, areas, and times between livestock and mule deer (Kie 1996, Cox *et al.* 2009), practices such as habitat and water source manipulation (e.g., fencing, shrub removal and reduction) in support of livestock production likely have greater effects to mule deer use of an area.

5.1.2 Climate Change

Climate change may increase environmental extremes and influence habitat changes for mule deer in the NGB. The primary impacts on mule deer and their habitats are through (a) effects of the moisture and temperature regime changes on availability of forage resources (i.e., productivity, species composition, and nutrient content are affected by drought, late frosts, etc.), and (b) snow depth on winter ranges and migration corridors. The rate of global warming has increased 30-fold in the last 10,000 to 20,000 years and has been observed in vegetative communities as a result of increased greenhouse gases including CO_2, changes in precipitation and snowfall patterns, and increased temperatures (Cox *et al.* 2009). Mule deer are less affected by severe cold weather than by high levels of snow cover, which restrict access to forage. Gilbert *et al.* (1970) stated that snow depth over 18 inches precluded use of winter range by deer, but energy costs of locomotion for mule deer increase significantly at 10 in (25 cm), regardless of the density of snow (Parker *et al.* 1984). Lower snowfall amounts are projected to occur in much of western North America as a result of climate change, which may reduce the importance of, or change locations of, winter ranges for mule deer. However, global warming patterns are projected to lead to loss of sagebrush winter ranges and increasing coniferous communities, which will reduce habitat quality of winter range (Lutz *et al.* 2003). In addition, climate-induced changes could begin to expose native plant communities to invasive weed species or exacerbate current invasive weed problems, which may alter range forage quality and fire regimes. Generally, ecoregional differences in the impact to mule deer populations are expected to occur as climate change progresses (deVos and McKinney 2007). Within the NGB, expanded distribution of woody species, reduced availability of high quality winter forage, increased frequency of stand-converting wildfires, and spread of invasive plants and insects have increased in the past 150 years, resulting in different biotic communities and interactions between species (Cox *et al.* 2009). As global climate change progresses, the extent of these changes and altered biological interactions are expected to increase.

Mule deer autumn migration is highly variable and likely associated with patterns of winter weather (cold and snow); whereas spring migration seems to be coincident with decreasing snow depth and advances in plant phenology. The likely association between seasonal migration and weather conditions provides evidence that those migratory patterns may be altered by global climate change. Climate change is thought to negatively affect abundance and distribution of mule deer in hotter and drier ecoregions, while in ecoregions where extreme winters presently limit these populations in some years, short-term effects on abundance and distribution may be positive, but long-term effects are uncertain.

5.1.3 Wildfire and Invasive Species

The effects of fire on mule deer habitat are widely varied and well documented in the literature. Fire generally has a beneficial impact on mule deer habitat, by stimulating earlier greenup the following spring, which increases availability and nutritional quality of forage and more herbaceous plants. However, fire can also facilitate invasion by cheatgrass (*Bromus tectorum*), which has low value as mule deer forage, and may reduce shrub cover and browse availability. Increasing fire intervals that are supported by the abundance of fine fuels (e.g., cheatgrass) tends to reduce and ultimately eliminate browse species that deer heavily rely on in the Intermountain West. Cox et al (2009) estimate that the historic 30- to 100-year fire cycle has been reduced to a 5- to 10-year cycle in portions of the region due to the abundance of invasive cheatgrass.

Conversely, in some areas the absence of fire for 50 years or more can facilitate conifer encroachment, canopy closure, and deterioration of herbaceous and shrub understories, also resulting in deterioration of mule deer open and varied habitats (Cox *et al.* 2009). Fire suppression results in overstocked of pine stands and, therefore, decreases decreasing shrubs and forbs that are important to mule deer. Mule deer generally prefer recently burned areas that create mosaics of forage and cover, as long as herbaceous vegetation and re-sprouting browse species remain viable and nutritious (Hobbs and Spowart 1984). Regrowth that follows burned sagebrush communities can result in significant increases of herbaceous plants favored by mule deer. However, when sagebrush is the only cover, its complete removal can be detrimental to mule deer, especially on winter range.

5.1.4 Disease

Several diseases that affect mule deer may increase in presence and result in effects on populations, especially those undergoing stresses from other factors, in the NGB (e.g., chronic wasting disease), bluetongue, epizootic hemorrhagic disease, etc). Currently, chronic wasting disease, which attacks the brains of infected deer, elk, and moose and is always fatal, is primarily concentrated in wild deer in mid-western states, the northern Rockies states and in July 2012 into Texas (Chronic Wasting Disease Alliance 2012). Farmed and captive deer in a wider geographic area have tested positive for chronic wasting disease (chronic wasting disease Alliance; http://www.cwd-info.org/index.php/fuseaction/about.map). Within the NGB states only Utah is known to have recorded occurrences of chronic wasting disease.

Hemorrhagic disease is caused by either of two closely related viruses, epizootic hemorrhagic disease (EHD) virus or bluetongue virus (SCWDS Group 2012). Because symptoms produced by these viruses are indistinguishable, a general term, hemorrhagic disease, often is used when the specific virus responsible is unknown. These viruses are seasonal, transmitted by biting flies, and fatal within 24 hours after a 7 to 10-day incubation period. Domestic and wild ruminants have been infected including mule deer, pronghorn, and bighorn sheep (SCWDS Group 2012). EHD was reported as severe in white-tailed deer in the central and eastern portions of Montana in 2011 (Pierce 2011).

None of these diseases that afflict mule deer are thought to be directly associated with habitat alterations or anthropogenic changes to habitat quality at this time, but the seasonality of infections by biting insects suggest a potential link with Climate Change.

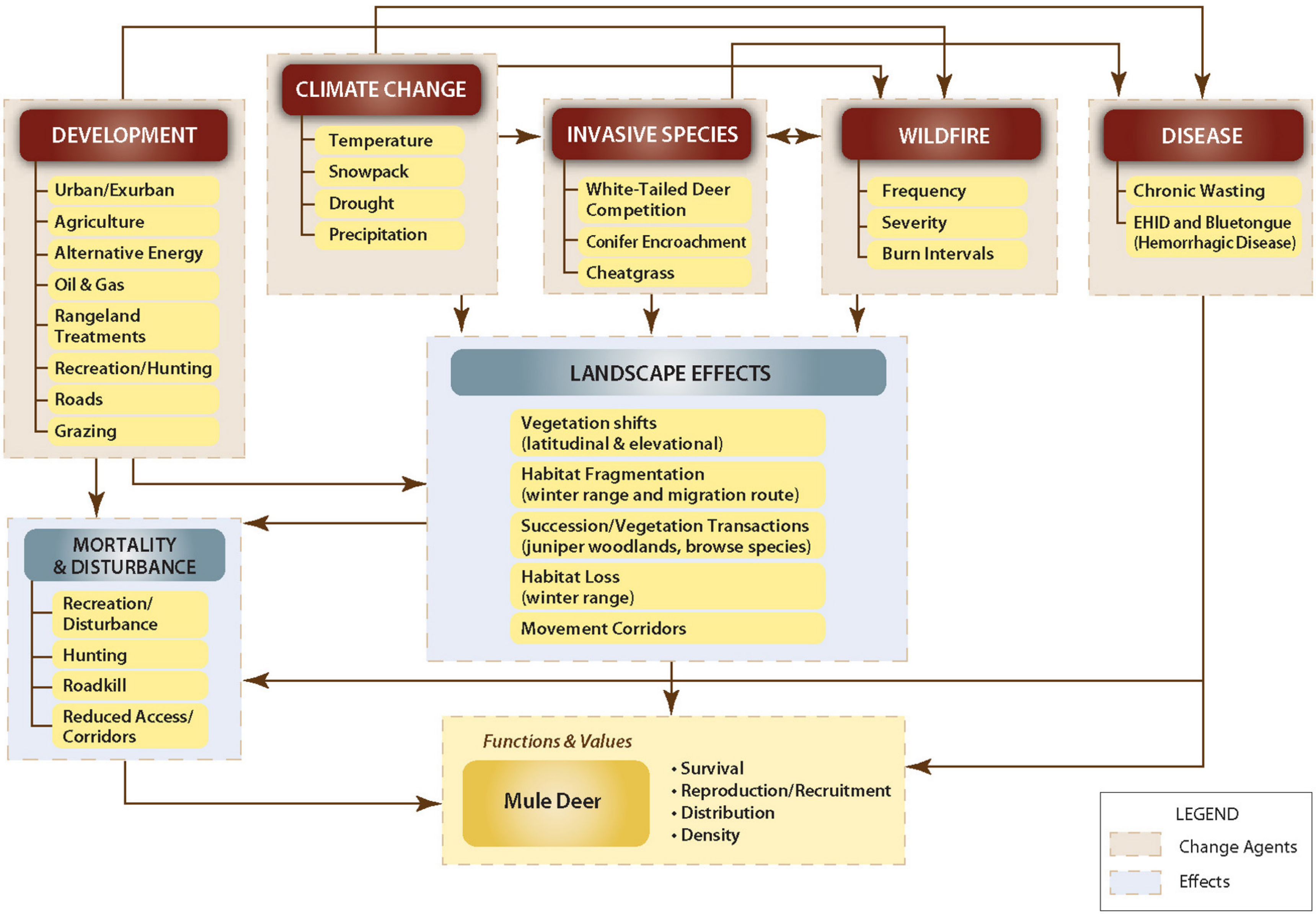


Figure 5-1. Mule Deer Conceptual Model

6 CA Threat Analysis

Current status and future threat assessments for mule deer were conducted for the NGB using both 30m pixels, 4 km and 12-digit HUCs as the analysis units. Once the ecological model was developed, preliminary indicators or key ecological attributes were identified for the current status and future threat analyses with an emphasis on the feasibility of measuring impacts that result from application of CAs using geospatial data. The indicators were selected to assist with answering the MQs that relate to what is happening to the CE across the ecoregion. The CAs evaluated for current status include development, wildfire, climate change, invasive species, and disease. The final CE package was based on input from the Rolling Review Team; Key Ecological Attributes and CAs that were revised or dropped from the analysis are discussed below.

6.1 Key Ecological Attributes

Key Ecological Attributes was compiled to provide indicators for assessing core habitat size, condition, and landscape context with respect to anthropomorphic influences. During the course of the analysis, data availability and consistency concerns caused the elimination of several of these preliminary key ecological attributes with concurrence by Rolling Review Team and Subject Matter Experts. The following Key Ecological Attributes were eliminated:

- Corridor Width at Narrowest Point is an important aspect of the quality and utility of habitat available to species such as mule deer. However, this indicator was excluded from the analysis because the modeled summer and winter habitat were not spatially mutually exclusive. This resulted because of the inclusion of year-long habitat within both models. The overlap between modeled seasonal habitat essentially encapsulated regions where corridors might be present and thus made it difficult to identify them.
- Fire regime data (VCC/FRCC) was reviewed and discussed with AMT and was determined to have a high level of error in shrubland and grassland cover types. For this reasons the VCC data was not evaluated because results would not be indicative of conditions on the ground. Fire perimeters and frequency data was suggested to be used as a surrogate, however it was found that historical data was not reliable enough to base analysis upon.
- Cheatgrass extent data was incomplete in the ecoregion with large portions not available for the northeastern and northwestern part of the ecoregion. Furthermore, there was not one individual study conducted that assessed cheatgrass presence that applied one set of methods for assessing conditions for the entire spatial extents of the study area, therefore making difficult to quantitatively compare data. For these reasons this metric was not evaluated.
- Energy Development: This metric essentially focuses on the density of energy development sites throughout the landscape. Similar to “Distance to other Development” the AMT and Rolling Review Team it was concluded that that the oil/gas well data represented geothermal production sites, which were assumed not to have a serious impact on mule deer in the region, thus this metric was not assessed
- Distance to Urban/Exurban: An accurate estimation of urban/exurban development geospatial dataset was not available. After discussions with Rolling Review Team and AMT no substitute was determined.
- Distance to chronic wasting disease was not assessed because chronic wasting disease data was not available for the ecoregion.

A final list of Key Ecological Attributes (Table 6-1) provides the key ecological attributes for mule deer used in the analysis.

Table 6-3. Final Key Ecological Attributes for Mule Deer

Category	Key Ecological Attribute	Indicator	Metric	Data Source	Citation
Size	Connectivity/ Patch Size	Availability of contiguous Core habitat Area fragment	> 500 ha = good 300-500 ha = fair < 1,000 m = poor	GAP, NLC national land cover dataset D	Best judgment home range size (multiple citations)
Condition	Quality Barrier to movement	Fire regime condition Class (FRCC) Mean annual snow depth	3 = poor< 10.4 in = good 10- 20.4 in = fair > 20.4 in = poor	LANDFIREN OAA	LANDFIRE Parker *et al.* 1984, Gilbert *et al.* 1970
	Cover Quality Fragmentation	Patch fragmentation (no./100 ha)	0.40 - 0.55=good >0.0 - 0.4= fair > 0.55 = poor	GAP, national land cover dataset	Kie et al 2002
Context	Anthropomorphic Influence	Distance to roads (proximity analysis)	> 1,000 m = good 300-1,000 m = fair < 300 m = poor	TIGER	Rost and Bailey 1979
		(e.g., well pads)Energy development (per legal section of 640 acres)Distance to urban/exurban development Distance to chronic wasting disease outbreaks	<3 miles= good 20 – 80 acres = poor	Derived from TIGER	USDI 1999

6.2 Current Status of the CE

This section documents the CA analysis under current conditions, i.e. the current extent of the CE's distribution and locations of the CAs. For each of the Key Ecological Attributes listed in Table 6-1 and used in the CA analysis, a discussion of the indicator, metrics, metric rank and value, data source(s), and references is provided. The analysis was based on spatially available attributes affecting the CE at the ecoregion level.

6.2.1 Size

6.2.1.1 Availability of Contiguous Core habitat

Core habitat area fragment size was selected as an indicator of spatial distribution of habitat at the home range scale. (home-range) which has been related to a variety of factors including body size, trophic level, sex and age reproductive status, season availability of forage and water, and intra- and inter-specific competition. Home-range size in mule deer correlates with a variety of landscape metrics and therefore, may play a role in determining population densities (Kie *et al.* 2002). The metrics used to assess the size of core habitat fragments was developed by considering the average home range for mule deer in the intermountain west (see also Kie *et al.* 2002). Mean home range size for adult does has been estimated range from 200-700 acres while that of bucks is considerably larger (700-2,500 acres). Home range size is a dynamic reflection of body size, resource distribution and seasonal habitat composition, and thus varies significantly across the ecoregion and among vegetation communities. A literature review did not provide a specific threshold of habitat fragment size. However, there was consensus among the Rolling Review Team members that core habitat fragments below approximately 750 acres (or approximately 300 ha) were not large enough to sustain individual deer on average across the ecoregion. The Rolling Review Team and Subject Matter Experts also suggested that core habitat fragments should be at least 1,250 acres (approximately 500 ha) to be classified as sufficient for sustaining a healthy population of mule deer. It is important to note that this fragment size does not pertain to the minimum habitat area, but rather reflects landscape fragments that are easily traversed by mule deer as they move between patches of suitable habitat. Fragmentation in the sense of this analysis pertains to barriers or filters to movement and is not based on habitat quality. Using the Habitat Core Area (HCA) toolset developed by WHCWG (2010), large, contiguous core habitat fragments were identified that presented no permeability restrictions and retained high levels of naturalness (i.e., core areas characterized by a relatively light human footprint). Using the HCA layer outputs for mule deer, the layer output was reclassified based on core habitat fragment acreage metrics and were values between 1 and 3 (Table 6-1, representing the gradient from 'Lower Quality" (i.e., 1) to "Preferred"(i.e., 3). This layer was converted to raster with assigned values. Zonal statistics were applied against the layer using the 4 km grid GIS layer to determine an overall summary score for the patches contained within each 4 km grid cell. The core habitat fragment size assessment by 4 km grid for both summer and winter modeled habitat data are presented in Figures 6-1 and 6-2 respectively.

Most of modeled summer habitat (Figure 6-1) scored within the preferred range while portions that abutted agricultural/urban or fell within agricultural areas were scored as lower quality. Modeled winter habitat (Figure 6-2) was scored similar to the summer habitat; however a greater number of regions within the Snake River floodplain yielded scores of lower quality. This was due to a larger portion of winter habitat incorporating agricultural regions, which tend to be fragmented by urban and transportation features.

6.2.2 Condition

6.2.2.1 Mean Annual Snow Depth

Mean annual snow depth data represents the mean monthly total accumulation derived from 4 km raster data. It does not incorporate melting, compression or sublimation. The data scoring categories were based on snow depth data categories. Snow depth data for the month of March was selected for analysis based on the following rationale:

- Mule deer densities on winter range are highest from January through March;
- Mule deer body reserve depletion (starvation, fat loss) is nearing its maximum at the end of winter (March);
- Mule deer begin migrating off winter range in late March and most have moved to transitional ranges in late May when fawns are born;
- Mule deer are most predation prone in March when they are in high density, poor body condition, and in their last trimester of gestation;
- Mule deer move off winter range where snow melt exposes fresh green – areas with deeper snow will green up later and most likely not be used much as all the deer will follow the receding snowline uphill.

Most of the modeled winter mule deer habitat was scored as preferred. However portions of the winter habitat did receive a lower quality to moderate rating in regions where snow depths were greater, which corresponded with regions of higher elevation (Figure 6-3).

6.2.2.2 Patch Core Habitat Fragmentation

Spatial heterogeneity is a structural feature of landscapes that can be defined as the complexity and variability in the habitat of the species. Habitat fragmentation was assessed by using the core habitat developed for the core fragment size analysis for both summer and winter ranges. Each dataset was evaluated by applying the following patch density equation to assess the level of habitat heterogeneity:

$$PD = \frac{N}{A}$$

where PD = Patch Density, N = number of unique patches, and A = unit area (100 ha).

Core habitat layer had the roads layer removed from it to develop a more realistic representation of the landscape. The patch density values were scored based on the metric values presented in Table 6-1. The patch density layer output for summer and winter are presented in Figures 6-4 and 6-5, respectively.

6.2.3 Context

6.2.3.1 Distance to Roads

Roads limit connectivity through the creation of physical barriers such as right-of-way fences, increased mortalities due to collisions, and behavioral responses (avoidance of roads or high traffic volumes (WHCWG 2010). This key ecological attribute was used as an indicator to assess potential impacts from development.

A proximity analysis was performed and then assigned scores based on the metric values presented in Table 6-1. The distance to roads analysis for modeled summer and winter mule deer habitat is presented in Figures 6-6 and 6-7, respectively.

The majority of both the modeled summer and winter mule deer habitat was rated as either moderate to preferred. Habitat located within/adjacent to urbanized or agricultural areas received lower quality ratings since these regions generally associated with a higher level of transportation networks.

6.2.3.2 Road Density

The road density of the TIGER roads in the ecoregion is presented in Figure 6-8 and 6-9.

6.2.4 Cumulative Indicator Score

Four of the Key Ecological Attributes were used to create a cumulative indicator score for summer mule deer habitat (patch size, habitat fragmentation, distance to roads, and road density) and five of the Key Ecological Attributes were used to create a cumulative indicator score for winter mule deer habitat (patch size, habitat fragmentation, distance to roads, road density and mean annual snow depth). The individual metrics for the Key Ecological Attributes were scored with a 1, 2 or 3 with 1 given to lowest quality indicator and 3 given to the highest quality indicator. The four/five Key Ecological Attributes (depending of season) were then added together using raster calculator to derive a range of cumulative scores from five to fifteen. Figure 6-10 shows the resulting high and low scoring areas with a stretched raster for summer habitat. Figure 6-11 shows the resulting high and low scoring areas with a stretched raster for winter habitat. The stretched raster was used to show the gradient from low scoring to high scoring 4 km analysis units.

The primary result of this analysis shows preferred conditions over much of the mule deer range in the ecoregion. Summer habitat quality is currently most affected on the fringes of the ecoregion, such as in the far western portion (Oregon, California) and at the northernmost extent in Idaho. This is primarily driven by fragmentation of the habitat, which results in smaller patches o habitat, more frequent disturbances and higher risks (e.g., traffic mortality). Winter habitat quality is primarily affected in the agricultural portions of the ecoregion, chiefly the Snake River Plain. Here, increasing habitat fragmentation and road density result in lower winter habitat quality, which may only marginally be compensated by higher forage availability (fields, haystacks etc). High winter habitat quality for mule deer is predominantly characterized by a relative absence of disturbance that necessitates energetically costly avoidance (flight) responses. The increasing fragmentation of habitat in agricultural areas of the ecoregion, as evidenced by higher road density and smaller patches of habitat, and coupled with low cover available in agricultural landscapes provides for a high stress environment for mule deer.

6.3 Future Threat Assessment

6.3.1 Climate Change

Climate change is predicted to produce a slight precipitation increase in the basins, valleys, and uplands and large increases in the mountains. Especially during spring, when deer rely on highly nutritious browse, increased precipitation in the mountains and uplands is predicted. No changes are predicted in the basins or the lower elevations of the Owyhee Uplands. Likewise, the climate change model predicts slight increases in the mountains and either no change or a very slight change in the basins, lower elevations of the Owyhee Uplands, and Snake River Plains. The western half of the NGB REA is predicted to become slightly warmer during June so the slight increase in precipitation may offset some of the increased evapotranspiration demand.

The implications of these predicted changes for mule deer are not straight forward. While higher precipitation in the mountains may increase snow pack and moisture availability later in the spring, it may keep mule deer from migrating uphill in the spring in time for fawning. Added moisture during spring is most certainly expected to increase the amount of cover and browse, both factors that may reduce fawn mortality and bolster the nutritional status of parturient and lactating does. On the other hand, higher biomass and vegetation growth may exacerbate the risk of frequent wildfires later in the summer, which may eliminate or reduce important browse species. Added moisture in higher elevations may also increase growth of coniferous forests that in return may out-compete and out-shade browse species.

6.3.2 Development

Mule deer are sensitive to increasing levels of fragmentation by roads, energy development and housing (Sawyer et al 2005, Trombulak and Frissell 2000, Gaines *et al.* 2003, Wisdom *et al.* 2004). Future development may affect the suitable habitat quality and availability for mule deer throughout the ecoregion, and especially near already fragmented habitat in the Snake River Plain, Northeastern California and Oregon. These threats include urban/exurban expansion, agriculture (especially when land conversion occurs), alternative and traditional energy exploration and development, and linear features (especially pipelines that disrupt vegetation and soil structure).

6.3.3 Wildfire

Wildfire is a major factor in the nutritional ecology of mule deer. Mule deer are adapted to natural fire frequencies in native shrubsteppe and woodland habitats, which tend to produce a reliable source of high quality browse and sufficient cover from predators and thermal extremes. Large deviations from natural fire regimes can be detrimental to mule deer. Wildfire now covers larger areas and occurs more frequently, reducing habitat quality and quantity of mature sagebrush communities used by mule deer. Furthermore, increased fire frequency has shortened the interval between fires, and thus reduced the time window for sagebrush and other browse species to recover. With an increasing number of fires exceeding 100,000 acres during the last decade, fire is currently the major contributing factor to the transition of many shrubsteppe ecological states to grass dominated conditions (especially when coupled with cheatgrass invasions). Increasing fire frequency, therefore, tends to decrease habitat quality and carrying capacity for mule deer. On the other hand, frequent fires and those burning large areas may also reduce the extent of Pinyon/Juniper woodlands, which typically have lower forage value for mule deer (but provide cover to mule deer). Woodlands have greatly increased during the past century as a result of overgrazing and fire suppression. Increasingly large fires have removed significant pinyon/juniper woodland cover throughout the ecoregion and are expected to continue to do so. Whether recently burned pinyon juniper stands can back-transition to shrub-dominated communities is however questionable.

6.3.4 Grazing

Grazing by livestock has declined since 2000 on public land, in terms of numbers of authorized animals units, from levels reported in the previous five years (BLM 2013). This change is not expected to significantly affect use of rangeland by mule deer. Most rangeland improvement aims to increase grass cover and develop water sources for domestic livestock; habitat improvement for mule deer is generally not the focus of management actions. These management actions have variable effects on mule deer; i.e., fences do not benefit mule deer and grass is not a significant forage resource. Moreover, there may be disagreement with regard to the effects of water developments for mule deer. Invasives and Disease

6.3.4.1 Cheatgrass

Climate envelope modeling indicates that cheatgrass habitat suitability will be reduced in the NGB REA if climate changes results in increased precipitation during the summer (June-September) (Bradley 2009), but it is not clear if the predicted increase will meet that threshold. While climate change projections indicate a significant increase in mean snow water equivalent during March and April, the deposition of dust from post cheatgrass-fire dust storms within the NGB REA on snow in downwind mountain ranges (see Germino *et al.* 2012) may cause reduced seasonal snow cover by 18 to 35 days (Painter *et al.* 2007). This may offset potential effects of higher snow depths and persistent snow cover on the spring migration of mule deer. If cheatgrass abundance and density is to decline, the risk of repeated fires and their negative effects on shrubs and forbs may decrease over time. This will benefit mule deer through an increasing availability of browse and increasing cover for fawns during the post-parturition hiding phase. Increasing cheatgrass cover is predicted for northwestern Nevada with significant risk of invasion into some of the best and least-fragmented mule deer habitat that is remaining in the ecoregion. As cheatgrass invades areas, increasing fire frequencies will affect not only the availability of quality browse, but also generate increasing development of fire roads and fire suppression activities.

6.3.4.2 Diseases

Several diseases that affect mule deer may increase in presence and affect populations, especially those undergoing stresses from other factors, in the NGB (e.g., chronic wasting disease), bluetongue, epizootic hemorrhagic disease, etc). None of the diseases that afflict mule deer are thought to be directly associated with habitat alterations or anthropogenic changes to habitat quality at this time, but the future importance of hemorrhagic diseases, which are transmitted by biting insects, may be potentially linked with Climate Change.

Increasing temperatures predicted by climate change models may increase the number of generations of insect vectors each year, potentially increasing overall numbers of these vectors and the extent of their seasonal presence in the NGB.

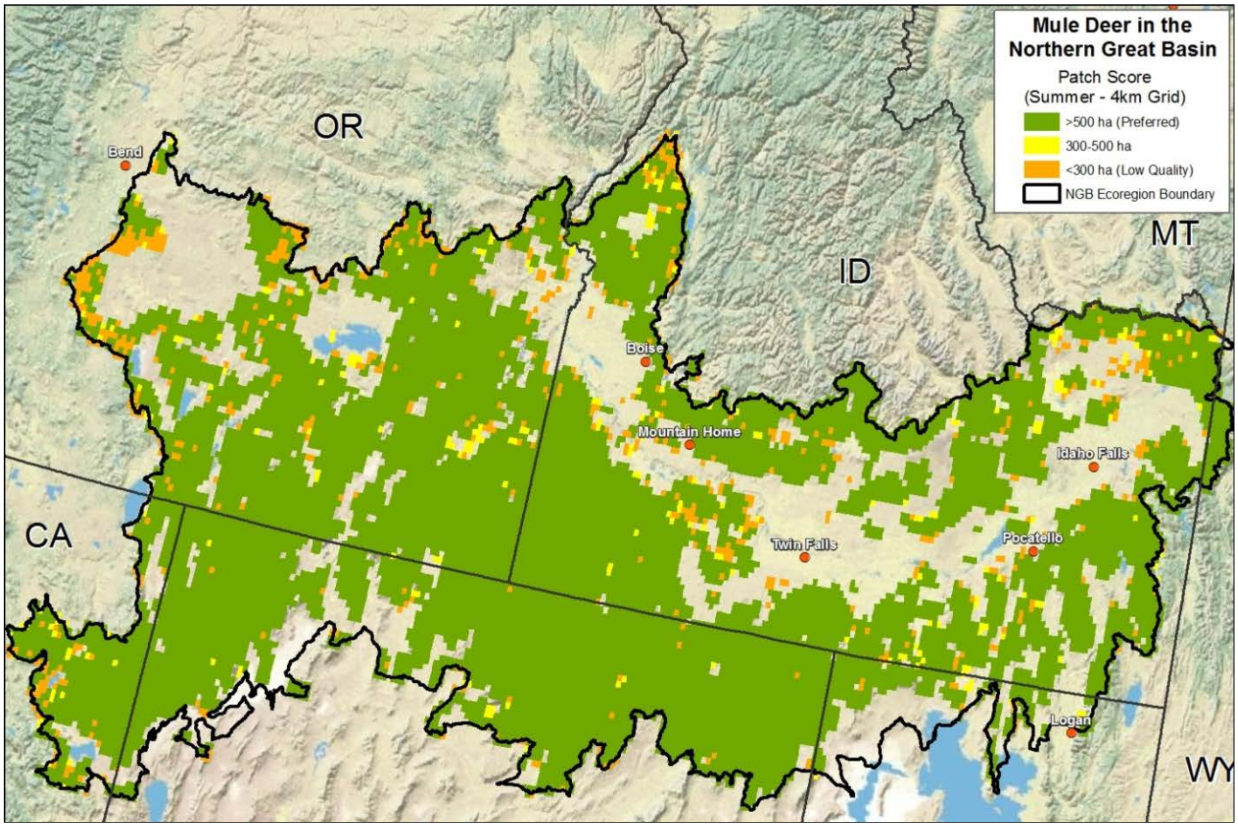


Figure 6-1. Habitat Patch Assessment for Modeled Mule Deer Summer/Year Long Habitat

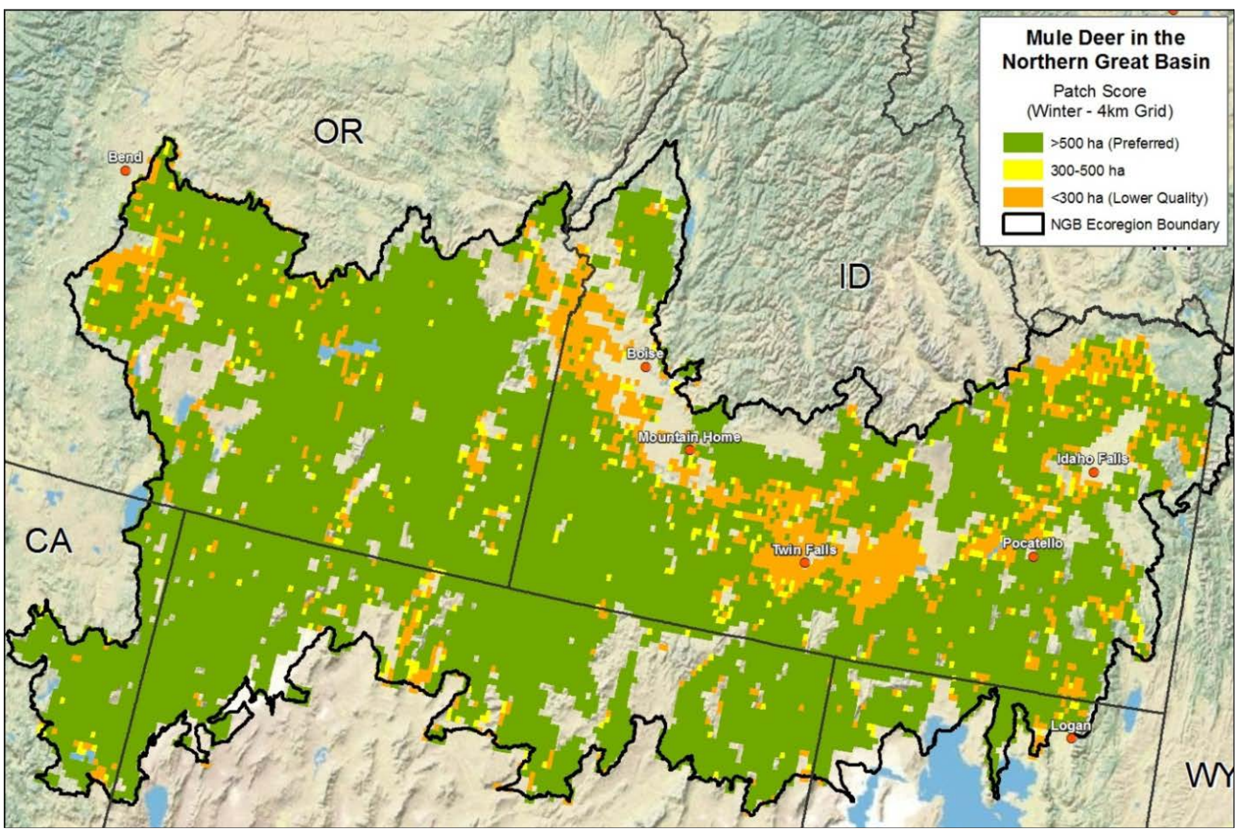


Figure 6-2. Habitat Patch Assessment for Modeled Mule Deer Winter/Year Long Habitat

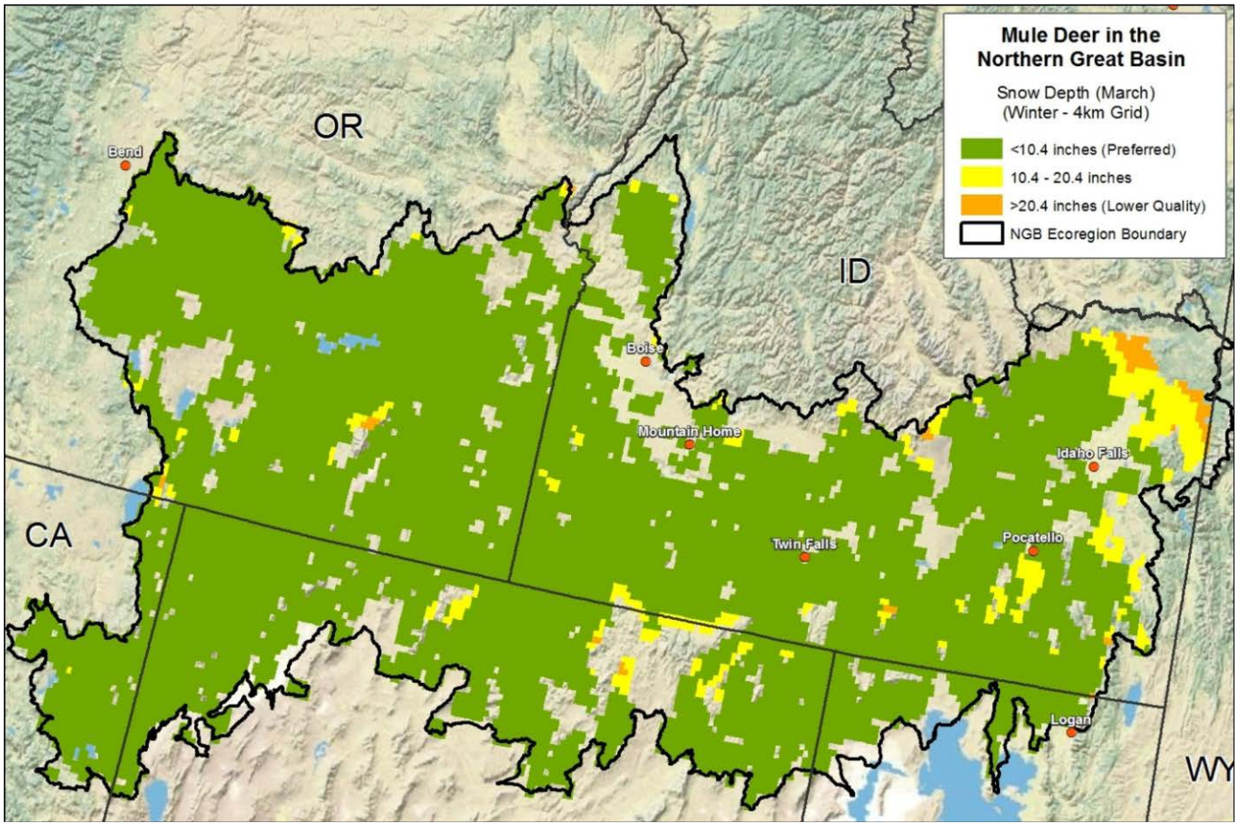


Figure 6-3. Snow Depth for Modeled Mule Deer Winter/Year Long Habitat

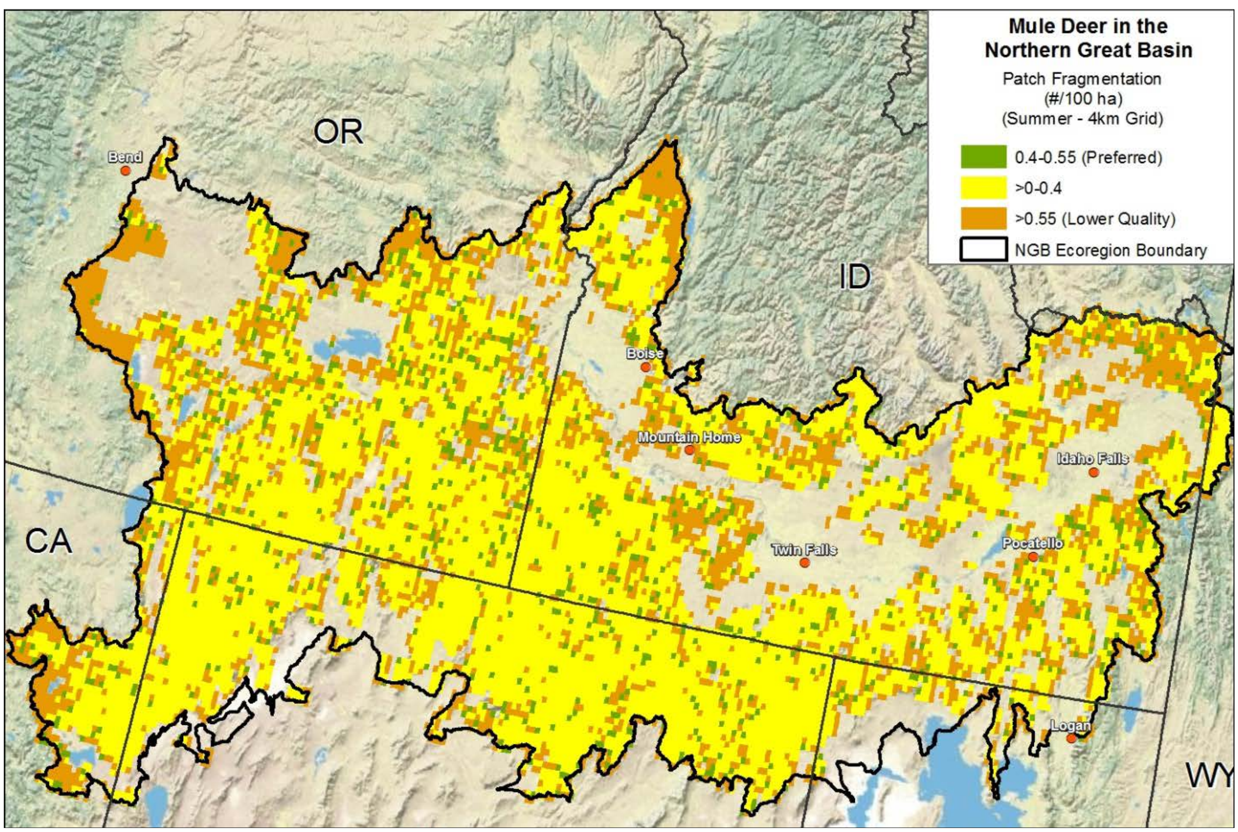


Figure 6-4. Core Habitat Fragmentation for Modeled Mule Deer Summer/Year Long Habitat

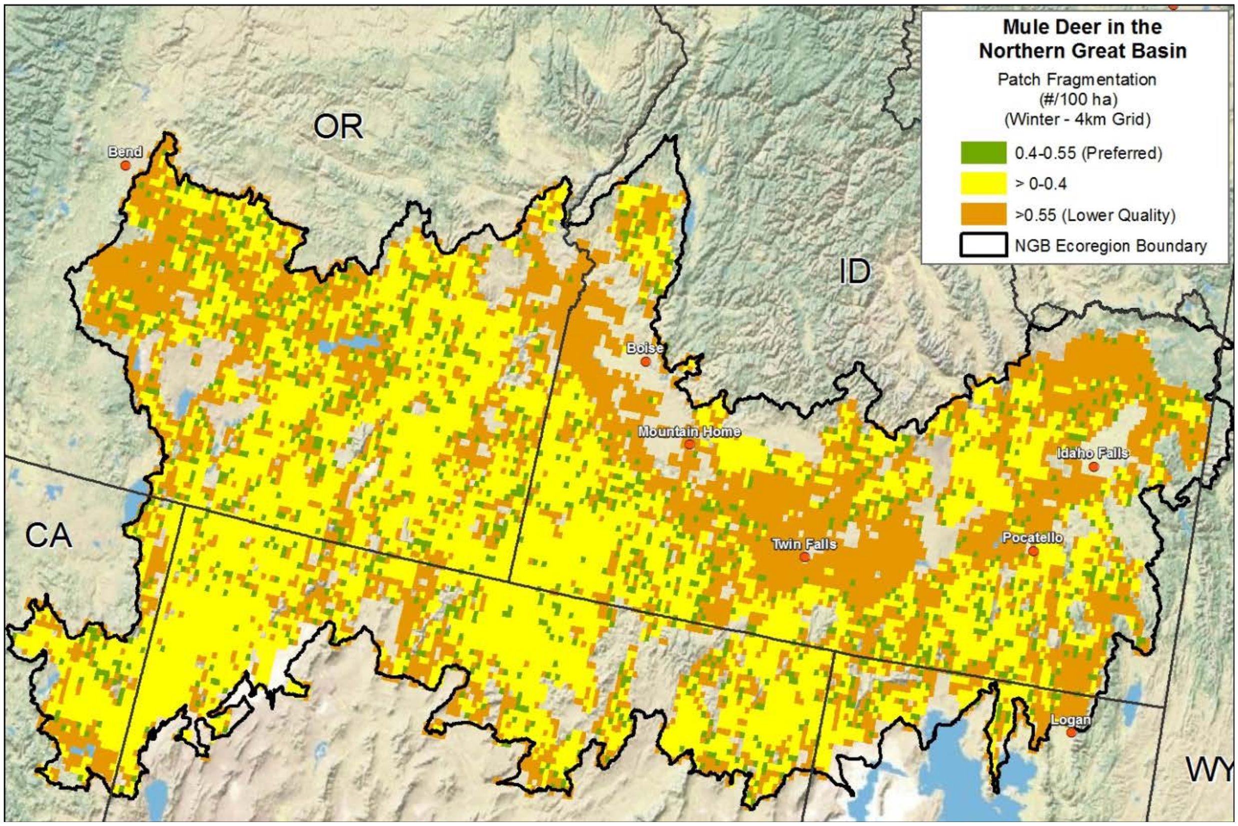


Figure 6-5. Core Habitat Fragmentation for Modeled Mule Deer Winter/Year Long Habitat

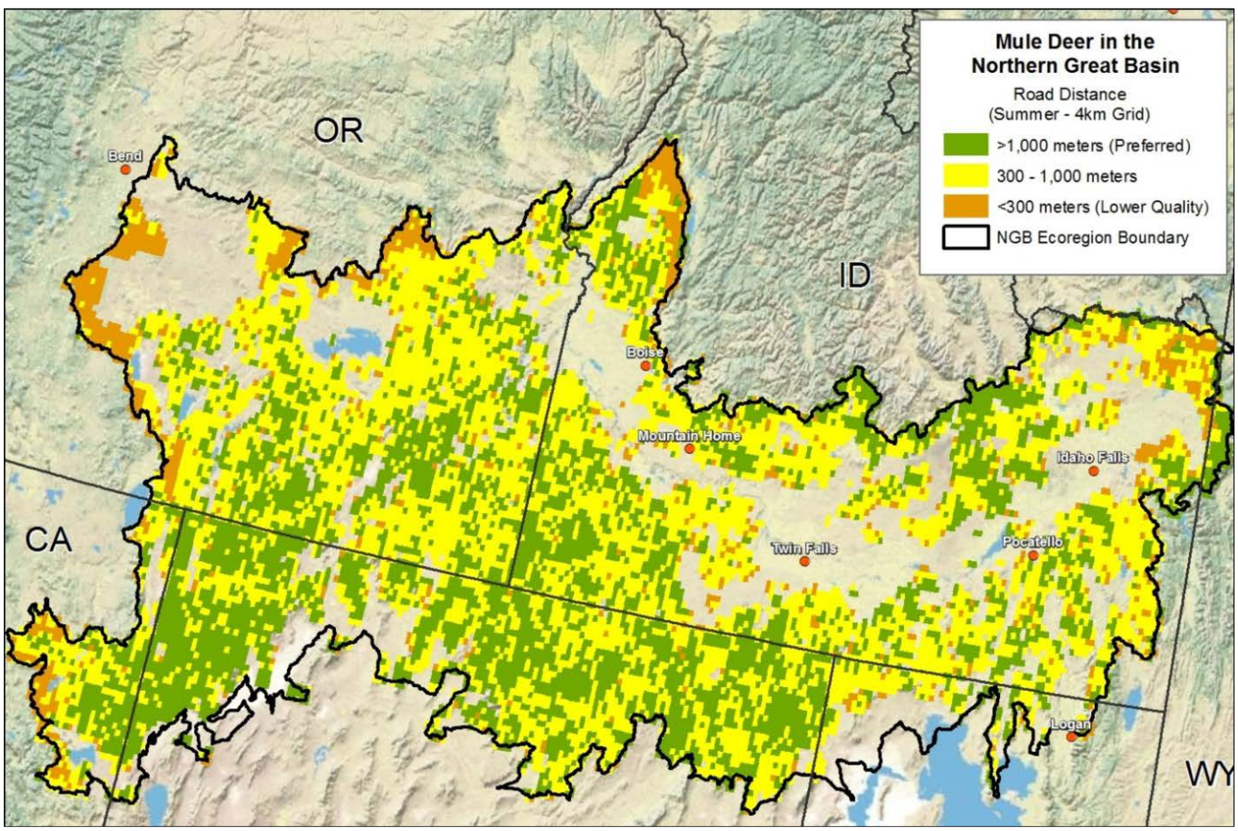


Figure 6-6. Distance to Roads for Modeled Mule Deer Summer/Year Long Habitat

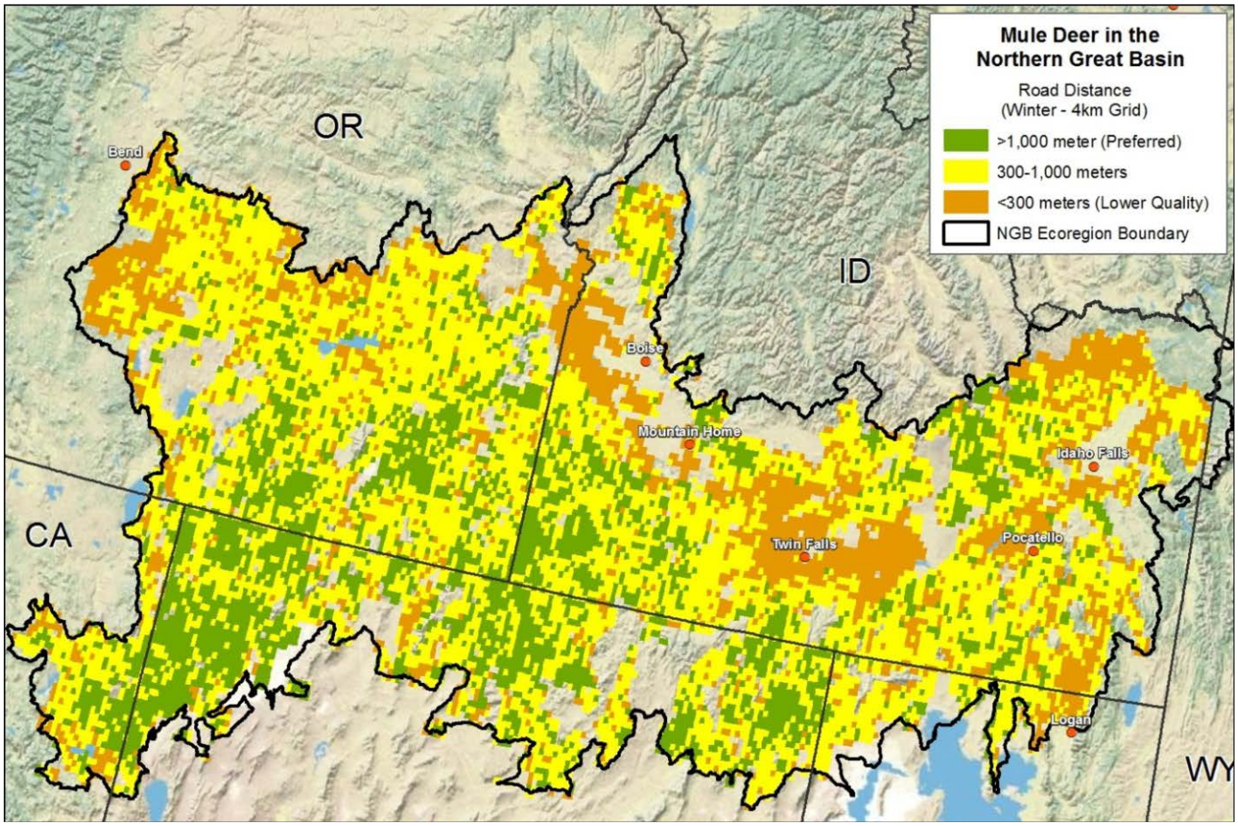


Figure 6-7. Distance to Roads for Modeled Mule Deer Winter/Year Long Habitat

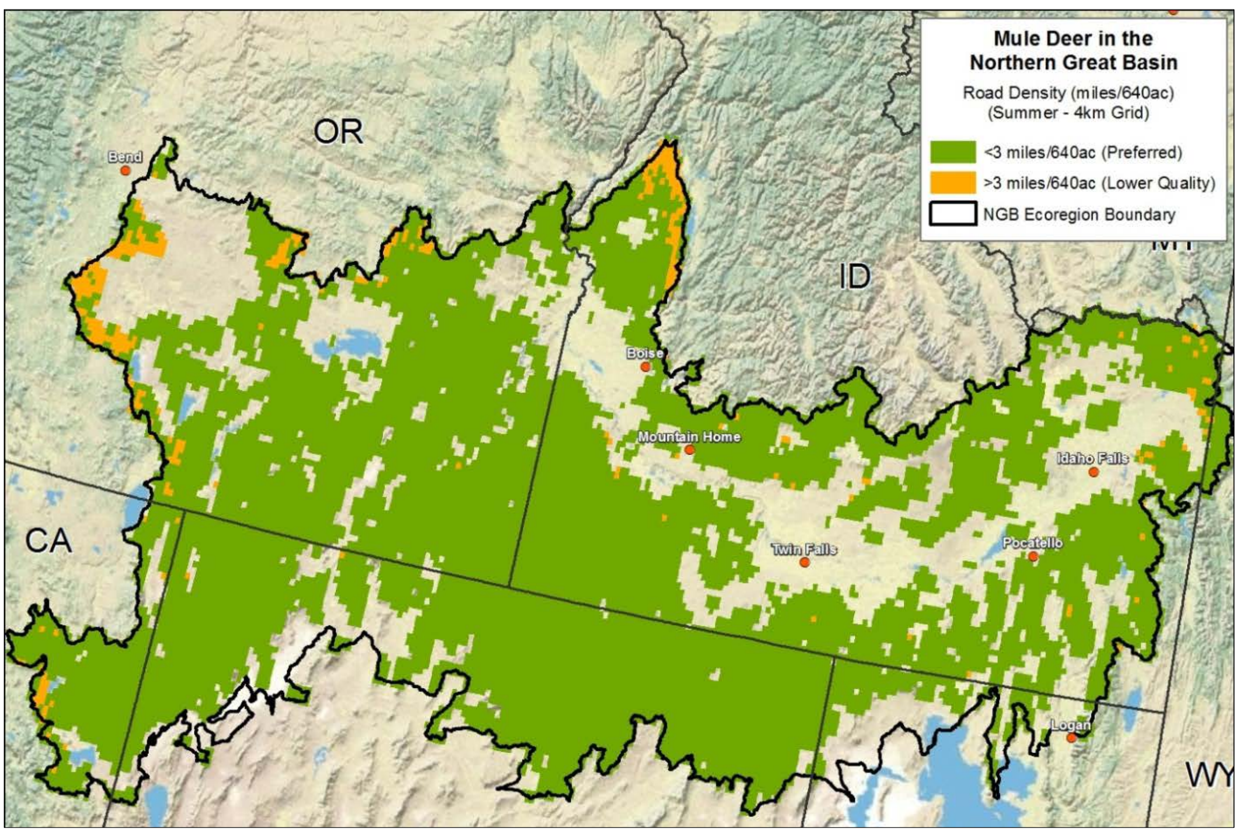


Figure 6-8. Road Density for Modeled Mule Deer Summer/Year Long Habitat

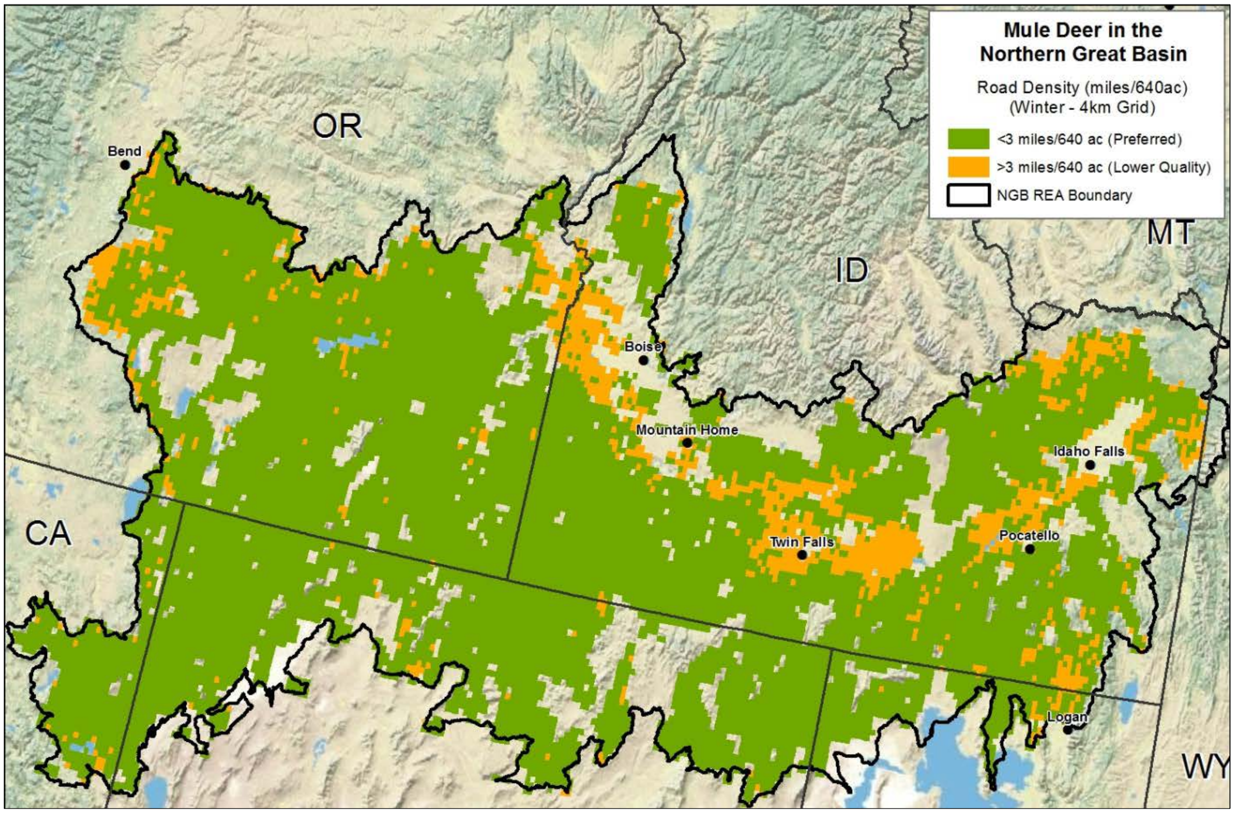


Figure 6-9. Road Density for Modeled Mule Deer Winter/Year Long Habitat

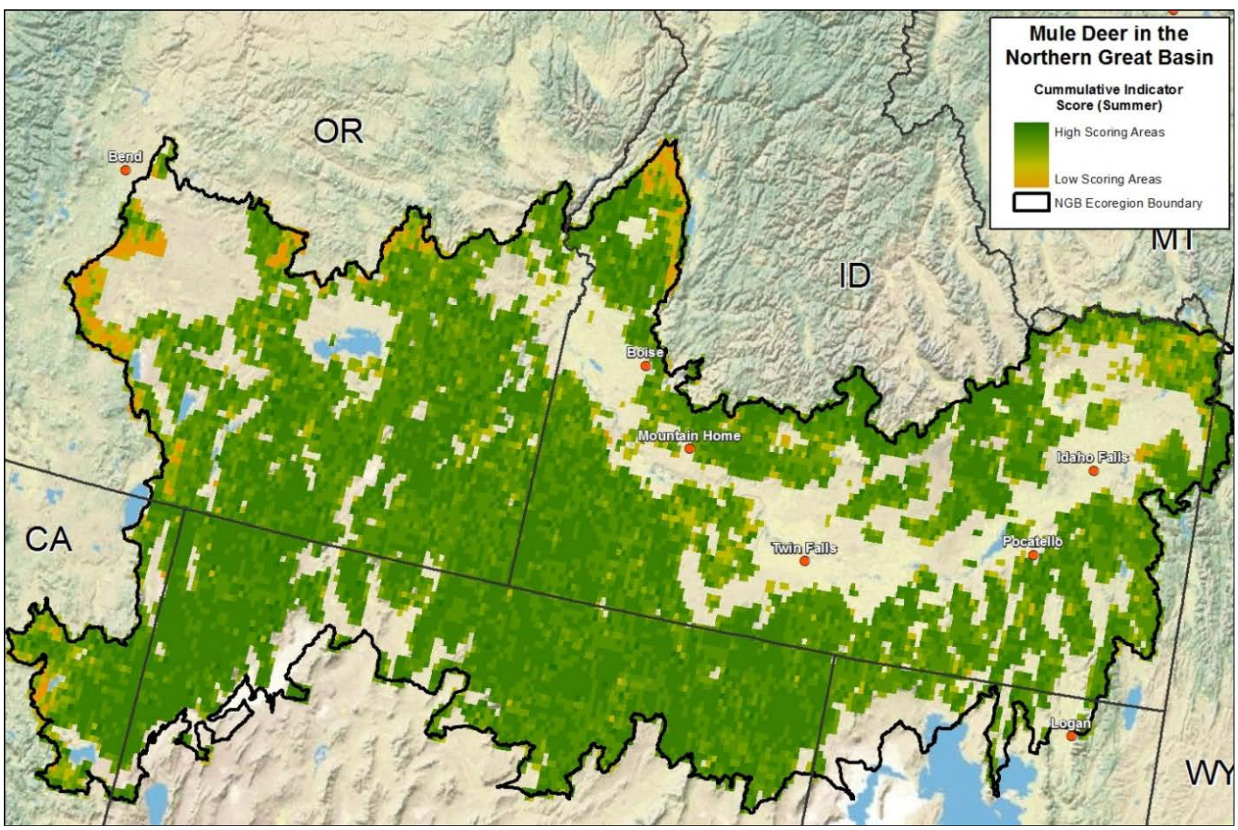


Figure 6-10. Cumulative Indicator Score for Modeled Mule Deer Summer Habitat

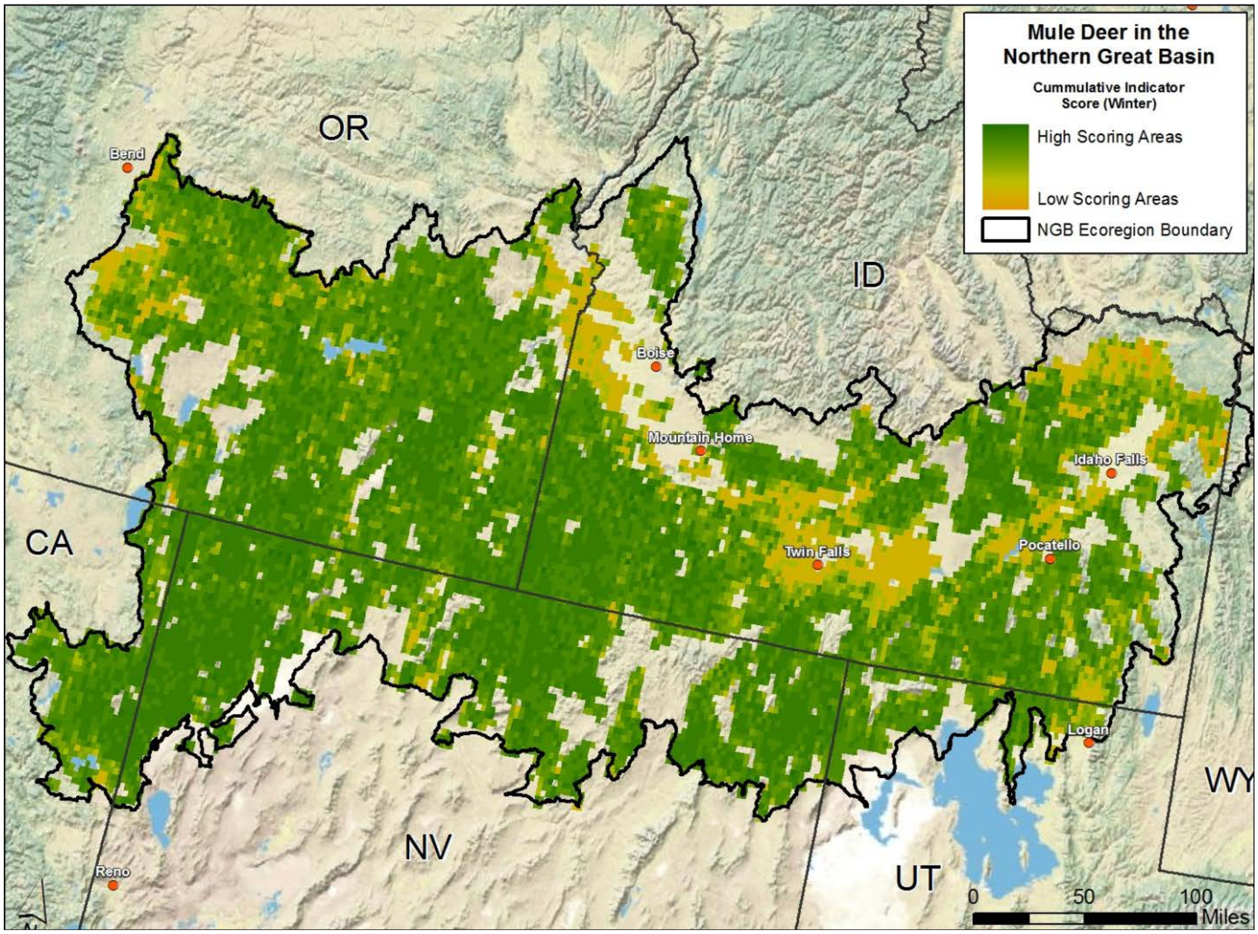


Figure 6-11. Cumulative Indicator Score for Modeled Mule Deer Winter Habitat

7 Management Questions

Management questions for the NGB were developed by BLM managers and refined by the AMT to answer questions regarding the agency's land management responsibilities—including planning land use, developing best management practices, authorizing uses, and establishing conservation and restoration priorities. Several management questions relate to this CE (with original numbering):

1 What is the currently occupied habitat or modeled suitable habitat for this CE?

The currently occupied and modeled suitable habitat for mule deer in the ecoregion is shown in Figure 4-1.

2 Where are the areas of greatest and least collective impact of existing CAs on occupied habitat or modeled suitable habitats of this CE?

The areas of greatest and least collective impact are shown in Figure 6-10 for the winter and Figure 6-11 for the summer. Areas in green have had the least collective impact and areas in orange have the most collective impact.

5 Where are current locations of this CE likely to overlap with the potential future distribution of CAs (other than climate change)?

Mule deer habitat overlaps areas with high burn probability in Idaho (see Wildfire CA). Shrub-steppe mule deer habitat in high burn probability areas may be vulnerable to type conversion to cheatgrass dominated grasslands, which could reduce available habitat for mule deer. Most growth in development is modeled to occur in existing population centers along the Snake River corridor where mule deer habitat is a high stress environment.

6 Given current and anticipated future locations of CAs, which habitat areas remain as opportunities for habitat enhancement/restoration for this CE?

The cumulative indicator scores for pygmy rabbit suitable habitat under current conditions should be useful in identifying the areas most in need of preservation or the best restoration opportunities in these drill-down evaluations. The Mule Deer Habitat Guidelines (Cox *et al.* 2009) provide detailed guidance on ways to enhance or restore mule deer habitat through proper grazing and development practices. Of key concern are herbivory by livestock grazing and spread of non-native species like cheatgrass. There are significant opportunities to improve or maintain mule deer habitat throughout the ecoregion by implementing the Mule Deer Habitat Guidelines for non-native invasive species and grazing. Grazing allotments are provided in the Grazing CA package and cheatgrass distribution is provided in the Invasives CA package.

7 Where are potential areas to restore connectivity for this CE, based on current locations of CAs?

The primary result of this analysis shows preferred conditions over much of the mule deer range in the ecoregion. Summer habitat quality is currently most affected on the fringes of the ecoregion, such as in the far western portion (Oregon, California) and at the northernmost extent in Idaho. This is primarily driven by fragmentation of the habitat, which results in smaller patches or habitat, more frequent disturbances and higher risks (e.g., traffic mortality). Winter habitat quality is primarily affected in the agricultural portions of the ecoregion, chiefly the Snake River Plain., increasing habitat fragmentation and road density result in lower winter habitat quality, which may only marginally be compensated by higher forage availability (fields, haystacks etc).

8 Where will this CE experience climate outside their current climate envelope? Or: Where will this CE experience significant deviations from normal climate variation?

The implications of these predicted changes for mule deer are not straight forward. While higher precipitation in the mountains may increase snow pack and moisture availability later in the spring, it may keep mule deer from migrating uphill in the spring in time for fawning. Added moisture during spring is most certainly expected to increase the amount of cover and browse, both factors that may reduce fawn mortality and bolster the nutritional status of parturient and lactating does. On the other hand, higher biomass and vegetation growth may exacerbate the risk of frequent wildfires later in the summer, which may eliminate or reduce important browse species. Added moisture in higher elevations may also increase growth of coniferous forests that in return may out-compete and out-shade browse species

8 References

Barnum, S. 2001. Preliminary Analysis of Locations Where Wildlife Crosses Highways in the Southern Rocky Mountains. In: International Conference on Ecology and Transportation (ICOET) 2001 Proceedings.

Berger, J., K.M. Berger, and J.P. Beckmann. 2006. Wildlife and Energy Development: Pronghorn of the Upper Green River Basin – Year 1 Summary. Wildlife Conservation Society, Bronx, NY. Available at: http://www.wcs.org/media/file/Shell%20Year%201%20Progress%20REVISED%20III.pdf.

Chronic Wasting Disease Alliance. 2012. Website for organization formed by non-profit wildlife conservation organizations that provides timely, scientifically accurate information regarding chronic wasting disease in U.S. states and Canadian provinces. Available on internet at: http://www.cwd-info.org/. Accessed August 15, 2012.

Cox, M., D.W. Lutz, T. Wasley, M. Fleming, B. B. Compton, T. Keegan, D. Stroud, S. Kilpatrick, K. Gray, J. Carlson, L. Carpenter, K. Urquhart, B. Johnson, and C. McLaughlin. 2009. Habitat Guidelines for Mule Deer: Intermountain West Ecoregion. Mule Deer Working Group, Western Association of Fish and Wildlife Agencies.

Craighead, A.C., F.L. Craighead, and E.A. Roberts. 2001. Bozeman Pass Wildlife Linkage and Highway Safety Study. In: International Conference on Ecology and Transportation (ICOET) 2001 Proceedings.

deVos, J.V. Jr. and T. McKinney. 2007. Potential Impacts of Global Climate Change on Abundance and Distribution of Elk and Mule Deer in Western North America. Final Report to the Western Association of Fish and Wildlife Agencies. Available online at: http://www.createstrat.com/i/globalwarmingdoc2.pdf.

Gaines, W., P. Singleton, and R. Ross. 2003. Assessing the Cumulative Effects of Linear Recreation Routes on Wildlife Habitats on the Okanogan and Wenatchee National Forests. General Technical Report PNW-GTR-586. U.S. Department of Agriculture, U.S. Forest Service, Pacific Northwest Research Station, Portland, OR.

Gilbert, P.F., O.C. Wallmo, and R.B. Gill. 1970. Effect of snow depth on mule deer in Middle Park, Colorado. Journal of Wildlife Management, Vol. 34, No. 1, pp. 15-23. January.

Hebblewhite, M. 2008. A literature review of the effects of energy development on ungulates: Implications for central and eastern Montana. Report prepared for Montana Fish, Wildlife and Parks, Miles City, MT.

Heffelfinger, J. R. and T. A. Messmer. 2003. Introduction. *In:* J.C. deVos Jr., M.R. Conover, and N.E. Headrick, editors. Mule deer conservation: issues and management strategies. Berryman Institute Press, Utah State University, Logan, USA.

Hobbs, N.T. and R.A. Spowart. 1984. Effects of prescribed fire on nutrition of mountain sheep and mule deer during winter and spring. Journal of Wildlife Management. 48(2): 551-560.

Hoffman, R.R. 1985. Digestive physiology of the deer: their morphophysiological specialisation and adaptation. *In:* P.F. Fennessy and K.R. Drew. Biology of Deer Production. Bulletin 22, The Royal Society of New Zealand, Wellington, New Zealand.

Holloran, M.J. 2005. Greater Sage-Grouse (*Centrocercus urophasianus*) Population Response to Natural Gas Field Development in Western Wyoming. Doctoral Dissertation, University of Wyoming, Laramie, WY.

Johnson, B. K, J. W. Kern, M. J. Wisdom, S. L. Findholt, and J. G. Kie. 2000. Resource selection and spatial separation of elk and mule deer in spring. Journal of Wildlife Management 64:685-697.

Keegan, T. W., and B. F. Wakeling. 2003. Elk and deer competition. *In:* J.C. deVos, Jr., M.R. Conover, and N. E. Headrick, editors. Mule deer conservation: issues and management strategies. Western Association of Fish and Wildlife Agencies and Jack H. Berryman Institute, Utah State University, Logan, Utah, USA.

Kei, J.G., R.T. Bowyer, M.C. Nicholson, B.B. Boroski, and E.R. Loft. 2002. Landscape Heterogeneity at Differing Scales: Effects on Spatial Distribution of Mule Deer. Ecology, 83(2): 530-544, February.

Kie, J.G. 1996. The effects of cattle grazing on optimal foraging in mule deer (*Odocoileus hemionus*). Forest Ecology and Management 88: 13I-138.

Lindzey, F. G., W. G. Hepworth, T. A. Mattason, and A. F. Reese. 1997. Potential for competitive interactions between mule deer and elk in the western United States and Canada: a review. Wyoming Cooperative Fisheries and Wildlife Research Unit, Laramie, USA.

Lutz, D. W., and 7 co-authors. 2003. Impacts and changes to mule deer habitat. *In:* Mule Deer Conservation: Issues and Management Strategies. J.C. deVos, Jr., M.R. Conover, and N.E. Hedrick, editors. Berryman Institute Press, Utah State University, Logan.

Lyon, L. J. 1979. Habitat effectiveness for elk as influenced by roads and cover. Journal of Forestry 79:658-660.

Parker, K.L., C.T. Robbins and T. A. Hanley. 1984. Energy expenditures for locomotion by mule deer and elk. Journal of Wildlife Manage. 48:474-488.

Pierce, B. 2011. EHD outbreak takes toll on white-tailed deer. Available on internet at: populationhttp://www.bozemandailychronicle.com/sports/outdoors/article_d2064d34-0806-11e1-8695-001cc4c03286.html. Posted Sunday, November 6, 2011.

Poole K. G. and G. Mowat. 2005 Winter Habitat Relationships of Deer and Elk in the Temperate Interior Mountains of British Columbia, Wildlife Society Bulletin 33: 1288-1302.

Rost, G.R. and J.A. Bailey. 1979. Distribution of mule deer and elk in relation to roads. Journal of Wildlife Management 43(3):634-641.

Rowland, M., M. Wisdom, B. Johnson, and M. Penninger. 2004. Effects of roads on elk: Implications for management of forested ecosystems. Pgs. 42-52 in Wisdom, M.J, technical editor, The Starkey Project: a Synthesis of Long-Term Studies of Elk and Mule Deer. 2004. Transactions of the North American Wildlife and Natural Resources Conference, Alliance Communications Group, Lawrence, Kansas, USA.

Sawyer, H. and R. Nielsen. 2010. Mule Deer Monitoring in the Pinedale Anticline Project Area: 2010 Annual Report. Western Ecosystems Technology, Cheyenne, WY. Accessed at http://www.wy.blm.gov/jiopapo/papo/reports/2010annualreport_muledeer.pdf

Sawyer, H., R. Nielson, F. Lindzey, and L. McDonald. 2006. Winter habitat selection of mule deer before and during development of a natural gas field. Journal of Wildlife Management 70:396-403.

Sawyer, H., F. Lindzey, and D. McWhirter. 2005. Mule deer and pronghorn migration in western Wyoming. Wildlife Society Bulletin 33:1266-1273.

Southeastern Cooperative Wildlife Disease Study Group (SCWDS Group). 2012. Information available on the internet at: http://www.growingdeer.tv/view/wp-content/uploads/2012/07/Epizootic-Hemorrhagic-Disease-Fact-Sheet.pdf. Accessed August 15, 2012.

Taylor and Knight. 2003. Wildlife responses to recreation and associated visitor perceptions. Department of Fishery and Wildlife Biology, Colorado State University, Fort Collins, Colorado. by the Ecological Society of America Ecological Applications 13(4): 951–963.

Trombulak, Stephen C. and C.A. Frissell. 2000. Review of Ecological Effects of Roads on Terrestrial and Aquatic Communities. Pages 18-30 in Conservation Biology, Vol. 14, No. 1, 2000. Journal of the Society for Conservation Biology. February.

U.S. Department of Interior (USDI), Bureau of Land Management. 1999. Glenwood Springs Resource Area; Oil and gas leasing and development: final supplemental environmental impact statement. Glenwood Springs Field Office, Colorado, USA.

Wisdom, M.J., A.A. Ager, H.K. Preisler, N.Cimon, and B.K. Johnson. 2004. Effects of off-road recreation on mule deer and elk. Transactions of the North American Wildlife and Natural Resources Conference 69:531-550.

Wyoming Game and Fish Department (WGFD). 2004. Recommendations for Development of Oil and Gas Resources within Crucial and Important Wildlife Habitat: A Strategy for Managing Energy Development Consistently with the FLPMA Principles of Multiple Use and Sustained Yield. Available at http://gf.state.wy.us/downloads/pdf/og.pdf.

U.S. Department of the Interior
Bureau of Land Management

Data Request Method

Rapid Ecoregional Assessments (REAs)—National Operations Center, CO

Individual REA data layers and some other products are still available but are no longer being published.

If you would like to obtain more information, including data and model zip files* (containing Esri ModelBuilder files for ArcGIS 10.x and relevant Python scripts), please email **BLM_OC_REA_Data_Portal_Feedback_Team@blm.gov**.
*Note that a few models require software that BLM does not provide such as R, Maxent, and TauDEM.

Models associated with individual REAs may require data links to be updated to function properly. REA reports, technical appendices, and model overviews (for some REAs) contain detailed information to determine what products are available and what datasets are necessary to run a certain model.

Please include the report name and any specific data information that you can provide with your request.

Other BLM data can be found on the Geospatial Business Platform Hub (https://gbp-blm-egis.hub.arcgis.com).