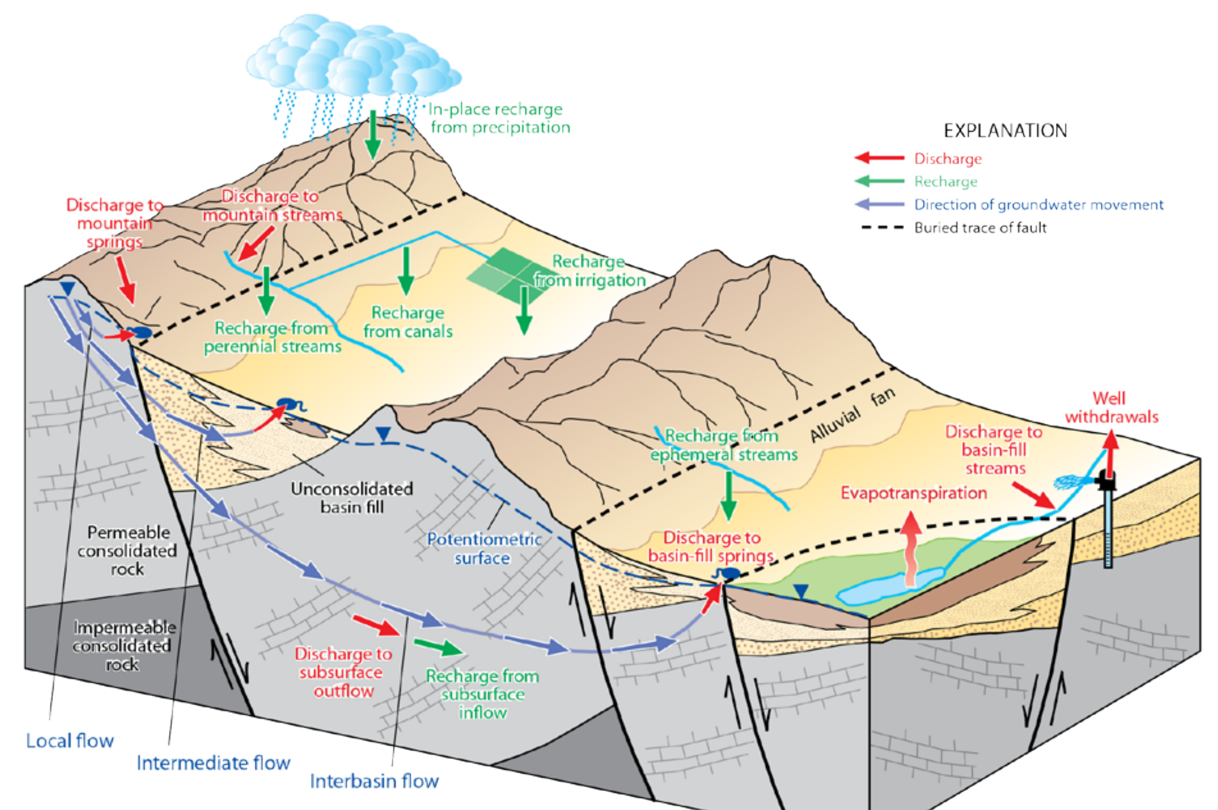
Groundwater
Coarse Filter Conservation Element Package

1 Conservation Element Description

Across the landscape surface water, groundwater, and geological characteristics control the presence of perhaps the most important element in shaping the West – water. Together with climate, are the key variables that lead to development and sustenance of ecological communities. These factors are of primary importance in influencing where human populations can exist as well because they control the available water supply.

Groundwater generally follows topography and flows from areas of high land-surface elevation to areas of lower land-surface elevation, creating a general pattern of flow from mountainous areas to lowlands (Figure 1-1); however, properties of the surface and underlying geology as well as hydraulic connections will influence whether water becomes surface runoff, groundwater recharge or discharge (USGS 2010).

Over ninety percent of the groundwater withdrawals in the ecoregion are used for agriculture. Groundwater withdrawals have also increased in the ecoregion by over fifty percent from 1995 to 2005, as agricultural lands have shifted from surface water to groundwater irrigation (Figure 1-2, Kenny *et al.* 2009). Increasing groundwater withdrawals and changes likely to occur to the available groundwater supply are of key interest to resource managers. Groundwater withdrawals can eventually result in a reduction in the previous discharge of an aquifer, reducing the flow of springs, streams, and the extent of groundwater dependent wetlands and riparian systems (Bredehoft and Durbin 2009)



Source: USGS; U.S. Department of the Interior 2010

Figure 1-1. Schematic Diagram Showing Conceptualized Groundwater Flow in the Great Basin

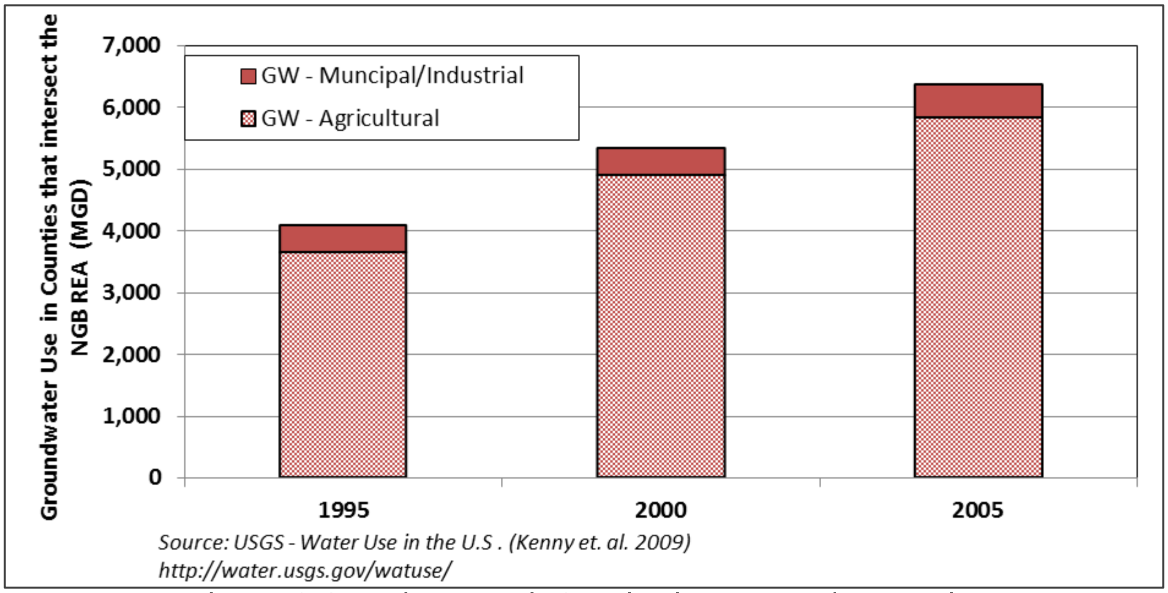


Figure 1-2. Groundwater Use in Counties that Intersect the Ecoregion

2 Conservation Element 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 Conservation Element Distribution Mapping

3.1 Data Identification

The major datasets identified to map the groundwater coarse filter are the field groundwater level measurements taken or compiled by the USGS and the State Agencies (Nevada, Oregon, and Idaho), the USGS Base Flow Index and Natural Recharge Grid, and the 2005 USGS water use estimates.

Table 3-1. Data Sources for the Groundwater Coarse Filter Conservation Element Distribution Mapping for the NGB Ecoregion

Data Required	Dataset Name	Source Agency	Type/Scale	Status	Use in REA
Base Flow Index	Base Flow Index	USGS	1km	Acquired	Yes
Groundwater Recharge	Rech48grd	USGS	1km	Acquired	Yes
Depth to Water	Groundwater level	USGS, State Water Resource Agencies	Depth to water from ground surface in feet	Acquired	Yes
Aquifers	Principal Aquifers	USGS	48 states	Acquired	Yes
Water Use	Water Use in U.S.	USGS	County use data	Acquired	Yes
Agricultural and Urban Land Use	LANDFIRE VCC	USGS	Raster (30m)	Acquired	Yes

3.2 Distribution Mapping Methods

The main datasets recommended by the AMT and USGS to analyze groundwater recharge were the Base Flow Index. The Base Flow Index reports the percentage of stream flow attributable to base flow. To estimate the mean annual natural ground-water recharge, the grid of Base Flow Index was multiplied by a grid of mean annual runoff values (Wolock, 2003). This assumes that long-term average natural ground-water recharge is equal to long-term average natural ground-water discharge to streams, and that the Base Flow Index reasonably represents, over the long term, the percentage of ground-water discharge in streamflow. Natural recharge estimated in this way is very uncertain. Uncertainty in arid regions (like this ecoregion) is due to high amounts of groundwater evapotranspiration via playas, isolated springs, and riparian vegetation which are not included in the recharge estimate based on stream baseflow. In addition, irrigation (which is common in the Snake River Plain) can be a significant component of recharge to groundwater that greatly exceeds natural recharge. The average annual natural recharge for the ecoregion is shown in Figure 3-1.

The estimates of groundwater use for the entire United States are completed at five-year intervals by the USGS. The most recent estimates available for the REA are for 2005 (Kenny et. al. 2009). The USGS provides the estimates at the county level for each county in the United States. The county level data are coarse and provide limited spatial distribution on where the groundwater extractions are occurring in the ecoregion. In order to scale the groundwater use to the HUC 12 watershed level, unit area groundwater use rates were developed based on estimated county water use and the area of agriculture and developed land area in the county using the LANDFIRE dataset. The unit area groundwater use rates were applied to the agricultural and developed land area in each HUC 12 watershed to estimate the total groundwater use in each watershed (Figures 3-2 and 3-3).

To understand the current condition of the groundwater levels in the aquifers throughout the ecoregion, the available USGS and state water agency groundwater depth measurements were compiled into one database. Wells with 10 or more years of recorded data were selected. Records with the last measurement taken before 2005 were eliminated. Groundwater depths are generally recorded on a regularly basis, however recording intervals vary from annual to daily throughout the ecoregion. To limit the impacts of seasonal variability on groundwater levels, the maximum depth to water measurement for each well for each year was selected. From this record, the percentile class of the most recent groundwater level was estimated. The percentile class scale is the same scale that is used by the USGS to estimate the groundwater conditions on a national level (Figure 3-4).

Many of the water levels in the Eastern Snake River Plain are much below normal when compared to historical records. However, there are also some wells with water levels that are much above normal throughout the ecoregion. Understanding the local geohydrology is important to interpret these trends at a local level. One most consider characteristics of the local aquifer and where each particular well is screened (where the well is perforated to collect water). For example, some groundwater wells may withdrawal water from a deep aquifer for irrigation. Return flows from agricultural irrigation then locally increase the water table of a shallow perched aquifer. Therefore it is possible for two wells in close proximity to have opposite groundwater levels trends because they are screened in to different portions of the aquifer.

The overall trends in groundwater levels over time were estimated by calculating the average annual change in the groundwater levels from the first to the last measurement (Figure 3-5). Based on all the available wells, the ecoregion groundwater levels have declined by -0.58 ft (0.18 m) per year.

3.3 Data Gaps, Uncertainty, and Limitations

- Groundwater level data was only collected from USGS and at the State water agencies. Groundwater level data is often collected at the local level (city or county) and may not have been included in the State or USGS databases.
- On a local level, groundwater level trends should be interpreted with an understanding of the local aquifer geology. Of most importance are the depth of the well and the distribution of confining layers.
- Many groundwater basins in the ecoregion are under management and have been adjudicated or are undergoing adjudication. Most notably, the largest basin, the Eastern Snake River Plain aquifer is under management by Idaho Department of Water Resources and is currently undergoing adjudication. Water rights are complicated and dealt with differently in each state. More detailed data and observations on groundwater can be found at a local level, especially if the basin is being actively managed or undergoing adjudication.
- Water use estimates are compiled at the county level. More detailed water use estimates can be collected at the water district and city level; however, collecting this data was not feasible for the entire ecoregion.
- Due to the uncertainty in groundwater recharge estimates, recharge has been used qualitatively to evaluate the condition of groundwater through-out the ecoregion. Caution should be exercised when applying the recharge estimates at a local level.

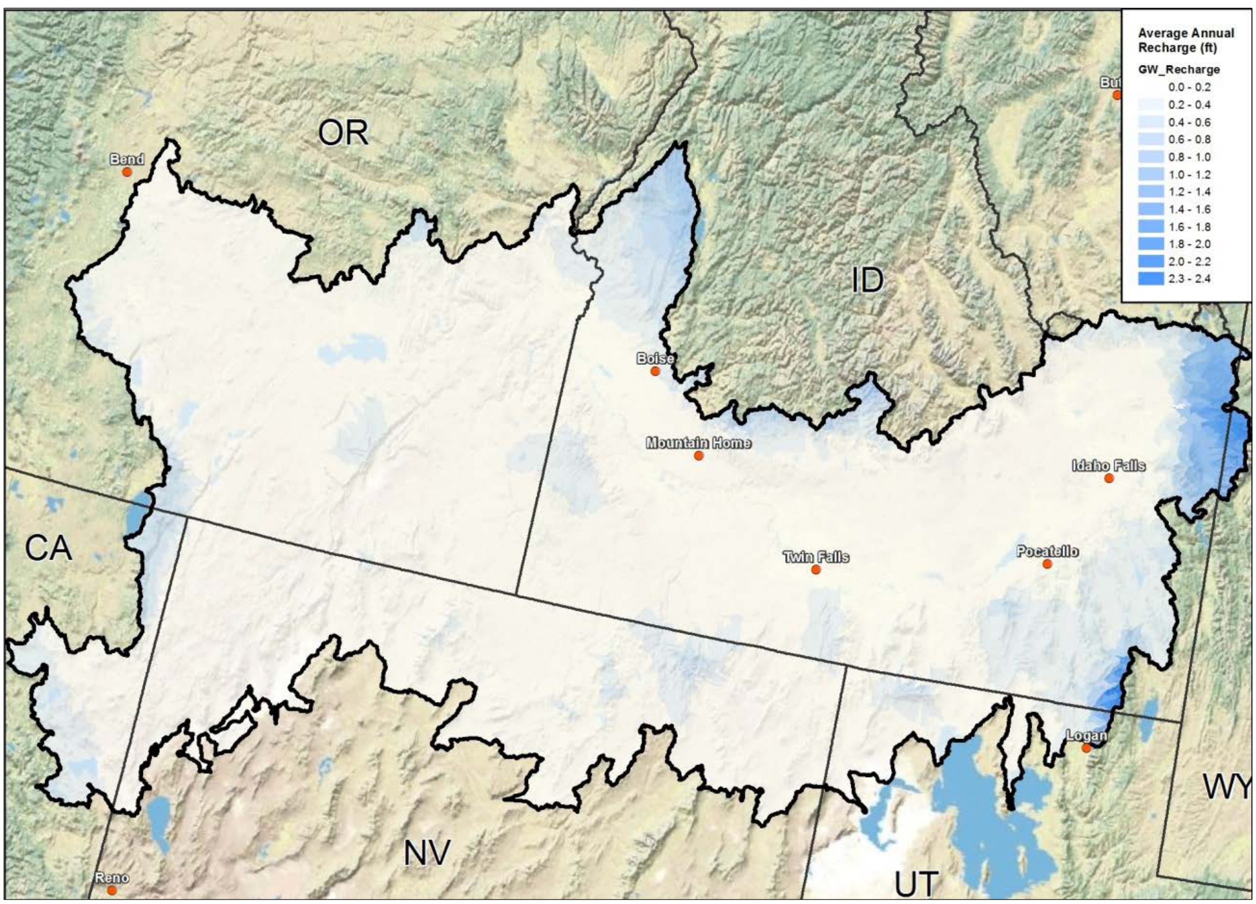


Figure 3-1. Average Annual Natural Recharge (USGS) in the Ecoregion

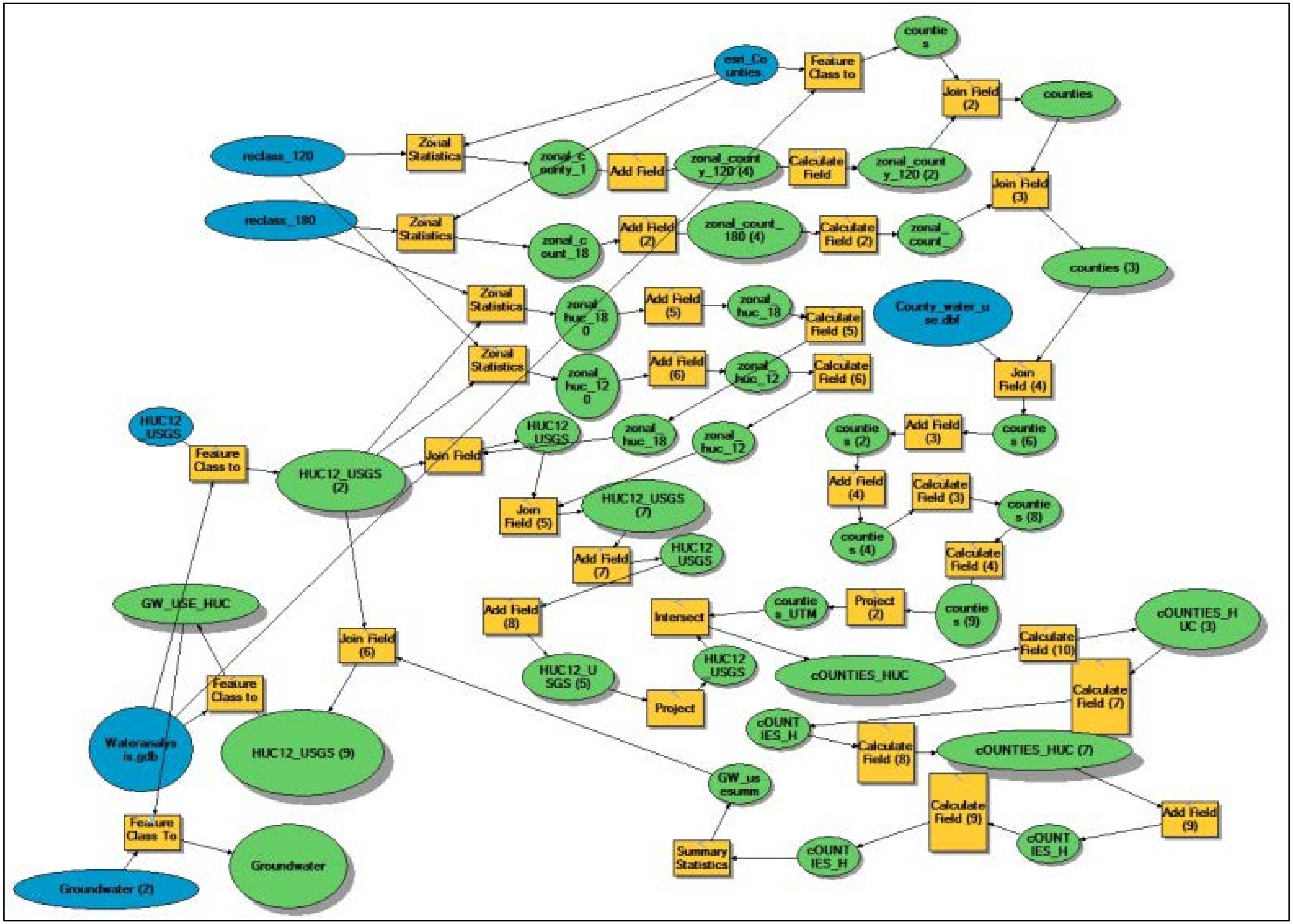


Figure 3-2. GIS Process Model to Downscale County Water Use to the HUC 12 Unit

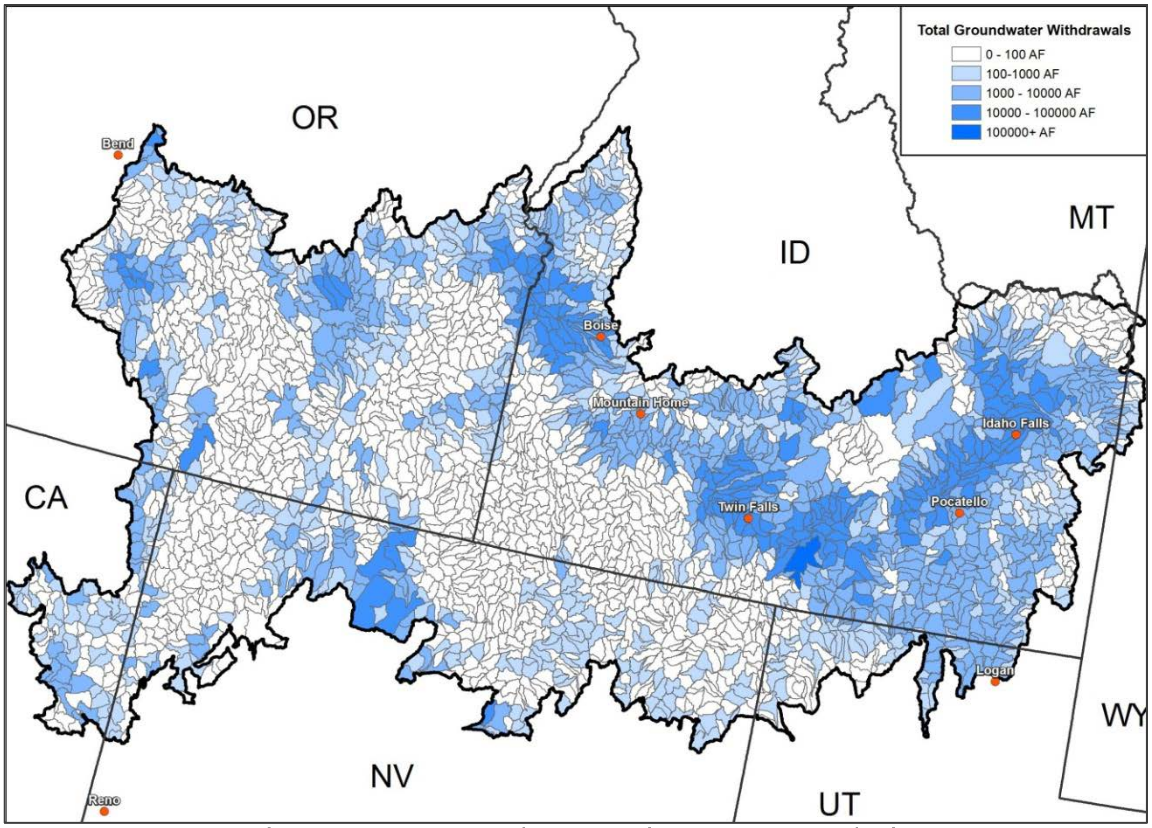


Figure 3-3. 2005 Groundwater Use by HUC 12 Watershed

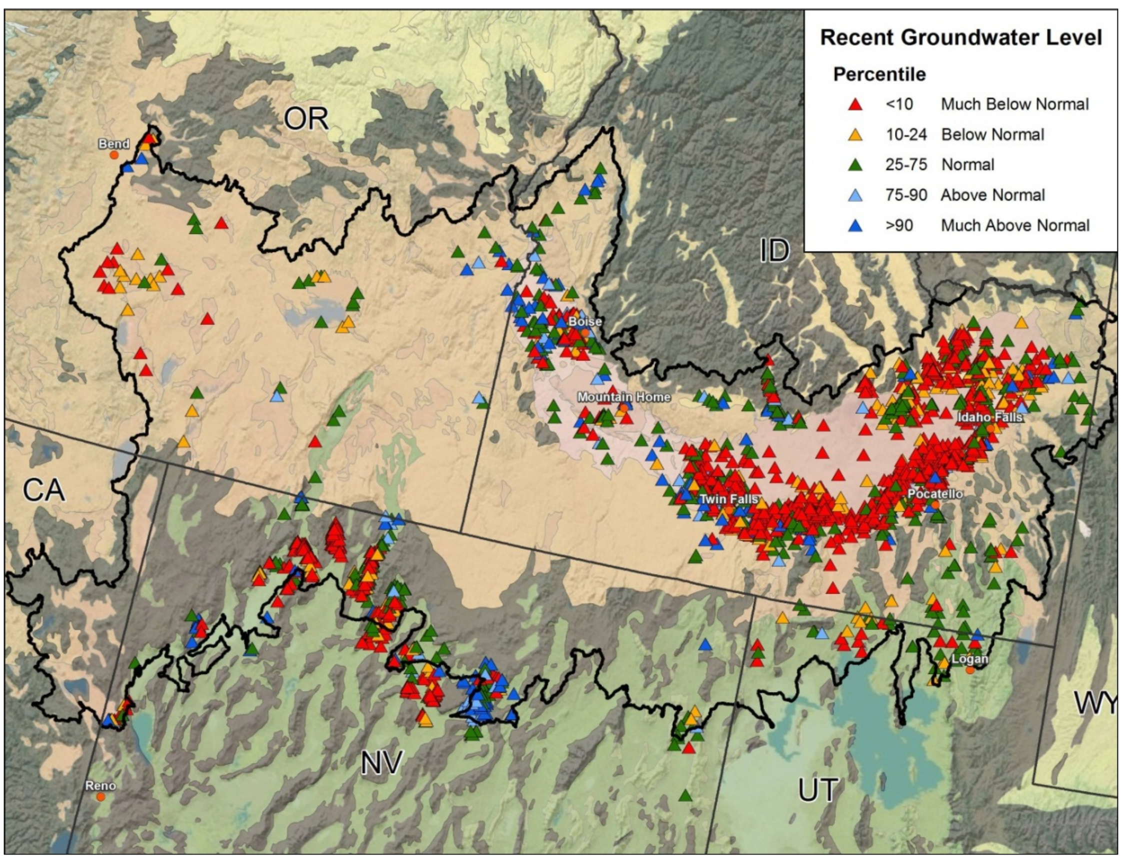


Figure 3-4. Current Groundwater Conditions in the Ecoregion

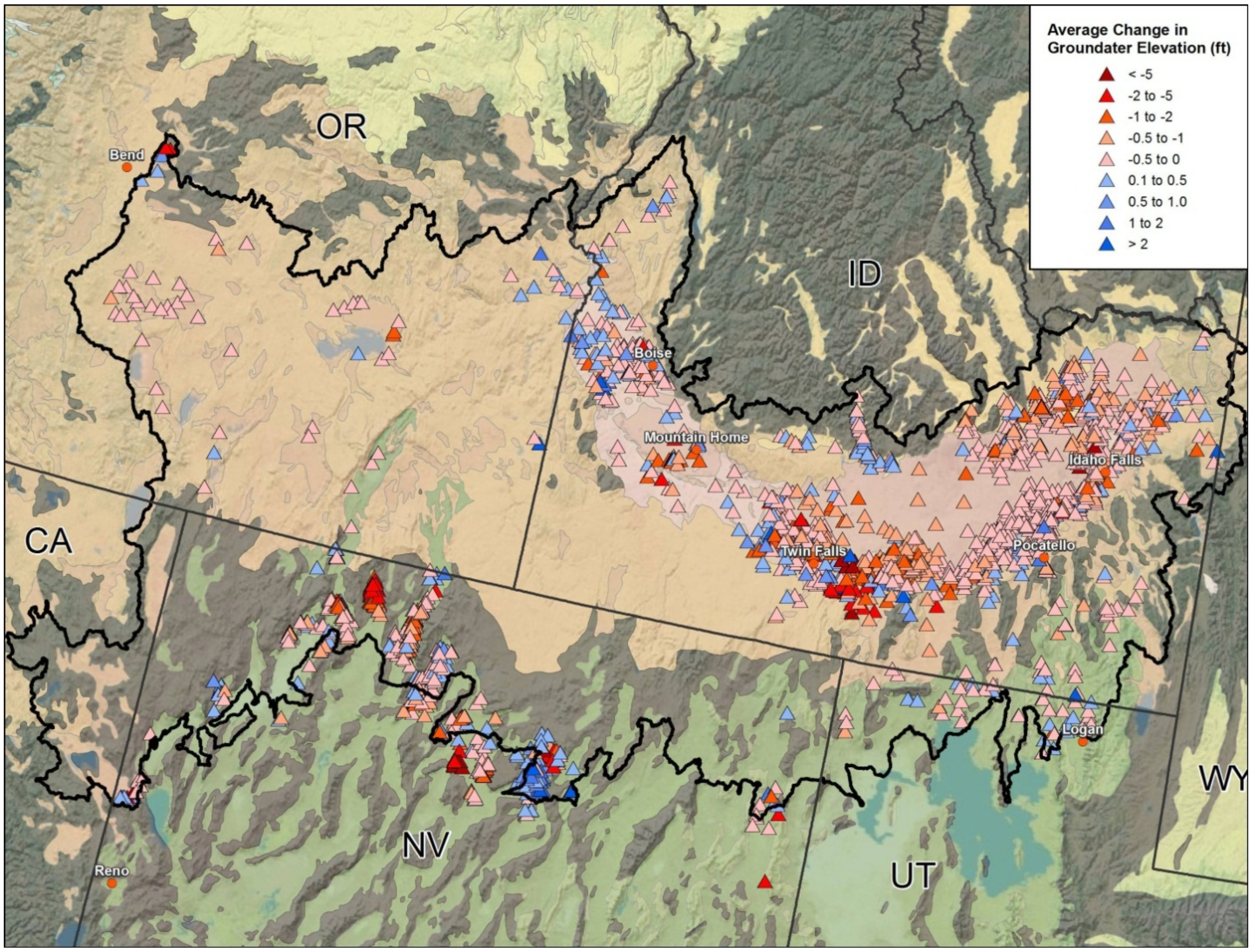


Figure 3-5. Average Change in Groundwater Elevation for the Available Wells in the Ecoregion

4 Conceptual Model

A conceptual model for groundwater in the ecoregion is presented in Figure 4-1. Change agents that affect the hydrology are of greatest importance to this system. These include dams, diversions, groundwater pumping, agricultural and other water uses. Other factors that may influence groundwater to a much lesser extent are wildfire that may lead to the removal of vegetation in the watershed, livestock grazing that may trample and consume vegetation that in time may alter the groundwater levels, and mining that could contaminate groundwater and also alter the groundwater levels. Vegetation cover is important in capturing and slowing down precipitation runoff, both from snow and rain, to allow water time to infiltrate into the substrate and recharge into the groundwater reservoir. Without vegetative cover, precipitation runs off quickly and leaves the watershed.

Climate change can influence groundwater amounts directly or indirectly by altering the timing, duration and amount of available water in the form of snowmelt and rainfall. A portion of the available water is subject to evapotranspiration, which is influenced by solar radiation, topographic shading, vegetation density, and cloudiness, all of which are influenced by climate. The remaining available water, fed by mountain streams, springs, and subsurface outflow consists of the surface runoff and groundwater discharge. The amount of water artificially removed from the system through dams, agricultural and groundwater pumping reduces the water available for groundwater storage, but are also actions that can be managed in a more sustainable way.

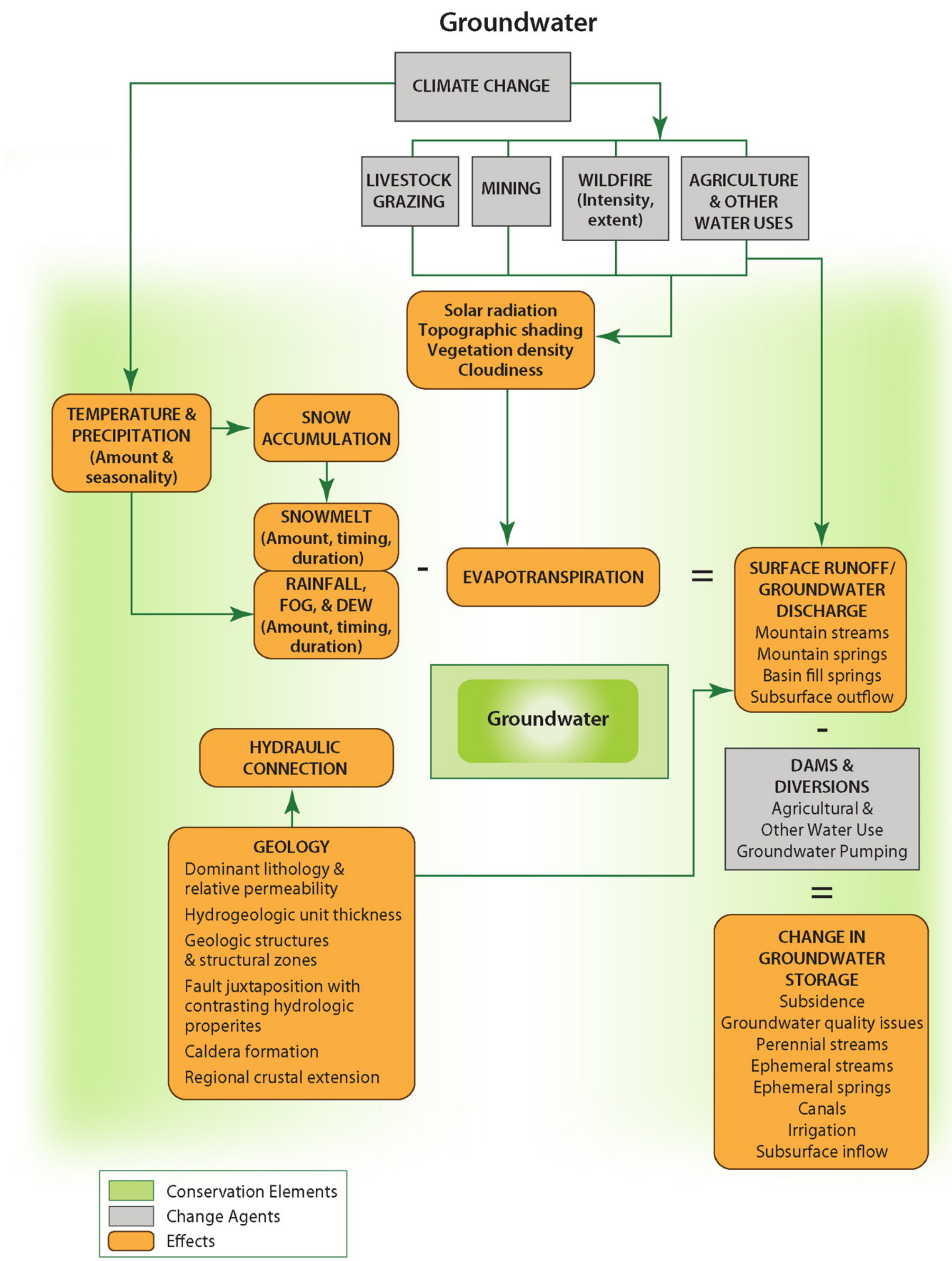


Figure 4-1. Groundwater Conceptual Model

5 Change Agent Analysis

5.1 Current Status of the Conservation Element

The groundwater conditions were evaluated at the HUC 12 level. For the watersheds with groundwater level data, the condition was based on the average annual change in groundwater levels. For watersheds without groundwater level data, the condition of the groundwater is based on the comparison of groundwater water use to groundwater recharge. Any groundwater withdrawal eventually results in a reduction of discharge in springs, streams, wetlands, or riparian areas. However, if groundwater use is greater than recharge, then groundwater is being mined from the aquifer. Mining groundwater can result in degraded water quality, land subsidence, and reduced storage in the aquifer (Alley *et al.* 1999).

Table 5-1. Groundwater Coarse Filter Conservation Element Attributes, Indicators, and Metrics for the NGB Ecoregion

Category	Ecological Attribute	Indicator / Unit of Measure	Metric			Data Source	Citation	Priority
Size	Suitable Habitat	HUC12				HUC 12		
Condition	Habitat condition	Average Change in GW levels	< -0.5 ft/yr	-0.5 to 0 ft/yr	>0	USGS and State Water Agencies	Metric based on greater than average decline of all wells	1
Context	Water Withdrawal Threat	2005 Groundwater Withdrawals (GWW), Average Annual Recharge (GWR)	GWW >GWR	GWW >0.5 GWR	GWW <0.5 GWR	USGS Water Use and Rech48grd	Kenny *et al.* 2009 and Wolock 2003	2

Portions of the ecoregion, especially in the Snake River Plain and developed basins in the NGB, show declines in groundwater elevations over time, indicating groundwater use in excess of recharge. On average, groundwater levels are declining by -0.58 ft/yr (0.18m/yr) across the ecoregion. There can be a significant time lag when the impacts from the groundwater withdrawals are realized as reduced flow in springs or stream baseflow (Bredehoft and Durbin 2009).

Similar to coarse filter vegetation conservation elements, the habitat status of areas that occur over important groundwater sources may be assessed geospatially. The groundwater conditions in the ecoregion are based primarily on groundwater level data. If the groundwater level data are not available, then the conditions are based on the comparing the overall groundwater extractions in the watershed to recharge rates (Figure 5-1). These metrics can be used to determine the whether there could be threats to groundwater-depended resources like perennial streams, springs, wetlands, and riparian vegetation.

5.2 Future Threat Analysis

5.2.1 Development

Overall water use in the ecoregion has not increased significantly from 2000 to 2005. Most of the prime agricultural land in the ecoregion is under cultivation, and agricultural use is not likely to expand. In the ecoregion, agriculture accounts for 97 percent of the overall water use and over 90 percent of the groundwater use. Therefore, water conservation practices in agricultural, such as improved irrigation efficiencies and changes in crop types, have more potential to reduce groundwater use than urban water conservation efforts. However, if urban development occurs on formerly agricultural land, overall water use would likely not change and may even decrease, because water use on a per acre basis is much greater on agricultural lands than in urban developed areas in the ecoregion.

The groundwater component of water use in ecoregion has increased by 20 percent from 2000 to 2005. The groundwater use increase has occurred while surface water use has decreased, such that the overall net water use did not change significantly from 2000 to 2005 (Figure 5-2), as agricultural lands have shifted from surface water to groundwater irrigation (Slaughter 2003; Kenney *et al*. 2009). If the trend of increasing groundwater use to replace surface water use continues, groundwater levels are likely to continue to decline in portions of the ecoregion.

5.2.2 Climate Change

Based on the Hostetler predictive models of climate change, there will be a slight increase precipitation in the basins, valleys, and uplands and large increases in precipitation the mountains by 2060. Observed climate trends in the Owyhee Uplands on Reynolds Creek have measured seasonal shifts in streamflow due to increased temperatures, with larger streamflows in winter and early spring and reduced streamflow in summer. While increased precipitation generally would result in corresponding increases in groundwater recharge, seasonal shifts in runoff patterns can affect recharge patterns, making climate change impacts to groundwater recharge difficult to predict. The models also predicts no change in annual temperature across the entire NGB REA. However, temperatures are expected to increase by one degree in July and August which could result in an increase in agriculture water use in those months.

5.2.3 Grazing, Wildfire, Invasive Species

The overall future threats from grazing, wildfire, and invasive species on groundwater in the ecoregion are minimal. Grazing, wildfire, and invasive species are change agents that can alter vegetation cover and type at a landscape scale. The alteration of vegetation may result in slight changes to evapotranspiration rates which could impact the groundwater recharge rates in the ecoregion. Whether the impact of grazing, wildfire, and invasive species are positive or negative depends on the existing vegetation and the nature of impact (well managed or poorly managed grazing, hydrophobic soils following fires, shallow or deep-rooted invasive plants, etc.).

5.2.4 Combined Future Threats

The greatest threat to the groundwater resource in the ecoregion is increasing groundwater extraction for agriculture and urban development. With 90 percent of the groundwater extractions used in agriculture, changes in agricultural practices which results in more efficient use of water would have the greatest impact on reducing extraction rates. While the overall water use will likely be relatively stable in the near future, the continuation of the shift from surface water to groundwater use in the ecoregion will likely put more pressure on the groundwater resources. Groundwater extractions may eventually result in a reduction the flow of springs, streams, and the extent of groundwater dependent wetlands and riparian systems (Brederhoft and Durbin 2009). Areas in the ecoregion with significant declining water levels or groundwater extractions in excess of groundwater recharge are more likely to experience reductions in surface water flows in springs and streams, degrading the habitat for resources that depend on those flows such as spring snails and coldwater fish.

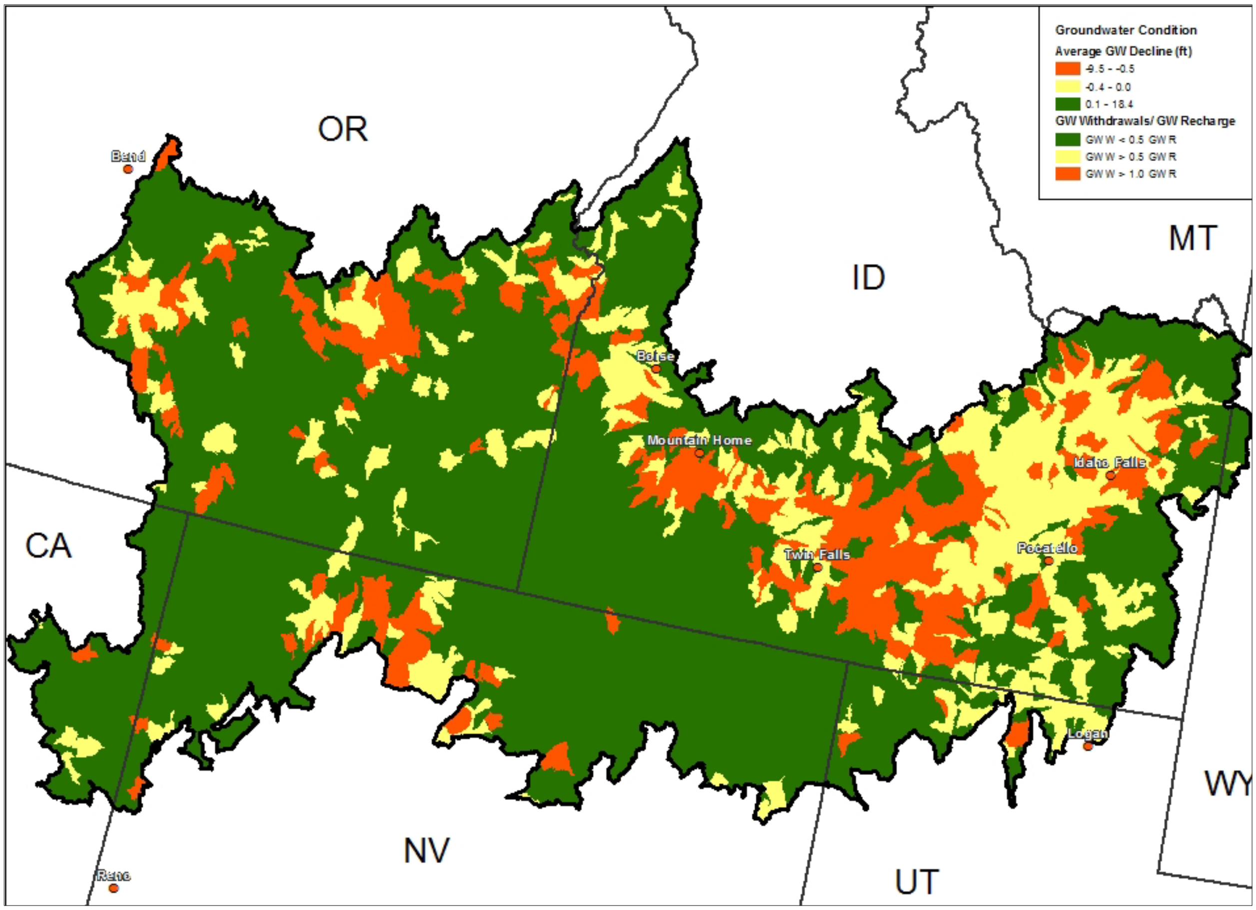


Figure 5-1. Current Groundwater Conditions

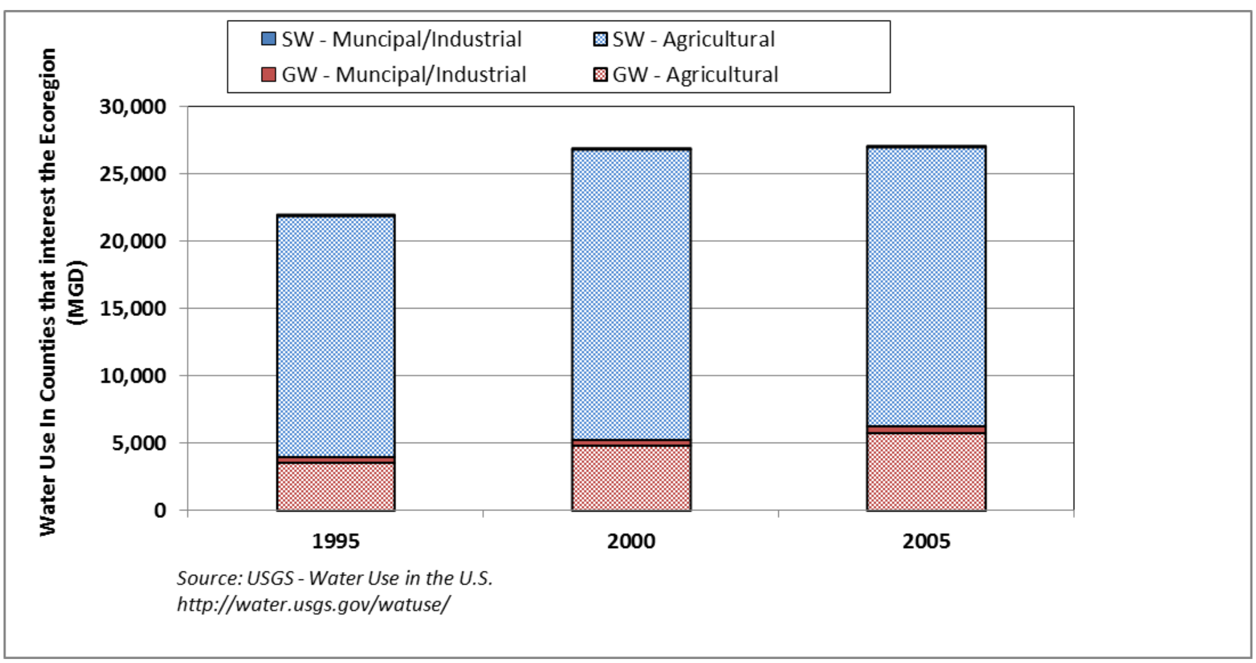


Figure 5-2. Historical Water Use

6 Management Questions

MQ 58a. Where are areas with current groundwater extraction?

Figure 3-2 provides the spatial distribution of groundwater extractions in the ecoregion based on 2005 USGS water use estimates. Agricultural areas in the ecoregion have the highest levels groundwater extractions. These areas include the Snake River Plain (ID), King's River Basin (NV), Christmas Valley (OR), and Lake Malheur area (OR).

MQ 58b. Where are the areas of potential future change in groundwater extraction?

Since over 90 percent of groundwater use in the region is in agricultural, changes in agriculture practices which improve water use efficiency could result in significant reductions in groundwater use. However, groundwater use has increased by 20 percent from 2000 to 2005 as surface water has been replaced with groundwater. If this trend continues, groundwater use may increase in the ecoregion. Urban development may also increase groundwater use if it occurs on undeveloped land. However, if urban development occurred on agricultural land, the resulting water use would be equal to or less than previous agricultural water use.

MQ 60. Where are the aquatic Conservation Elements showing degraded ecological integrity from existing groundwater extraction?

The majority of the ecoregion has limited development and groundwater levels are stable. However, in agriculture intensive areas, declining water levels have been observed (e.g., Snake River Plain, surrounding Lake Malheur in Oregon, and in the King's River Basin). Groundwater extractions eventually result in a reduction the flow of springs, streams, and the extent of groundwater dependent wetlands and riparian systems. Where groundwater levels are significantly declining or extractions are in excess of recharge the springs and streams eventually will experience degraded ecological integrity due to reduced flows from prior excess groundwater extractions.

7 References

Alley,William M., Reilly, Thomas E and Franke, O. Lehn.1999. Sustainability of ground-water resources USGS Circular 1186.

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Springs and Seeps
Coarse Filter Conservation Element Package

1 Conservation Element Description

Springs and seeps are known as biological hotspots, associated with unique aquatic ecosystems. Springs and seeps are small wetlands typically but not always found in sloping terrain and hydrologically supported by groundwater discharge. Discharge is from relatively deep groundwater flow systems that rise through a distinct hole from which shallow, broad flows move outward and create a saturated zone (Howard and Merrifield 2010). Springs and seeps can vary seasonally and tend to have a relatively constant concentration of dissolved minerals and water temperature, which make them distinct from other wetlands and riparian surface-fed streams that vary in response to rainfall and snowmelt (Culver 2008).

Springs in arid regions are isolated and have experienced endemism and other processes that can make each spring a unique feature (Miller *et al.* 2007). Springs also can be important stopover or nesting sites for summer resident or migratory neotropical bird species. They often support rare plants such as orchids that are restricted to habitats with wet or marshy soils, as well as organisms such as aquatic and land snails, pillbugs, amphipods and arthropods particular to isolated individual or small groups of springs. However, for the interest of this ecoregion, the springsnail of the genus *Pyrgulopsis*, which has been documented across North America and occurs throughout much of the area of interest (Hershler 1994; Hershler *et al.* 2007) was investigated as a possible indicator of spring and seep health.

The small (1-8 mm maximum shell dimension) springsnails of the genus *Pyrgulopsis* are an indicator of the aquatic biodiversity that occurs in this ecoregion; at least 80 species within this genus occur in the Great Basin and at least 133 species are described in North America (Hershler 1994, 1995; Hershler and Sada 2000, 2002; Hershler *et al.* 2007; Liu and Hershler 2012). Since their review in Hershler (1994), approximately 70 additional species have been described, with an estimated 70% of these occurring within the Great Basin (Hershler and Liu 2009; Liu and Hershler 2012). Most *Pyrgulopsis* species are endemic to single springs, spring systems, or drainage systems, with abundance generally greater near the spring source than habitats further downstream (Hershler and Sada 2002). This snail is obligatory for aquatic habitats throughout each stage of its lifecycle (Hershler and Sada 2002). The habitats utilized by this genus are isolated, which limits dispersal and connectivity to other populations, resulting in greater species differentiation (Hershler and Sada 2000). As a result, loss of suitable aquatic habitats not only results in a reduction of the overall otherwise broad distribution of the genus, but also has the potential to result in localized extinctions of *Pyrgulopsis* species.

Due to the increased investigation and documentation of *Pyrgulopsis* occurrence, the rapidly expanding number of species of the genus being described (approximately four per year since 1994), and the dependence of this genus on springs, seeps, and drainage systems, monitoring for this genus would duplicate seep and spring monitoring, with no additional benefit to the ecoregion in the area of interest. Therefore, establishing the relationship between *Pyrgulopsis* and these vulnerable aquatic habitats is ecologically important due to the extinction risk. For this ecoregion, it is more feasible to track the habitats than the occurrence of *Pyrgulopsis* in these habitats.

2 Conservation Element 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 Conservation Element Distribution Mapping

3.1 Data Identification

The major datasets identified to map the distribution of the springs and seeps conservation element were the National Hydrographic Dataset point data. An additional spring dataset from the Great Basin Center for Geothermal Exploration was identified but it was based on USGS data from 2005 (Table 3-1).

The best available, already compiled, data set on springsnails (*Pyrgulopsis sp.)* is in the Smithsonian National Museum of Natural History records. The available online records were searched and Dr. Robert Hershler (Smithsonian Inst.) was contacted to see if there were any other methods better suited to capturing the best available data set. The data set Dr. Hershler provided was based on the Smithsonian Institution's records and included approximately 2,294 records, though not all records included georeferenced data.

Table 3-1. Data Sources for the Springs and Seeps Coarse Filter Conservation Element Distribution Mapping for the NGB Ecoregion

Data Required	Dataset Name	Source Agency	Type/Scale	Status	Use in ecoregion
Terrestrial Systems					
Springs and Seeps	National Hydrographic Dataset	USGS	Point	Acquired	Yes
	Great Basin Springs and Seeps	Great Basin Center for Geothermal Exploration	Point	Acquired	No. Based on USGS Data from 2005
Springsnails	Springsnail records	Smithsonian	Point	Acquired	Yes

3.2 Distribution Mapping Methods

3.2.1 Springs

Using the springs and seeps feature type within the USGS National Hydrographic Dataset, the currently-known 47,222 springs and seeps in the ecoregion were be mapped (Figure 3-1). The Smithsonian electronic database of spring snail (*Pyrgulopsis sp.*) collection records with coordinates were overlaid over the spring layer (Figure 3-1).

3.2.2 Springsnails

The Smithsonian data set was sorted for georeferenced records. Only 769 records included latitude and longitude within California, Idaho, Nevada, Oregon, and Utah. Many of these records only included latitude and longitude to the nearest minute which translates to a precision of only 1.8 km or 1.2 miles at this latitude (for each minute). A point class shapefile was created based on the WGS 1984 geographic coordinate system from the latitude and longitudes provided, regardless of precision.

The data set was further refined to include only those records that occurred within the NGB Ecoregion boundary; this resulted in 157 appropriate records. A further review indicated that of the 157 records that occurred within the boundary, 145 had a locational precision to the nearest second; the remaining 12 only had locational precision to the nearest minute (Figure 3-1).

3.3 Data Gaps, Uncertainty, and Limitations

- There are was limited flow data available from USGS for the springs in the ecoregion. It is not possible to evaluate long-term trends in spring flow without long-term measurements of spring flows.
- Many of the spring snail collection records do not have coordinates. The lack of spring snail collections at particular spring does not mean that there are not spring snails at that springs. The data should be used to affirm positive locations to determine where spring snails are present, but should not be used to determine where spring snails are absent.

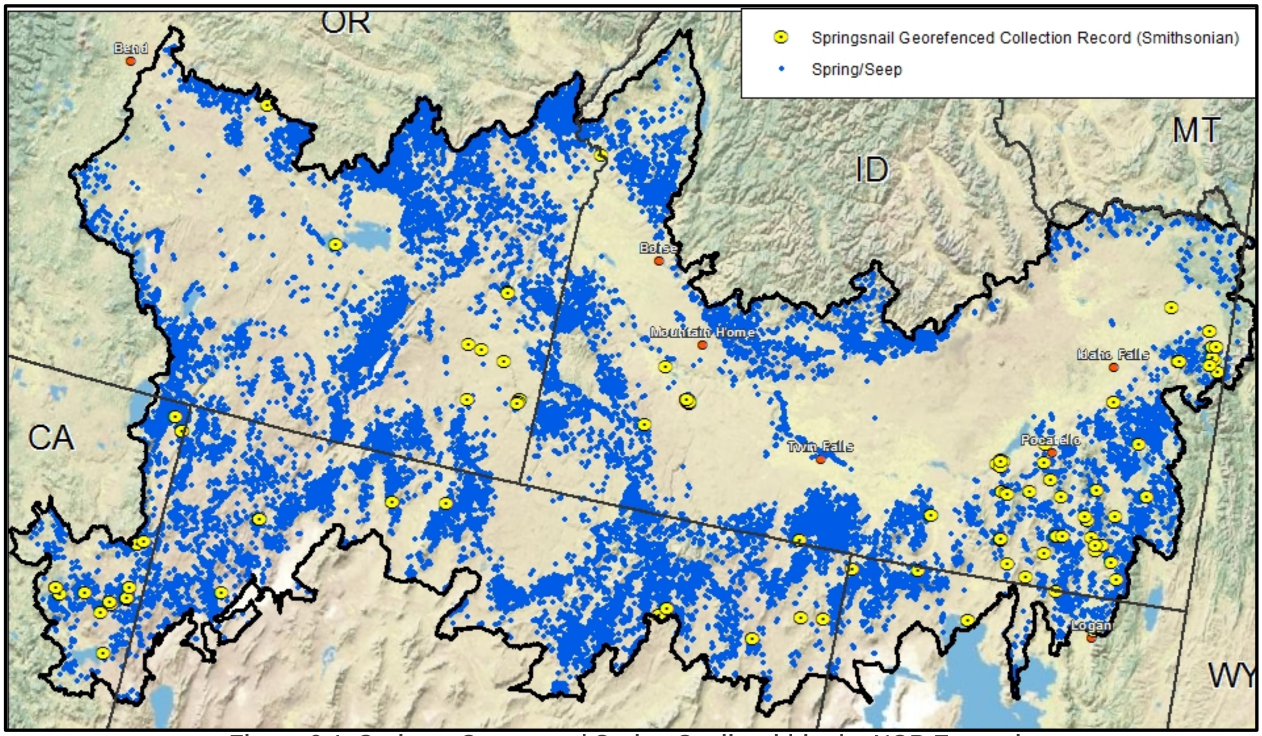

Figure 3-1. Springs, Seeps, and Spring Snails within the NGB Ecoregion

4 Conceptual Model

A conceptual model of springs and seep ecosystems in the ecoregion is presented in Figure 4-1. Springs and seeps have the same primary change agents and interlinked effects as discussed in the wetlands section. The many change agents (including anthropomorphic and climate-based) that affect groundwater are of greatest importance to the springs and seeps ecosystem because of their dependence upon groundwater sources for water recharge and their sensitivity to changes in water supply. A common practice in the West, especially for privately-owned springs, is for them to be developed by piping water into a trough or pond for livestock use. This changes the nature of the spring/seep hydrology, vegetation, and local landscape and reduces water available for native plants and wildlife. Other important influences may include livestock and wildlife grazing/browsing and congregating at seeps and springs and invasive plant and animal species utilizing scarce space and water resources.

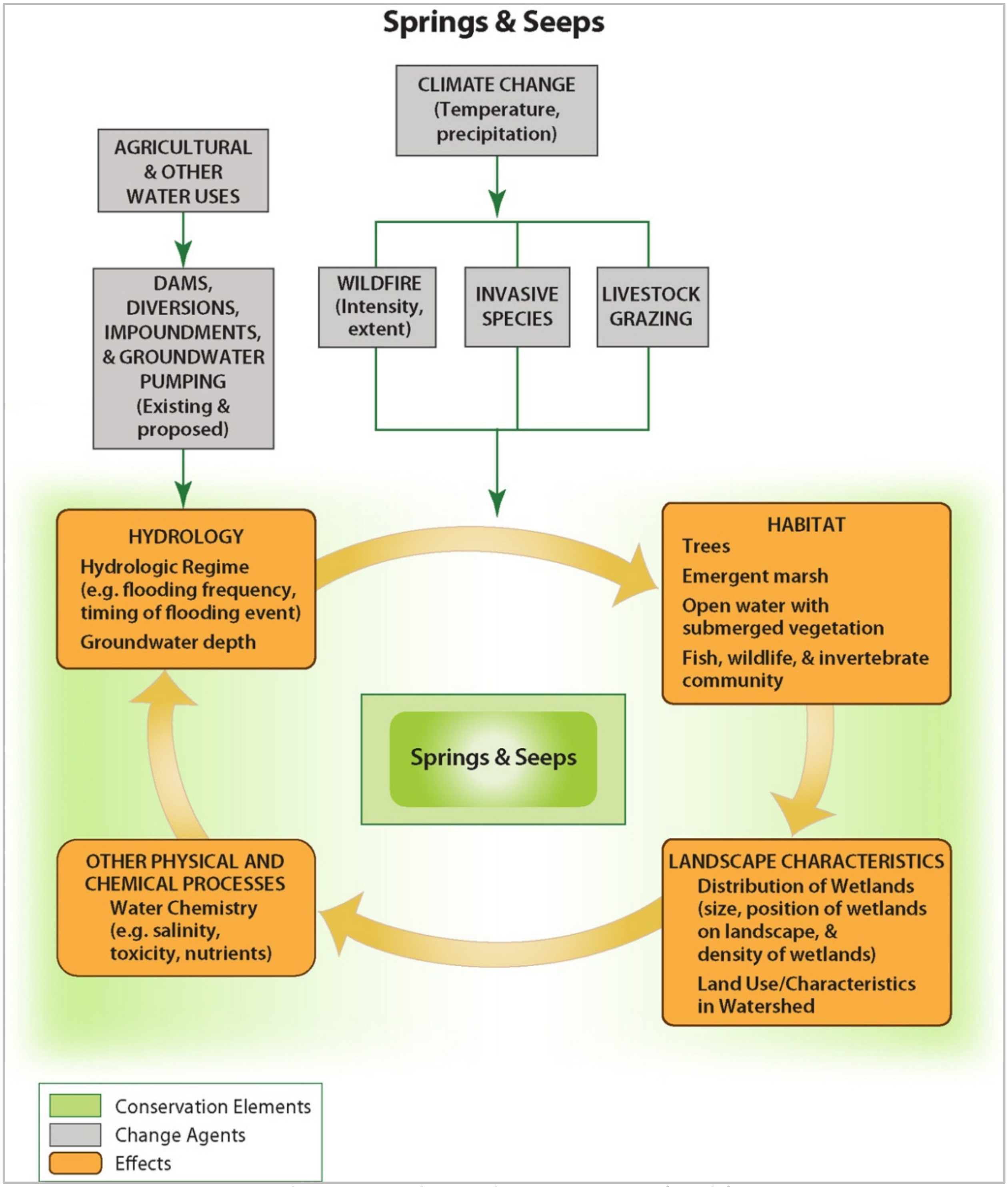

Figure 4-1. Springs and Seeps Conceptual Model

5 Change Agent Analysis

5.1 Current Status of the Conservation Element

The groundwater conditions and the impacts of groundwater withdrawals are most important in evaluating the status of springs and seeps ecosystem. Springs are dependent upon groundwater sources for water recharge and are sensitive to changes in water supply. Figure 5-1 overlays the estimated areas in the ecoregion with declining groundwater conditions (see Groundwater conservation element Package) with the springs/seeps and spring snails.

One well-known example of the interaction between groundwater development, springs, and springsnails is along the Bruneau River south of Mountain Home. There is a series of hot springs there that support the endemic the Bruneau hot springsnail (*Pyrgulopsis bruneauens*). In 1993, the Bruneau hot springsnail was listed as endangered due to reduced flows at the springs caused by agricultural groundwater withdrawals. This area continues to be characterized as an area with declining groundwater levels based on the groundwater conditions (see Groundwater conservation element package).

Spring discharge is also important in supporting the perennial flow of streams and rivers. Springs are especially important in supporting the flows in the Snake River. Surface water diversion for agriculture in the eastern Snake River Plain in the first half of the 20th century increased groundwater recharge, raised water levels, and increased spring discharge. In the mid-1950s, irrigation technology began to change to more sprinkler irrigation instead of flood irrigation. The increased efficiency in surface water irrigation led to decreased ground-water recharge that has contributed to the decline of ground water levels and spring discharge from the 1950s onward (Janzak 2001). In addition, ground-water withdrawals for irrigation increased dramatically during the last half of the century. The decreased recharge from surface water irrigation and increased ground-water withdrawals are apparent in the declines observed in spring discharge since the mid-1950s. However, spring discharge in the Snake River is still higher than the period before agricultural development.

5.2 Threat Analysis

5.2.1 Development

Agricultural and urban development generally results in increased water usage and groundwater extractions. The groundwater component of water use in ecoregion has increased by 20 percent from 2000 to 2005. The groundwater use increase has occurred while surface water use has decreased, such that the overall net water use did not change significantly from 2000 to 2005, as agricultural lands have shifted from surface water to groundwater irrigation (Slaughter 2003). If the trend of increasing groundwater use to replace surface water use continues, groundwater levels are likely to continue to decline in portions of the ecoregion and adversely impact spring and seep flows.

5.2.2 Invasives and Disease

Many nonnative species have been introduced into North American waters which have changed the structures of native communities and caused extinction through hybridization, predation, and competition (Sada and Vinyard 2002). In the Great Basin region, introductions of non-native species and habitat modification have caused the extinction of 16 endemic species, subspecies, or other distinctive populations since the late 1800s (Sada and Vinyard 2002). Endemic fish species have been most severely impacted. Little is known about nonnative invertebrates, but crayfish, Asian clams, and red-rimmed thiara snail are common nonnative introductions in the Great Basin. Introductions of the red-rimmed thiara snail may have led to reductions in spring snail populations in southern Nevada, just outside of the ecoregion (Sada and Vinyard 2002).

5.2.3 Grazing

Livestock can trample and disturb riparian vegetation surrounding springs. Livestock also can impact water quality by increasing nutrient and bacteria concentrations in spring water (Hubbard *et al.* 2004). In addition, springs are often developed for livestock by piping water into a trough or pond. Spring development changes the nature of the spring/seep hydrology, vegetation, and local landscape and reduces water available for native plants and wildlife.

5.2.4 Climate Change

RegCM3 (Hostetler *et al.* 2011) climate modeling for the ecoregion predicts a slight increase precipitation in the basins, valleys, and uplands and large increases in precipitation the mountains by 2060. However, climate change may result in seasonal shifts in streamflow. As a result, climate change impacts on spring flow are difficult to predict.

5.2.5 Wildfire

Wildfire can temporally increase the flow of springs by reducing plant evapotranspiration. Wildfire could also result in shifts in vegetation composition which could slightly impact recharge to springs and seeps.

5.2.6 Combined Threat Summary

The primary threat to springs and seeps in the ecoregion is agricultural groundwater withdrawals. Groundwater withdrawals have increased by 20 percent and there is evidence of declining groundwater levels in agriculturally developed areas. The spread of invasive aquatic species can also locally impact endemic spring species. Livestock grazing often involves the development of springs which can impact sensitive spring-dependent species like springsnails. Livestock can also impact the water quality of spring discharge through sedimentation from trampling and deposition of nutrients and bacteria in the water.

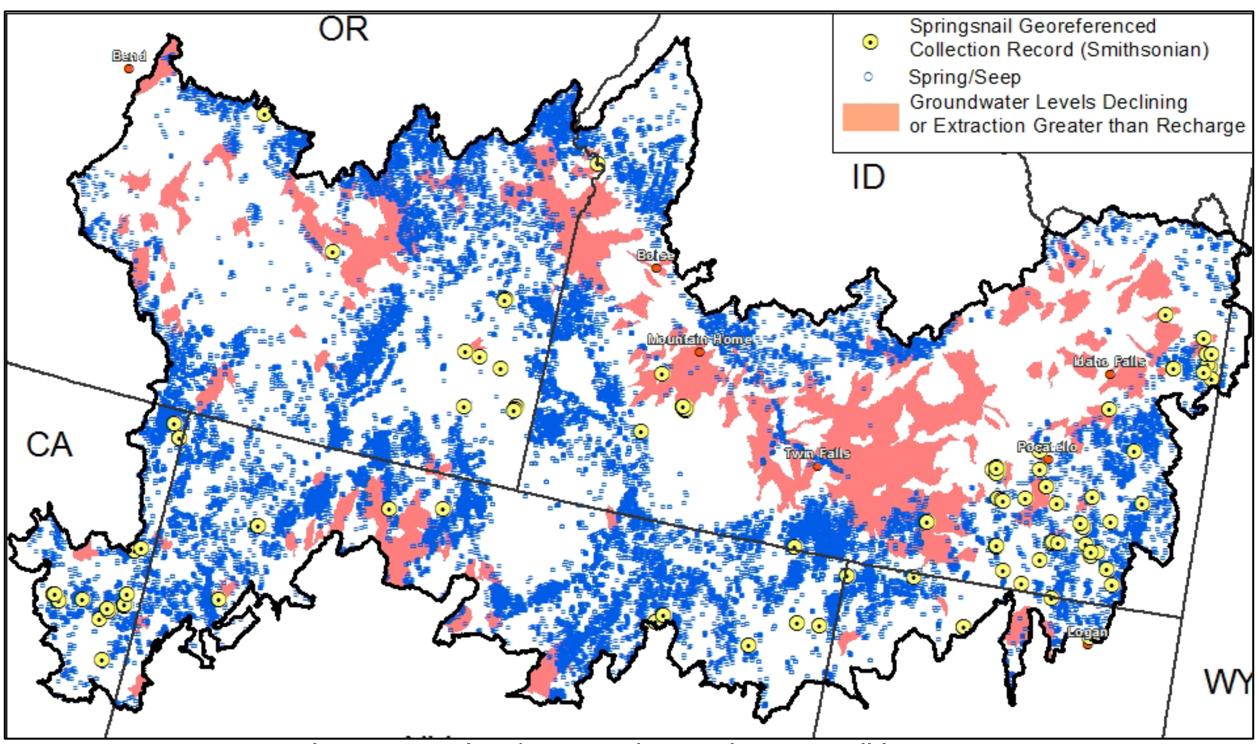

Figure 5-1. Springs/Seeps and Groundwater Condition

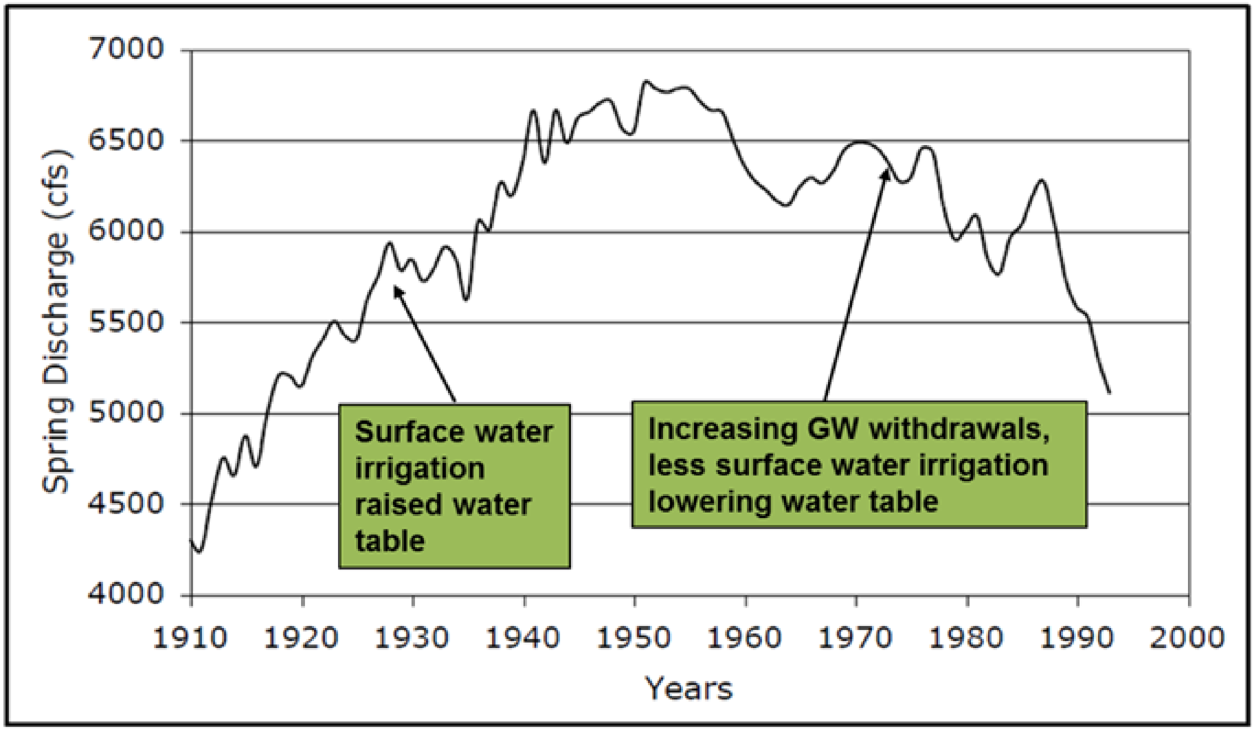

Figure 5-2. Spring Discharge in the Snake River (Janzak 2001)

6 Management Questions

Applicable MQs include the following (from Section 8.3.2 of Draft Final Memo 4c).

MQ 16. Where do spring snails occur?

Based on the collection records data provided by the Smithsonian, springsnails occur throughout the ecoregion (Figure 3-1). Not all the collection records have been georeferenced and not all the springs have been surveyed for spingsnails. Therefore, the lack of springsnail collection record in a particular location should not be interpreted as an absence of a springsnail, but rather as a gap in the data.

MQ 34. What is the condition (ecological integrity) of aquatic conservation elements?

The condition of the springs/seeps was estimated based on the groundwater condition, as springs/seeps are dependent on groundwater to sustain their flow. The comparison of springs and seeps and the groundwater condition is shown in Figure 5-1.

MQ 60. Where are the aquatic conservation elements showing degraded ecological integrity from existing groundwater extraction?

The comparison of springs and seeps and the groundwater condition is shown in Figure 5-1.

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

RegCM3 (Hostetler *et al*. 2011) climate modeling for the ecoregion predicts a slight increase precipitation in the basins, valleys, and uplands and large increases in precipitation the mountains by 2060. However, climate change may result in seasonal shifts in streamflow. As a result, climate change impacts on spring flow are difficult to predict.

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Perennial Streams & Rivers
Coarse Filter Conservation Element Package

1 Conservation Element Description

Perennial streams and rivers are the lifeblood of the NGB ecoregion and reflect effects occurring on a landscape scale because they are natural watercourses closely related to their watershed. The water in a stream or river is generally derived from precipitation through a combination of surface runoff and groundwater inflows. Furthermore, the productivity of streams and wetlands is largely dependent on the types and condition of plants and other land cover at higher elevations in the watershed (Horne and Goldman 1994). Plant community structure can vary immensely from the headwaters to the mouth of a stream system. These dynamic systems incorporate many physical and biological processes and are the focus of management and restoration efforts due to their high value in the NGB.

2 Conservation Element 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 Conservation Element Distribution Mapping

3.1 Data Identification

The major datasets identified to map the distribution of the perennial streams and rivers conservation element were the National Hydrographic Dataset rivers and streams. This dataset consists of detailed polyline data showing the location of perennial streams and rivers (Table 3-1).

Table 3-1. Data Sources for the Perennial Streams and Rivers Coarse Filter Conservation Element Distribution Mapping for the NGB Ecoregion

Data Required	Dataset Name	Source Agency	Type/Scale	Status	Use in REA
Aquatic and Terrestrial Systems					
Streams and Rivers	National Hydrographic Dataset	USGS	Polyline, Polygon	Acquired	Yes
Streamflow Data	USGS NWIS Surface water	USGS	Stream gage measurements (cfs)	Acquired	Yes
Impaired Water Bodies	303D_Impaired	EPA	Polyline, Polygon	Acquired	Yes
Surface water withdrawals	Surface water use	USGS	County water use data	Acquired	Yes
Dams	Major Dams	USACE	Points	Acquired	Yes

3.2 Distribution Mapping Methods

The estimates of surface water use for the entire United States are completed at five-year intervals by the USGS. The most recent estimates available for the REA are for 2005 (Kenny *et al.* 2009). The USGS provides the estimates at the county level for each county in the United States (Figure 3-1). The county level data are coarse and provide limited spatial distribution on where the surface water diversions are occurring in the REA. In order to scale the surface use to the HUC 12 watershed level, unit area groundwater use rates were developed based on estimated county water use and the area of agriculture and developed land area in the county using the LANDFIRE dataset. The unit area surface use rates were applied to the agricultural and developed land area in each HUC 12 watershed to estimate the total surface use in each watershed (Figure 3-2).

To map distribution of perennial stream and river systems in the NGB ecoregion, SAIC downloaded and extracted flow lines and water bodies from the National Hydrographic Dataset plus data layers and clipped it to the ecoregion (Figure 3-3). The National Hydrographic Dataset stores the layers in a series of lines and polygons representing natural streams, and lakes as well as man-made reservoirs. One difficulty in using the National Hydrographic Dataset is that focusing just on streams and rivers can't be accomplished just by looking at flow lines. Some large rivers such as the Snake River are made up of river sections, dams, man-made reservoirs, and lakes.

The monthly stream flow statistics were also acquired from the USGS for key stream gages throughout the ecoregion (Figure 3-3). Generally peak flows occur throughout the ecoregion in May, at the peak of snow melt. Smaller, more unregulated watersheds like the Malheur River, Bear River, and Humboldt River have significantly reduced flows in the winter months. Whereas the heavily regulated and spring-fed Snake River flows are more steady throughout the year, with significant declines in summer during the peak irrigation months.

3.3 Data Gaps, Uncertainty, and Limitations

3.3.1 Data Gaps

Perennial streams are based on the USGS mapping of ephemeral, intermittent, and perennial streams in the National Hydrographic Dataset. Often mountain streams can be both perennial and intermittent, where some sections support year-round flow, while flow in other sections goes underground in the alluvial aquifer. Surface water and groundwater extraction near streams can alter the flow regime from perennial to intermittent. Flows measurements provided by the stream gages only provided data at fixed locations. For rivers where perennial flow status is of interest throughout the watershed, the rivers need to be mapped as wet or dry at the driest time of the year. This takes substantial field effort, but has been successfully done on the San Pedro River in Arizona with assistance from volunteers (Turner and Richer 2011).

The surface water use is estimated based on county water use data and is based on the point of use, not on the location of diversion. Often surface water diversions can be transported over tens or hundreds of miles to their place of use. Each state handles its water right permitting and monitoring differently. It would take significant effort to compile all the water rights and surface diversion data for the ecoregion which was beyond the scope of this analysis.

The 303(d) list of impaired water bodies includes impairments for nutrients, sedimentation, dissolved oxygen, temperature, heavy metals, etc. The type of water quality impairment was not available in the geospatial data for impaired streams and would have to be looked up in the EPA database on a reach by reach basis.

3.3.2 Uncertainty

The analysis for flow regulation only considered whether or not a major dam was located upstream of the particular HUC12 unit of the watershed. It does not factor in how large the dam is or how much of the watershed is captured upstream or whether the dam is operated for hydroelectricity, water storage or flood control. Flow regulation throughout the ecoregion can vary significantly. 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.

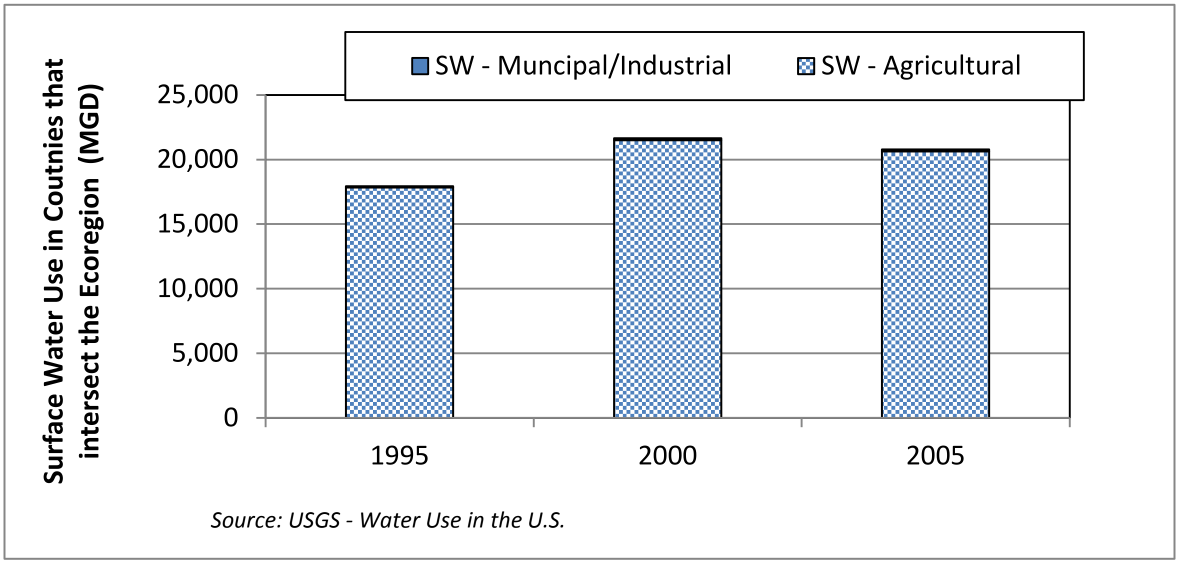

Figure 3-1. Surface Water Use

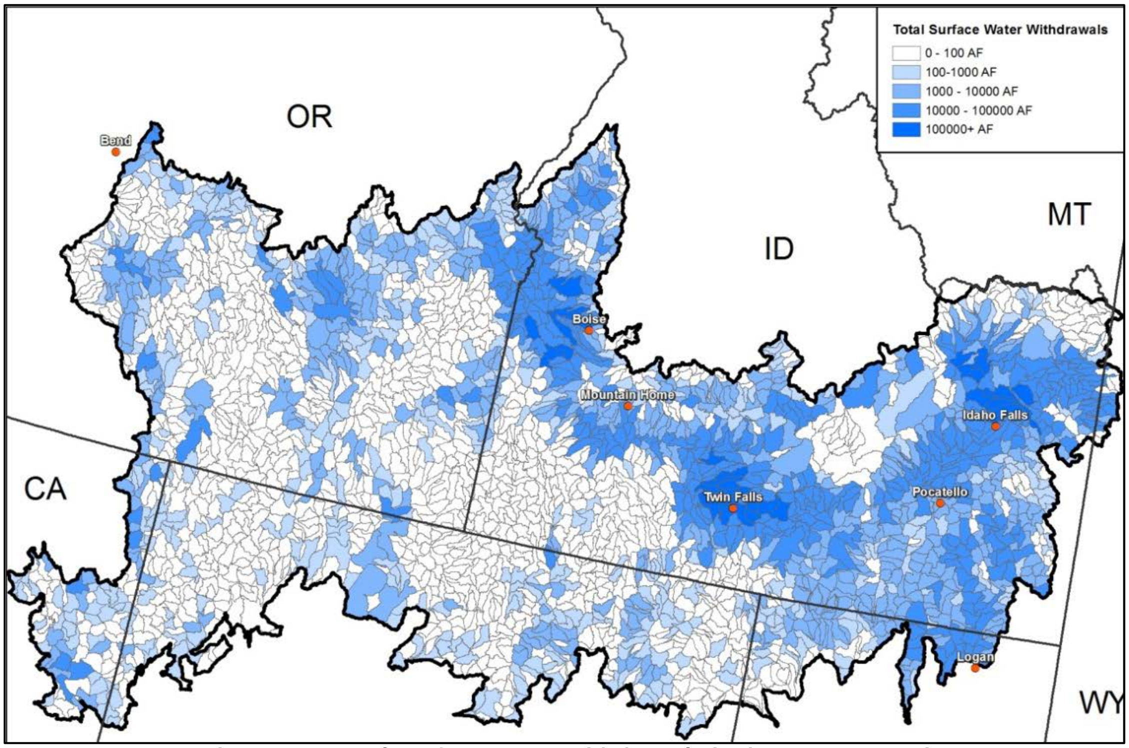

Figure 3-2. Total Surface Water Withdrawals in the NGB Ecoregion

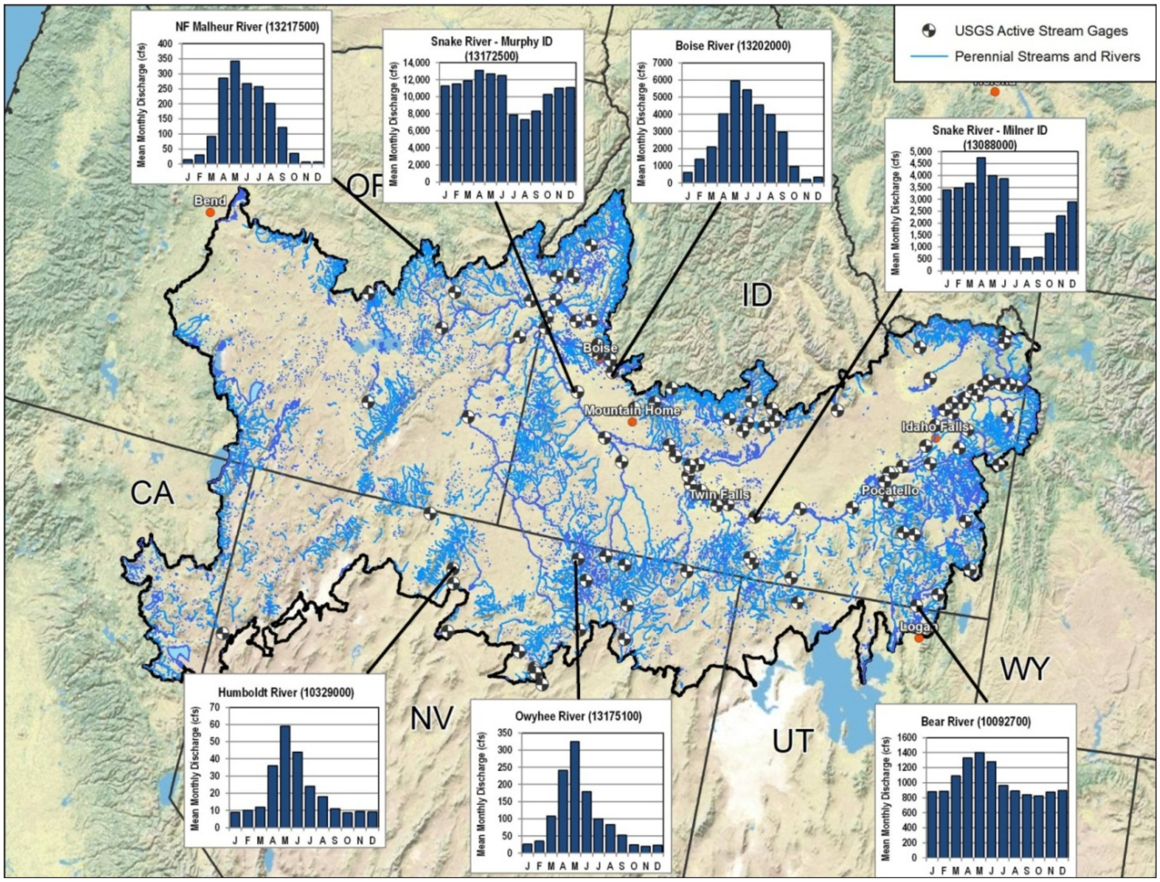

Figure 3-3. Perennial Streams and Rivers in the NGB Ecoregion

4 Conceptual Model

A conceptual model of perennial streams and rivers ecosystems in the ecoregion is presented in Figure 4-1. Change agents that affect the hydrology and floodplain, cause erosion (and resulting sedimentation into streams), or alter the riparian/aquatic biotic community are of greatest importance to this ecosystem. These change agents include agriculture, dams, groundwater pumping, development, wildfire, livestock grazing, invasive species, insects and disease, and climate change. An increase in erosion, soil loss, and resulting sedimentation runoff can be caused by many forms of development that disturbs land cover, wildfire that occurs in the watershed and, more locally, by livestock overgrazing. Ultimately, an increase in erosion and sedimentation will directly affect the water quality (Figure 4-1).

Climate change will influence perennial streams and rivers by shifting the timing, duration and amount of precipitation (including amount of snowpack and timing of snowmelt). Climate change may also affect the duration and frequency of wildfires; invasive species and the extent of invasive plant expansion; insects, diseases; and grazing opportunities for both livestock and wildlife. Invasive species, insects, diseases and grazing will influence the riparian/aquatic biotic community structure directly. As shown in the model (Figure 4-1), the effects of the change agents are interlinked and these correlations may intensify resulting effects to important perennial streams/rivers community structure. Such effects may involve aquatic invertebrates, phytoplankton, zooplankton, bacteria, fungi, viruses, fish, amphibians, birds, wildlife, and vegetation. Other potential combined effects may result in alterations to floodplain/channel connectivity and fluvial dynamics; water flow including discharge, flooding frequency, timing of flooding event, water levels and groundwater depth and velocity; and water quality including water chemistry, temperature, dissolved oxygen, sediments and nutrients (Figure 4-1).

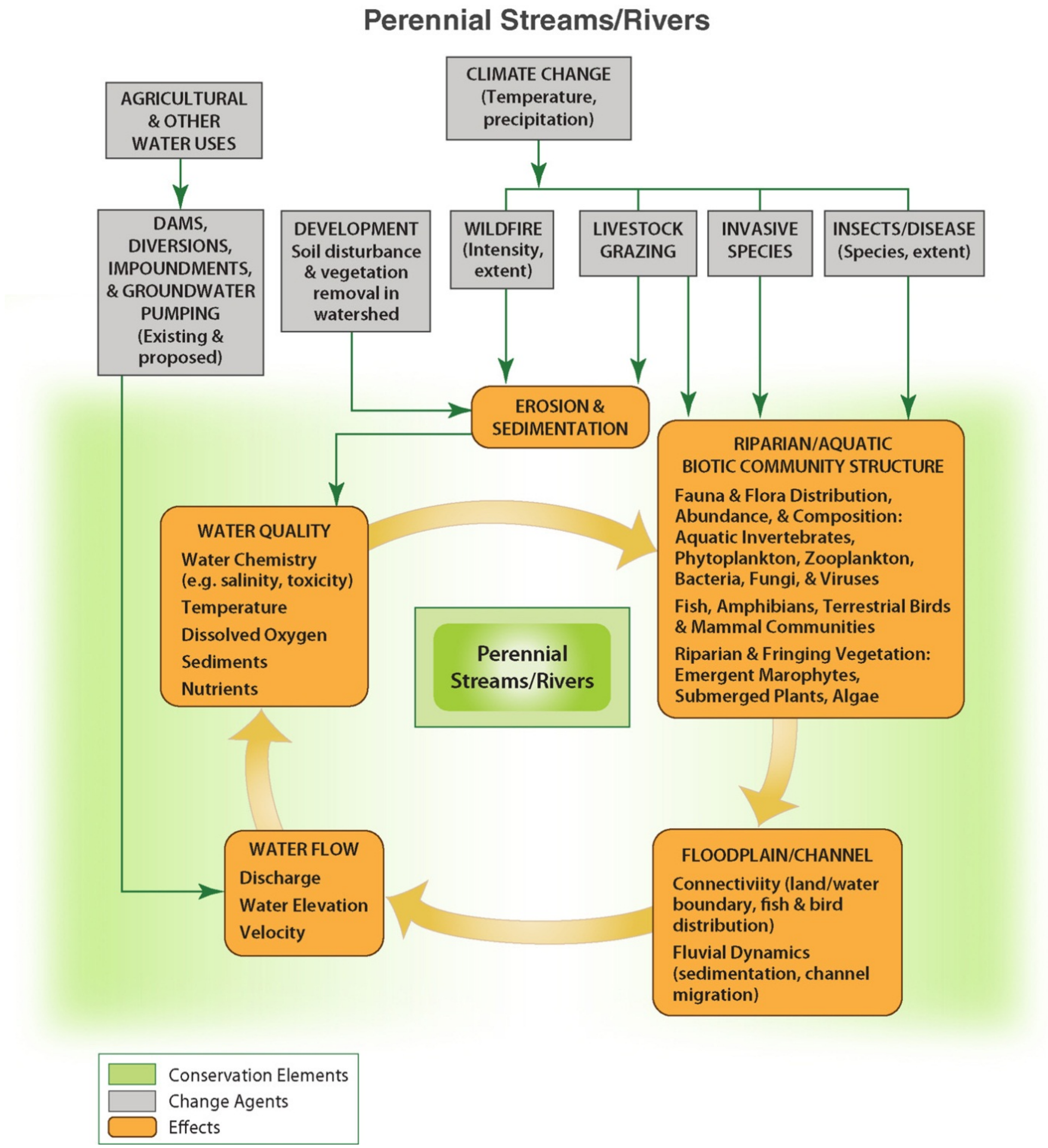

Figure 4-1. Perennial Streams and Rivers Conceptual Model

5 Change Agent Analysis

5.1 Current Status of the Conservation Element

The indicators, and metrics listed in Table 5-1 were evaluated using geospatial data. Flow evaluations were based on the occurrences of dams upstream and the groundwater condition in the watershed. Water quality was based on the list of 303(d) impaired water bodies in the ecoregion. Development within the riparian corridor was estimated in the Riparian conservation element package. Agriculture and urban development are sources of water quality contaminants. Finally, the analysis of the status of the perennial rivers and streams also included detections of invasive aquatics in the watershed.

Table 5-1. Key Ecological Attribute Table for the Streams & Rivers Coarse Filter Conservation Element for the Northern Basin and Range/Snake River Plain Ecoregion

Category	Ecological Attribute	Indicator / Unit of Measure	Metric			Data Source
Condition	Habitat Quality Stability	Water Quality	Yes	-	No	303(d) Impaired
		Aquatic Invasives Species	Yes	-	No	USFS Invasive Aquatic
		Dams Upstream	Yes	-	No	USACE
Context	Extent and Continuity of suitable habitat (at watershed level)	Average Change in gw levels (ft/yr)	< -0.5	-0.5 to 0	>-0.5	USGS
		Water Withdrawal Threat	GWW> 1.0 GWR	GWW> 0.5 GWR	GWW< 0.5 GWR	USGS
		Fraction Natural Cover in Riparian Corridor	0.0 - 0.25	0.26 – 0.8	0.8 – 1.0	Riparian conservation element package

5.1.1 Current Status of Habitat

5.1.1.1 Water Quality

The 303(d) impaired water bodies dataset from the EPA was used as a surrogate to determine the water quality of the streams in the ecoregion. The main causes of 303(d) classification within coldwater fish assemblage waters was: arsenic, dissolved oxygen, e. coli, fecal coliform, mercury, phosphorus, sedimentation/siltation, selenium, temperature, total suspended solids/ total dissolved solids and zinc. Figure 5-1 shows the 303(d) impaired water bodies within the ecoregion.

5.1.1.2 Aquatic Invasives

The source for aquatic invasive species was the USFS aquatic invasive detections dataset. Figure 5-2 shows the detections with the analysis units (HUC 12). The majority of the detections were located along the Snake River, however there are occurrences aquatic invasives throughout the ecoregion.

5.1.1.3 Flow Regulation (Dams)

Flow regulation due to dam operations can alter the natural hydrology of perennial streams in rivers. Dams are operated for multiple purposes in the ecoregion: flood control, water storage and hydroelectricity. The Major Dams data set was created by extracting dams 50 feet (15.2 m) or more in height, or with a normal storage capacity of 5,000 acre-feet or more, or with a maximum storage capacity of 25,000 acre-feet or more, from the 75,187 dams in the U.S. Army Corps of Engineers National Inventory of Dams. The HUC12 watershed boundary dataset provides the flow connection between one watershed and the next. Using the flow connections from the HUC12 dataset and the major dam dataset, it was determined whether or not there was a major dam upstream for each watershed in the REA, as shown in Figure 5-3.

5.1.1.4 Groundwater Condition

The groundwater conditions were evaluated at the HUC 12 level (see Groundwater conservation element package). For the watersheds with groundwater level data, the condition was based on the average annual change in groundwater levels. For watersheds without groundwater level data, the condition of the groundwater is based on the comparison of groundwater water use to groundwater recharge (Figure 5-4). Any groundwater withdrawal eventually results in a reduction of discharge in springs, streams, wetlands, or riparian areas.

5.1.1.5 Riparian 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 conservation element package. Figure 5-5 shows the fraction of natural land cover (undeveloped) land in the riparian corridor by HUC 12 watershed.

5.1.1.6 Cumulative Indicator Score

Five of the metrics were used to create a cumulative indicator score (water quality, aquatic invasives, flow regulation, groundwater condition, and riparian condition). 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 five metrics were then added together to derive a range of cumulative scores from five to fifteen. Figure 5-6 shows the resulting high and low scoring areas.

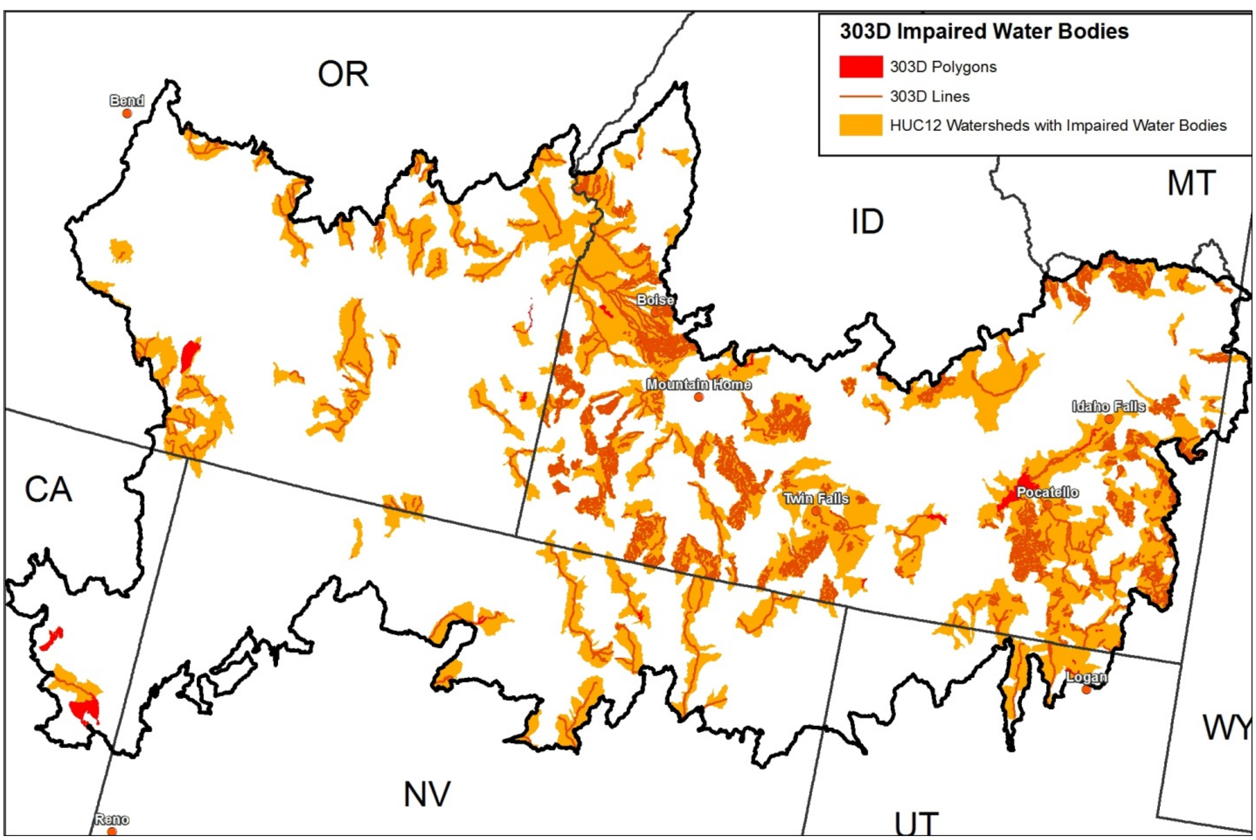

Figure 5-1. Impaired 303(d) Water Bodies

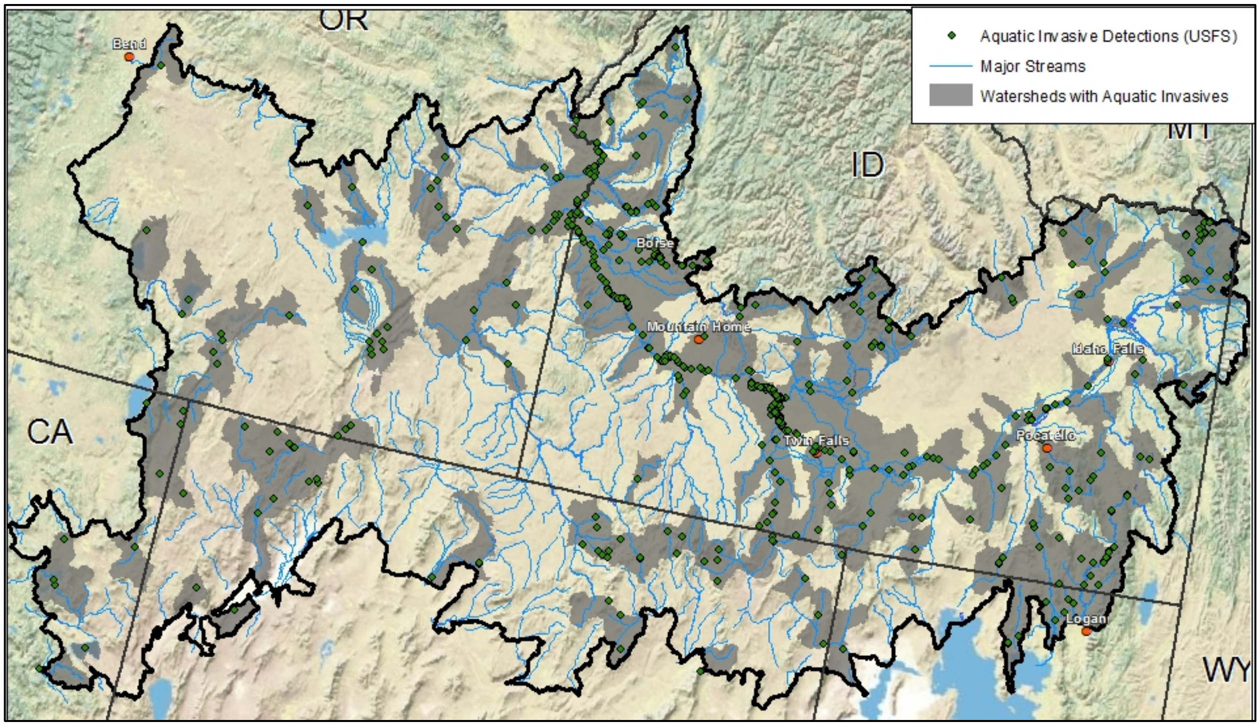

Figure 5-2. Aquatic Invasive Detections

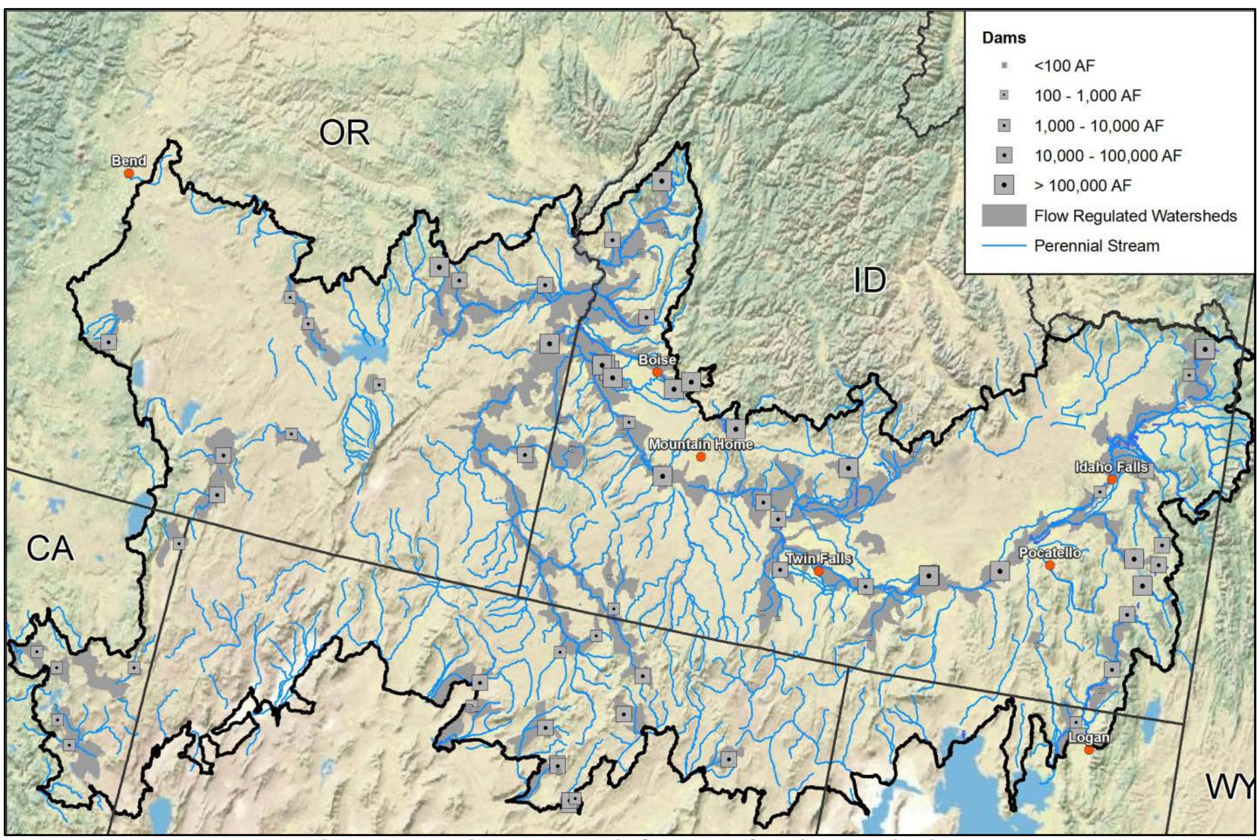

Figure 5-3. Major Dams and Flow Regulated Watersheds

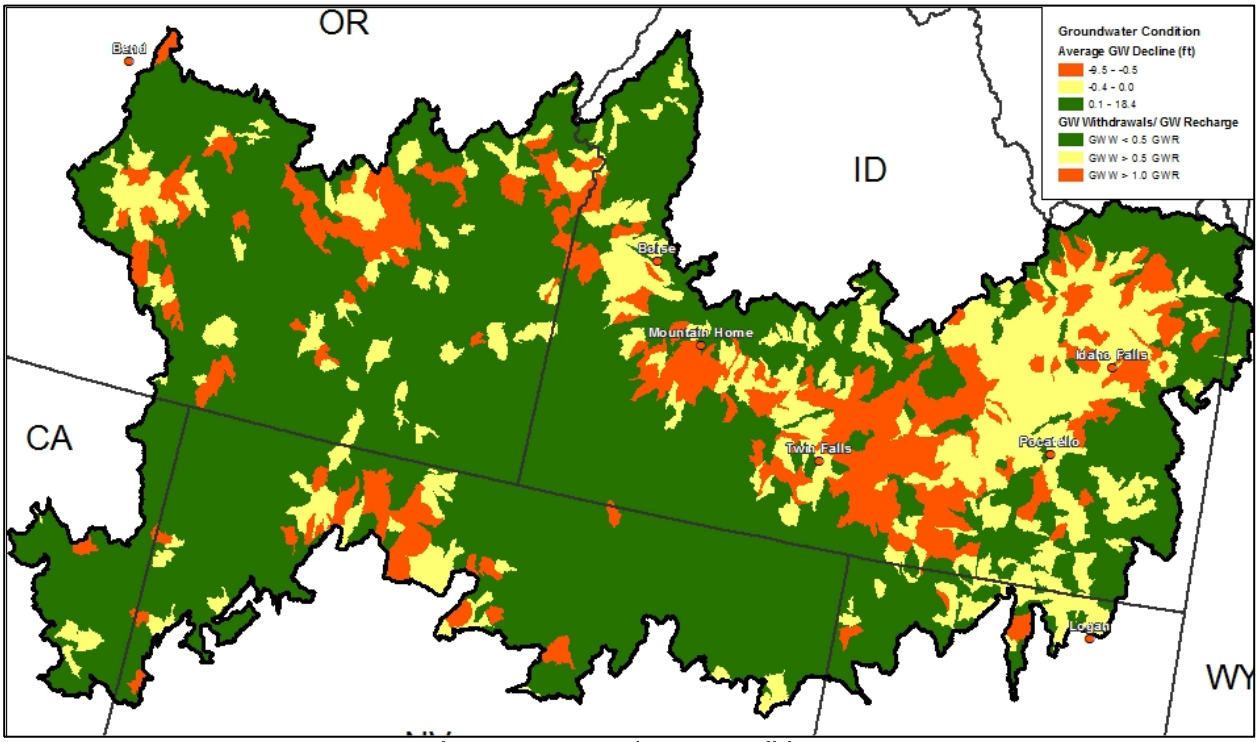

Figure 5-4. Groundwater Condition

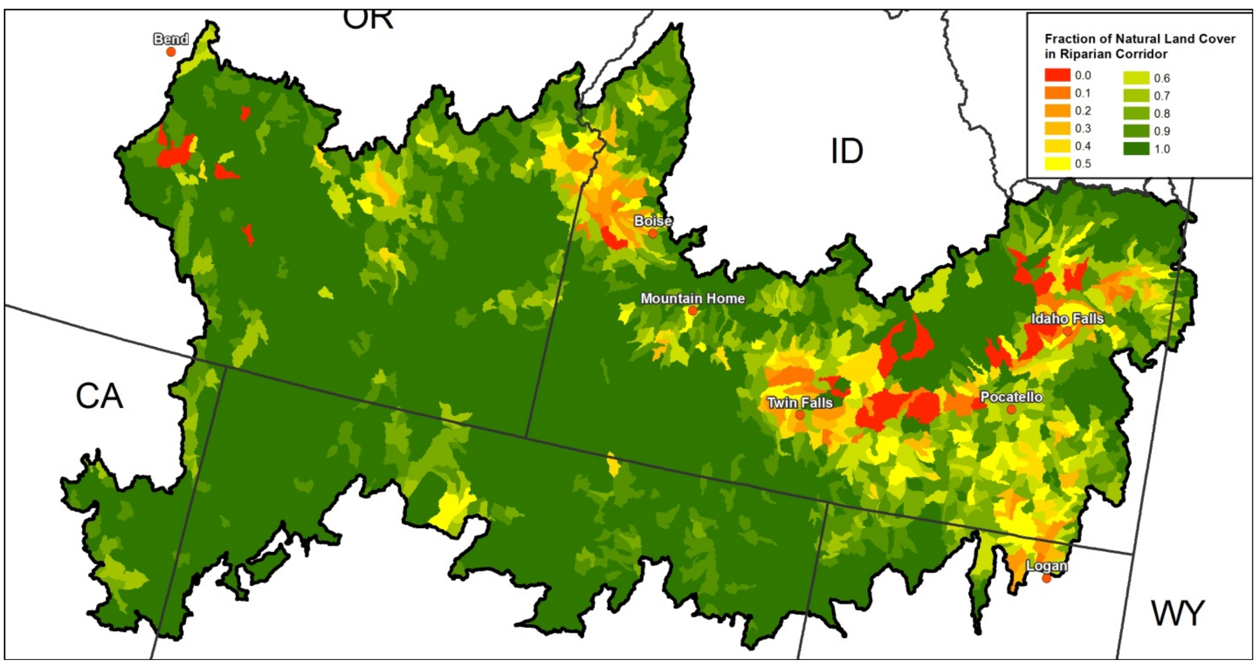

Figure 5-5. Fraction of Natural or Undeveloped Land Cover in the Riparian Corridor

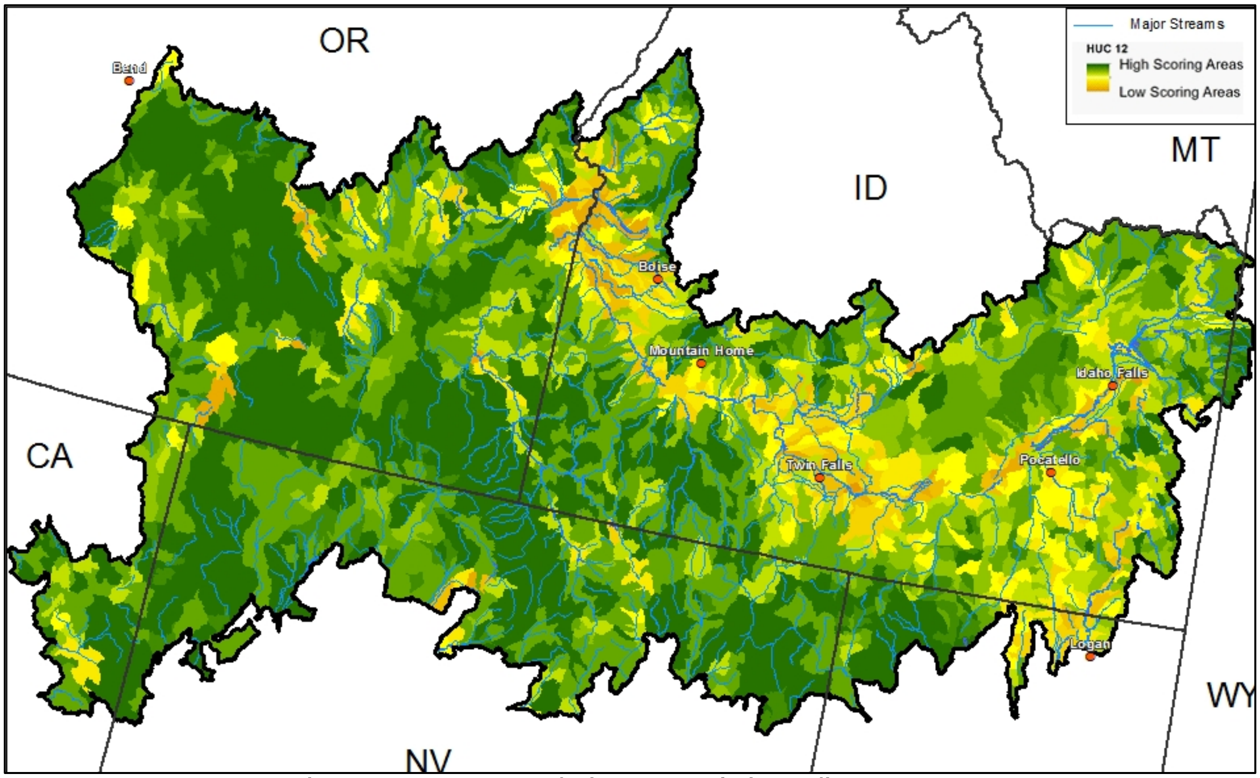

Figure 5-6. Streams and Rivers Cumulative Indicator Score

5.2 Future Threat Analysis

5.2.1 Development

Agricultural development in the ecoregion has resulted in widespread construction of dams or diversion structures that reduce flows. The Snake River Plain supports over 3 million acres of agricultural land with over 99 percent of the surface water diversions in the ecoregion for agricultural irrigation. Tailwater from agricultural irrigation can also have elevated concentrations of nutrients and pesticides, impairing water quality as it returns to streams and rivers. Increasing groundwater withdrawals also can reduce flows in spring-fed sections of streams. 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.

5.2.2 Climate Change

Long-term snow, climate, and streamflow trends at the Reynolds Creek in the Owyhee Mountains, have measured increasing temperatures at all elevations with decreasing proportions of snow to rain at all elevations. As a result, streamflow has seasonally shifted to larger winter and early spring flows and reduced late spring and summer flows (Nayak *et al*. 2010). RegCM3 (Hostetler *et al*. 2011) climate modeling predicts a increases in temperature from November to February from the Owyhee uplands westward. Therefore, observed trends of larger winter and early spring flows and reduced late spring and summer flows could potentially continue. The RegCM3 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 area 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. Coldwater fish are sensitive to instream temperature (Haak *et al.* 2010). Climate change impacts on instream temperature are discussed in the Coldwater Fish Conservation Element Package. In addition, climate change has the potential to increase winter flood risk (Haak et 2010), which is also covered in detail under the Coldwater Fish conservation element.

5.2.3 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 (IDFG 2012).

Larger, more severe 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 detrimental to recovery of the species as a whole due to the loss of unique genetic material.

5.2.4 Invasives and Disease

Many nonnative species have been introduced into North American waters which have changed the structures of native communities and caused extinction through hybridization, predation, and competition (Sada and Vinyard 2002). In the Great Basin region, introductions of non-native species and habitat modification have caused the extinction of 16 endemic species (12 fish, 3 mollusks, and one aquatic insect), subspecies, or other distinctive populations since the late 1800s (Sada and Vinyard 2002). Most Great Basin fish assemblages are dominated by non-native taxa. Fifty non-native fish taxa and several invertebrate taxa have been introduced in the Great Basin. Declines in native aquatic populations have been greatest among the most narrowly distributed and vulnerable populations (Sada and Vinyard 2002).

5.2.5 Grazing

Good management practices that maximize forage production protect the soil surface from erosion and produces less erosion than when compared with conventionally produced crops (Hubbard 2004). However, with high-density stocking and poor forage stands erosion and sediment transport can increase. Grazing animals and pasture production can also negatively affect water quality through erosion and 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).

6 Management Questions

MQ 30. Where are current natural and man-made surface water resources, and which are perennial, seasonal, ephemeral, spatially intermittent, etc.?

The National Hydrographic Dataset contains most of the available natural and man-made water resources. This data was overlaid on the maps to show perennial streams in Figure 5-3. The location of man-made major dams is provided in Figure 5-3.

MQ 31. What is the natural variation of monthly discharge and monthly base flow for streams and rivers?

Seven different stream gages were selected from the perennial streams and rivers in the REA and the monthly flow statistics were provided (Figure 5-3). Peak flows in mountainous areas generally occur in May, with the lowest flows occurring in winter. However, in heavily-regulated and spring-fed Snake River flows are more steady throughout the year, with significant declines in summer during the peak irrigation months.

MQ 32. Where are the likely recharge areas within a HUC?

Recharge in a watershed in the Great Basin area is generally greatest in the mountain fronts, surface water runoff from mountains percolates into the coarser sediments that have been deposited in the alluvium at the base of the mountains. The estimated natural recharge is shown in Groundwater Conservation Element Package

MQ 33. Where will the recharge areas (relating to aquatic conservation elements) identified in MQ 32 potentially be affected by change agents?

Natural recharge should be minimally impacted by the change agents. Climate change could have the greatest impact, but climate models predict and increase in precipitation in the mountains, which means that recharge would likely increase slightly. Agricultural irrigation has been shifted from surface water to groundwater, which reduces the overall amount of human-caused recharge in the agricultural areas.

MQ 34. What is the condition (ecological integrity) of aquatic conservation elements?

The condition of the perennial stream was estimated using five factors: water quality, aquatic invasives, flow regulation by dams, groundwater condition and riparian condition and the results are presented in Figure 5-6. Generally, the lowest-scoring areas are near the highly-developed agricultural areas in the REA. The highest scoring areas are the free-flowing streams and rivers on protected or undeveloped lands.

MQ 60. Where are the aquatic conservation elements showing degraded ecological integrity from existing groundwater extraction?

This question is answered in the Groundwater Model Conservation Package. The results from that analysis are used to estimate the conditions of perennial streams and are presented in Figure 5-4.

MQ 61. Where are current surface water diversions?

The most recent surface water use data available on an ecoregional scale is from the last USGS water use report (Kenney *et al.* 2009) for 2005. The county use data was downscaled to the HUC12 watershed using land use and land use water use factors derived from the county data. The results are shown in Figure 5-2. Figure 5-2 shows the surface water use, not the location of the surface water diversions, which can be different from where it is used if there are conveyance facilities to delivery surface water from the point of diversion.

Each state handles its water right permitting differently, and collecting all the water rights and surface diversion data was too time intensive at the ecoregional scale.

MQ 62. Where are the areas of potential future change in surface water diversion?

Over 99 percent of surface water use in the ecoregion is agriculture. Future surface water diversions could occur in areas of agricultural growth. However, agricultural water use has been stable from 2000 to 2005 and surface water use has been reduced by 4 percent with groundwater use increasing. Therefore, based on the historical trends, surface water diversions in agricultural regions may continue to decrease in the future.

MQ 63. Where are the conservation elements showing degraded ecological integrity from existing surface water diversion?

Using the Major Dams subset of the National Dam Inventory, Figure 5-3 provides the flow-regulated watersheds where surface water diversions are likely impacting the ecological integrity of streams and rivers.

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

The climate models predict that the mountains will receive more snow water equivalent precipitation which will slightly increase the flow in the streams and rivers in most of the ecoregion. The changes are discussed in more detailed in the change agent package and the Coldwater Fish conservation element package.

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Open Water
Coarse Filter Conservation Element Package

1 Conservation Element Description

Open water habitat areas include lakes, reservoirs and other large water body types (Copeland *et al.* 2010). Water bodies in the West are extremely important and support diverse ecological communities with concentrated wildlife seasonal and migration use. The unique and diverse assemblage of terrestrial, emergent, and aquatic plant and animal species supported by open water habitats on a relatively small proportion of lands has increased the need for focused open water habitat management and restoration efforts. Reservoirs make up the majority of open water in the NGB, and we may want to distinguish them from natural lakes, although dams per area and water storage per area are smaller in the NGB than in other regions (Graf 1999). The greatest impacts from water storage projects have severely affected downstream hydrology and ecology, and these effects are disproportionately higher in more arid regions. Reservoir storage can hold back over three times the mean annual runoff that should be occurring from dammed rivers (Graf 1999). The nation's reservoirs store an average of 5,000 m^3 (4 acre-feet) of water per person. Most water storage projects were completed from the late 1950s through the 1970s. The development of new reservoirs is much less common now and with the increase in water and recreation demand from increasing human populations, those open water habitats that exist in the NGB are all the more important for people and the organisms that have come to rely upon them.

2 Conservation Element 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 Conservation Element Distribution Mapping

3.1 Data Identification

The two major datasets identified to map the distribution of the open water conservation element were the National Hydrographic Dataset waterbody layer and land cover classifications found in ReGAP and LANDFIRE datasets (Table 3-1). The ReGAP and LANDFIRE datasets consist of vegetative or land use communities with corresponding codes. Table 3-2 lists the codes and class names for each of the data sources that can be used to extract open water.

Table 3-1. Data Sources for the Open Water Coarse Filter Conservation Element Distribution Mapping for the NGB Ecoregion

Data Required	Dataset Name	Source Agency	Type/Scale	Status	Use in REA
Water Bodies	National Hydrographic Dataset Water Body	National Hydrographic Dataset	Polygon	Acquired	Yes
Open Water	LANDFIRE EVT Northwest ReGAP Southwest ReGAP	USGS	Raster (30m)	Acquired	Yes

Table 3-2. Land Use Class Code and Name

Code	Data Source	Class Name
11	Northwest ReGAP	Open Water
N11	Southwest ReGAP	Open Water
10	LANDFIRE EVT	Open Water

3.2 Distribution Mapping Methods

To map distribution of open water in the NGB ecoregion, a combination of National Hydrographic Dataset layers was used. The National Hydrographic Dataset layers are broken up into water bodies and general areas. The water body's layer consists of naturally occurring features while the National Hydrographic Dataset areas consist more of man-made features such as canals and reservoirs. Figure 3-1 shows the location of open water within the ecoregion.

3.3 Data Gaps, Uncertainty, Limitations

One problem with the National Hydrographic Dataset is that it can be difficult to differentiate between lakes and reservoirs as both will sometimes need to be combined to create a continuous water body. ReGAP or LANDFIRE can be used to map open water but there are not attributes to indicate intermittent or perennial water bodies and man- made vs. natural.

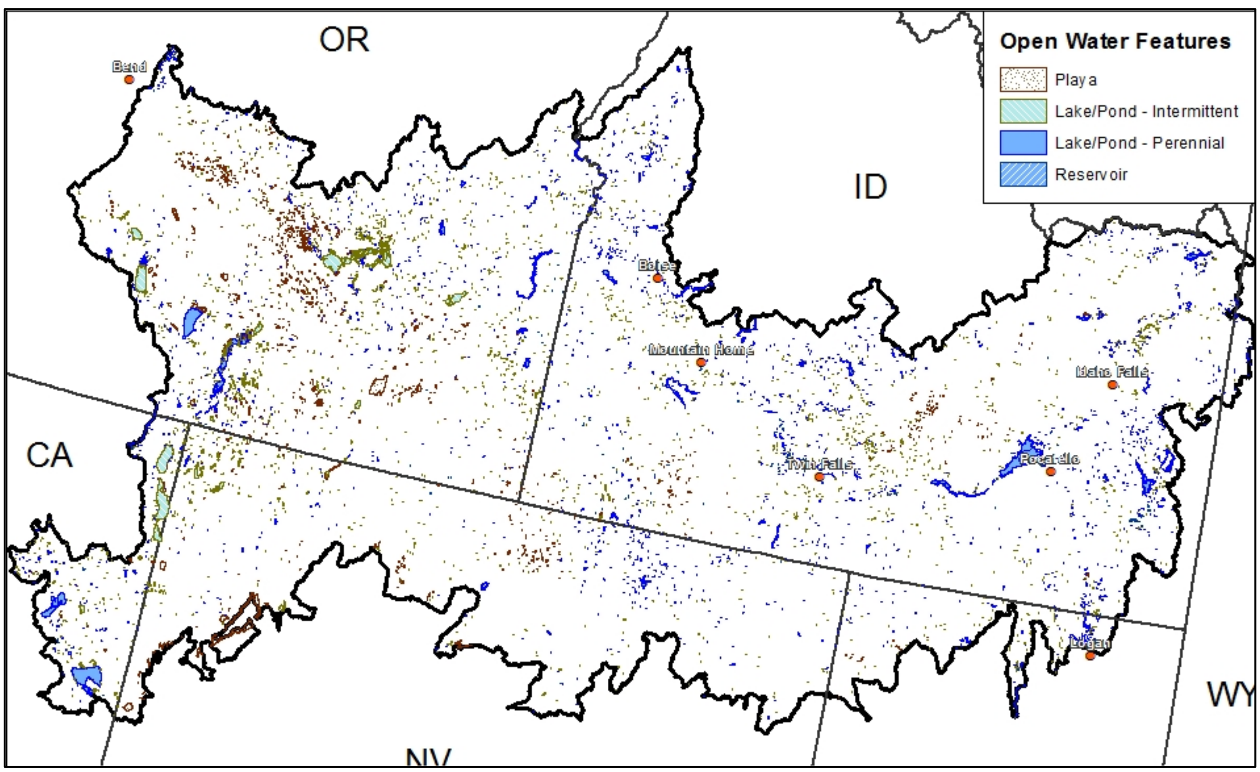

Figure 3-1. Location of Open Water within the Ecoregion

4 Conceptual Model

A conceptual model of open water habitats in the ecoregion is presented in Figure 4-1. Change agents that effect hydrology are of greatest importance to this ecosystem and include agriculture, dams and diversions, groundwater pumping, development that affects land cover, invasive species, insect and disease, livestock grazing, and climate change. Those activities that extract water from the system (irrigation for agriculture, dams, diversions and groundwater pumping) have a direct impact on the hydrology of an open water habitat within the same watershed for as long as they are functional and demand exceeds inputs.

Climate change will not only alter the amount and timing of precipitation that supplies water to lakes and reservoirs, it can alter temperature patterns that are important for thermal stratification of the open water system, as well as sediment and nutrient transport (Horne and Goldman 1994). Stable thermal stratification is important in determining the distribution of dissolved chemicals, gases and biota in open water. In addition, climate change has the potential to affect the timing and intensity of wildfires, forage resources for livestock grazing, aquatic invasive species (e.g., carp; quagga mussel), and insects and diseases (Figure 4-1). Invasive species, insects and disease, and livestock grazing will affect the riparian/aquatic biotic community structure in a myriad of ways.

Some of the identified change agents (wildfires, livestock grazing, and development) will influence erosion, soil loss, and subsequent sedimentation that will directly affect water quality in open water habitats. The flora and fauna that rely on the open water terrestrial and aquatic habitats will undoubtedly be adversely affected when water quality diminishes. The effects of these change agents are interlinked and feedback loops among them exist as well as the potential for cumulative impacts (e.g., following fires, cattle may utilize the forage resources around water habitats more intensely). Other change agent effects include a) changes to morphometry and geomorphology including the shape of the open water habitat (e.g., deep, steep banks or shallow banks) and its geologic origin; b) hydrological effects including water depth, duration and frequency of flooding events, and chemical factors including chemistry, temperature, light, nutrients, toxins and decomposition and allochtonous (native) material and c) riparian/aquatic biotic community structure, that includes invertebrates, phytoplankton, fish, amphibians, birds and mammals and riparian vegetation.

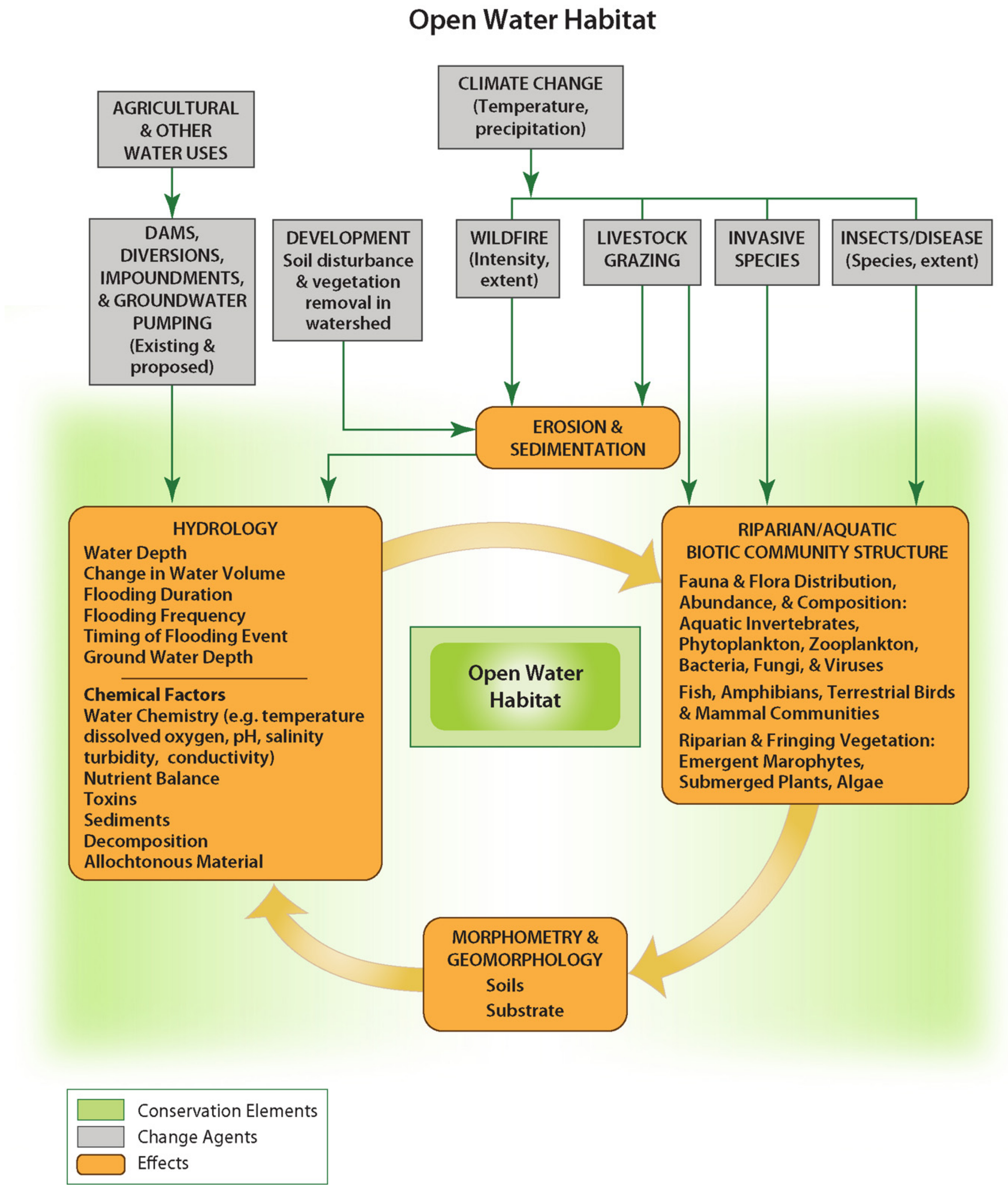

Figure 4-1. Open Water Habitat Conceptual Model

5 Change Agent Analysis

5.1 Current Status of the Conservation Element

The indicators and metrics listed in Table 5-1 were evaluated using geospatial data. Some attributes/indicators included in the conceptual model are not included in this table because either the Key Ecological Attributes/indicator is not suitable for a landscape level analysis or data are not available to support the analysis. Where possible, data gaps were identified for future data gathering efforts.

Table 5-1. Open Water Coarse Filter Conservation Element Attributes, Indicators, and Metrics for the NGB Ecoregion

Category	Ecological Attribute	Indicator / Unit of Measure	Metric			Data Source
			Poor = 3	Fair = 2	Good = 1	
Condition	Habitat Quality	Water Quality	Yes	No	No	303(d) Impaired
	Stability	Invasive Aquatic Species	Yes	No	No	USFS Invasive Aquatic
Context	Extent and Continuity of suitable habitat (at watershed level)	Proportion of natural land cover (undeveloped) habitat in HUC 12 watershed	<0.5	0.5 – 0.8	>0.8	ReGAP
	Threat of Pollution/ Contaminants	Lateral distance to anthropogenic influence including croplands	< 0.5 km	0.5 km – 2.5 km	> 2.5 km	Agricultural, Development, Mines, Major Roads, Ski slopes

5.2 Current Status of Habitat

5.2.1 Water Quality

The 303(d) impaired water body dataset from the EPA was used as a surrogate to determine the water quality of the streams in the ecoregion. The main causes of 303(d) classification within open water assemblage waters was: arsenic, dissolved oxygen, e. coli, fecal coliform, mercury, phosphorus, sedimentation/siltation, selenium, temperature, total suspended solids/ total dissolved solids and zinc. Figure 5-1 shows the 303(d) impaired water bodies within the ecoregion.

5.2.2 Aquatic Invasives

The source for aquatic invasive species was the USFS aquatic invasive detections dataset. Figure 5-2 shows the detections with the analysis units (HUC 12). The majority of the detections were located along the Snake River, however there are occurrences aquatic invasives throughout the ecoregion.

5.2.3 Development in the Watershed

Urban and agricultural development are sources of water quality contamination for open water bodies. The development in the watershed was based on the urban and agricultural development layers from the LANDFIRE dataset. Figure 5-3 shows the remaining undeveloped or natural land cover.

5.2.4 Distance to Anthropogenic Influences

Anthropogenic sources include urban areas, agricultural development and major roads. The distance to anthropogenic sources was calculated on a 30 m raster for each open water body. The average distance from anthropogenic influences to an open water body was then calculated for each watershed in the ecoregion. The results are shown in Figure 5-4.

5.2.5 Cumulative Indicator Score

Four of the metrics were used to create a cumulative indicator score (water quality, aquatic invasives, development within the watershed, and distance to anthropogenic sources). 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 four metrics were then added together to derive a range of cumulative scores from four to twelve. Figure 5-5 shows the resulting high and low scoring areas.

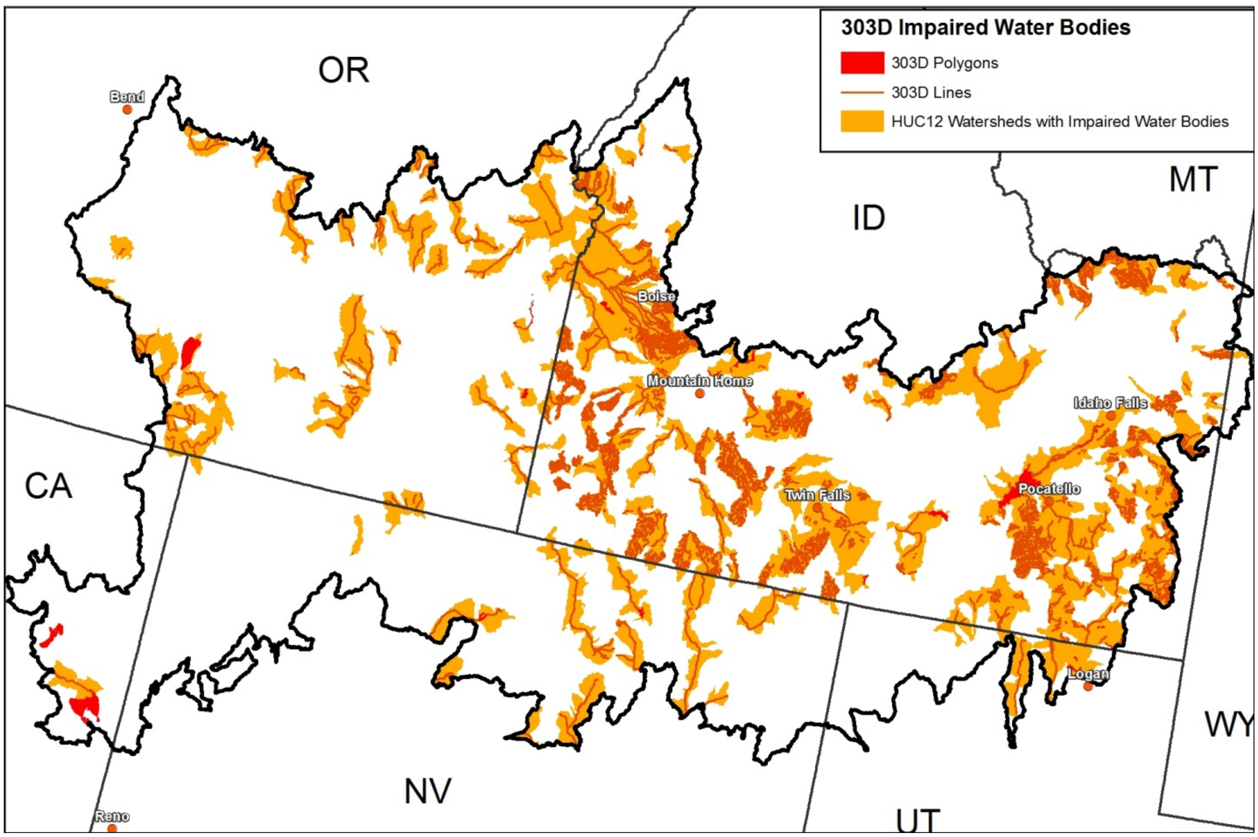

Figure 5-1. Impaired 303(d) Water Bodies

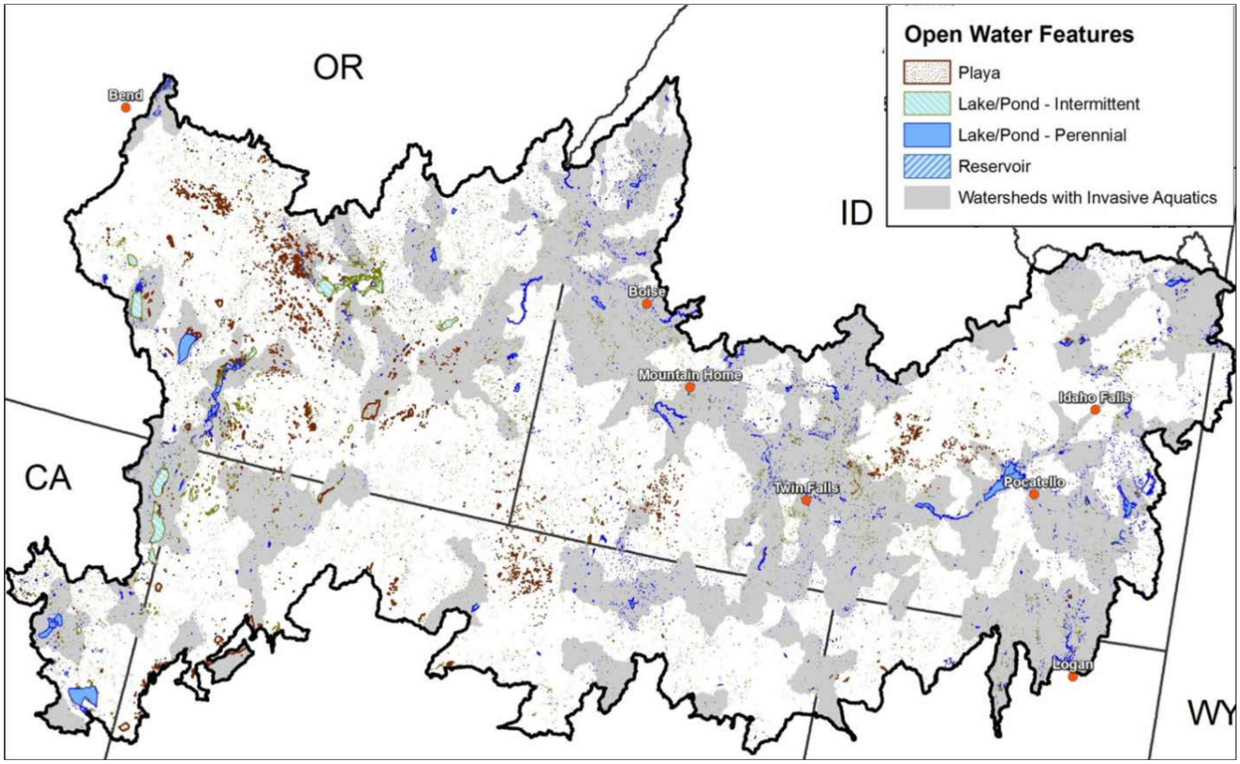

Figure 5-2. Watersheds with Aquatic Invasive Detections

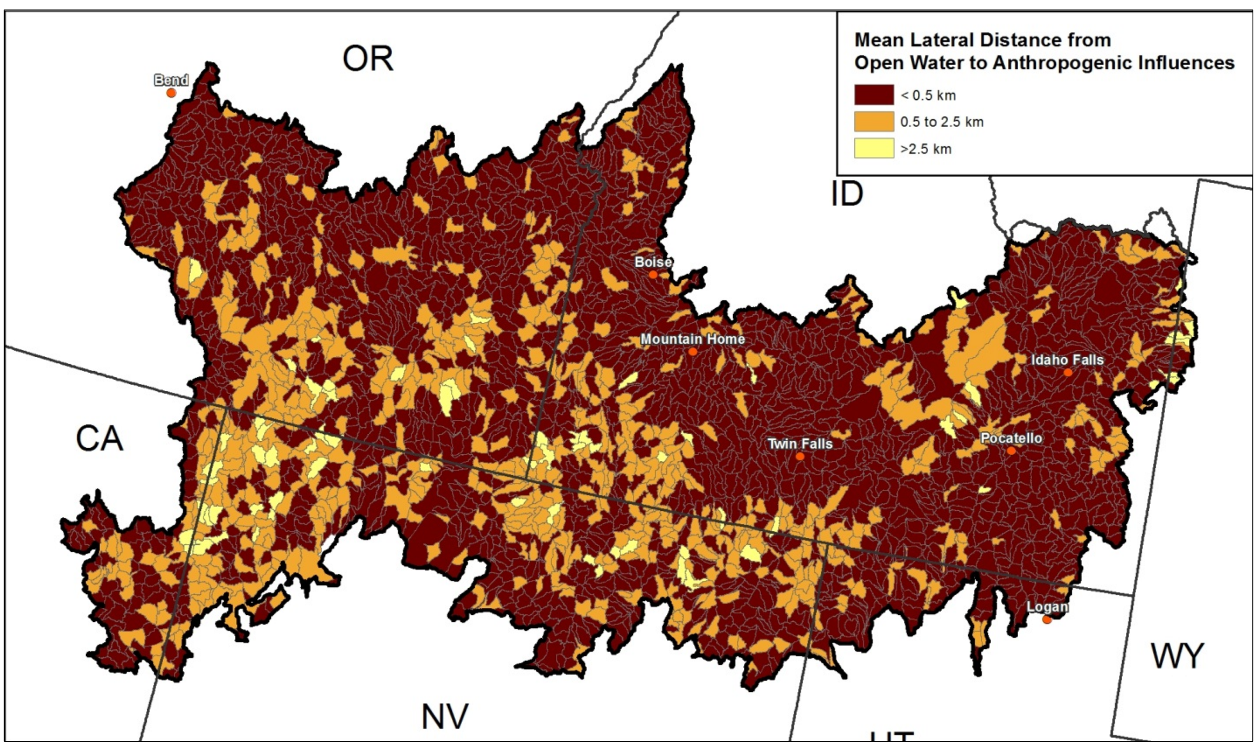

Figure 5-3. Lateral Distance from Anthropogenic Sources

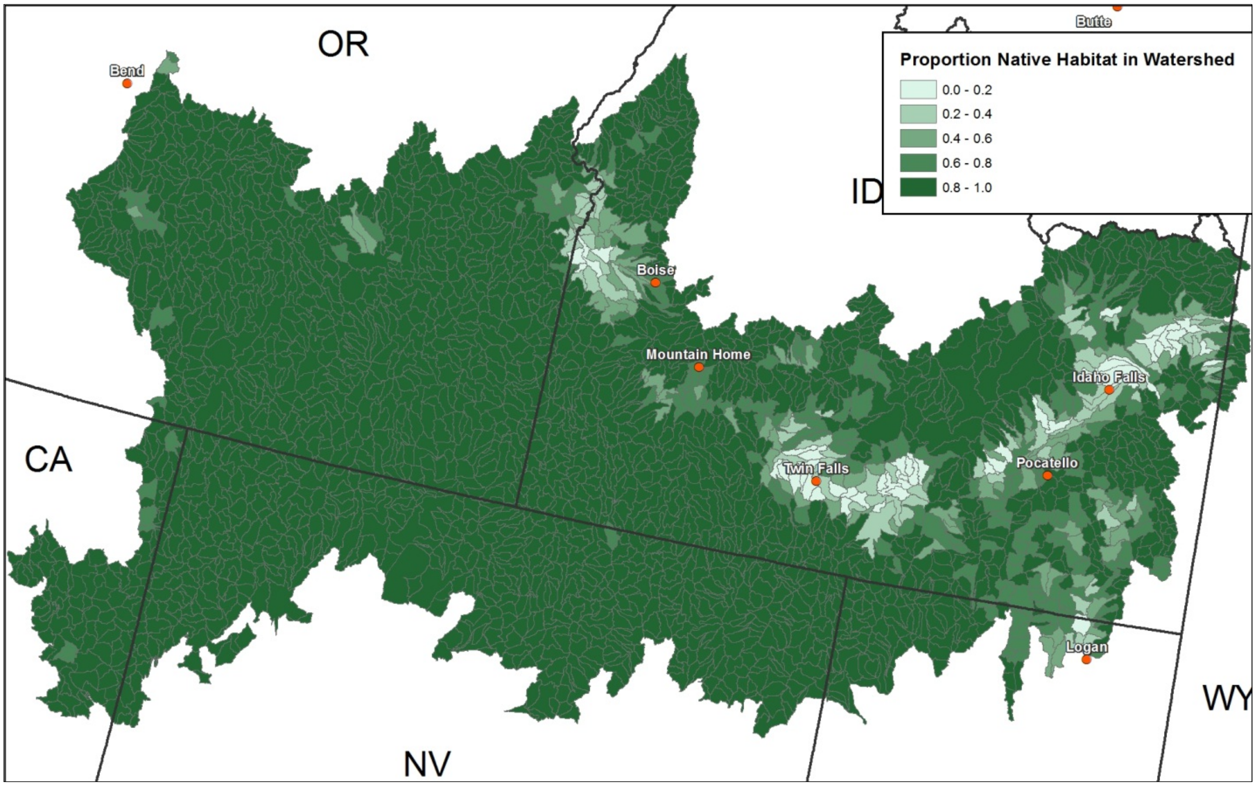

Figure 5-4. Proportion of Undeveloped Land in the Watershed

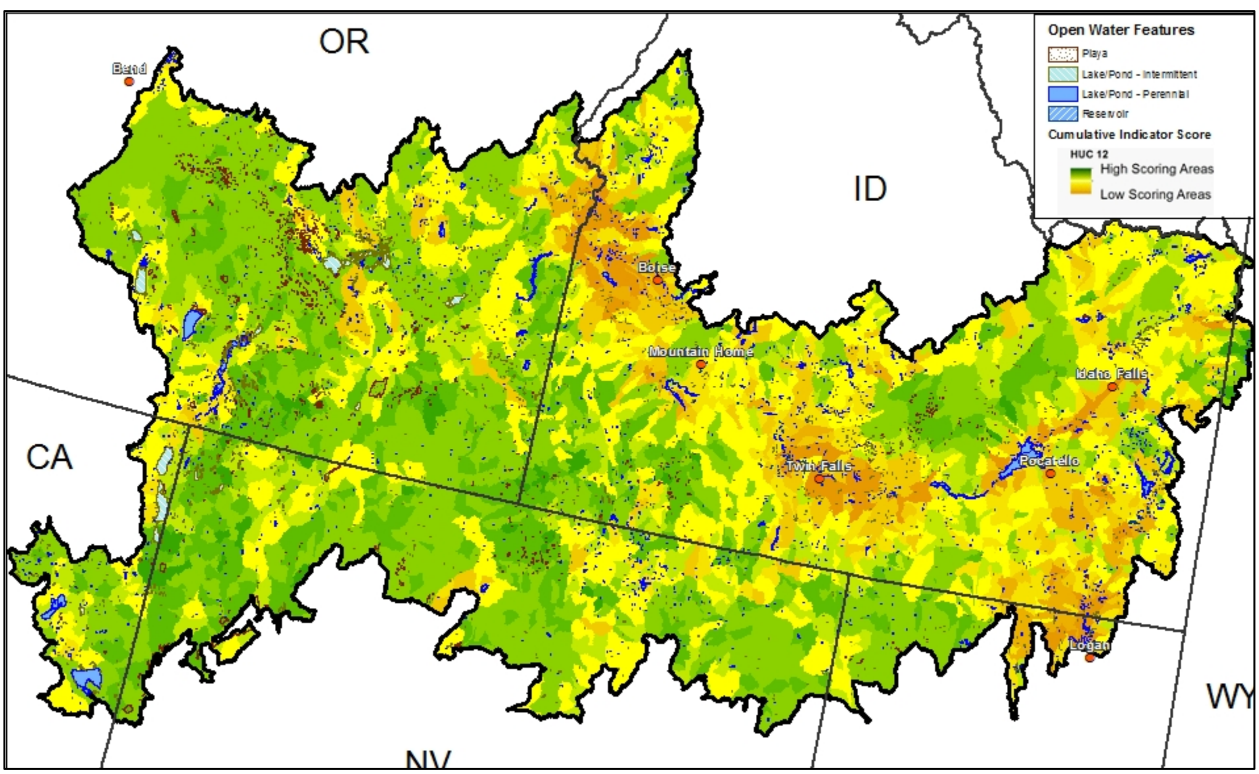

Figure 5-5. Open Water Cumulative Indicator Score

5.2.6 Future Threats

5.2.6.1 Development

Agricultural development in the ecoregion has resulted in widespread construction of dams or diversion structures for surface water withdrawals that have reduce flows, but increased the acreage of open water bodies in the ecoregion. Tailwater from agricultural irrigation can also have elevated concentrations of nutrients and pesticides, impairing water quality, and can lead to eutrophication in open water bodies.

5.2.6.2 Climate Change

Overall, RegCM3 (Hostetler *et al.* 2011) climate modeling predicts increased precipitation, however, temperature increases from November to February could reduce the proportion of snow to rain and result in a seasonal shift of increased winter flows and reduced summer flows. In addition, increasing temperatures in July and August, could increase irrigation demands at the height of summer. Reduced flows in the summer combined with increased irrigation demands, could reduce the water available in the open water bodies and increase evaporation in the late summer months.

5.2.6.3 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 and can result in reservoir sedimentation and shorten the lifespan of reservoirs within the ecoregion. Reservoirs filled with sediment often no longer function for their intended purposes and restrict fish migration in streams and rivers.

5.2.6.4 Invasives and Disease

Many nonnative species have been introduced into North American waters which have changed the structures of native communities and caused extinction through hybridization, predation, and competition (Sada and Vinyard 2002). In the Great Basin region, introductions of non-native species and habitat modification have caused the extinction of 16 endemic species (12 fish, 3 mollusks, and one aquatic insect), subspecies, or other distinctive populations since the late 1800s (Sada and Vinyard 2002). Most Great Basin fish assemblages are dominated by non-native tax. Fifty non-native fish taxa and several invertebrate taxa have been introduced in the Great Basin. The most common introduced fish in open water bodies include channel catfish, largemouth bass, common carp, and brown trout. Declines in native aquatic populations have been greatest among the most narrowly distributed and vulnerable populations (Sada and Vinyard 2002).

5.2.6.5 Grazing

With high-density stocking and poor forage stands erosion and sediment transport can increase. Grazing animals and pasture production can also negatively affect water quality in open water bodes through erosion and nutrients dropped by the animals and through pathogens from the wastes (Hubbard 2004).

6 Management Questions

Many of the other management questions related to surface water are covered in the Perennial Streams and Rivers conservation element package.

MQ 30. Where are current natural and man-made surface water resources, and which are perennial, seasonal, ephemeral, spatially intermittent, etc.?

The National Hydrographic Dataset contains most of the available natural and man-made water resources. The National Hydrographic Dataset water bodies overlaid on the maps to show perennial lakes, intermittent lakes, and playas (Figure 5-1).

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

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. Therefore flow into lakes and seasonally ponded water bodies should decline on average due to climate change. The 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 area highest in the summer (July and August) and the slight increase in temperature may increase evaporation form open water bodies.

7 References

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Vulnerable Soils
Coarse Filter Conservation Elements Package

1 Conservation Elements Description

Vulnerable soils are defined as soils susceptible to wind or water erosion. Soil erosion caused by water and wind is a natural process; however human activities have accelerated the natural erosion process in some areas, which can cause widespread soil loss or degradation with ecosystem-level impacts. Vulnerable soils typically have fine texture (e.g., loess) and may be on sloping terrain or exposed to a long fetch in the direction of prevailing high winds. Lack of protective cover by vegetation, biological soil crust (cryptogams), rock or gravel contributes to the vulnerability of soil to wind or water erosion. Microphytic crusts were experimentally shown to contribute to soil stability exposed to wind by binding soil particles, mainly by linked strands of cyanobacteria (Williams *et al.* 1995). Therefore, soil texture, slope, aspect, and cover type are important factors in identifying vulnerable soils.

2 Conservation Elements 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 Conservation Element Distribution Mapping

3.1 Data Identification

The major dataset identified to map the distribution of the vulnerable soils (wind and water erodible) is the available SSURGO data with STATSGO soils data used to fill in areas with no available SSURGO data (Table 3-1, Figure 3-1). Other important data sources are NRCS calculated Rainfall-Erosivity and Slope from the USGS DEM.

Table 3-1. Data Sources for the Vulnerable Soils Coarse Filter Conservation Element Distribution Mapping for the NGB Ecoregion

Data Required	Dataset Name	Source Agency	Type/Scale	Status	Use in REA
Terrestrial Systems					
Soils Data	STATSGO2	USDA	Polygon	Acquired	Yes
Soils Data	SSURGO	USGS	Polygon	Acquired	Yes
Soil Erodibility (K)	K_Fact	PSU	Polygon STASTGO map units	Acquired	Yes
Rainfall Erosivity (R)	Erosivity_us	EPA 2001	Raster	Acquired	Yes
Slope	Slope	USGS	DEM	Acquired	Yes
Climate Factor	C-Factor	USDA	Polygon	Acquired	No

3.2 Distribution Mapping Methods

3.2.1 Soils Vulnerable to Water Erosion

Water erosion can occur by sheet, rill, or gully erosion. Sheet and rill erosion is defined as the removal of layers of soil from the land surface by the action of rainfall and runoff. Typically, sheet and rill erosion creates shallow, parallel channels that are uniformly spaced and sized. Estimates of soil loss from sheet and rill erosion can be calculated using the Revised Universal Soil Loss Equation (RUSLE). The RUSLE estimates *long-term* soil loss due to water erosion in the form of sheet and rill erosion from moderate slopes. This equation does not predict soil loss from individual rainfall events nor does it estimate the soil loss from concentrated flow in gullies. The RUSLE is the standard, field-tested formula for soil and water conservation practices. The RUSLE is centered on statistical relationships obtained through regression analysis of observed soil erosion data. The original Universal Soil Loss Equation was developed specifically for agricultural lands. The RUSLE has been adapted for natural land conditions, as follows:

$$A = R * K * LS * C * P$$

Where A is the computed spatial and temporal average soil loss per unit area (usually expressed as tons per acre per year [t/ac/yr]), R is the rainfall erosivity factor, K is the soil erodibility factor, LS is the slope length and steepness factor, C is the surface cover and management factor, and P is the supporting conservation practices (Renard *et al.*, 1997).

To evaluate soils that are vulnerable to water erosion on an ecoregional scale, the RUSLE equation was applied assuming that the surface cover and management factors were 1, or represented bare soil conditions following a wildfire. The three factors left for the calculation include Rainfall Erosivity (R) Soil Erodibility (K), and Steepness. The Rainfall Erosivity is 10 over the majority of the ecoregion (Figure 3-2). The mean Soil Erodibility (K) across the ecoregion is 0.35, and ranges from 0 to 0.64 (Figure 3-3). Steepness is calculated from the slope which is estimated by the USGS DEM with the following formula (Figure 3-4):

$$S = 10.8 \sin \theta + 0.03 \qquad s < 9\%$$

$$S = 16.8 \sin \theta - 0.50 \qquad s \geq 9\%$$

The water erosion potential can be calculated as R*K*S / T where T is the tolerable soil loss. The NRCS defines highly erodible lands as having a water erosion potential greater than 8 (citation). For the purposes of this analysis the range of values are provided to illustrate the varying distribution of water erosion potential throughout the ecoregion (Figure 3-5). Generally, the area's most vulnerable to water erosion are steeper slopes in the ecoregion. The distribution of water erosion potential as calculated with RUSLE was in alignment with local expert knowledge of areas with high water erosion potential in the ecoregion.

3.2.2 Soils Vulnerable to Wind Erosion

Wind erosion occurs when vegetation cover is removed, the soil layer dries and wind velocities are high. All types of soil and soil particles can be affected by wind erosion. Fine soil particles can be carried high into the air and transported across oceans. The sand in sand dunes is transported through saltation, where the sand particles move by a series of short bounces. Larger soil particles can creep along the land surface through rolling and sliding. The susceptibility of soils to wind erosion is dependent on the moisture content of the soils, the soil particle size, the presence and stability of the soil crust, the velocity of the wind, the fetch or unsheltered distance of a field, and the nature and orientation of the vegetation (Brady and Weill 2002).

Two models were evaluated to estimate wind erosion at an ecoregional scale: (1) The Wind Erosion Prediction System and (2) Wind Erosion Equation. The Wind Erosion Equation and the Wind Erosion Prediction System were developed for agricultural lands and the models have not been adapted to rangelands or disturbed lands. The Wind Erosion Prediction System is a physical process based model and is too data intensive to apply at an ecoregional scale. The Natural Resource Conservation Service (NRCS) has used the Wind Erosion Equation to assess the effects of field management in agriculture on the potential for wind erosion since the 1960s. The foundation of the Wind Erosion Equation is the wind erodibility factor (I) and the climate factor (C). The definition of I is the potential soil erosion in tons per acre per annum from a wide, unsheltered, isolated field with bare, smooth, non-crusted surface. The definition for C is based on how the temperature, precipitation, and annual average wind speed compare to the agricultural test site in Garden City, Kansas. The C and I data are readily available and were acquired for the ecoregion. Using the C and I factors applicable to the ecoregion, agricultural-based Wind Erosion Equation potential soil erosion without influence of vegetative cover or management was estimated. The results were compared to recent examples of significant erosion events within the ecoregion. It was determined that the Wind Erosion Equation underestimated the wind erosion potential in rangelands parts of the ecoregion where significant wind erosion has occurred following wildfires. Since Wind Erosion Equation was developed for agricultural fields it has limited applications to rangelands and only the results from agricultural areas are shown (Figure 3-6). Wildfires generally progress in the direction of the wind and the long, wide unsheltered fetches created following a wildfire can be much greater than an individual agricultural field and significantly increase erosion.

Therefore rather than depending on the standard NRCS wind erosion models for rangelands, the rangeland areas with a high potential for wind erosion are estimated by selecting flatter areas (Steepness (S) < 0.5), and excluding rocky soils and urban and agricultural development. This assessment is based on local expert knowledge of the wind erosion processes in the ecoregion. A post-wildfire study found that that wildfire can convert a relatively wind-resistant landscape into one that produces as much soil and dust as some of the most wind erodible landscapes known, including the US southern high plains and the Loess Plateau in China (Wagenbrenner *et al.* 2011). Figure 3-7 shows the steepness with overlays of non-erodible soil (rocky soils, water features, etc.) and urban and agricultural development. Figure 3-8 shows an interpretation wind erosion potential based on steepness, non-erodible soils, and development.

3.3 Data Gaps, Uncertainty, Limitations

- Detailed SSURGO data is not available for the entire ecoregion. STATSGO was used to fill in the gaps. The soils data for the ecoregion should be updated as more areas are mapped and added to the SSURGO database.
- Soil properties for each mapping unit are based on the predominant soil series in the map unit. In SSURGO data, map units can contain several different soil series. In the STATSGO data, map units often can contain ten to twenty different series.
- Wind erodibility group and wind erodibility index data should be used with caution in the ecoregion. Local experts for the ecoregion have found that areas that wind erosivity (climate, fetch, and other wind erosion variables not directly related to the physical properties of the soil) is a more important factor in determining areas vulnerable to wind erosion. For this analysis only non-erodible (i.e., water surfaces, rocky outcrops, developed areas, etc.) groups were not considered vulnerable to wind erosion.
- Agricultural lands are susceptible to wind erosion at certain times of year when the soil surface is exposed through plowing. Good management practices can reduce the amount of wind erosion from agricultural lands. This analysis focused on rangeland soils vulnerable to wind erosion and agricultural lands were not included in the evaluation.

- Given that erosion data are never 100 percent accurate and that the RUSLE was developed for use in agriculture, results should generally be treated qualitatively, not quantitatively (Van Mortel *et al.* 2001). Erosion models are typically very good at identifying areas with high, moderate and low erosion potential but may not accurately predict the actual rates of erosion.

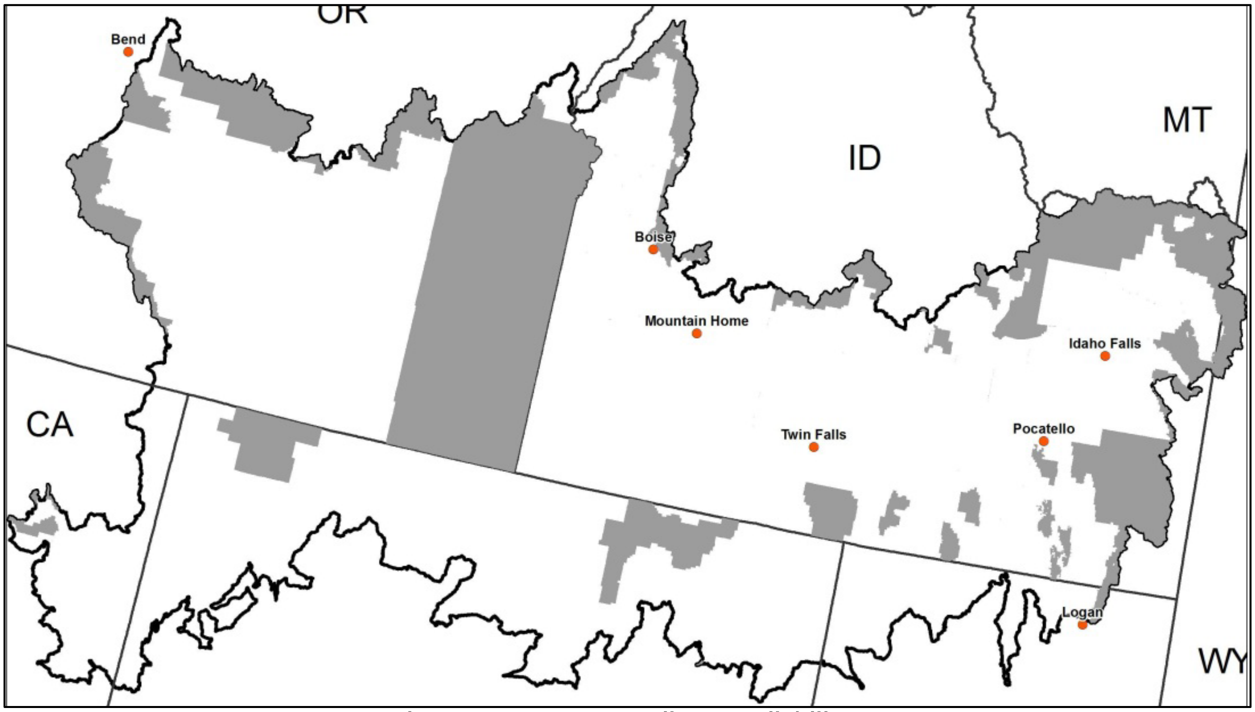

Figure 3-1. SSURGO Soils Unavailability

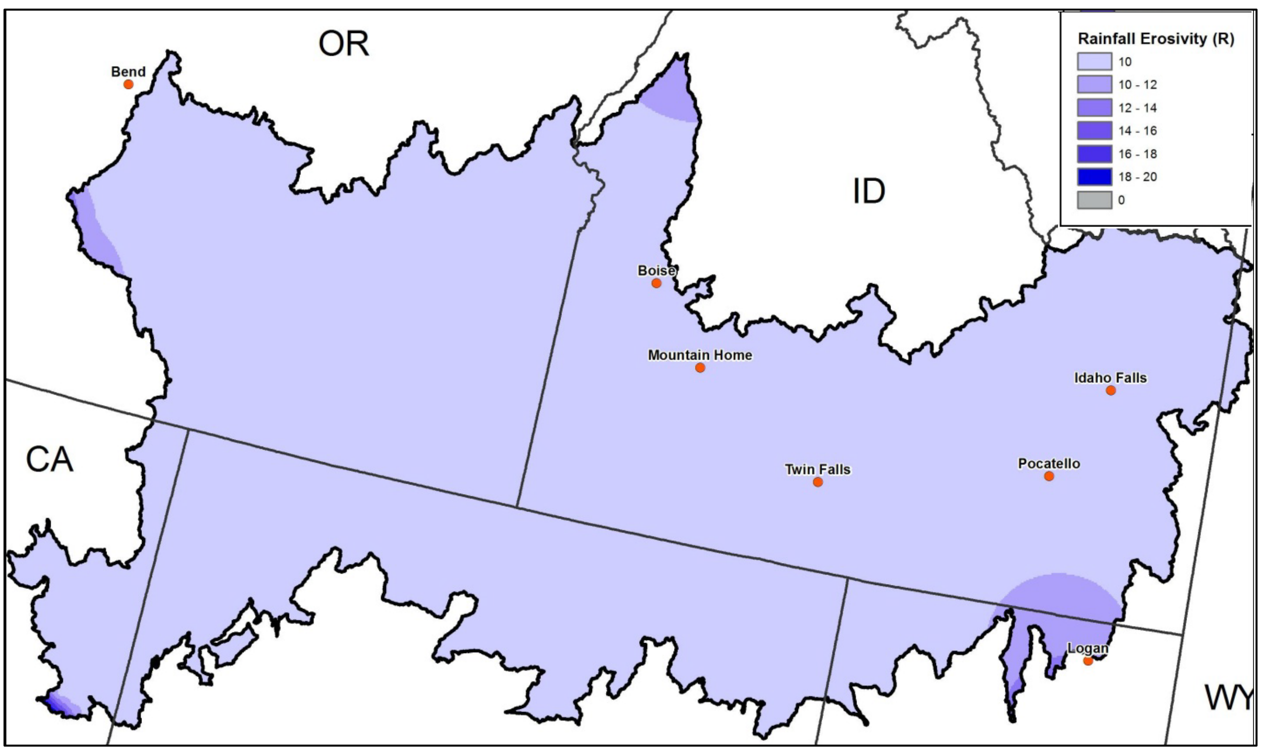

Figure 3-2. Rainfall Erosivity

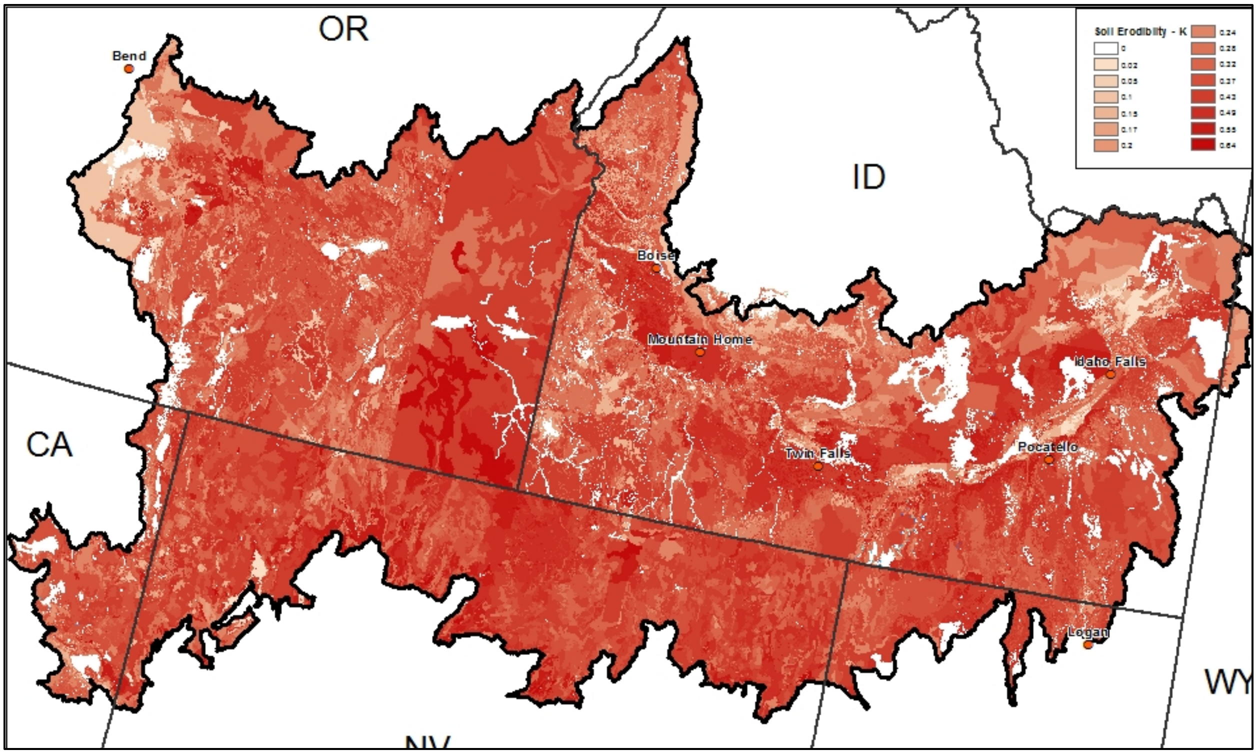

Figure 3-3. Soil Erodibility (K)

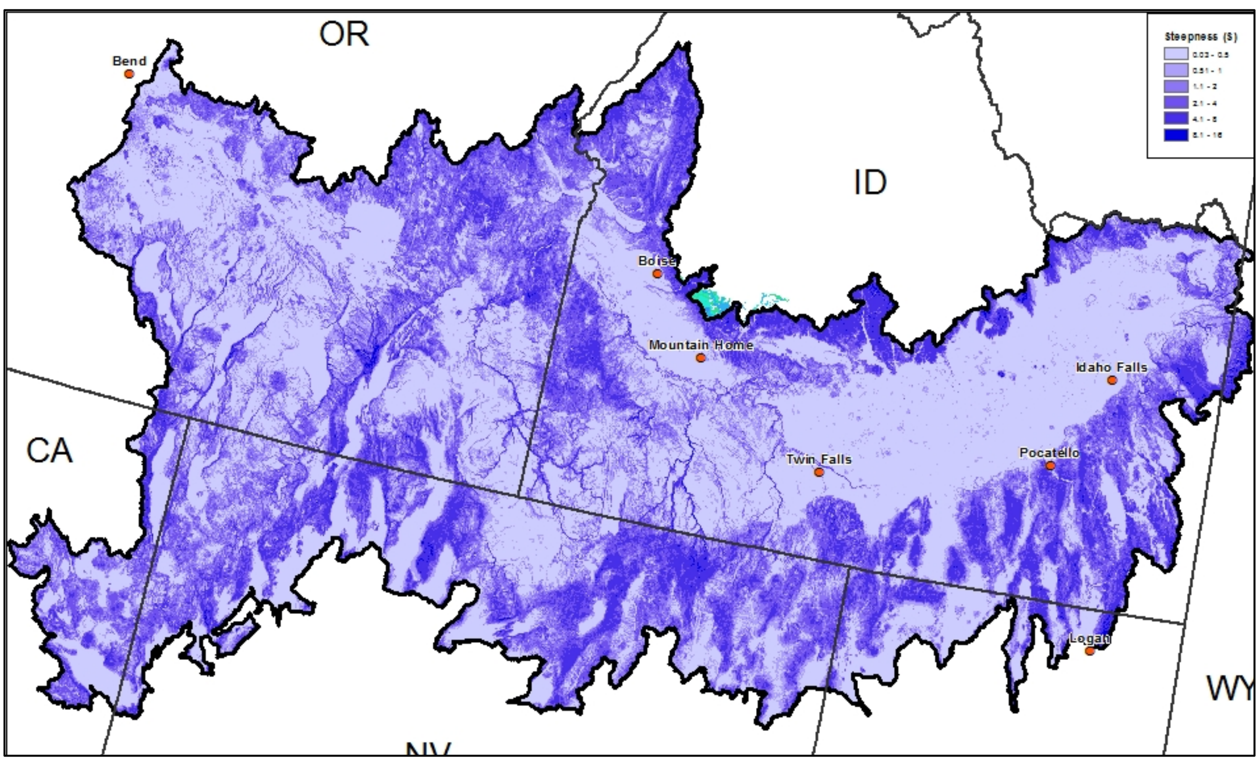

Figure 3-4. Steepness (S)

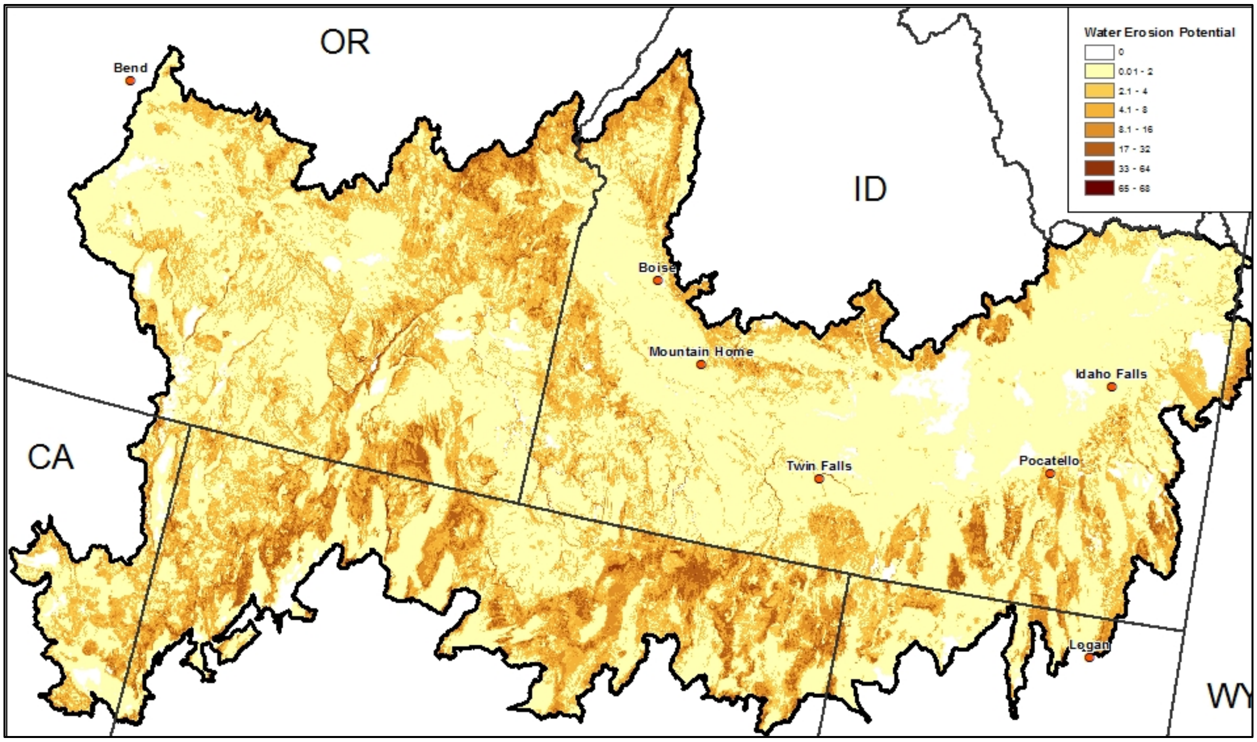

Figure 3-5. Water Erosion Potential

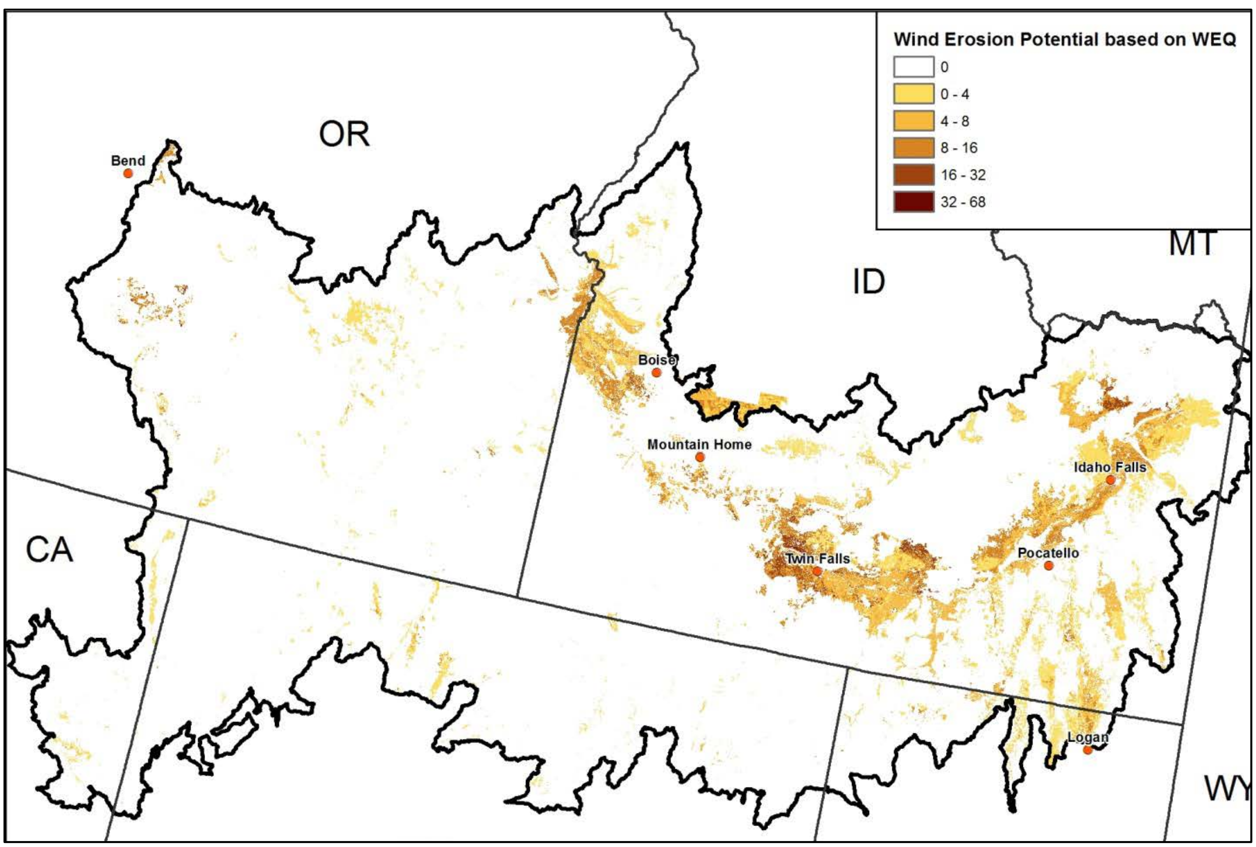

Figure 3-6. Agricultural Land Wind Erosion Potential Based on Wind Erosion Equation (WEQ)

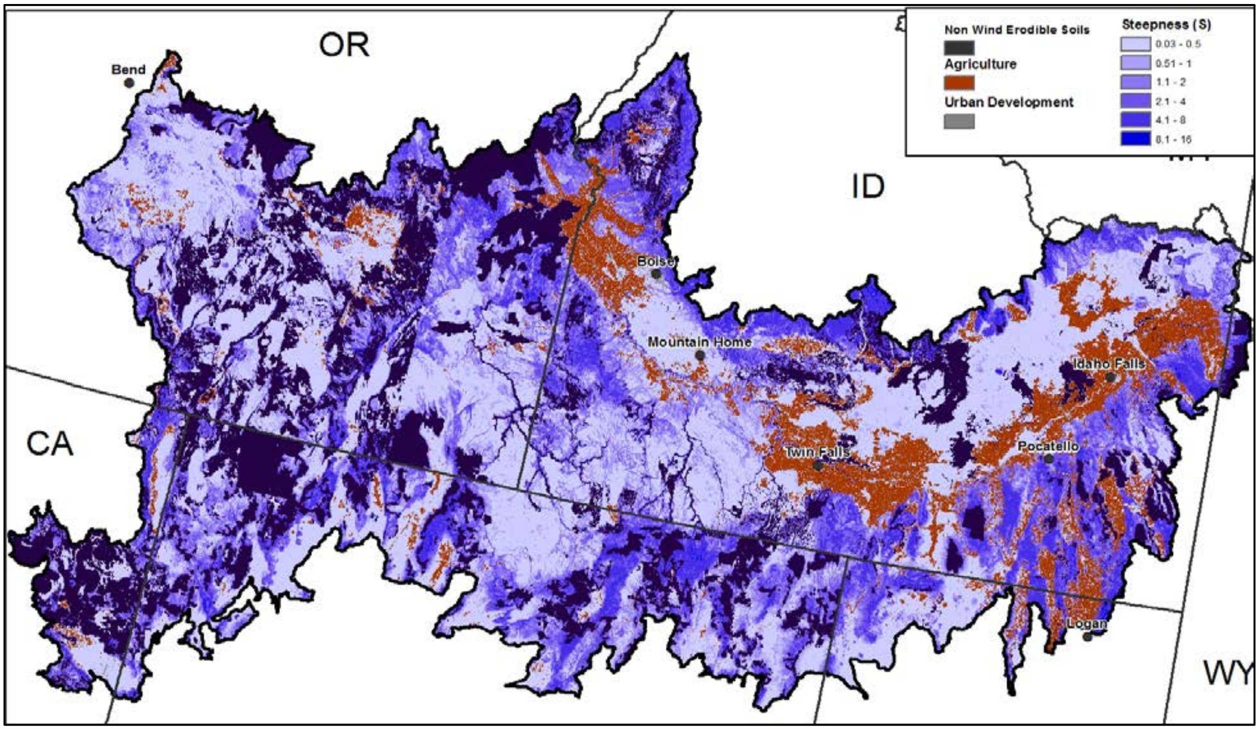

Figure 3-7. Steepness, Non Wind Erodible Soils, and Development

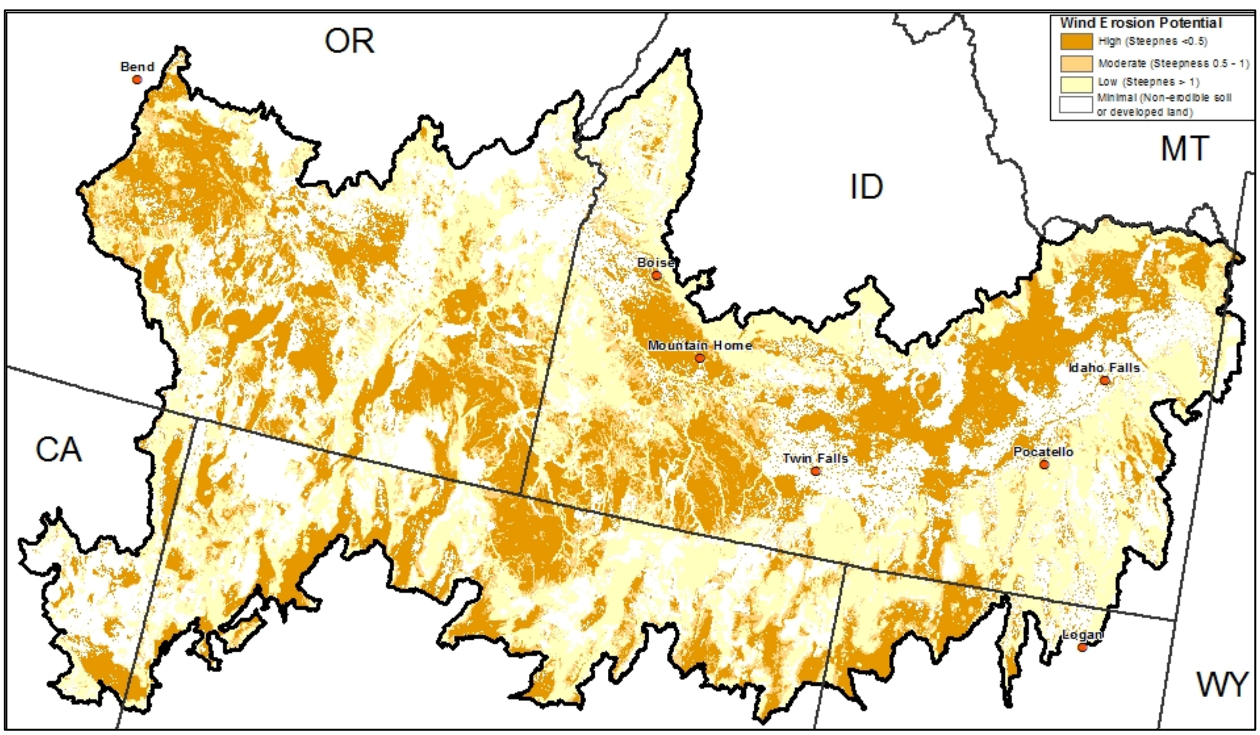

Figure 3-8. Rangeland Wind Erosion Potential

4 Conceptual Model

A conceptual model of vulnerable soils in the ecoregion is presented in Figure 4-1. Change agents of greatest importance to this conservation element are activities that remove vegetation cover. Wildfire and poorly managed livestock grazing are the change agents with the greatest potential to expose vulnerable soils to wind erosion and water erosion. Other potential change agents include agriculture, large scale vegetation removal, mining, off highway vehicles and climate change. Multiple change agents have the ability to accelerate soil erosion or lead to high soil loss.

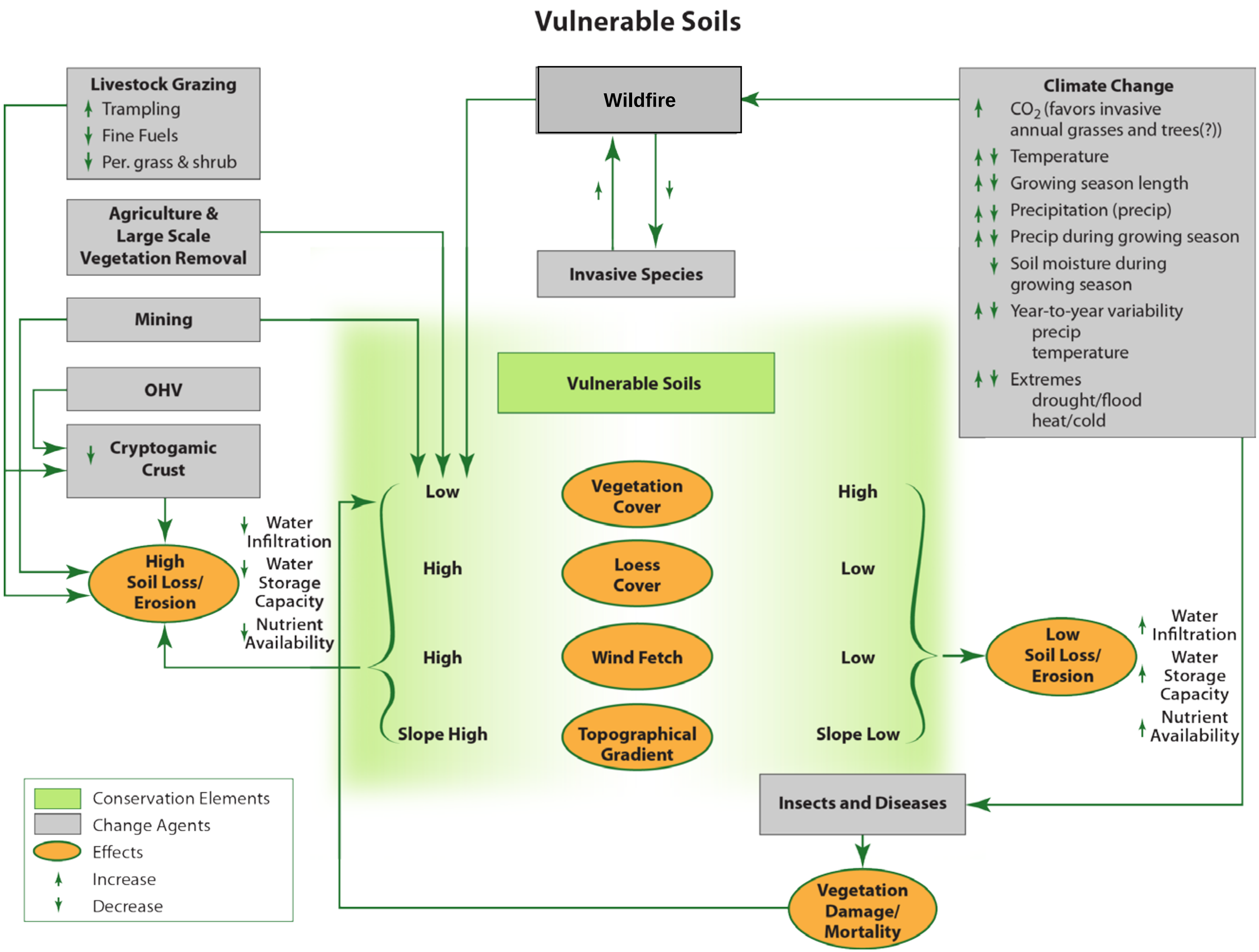

Figure 4-1. Vulnerable Soils Conceptual Model

5 Change Agent Analysis

5.1 Current Status of the Conservation Element

Vegetation cover is the best frontline defense against soil erosion and is inexpensive and sustainable in many areas of the United States. As vegetation cover is reduced, soil erosion exponentially increases (USACE 2004). Therefore it is highly important to establish vegetation on denuded lands as quickly as possible (Wischmeier and Smith 1978). In general, if all constants in the RUSLE equation are held equal and vegetation cover is increased from bare ground to twenty percent the soil loss is reduced by fifty percent. Based on a recent study of burned and unburned sites in ecoregion, unburned sites with vegetative cover had little to no wind erosion detected (Sankey *et al.* 2009).

5.2 Future Threat Analysis

As discussed in the conceptual model, change agents of greatest importance to this conservation element are activities that remove vegetation cover. Wildfire and poorly managed livestock grazing are the change agents with the greatest potential to expose vulnerable soils to wind erosion and water erosion in the ecoregion. However, all the change agents have the potential to accelerate the natural soil erosion process.

5.2.1 Wildfire

Large, severe wildfires have recently exposed large areas of bare soil in the ecoregion to wind erosion. Erosion rates measured on these areas have been as great (or greater) magnitude than many previously studied environments in Africa, Australia, and the USA (Sankey *et al.* 2009). These large wind erosion episodes are of concern to the scientists and land managers in the ecoregion. Figure 5-1 presents the burn probability overlain over the areas with high wind erosion potential (Figure 3-7).

5.2.2 Grazing

Livestock grazing is the most widespread land management practice in western North America. Approximately 70 percent of the ecoregion is under a grazing allotments. Based on the scientific literature, there is no scientific consensus regarding potentially detrimental effects of livestock grazing on arid rangelands (Allen 2001). However, there are abundant examples of apparent overgrazing in North American arid systems (Fleischner 1994).

The BLM uses rangeland health standards and guidelines to manage the grazing allotments. Guidelines are the management techniques designed to achieve or maintain healthy public lands, as defined by the standards. These techniques include such methods as seed dissemination and periodic rest or deferment from grazing in specific allotments during critical growth periods (BLM 2012).

Based on the Fiscal Year 2012 Inventory of Grazing allotments in Idaho, over 80 percent of the inventoried allotments are meeting all standards or making significant progress toward meeting the standards and 20 percent of the allotments are failing to meet the standards (BLM 2012). The water erosion potential and grazing allotments are shown in Figure 5-2.

5.2.3 Climate Change

Climate change will also indirectly effect soil erosion. A change in climatic patterns of precipitation and temperatures can influence many factors affecting soil health including insects and diseases, the increase of which can cause vegetation damage and mortality potentially creating exposed soils that are vulnerable to erosion. Increasing precipitation rates modeled to occur in the mountains may accelerate the loss of soil in the higher elevations. Climate modeling forecasts increasing summer temperatures which may increase the frequency and intensity of wildfire. Large, severe wildfire, could increase water and wind erosion.

5.2.4 Invasive Species

Cheatgrass and other annual species provide good soil protection when present. However, cheatgrass and other annual species indirectly influence soil loss because an increasing dominance of invasive annuals produces fuel for wildfire and facilitates short fire return intervals. Annual grass monocultures do not have a diversity of aboveground vegetation to reduce ground-level windspeeds, and do not have a diversity of belowground rooting structures to stabilize soils, and are often lacking stabilizing biotic soil crusts. However, after a wildfire, prefire cover and soil protection can be re-established by the start of the second growing season.

5.2.5 Development

Agriculture and large scale vegetation removal have significant effects on the soil, not only changing the soil structure but also causing other forms of soil degradation including nutrient loss, compaction, and increased salinity. Mining can cause soils erosion and contaminate soils. Off-highway vehicles can destroy cryptogamic crusts, which are important for soil stabilization. All these factors will generally lead to a decrease in water infiltration, water storage capacity and nutrient availability contributing to increased soil erosion.

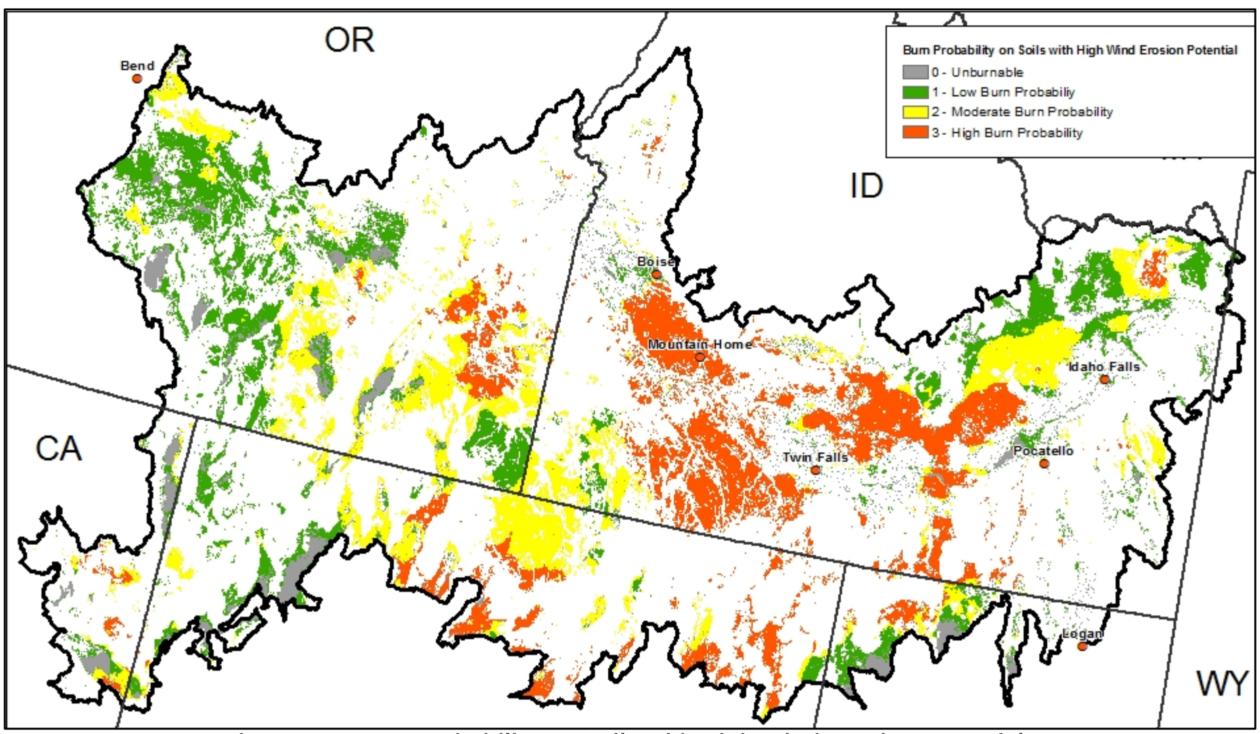

Figure 5-1. Burn Probability on Soils with High Wind Erosion Potential.

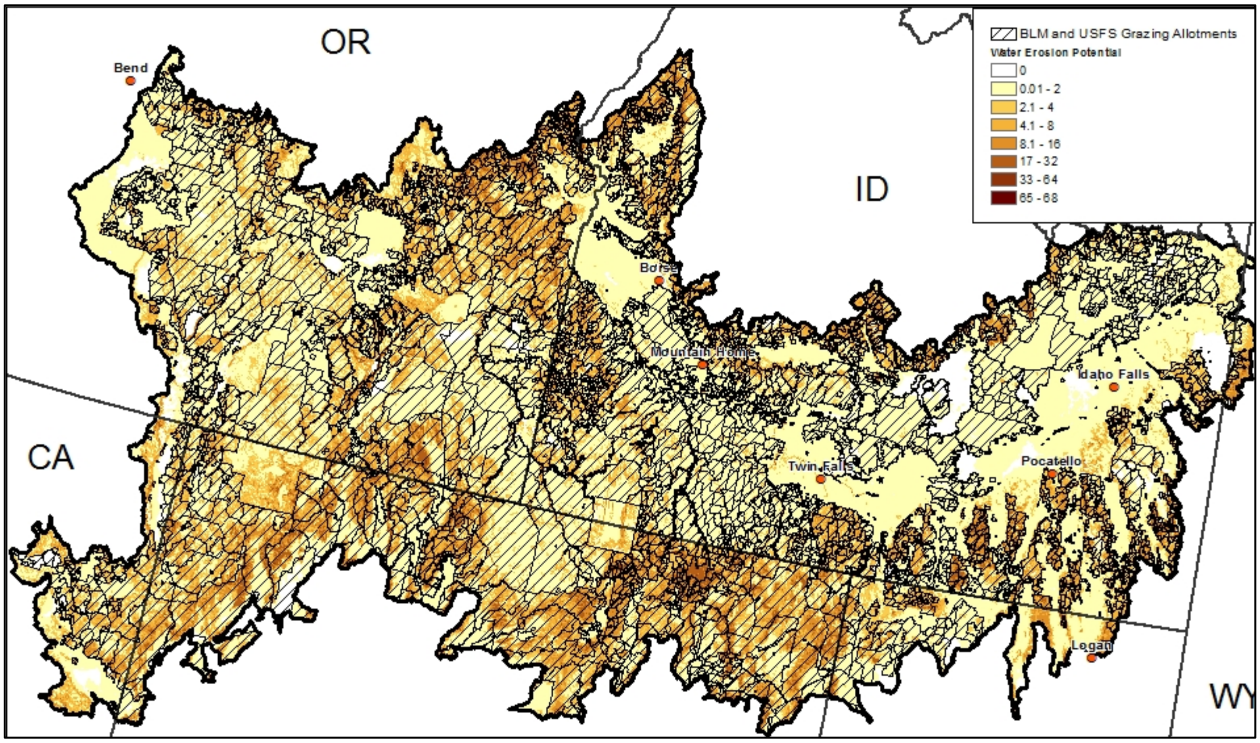

Figure 5-2. Water Erosion Potential within Grazing Allotments.

6 Management Questions

MQ 27. Where are vulnerable (e.g., wind or water erodible, slickspot) soil types within the ecoregion?

The soils that are vulnerable to water erosion are shown in Figure 3-5. The soils that are vulnerable to wind erosion are shown for agricultural lands in Figure 3-6 and for rangelands in Figure 3-8.

MQ 28. Where will vulnerable soil types overlap with change agents (aside from climate change) under each time scenario?

The change agents that have the greatest potential to increase soil erosion from vulnerable soils are wildfires and grazing. The burn probability overlaid over the areas high wind erosion potential is shown on Figure 5-1. The existing grazing allotments are overlaid over the water erosion potential areas in Figure 5-2.

MQ 29. Where will current vulnerable soil types experience significant deviations from normal climate variation?

Increasing precipitation rates modeled to occur in the mountains may accelerate the loss of soil in the higher elevations. Increasing summer temperatures may increase the potential for large, severe wildfire, which could increase water and wind erosion.

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Riparian
Coarse Filter Conservation Element Package

1 Conservation Element Description

Riparian habitats are dynamic systems that are significantly important to a diverse assemblage of wildlife, aquatic and plant species, especially in the western U.S. where water can be available only seasonally or intermittently. Riparian vegetation in the NGB is dominated by deciduous trees and shrubs, such as willows (*Salix* spp.), mountain alder (*Alnus viridis* ssp. *crispa*), aspen, cottonwood, and red-osier dogwood (*Cornus sericea*).

Well protected riparian habitats reduce the amount of sediment, organic nutrient, and other pollutants in surface water runoff. They also create shade for lower water temperatures improving habitat for fish, provide source of detritus and large woody debris that shelters fish and other organism, and provide for water courses to establish geomorphic stability.

Natural riparian buffers are linear patches of vegetation adjacent to streams, lakes, reservoirs, or wetlands. The riparian zone can vary in width from a few feet along the margins of high elevation meadow creeks to hundreds of feet in lower elevation floodplains. Riparian plant communities are populated by species dependent on moist soils, surface water, or a high water table, and for many species, the presence of periodic flooding (Johnson and Buffler 2008). Riparian vegetation in the NGB is dominated by deciduous trees and shrubs, such as willows (*Salix* spp.), mountain alder (*Alnus viridis* ssp. *crispa*), aspen, cottonwood, and red-osier dogwood (*Cornus sericea*). The transition from riparian to upland vegetation may be abrupt or gradual depending upon site specific environmental conditions.

Vegetation types that occur within riparian communities are based primarily upon dominant vegetation cover and defined by Burks-Copes and Webb (2009) as:

- **Mature riparian forests** which have tall trees ranging from 50 to 60 feet (15.2 – 18.3m) in height or more, closed canopies, and well-established (relatively dense) understory composed of saplings and shrubs, many of which provide fruit and berries for wildlife.
- **Intermediate-aged Riparian Woodland/Savannahs** which are characterized by open stands of midsized trees with widely scattered shrubs and sparse herbaceous growth underneath.
- **Meadows and Wet Marshes** which are characterized by scattered plant growth composed of short shrubs (less than 5 feet [1.5 m] in height), emergent macrophytes, seedlings, and grasses.

Cottonwood galleries are unique riparian habitats across the West that occur in the NGB floodplains, lining the major streams of the foothills and adjacent semiarid lowlands. Dominated by cottonwood trees (Populus fremontii), these communities are central to the structure and ecosystem functioning of riparian forests and the numerous species that depend on these corridors. Providing various layers or strata of foliage from the tops of tall trees to ground level, cottonwood gallery forests provide some of the most important habitat for migratory birds and other fish and wildlife species. Cottonwood galleries fit primarily into the first two categories. Cottonwood seeds require moist, bare soils for successful germination and water affects many morphological characteristics including wood formation and shoot growth; therefore flooding events are essential for stand renewal. Release of the very short-lived seeds is generally coincident with the receding flows following spring high water in natural (unaltered) regimes. With stream systems that have been impounded or dammed, or where groundwater is being used, the available of moist soils is diminished and seeds have less opportunity to germinate.

Human development (particularly dams, water diversions, conversion to agriculture and other land uses, and groundwater pumping) have substantially altered the natural streamflow, reduced water availability, and diminished and threatened riparian areas including cottonwood galleries across the western U.S.

2 Conservation Element 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 Conservation Element Distribution Mapping

3.1 Data Identification

The major datasets identified to map the distribution of the riparian conservation element were the ReGAP land cover and LANDFIRE datasets. Both datasets have adequate coverage across the ecoregion and have been used in similar analysis. The riparian forest distribution datasets are further described in Table 3-1. The individual codes and classifications are listed in Table 3-2. The list in Table 3-2 was further refined after to eliminate riparian vegetation classes that do not have occurrences within the actual REA boundaries (e.g., North Pacific Lowland Riparian Forest and Shrubland).

Table 3-1. Data Sources for the Riparian Coarse Filter Conservation Element Distribution Mapping for the NGB Ecoregion

Data Required	Dataset Name	Source Agency	Type/Scale	Status	Use in REA
Terrestrial Systems					
Ecological Systems	Northwest ReGAP	USGS	Raster (30m)	Acquired	Yes
	Southwest ReGAP	USGS	Raster (30m)	Acquired	Yes
	LANDFIRE EVT	USGS	Raster (30m)	Acquired	Yes

Table 3-2. Data Sources for the Riparian Coarse Filter Conservation Element Distribution Mapping for the NGB Ecoregion

Code	Data Source	Vegetation Class Name
8406	Northwest ReGAP	Introduced Riparian and Wetland Vegetation
9106	Northwest ReGAP	North Pacific Lowland Riparian Forest and Shrubland
9108	Northwest ReGAP	North Pacific Montane Riparian Woodland and Shrubland
9155	Northwest ReGAP	Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland
9156	Northwest ReGAP	Rocky Mountain Lower Montane Riparian Woodland and Shrubland
9168	Northwest ReGAP	Great Basin Foothill and Lower Montane Riparian Woodland and Shrubland
9170	Northwest ReGAP	Columbia Basin Foothill Riparian Woodland and Shrubland
9171	Northwest ReGAP	Rocky Mountain Subalpine-Montane Riparian Woodland
9187	Northwest ReGAP	Rocky Mountain Subalpine-Montane Riparian Shrubland
9329	Northwest ReGAP	Western Great Plains Riparian Woodland and Shrubland
S091	Southwest ReGAP	Rocky Mountain Subalpine-Montane Riparian Shrubland
S092	Southwest ReGAP	Rocky Mountain Subalpine-Montane Riparian Woodland

Table 3-2. Data Sources for the Riparian Coarse Filter Conservation Element Distribution Mapping for the NGB Ecoregion

Code	Data Source	Vegetation Class Name
S093	Southwest ReGAP	Rocky Mountain Lower Montane Riparian Woodland and Shrubland
S094	Southwest ReGAP	North American Warm Desert Lower Montane Riparian Woodland and Shrubland
S097	Southwest ReGAP	North American Warm Desert Riparian Woodland and Shrubland
S098	Southwest ReGAP	North American Warm Desert Riparian Mesquite Bosque
S118	Southwest ReGAP	Great Basin Foothill and Lower Montane Riparian Woodland and Shrubland
2151	LANDFIRE EVT	California Central Valley Riparian Woodland and Shrubland
2152	LANDFIRE EVT	California Montane Riparian Systems
2154	LANDFIRE EVT	Inter-Mountain Basins Montane Riparian Systems
2158	LANDFIRE EVT	North Pacific Montane Riparian Woodland and Shrubland
2159	LANDFIRE EVT	Rocky Mountain Montane Riparian Systems
2160	LANDFIRE EVT	Rocky Mountain Subalpine/Upper Montane Riparian Systems
2163	LANDFIRE EVT	Pacific Coastal Marsh Systems

3.2 Distribution Mapping Methods

3.2.1 Riparian Vegetation

The vegetation codes and data sources listed in Tables 3-1 and 3-2 were used to extract vegetation for the riparian coarse filter conservation element. These vegetation types were merged together and displayed in the Figure 3-3 showing the location of riparian vegetation across the ecoregion. Based on the ReGAP and LANDFIRE riparian vegetation classes, there are 877,368 acres of riparian vegetation which covers 0.08 percent of the ecoregion.

3.2.2 Riparian Corridor

The riparian corridor is that part of the floodplain closest to stream channel. A healthy riparian corridor of natural vegetation improves a streams biodiversity, water quality, flow regime, physical habitat and provides sources of food energy. A vegetated riparian can influence water quality by reducing sedimentation, provided shade to reduce increases in water temperature and increase dissolved oxygen in water. Large woody debris from the riparian corridor also provides diversification of stream habitats affecting current velocities, substrates and water depth. The size of a riparian corridor varies with the size and shape of the stream channel which is influenced by the drainage area, climate, topography, and geology (Lobb and Femmer 2008). The NRCS recommends a riparian forest buffer of at least 100 feet (30.5 m) wide on either side of a stream to reduce excess sediment, nutrients, and contaminants in surface water runoff and reduce excess nutrients and chemicals in the shallow groundwater. The entire riparian corridor can be approximated by multiplying the width of the river (or stream at ordinary high water mark) by 10 ft and adding 50 ft (NRCS). The bankfull width (as a proxy for ordinary high water mark) was correlated to the drainage area using a regional curve for the region (Figure 3-2, USEPA 2012). Drainage area was available for each reach in the National Hydrographic Dataset Plus stream attributes. The estimated riparian corridors in the ecoregion are shown in Figure 3-3.

3.3 Data Gaps, Uncertainty, and Limitations

3.3.1 Data Gaps

This analysis does not include efforts by riparian service teams to determine the proper function condition. The proper function condition (PFC) is a methodology for assessing the physical functioning of riparian and wetland areas. This proper function condition for streams and rivers was not available at the ecoregional scale.

Cottonwood galleries are difficult to extract from vegetation datasets such as LANDFIRE or ReGAP since these communities tend to be small, linear and may get rolled into a riparian classification. No cottonwood data layers have been found for the ecoregion.

3.3.2 Uncertainty

The riparian corridor is based on the correlating the drainage area of a reach to the bankfull-width using a regional curve for the Salmon River. This method was used because it could be applied across the ecoregion based on the available datasets. The estimated riparian corridor is used to evaluate development in the riparian zone at an ecoregional scale. At a local level, natural resource planners working with agricultural land owners should not rely on this estimate of the riparian corridor. The Riparian Buffer Design Guidelines developed for the Intermountain West (Johnson and Buffler 2008) should be applied using site specific data.

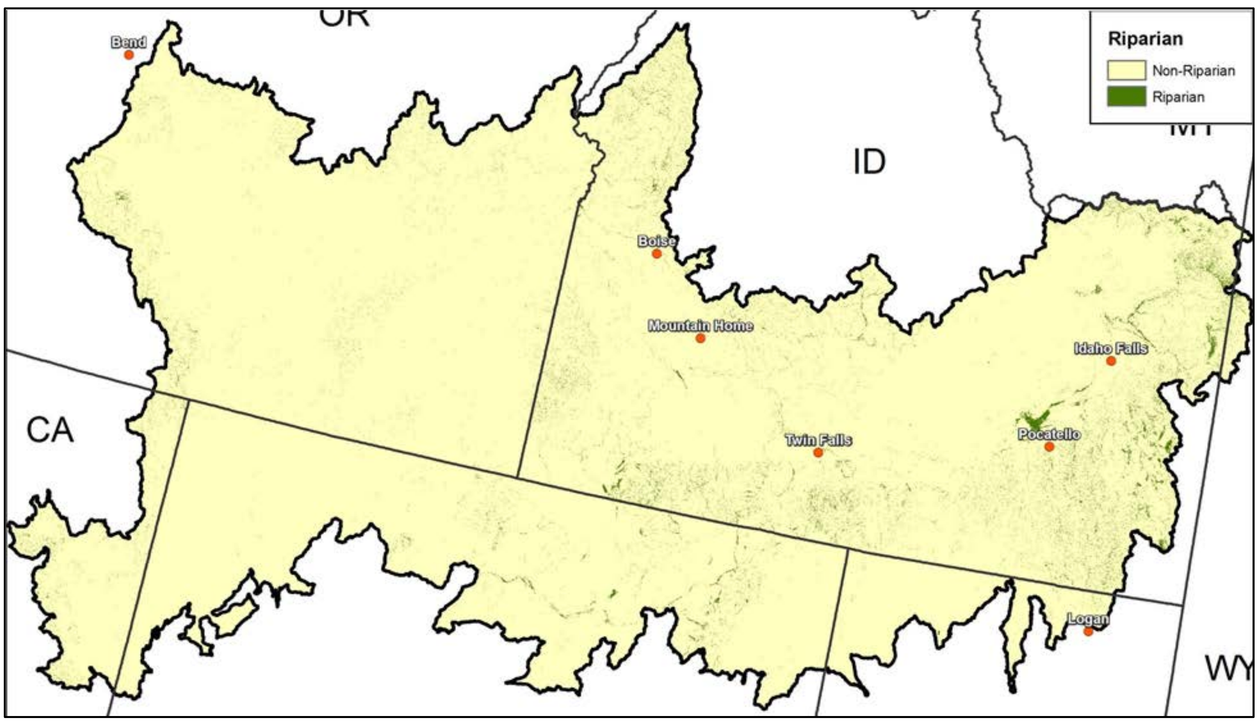

Figure 3-1. Riparian Vegetation based on ReGAP and LANDFIRE vegetation

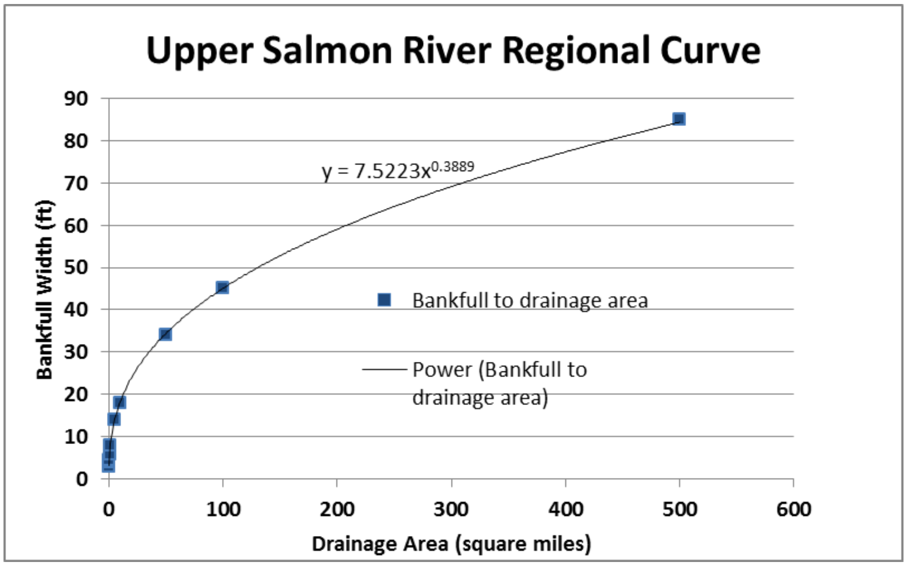

Figure 3-2. Regional Curve for the Salmon River

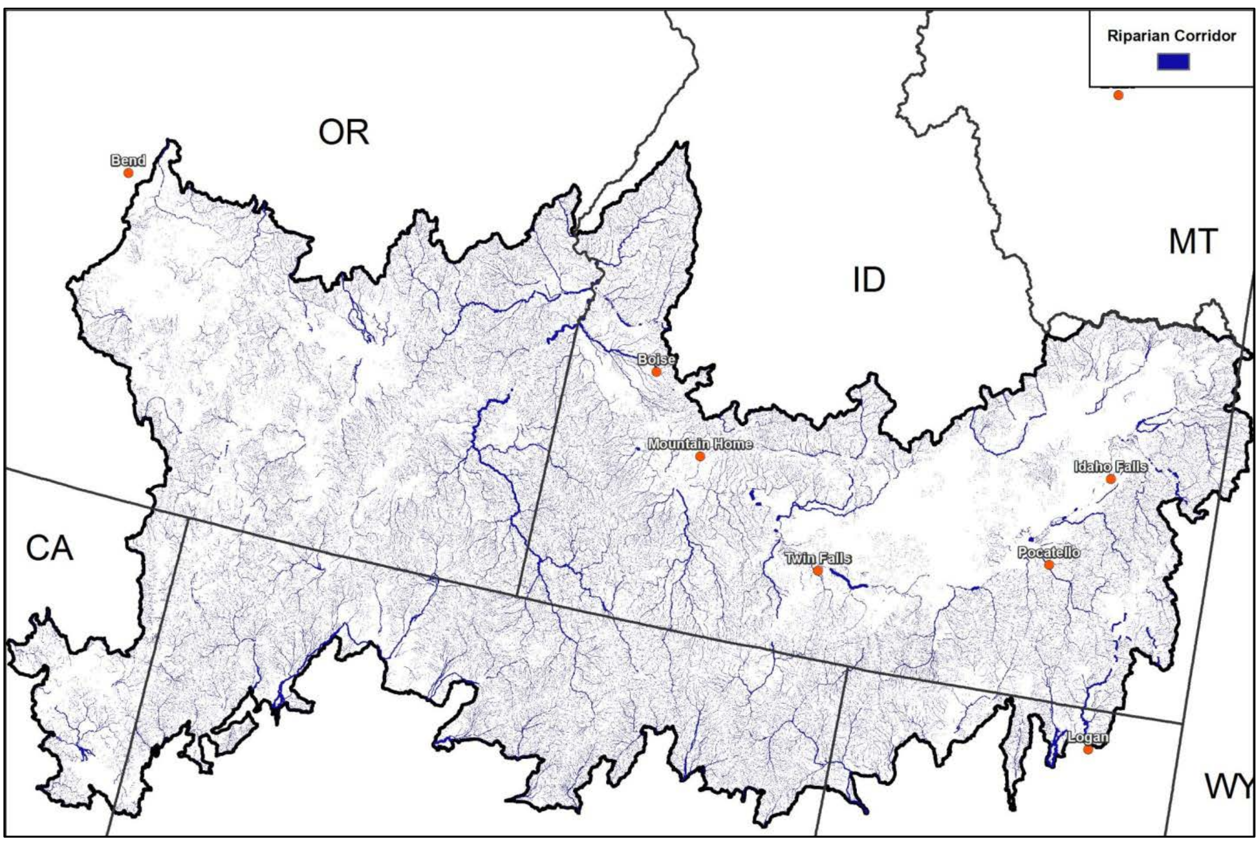

Figure 3-3. Estimated Riparian Corridor in the Ecoregion

4 Conceptual Model

Similar to those for other water-dependent systems, key change agents identified for the riparian habitat conservation element in the NGB include climate change, agriculture and other water uses, invasive species, insects/diseases, livestock grazing, and wildfire. In addition, wildlife including beavers, ungulates, and other herbivores may function as change agents. A conceptual model of riparian habitat ecosystems in the ecoregion depicting these change agents is presented in Figure 4-1. Vegetation distribution and composition is dependent upon flood dynamics, and influenced by elevation, stream gradient, floodplain width, and flooding events.

Riparian areas throughout the NGB ecoregions might be some of the first places to show signs of stress from climate change. Warmer temperatures provide more conducive environments for invasive plants such as tamarisk that utilize shallow groundwater making it unavailable for native plants. Changes in water regimes could also favor other exotic plant invasions. Existing vegetation sheltering streams not only provides refugia for a variety of wildlife but also maintains the thermodynamics of streams and water, regulating temperatures and humidity levels. As the riparian vegetation is replaced with non-native vegetation, these conditions and wildlife habitat quality of these areas has the potential to be altered.

With the continual additions of dams, diversions, impoundments, and groundwater extractions occurring in the West, riparian habitats have steadily declined in extent and health. Grazing and development pressures can add to the disturbance and damage in fragile riparian soils and drainages.

Riparian Habitat

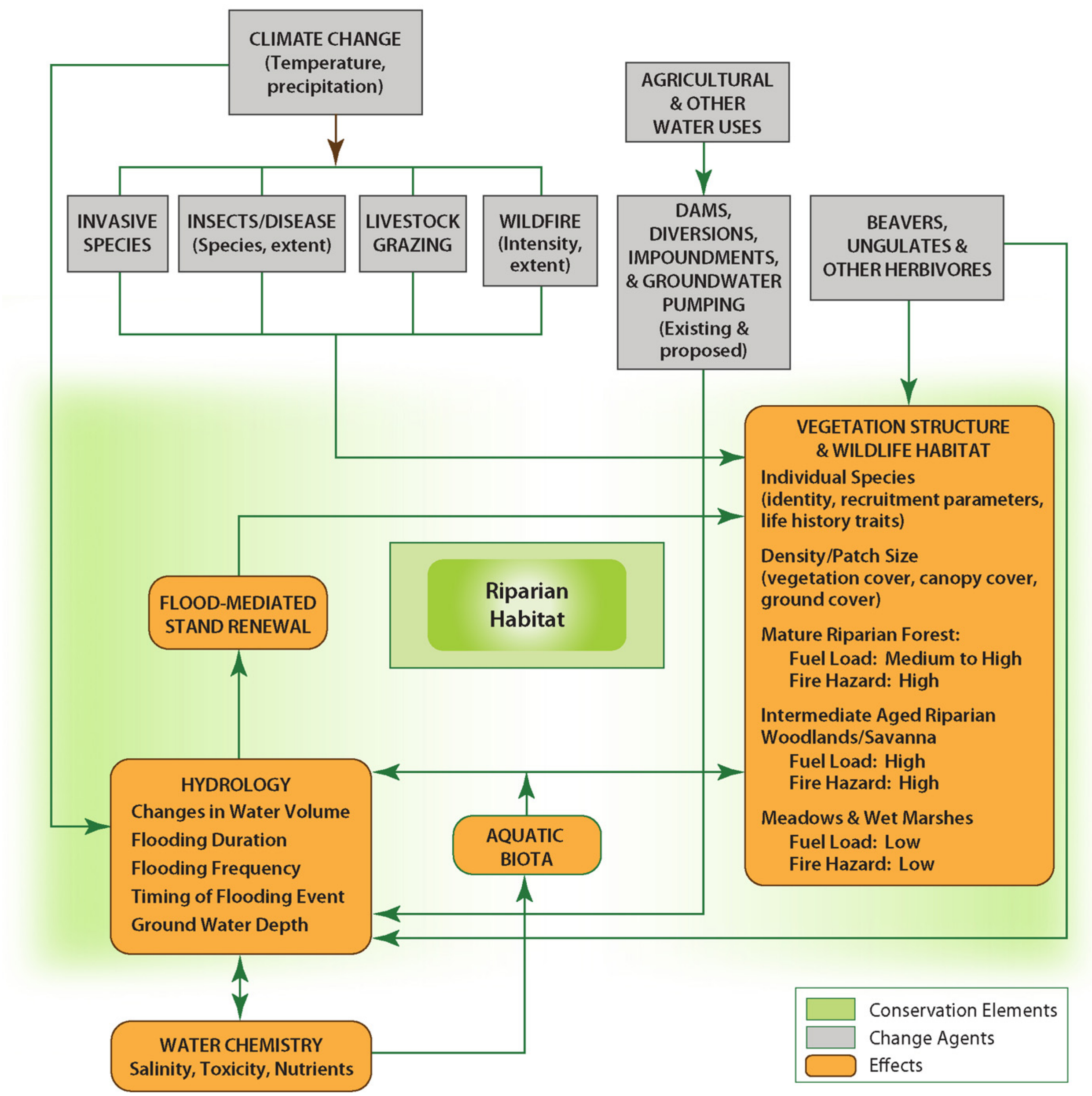

Figure 4-1. Riparian Habitats Conceptual Model

5 Change Agent Analysis

5.1 Current Status of the Conservation Element

The condition of the riparian habitat was based on how much development has occurred in the estimated riparian corridor. The metrics listed in Table 5-1 were used to evaluate the riparian habit condition for other resources (perennial rivers, coldwater fish, and bull trout) that depend on a healthy riparian habitat. Development was divided into two subcategories: agriculture (Figure 5-1) and developed lands (Figure 5-2). The two development layers were combined to estimate the fraction of land cover in the riparian corridor (Figure 5-3).

Table 5-1 Key Ecological Attribute Table for the Riparian Coarse Filter Conservation Element for the Northern Great Basin Ecoregion

Category	Ecological Attribute	Indicator / Unit of Measure	Metric			Data Source	Citation
			Poor = 3	Fair = 2	Good = 1		
Condition	Habitat Health	Percent of Riparian Corridor with Natural Landcover	>80	>25-80	<25	National Land Cover Dataset - 2006	USDA 2011
	Fragmentation/ Pollution Threat	Percent of Riparian Corridor in Ag use (cropland)	>60	>30-60	<30	National Land Cover Dataset - 2006	Stagliano 2007
Context	Development	Percent of Riparian Corridor in Urban development	>10	>5-10	<5	National Land Cover Dataset - 2006	Wang *et al.* 2008

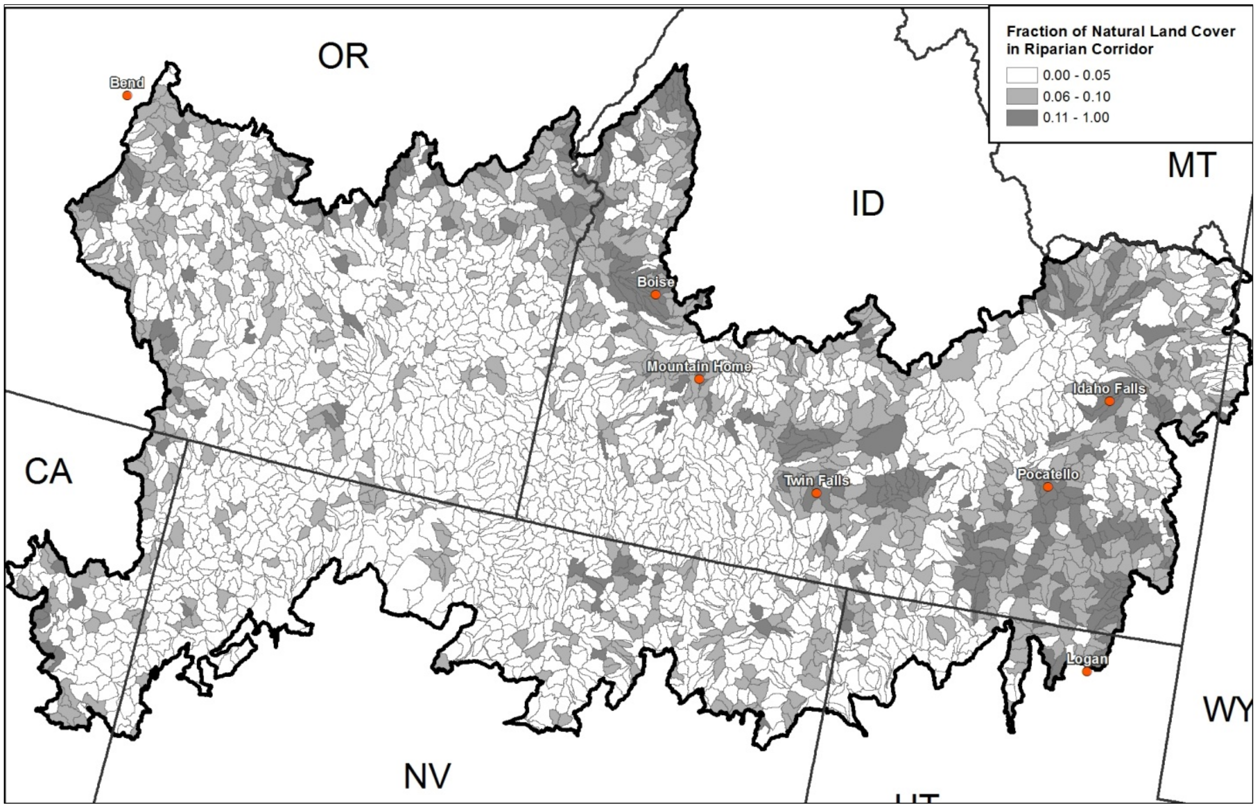

Figure 5-1. Fraction of Developed Lands in the Riparian Corridor

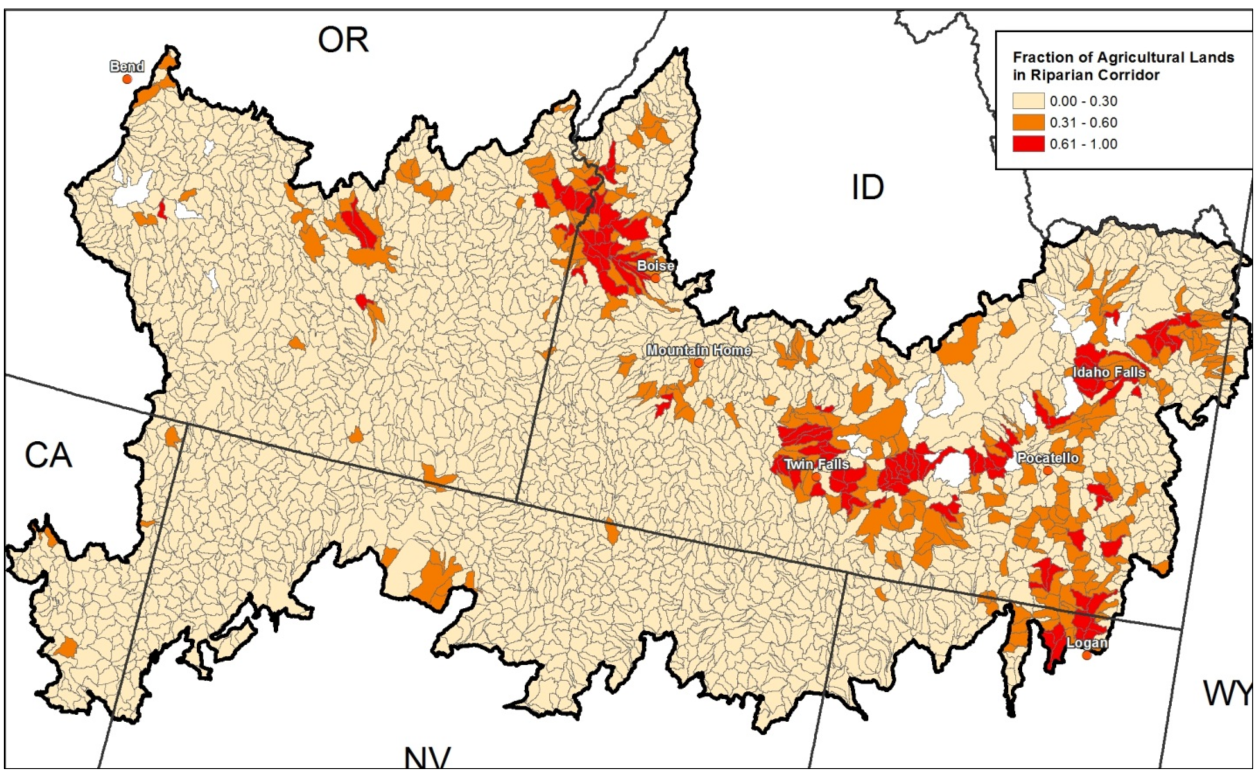

Figure 5-2. Fraction of Agricultural Lands in the Riparian Corridor

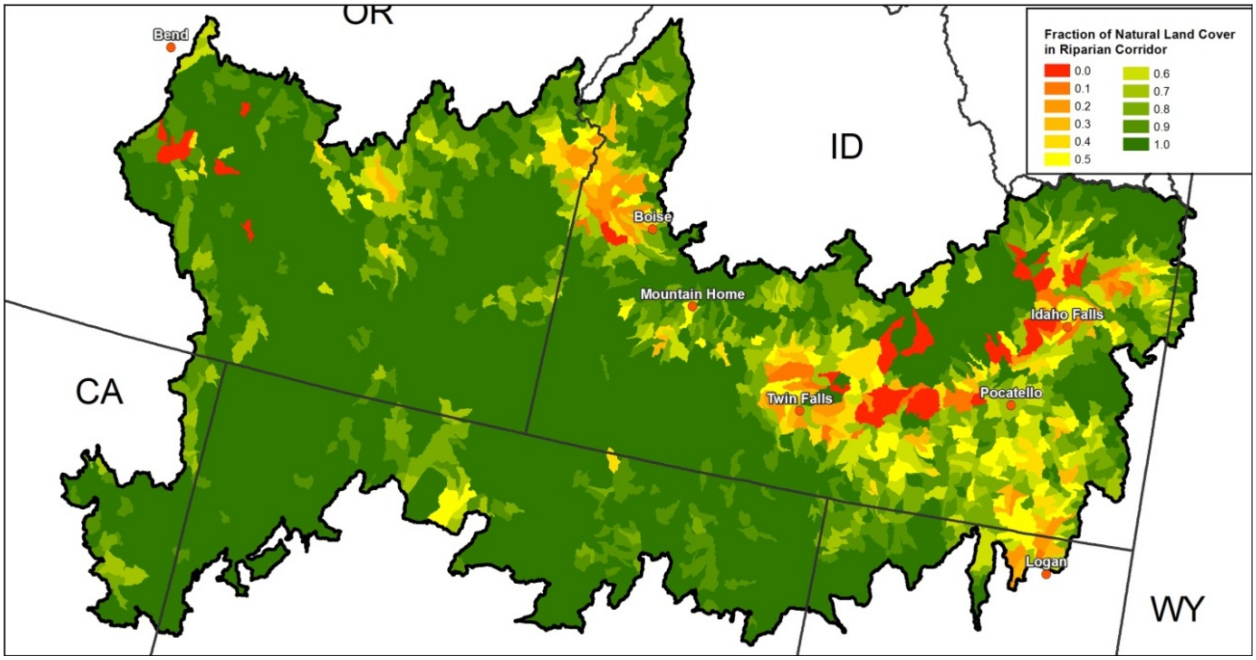

Figure 5-3 Fraction of Natural (Undeveloped) Land Cover in the Riparian Corridor

5.2 Future Threat Analysis

5.2.1 Development

Riparian corridors have been most severely impacted by agricultural and urban development in the Snake River Plain. Development that reduces the riparian vegetation cover can produce an environment that is hostile to stream life due to greater temperature fluctuations, increased sedimentation, less woody debris, higher stream velocities, and increased pollution. In addition, groundwater extractions can lower the water table and reduce the growth of phreatophytic plants.

5.2.2 Climate Change

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. Therefore, overall flows along riparian habitats are not expected to decline due to climate change in the ecoregion.

However, temperatures are expected to increase by one degree in July and August. Warmer temperatures provide more conducive environments for invasive plants such as tamarisk that utilize shallow groundwater so it is unavailable for native plants.

5.2.3 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 (IDFG 2012).

5.2.4 Invasives and Disease

Saltcedar or tamarisk (*Tamarix* spp.) and Russian-olive (*Eleagnus angustifolia*) are invasive woody plants that establish in riparian habitats, often outcompeting native plants (Shafroth *et al.* 1995). Both species are present in the Great Basin, and Kerns *et al.* (2009) predicted that the range of tamarisk will expand within the NGB ecoregion in response to climate change. Dense stands of these shrubby trees can replace native willows, increase soil salinity, and increase water loss from riparian system (Lovich 1996). The presence of tamarisk in particular is associated with dramatic changes in geomorphology (including narrowing of stream channels), reduced groundwater availability, and changes in soil chemistry, fire frequency, plant community composition, and native wildlife diversity.

5.2.5 Grazing

Grazing animals and pasture production can also negatively affect water quality through erosion and 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 coldwater fish depend on.

6 Management Questions

MQ 9. Where are coarse filter conservation element vegetative communities located?

The riparian vegetation based on LANDFIRE and GAP is shown in Figure 5-1. The estimated riparian corridor is shown in Figure 5-3.

MQ 10. Where are intact (i.e., minimally disturbed by human activities) coarse filter conservation element vegetative communities located?

The minimally disturbed areas are shown in Figure 5-3 as those watersheds with a high fraction of natural land cover in the riparian corridor in the watershed.

MQ 11. Where will existing and potential future change agents (aside from climate change) affect current communities?

The main change agent that affects riparian areas is development. The current development within the estimated corridor is shown in Figures 5-1 and Figure 5-2. Future projected development is shown in the Development Change Agent Package.

MQ 34. What is the condition (ecological integrity) of aquatic conservation elements?

The condition of riparian habitat is based on the fraction of natural land cover along the riparian corridor (Figure 5-3).

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Wetlands
Coarse Filter Conservation Elements Package

1 Conservation Element Description

Wetlands are areas inundated or saturated by surface or groundwater and generally include swamps, marshes and bogs. This conservation element supports unique, biologically diverse communities and provides multiple functions to ecosystems such as preventing flooding; holding water; regulating flows; providing habitat; and filtering sediment, nutrients and toxins from water. Wetlands are used by terrestrial and aquatic species year-round, seasonally, and during migration. Wetlands occupy a proportionately tiny area of the NGB but provide disproportionately high ecological values and services to a vast array of organisms. Due to a number of practices including draining wetlands for agriculture, urban and rural development, Idaho has less than half its original wetlands and most remaining have some degree of degradation (IDFG 2004). Mitigation of damaged wetlands has been largely unsuccessful as it is difficult to replicate these systems, especially forested and peat-dominated wetlands. Along with other water systems in the West, there is concern for the loss of area and/or quality and therefore wetlands require careful consideration and management by resource managers.

2 Conservation Element 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 Conservation Element Distribution Mapping

3.1 Data Identification

The major datasets identified to map the distribution of wetlands were the National Wetlands Inventory. Since not all of the ecoregion is digitally mapped with NWI, state wetland mapping was used to supplement these areas (Table 3-1).

Table 3-1. Data Sources for Wetlands Coarse Filter Conservation Element Distribution Mapping for the NGB Ecoregion

Data Required	Dataset Name	Source Agency	Type/Scale	Status	Use in REA
Aquatic Systems					
Wetland Location	National Wetlands Inventory	USFWS	Polygon	Acquired	Yes
	Wetlands (UT, ID) to fill gaps in NWI	State	Polygon	Acquired	Yes
Soils Data	STATSGO2	USDA	Raster	Acquired	No

3.2 Distribution Mapping Methods

The NWI wetland data was merged from each state and clipped to the ecoregion. Areas that aren't mapped digitally (Figure 3-1) were supplemented with wetland data from each state wetland dataset to fill in the gaps. Currently only the Utah portion of the ecoregion and southern Idaho was supplemented. The distribution of the wetlands based on NWI, Idaho, and Utah data is shown in Figure 3-2. There over 1.5 million acres of mapped wetlands in the ecoregion, excluding the lakes and freshwater ponds in the NWI database.

Wetland Type	Acreage in Ecoregion
Freshwater Emergent Wetland	1,181,618
Lake	1,044,721
Freshwater Forested/Shrub Wetland	288,896
Riverine	101,796
Freshwater Pond	35,006
Other	14,974
Total	2,667,011

3.3 Data Gaps, Uncertainty, and Limitations

- There are data gaps in the national wetlands inventory in Utah and Idaho. State data was used to fill those data gaps.
- National wetland inventory consists of reconnaissance level information on the location, type and size of these resources. The maps are prepared from the analysis of high altitude imagery. Wetlands are identified based on vegetation, visible hydrology and geography. A margin of error is inherent in the use of imagery; thus, detailed on-the-ground inspection of any particular site may result in revision of the wetland boundaries or classification established through image analysis.
- The accuracy of image interpretation depends on the quality of the imagery, the experience of the image analysts, the amount and quality of the collateral data and the amount of ground truth verification work conducted. Metadata should be consulted to determine the date of the source imagery used and any mapping problems.
- Wetlands or other mapped features may have changed since the date of the imagery and/or field work. There may be occasional differences in polygon boundaries or classifications between the information depicted on the map and the actual conditions on site.
- Federal, state, and local regulatory agencies with jurisdiction over wetlands may define and describe wetlands in a different manner than that used in this inventory. There is no attempt, in either the design or products of this inventory, to define the limits of proprietary jurisdiction of any Federal, state, or local government or to establish the geographical scope of the regulatory programs of government agencies. Persons intending to engage in activities involving modifications within or adjacent to wetland areas should seek the advice of appropriate federal, state, or local agencies concerning specified agency regulatory programs and proprietary jurisdictions that may affect such activities.

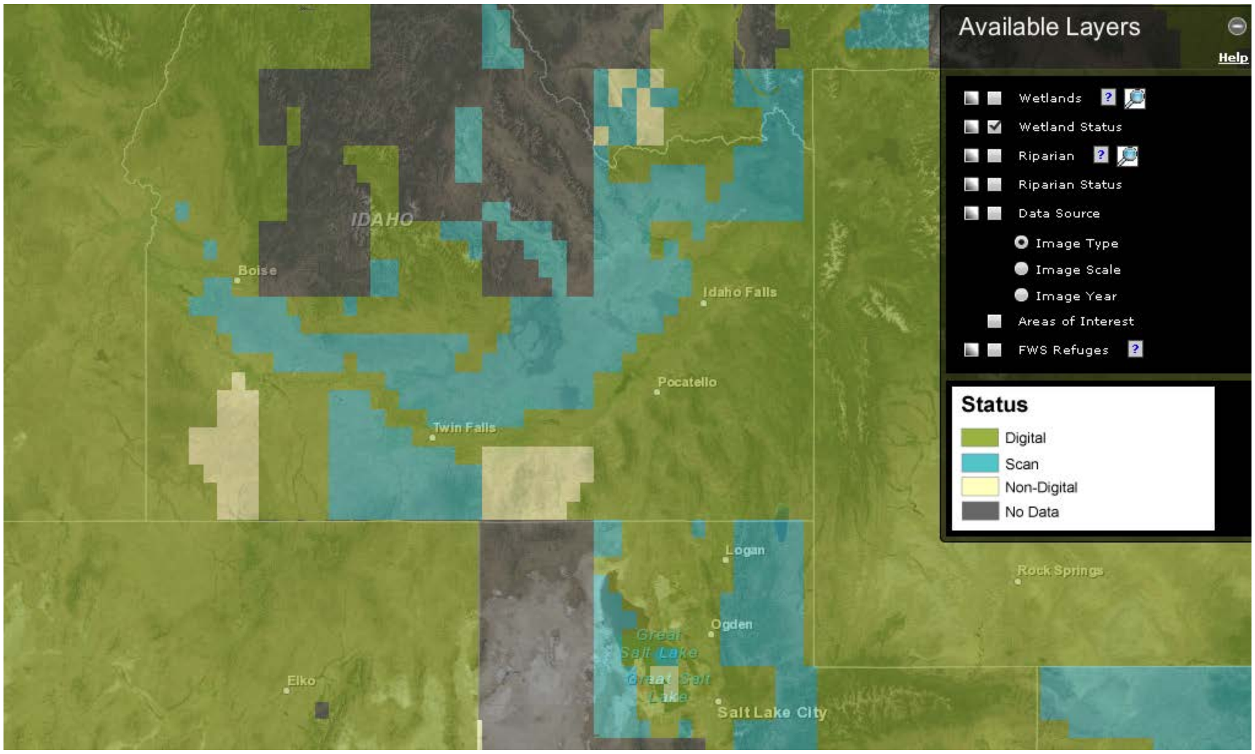

Figure 3-1. NWI Wetland Mapping Gaps

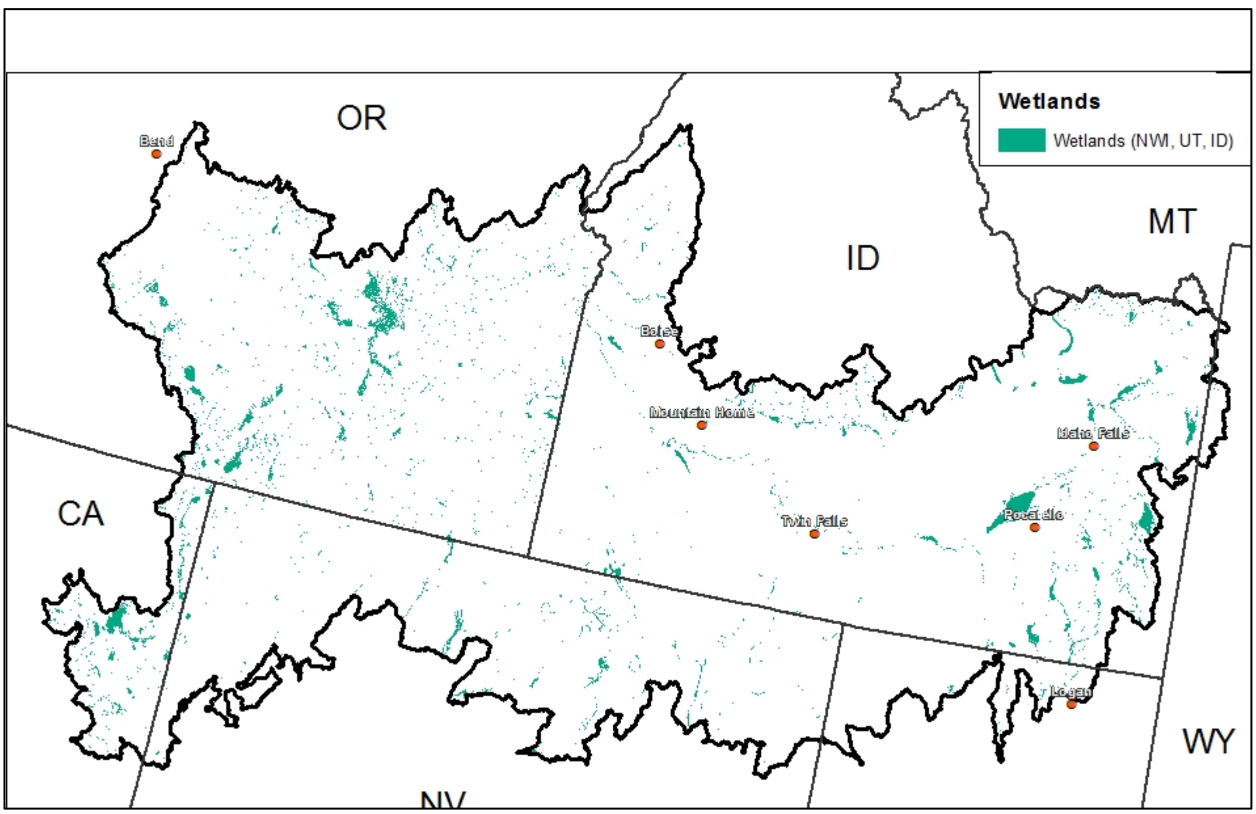

Figure 3-2. Wetland Distribution in the Ecoregion

4 Conceptual Model

A conceptual model of wetland ecosystems in the ecoregion is presented in Figure 4-1. Change agents that affects the hydrology are of greatest importance to this ecosystem. These include agricultural and other water uses, dams, diversions, and groundwater pumping. In some cases, water diversions have been used to enhance habitat for wildlife such as at the Malheur National Wildlife Refuge (NWR) in the high desert of southeastern Oregon, which includes 120,000 acres of wetlands on the Pacific Flyway (USFWS 2012). There a series of dams, canals, levees, and ditches are used to maintain water levels during spring brood-rearing. National Wildlife Refuge managers can also raise or lower water levels to improve marsh soils, stimulate plant growth, and control unwanted aquatic organisms such as carp.

Agricultural processes also may contribute runoff including fertilizers, pesticides, herbicides, and other chemicals to downstream wetlands. Other factors that my influence wetlands are erosion, soil loss, and the resulting sedimentation that can be caused by wildfire, development that includes the removal of vegetation, and livestock overgrazing in the watershed. Erosion and sedimentation will directly affect wetland physical and chemical processes that will influence habitat quality for organisms that use these systems. In addition, climate change will influence wetlands by shifting the timing, duration and amount of precipitation, which will also have an effect on wildfires, invasive species, and livestock grazing.

The effects of the change agents mentioned above are interlinked and affect each other in various feedback loops (Figure 4-1). Important effects that may change wetland ecological integrity are to: a) hydrology, including hydrological regime, flooding frequency, timing of flooding event and groundwater depth; b) habitat, the current vegetation cover and composition and biotic community (e.g., trees, emergent marshes and open water with submerged vegetation or suspended particles, which are required for filter-feeding organisms to survive, fish, wildlife and invertebrate community composition); c) landscape characteristics such as the distribution of wetlands on the landscape, and land use characteristics in the watershed; and d) other physical and chemical processes (e.g., water chemistry, salinity, toxicity and nutrients).

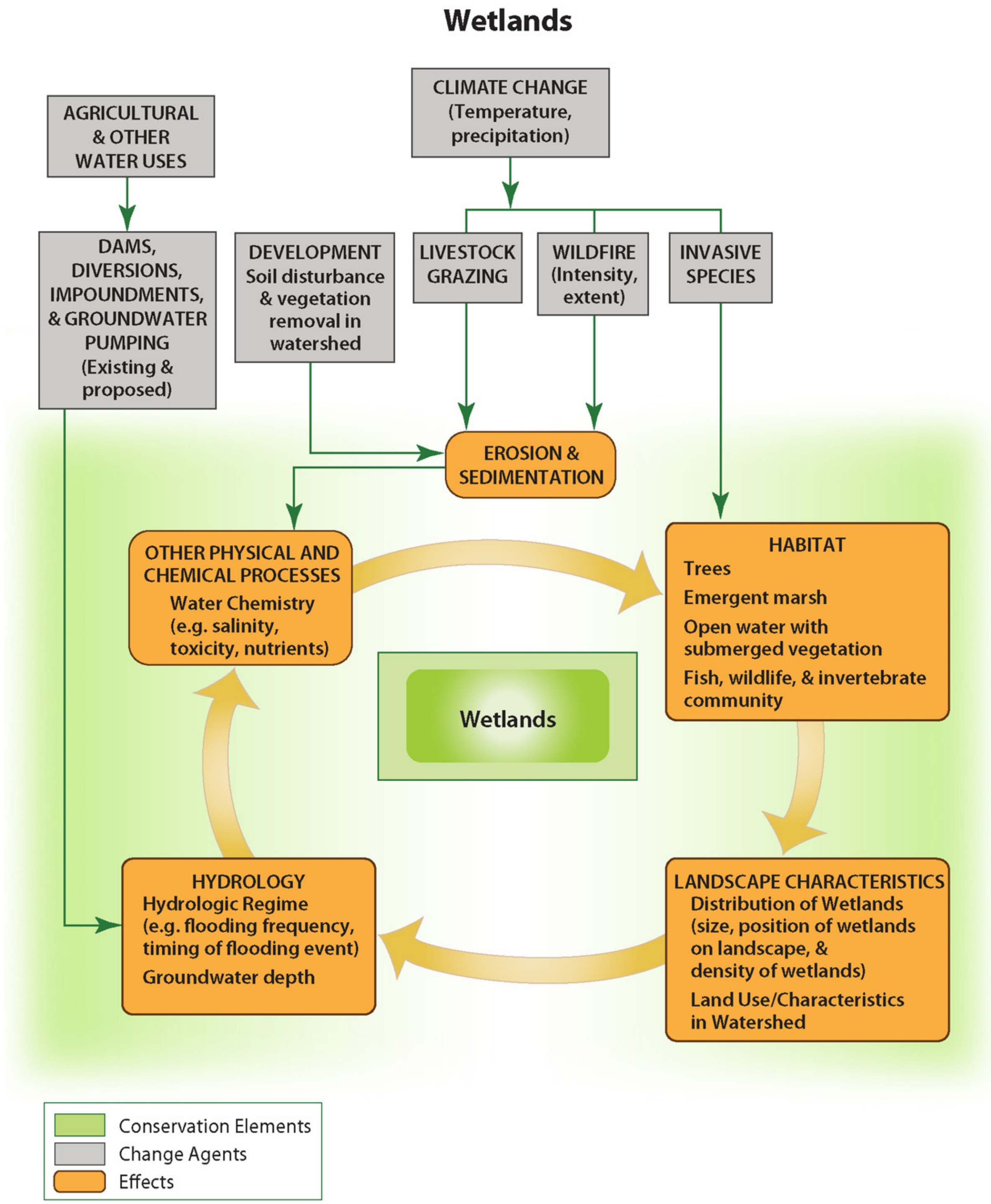

Figure 4-1. Wetlands Conceptual Model

5 Change Agent Analysis

5.1 Current Status of the Conservation Element

The metrics listed in Table 5-1 were evaluated using geospatial data. It is important to note that some attributes/indicators that could affect this conservation element are not included in this table because either the EA/indicator is not suitable for a landscape level analysis or data is not available to support the analysis.

Table 5-1 Key Metrics the Wetlands Coarse Filter Conservation Element for the NGB Ecoregion

Category	Ecological Attribute	Indicator / Unit of Measure	Metric*			Data Source
			Poor = 3	Fair = 2	Good = 1	
Condition	Habitat Quality	Invasive Aquatic Species	Yes	-	No	USFS database
		Water Quality Impairment	Yes	-	No	EPA 303(d)
Context	Extent and Continuity of suitable habitat (at watershed level)	Average Change in gw levels (ft/yr)	< -0.5	-0.5 to 0	>-0.5	USGS
		Water Withdrawal Threat	GWW> 1.0 GWR	GWW> 0.5 GWR	GWW< 0.5 GWR	USGS
	Quality Threats	Proportion of native habitat in HUC 12 watershed	< 0.5	0.5 – 0.8	> 0.8	REGAP

5.1.1 Water Quality

The 303(d) impaired water body dataset from the EPA was used as a surrogate to determine the water quality of the streams in the ecoregion. The main causes of 303(d) classification within open water assemblage waters was: arsenic, dissolved oxygen, e. coli, fecal coliform, mercury, phosphorus, sedimentation/siltation, selenium, temperature, total suspended solids/ total dissolved solids and zinc. Figure 5-1 shows the 303(d) impaired water bodies within the ecoregion.

5.1.2 Aquatic Invasives

The source for aquatic invasive species was the USFS aquatic invasive detections dataset. Figure 5-2 shows the detections with the analysis units (HUC 12). The majority of the detections were located along the Snake River, however there are occurrences aquatic invasives throughout the ecoregion.

5.1.3 Groundwater Condition

The groundwater conditions were evaluated at the HUC 12 level (see Groundwater conservation element package). For the watersheds with groundwater level data, the condition was based on the average annual change in groundwater levels. For watersheds without groundwater level data, the condition of the groundwater is based on the comparison of groundwater water use to groundwater recharge (Figure 5-3). Any long term groundwater withdrawal eventually results in a reduction of discharge in springs, streams, wetlands, or riparian areas.

5.1.4 Development in the Watershed

Urban and agricultural development are sources of water quality contamination for open water bodies. The development in the watershed was based on the urban and agricultural development layers from the LANDFIRE dataset. Figure 5-4 shows the remaining undeveloped or natural land cover.

5.1.5 Cumulative Indicator Score

Four metrics were used to cumulatively assess the health and function of wetlands at the ecoregion scale: water quality based on 303(d) impairment, detection of aquatic invasives, groundwater condition, and the fraction of undeveloped land in the watershed (Figure 5-5). 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 four metrics were then added together to derive a range of cumulative scores from four to twelve. Figure 5-5 shows the resulting high and low scoring areas.

5.2 Future Threat Analysis

5.2.1 Development

Historically, development has been the primary threat to wetlands through the draining and filling of wetlands for agriculture, urban and rural development. Groundwater dependent wetlands can also be impacted by groundwater withdrawals. Groundwater withdrawals have increased by fifty percent from 1995 to 2005.

5.2.2 Invasive Species

Wetlands are susceptible to invasion from both aquatic invertebrates and plant species. Many nonnative species have been introduced into North American waters, which have changed the structures of native communities and caused extinction through hybridization, predation, and competition (Sada and Vinyard 2002).

5.2.3 Climate Change

Long-term snow, climate, and streamflow trends at the Reynolds Creek in the Owyhee Mountains, have measured increasing temperatures at all elevations with decreasing proportions of snow to rain at all elevations. As a result, streamflow has seasonally shifted to larger winter and early spring flows and reduced late spring and summer flows (Nayak *et al.* 2010). 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. Therefore, water supply to wetlands may be greater in the winter and early spring and reduced in the summer.

5.2.4 Wildfire

Wildfire is expected to have a minimal impact on wetlands although type conversion in adjacent uplands and reduced cover can decrease water quality through increased sedimentation.

5.2.5 Grazing

Livestock can trample and disturb riparian vegetation surrounding springs and wetlands which can reduce habitat quality for native plants and animals and alter hydrologic function.

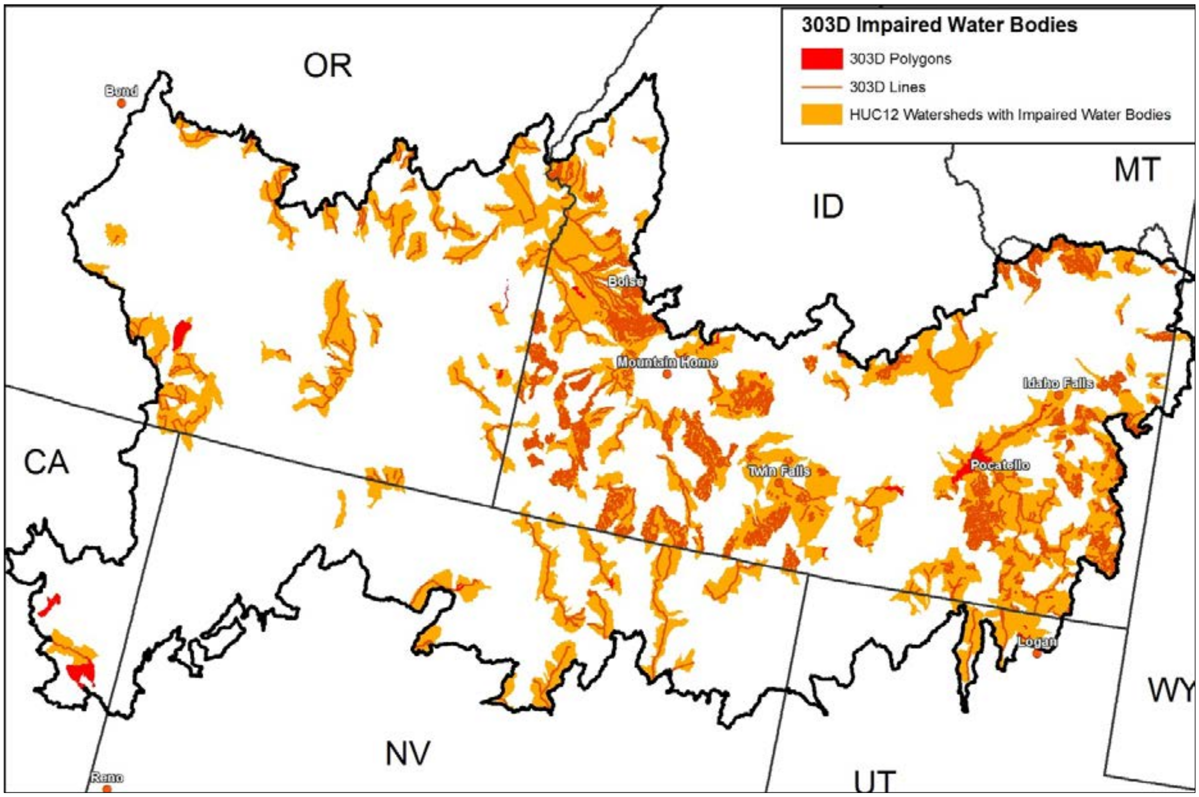

Figure 5-1. Impaired 303(d) Water Bodies

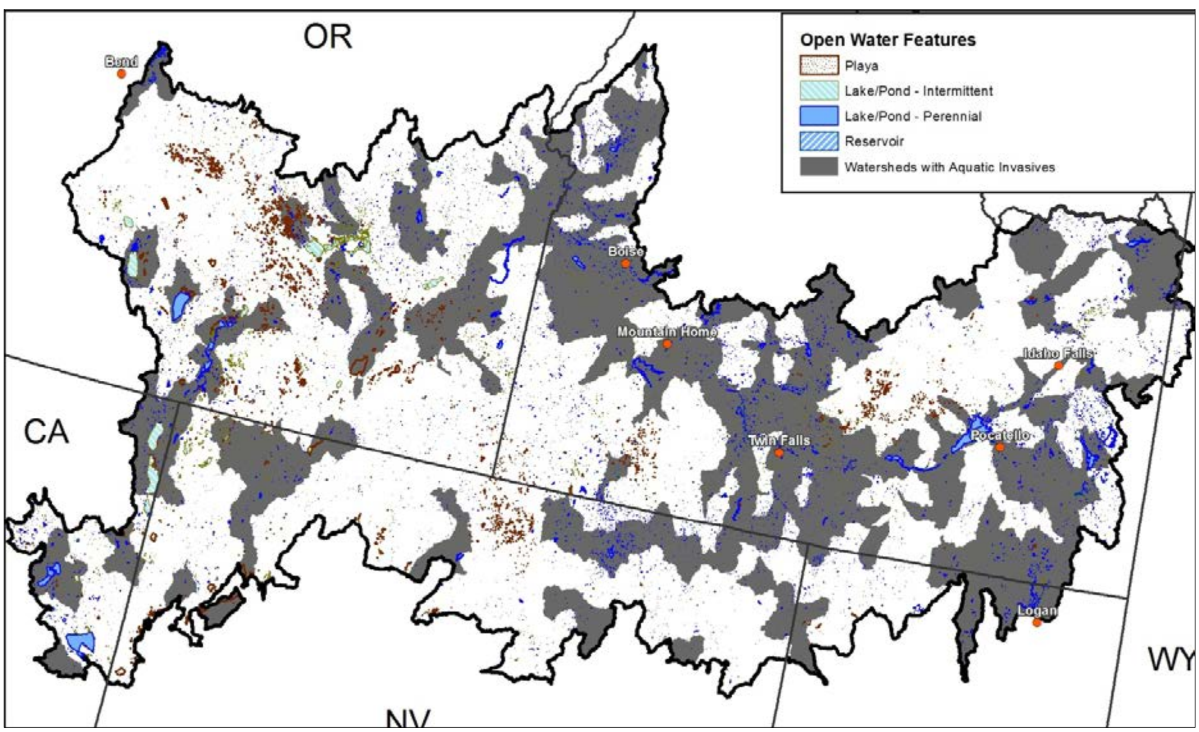

Figure 5-2. Watersheds with Aquatic Invasive Detections

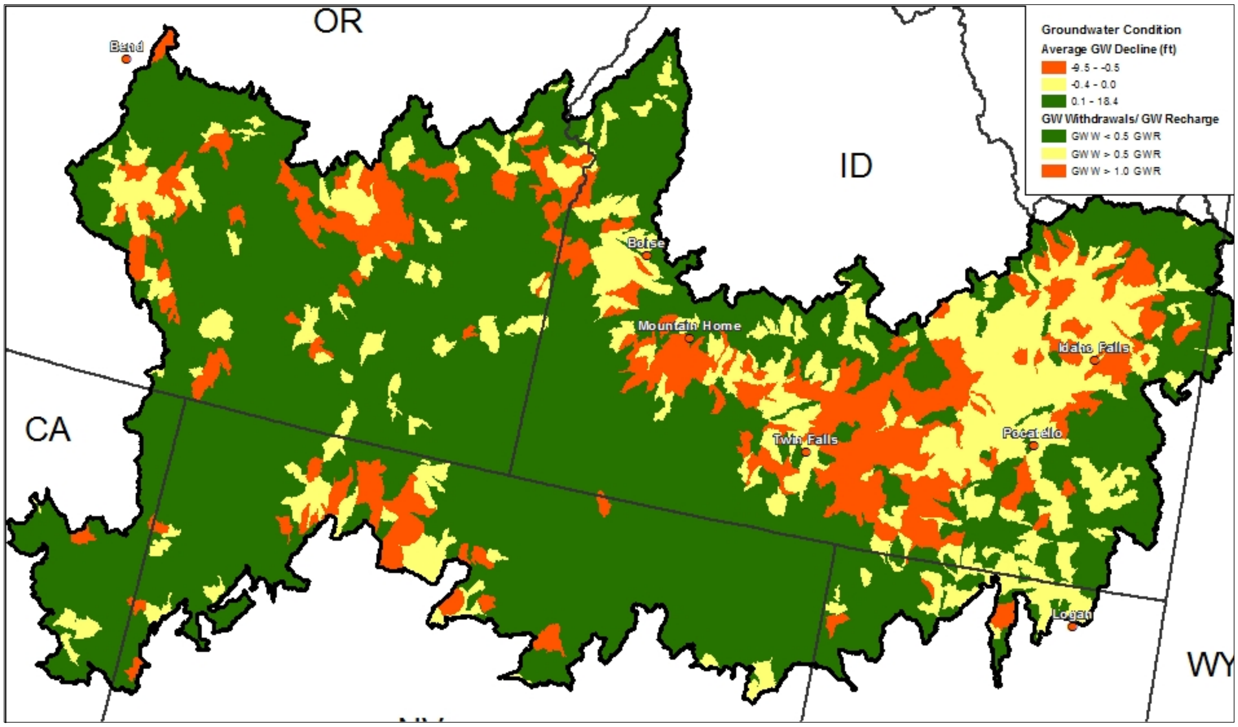

Figure 5-3. Groundwater Condition

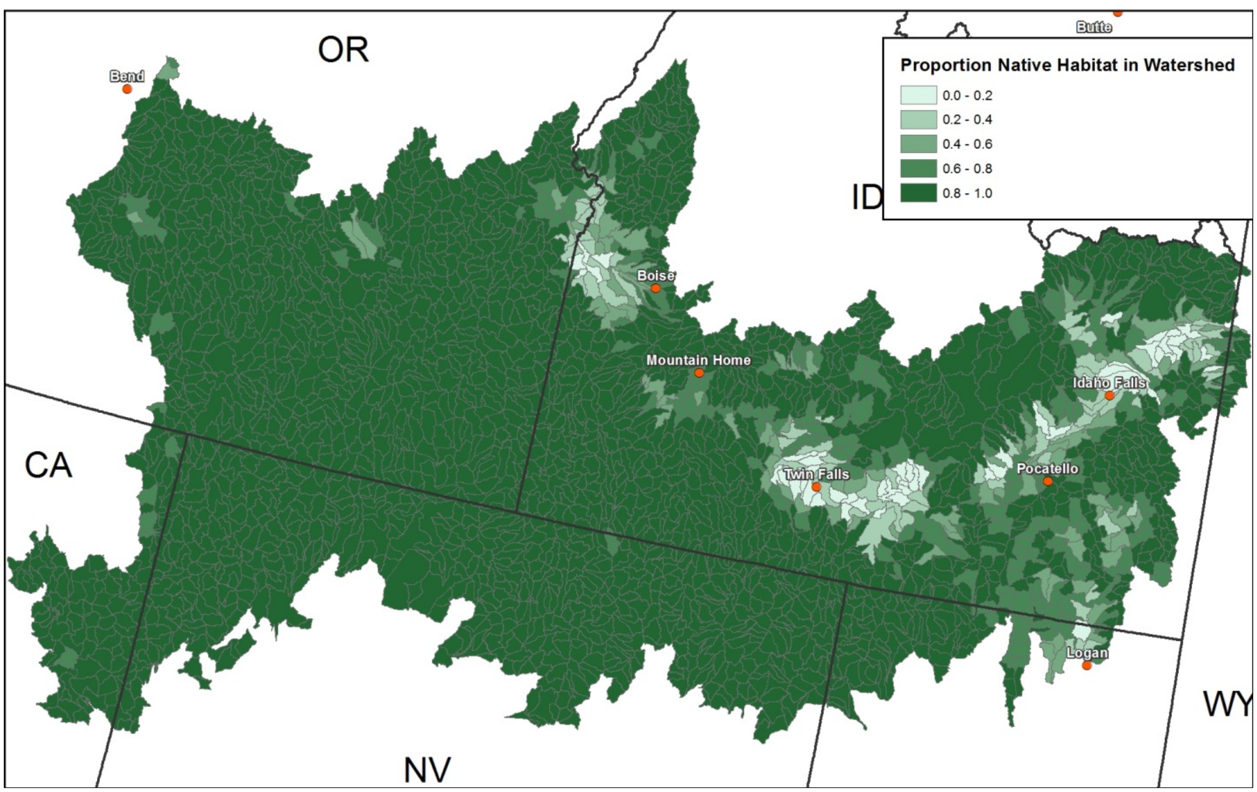

Figure 5-4. Proportion of Undeveloped Land in the Watershed

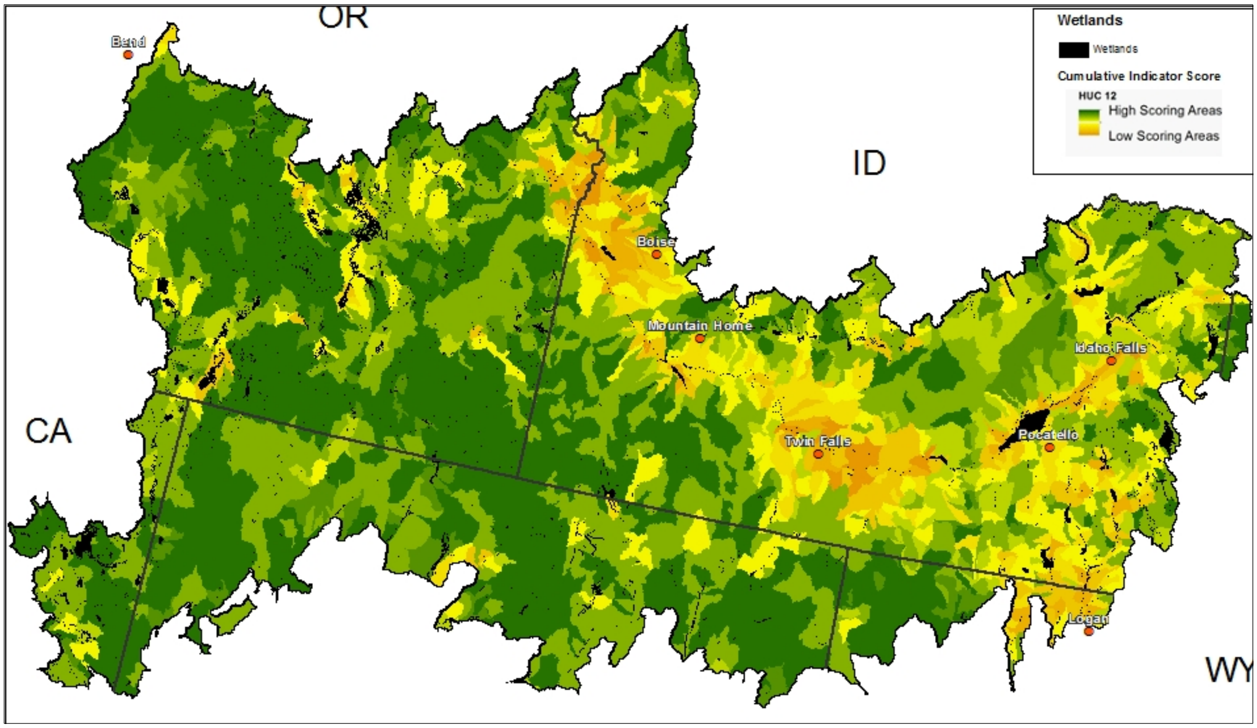

Figure 5-5. Wetland Cumulative Indicator Score

6 Management Questions

MQ 34. What is the condition (ecological integrity) of aquatic conservation elements?

Four metrics were used to cumulatively assess the health and function of wetlands at the ecoregion scale: water quality based on 303(d) impairment, detection of aquatic invasives, groundwater condition, and the fraction of undeveloped land in the watershed (Figure 5-5).

MQ 60. Where are the aquatic conservation elements showing degraded ecological integrity from existing groundwater extraction?

The groundwater condition is described in the Groundwater conservation element Package. Wetlands may experience decrease water supply in areas where groundwater levels are declining, which is shown spatial in Figure 5-3.

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

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. Therefore inflow into wetlands would be expected to slightly increase in the majority of the ecoregion.

7 References

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Salt Desert Shrub
Coarse Filter Conservation Element Package

1 Conservation Element Description

Salt Desert Shrub is a term that refers to shrub-dominated systems occupying extremely arid sites toward the bottom of basins where soils may be salt-affected and where heat and aridity are locally the greatest. Key references consulted for this summary of salt desert shrub include Blaisdell and Holmgren (1984), Brooks and Chambers (2011), Haubensak *et al.* (2009), and Dragt and Provencher (2005). With increasing elevation and decreasing soil salinity salt desert shrub systems give way to sagebrush dominated systems. The dominant shrubs in salt desert shrub may vary considerably from site to site and many sites are strongly dominated by a single shrub species. Generally, topographic gradients are very gentle in areas occupied by salt desert shrub. In basins, soils become progressively finer toward the bottom of the basin. Precipitation and productivity generally decrease with decreases in elevation.

The saltbush or goosefoot family (Chenopodiaceae) is extremely well represented by numerous species of saltbush (for example shadscale, *Atriplex confertifolia*), greasewood (*Sarcobatus* spp.), winterfat (*Krascheninnikovia lanata*), gray molly (*Kochia americana*) and hopsage (*Grayia spinosa*). Black sagebrush (*Artemisia nova*), budsage (*Picrothamnus* [*Artemisia*] *desertorum*), basin big sagebrush (*Artemisia tridentata* subsp. *tridentata*), and species of rabbitbrush (*Chrysothamnus viscidiflorus*) may be co-dominants or locally dominant. There are a variety of associated perennial grasses such as sand dropseed (*Sporobolus cryptandrus*), alkali sacaton (*Sporobolus airoides*), Indian ricegrass (*Achnatherum hymenoides*), galleta grass (*Pleuraphis jamesii*), and Great Basin wildrye (*Leymus cinereus*) on ranges in good condition. The primary use of Salt Desert Shrub has been for livestock grazing.

2 Conservation Element 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 Conservation Element Distribution Mapping

3.1 Data Identification

The major datasets identified to map the distribution of the salt desert shrub conservation element were the ReGAP land cover and LANDFIRE datasets. The datasets used for the salt desert shrub coarse filter are display in Table 3-1. The ReGAP and LANDFIRE datasets consist of vegetative communities with corresponding codes. Table 3-2 lists the codes and class names for each of the data sources used to extract salt desert shrub.

Table 3-1. Data Sources for the Salt Desert Shrub Coarse Filter Conservation Element Distribution Mapping for the Northern Great Basin Ecoregion

Data Required	Dataset Name	Source Agency	Type/Scale	Status	Use in REA
Terrestrial Systems					
Ecological Systems	Northwest ReGAP Southwest ReGAP	USGS	Raster (30m)	Acquired	Yes
	LANDFIRE EVT	USGS	Raster (30m)	Acquired	Yes

Table 3-2. Vegetation Class Code and Name

Code	Data Source	Vegetation Class Name	Area (Acres)	Percentage
2081	Landfire	Inter-Mountain Basins Mixed Salt Desert Scrub	23,705	0.7
2211	Landfire	Grayia spinosa Shrubland Alliance	28	0.0
2153	Landfire	Inter-Mountain Basins Greasewood Flat	69,696	2.0
5258	NWREGAP	Inter-Mountain Basins Mixed Salt Desert Scrub	330,223	9.6
3179	NWREGAP	Inter-Mountain Basins Playa	493,186	14.3
5203	NWREGAP	Inter-Mountain Basins Mat Saltbush Shrubland	7	0.0
9103	NWREGAP	Inter-Mountain Basins Greasewood Flat	603,848	17.5
S065	SWREGAP	Inter-Mountain Basins Mixed Salt Desert Scrub	1,073,088	31.1
S015	SWREGAP	Inter-Mountain Basins Playa	261,493	7.6
S096	SWREGAP	Inter-Mountain Basins Greasewood Flat	594,632	17.2
Total			3,449,908	100

3.2 Distribution Mapping Methods

To map the distribution of salt desert shrub in the NGB ecoregion, SAIC used a combination of ReGAP and Landfire data sources. Most of the states rely on ReGAP for their vegetation while California will use Landfire. This approach was used to maintain consistency with the Central Basin and Range REA. The selected vegetation communities in Table 3-2 were extracted using a GIS process model and merged together to show salt desert shrub locations within the ecoregion. An additional step was recommended by the AMT for this coarse filter, which was to run a moving window analysis on the results. The moving window (10 km) was run as a spatial operation to remove any area with less than 10% coverage within 10 km of a pixel of salt desert shrub. This was done to remove small isolated clusters of pixels that were causing an overrepresentation of salt desert shrub within the ecoregion when rolling up results to large analysis units such as a HUC 12 watershed or 4 km grid.

3.3 Data Gaps, Uncertainty, and Limitations

3.3.1 Data Gaps

Coverage of the datasets used in the analysis was generally complete across the ecoregion, which was a factor in their selection. Discontinuities between the LANDFIRE (California), Northwest ReGAP (OR, ID), and Southwest ReGAP (NV, UT) data sets across state lines do not appear to be a substantial limitation with regard to this conservation element.

3.3.2 Uncertainty

Vegetation mapping at the Ecoregion scale is expected to contain errors that would be addressable through the use of higher resolution imagery and larger mapping scales coupled with local knowledge and ground truthing suitable for step-down analyses over smaller areas.

4 Conceptual Model

As depicted in the model for the salt desert shrub conservation element (Figure 4-1), the relevant change agents identified include livestock grazing, wildfire, climate change, invasive species, land treatments, and insects and diseases. Invasive species most prevalent in this ecoregion include cheatgrass (*Bromus tectorum*), halogeton (*Halogeton glomeratus*), Russian-thistle (*Salsola tragus; S. spp.*), and various mustards (Brassicaceae). Red brome (*Bromus madritensis* var. *rubens*) and North Africa grass (*Ventenata dubia*) have the potential to become more widespread and abundant in the region. Neither red brome or North Africa grass is known to be currently a problem in salt desert shrub communities. Biological soil crusts (cryptogamic crusts) are important in soil stabilization and are likely adversely affected by heavy grazing (Figure 4-1). Regeneration of damaged soil crusts is very challenging because of low and erratic precipitation and salt-affected soils. In this region, wildfire ties directly to growth and persistence of invasive annuals. Because of the low productivity, fuel availability, and vegetation continuity in salt desert shrub communities, wildfire was believed to have been very infrequent under pre-settlement conditions (> 500 years), but has become prevalent in recent years. The increase in wildfire is associated with the spread and increasing dominance of invasive annuals, particularly cheatgrass, which have altered vegetation composition and soil characteristics. Wildfire frequency and extent are increased by cheatgrass while fire intensity is reduced as the shrub component is reduced and replaced by cheatgrass. Livestock can reduce cheatgrass in infested areas by grazing and trampling, which can have a slight to moderate effect on reducing wildfires. Land treatments, which historically involved soil disturbance and removal of native shrub land cover type, increased the potential for cheatgrass invasion and wildfire as depicted in the model. More recently, land treatments have involved attempts to restore the native shrub and perennial grass cover (especially after wildfire) and reduce cheatgrass cover. These restorative treatments are not specifically addressed in the model. A few shrubs (e.g., four-wing saltbush [*Atriplex canescens*], sickle saltbush [*A. falcata*], black greasewood [*Sarcobatus vermiculatus*]) are capable of post-fire resprouting, however, most of the native shrubs lack specialized adaptations for post-fire regeneration. In contrast, the invasive annual grasses increase in dominance after fire, capitalizing on nutrient release and greater availability of soil moisture due to lack of other vegetation. Additionally biological soil crusts regenerate slowly after fire, especially when dense stands of annual grasses emerge. Although seeding of native grasses and shrubs after fire has shown some promise in reducing post-fire dominance of cheatgrass (Jessop and Anderson 2007), the harshness of these sites makes post-disturbance establishment of native species far from certain and protection from annual grass invasion pre-fire would be a safer strategy for protecting these sites from fire and ensuring that the herbaceous component can recover if they do burn.

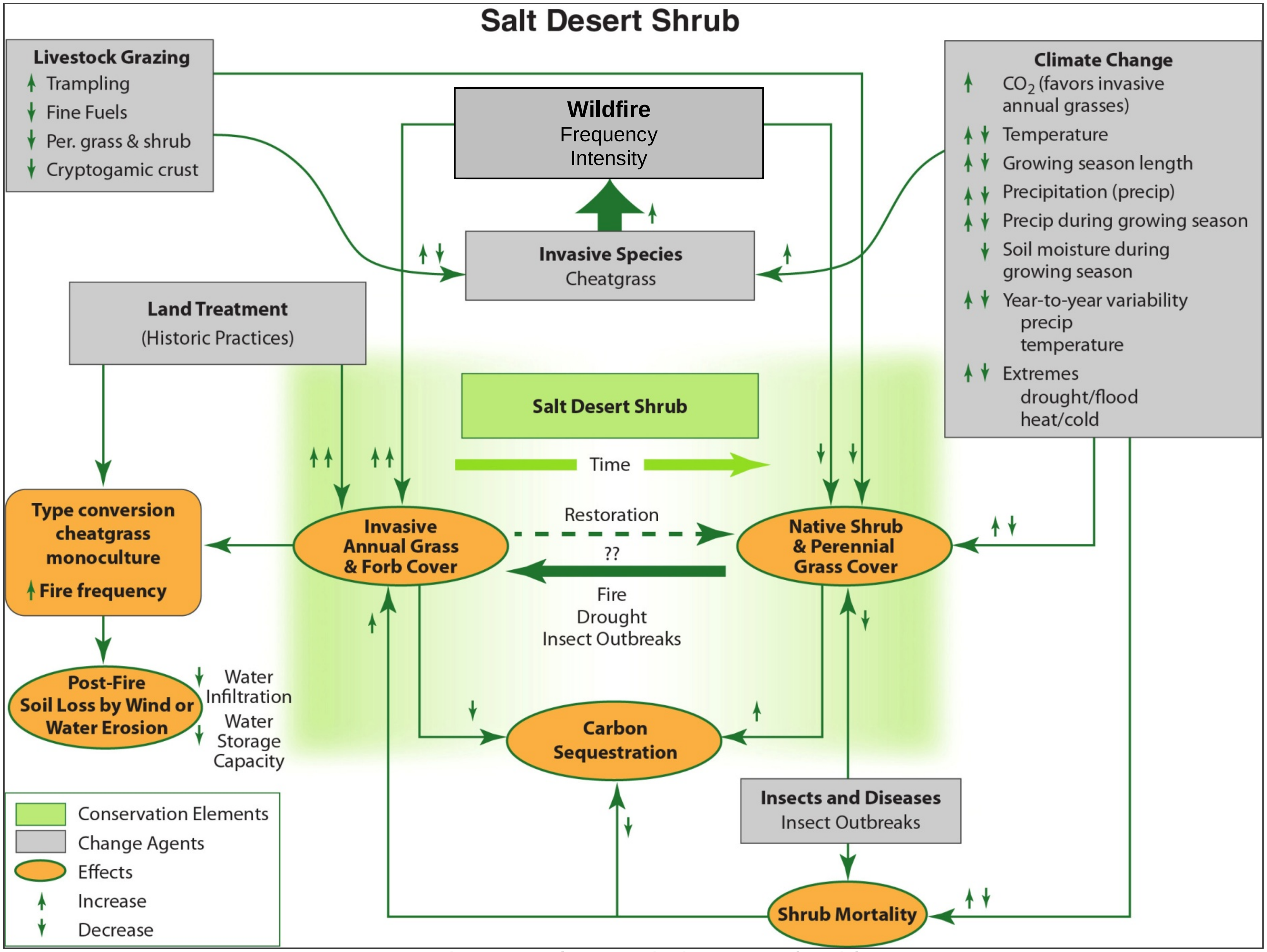

Figure 4-1. Salt Desert Shrub Conceptual Model

5 Management Questions

5.1 Where is Salt Desert Shrub?

Salt Desert shrub occurs in generally large patches mostly in the western and southern portions of the ecoregion (Figure 5-1). It tends to occupy extremely arid sites toward the bottom of basins where soils are generally fine-textured, salt-affected and where heat and aridity are locally the greatest. With increasing elevation salt desert shrub tends to give way to sagebrush dominated systems. Some of the densest locations of salt desert shrub (Figure 5-2) are near the Great Salt Lake in Utah, the Black Rock Desert Wilderness in Nevada and Honey Lake Valley on the border between California and Nevada.

5.2 Where does Salt Desert Shrub interact with Change Agents

5.2.1 Development

The distance to development was determined by merging many types of development into one spatial layer and then determining the Euclidean distance to from salt desert shrub to any type of development. The development spatial layer consisted of:

- Ski resorts,
- TIGER roads,
- Railroads,
- Mines,
- Agriculture,
- Developed areas,
- Ruby Pipeline (NV only),
- Land Treatments,
- Wind Turbines, and
- Transmission lines.

Figure 5-3 displays the results of determining the average distance by 4km grid from salt desert shrub to one of the listed types of development. The most prominent type of development interacting with salt desert shrub is roads. The TIGER (Topologically Integrated Geographic Encoding and Referencing) roads spatial layer (US Census) is very detailed and includes some off highway vehicles, 4WD forest service roads, BLM routes along with urban roads and major highways. Throughout most of the ecoregion salt desert shrub is less than 300 m and 300 – 1,000 m from development. Few salt desert shrub areas have development >1 km away.

5.2.2 Invasive Species and Disease

Figure 5-4 shows the results of overlaying cheatgrass mapping from 2010 from the USGS / EROS study that overlaps salt desert shrub identified within Figure 5-1. The areas with the highest encroachment of cheatgrass would be within the Snake River Plain. The lowest lying areas near Black Rock Desert Wilderness, Great Salt Lake and playas have little to no cheatgrass.

Disease and insect infestations have been identified as major contributors to shrub die-off in salt desert shrub, including shadscale communities. Die-off's following extended excessively wet periods have been attributed to phytophora fungus attacks as well as to changes in soil chemistry associated with prolonged saturation as summarized in McArthur *et al.* (1990). Periodic outbreaks of grasshoppers and Mormon crickets have been known to cause widespread defoliation but many additional insect types including mealy bugs (homoptera) and beetles and their larvae (coleoptera) have the potential to cause die-off's through damage to above-ground or below-ground portions of plants as summarized in McArthur *et al.* (1990).

5.2.3 Wildfire

FSIM burn probability data was modeled by the USGS and USFS and was used to determine wildfire risk to salt desert shrub within the ecoregion. Figure 5-5 shows the burn probability (low, moderate and high) for salt desert shrub range by the most common value within the 4km grid. It also includes the GeoMAC fire perimeters for the past two years to show where recent fire activity has occurred. The highest burn probability salt desert shrub areas are within the southwestern Idaho (Snake River Plain near the Owyhee Mountains) and the north central Nevada portions of the ecoregion. Much of the salt desert shrub in the ecoregion is classified as low or 'unburnable' due to being a playa or having low amounts of fuel. Recent fire activity focuses mainly on the south side of the Snake River Plain in Idaho such as the Big Hill fire in 2011 (67,000 ac). The Rush fire (328,000 ac), one of the largest fires in 2012, burned close to Honey Lake Valley and its large concentration of salt desert shrub.

5.2.4 Grazing

The relationship between livestock grazing and salt desert shrub ecosystems is complex and livestock grazing is relatively widespread within this ecosystem. The effects of past practices may persist today, complicating the evaluation of current management practices. The principal effect of grazing is removal of preferred herbaceous species, modifying the competition dynamics and possibly creating a niche for cheatgrass establishment. Fall and winter grazing could result in modifications to the shrub component of the system at the site level. Late winter grazing can be especially deleterious to winterfat and other desirable shrubs (Blaisdell and Holmgren 1984). As discussed above under the conceptual model, livestock grazing, wildfire, and expansion of invasive species including cheatgrass, halogeton, and Russian-thistle are interrelated and affect salt desert shrub. Additional references on salt desert shrubland stability can be found at http://www.fs.fed.us/rm/grassland-shrubland-desert/research/projects/shrubland-stability/

5.3 How will Salt Desert Shrub be impacted by modeled Climate Change

Salt desert shrub communities occupy the harshest sites in the ecoregion. High temperatures, aridity, and accumulated mineral salts characterize the sites where salt desert shrub dominates. Elevated levels of saline groundwater may be present in areas occupied by greasewood and other halophytes, which has tolerance to the elevated salt and mineral content. Closed drainage basins contain playas, which may be periodically flooded limiting plant growth except around infrequently flooded margins. Away from the influence of salt affected groundwater or surface water, salt desert shrub species are faced with aridity, fine, salt-affected soils, limiting water availability, and temperature extremes.

The uncertainties involved in predicting climate change coupled with the complexity and heterogeneity of conditions and species in salt desert shrub make predictions a complex and very uncertain undertaking. It is likely that there will be greater year to year fluctuations and more frequent incidence of periods of drought or elevated temperatures than experienced in the past half century. Predictions are for June through August mean daily temperatures to increase by approximately 1 degree Celsius by 2050-2069 compared to

1980-1999 baseline (REGCM3) in much of the area occupied by salt desert shrub. The same model predicts winter precipitation to increase moderately (51-150 mm) and March to May precipitation to increase slightly (21-50 mm) with negligible increases or slight decreases in other months. The rapidity of climate change coupled with the prevalence of cheatgrass and other invasives, and the apparent recent trend toward larger and more frequent wildfires are interrelated factors that need to be taken into account. Post-fire recovery of salt desert shrub, if it does burn, would be expected to be slow and may be largely preempted by rapid reestablishment of invasive species. Undoubtedly there will be local range expansions and contractions of individual species responding to changes in climatic variables according to their individual tolerances but it is likely that there will be unanticipated effects resulting from complex and unforeseeable interactions.

5.4 Where is intact Salt Desert Shrub (minimally impacted by Human Activities)

To derive where intact salt desert shrub stands (minimally impacted by human activities) are located, the following two layers were classified and combined: Distance to Development and Burn Probability. Using the values as classified in Figures 5-3 and 5-5, the results were reclassified 1, 2 or 3 (e.g., 1 would be the highest burn probability or closest to development while 3 would be the lowest burn probability (or unburnable) or furthest from development. Using the raster calculator, the values were combined to derive a score from 2 to 6 and then averaged within an analysis unit (4 km grid). A stretched raster was used to show the range of values from the lowest 2 (orange) to the highest 6 (green).

Figure 5-6 shows the extensive areas of relatively undisturbed salt desert shrub and large blocks of salt desert shrub in the southern and western parts of the ecoregion with anthropogenic affected areas being present but somewhat limited. The area between the Owyhee Mountains and Snake River Plain seems to be one of the least intact areas for salt desert shrub in the ecoregion due to the high burn probability.

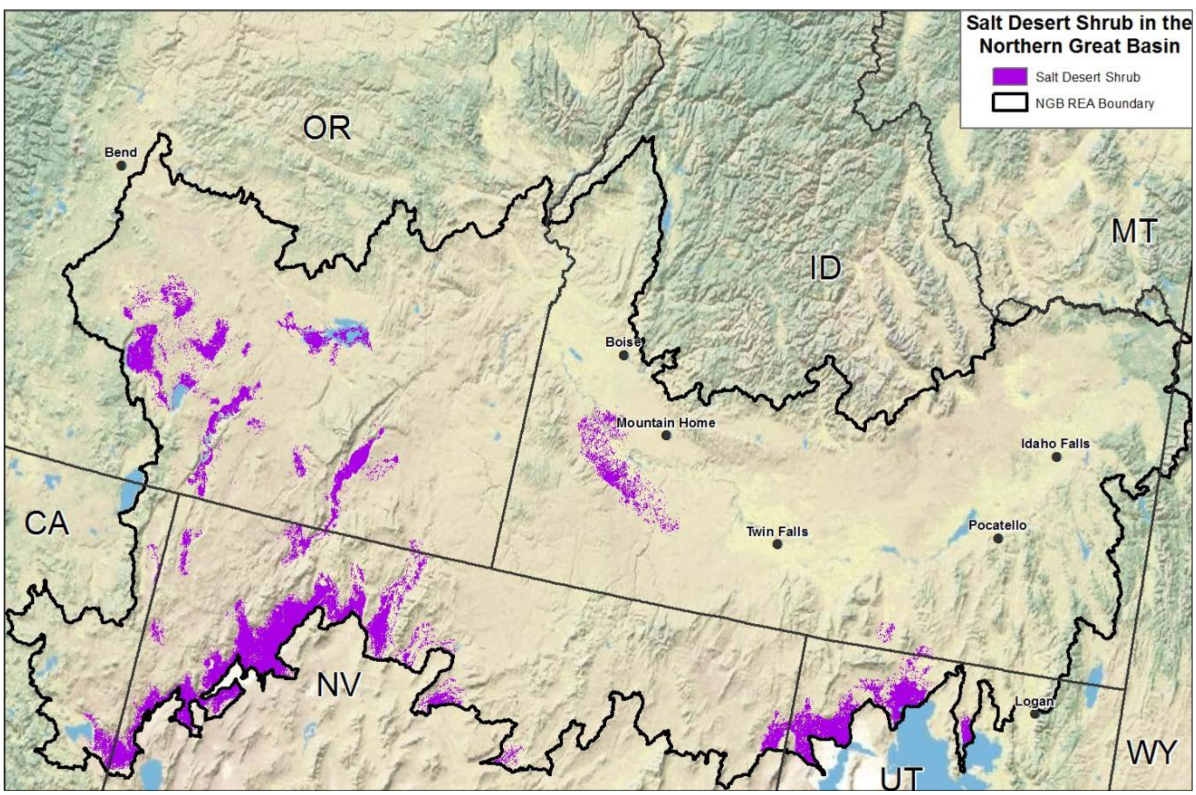

Figure 5-1. Salt Desert Shrub Locations in the NGB

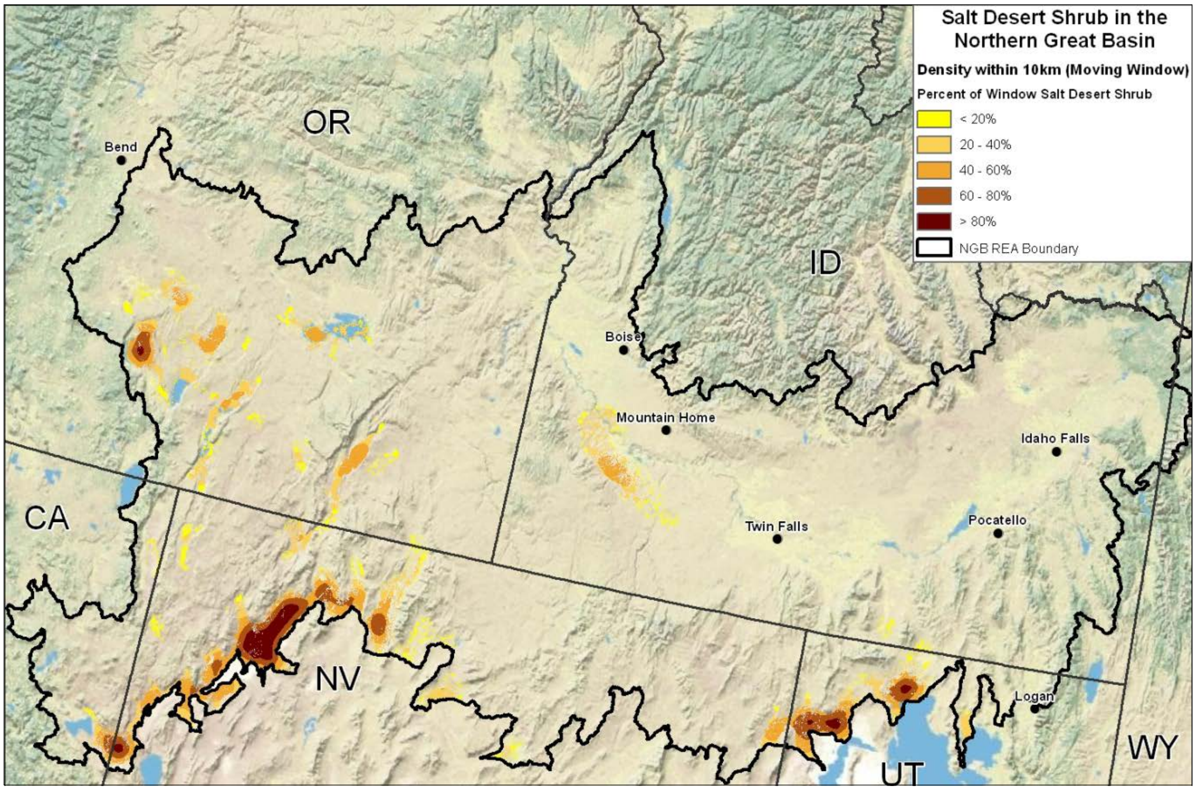

Figure 5-2. Density of Salt Desert Shrub within a 10km Moving Window Analysis

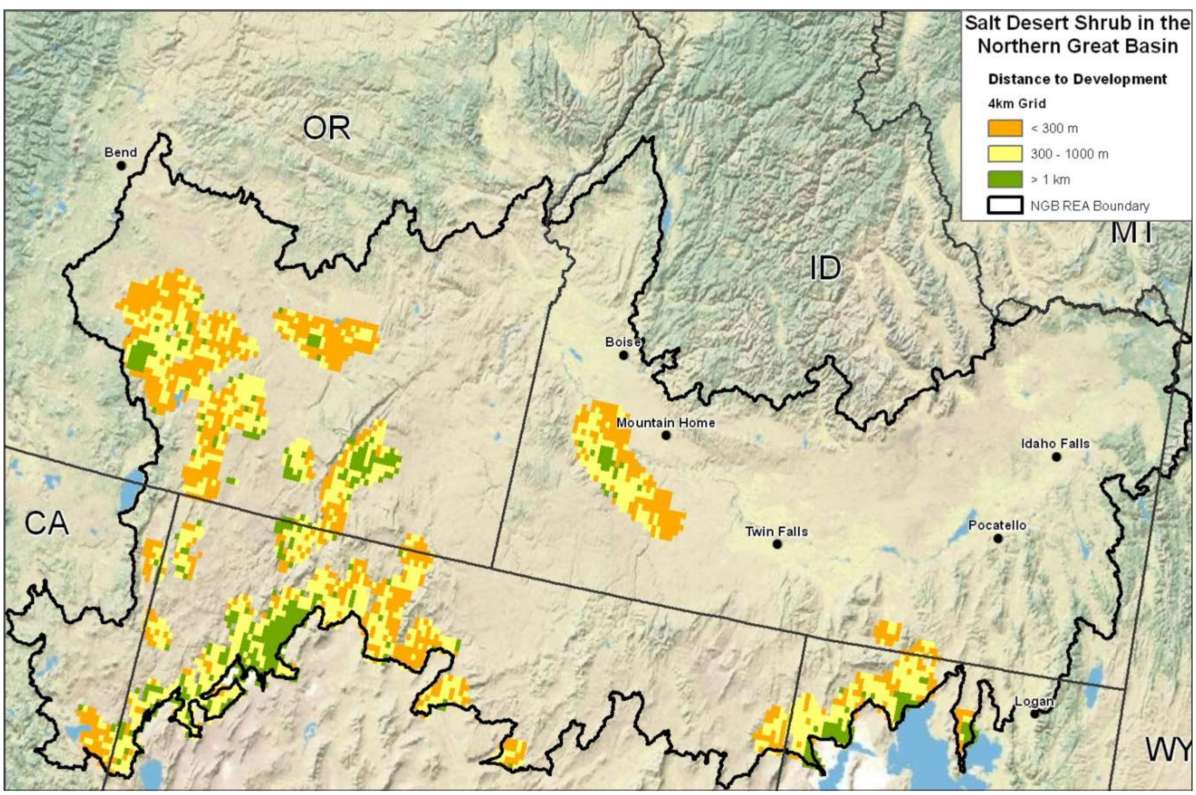

Figure 5-3. Distance to Development for Salt Desert Shrub

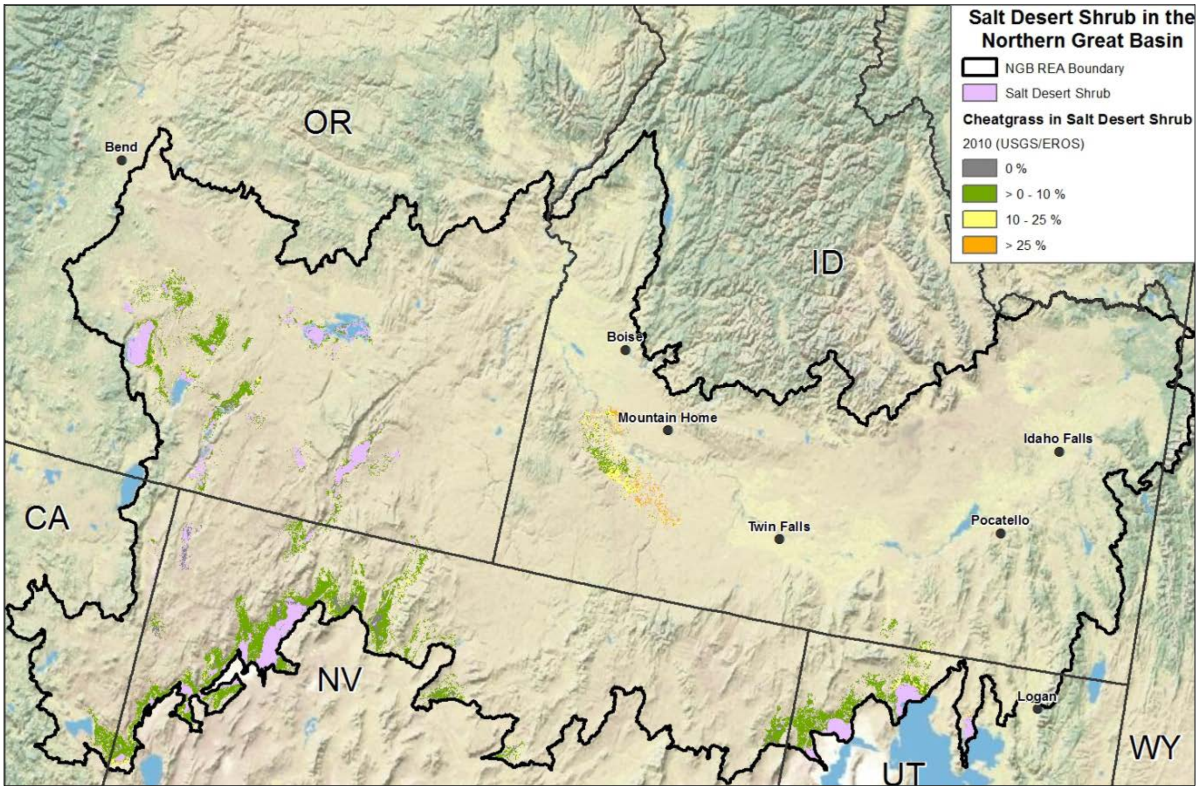

Figure 5-4. Cheatgrass Encroachment from USGS/EROS 2010 data within Salt Desert Shrub vegetation.

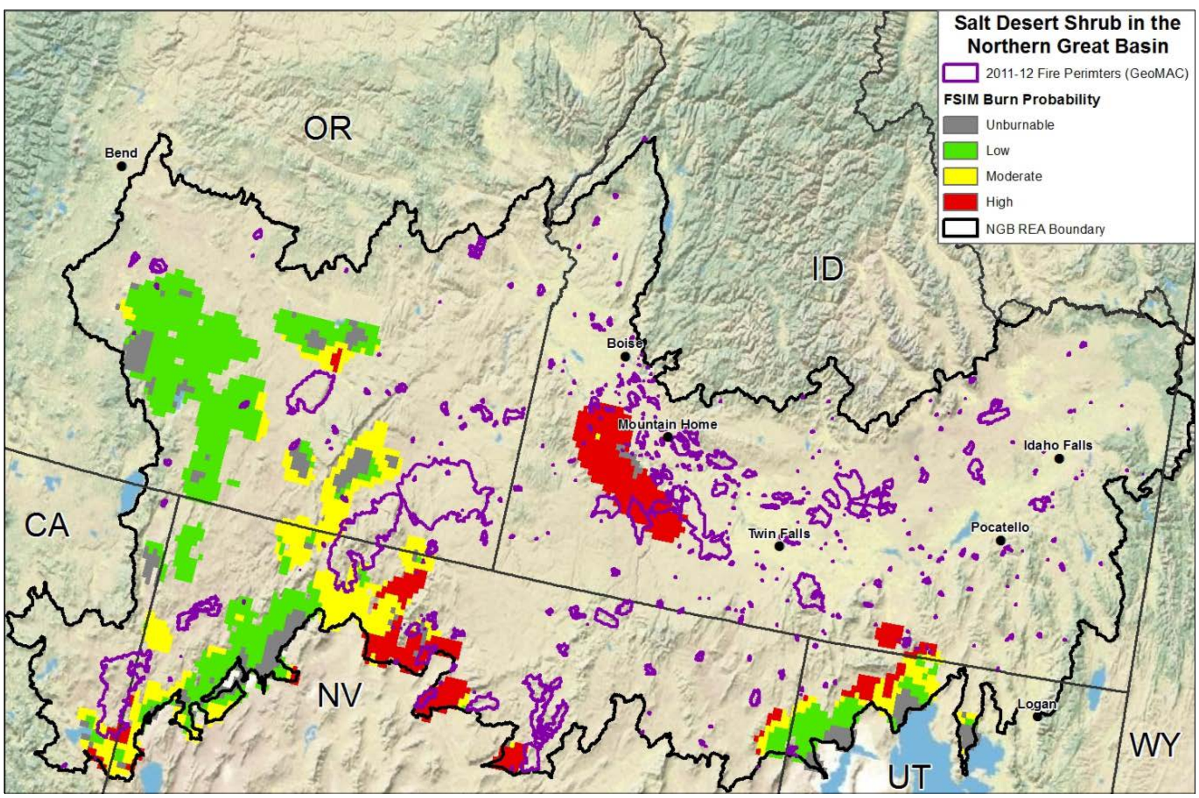

Figure 5-5. FSIM Burn Probability and Recent Fire Perimeters near Salt Desert Shrub

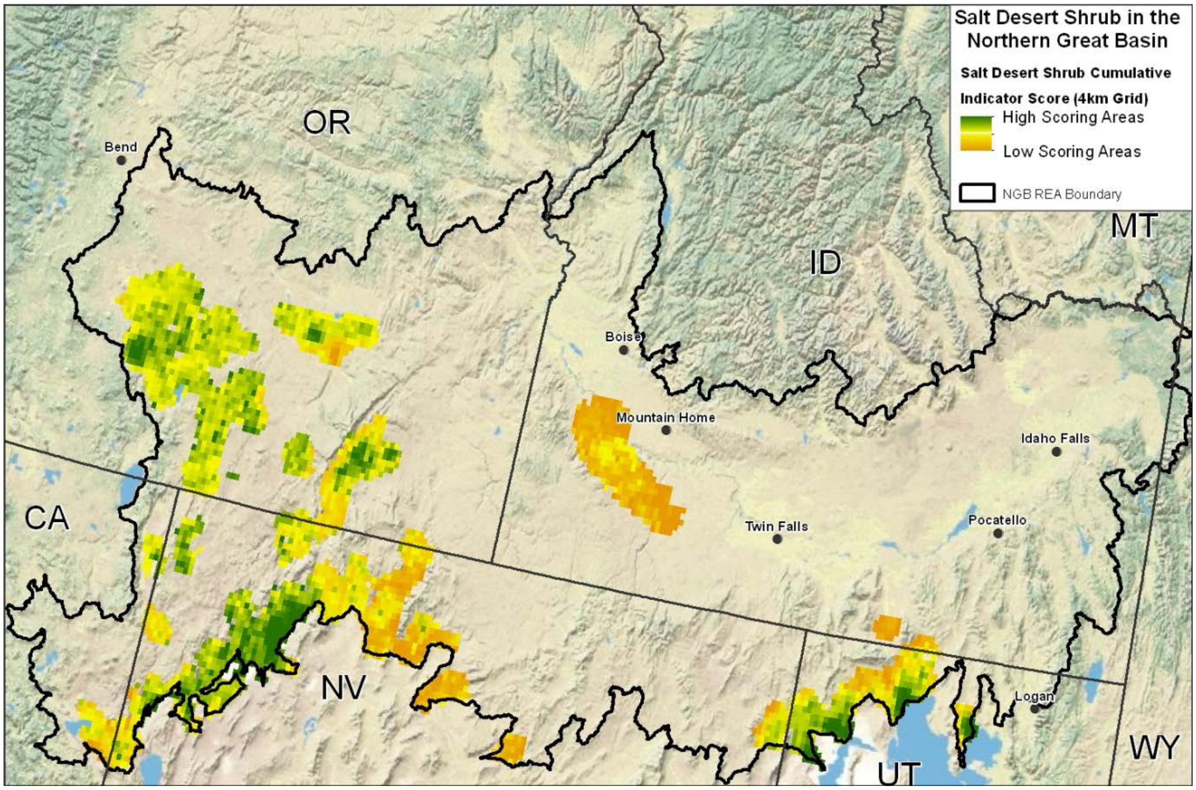

Figure 5-6. Cumulative Indicator Score for Salt Desert Shrub

6 Summary of Salt Desert Shrub in the NGB

Salt desert shrub inhabits some of the most challenging environments for plant growth in the ecoregion and has principally been used for livestock grazing in the past. Salt desert shrub, including associated biological soil crusts, is slow to recover following disturbance given the harshness and aridity of the environment and the great year-to-year variation in precipitation. It seems unlikely that other native vegetation cover is likely to replace the perennial land cover type of salt desert shrub and associated biological soil crusts in the event of fire or other disturbance. A more likely scenario would be expansion of annual invasives such as cheatgrass which can vary in cover from year to year according to variations in rainfall leaving soils more vulnerable to wind erosion during dry years.

The dominant shrubs in salt desert shrub may vary considerably from site to site and many sites are strongly dominated by a single shrub species. In general, salt desert shrub occurs in large patches mostly in the western and southern portions of the ecoregion. Some of the densest locations of salt desert shrub are near the Great Salt Lake in Utah, the Black Rock Desert Wilderness in Nevada and Honey Lake Valley on the border between California and Nevada.

The most prominent type of development interacting with salt desert shrub is roads. Throughout most of the ecoregion salt desert shrub is less than 300 m and 300 – 1,000 m from development. Few salt desert shrub areas have development >1 km away.

Invasive species including cheatgrass, halogeton, and Russian-thistle have very different reactions to disturbance and fire in salt desert shrub. Halogeton generally is limited to very disturbed areas and doesn’t generally result in high fuel loads, whereas cheatgrass can invade relatively intact areas and promotes the fire cycle. Russian thistle seems to be somewhere between these two. Disease has not been identified as a factor limiting salt desert shrub.

Salt shrub species can vary in their tolerance for wildfire. The highest burn probability salt desert shrub areas are within the southwestern Idaho (Snake River Plain near the Owyhee Mountains) and the north central Nevada portions of the ecoregion. Much of the salt desert shrub in the ecoregion is classified as low (40%) or ‘unburnable’ (28%) due to being a playa or having low amounts of fuel. Low burn probability areas are extensive in the western portion of the ecoregion in Oregon and northwestern Nevada, and also in northwestern Utah (Figure 5-4).

The relationship between livestock grazing and salt desert shrub ecosystems is complex and livestock grazing is relatively widespread within this ecosystem. The effects of past practices may persist today, complicating the evaluation of current management practices. The principal effect of grazing is removal of preferred herbaceous species, modifying the competition dynamics and possibly creating a niche for cheatgrass establishment. Fall and winter grazing could result in modifications to the shrub component of the system at the site level.

The uncertainties involved in predicting climate change coupled with the complexity and heterogeneity of conditions and species in salt desert shrub make predictions a complex and very uncertain undertaking. Undoubtedly there will be local range expansions and contractions of individual species responding to changes in climatic variables according to their individual tolerances but it is likely that there will be unanticipated effects resulting from complex and unforeseeable interactions.

Intact salt desert shrub stands in the southern and western parts of the ecoregion are extensive areas of undisturbed salt desert shrub. The area between the Owyhee Mountains and Snake River Plain seems to be one of the least intact areas for salt desert shrub in the ecoregion due to the high burn probability.

6 References

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Sagebrush
Coarse Filter Conservation Element Package

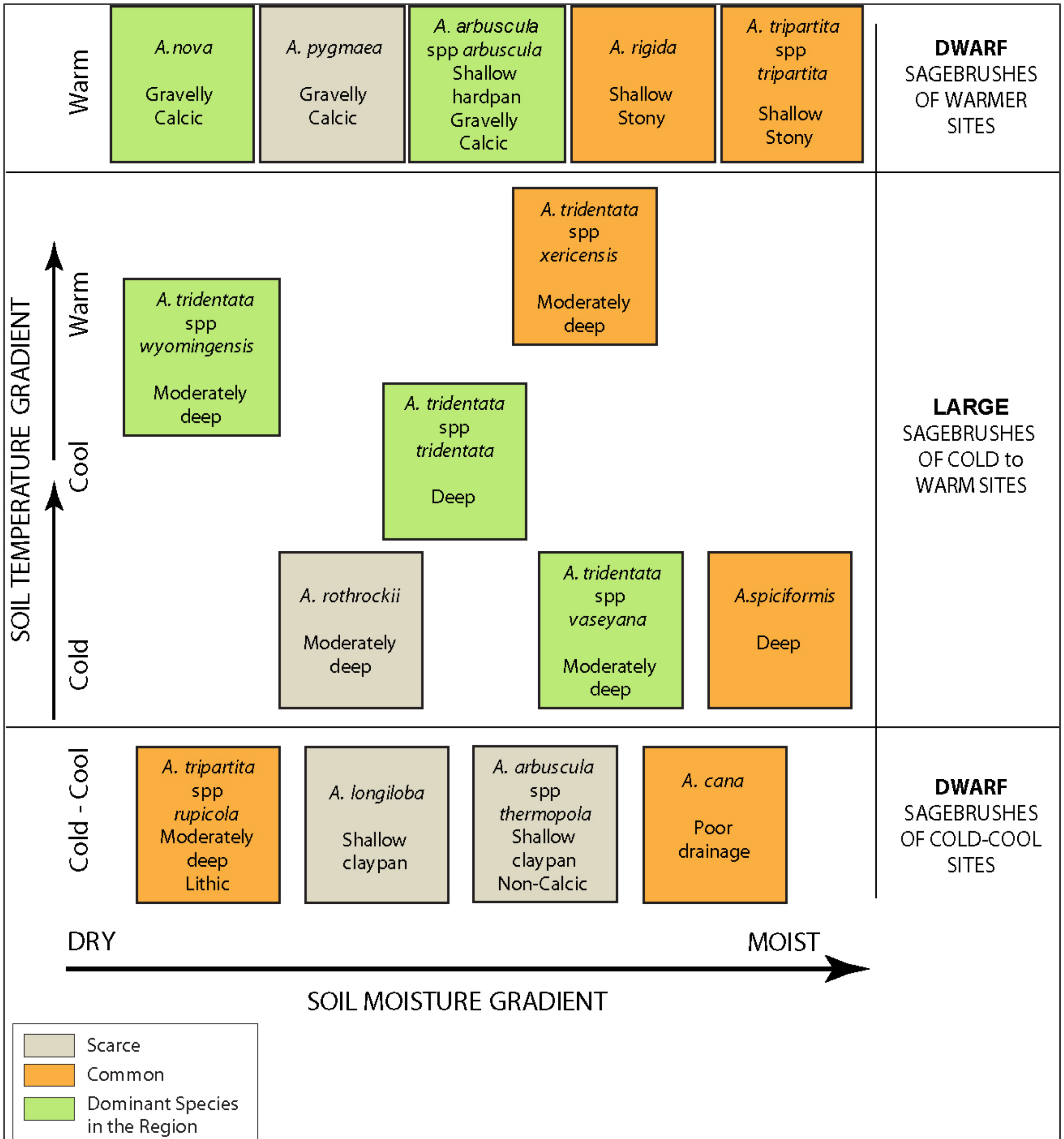
1 Conservation Element Description

Sagebrush-steppe ecosystems are dominated by species of sagebrush (*Artemisia* spp.) and perennial grasses. They are the focus of broad-based ecosystem conservation efforts (e.g., Davies *et al*. 2011; Knick and Connelly 2011; Great Basin Restoration Initiative 2012; Great Basin Consortium 2012). There are numerous species of sagebrush in the ecoregion that dominate different sites, generally assorting along soil temperature and moisture gradients. These species, their common names and an overview of their distribution in the states within the ecoregion are provided in Table 1-1. A schematic showing how these species tend to sort against these gradients soil moisture and temperature is shown in Figure 1-1 (adapted from Miller *et al*. 2011). The Y-axis shows increasing growing season soil temperature and the X-axis shows increasing soil moisture during the growing season. The three most important large sagebrush species, Wyoming big sagebrush, basin big sagebrush, and mountain big sagebrush, are highlighted in Figure 1-1. Shorter-statured species important to greater sage-grouse within the ecoregion are also highlighted. These include black sagebrush, little sagebrush, and silver sagebrush (Miller *et al*. 2011). These sagebrush species differ importantly in their ability to recover after fire or other disturbance.

Table 1-1. Common Names, Distribution, and Stature of Selected Sagebrush Taxa within States Included in the REA.

Scientific Name	Common Name	Distribution of Selected Sagebrush Taxa by State						Stature	
		CA	ID	OR	NV	UT	WY	Low	Tall
Artemisia arbuscula ssp. *Arbuscula*	Gray low sagebrush (Little sagebrush)	✓	✓	✓	✓	✓	✓	✓	
A. arbuscula ssp. *longiloba*	Alkali sagebrush (Little sagebrush)		✓	✓	✓	✓	✓	✓	
A. arbuscula ssp. *thermopola*	Little sagebrush	✓	✓	✓		✓	✓	✓	
A. arbuscula ssp. *longicaulis*	Lahontan sagebrush (Little sagebrush)	✓		✓	✓			✓	
*A. cana** ssp. *bolanderi*	Silver sagebrush	✓		✓	✓				✓
*A. cana** ssp. *cana*	Silver sagebrush						✓		✓
*A. cana** ssp. *viscidula*	Silver sagebrush		✓		✓	✓	✓		✓
A. nova	Black sagebrush	✓	✓	✓	✓	✓	✓	✓	
A. pygmaea	Pygmy sagebrush				✓	✓		✓	
A. rigida	Scabland sagebrush		✓	✓				✓	
A. rothrockii	Timberline sagebrush	✓							✓
A. tridentata ssp. *spiciformis*	subalpine big sagebrush; snowfield sagebrush	✓	✓		✓	✓	✓		✓
A. tridentata ssp. *tridentata*	Basin big sagebrush	✓	✓	✓	✓	✓	✓		✓
A. tridentata ssp. *vaseyana*	Mountain big sagebrush	✓	✓	✓	✓	✓	✓		✓
A. tridentata ssp. *wyomingensis*	Wyoming big sagebrush	✓	✓	✓	✓	✓	✓		✓
A. tridentata ssp. *xericensis*	Xeric big sagebrush; foothill big sagebrush		✓						✓
*A. tripartita** ssp. *rupicola*	Wyoming threetip sagebrush						✓		
*A. tripartita** ssp. *tripartita*	Threetip sagebrush		✓	✓	✓	✓	✓		✓

*Notes:**
Artemisia cana and *Artemisia tripartita* are capable of resprouting after fire; other species in the table are killed by fire and must regenerate from seed (Miller *et al.* 2011).
Sources:
Miller *et al.* (2011); USDA Plants Profile http://plants.usda.gov/java/nameSearch
Tilley, *et al.* ND. NRCS Plant Guide: Big Sagebrush. http://plants.usda.gov/plantguide/pdf/pg_artrx.pdf



Source: Miller er al. (inprogress)

Matrix of major sagebrush taxa in the Great Basin and Columbia Basin positioned along gradients of soil temperature and soil moisture (adapted from West and others 1978, West and Young 2000, Robertson and others 1966; McArthur 1983). Key soil characteristics each species is associated with is also included. Colors represents importance based on relative abundance among the sagebrush species and subspecies.

Figure 1-1. Assortment of Various Sagebrush Species Along Gradients of Increasing Soil Temperature and Water Availability During the Growing Season (Adapted from Miller et al. in progress). See Table 1-1 for common names of the sagebrush taxa.

2 Conservation Element 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 Conservation Element Distribution Mapping

3.1 Data Identification

The major datasets identified to map the distribution of the sagebrush conservation element were the ReGAP land cover and LANDFIRE datasets. The datasets used for the sagebrush coarse filter are display in Table 3-1. The ReGAP and LANDFIRE datasets consist of vegetative communities with corresponding codes. Table 3-2 lists the codes and class names for each of the data sources used to extract sagebrush stands.

Table 3-1. Data Sources for the Sagebrush Coarse Filter Conservation Element Distribution Mapping for the NGB Ecoregion

Data Required	Dataset Name	Source Agency	Type/Scale	Status	Use in REA
Terrestrial Systems					
Ecological Systems	Northwest ReGAP	USGS	Raster (30m)	Acquired	Yes, OR, ID
	Southwest ReGAP	USGS	Raster (30m)	Acquired	Yes, NV, UT
	LANDFIRE EVT	USGS	Raster (30m)	Acquired	Yes, CA

3.2 Distribution Mapping Methods

To map the distribution of sagebrush in the NGB ecoregion, SAIC used a combination of ReGAP and Landfire data sources. Most of the states rely on ReGAP for their vegetation while California uses Landfire. This approach was used to maintain consistency with the Central Basin and Range REA. Sagebrush was also separated into three types of sagebrush since the change agents can have a differing affects depending on type. The selected vegetation communities in Table 3-2 were extracted using a GIS process model and merged together to show the locations of the three types of sagebrush within the ecoregion. An additional step was recommended by the AMT for this coarse filter, which was to run a moving window analysis on the results. The moving window (10 km) was run as a spatial operation to remove any area with less than 0.5% coverage within 10 km of a pixel of sagebrush. This was done to remove small isolated clusters of pixels that were causing a lot of the ecoregion to be populated when using analysis units such as a HUC 12 watershed or 4 km grid. Total acreage by vegetation class name is provided in Table 3-2 and the totals for the three combined categories, Mountain Big Sagebrush, Low Sagebrush, and Wyoming Big Sagebrush/Basin Big Sagebrush are given in Table 3-3. Threetip sagebrush (*Artemisia tripartita* ssp. *tripartita*) is mapped with the Wyoming Big Sagebrush/Basin Big Sagebrush. At the scale of the mapping there are inclusions of species representative of one type in areas mapped as another type. For example, Basin Big Sagebrush often occurs along draws in areas otherwise dominated by Mountain Big Sagebrush and mapped as such. The draws are not mappable at this scale.

A recommendation of trying to further extract and split types of sagebrush (Wyoming Big sagebrush and Basin Big sagebrush) was analyzed using the ecological site descriptions and SSURGO soils database. The ecological site description report available from NRCS website did contain information on vegetation types in the soil unit but there were large gaps in the SSURGO soils in ecoregion. The vegetation reports were also needed to be extracted for every soil map unit one report at a time which would make it very time consuming to complete for a large ecoregion. This more detailed approach for trying to extract sagebrush into more data types might be better served in a step down approach using a smaller area of analysis.

3.3 Data Gaps, Uncertainty, and Limitations

3.3.1 Data Gaps

Coverage of the datasets used in the analysis was generally complete across the ecoregion, which was a factor in their selection. Discontinuities between the LANDFIRE (California), Northwest ReGAP (OR, ID), and Southwest ReGAP (NV, UT) data sets across state lines do not appear to be a substantial limitation with regard to this conservation element, although some discontinuities were noted.

3.3.2 Uncertainty

Vegetation mapping at the Ecoregion scale is expected to contain errors that would be addressable through the use of higher resolution imagery and larger mapping scales coupled with local knowledge and ground truthing suitable for step-down analyses over smaller areas.

Table 3-2. Vegetation Class Code and Name

Code	Sagebrush Type	Data Source	Vegetation Class Name	Species Notes	Acres	% of Total
5209	Low Sagebrush	Northwest ReGAP	Wyoming Basins Dwarf Sagebrush Shrubland and Steppe	Dry, windy sites dominated or codominated by *Artemisia nova, Artemisia tripartita* ssp. *rupicola, A. arbuscula ssp. longiloba, and wind-dwarfed A. tridentata ssp. Wyomingensis*. >2,135 m	273	<0.1
5453	Low Sagebrush	Northwest ReGAP	Columbia Plateau Low Sagebrush Steppe	*Artemisia arbuscula ssp. arbuscula* and close relatives (*Artemisia arbuscula ssp. longiloba* and occasionally *Artemisia nova*)	2,335,945	*6.8*
S040	Low Sagebrush	LANDFIRE EVT	Columbia Plateau Low Sagebrush Steppe	*Artemisia arbuscula ssp. arbuscula* and close relatives (*Artemisia arbuscula ssp. longiloba* and occasionally *Artemisia nova*) form stands in shallow, fine-textured soils at 1,000-3,000 m	48,770	*0.1*
5256	WBBS/Other Low Sagebrush	Northwest ReGAP	Great Basin Xeric Mixed Sagebrush Shrubland	Dominated by *Artemisia nova* at low and mid elevations and *Artemisia arbuscula* at higher elevations. May be codominated by *Artemisia tridentata* ssp. *Wyomingensis*	75,964	0.2
S055	Low Sagebrush	Southwest ReGAP	Great Basin Xeric Mixed Sagebrush Shrubland	Dominated by *Artemisia nova* at low and mid elevations and *Artemisia arbuscula* at higher elevations. May be codominated by *Artemisia tridentata* ssp. *Wyomingensis*	1,779,813	5.2
2079	Low Sagebrush	LANDFIRE EVT	Great Basin Xeric Mixed Sagebrush Shrubland	Dominated by *Artemisia nova* at low and mid elevations and *Artemisia arbuscula* at higher elevations. May be codominated by *Artemisia tridentata* ssp. *Wyomingensis*	166,864	0.5
5257	WBBS/Other	Northwest ReGAP	Great Basin Big Sagebrush Shrubland	*Artemisia tridentata* ssp. *tridentata* and *ssp. Wyomingensis;*	7,028,762	*20.4*
5454	WBBS/Other	Northwest ReGAP	Inter-Mountain Basins Big Sagebrush Steppe	*Artemisia tridentata* ssp. *tridentata, ssp. Wyomingensis; ssp. xericensis,* and *A. tripartita ssp. tripartita.* May shift to grassland without fire; much of BBS has deeper soils and has been converted to other land uses	10,334,586	*30.0*
S054	WBBS/Other	Southwest ReGAP	Inter-Mountain Basins Big Sagebrush Shrubland	*Artemisia tridentata* ssp. *tridentata* and/or *ssp. Wyomingensis* 1,500-2300 m	5,931,982	*17.2*

Table 3-2. Vegetation Class Code and Name

Code	Sagebrush Type	Data Source	Vegetation Class Name	Species Notes	Acres	% of Total
S078	WBBS/Other	Southwest ReGAP	Inter-Mountain Basins Big Sagebrush Steppe	*Artemisia tridentata* ssp. *tridentata, ssp. Wyomingensis; ssp. xericensis,* and *A. tripartita ssp. tripartita.* May shift to grassland without fire; much of BBS has deeper soils and has been converted to other land uses	189,540	*0.5*
2080	WBBS/Other	LANDFIRE EVT	Inter-Mountain Basins Big Sagebrush Shrubland	*Artemisia tridentata* ssp. *tridentata* and/or *ssp. Wyomingensis* 1,500-2300 m	598,418	*1.7*
2125	WBBS/Other	LANDFIRE EVT	Inter-Mountain Basins Big Sagebrush Steppe	*Artemisia tridentata* ssp. *tridentata, ssp. Wyomingensis; ssp. xericensis,* and *A. tripartita ssp. tripartita.* May shift to grassland without fire; much of BBS has deeper soils and has been converted to other land uses	31,706	*0.1*
5455	Mountain Big	Northwest ReGAP	Inter-Mountain Basins Montane Sagebrush Steppe	May have *A.t. spiciformis and A. cana ssp. viscidula;* this system also includes Mountain Big Sagebrush Shrublands. 1,000-3,000 m	3,461,323	10.0
S071	Mountain Big	Southwest REGAP	Inter-Mountain Basins Montane Sagebrush Steppe	May have *A.t. spiciformis and A. cana ssp. viscidula;* this system also includes Mountain Big Sagebrush Shrublands. 1,000-3,000 m	2,413,418	17.3
2126	Mountain Big	LANDFIRE EVT	Inter-Mountain Basins Montane Sagebrush Steppe	May have *A.t. spiciformis and A. cana ssp. viscidula;* this system also includes Mountain Big Sagebrush Shrublands. 1,000-3,000 m	27,703	0.1

Table 3-3. Total Areas In Ecoregion by Sagebrush Type

Sagebrush Type	Acres	Percentage
Mountain Big Sagebrush	5,964,698	17.3
Wyoming Big Sagebrush/ Basin Big Sagebrush	24,114,994	69.9
Low Sagebrush	4,407,629	12.8
Totals	34,487,322	100%

4 Conceptual Model

A conceptual model of sagebrush-steppe ecosystems in the ecoregion is presented in Figure 4-1. It shows the general relationships among change agents including climate change, wildfire, livestock grazing, invasive species, and insects and disease and the relationship of these change agents with the sagebrush steppe plant association. This model and the following discussion are based on many sources including Miller *et al.* (2011) and Rosentreter (2005). Frequency, intensity, and areal extent of wildfires are of greatest importance to this ecosystem and are in turn affected by characteristics of the vegetation (fuel characteristics) and livestock grazing (which affects vegetation and soils). As mentioned above, the dominant sagebrush species lack the ability to resprout after fire and tend to have short-lived seeds. Because of this, dispersal from surviving (unburned) individuals becomes very important in regeneration, making the areal extent of the fire and the completeness vs. patchiness of the burn critical factors in regeneration. Differences in site productivity as well as differences in seed longevity in the soil may play a role in the differences in the speed at which systems dominated by mountain big sagebrush recovers from fire compared to Wyoming big sagebrush (e.g., see Wijayratne and Pyke 2009). Seeds of both species are very short-lived unless covered with soil.

A key factor not shown in the model is the type of sagebrush and the characteristics of the ecological sites. Wyoming big sagebrush, which occurs at lower elevations on drier, less productive sites, is especially vulnerable to type conversion to cheatgrass monocultures after fire. In contrast, mountain big sagebrush, which occurs at higher elevations with higher precipitation, cooler conditions and more productive sites, is less vulnerable to cheatgrass invasion but is susceptible to juniper invasion under conditions of infrequent wildfire (Miller *et al.* 2011; McIver *et al.* 2010). Both conditions can lead to increased wind and water erosion, especially on sloping ground and after fire, and the loss of soil can ultimately lead to permanent site degradation and inability to return the site to its original shrub steppe condition.

A conceptual model showing the relationship between fire return interval and site characteristics in sage-steppe sites is shown in Figure 4-2. Although trees are not a part of the reference condition in sagebrush-steppe communities, trees (principally junipers) have a tendency to establish on sagebrush sites, especially when the sagebrush-perennial grass cover is altered. The model shows that with longer periods between fires under comparatively moist cool conditions there is a high probability of woodland development in areas of grass or shrub dominated shrub steppe. State-and-transition models are shown in Figures 4-3 and 4-4 for more productive (12-14" precip.) and less productive (10-12" precip.) sage-steppe sites, respectively. The higher precipitation sites, exemplified by mountain big sagebrush, are more prone to juniper encroachment, whereas the lower precipitation sites, exemplified by Wyoming big sagebrush, are more prone to type conversion to cheatgrass (McIver *et al.* 2010).

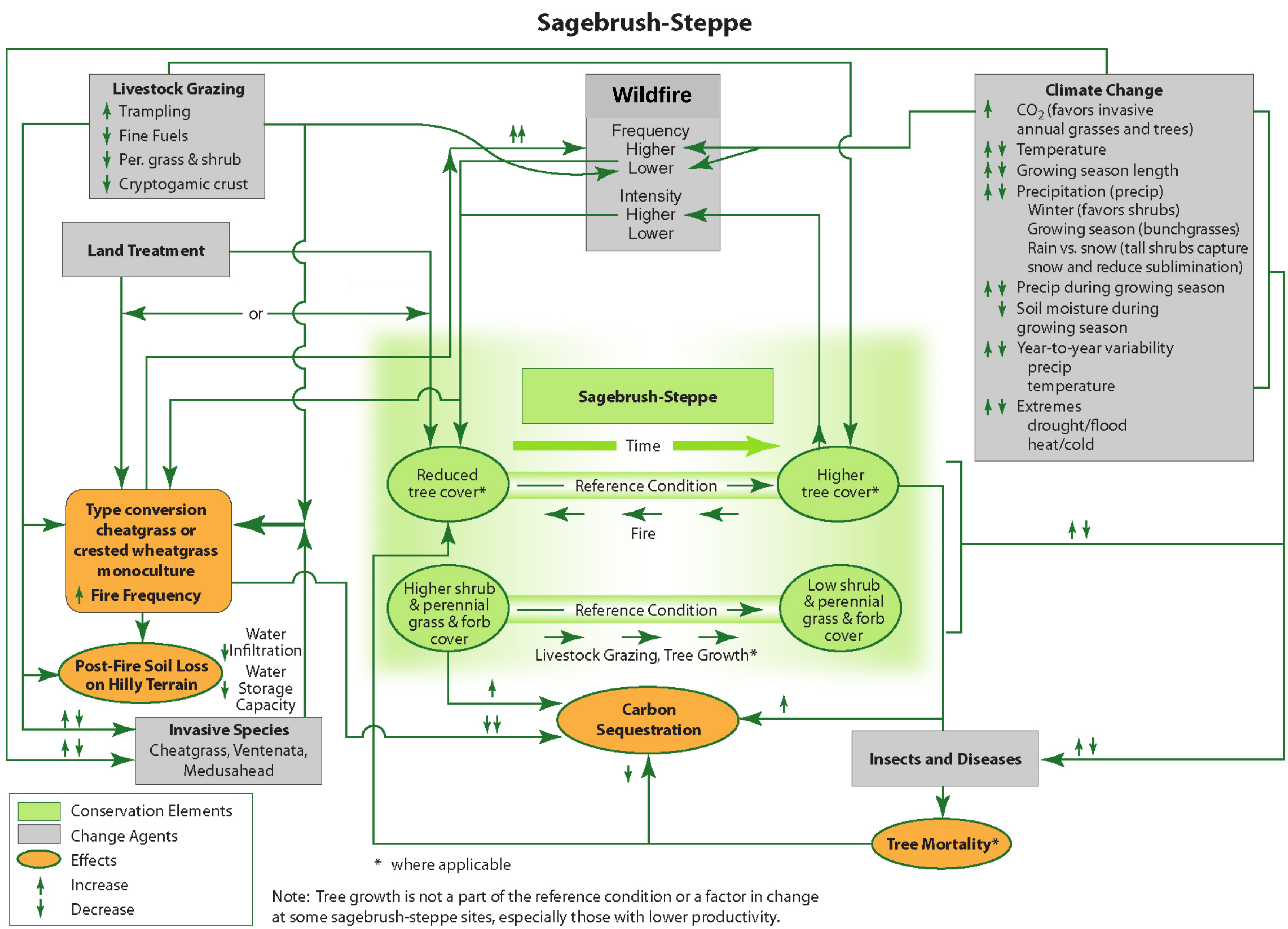


Figure 4-1. Sagebrush Conceptual Model

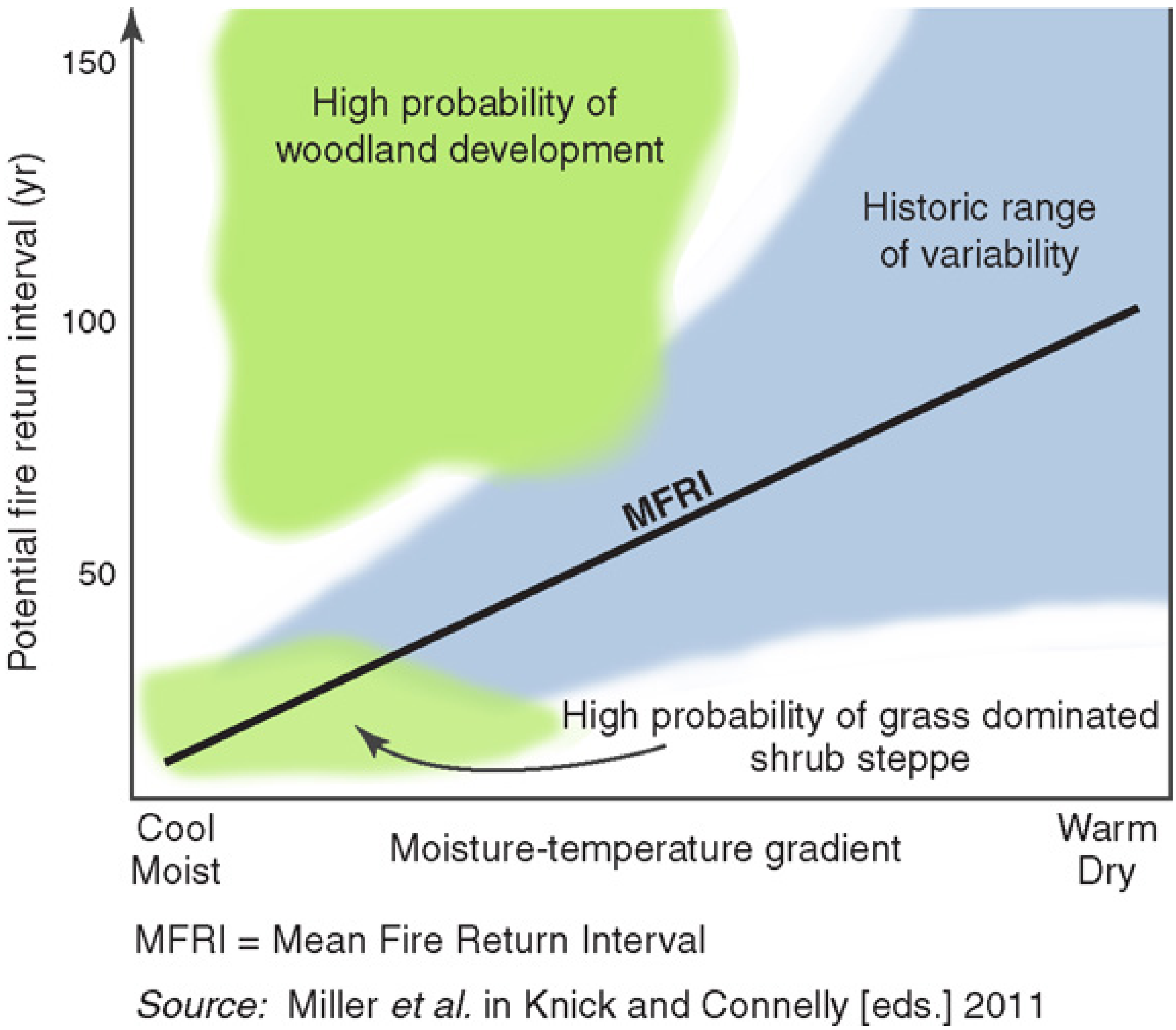
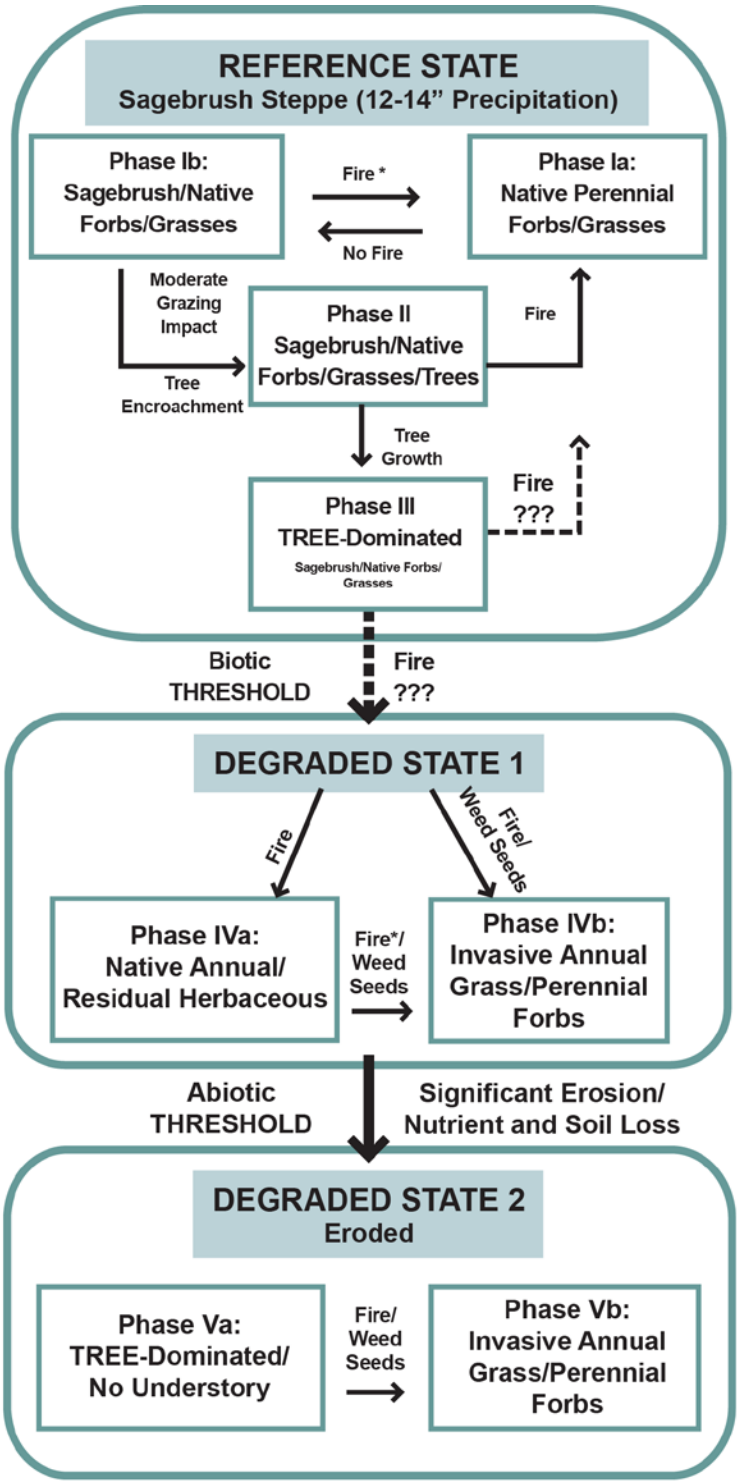


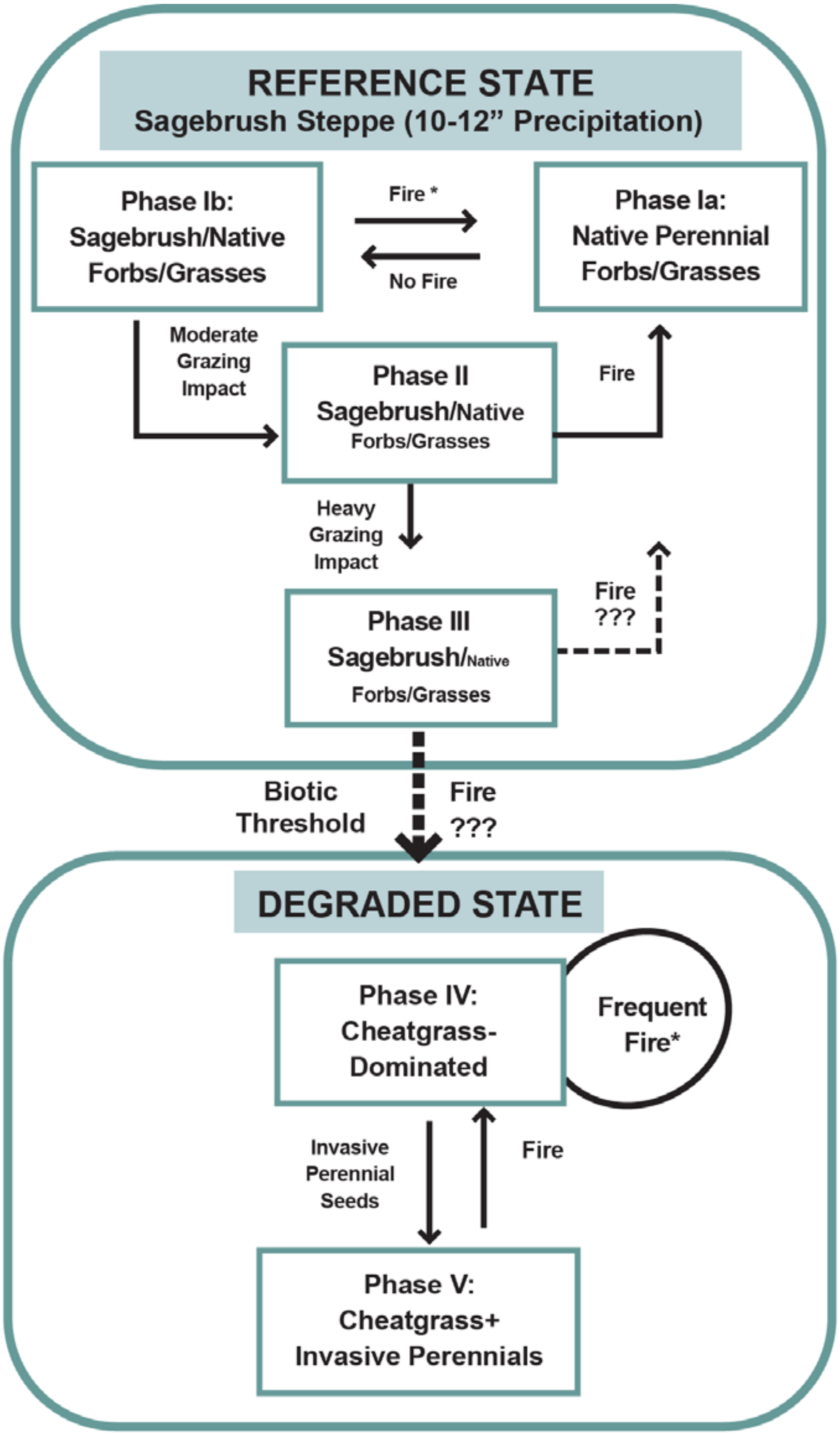
Figure 4-2. Conceptual Model Showing the Relationship between Potential Fire Return Interval (in years) and Moisture-temperature Gradient (Source: Miller et al. 2011)



Source: McIver *et al.* 2010

State-and-transition model for the woodland system (12- to 14-inch precipitation zone) focusing on vegetation only. Font size indicates relative dominance of vegetation life form within each phase.
*Fire is assumed to be severe enough to kill most of the woody vegetation.

Figure 4-3. State-and-Transition Model Applicable to High Productivity Sagebrush Steppe Sites (e.g., dominated by mountain big sagebrush), which are Vulnerable to Invasion by Junipers, including Utah Juniper and Western Juniper (from McIver et al. 2010, modified to remove cheatgrass from the reference state. Grazing impacts refer to native herbivores and the tree dominated phase in the reference state still has sufficient understory species to return to a sagebrush/native forbs/grasses phases.



Source: McIver *et al.* 2010

State-and-transition model for the sage/cheat system (10- to 12-inch precipitation zone) focusing on vegetation only. Font size indicates relative dominance of vegetation life form within each phase. *Fire is assumed to be severe enough to kill most of the woody vegetation.

Figure 4-4. State-And-Transition Model for Low Productivity Sagebrush Steppe Sites (e.g., dominated by Wyoming big sagebrush), which are Vulnerable to Invasion by Annual Grasses, Especially Cheatgrass (from McIver et al. 2010, modified to remove cheatgrass from the reference state). Grazing impacts refer to native herbivores.

5 Management Questions

Where is Sagebrush?

Low Sagebrush

Species classified as low sagebrush tend to occupy a variety of sites over a considerable elevational range (Table 3-2). The sites tend to have soil-related restrictions on plant growth (e.g., bedrock near surface or shallow confining layer) in addition to climatic restrictions (dry, windy). Low sagebrush occupies about 13 percent of the total area occupied by sagebrush in the ecoregion and is more prevalent in the western and southern portions of the ecoregion (Figure 5-1) than elsewhere.

Wyoming / Basin Big Sagebrush

This category is the most widespread category of sagebrush land cover type and is distributed nearly throughout the ecoregion (Figure 5-1). This type generally occupies lower elevation, less productive sites than mountain big sagebrush and is more vulnerable to fire and susceptible to cheatgrass invasion than mountain big sagebrush. Basin big sagebrush tends to occupy deeper soils than Wyoming big sagebrush and many of these soils have been developed for agriculture. Where the two species occur together, basin big sagebrush tends to occupy the deeper soils near drainages within the Wyoming big sagebrush community.

Mountain Big Sagebrush

Mountain big sagebrush tends to occupy higher elevation sites than its close relatives basin big sagebrush and Wyoming big sagebrush and has a more limited distribution within the ecoregion (Figure 5-1). As a result of higher precipitation (a function of elevation) mountain big sagebrush sites tend to be more productive and less vulnerable to cheatgrass invasion than sites occupied by the latter two species. Mountain big sagebrush occupies about 17% of the total area occupied by sagebrush in the ecoregion (Table 3-3).Sagebrush has the greatest density throughout the western, southern and northeastern portion of the ecoregion, see Figure 5-2.

Where does Sagebrush interact with Change Agents

Development

The distance to development was determined by merging many types of development into one spatial layer and then determining the Euclidean distance from sagebrush to any type of development. The development spatial layer consisted of:

- Ski resorts,
- TIGER roads,
- Railroads,
- Mines,
- Agriculture,
- Developed areas,
- Ruby Pipeline (NV only),
- Wind Turbines, and
- Transmission lines.

Figure 5-3 displays the results of determining the average distance by 4km grid from sagebrush to one of the listed types of development. The most prominent type of development interacting with sagebrush is roads. The TIGER (**T**opologically **I**ntegrated **G**eographic **E**ncoding and **R**eferencing) roads spatial layer (US Census) is very detailed and includes some off highway vehicles, 4WD forest service roads, BLM routes along with urban roads and major highways. Throughout most of the ecoregion sagebrush is 300 – 1,000 m and less than 300 m from development. Few sagebrush areas scattered around the ecoregion have development >1 km away.

Disease

Periodic outbreaks of Aroga Moths have been linked to defoliation of sagebrush but the causes and ecological significance of these disturbances is not well understood.

Wildfire

FSIM burn probability data was modeled by the USGS and USFS and was used to determine wildfire risk to sagebrush within the ecoregion. Figure 5-4 shows the burn probability (low, moderate and high) for sagebrush range by the most common value within the 4km grid. It also includes the GeoMAC fire perimeters for the past two years to show where recent fire activity has occurred. Figures 5-5, 5-6 and 5-7 show the burn probability for each of the types of sagebrush. The highest burn probability sagebrush areas are within southeastern Idaho, northeastern Nevada and Utah. The areas with the lowest burn probability are on the periphery of the ecoregion and in southern Oregon and western Nevada. In 2012 the largest fires within the ecoregion have predominantly been in sagebrush. The three largest fires were been Long Draw (597,000 ac), Holloway (468,000 ac) and Rush (328,000 ac). These fires burned all three types of sagebrush with Wyoming and Basin Big sagebrush the most effected by area.

Grazing

The relationship between livestock grazing and sagebrush ecosystems is complex and livestock grazing is widespread within sagebrush ecosystems. The effects of past practices remain today complicating the evaluation of current management practices. The principal effect of grazing is removal of preferred herbaceous species, modifying the competition dynamics and possibly creating a niche for cheatgrass establishment. Fall and winter grazing could result in modifications to the shrub component of the system at the site level. As discussed above under the conceptual model, livestock grazing, wildfire, cheatgrass, and expansion of junipers into sagebrush systems are interrelated and affect sagebrush ecosystems.

Juniper Expansion

Figure 5-8 shows the distance from juniper from all varieties of sagebrush combined. Figures 5-9 to 5-11 show the distances to juniper for each of the sagebrush types (low, WY and Basin Big, and Mountain Big).

How will Sagebrush be impacted by modeled Climate Change?

The broad ecological amplitude of the various species of sagebrush present in the ecoregion and the uncertainties involved in predicting climate change make predictions a complex and very uncertain undertaking. It is likely that there will be greater year to year fluctuations and more frequent incidence of periods of drought or elevated temperatures than experienced in the past half century. The rapidity of climate change coupled with prevalence of cheatgrass, the expansion of junipers, and the apparent recent trend toward larger and more frequent wildfires are interrelated factors that need to be taken into account when considering the effects of climate change on sagebrush communities. Post-fire recovery of sagebrush communities, would likely be influenced by a rapid reestablishment of invasive species. Undoubtedly there will be local range expansions and contractions of individual species responding to changes in climatic variables according to their individual tolerances but it is likely that there will be unanticipated effects resulting from complex and unforeseeable interactions.

Where are intact Sagebrush communities (minimally impacted by Human Activities)

To derive where intact sagebrush stands (minimally impacted by human activities) are located, the following two layers were classified and combined: Distance to Development and Burn Probability. Using the values as classified in Figures 5-3 and 5-4, the results were reclassified 1, 2 or 3 (e.g., 1 would be the highest burn probability or closest to development while 3 would be the lowest burn probability (or unburnable) or furthest from development. Using the raster calculator, the values were combined to derive a score from 2 to 6 and then averaged within an analysis unit (4km grid). A stretched raster was used to show the range of values from the lowest 2 (orange) to the highest 6 (green).

Figure 5-12 shows the extensive areas of relatively undisturbed sagebrush and large blocks of sagebrush in the southern and western parts of the ecoregion and to a lesser degree to the north of the Snake River Plain. Not surprisingly habitat within and adjacent to the Snake River Plain tends to be the most fragmented and anthropogenic affected.

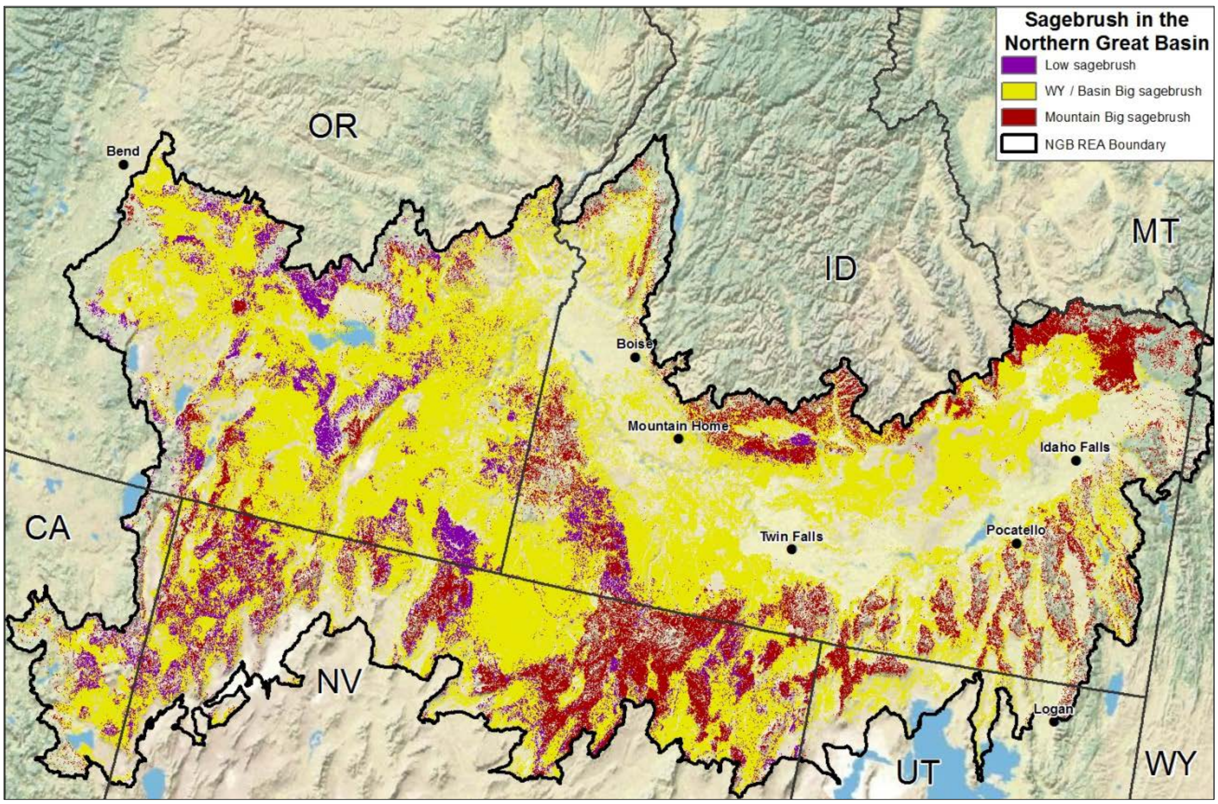


Figure 5-1. Sagebrush Locations in the NGB

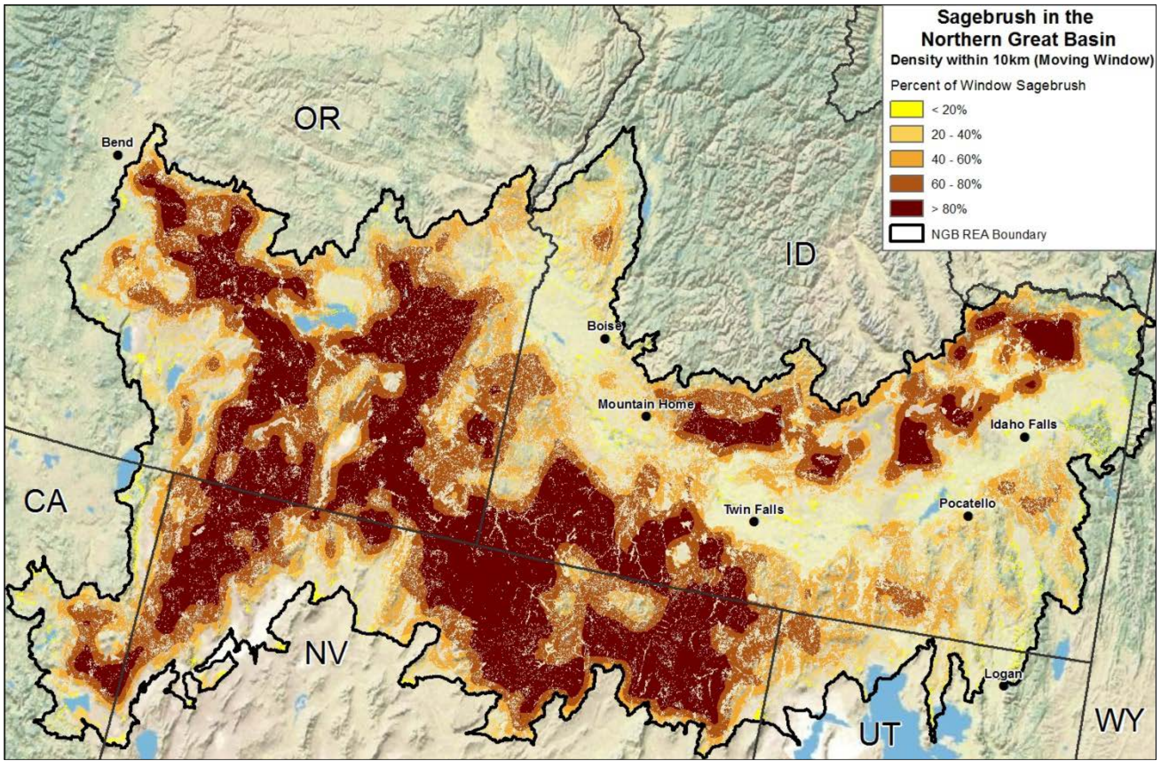


Figure 5-2. Density of Sagebrush within a 10km Moving Window Analysis

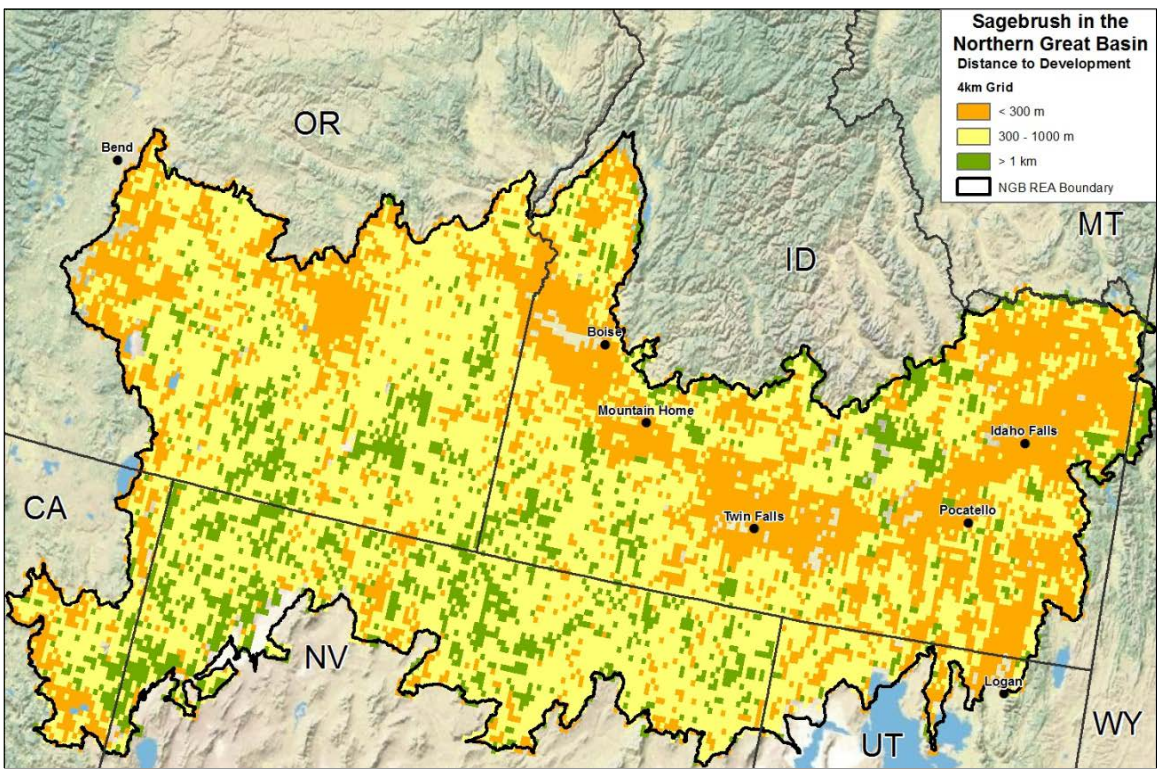


Figure 5-3. Distance to Development for Sagebrush

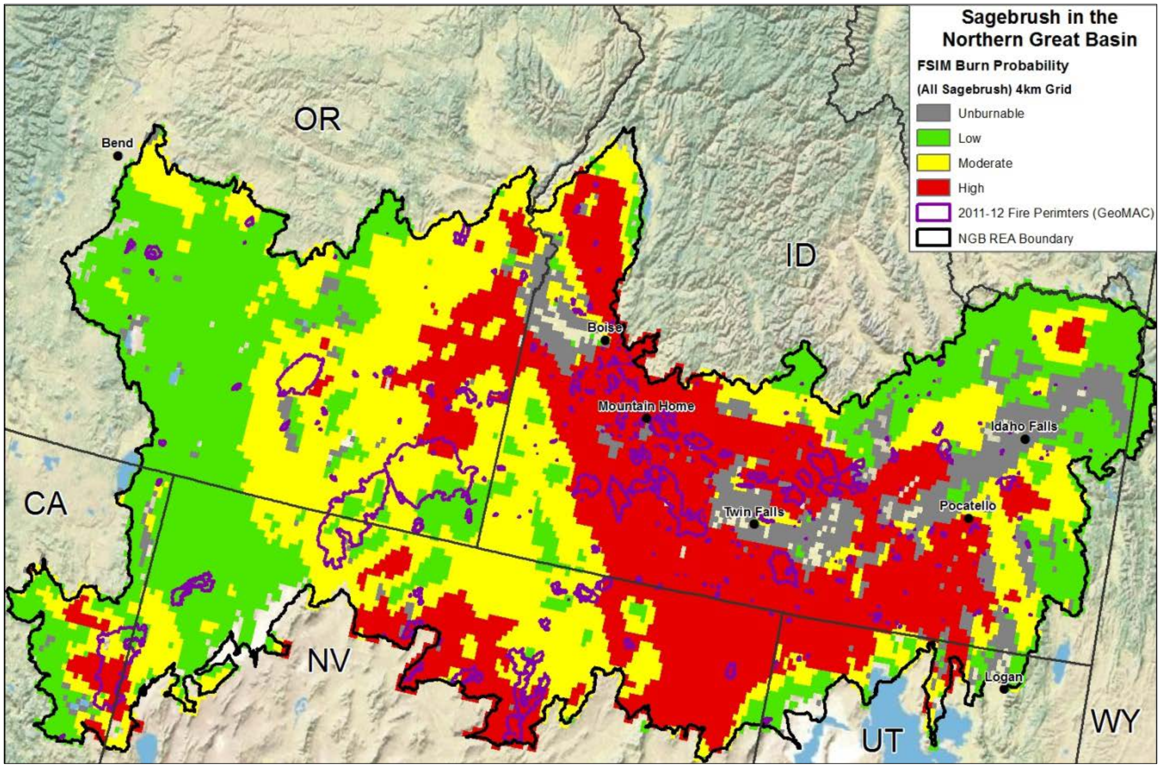
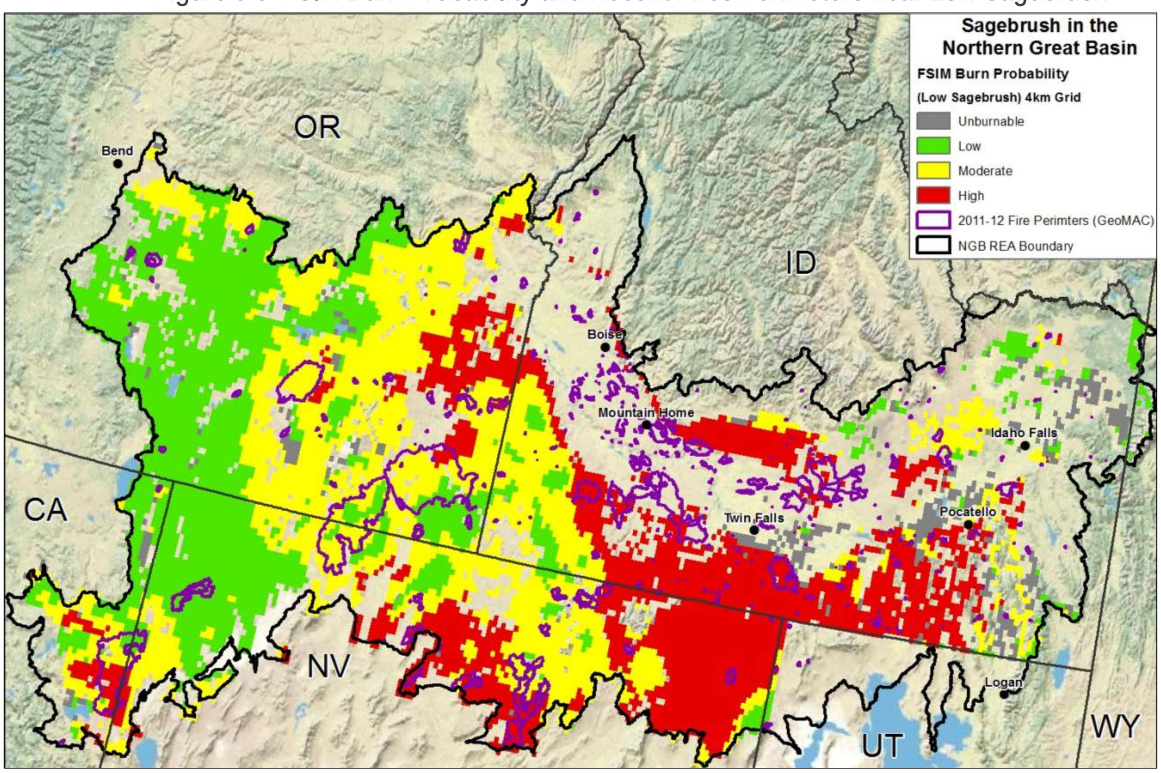


Figure 5-4. FSIM Burn Probability and Recent Fires Perimeters near Sagebrush (All)

Figure 5-5. FSIM Burn Probability and Recent Fires Perimeters near Low Sagebrush



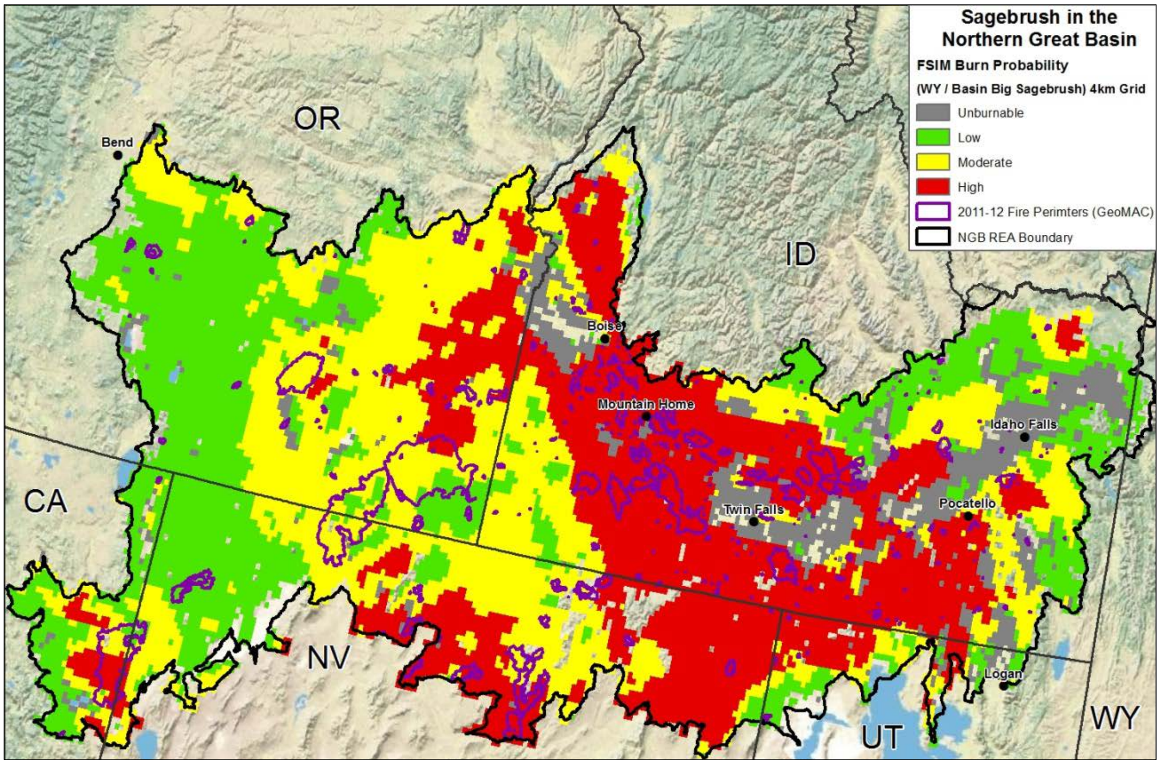


Figure 5-6. FSIM Burn Probability and Recent Fires Perimeters near WY / Basin Big Sagebrush

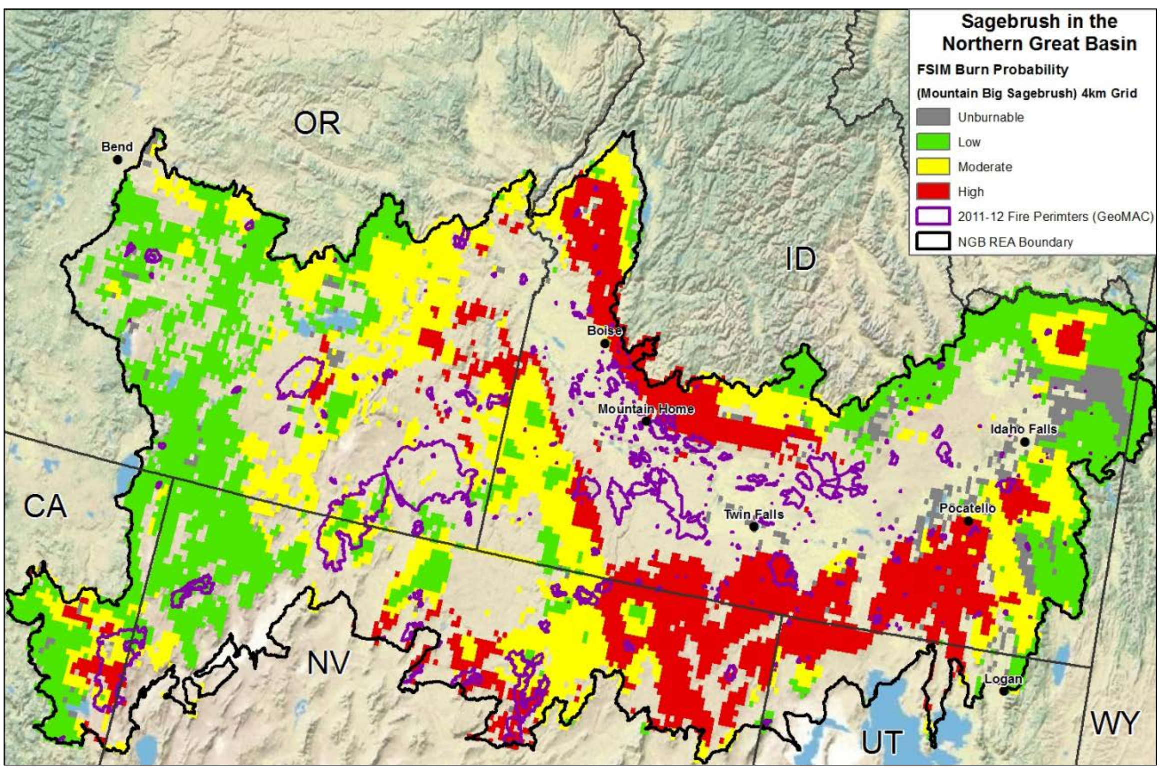


Figure 5-7. FSIM Burn Probability and Recent Fires Perimeters near Mountain Big Sagebrush

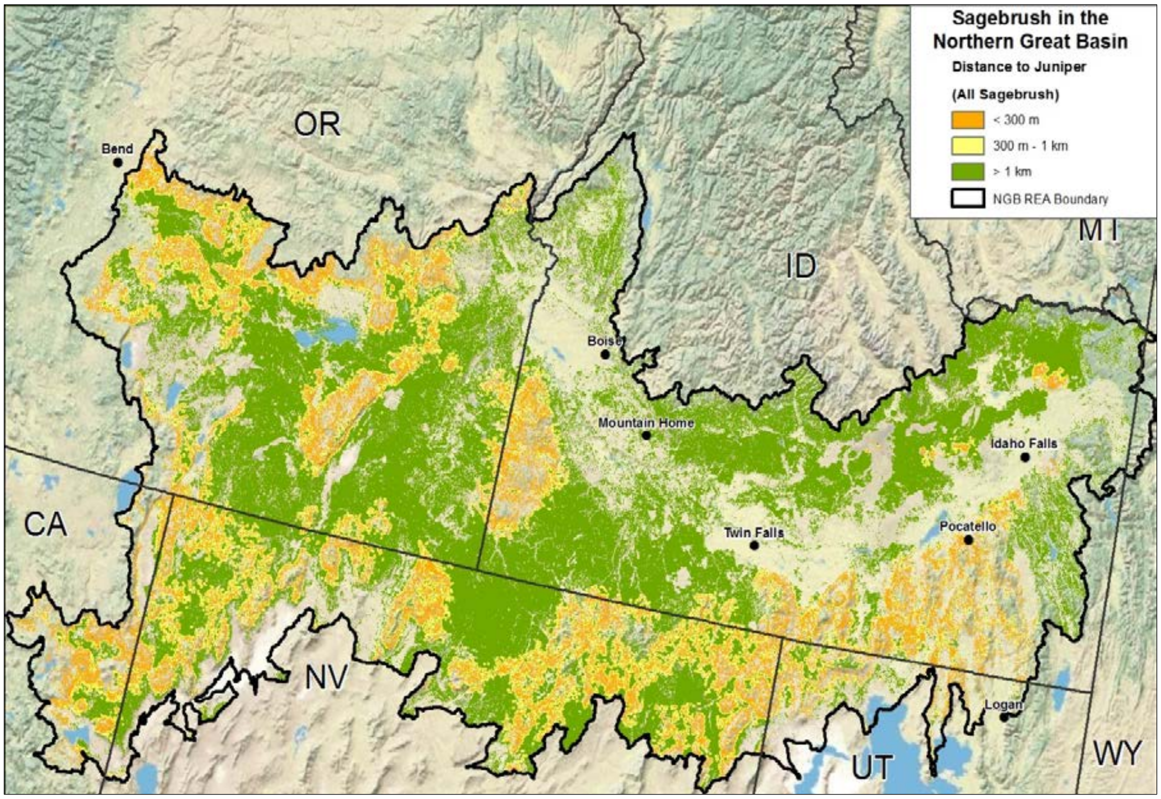


Figure 5-8. Distance to Juniper for All Sagebrush

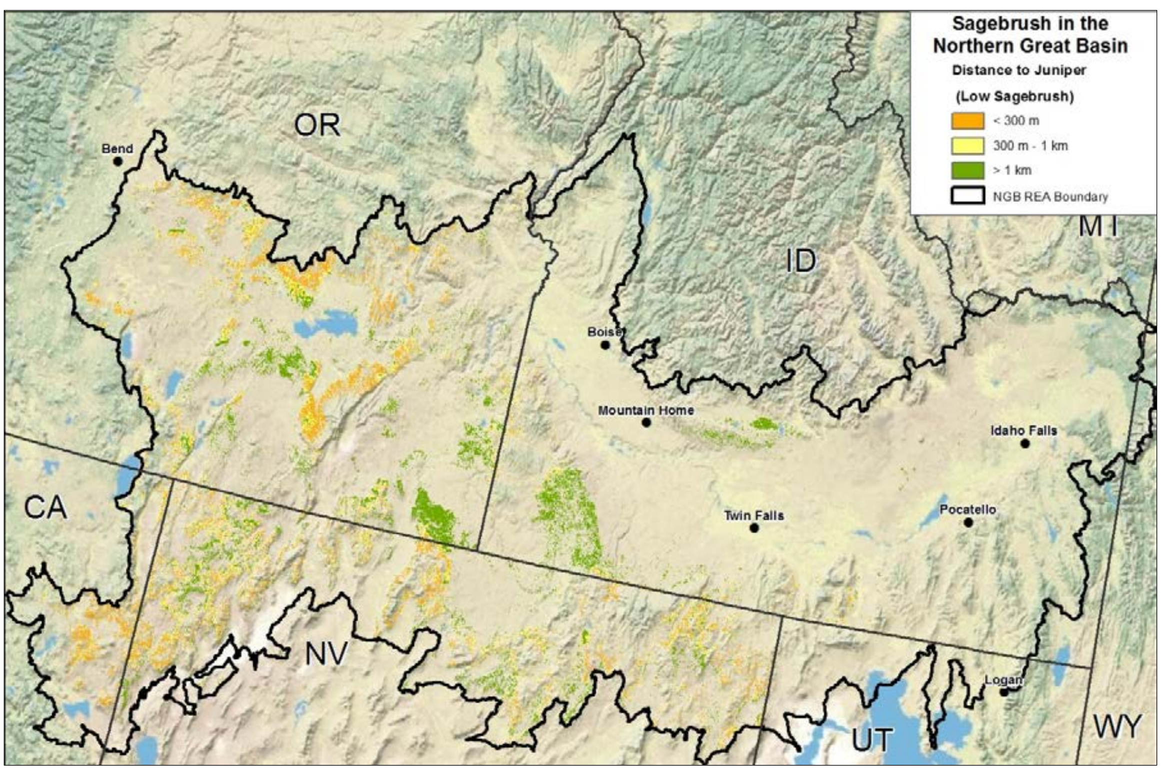


Figure 5-9. Distance to Juniper for Low Sagebrush

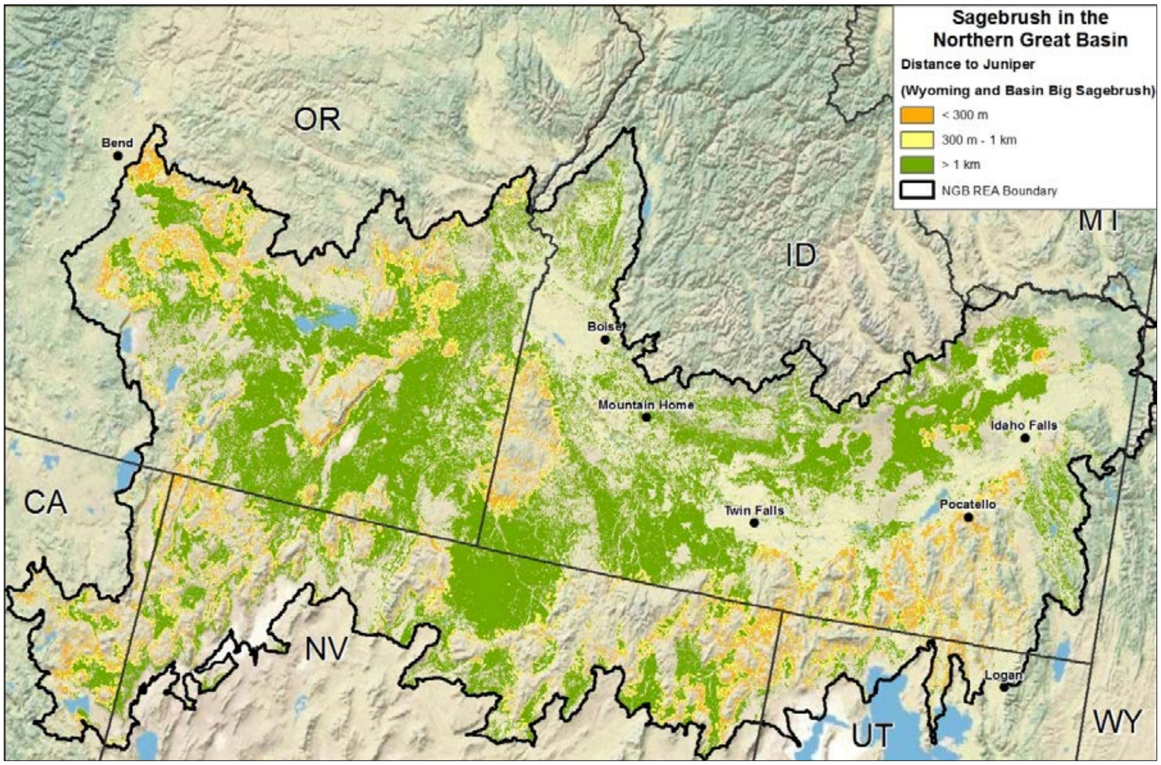


Figure 5-10. Distance to Juniper for WY and Basin Big Sagebrush

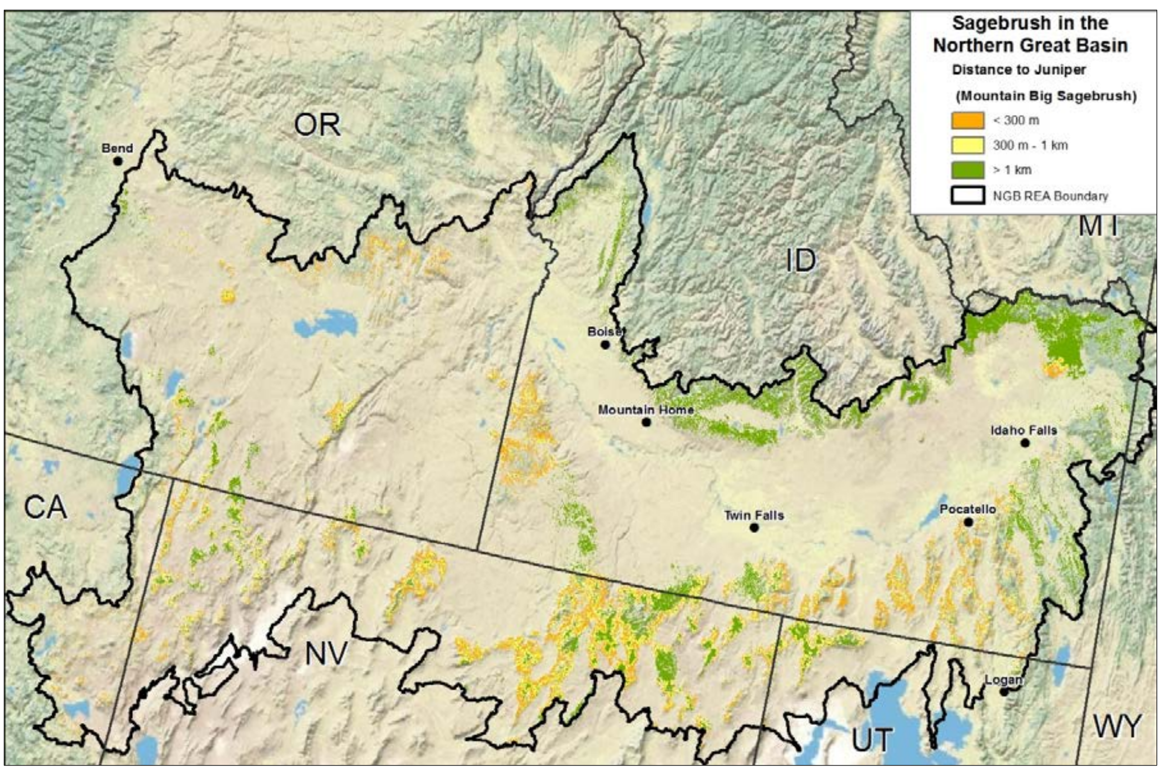


Figure 5-11. Distance to Juniper for Mountain Big Sagebrush

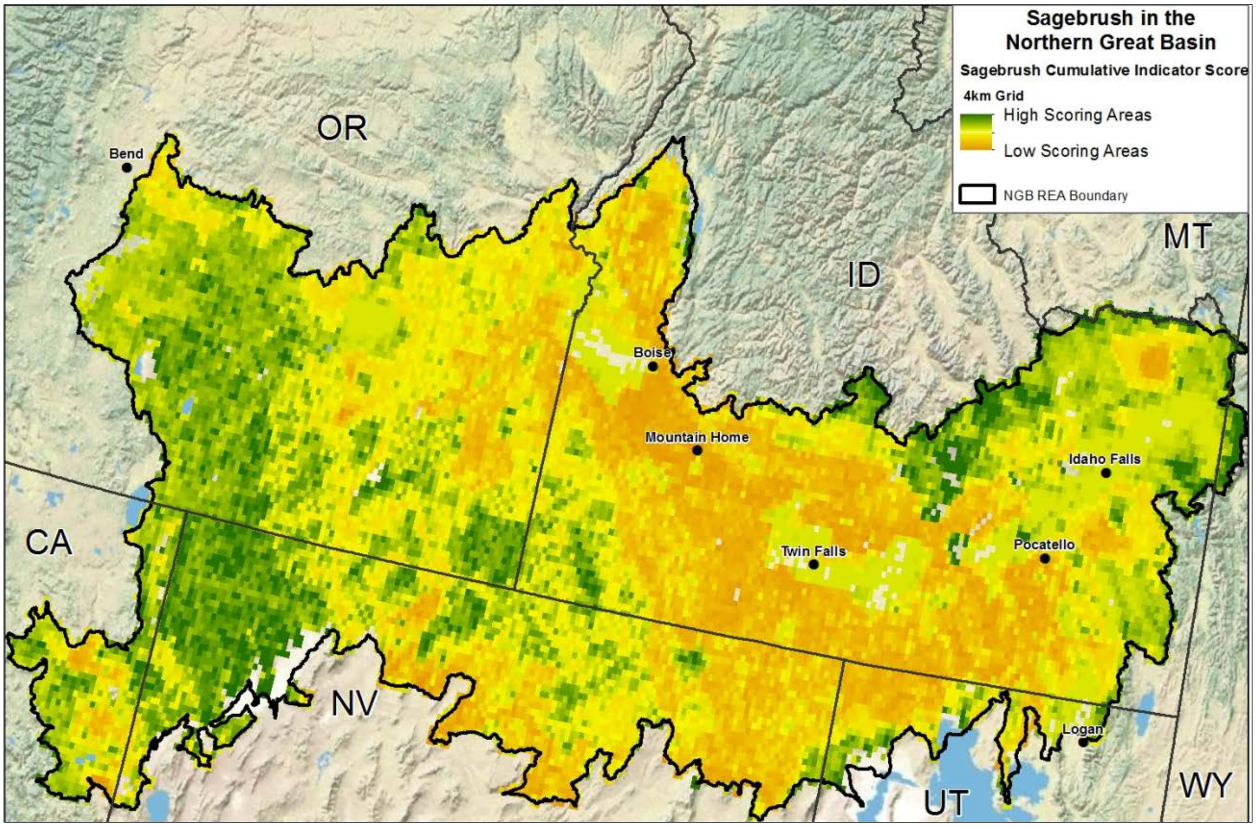


Figure 5-12. Cumulative Indicator Score for Sagebrush

6 Summary of Sagebrush in the NGB

Sagebrush communities are emblematic as the most characteristic and widespread native plant communities in the northern Great Basin and Intermountain West. Once taken for granted, sagebrush communities have undergone sweeping ecological changes gaining recognition since the middle of the twentieth century and sagebrush ecosystems are now of great conservation concern and are currently receiving management and restoration efforts in recognition of the many species that depend on sagebrush, notably the greater sage-grouse.

Sagebrush communities were separated into, Low Sagebrush, Wyoming Big Sagebrush/Basin Big Sagebrush and Mountain Big Sagebrush. Low sagebrush tend to occupy a variety of xeric sites over a considerable elevational range and cover about 13 percent of the total area occupied by sagebrush in the ecoregion. Low sagebrush is more prevalent in the western and southern portions of the ecoregion. Wyoming / Basin Big Sagebrush is the most widespread category of sagebrush land cover type and is distributed nearly throughout the ecoregion. Mountain big sagebrush tends to occupy higher elevation sites than its close relatives basin big sagebrush and Wyoming big sagebrush and has a more limited distribution within the ecoregion

The most prominent type of development interacting with sagebrush is roads. Throughout most of the ecoregion sagebrush is 300 – 1,000 m and less than 300 m from development. Few sagebrush areas scattered around the ecoregion have development >1 km away.

Wyoming big sagebrush is especially vulnerable to type conversion to cheatgrass monocultures after fire whereas mountain big sagebrush is less vulnerable to cheatgrass invasion but is susceptible to juniper invasion under conditions of infrequent wildfire. Douglas-fir and other conifers have been the focus of additional attention because of their ability to rapidly colonize and establish in sagebrush communities. Periodic outbreaks of Aroga Moths have been linked to defoliation of sagebrush but the causes and ecological significance of these disturbances is not well understood.

The broad ecological amplitude of the various species of sagebrush present in the ecoregion and the uncertainties involved in predicting climate change make predictions a complex and very uncertain undertaking. It is likely that there will be greater year to year fluctuations and more frequent incidence of periods of drought or elevated temperatures than experienced in the past half century. The rapidity of climate change coupled with prevalence of cheatgrass, the expansion of junipers, and the apparent recent trend toward larger and more frequent wildfires are interrelated factors that need to be taken into account. Post-fire recovery of sagebrush, if it does burn, would be likely be influenced by rapid reestablishment of invasive species.

Extensive areas of relatively undisturbed sagebrush and large blocks of sagebrush occur in the southern and western parts of the ecoregion and to a lesser degree to the north of the Snake River Plain. Habitat within and adjacent to the Snake River Plain tends to be the most fragmented and anthropogenic affected.

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Combined Juniper
Coarse Filter Conservation Element Package

1 Conservation Element Description

Western juniper (*Juniperus occidentalis*) and Utah juniper (*J. osteosperma*) dominate large areas across the Intermountain Region including the Northern Basin and Range Ecoregion. In the ecoregion, western juniper is prevalent in Oregon, northeastern California, northwestern Nevada and southwestern Idaho. It is geographically replaced by Utah juniper to the south and east. Utah juniper has extensive distribution in Nevada and Utah and is present in southeastern Idaho. Along the California-Nevada border, western juniper is represented by two subspecies: typical western juniper (subspecies *occidentalis*), which occurs as woodlands in sagebrush-steppe, and subspecies *australis* (known as Sierra juniper), which differs from subspecies *occidentalis* in being a large tree occurring in montane forested habitats at higher elevations. Sierra juniper occurs mostly south of the ecoregion. The ecological relationships of the Utah juniper and the typical western juniper are very similar.

2 Conservation Element 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 Conservation Element Distribution Mapping

3.1 Data Identification

The major datasets identified to map the distribution of the juniper conservation element were the ReGAP land cover and LANDFIRE datasets. The datasets used for the Juniper coarse filter are display in Table 3-1. The ReGAP and LANDFIRE datasets consist of vegetative communities with corresponding codes. Table 3-2 lists the codes and class names for each of the data sources used to extract juniper stands.

Table 3-1. Data Sources for the Juniper Coarse Filter Conservation Element Distribution Mapping for the Northern Great Basin Ecoregion

Data Required	Dataset Name	Source Agency	Type/Scale	Status	Use in REA
Terrestrial Systems					
Ecological Systems	Northwest ReGAP Southwest ReGAP	USGS	Raster (30m)	Acquired	Yes
	LANDFIRE EVT	USGS	Raster (30m)	Acquired	Yes

Table 3-2. Vegetation Class Code and Name

Code	Data Source	Vegetation Class Name	Juniper Species	Area	Percent age
4204	Northwest ReGAP	Columbia Plateau Western Juniper Woodland and Savanna	Western	1,174,803	43.7
4236	Northwest ReGAP	Rocky Mountain Foothill Limber Pine-Juniper Woodland	Utah	1,543	0.1
5404	Northwest ReGAP	Inter-Mountain Basins Juniper Savanna	Utah	314,378	11.7
S039	Southwest ReGAP	Colorado Plateau Pinyon-Juniper Woodland	Utah	3,377	0.1
S040	Southwest ReGAP	Great Basin Pinyon-Juniper Woodland	Utah	963,342	35.8
S075	Southwest ReGAP	Inter-Mountain Basins Juniper Savanna	Western?	287	0.0
2202	LANDFIRE EVT	Juniperus occidentalis Wooded Herbaceous Alliance	Western	996	
2203	LANDFIRE EVT	Juniperus occidentalis Woodland Alliance	Western	9,890	0.4
2017	LANDFIRE EVT	Columbia Plateau Western Juniper Woodland and Savanna	Western	10,033	0.4
2019	LANDFIRE EVT	Great Basin Pinyon-Juniper Woodland	Utah	212,098	7.9
			Total	2,690,747	100%

3.2 Distribution Mapping Methods

To map the distribution of juniper in the NGB ecoregion, SAIC used a combination of ReGAP and Landfire data sources. Most of the states rely on ReGAP for their vegetation while California uses Landfire. This approach was used to maintain consistency with the Central Basin and Range REA. The selected vegetation communities in Table 3-2 were extracted using a GIS process model and merged together to show juniper locations within the ecoregion. An additional step was recommended by the AMT for this coarse filter, which was to run a moving window analysis on the results. The moving window (10 km) was run as a spatial operation to remove any area with less than 1% coverage within 10 km of a pixel of juniper. This was done to remove small isolated clusters of pixels that were causing a lot of the ecoregion to be populated when using analysis units such as a HUC 12 watershed or 4 km grid.

3.3 Data Gaps, Uncertainty, and Limitations

3.3.1 Data Gaps

Coverage of the datasets used in the analysis were generally complete across the ecoregion, which was a factor in their selection. Discontinuities between the LANDFIRE (California), Northwest ReGAP (OR, ID), and Southwest ReGAP (NV, UT) data sets across state lines do not appear to be a limitation with regard to this conservation element.

3.3.2 Uncertainty

Vegetation mapping at the Ecoregion scale is expected to contain errors that would be addressable through the use of higher resolution imagery and larger mapping scales coupled with local knowledge and ground truthing suitable for step-down analyses over smaller areas.

Separating the distributions of the two juniper species based on the ReGAP and LANDFIRE classifications is not completely reliable in portions of the ecoregion, which is not surprising given their ecological similarity. Based on other sources (Griffin & Critchfield 1972; Charlet 1996; Miller *et al.* 2005; Tausch *et al.* 2009), western juniper evidently predominates in California and northwestern Nevada portions of the ecoregion as well as in Oregon and the Owyhee's in southwestern Idaho, whereas Utah juniper predominates in south-central and southeastern Idaho, northeastern Nevada, and northwestern Utah.

It should be noted that sites mapped as juniper, especially where juniper has expanded its distribution into sagebrush sites, may still support a sagebrush component. Identification of old-growth (pre-settlement) juniper stands, which are of conservation interest as discussed below, will probably require field determination (Miller *et al*. 2005).

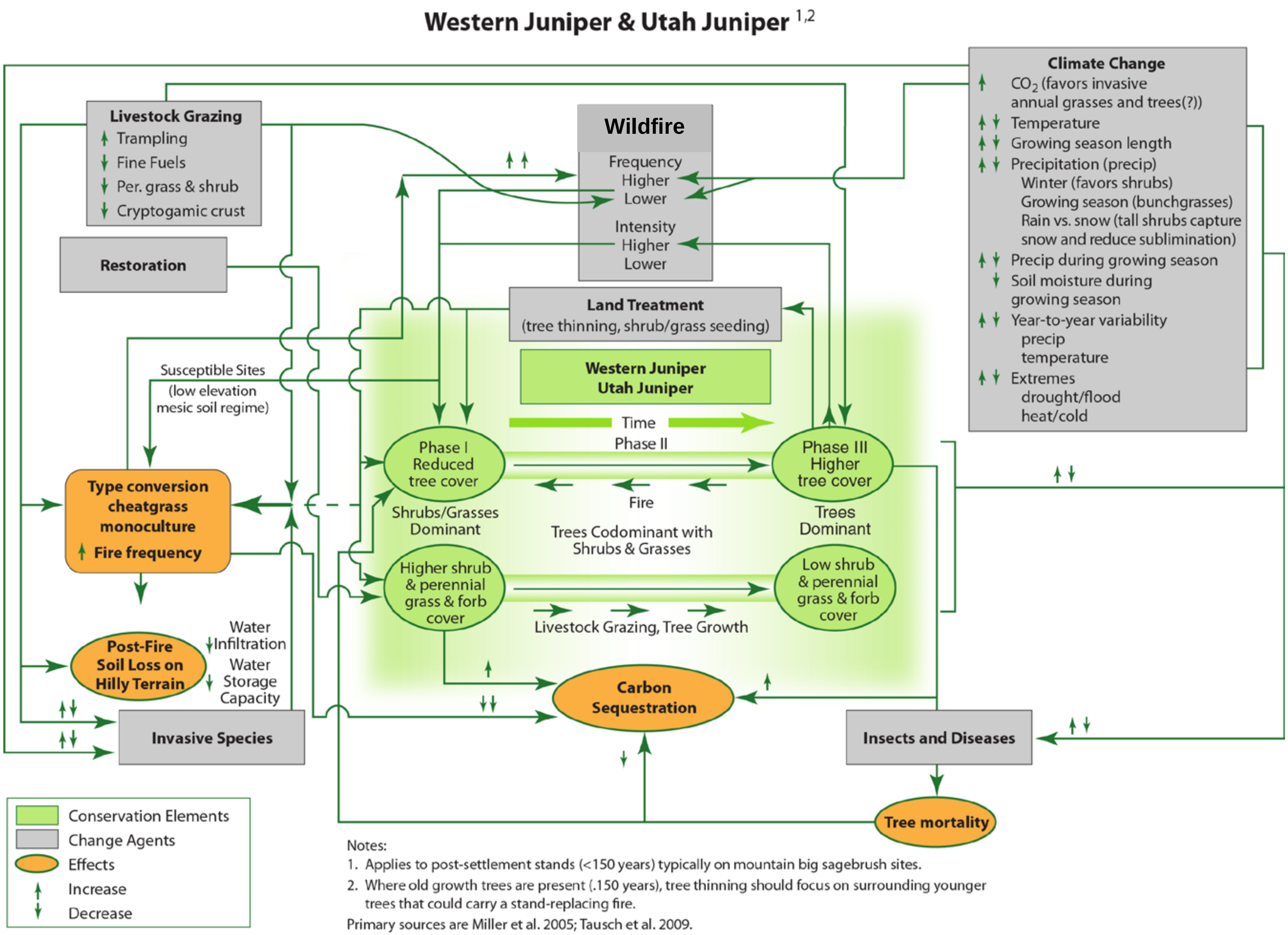
4 Conceptual Model

The conceptual model presented here (Figure 4-1) is applicable to both Utah juniper and western juniper. Both junipers have expanded their distributions into sagebrush steppe since the mid-1800s and especially in the early 1900s. By reducing cover of competing perennial grasses and shrubs, livestock grazing historically made wildfire less frequent and contributed to development of higher juniper land cover type (e.g., see Miller and Rose 1999; Miller *et al.* 2008). Comparatively mild and wet conditions favorable to juniper establishment during the late 1800s and early 1900s probably contributed to the spread of junipers, which was rapid during that period of time (Miller et al 2008; Miller and Rose 1995). Juniper expansion has been documented in relict ungrazed areas as well as in grazed areas (Soule and Knapp 1999) suggesting that other factors could have contributed to the expansion, although the ungrazed site was probably not exposed to greater fire frequency than the grazed sites. Three phases of increasing juniper expansion into sagebrush steppe (Phase I-III) are recognized (Miller *et al.* 2005). They are distinguished by characteristics including juniper land cover type on the site and the degree of annual leader growth on individuals (which declines as junipers age).

In expansion areas, as the junipers increase in land cover type, perennial grass and shrub land cover type decreases in the intervening spaces, which may lead to increased propensity to soil erosion especially on sloping sites after a fire (Figure 4-1). Juniper ecological sites, especially those with pre-settlement juniper, tend to be on rocky sites with very thin eroded soils, which are less subject to cheatgrass conversion or to severe erosion after wildfire.

Avian species richness increases in the early phases of juniper expansion into sage steppe, peaks in Phase I to early Phase II and decreases in the later phases. Old growth junipers (established prior to about 1850), which have very irregular crowns and typically have an abundance of dead wood, support high numbers and densities of cavity nesting and tree nesting avian species. Several of these avian species occur in greater numbers in old growth (pre-settlement) woodlands compared to post-settlement woodlands (Miller *et al.* 2005b). Pre-settlement stands of western and Utah junipers typically occupied "fire-safe" sites such as rocky areas, which lack sufficient fuel to carry a damaging fire.

Except for large individuals in relatively fire safe sites, both Utah and western junipers are killed outright by fire and do not resprout. For these species to regenerate, seeds must survive a fire or disperse back into a burned area. Establishment typically takes place under a shrub (Miller *et al.* 2005). All of this means that a certain amount of time must elapse to allow post-fire reestablishment of shrubs and seed dispersal of junipers to take place before western or Utah junipers can begin to reoccupy a burned site. Low elevation sites into which junipers have expanded are vulnerable to cheatgrass invasion which can ultimately lead to a type conversion and soil loss (Figure 4-1). Post-fire recovery of native vegetation in higher elevation stands is more rapid and these stands are less susceptible to cheatgrass invasion and type conversion (Figure 4-1) Because of their aesthetic value and value as wildlife habitat, old growth stands of junipers are considered valuable and receive management attention. Restoration of western and Utah juniper stands is addressed in detail in Miller *et al.* (2005), Miller *et al.* (2007b), and Tausch *et al.* (2009), with special attention to analyzing the site and its potential. Restoration of stands in which junipers have increased to undesirable levels is possible and entails thinning of trees (often using chain saws) and possible reseeding of suitable native grass and shrub species. Combinations of cutting and fire may also be effective. Fire alone can be effective in Phase I and early Phase II stands if cover of native grasses is sufficient to support regeneration of grass cover. However, use of fire to thin post-settlement junipers that have infilled within or adjacent to an old-growth stand would have to be implemented with caution. This is because the increased tree density within or adjacent to old growth stands creates the potential to fuel stand-replacing wildfire, killing the old growth trees.



Notes:

1. Applies to post-settlement stands (<150 years) typically on mountain big sagebrush sites.
2. Where old growth trees are present (.150 years), tree thinning should focus on surrounding younger trees that could carry a stand-replacing fire.

Primary sources are Miller et al. 2005; Tausch et al. 2009.

Figure 4-1. Western Juniper and Utah Juniper Conceptual Model

5 Management Questions

Where are the Juniper Stands?

The juniper within the NGB consists mainly of Utah and western juniper. As noted above, the distinction between western juniper and Utah juniper is not completely reliable in the ReGAP and LANDFIRE coverages in the western part of the ecoregion where the two species overlap. The two species were combined for the analysis against change agents and were to be referred to as combined juniper. Figure 5-1 shows the location of combined juniper within the NGB. Combined juniper is mostly concentrated in the southeastern part of the ecoregion and along the northwestern and western periphery. Juniper is also scattered along the southern portion of the ecoregion and there are a few isolated patches in the center within the Owyhee and Steens Mountains.

Utah Juniper

Utah juniper predominates in south-central and southeastern Idaho, northeastern Nevada, and northwestern Utah according to sources including Griffin & Critchfield 1972; Charlet 1996; Miller *et al.* 2005; and Tausch *et al.* 2009. Figure 5-2 shows the location of Utah juniper within the ecoregion. The majority of the Utah juniper is located in the tri-state region, especially along the Grouse Creek Mountains.

Western Juniper

Western juniper predominates in the California and northwestern Nevada portions of the ecoregion as well as in Oregon and in the Owyhee in southwestern Idaho according to the sources cited above. There is evidently little or no Utah juniper in these areas. Figure 5-2 shows the location of western juniper within the ecoregion. Western juniper is located along the Owyhee Mountains, Steens Mountain and the periphery of the northwestern part of the ecoregion.

Pre-settlement Juniper vs. Expanding Juniper

Juniper stands fall into two classes: (1) historic (pre-settlement) stands and (2) areas into which Utah or western juniper have expanded. These will be discussed separately.

Pre-settlement stands. Because of their aesthetic value and value as wildlife habitat, old growth stands of junipers are considered valuable and receive management attention. In much of the ecoregion these stands tend to be in relatively “fire-safe” sites where soil conditions limit the development of dense grasses or a dense woody vegetation cover that can carry fire. The LANDFIRE BpS model attempts to show where juniper was located prior to European Settlement. However, until an independent data source is available for comparison, these results must be regarded with caution given the need for on-the-ground investigation in confirming the location of pre-settlement juniper and the lack of data to compare with the modeled result. It is recommended that on-the-ground investigation be conducted when possible as part of step-down analyses in order to build an understanding of pre-settlement juniper locations for management at the resource area level.

Juniper expansion areas. The juniper expansion areas were formerly vegetated by shrub-steppe into which junipers have been able to expand due to a variety of factors discussed above, most notably a decrease in fire frequency and intensity allowing fire-intolerant junipers to expand their distribution. Fire was the natural control on juniper expansion into sagebrush steppe. However, areas into which junipers have expanded typically lack the natural factors that reduce the burn probability in pre-settlement stands and are therefore vulnerable to severe wildfire. Areas into which junipers have expanded are receiving management attention in attempts to make them less fire prone and improve habitat value by reducing the density of junipers as well as encouraging reestablishment of native perennial grasses and shrubs. The management emphasis on reducing fire danger in juniper expansion areas is related to the ability of dense juniper land cover type in expansion areas to carry very hot and damaging wildfires compared to fire intensity possible in pre-existing shrub-steppe vegetation.

Density

Figure 5-3 show the relative density of combined juniper based on a moving window analysis. Three areas stand out as large and dense locations of juniper in the NGB: Steens Mountains, Owyhee Mountains and the area around the border of northeastern Nevada / northwestern Utah (Grouse Mountains).

Where do Juniper stands interact with Change Agents?

Development

The distance to development was determined by merging many types of development into one spatial layer and then determining the Euclidean distance to from juniper to any type of development. The development spatial layer consisted of:

- Ski resorts,
- TIGER roads,
- Railroads,
- Mines,
- Agriculture,
- Developed areas,
- Ruby Pipeline (NV only),
- Land Treatments,
- Wind Turbines, and
- Transmission lines.

Figure 5-4 displays the results of determining the average distance by 4km grid from juniper to one of the listed types of development. The most prominent type of development interacting with juniper is roads. The TIGER (**T**opologically **I**ntegrated **G**eographic **E**ncoding and **R**eferencing) roads spatial layer (US Census) is very detailed and includes some off highway vehicles, 4WD forest service roads, BLM routes along with urban roads and major highways. Throughout most of the ecoregion, roads are found within 1,000 m of juniper, and often at much less distances. Few juniper areas, scattered around the ecoregion, have roads greater than 1 km away."

Disease

Disease does not appear to be a significant change agent in juniper stands of either species.

Wildfire

FSIM burn probability data was modeled by the USGS and USFS and was used to determine wildfire risk to juniper within the ecoregion. Figure 5-5 shows the burn probability (low, moderate and high) for juniper range by the most common value within the 4km grid analysis unit. It also includes the GeoMAC fire perimeters for the past two years to show where recent fire activity has occurred. The highest burn probability juniper areas are within southeastern Idaho, northeastern Nevada and Utah. The areas with the lowest burn probability are in the western portions of the ecoregion including Oregon, California, and western Nevada. In the past year, the three largest fires in the ecoregion (Long Draw, Holloway and Rush) contained some juniper (Rush and Holloway) but fairly low densities. Most of the fires that occurred in the highest density areas were fairly small in size such as the Red Butte fire in the Grouse Creek Mountains of Utah (1,200 ac).

Grazing

Both juniper species have expanded their distributions into sagebrush steppe since the mid-1800s and especially during the early 1900s as discussed above under the conceptual model. By reducing cover of competing perennial grasses and shrubs, livestock grazing historically made wildfires (which tend to kill junipers outright) less frequent and contributed to development of higher juniper land cover type (e.g., see Miller and Rose 1999; Miller *et al.* 2008). Several other factors discussed above probably also contributed to juniper expansion. On pre-settlement juniper sites of conservation concern livestock grazing may not have a substantial effect because of the sparseness of the vegetation on these sites and soil conditions that do not favor a prevalence of grasses or other fine fuels that could lead to burning of presettlement junipers.

How will Juniper be impacted by modeled Climate Change?

USFS Climate Modeling

The USFS Moscow Forestry Sciences Laboratory developed climate models for various tree species modeling the effects of climate change in various future scenarios. The climate change modeling uses three different global climate models (Canadian Center for Climate Modeling and Analysis [CGCM3], Geophysical Fluid Dynamics Laboratory [GFDLCM21] and Hadley Center/World Data Center [HADCM3] for a total of seven climate scenarios (Table 5-1). The seven scenarios were added together for the 2030 and 2060 future time frames to create an average climate scenario that can be used without having to the reader to pick a scenario. The models produce a viability that ranges from 0 – 1.0 with species with a viability below 0.5 having little chance of a species surviving (Crookston *et al.* 2010).

Table 5-1 Description of Climate Scenarios used in USFS Climate Modeling (Crookston et al. 2010)

Climate Scenario	Description
A2	High emissions, regionally diverse world, rapid growth
A1B	Intermediate emissions, homogeneous world, rapid growth
B1	Lower emissions, local environmental sustainability
B2	Lowest emissions, global environmental sustainability

The climate change modeling done by the USFS was completed for individual species (Utah and western juniper) while the analysis done against other change agents were completed using combined juniper. The climate model results were not combined together but kept separate to show what the original modeling depicted.

Figure 5-6 and 5-9 shows the current viability for Utah and western juniper within the NGB based on the modeling done by the USFS (Crookson *et al.* 2010). Figure 5-7 and 5-10 show the results of the average of the seven climate scenarios at the year 2030 timeframe and Figure 5-8 and 5-11 shows the average of the 2060 timeframe.

Although there is considerable uncertainty in individual climate change projections, these results suggest a continued viability of juniper in the ecoregion but that areas where viability is highest will shift around and, in many cases, away from areas where junipers are abundant into areas where junipers are currently sparse or absent and that consequent shifts in juniper distribution would be expected to gradually follow, at least in areas where barriers such as large areas of inhospitable habitat (e.g., low saline areas, extensive agricultural areas) do not inhibit dispersal.

Where are intact Juniper stands (minimally impacted by Human Activities)?

Intactness is a difficult term to define for juniper since the expanding junipers may occur in areas with high burn probabilities which will score low in intactness using the methodology used below. To derive where intact juniper stands (minimally impacted by human activities) are located, the following two layers were classified and combined: Distance to Development and Burn Probability. Using the values as classified in Figures 5-3 and 5-4, the results were reclassified 1, 2 or 3 (e.g., 1 would be the highest burn probability or closest to development while 3 would be the lowest burn probability or furthest from development. Using the raster calculator, the values were combined to derive a score from 2 to 6 and then averaged within an analysis unit (4 km grid). A stretched raster was used to show the range of values from the lowest 2 (orange) to the highest 6 (green).

One factor when determining the intact stands is determining where the historic stands of juniper are and where the juniper may be expanding into other areas. The LANDFIRE BpS model attempts to show where juniper was located prior to European Settlement. Until an independent data source is available for comparison, these results must be regarded with caution given the need for on-the-ground investigation in confirming the location of pre-settlement juniper and the lack of data to compare with the modeled result. It is recommended that on-the-ground investigation be conducted when possible as part of step-down analyses in order to build an understanding of pre-settlement juniper locations for management at the site specific level. A figure showing the BpS for juniper wasn't included because of the uncertainty it presents.

Distance from roads can be used as an indicator of the intactness of well-established juniper stands existing today, given that roads serve as vectors for disturbance (e.g., spread of invasive species, effects on wildlife). Figure 5-12 shows the southeastern portion of the ecoregion to be less intact due to high density of roads and high burn probability while the western side of the ecoregion is much more intact for the opposite reason.

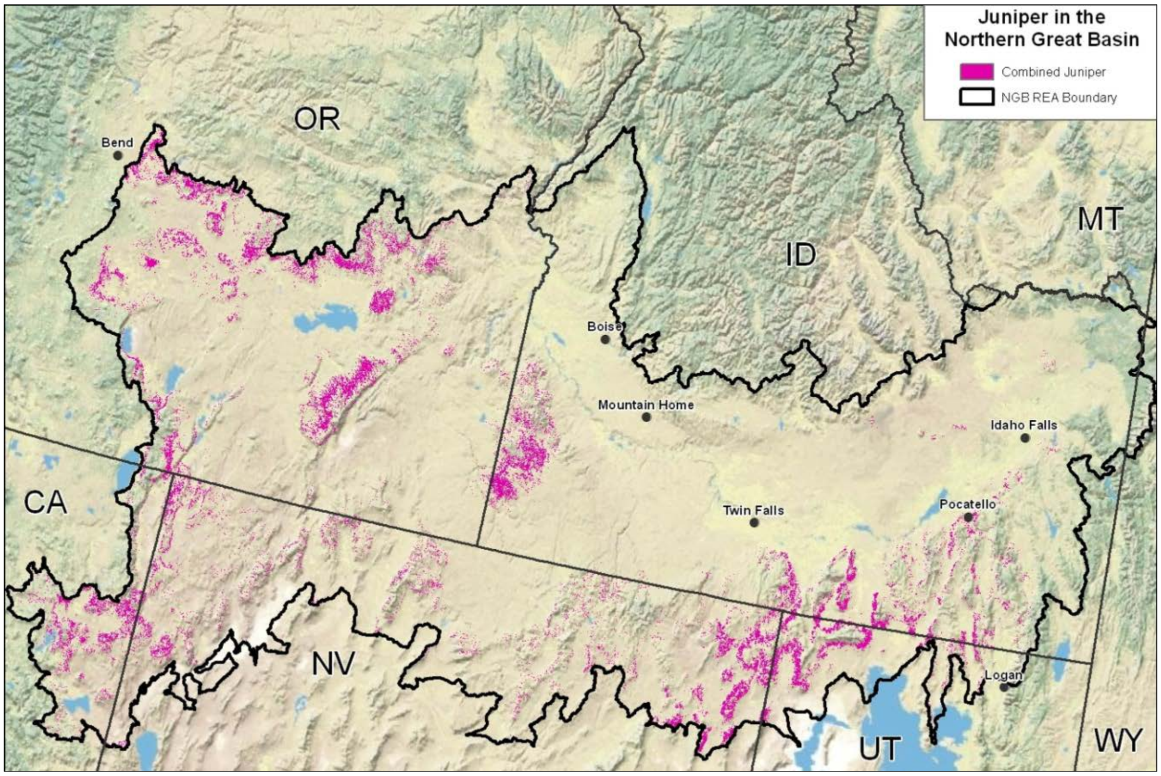


Figure 5-1. Locations of Combined Juniper within the NGB

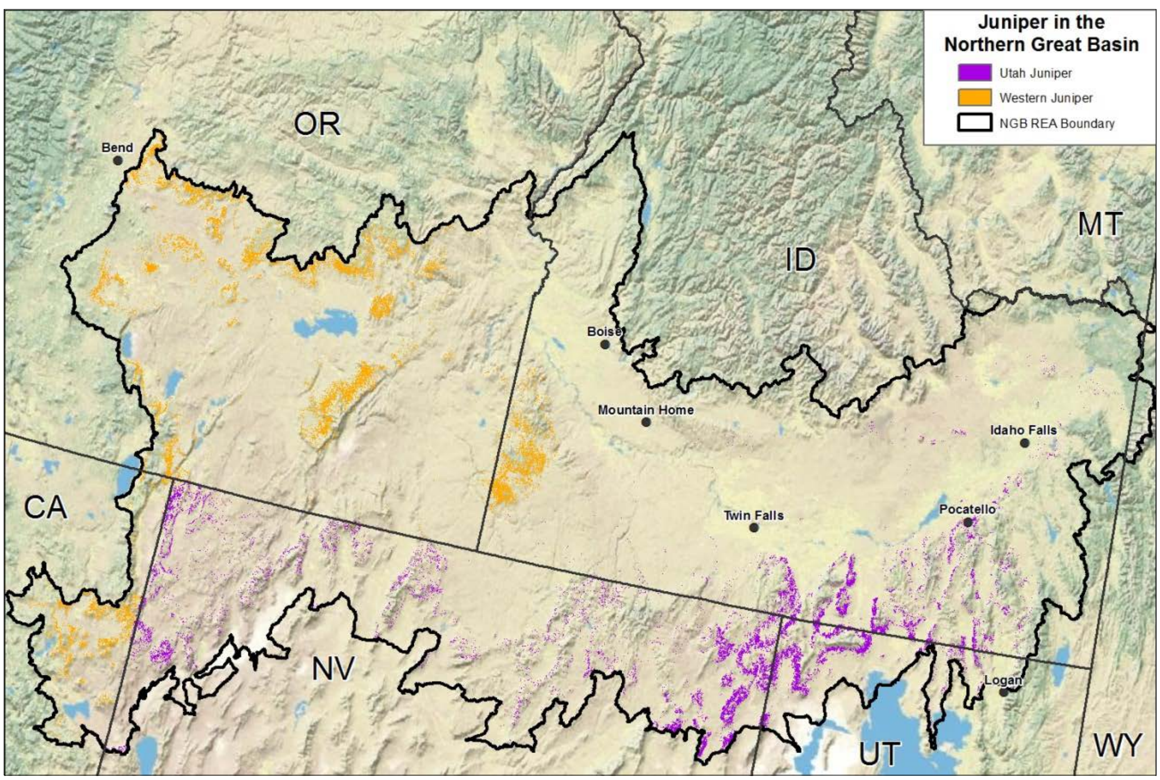


Figure 5-2. Locations of Western and Utah Juniper within the NGB

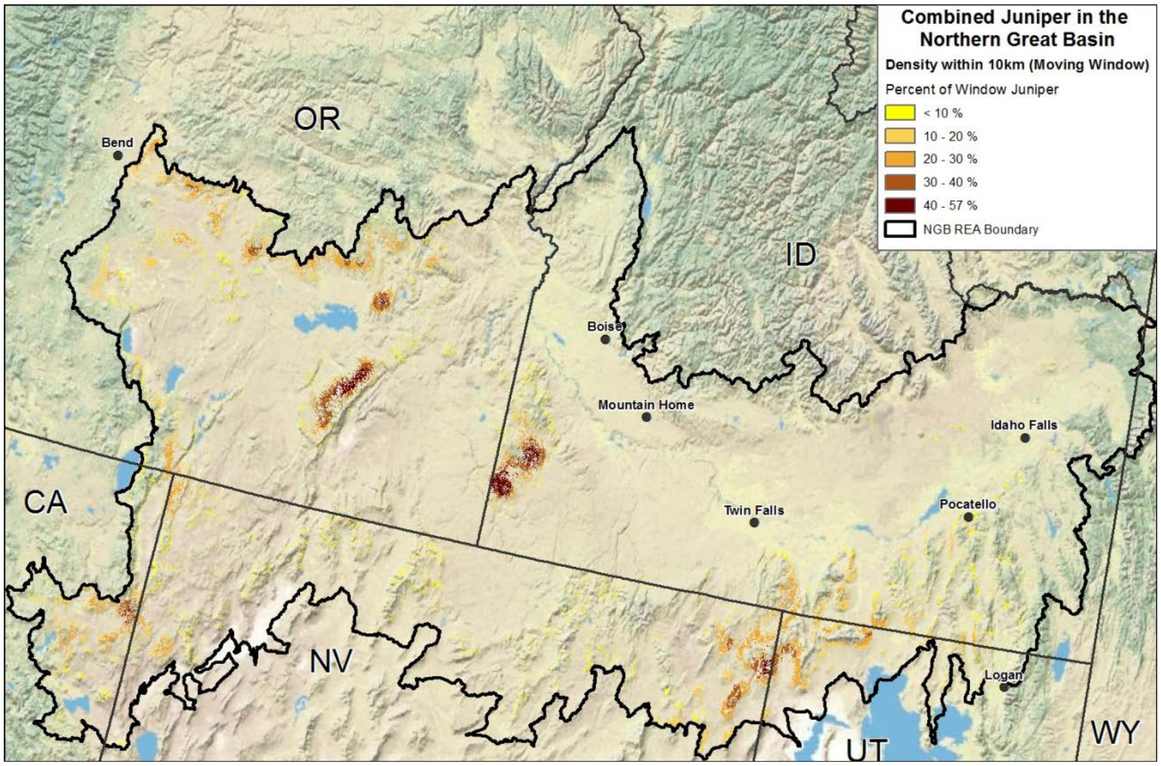


Figure 5-3. Density of Juniper within 10km of Moving Window Analysis

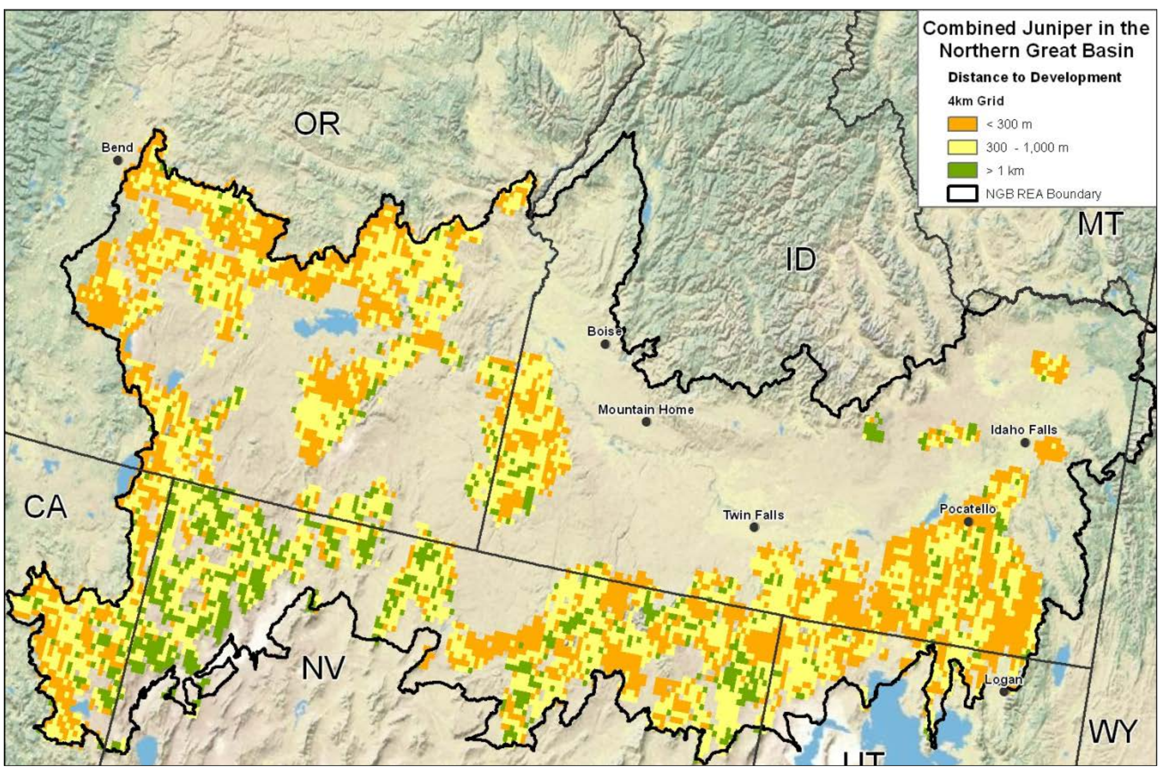


Figure 5-4. Distance to Development for Juniper in the NGB

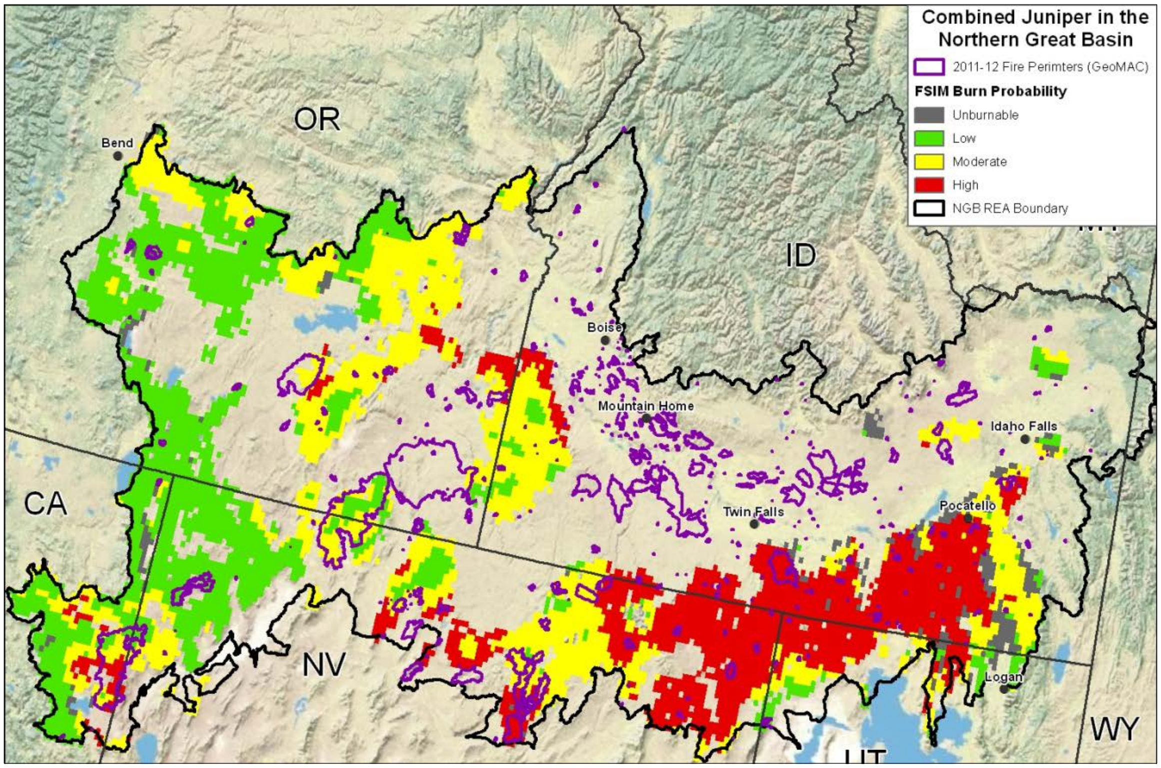


Figure 5-5. FSIM Burn Probability and Recent Fire Perimeters near Juniper

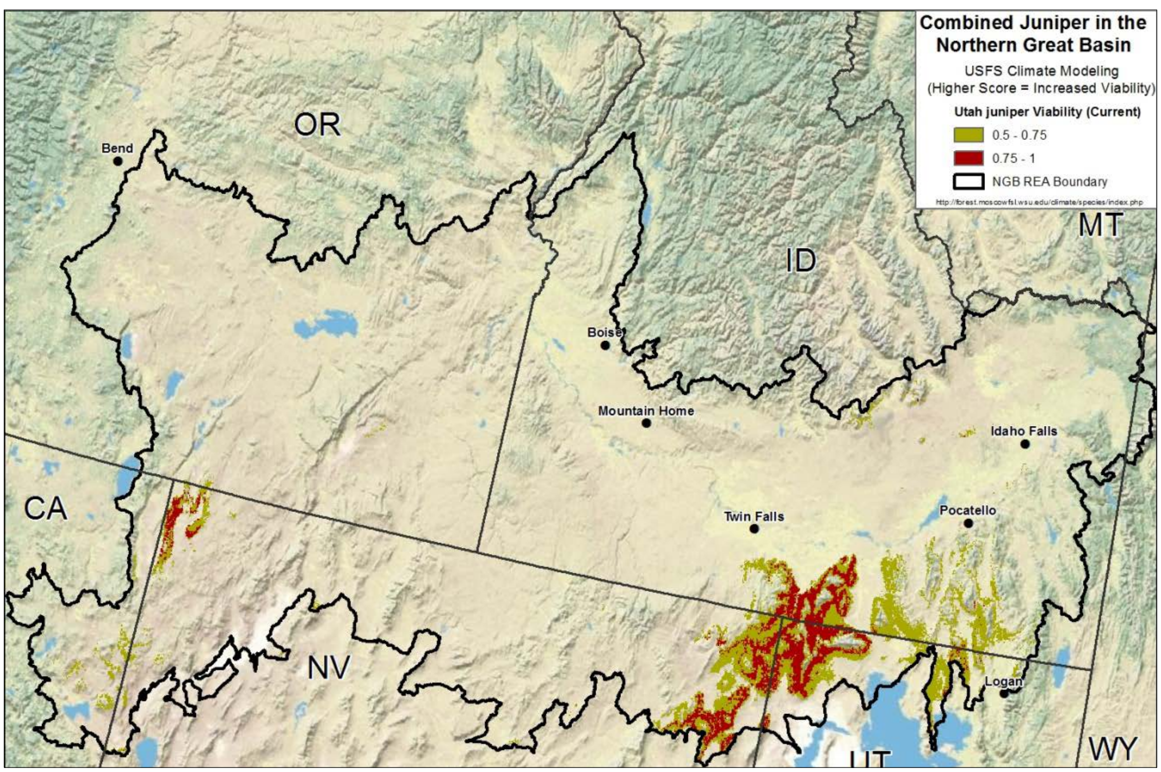


Figure 5-6. USFS Climate Modeling Utah Juniper Current Viability

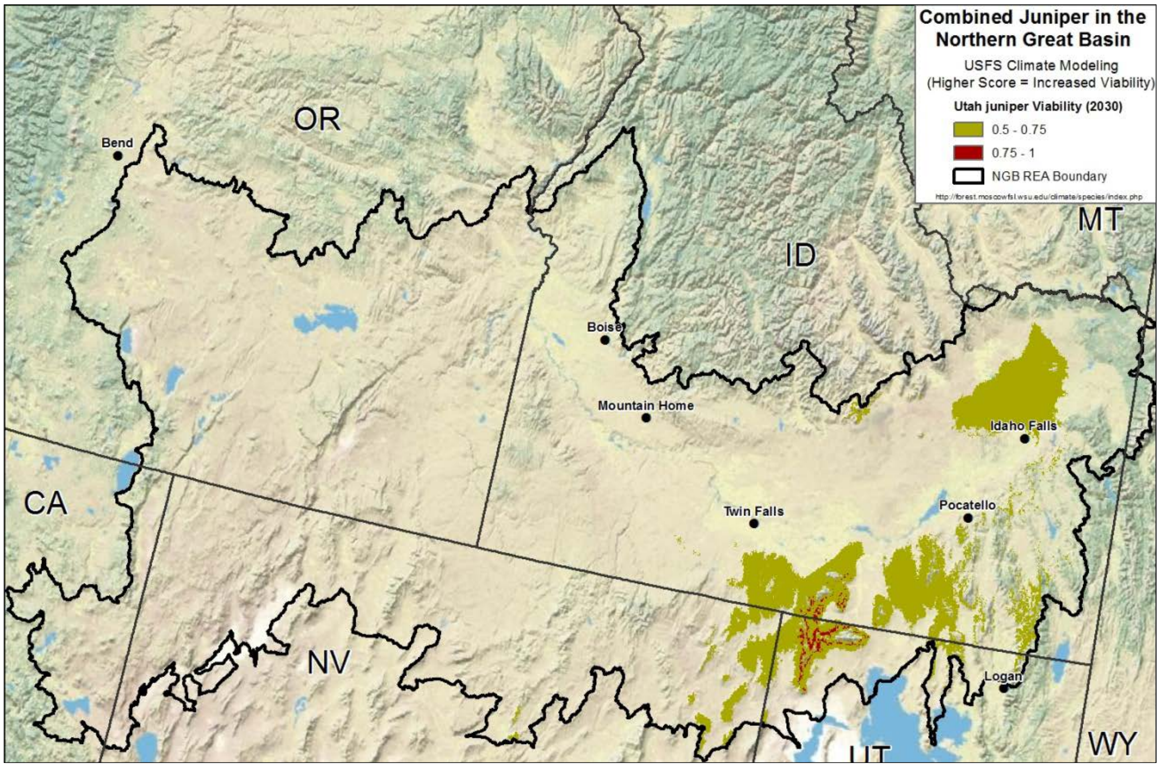


Figure 5-7. USFS Climate Modeling Utah Juniper 2030 Viability

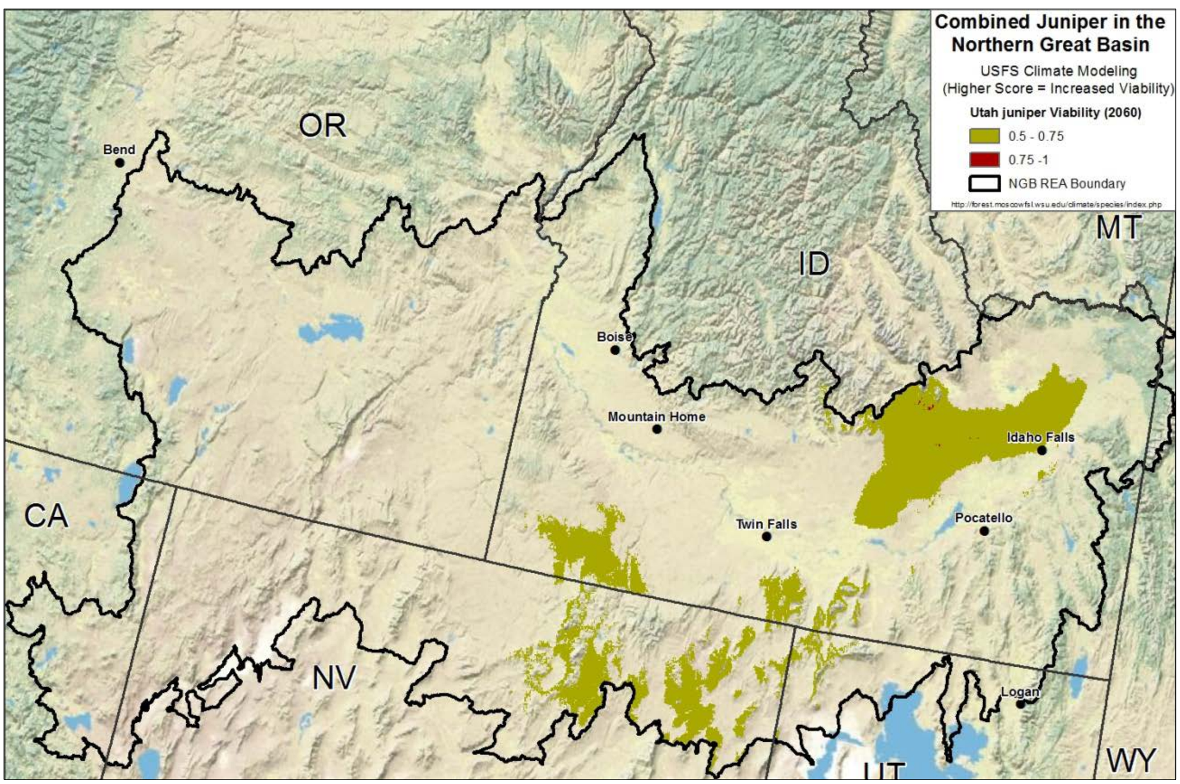


Figure 5-8. USFS Climate Modeling Utah Juniper 2060 Viability

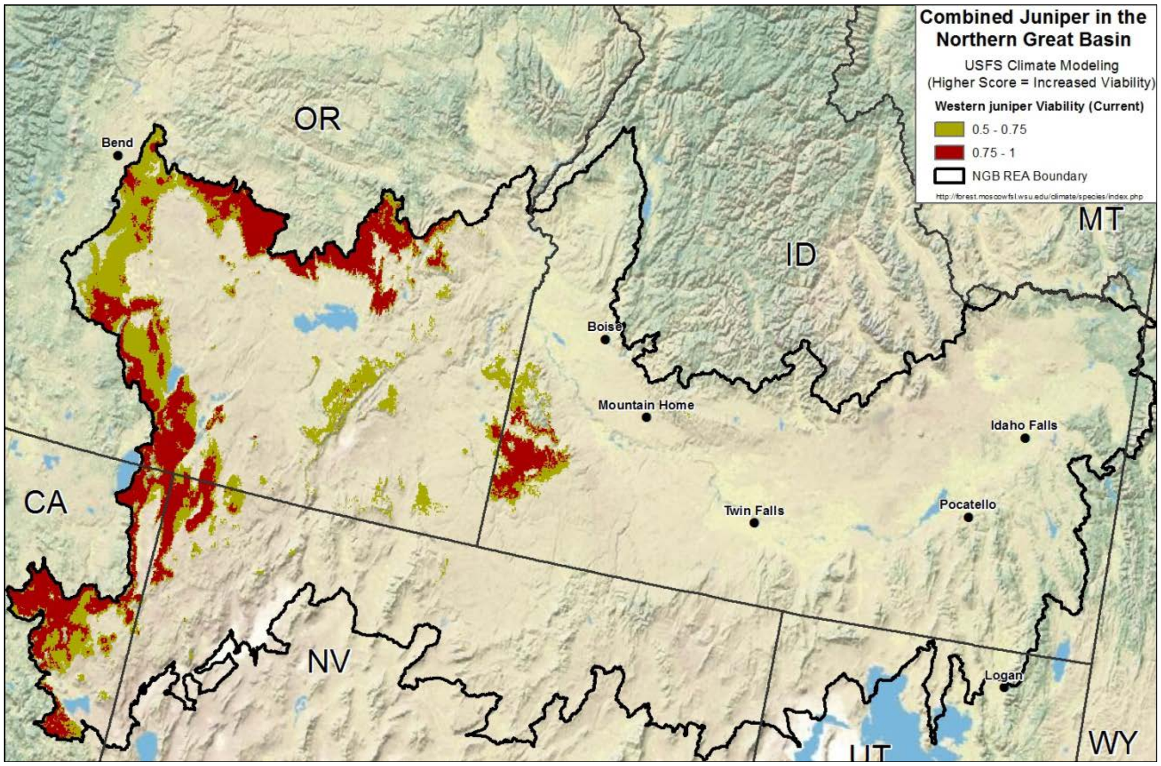


Figure 5-9. USFS Climate Modeling Combined Juniper Current Viability

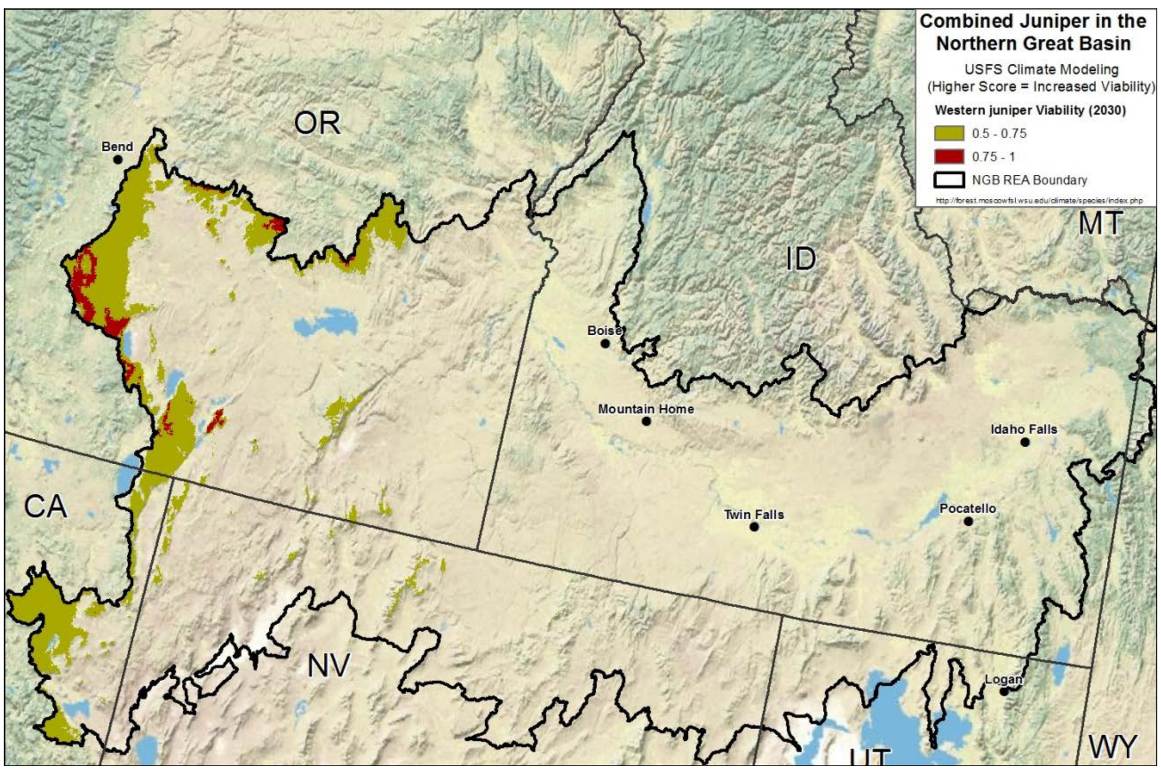


Figure 5-10. USFS Climate Modeling Western Juniper 2030 Viability

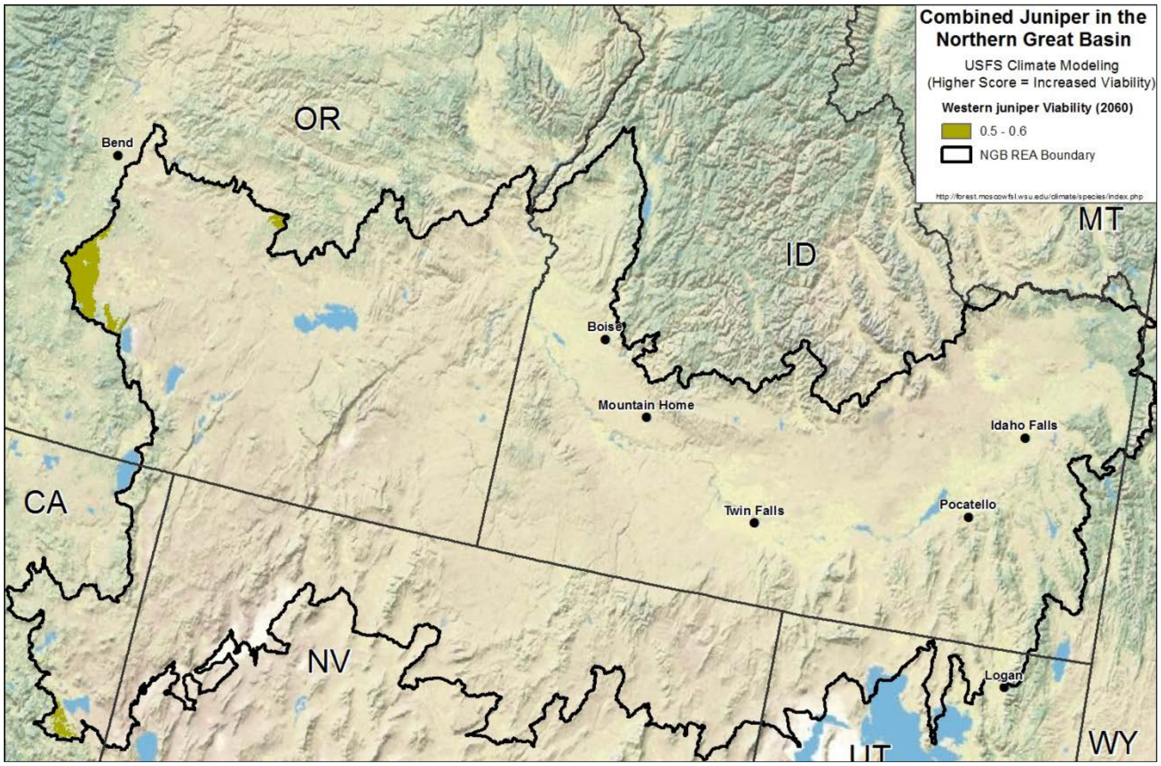


Figure 5-11. USFS Climate Modeling Western Juniper 2060 Viability

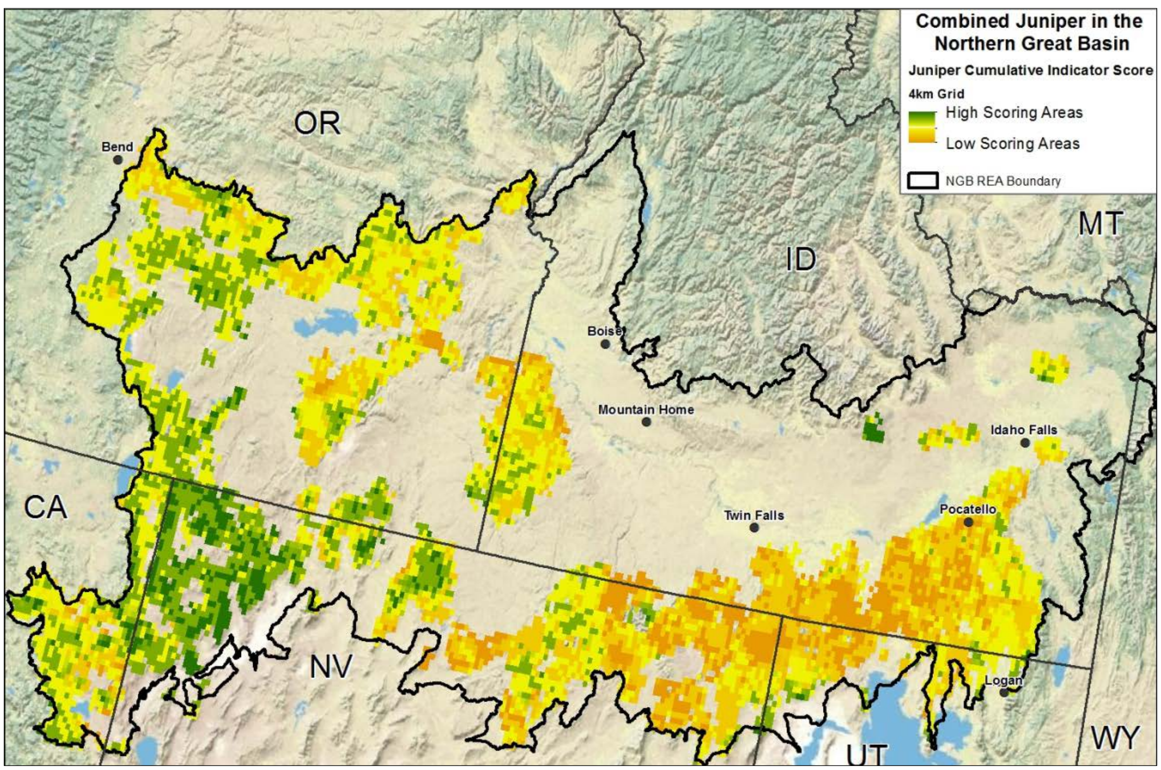


Figure 5-12. Cumulative Indicator Score for Combined Juniper

6 Summary of Juniper in the NGB

Both western juniper and Utah juniper have expanded their ranges dramatically since European settlement mostly into areas previously dominated by different species of sagebrush. Many factors including livestock grazing, fire suppression, and decades of favorable conditions for juniper establishment are believed to have contributed to that range expansion. Efforts are underway to manage and reduce the prevalence of junipers in areas where sagebrush is a desired habitat dominant. At the same time areas of pre-settlement juniper, which are believed to be very limited in areal extent, are of ecological interest and of management and conservation concern. At present these areas cannot be identified without use of on the ground methods and therefore their identification would have to be performed at more local scales.

Utah juniper and western juniper were used for juniper occurrence. Utah juniper is mostly concentrated in the southeastern part of the ecoregion along the Grouse Creek Mountains whereas Western juniper is along the northwestern and western periphery with isolated patches in the Owyhee and Steens Mountains. Juniper is also scattered along the southern portion of the ecoregion. Three areas stand out as large and dense locations of juniper in the NGB: Steens Mountains, Owyhee Mountains and the area around the border of northeastern Nevada / northwestern Utah (Grouse Mountains).

The distance to development was determined by merging many types of development (e.g., ski resorts, roads, agricultural, development, transmission lines). The most prominent type of development interacting with junipers is roads. Throughout most of the ecoregion junipers are less than 300 m and 300 – 1,000 m from development. Few juniper stands, especially in the south and southwest, have development >1 km away.

Low elevation sites into which junipers have expanded are vulnerable to cheatgrass invasion which can ultimately lead to a type conversion and soil loss. Disease does not appear to be a significant change agent in juniper stands of either species.

Except for large individuals in relatively fire safe sites, both Utah and western junipers are killed outright by fire and do not resprout. The highest burn probability juniper areas are within southeastern Idaho, northeastern Nevada and Utah. The areas with the lowest burn probability are in the western portions of the ecoregion including Oregon, California, and western Nevada.

Livestock grazing is common in the ecoregion and approximately70 percent of the REA is under grazing allotments. Livestock grazing is thought to be a potential causal mechanism for juniper expansion. Livestock grazing reduces the cover of competing perennial grasses and shrubs and reduces the fuel load and suppressed wildfires (which tend to kill junipers). In addition, livestock grazing historically made wildfires less frequent and contributed to development of higher juniper land cover type (e.g., see Miller and Rose 1999; Miller *et al.* 2008).

Although there is considerable uncertainty, the results from the individual climate change projections suggest a continued viability of juniper in the ecoregion. However, the areas where viability is highest will shift around and, in many cases, away from areas where junipers are abundant into areas where junipers are currently sparse or absent. A shift in juniper distribution would be expected to gradually follow, at least in areas where barriers such as large areas of inhospitable habitat (e.g., low saline areas, extensive agricultural areas) do not inhibit dispersal.

Intact juniper stands occur in the western portion of the ecoregion due to fewer roads and lower burn probability whereas the southeastern portion of the ecoregion is less intact due to the high density of roads and high burn probability.

7 References

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Aspen
Coarse Filter Conservation Element Package

1 Conservation Element Description

Quaking aspen (*Populus tremuloides)* is one of the most widely distributed tree species in the U.S. and aspen forests rank among the most biologically diverse plant communities across the intermountain region of western North America (Strand *et al.* 2009). This forest system includes upland forests and woodlands dominated by aspens without a significant conifer component (<25 percent relative tree cover). This cover type usually occurs within a mosaic of many plant associations and may be surrounded by a diverse array of other systems, including grasslands, wetlands, meadows, coniferous forests, etc. The understory structure may be complex with multiple shrub, forb, and herbaceous layers or simple and dominated by grasses (Faber-Langendoen 2011). Aspen stands provide habitat for a diversity of species and are one of the few broad-leaved trees that can grow at high elevations.

Aspen stands can occur on gentle to moderate slopes, in swales, or on level sites. At lower elevations, occurrences are found on cooler, north aspects and mesic sites. Elevations generally range from 1,493 to 2,743 meters (4,900-9,000 feet), but occurrences can be found at lower elevations in some regions. Soils are usually deep and well developed with rock often absent from the soil. Soil texture ranges from sandy loam to clay loams. The climate preferred by aspen stands is temperate with a relatively long growing season, typically cold winters and deep snow. Aspen occurrences are primarily limited by adequate soil moisture required to meet high evapotranspirative demand, length of growing season, and temperatures. Mean annual precipitation where these systems occur is generally greater than 38 centimeters (15 inches) and typically greater than 51 centimeters (20 inches), except in semi-arid environments where occurrences are restricted to mesic microsites such as seeps or areas below large snow drifts. Recent declines of aspen stands have resulted in the need for increased aspen management and restoration efforts.

2 Conservation Element 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 Conservation Element Distribution Mapping

3.1 Data Identification

The major datasets identified to map the distribution of the aspen conservation element were the ReGAP land cover and LANDFIRE datasets. The datasets used for the aspen coarse filter are displayed in Table 3-1. The ReGAP and LANDFIRE datasets consist of vegetative communities with corresponding codes. Table 3-2 lists the codes and class names for each of the data sources used to extract aspen stands.

Table 3-1. Data Sources for the Aspen Coarse Filter Conservation Element Distribution Mapping for the NGB Ecoregion

Data Required	Dataset Name	Source Agency	Type/Scale	Status	Use in REA
Terrestrial Systems					
Aspen Ecological Systems	Northwest ReGAP Southwest ReGAP	USGS	Raster (30m)	Acquired	Yes
	LANDFIRE EVT	LANDFIRE	Raster (30m)	Acquired	Yes
Aspen in Decline	Aerial Detection Surveys	USFS	Polygon	Acquired	Yes

Table 3-2. Vegetation Class Code and Name

Code	Data Source	Vegetation Class Name
4104	Northwest ReGAP	Rocky Mountain Aspen Forest and Woodland
4302	Northwest ReGAP	Inter-Mountain Basins Aspen-Mixed Conifer Forest and Woodland
S023	Southwest ReGAP	Rocky Mountain Aspen Forest and Woodland
S042	Southwest ReGAP	Inter-Mountain West Aspen-Mixed Conifer Forest and Woodland Complex
2011	LANDFIRE EVT	Rocky Mountain Aspen Forest and Woodland
2061	LANDFIRE EVT	Inter-Mountain Basins Aspen-Mixed Conifer Forest and Woodland

3.2 Distribution Mapping Methods

Southwest and Northwest ReGAP and LANDFIRE (in California) were used to map the distribution of aspen in the NGB ecoregion. This approach was used to maintain consistency with the Central Basin and Range REA. The selected vegetation communities in Table 3-2 were extracted using a GIS process model and merged together to show aspen locations within the ecoregion.

3.3 Data Gaps, Uncertainty, and Limitations

3.3.1 Data Gaps

Coverage of the datasets used in the analysis were generally complete across the ecoregion, which was a factor in their selection. Discontinuities between the LANDFIRE (California), Northwest ReGAP (OR, ID), and Southwest ReGAP (NV, UT) data sets across state lines do not appear to be a limitation with regard to this conservation element.

3.3.2 Uncertainty

Vegetation mapping at the Ecoregion scale is expected to contain errors that would be addressable through the use of higher resolution imagery and larger mapping scales coupled with local knowledge and ground truthing suitable for step-down analyses over smaller areas.

4 Conceptual Model

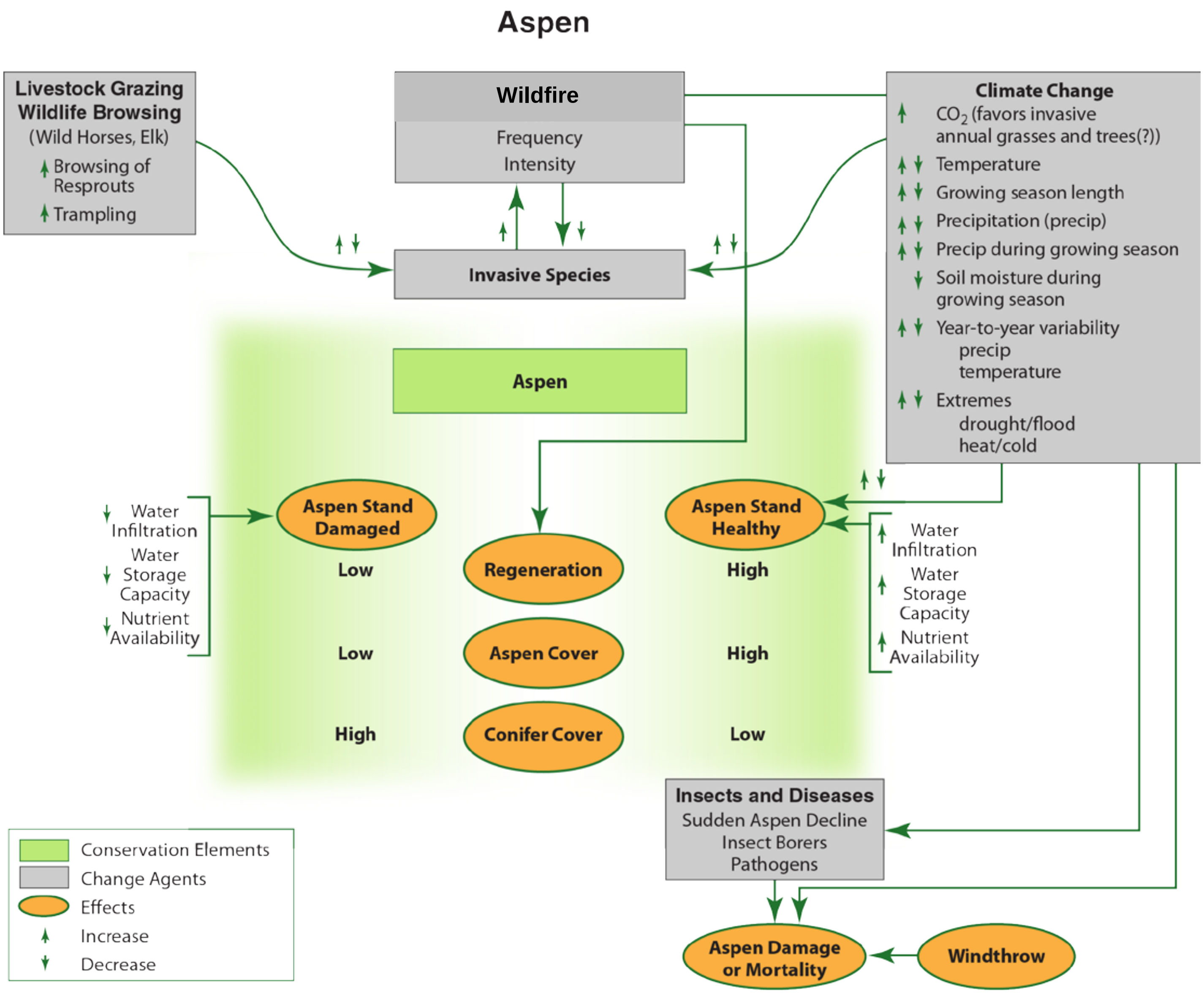
A conceptual model of aspen ecosystems in the ecoregion is presented in Figure 4-1. Change agents of greatest importance to this conservation element are climate change, insect and diseases, and wildfire and these change agents are intertwined in a complex feedback loop, the effects of some change agents affecting other change agents.

Occurrences of this system originate with and are maintained by stand-replacing disturbances such as avalanches, crown fire, insect outbreak, disease and windthrow, or clearcutting by man or beaver, within the matrix of conifer forests, with which they compete for space and resources (Faber-Langendoen 2011, Strand 2009). In recent years, many aspen stands have exhibited declines from the effects of several change agents and mortality from biotic vectors. Pathogens primarily infect clones already stressed by drought, insects, wind damage, heavy livestock and wildlife use, and similar factors. Increasing decline of the aspen populations was first noticed in Utah in the late 1990s (Huang and Anderegg 2012). In 2004, widespread branch dieback and mortality of whole portions of aspen stands occurred across Utah, Wyoming, Arizona and Colorado landscapes (Nijhuis 2008). This scale of aspen mortality had never been seen before and the phenomenon was named "sudden aspen decline," or SAD (Frey *et al.* 2004). Aspens grow in large clonal colonies that form from a single seedling and spread by root suckers. Natural disturbances such as wildfires or disease usually prompt clones to send up numerous fresh sprouts, but new growth is rare in Sudden Aspen Decline-affected stands. Studies suggest that numerous factors are contributing to the rapid decline in aspen stands (Huang and Anderegg 2012).

Several interacting factors have been pinpointed as causes of Sudden Aspen Decline in aspen stands including site-related (low elevations, south and southwest aspects, open stands); higher temperatures; and drought stress (Hogg *et al.* 2008, Rehfeldt *et al.* 2008, Worrall *et al.* 2008, Fairweather et al 2008, Worrall *et al.* 2010). The impacts of Sudden Aspen Decline were consistent with projected effects of climate change. The Intermountain Region (USDA Forest Service R4), that generally includes the NGB, experienced a significant drought from 1999-2004 immediately prior to the most recent episode of aspen dieback (Guyon and Hoffman 2011). Following this, surveys reported different patterns of aspen mortality, caused by a variety of damage agents (e.g., animals foraging on resprouts or seedlings, insects, diseases) and varying susceptibility of different stem sizes (Guyon and Hoffman 2011). Some stands experiencing dieback were still capable of regenerating although recruitment may be below the threshold suggested for successful aspen sustainment (O'Brien *et al.* 2010). Change agent effects can vary geographically as well depending upon the stability of aspen stands. For example, stands in Nevada are relatively stable and generally are not faced with conifer encroachment whereas in Utah, aspen are seral and undergo succession toward a conifer canopy (Guyon and Hoffman 2011).

According to the Idaho Department of Lands, aspen decline in southern Idaho is likely caused by a combination of factors including increased conifer encroachment due to fire suppression, diseases and insects, and heavy ungulate grazing on regenerating aspen trees.

Climate change, in particular hot and dry conditions, is thought to weaken the trees, making them more vulnerable to insect attack and disease, and at risk for Sudden Aspen Decline. Bronze poplar borer larva are known to weaken the trees and make the trees more susceptible to fungal infections, and bark beetles cut off the tree's nutrient supply (Nijhuis 2008). The physiological mechanisms of how drought induces Sudden Aspen Decline are currently being investigated (Huang and Anderegg 2012). Drought has been known to cause the loss of seral aspen stands and contribute to a decline in aspen regeneration and may continue to be an important factor in future mortality (Steed and Kearns 2010).



Aspen health: Healthy = Full aspen crowns with little to no die-off (<25% overstory mortality, <25% conifer cover);
Damaged = Dead or dying aspen stands with considerable to full overstory die-off and/or foliage loss (25-100% overstory mortality, <25% conifer cover.
(*Source:* Oukrop et al. 2011).

Figure 4-1. Aspen Conceptual Model

Without disturbances like wildfire aspen tend to decline under conifer encroachment. Fire suppression over decades allowed conifer spread with little opportunity for aspen regeneration. Aspen root systems can survive most wildfire and regenerate from sucker sprouts once conifer canopies are reduced. Following wildfires optimal conditions exist for aspen regeneration; the open areas that receive high light allow root suckers to resprout. Fire suppression in western forests has allowed unnatural encroachment by conifers, which has created dense canopies that reduce the ability for aspens to survive or regenerate. Because of recent widespread conifer mortality due to the bark beetle infestations, fuel loads are increasing, which could lead to more intense wildfires that aspen may not be able to survive. This would be exacerbated by drought or early snowmelt.

Invasive plant species, livestock grazing and wildlife browsing by elk, deer, bison and horses are also factors that affect aspen health and cover. Wildlife and livestock browsing on resprouts in particular may retard or prevent regeneration.

Future prediction of aspen distribution suggest the highest mortality will occur in the hottest and driest areas on south-facing slopes, trees at lower elevations are likely to decline, and those at higher elevations may be becoming weaker and sparser (Nijhuis 2008).

5 Management Questions

Where are the Aspen Stands?

Aspen

The aspen within the ecoregion are most concentrated within the southeastern part of Idaho and northeastern Nevada and along the periphery of the ecoregion border. The two vegetation types making up aspen are listed in Table 3-2, those being mixed conifer aspen and Rocky Mountain aspen. Figure 5-1 combines the two types of aspen into one class that will be used in further analysis.

Mixed Conifer Aspen and Rocky Mountain Aspen

The most prominent locations of mixed conifer aspen stands are in the southeastern section of Idaho (Figure 5-2) in the Portneuf, Bannock, Wasatch Ranges along with the Deep Creek and Grouse Creek Mountains. Mixed Conifer aspen appears to be the densest in the higher elevations (> 7,000 ft) within these ranges/mountains. The majority of the rest of the ecoregion is dominated by Rocky Mountain aspen vegetation type with the highest concentrations in southeastern Idaho.

Density

Figure 5-3 shows the relative density of aspen based on a moving window analysis. Some of the densest aspen stands can be found in the Sawtooth National Forest south of Twin Falls and the Portneuf Range east of Pocatello.

Where do Aspen stands interact with Change Agents?

Development

The distance to development was determined by merging many types of development into one spatial layer and then determining the Euclidean distance to from Aspen to any type of development. The development spatial layer consisted of:

- Ski resorts,
- TIGER roads,

- Railroads,
- Mines,
- Agriculture,
- Developed areas,
- Ruby Pipeline (NV only),
- Land Treatments,
- Wind Turbines, and
- Transmission lines.

Figure 5-4 displays the results of determining the average distance by 4km grid from aspen to one of the listed types of development. The most prominent type of development interacting with aspen is roads. The TIGER Topologically Integrated Geographic Encoding and Referencing) roads spatial layer (US Census) is very detailed and includes some off highway vehicles, 4WD forest service roads, BLM routes along with urban roads and major highways. Throughout most of the ecoregion aspen stands are less than 300 m or 300 – 1,000 m from development. Aspen stands in the southern ecoregion and a few stands in the north and northwest have development >1 km away.

Disease

The data source for disease affecting aspen was the USFS Aerial Disease Surveys. The main disease identified and mapped by the Aerial Disease Surveys was Sudden Aspen Decline. Using the location of the Sudden Aspen Decline affected aspen, the Euclidean distance spatial operation was used to calculate the distance from aspen stands. Figure 5-5 shows the average distance by 4km grid from aspen to aspen identified by Aerial Disease Surveys as being impacted by Sudden Aspen Decline. The areas that are closest to Sudden Aspen Decline areas are mostly in the periphery of the northern part of the ecoregion. The dense aspen areas within the southeastern parts of the Idaho and northeastern Nevada also have the majority of stands being in the 1 – 10 km distance from Sudden Aspen Decline stands. The part of the ecoregion that has the highest distance from aspen to Sudden Aspen Decline stands is the southern part of Oregon and the western part of Nevada. These areas also have fairly low density of aspen as displayed in Figure 5-3.

Wildfire

FSIM burn probability data was modeled by the USGS and USFS and was used to determine wildfire risk to aspen within the ecoregion. Figure 5-6 shows the burn probability (low, moderate and high) for aspen range by the most common value within the 4km grid. It also includes the GeoMAC fire perimeters for the past two years to show where recent fire activity has occurred. The areas where conifer is already present are also in the areas with the highest burn probability southeastern Idaho, northeastern Nevada and northwestern Utah. The areas with the lowest burn probability are on the periphery of the ecoregion and in southern Oregon and western Nevada. So, the threat from wildfire at present addresses losses of current aspen areas; however, this same wildfire risk in the long term will help retain aspen in the landscape. Most of the recent fire activity, in the densest stands of aspen (in the southeastern part of Idaho) has been fairly small in size compared to the large fires that occurred in 2012 such as the Long Draw, Holloway and Rush. The Minidoka Complex was the largest fire perimeter within dense aspen area with a burn area around 2,800 ac. Wildfire *per se* can have a renewing effect on aspen stands by killing competing shade-tolerant conifers and removing senescent aspen top growth, provided that browsing pressure from ungulates is moderated sufficiently to allow regrowth of aspen beyond the sapling stage.

Grazing

Livestock grazing is the most widespread land management practice in western North America and approximately 70 percent of the REA is under grazing allotments. Livestock grazing can affect aspen health and cover. Livestock browsing on resprouts may retard aspen regeneration and cause stress that may lead to Sudden Aspen Decline. In addition, trampling by cattle can cause soil compaction, reduce bank stability, widen channels, and increase groundwater depth that can directly and indirectly affect aspen. Managed livestock grazing is generally compatible with aspen occurrence. For example, Earnst *et al.* (2012) investigated aspen areas in the northwestern Great Basin in southeastern Oregon 12 years following cessation of <100 years of livestock grazing. The study showed that removing livestock from aspen woodlands in riparian and snow pocket areas resulted in an increase aspen shoots and small trees and created a structurally robust understory of native species (Earnst *et al.* 2012).

How will Aspen be impacted by modeled Climate Change?

USFS Climate Modeling

The USFS Moscow Forestry Sciences Laboratory developed climate models for various tree species modeling the effects of climate change in various future scenarios. The climate change modeling uses three different global climate models (Canadian Center for Climate Modeling and Analysis [CGCM3], Geophysical Fluid Dynamics Laboratory [GFDLCM21] and Hadley Center/World Data Center [HADCM3] for a total of seven climate scenarios (Table 5-1). The seven scenarios were added together for the 2030 and 2060 future time frames to create an average climate scenario that can be used without having to the reader to pick a scenario. The models produce a viability that ranges from 0 – 1.0 with species with a viability below 0.5 having little chance of a species surviving (Crookston *et al.* 2010).

Table 5-1 Description of Climate Scenarios used in USFS Climate Modeling (Crookston *et al.* 2010)

Climate Scenario	Description
A2	High emissions, regionally diverse world, rapid growth
A1B	Intermediate emissions, homogeneous world, rapid growth
B1	Lower emissions, local environmental sustainability
B2	Lowest emissions, global environmental sustainability

Figure 5-7 shows the current viability for aspen within the NGB based on the modeling done by the USFS (Crookson *et al.* 2010). Figure 5-8 shows the results of the average of the seven climate scenarios at the year 2030 timeframe and Figure 5-9 shows the average of the 2060 timeframe.

Although there is substantial uncertainty in individual projections, modeled climate change shows the potential for dramatic reduction in aspen viability by 2030 (Figure 5-7) and further reduction throughout the ecoregion by 2060 (Figure 5-8). The critical factor for aspen persistence is adequate summer soil moisture. Factors that could reduce summer moisture in the ecoregion's predominantly winter precipitation regime include decreasing overall precipitation, early melting of snowpack (e.g., due to spring rains at aspen elevations or higher), and increased evapotranspiration during summer (e.g., as a result of higher temperatures). Any factor leading to additional growing season water stress, especially when prolonged over periods of years would lead to increased susceptibility to insects and disease, leading to declines in aspen.

Where are intact Aspen stands (minimally impacted by Human Activities)?

To derive where intact aspen stands (minimally impacted by human activities) are located, the following three layers were classified and combined: Distance to Development, Burn Probability and Distance to Disease Stands. Using the values as classified in Figures 5-4, 5-5, and 5-6, the results were reclassified 1, 2 or 3 (e.g., 1 would be the highest burn probability, closest to development or closest to disease stand while 3 would be the lowest burn probability, furthest from development and furthest from a diseased stand). Using the raster calculator, the values were combined to derive a score from 3 to 9 and then averaged within an analysis unit (4 km grid). A stretched raster was used to show the range of values from the lowest 3 (orange) to the highest 9 (green).

Figure 5-10 shows a cumulative indicator score for aspen, with the highest scoring areas being in the western Nevada, southern Oregon, and southwestern Idaho portions of the ecoregion. Aspen stands tend to be smaller and further apart in the higher scoring portions of the ecoregion compared to mountain ranges in the southeastern Idaho, northeastern Nevada and along the western and northern ecoregion boundaries, where aspen is more prevalent. In general, the highest scoring areas have somewhat greater distance from development, greatest distance to diseased stands, and lowest burn probability compared to lower scoring areas. This portion of the analysis does not take into account climate change projections. Mixed conifer aspen stands could be considered less intact than Rocky Mountain aspen because without fire the shade tolerant conifers will eventually outcompete the aspen. However the mixed conifer aspen wasn't scored differently than Rocky Mountain aspen.

6 Summary of Aspen in the NGB

Across the intermountain region of western North America, aspen forests rank among the most biologically diverse plant communities (Strand *et al.* 2009). Aspen are one of the few broad-leaved trees capable of growing at high elevations and can also occur on a variety of terrain, from gentle to moderate slopes, in swales, or on level sites. Aspen occurrences are primarily limited by adequate soil moisture required to meet high evapotranspirative demand, length of growing season, and temperatures. Recent declines of aspen stands have resulted in the need for increased aspen management and restoration efforts.

Two vegetation types, mixed conifer aspen and Rocky Mountain aspen, were combined to make up one class for aspen occurrence. Aspen in the NGB have the highest concentration in the southeastern part of Idaho and northeastern Nevada and along the periphery of the ecoregion border. Some of the densest aspen stands can be found in the Sawtooth National Forest south of Twin Falls and the Portneuf Range east of Pocatello.

The distance from an aspen stand to development was determined by merging many types of development (e.g. ski resorts, roads, agricultural, development, transmission lines). The most prominent type of development interacting with aspen is roads. Throughout most of the ecoregion aspen stands are less than 300m or 300 – 1000m from development. Aspen stands in the southern ecoregion and a few stands in the north and northwest have development >1 km away.

The main disease affecting aspen is Sudden Aspen Decline. The areas that are closest to Sudden Aspen Decline areas are mostly in the periphery of the northern part of the ecoregion. The part of the ecoregion that has the highest distance from aspen to Sudden Aspen Decline stands is the southern part of Oregon and the western part of Nevada.

Aspen are somewhat adapted to wildfires such that there root systems can survive most wildfire and regenerate from sucker sprouts once conifer canopies are reduced. Wildfire *per se* can have a renewing effect on aspen stands by killing competing shade-tolerant conifers and removing senescent aspen top growth. Without wildfires aspen tend to decline under conifer encroachment. The highest burn probability aspen areas are within southeastern Idaho, northeastern Nevada and Utah. The areas with the lowest burn probability are on the periphery of the ecoregion and in southern Oregon and western Nevada.

Livestock grazing is common in the ecoregion and approximately70 percent of the REA is under grazing allotments. Livestock grazing can affect aspen health and cover. Livestock browsing on resprouts may retard aspen regeneration and cause stress that may lead to Sudden Aspen Decline. Trampling by cattle can cause soil compaction, reduce bank stability, widen channels, and increase groundwater depth that can directly and indirectly affect aspen. Managed livestock grazing is generally compatible with aspen occurrence.

Climate change, in particular hot and dry conditions, is thought to weaken the trees, making them more vulnerable to insect attack and disease, and at risk for Sudden Aspen Decline. Modeled climate change shows the potential for dramatic reduction in aspen viability by 2030 and further reduction throughout the ecoregion by 2060. The critical factor for aspen persistence is adequate summer soil moisture.

Aspen stands tend to be smaller and further apart in the intact aspen stands which occur in western Nevada, southern Oregon, and southwestern Idaho portions of the ecoregion. Aspen is more prevalent in the lower scoring areas or less intact areas, which occur in the mountain ranges in southwestern Idaho, northeastern Nevada and along the western and northern ecoregion boundaries.

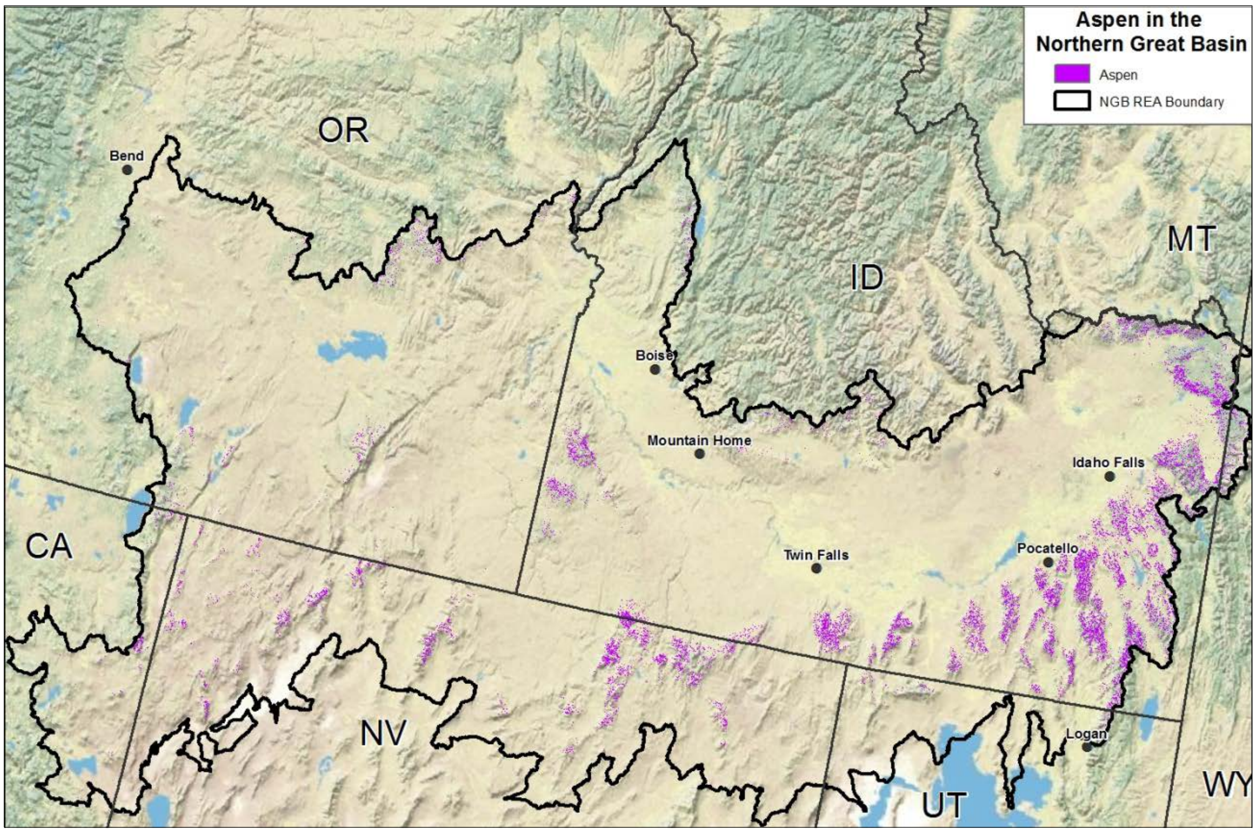


Figure 5-1. Aspen Locations within the NGB.

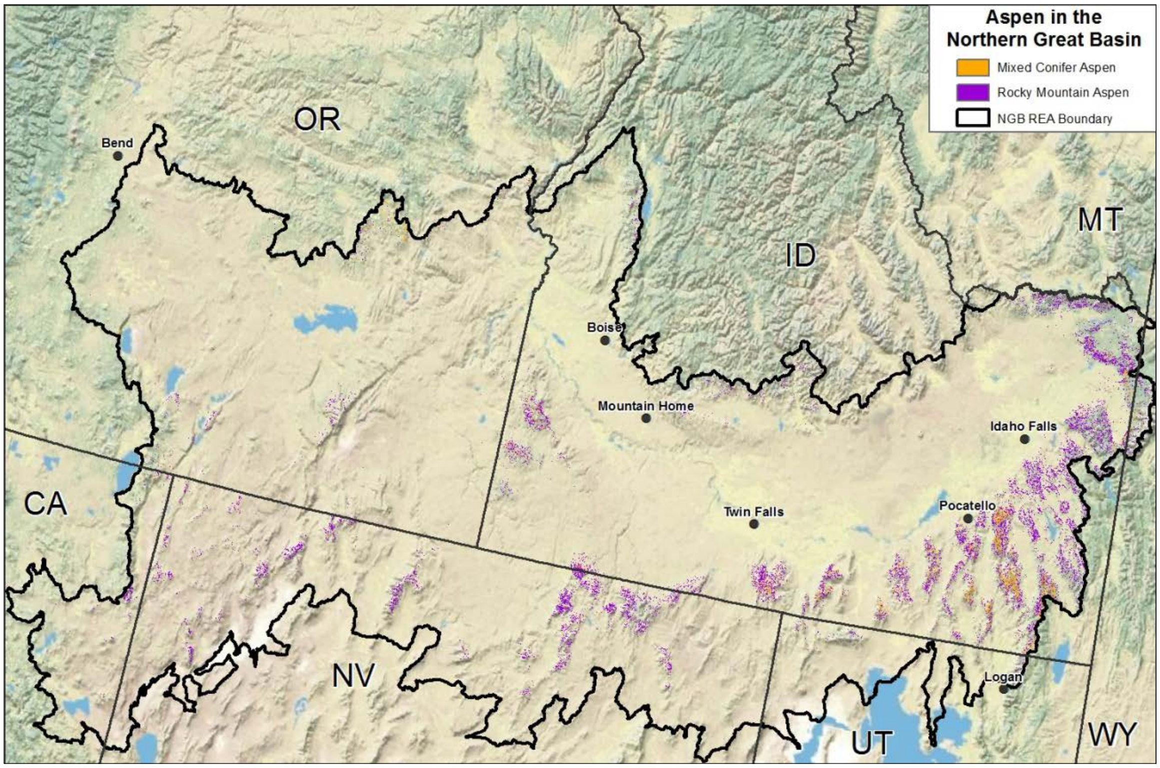


Figure 5-2. Rocky Mountain Aspen and Mixed Conifer Locations within the NGB.

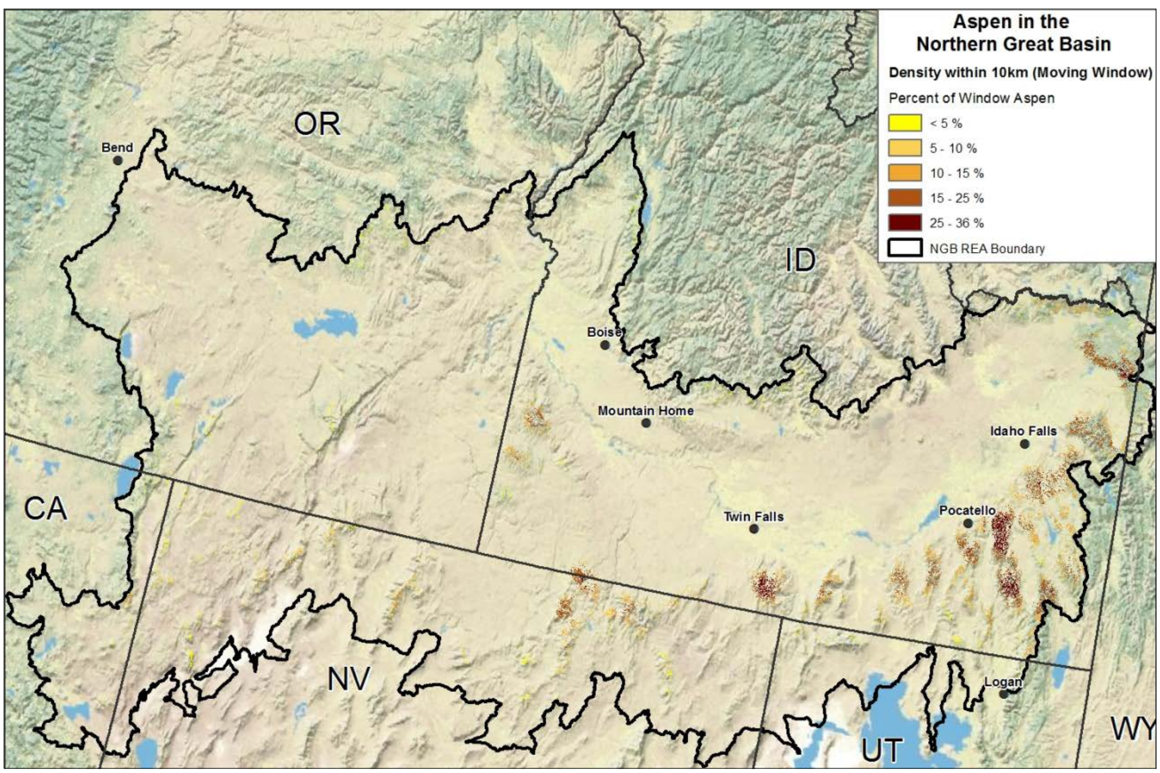


Figure 5-3. Density of Aspen within 10km of a Moving Window Analysis

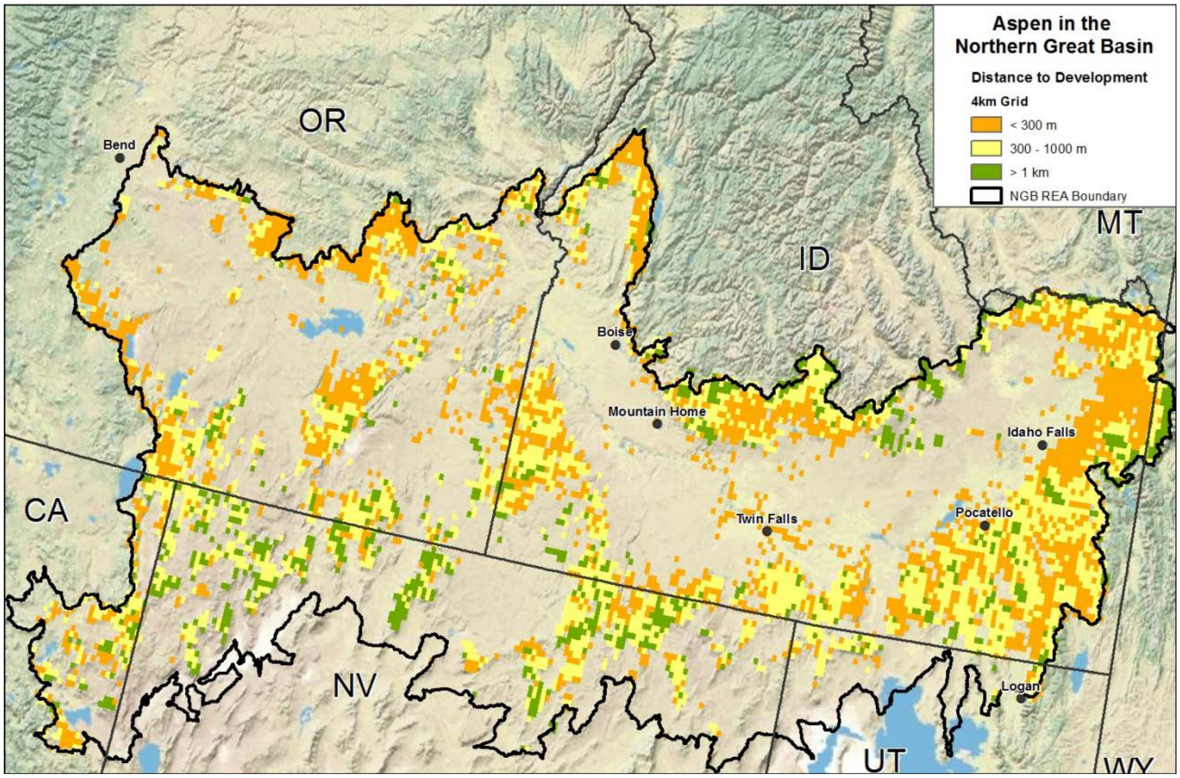


Figure 5-4. Distance to Development for Aspen in the NGB

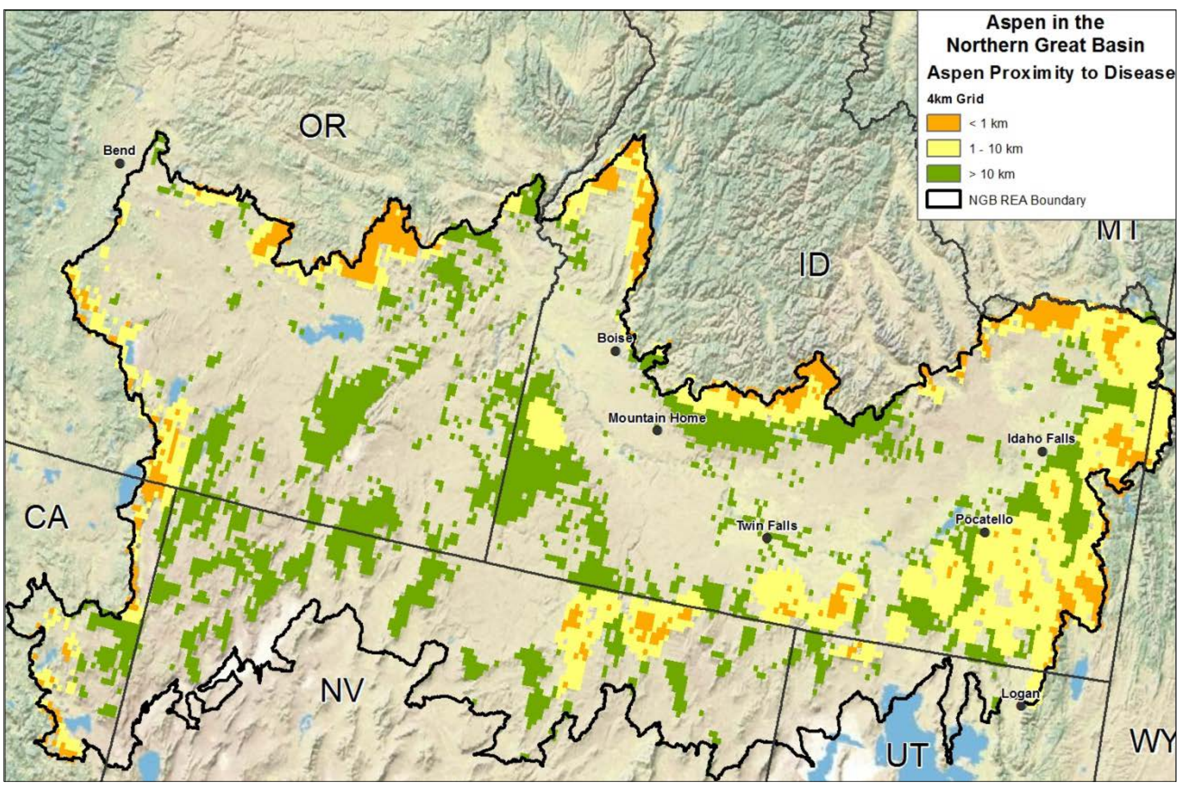


Figure 5-5. Distance to Sudden Aspen Decline Stands in the NGB

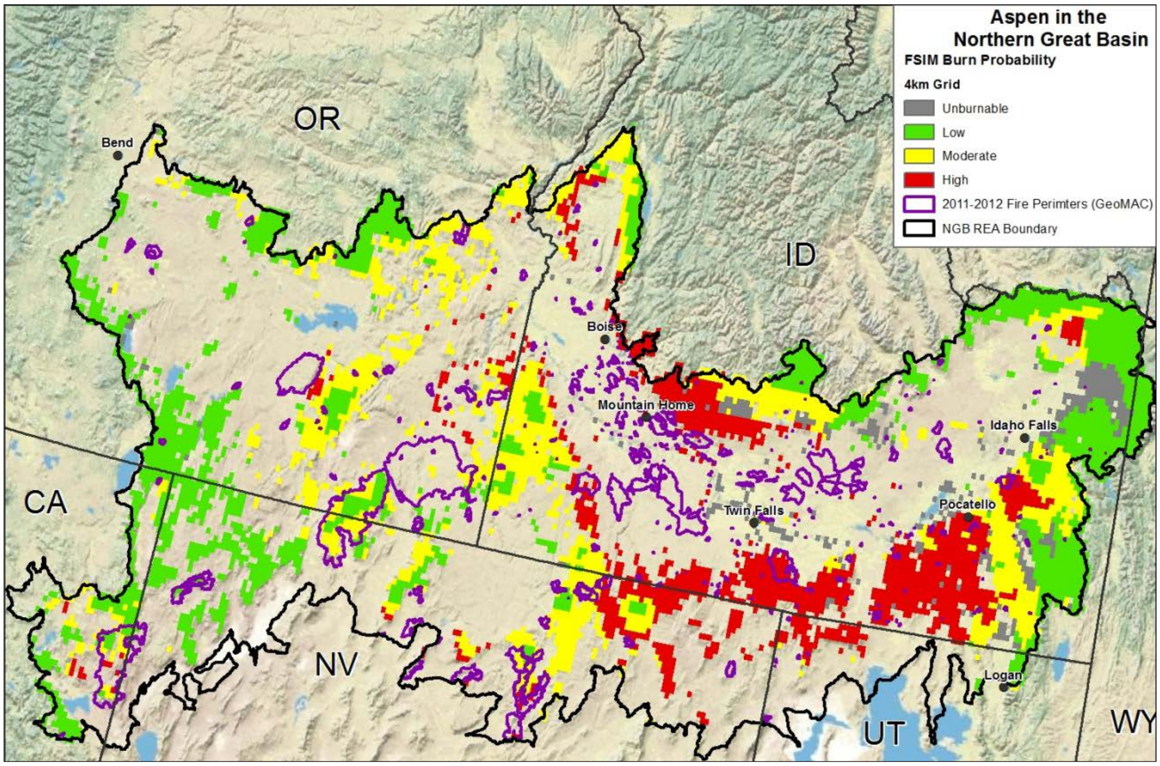


Figure 5-6. FSIM Burn Probability and Recent Fire Perimeters near Aspen

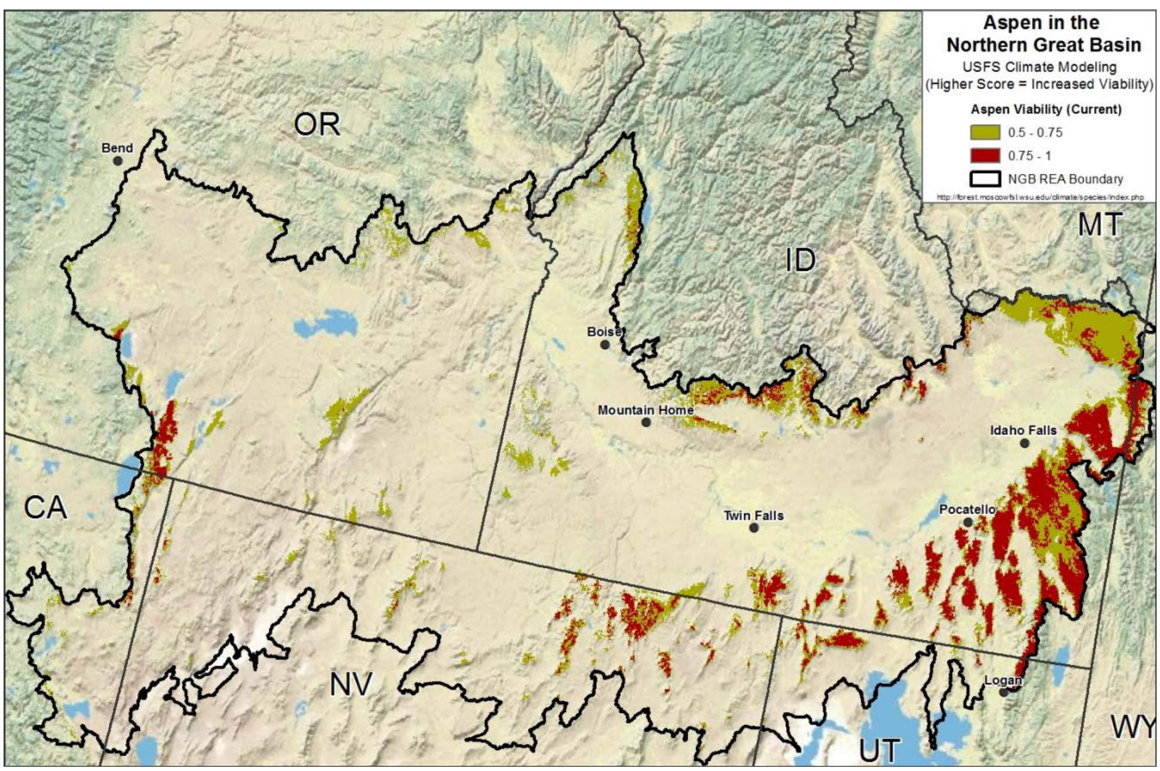


Figure 5-7. USFS Climate Modeling Aspen Current Viability

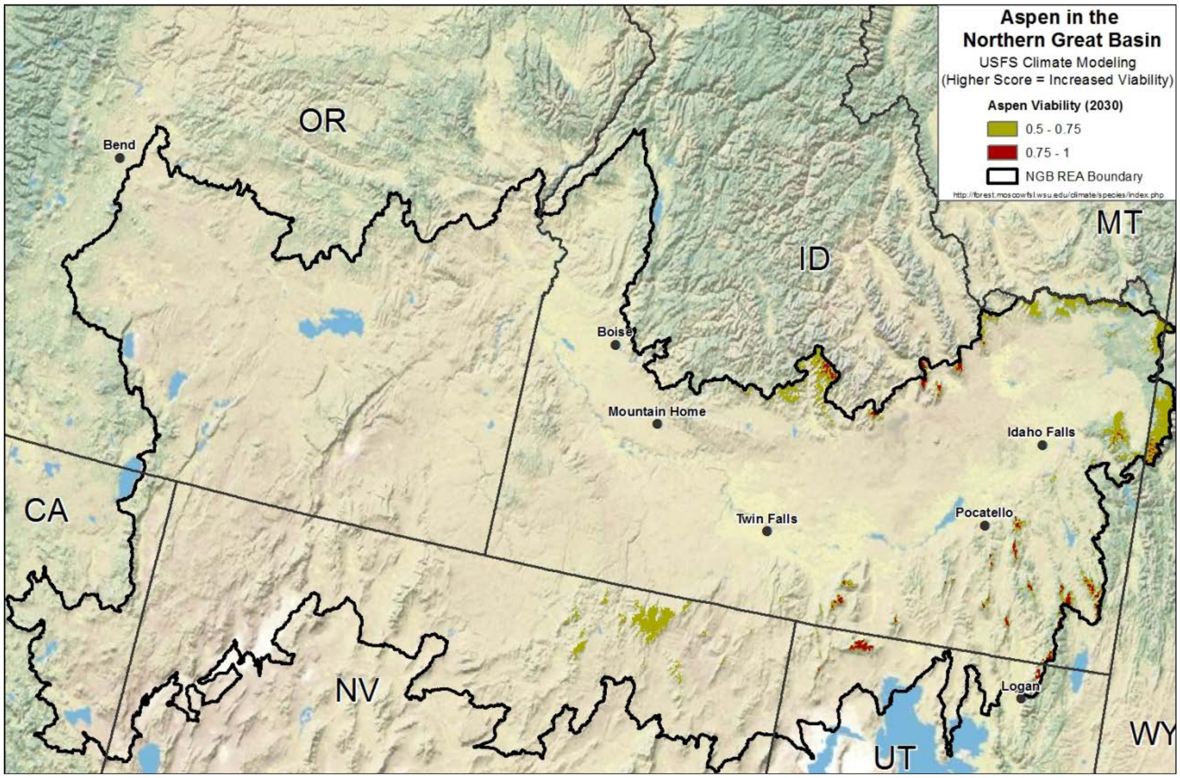


Figure 5-8. USFS Climate Modeling Aspen 2030 Viability

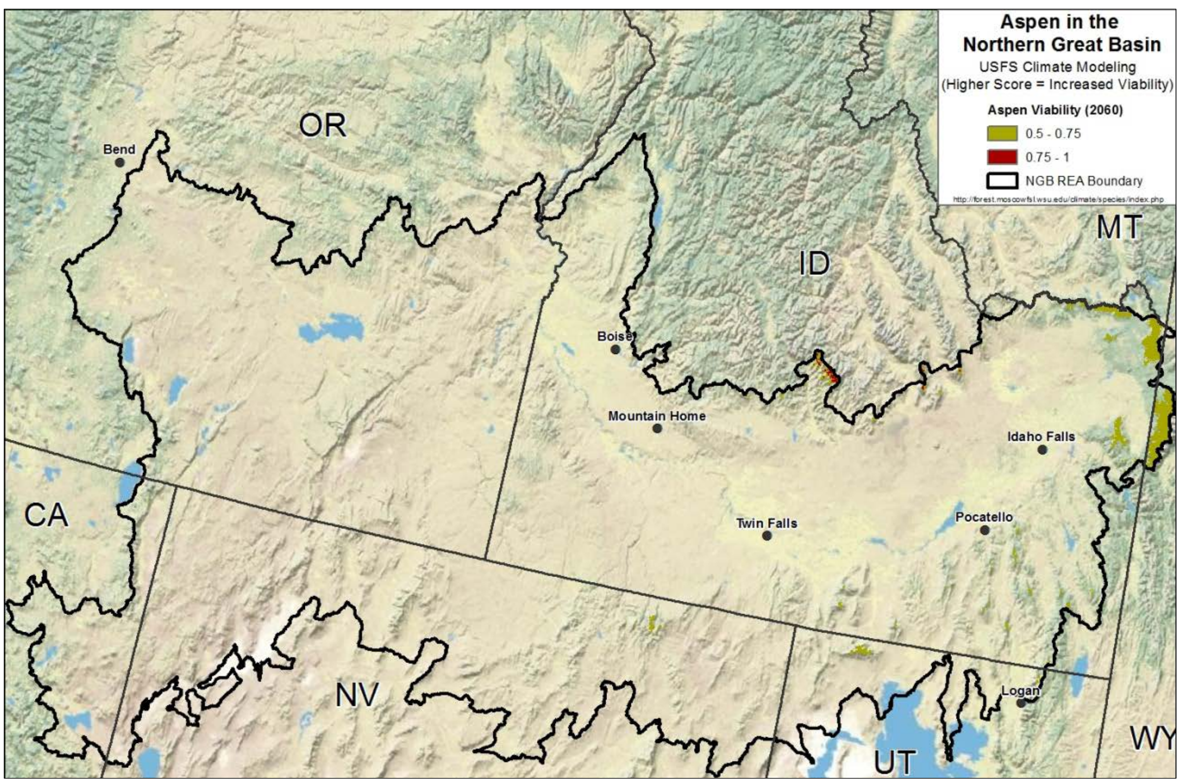


Figure 5-9. USFS Climate Modeling Aspen 2060 Viability

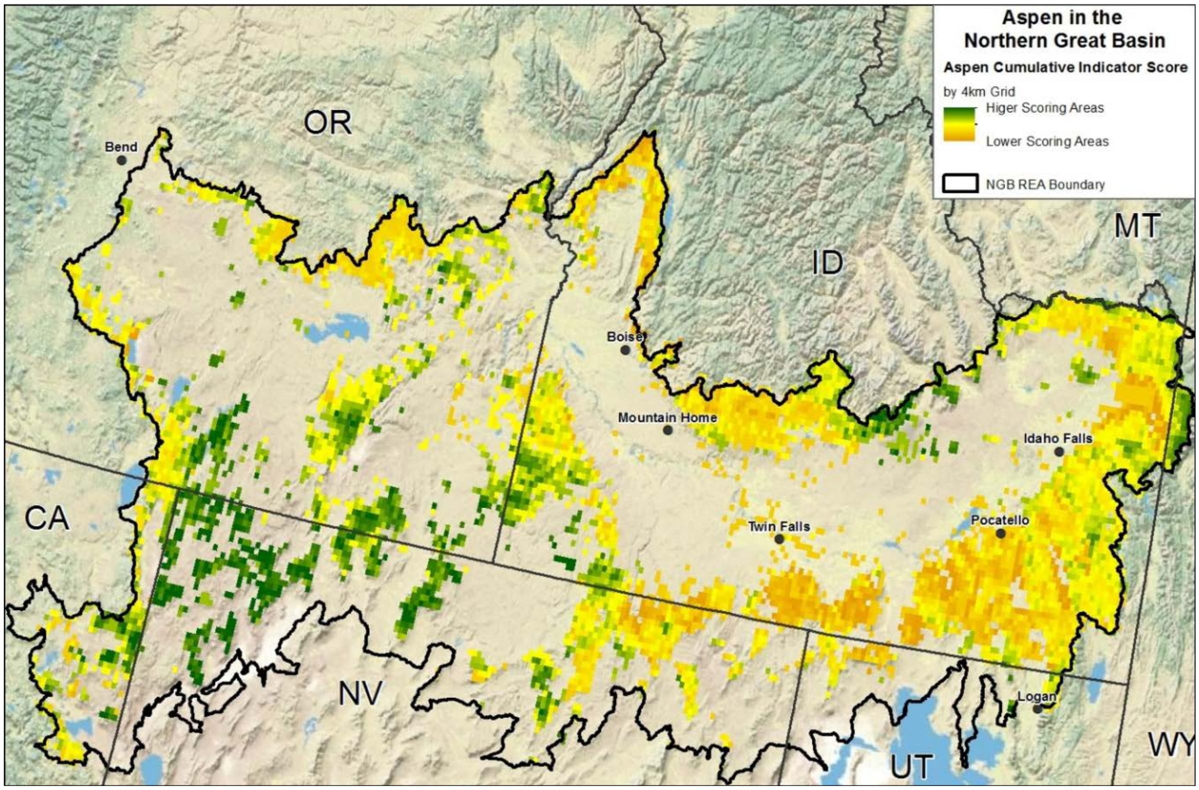


Figure 5-10. Cumulative Indicator Score for Aspen

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Other Conifer
Coarse Filter Conservation Element Package

1 Conservation Element Description

Conifers are an integral component of forest communities at higher elevations in the NGB. Common dominant species are Douglas-fir (*Pseudotsuga menziesii*), lodgepole pine (*Pinus contorta*), ponderosa pine (*Pinus ponderosa*) and Engelmann spruce (*Picea engelmannii*). Conifers serve as an important food source and habitat for various fauna, many of which are specially adapted for the high-elevation conditions. Conifer forests are the primary species used for timber harvest. Douglas-fir and other conifers have been the focus of additional attention because of their ability to rapidly colonize and establish in sagebrush and aspen communities. A combination of overgrazing, changes in microenvironment and climatic patterns, and fire suppression may contribute to conifer expansion into these communities. Conifer establishment is increasingly common and leads to new management decisions on existing stands and conifer expansion into sagebrush and aspen communities.

2 Conservation Element 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 Conservation Element Distribution Mapping

3.1 Data Identification

The major datasets identified to map the distribution of the other conifer conservation element were the ReGAP land cover and LANDFIRE datasets. The datasets used for the other conifer coarse filter are display in Table 3-1. The ReGAP and LANDFIRE datasets consist of vegetative communities with corresponding codes. Table 3-2 lists the codes and class names for each of the data sources used to extract other conifer stands.

Table 3-1. Data Sources for the Other Conifer Vegetation Systems Coarse-Filter Conservation Element Distribution Mapping for the NGB Ecoregion

Data Required	Dataset Name	Source Agency	Type/Scale	Status	Use in REA
Terrestrial Systems					
Ecological Systems	LANDFIRE EVT Northwest ReGAP Southwest ReGAP	USGS	Raster (30m)	Acquired	Yes
	LANDFIRE EVT	USGS	Raster (30m)	Acquired	Yes
Invasive Species	Aerial Disease Detection Survey	USFS	Polygon	Acquired	Yes

Table 3-2. Vegetation Class Code and Name

Code	Data Source	Vegetation Class Name
4224	Northwest ReGAP	North Pacific Maritime Dry-Mesic Douglas-fir-Western Hemlock Forest
4226	Northwest ReGAP	North Pacific Maritime Mesic-Wet Douglas-fir-Western Hemlock Forest
4237	Northwest ReGAP	Rocky Mountain Lodgepole Pine Forest
4245	Northwest ReGAP	Sierra Nevada Subalpine Lodgepole Pine Forest and Woodland
4266	Northwest ReGAP	Middle Rocky Mountain Montane Douglas-fir Forest and Woodland
4267	Northwest ReGAP	Rocky Mountain Poor-Site Lodgepole Pine Forest
4272	Northwest ReGAP	North Pacific Dry-Mesic Silver Fir-Western Hemlock-Douglas-fir Forest
S122	Southwest ReGAP	Sierra Nevada Subalpine Lodgepole Pine Forest and Woodland
S031	Southwest ReGAP	Rocky Mountain Lodgepole Pine Forest
2018	LANDFIRE EVT	East Cascades Mesic Montane Mixed-Conifer Forest and Woodland
2027	LANDFIRE EVT	Mediterranean California Dry-Mesic Mixed Conifer Forest and Woodland
2035	LANDFIRE EVT	North Pacific Dry Douglas-fir(-Madrone) Forest and Woodland
2037	LANDFIRE EVT	North Pacific Maritime Dry-Mesic Douglas-fir-Western Hemlock Forest
2039	LANDFIRE EVT	North Pacific Maritime Mesic-Wet Douglas-fir-Western Hemlock Forest
2045	LANDFIRE EVT	Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest
2047	LANDFIRE EVT	Northern Rocky Mountain Mesic Montane Mixed Conifer Forest
2050	LANDFIRE EVT	Rocky Mountain Lodgepole Pine Forest
2055	LANDFIRE EVT	Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland
2056	LANDFIRE EVT	Rocky Mountain Subalpine Mesic-Wet Spruce-Fir Forest and Woodland
2058	LANDFIRE EVT	Sierra Nevada Subalpine Lodgepole Pine Forest and Woodland
2166	LANDFIRE EVT	Middle Rocky Mountain Montane Douglas-fir Forest and Woodland
2167	LANDFIRE EVT	Rocky Mountain Poor-Site Lodgepole Pine Forest
2172	LANDFIRE EVT	Sierran-Intermontane Desert Western White Pine-White Fir Woodland
2173	LANDFIRE EVT	North Pacific Wooded Volcanic Flowage
2174	LANDFIRE EVT	North Pacific Dry-Mesic Silver Fir-Western Hemlock-Douglas-fir Forest
2200	LANDFIRE EVT	*Pseudotsuga menziesii-Quercus garryana* Woodland Alliance
2206	LANDFIRE EVT	*Pseudotsuga menziesii* Giant Forest Alliance
2227	LANDFIRE EVT	*Pseudotsuga menziesii* Forest Alliance

The list in Table 3-2 only includes conifer vegetation classes that occur within the actual REA boundaries (e.g., North Pacific Maritime Mesic-Wet Douglas-fir-Western Hemlock Forest).

3.2 Distribution Mapping Methods

To map the distribution of other conifer in the NGB ecoregion, SAIC used a combination of ReGAP and Landfire data sources. Most of the states rely on ReGAP for their vegetation while California uses Landfire. This approach was used to maintain consistency with the Central Basin and Range REA. The selected vegetation communities in Table 3-2 were extracted using a GIS process model and merged together to show other conifer locations within the ecoregion.

3.3 Data Gaps, Uncertainty, and Limitations

Coverage of the datasets used in the analysis were generally complete across the ecoregion, which was a factor in their selection. Discontinuities between the LANDFIRE (California), Northwest ReGAP (OR, ID), and Southwest ReGAP (NV, UT) data sets across state lines do not appear to be a limitation with regard to this conservation element.

3.3.1 Uncertainty

Vegetation mapping at the Ecoregion scale is expected to contain errors that would be addressable through the use of higher resolution imagery and larger mapping scales coupled with local knowledge and ground truthing suitable for step-down analyses over smaller areas. The assemblage of conifers in LANDFIRE, Southwest and Northwest ReGAP datasets made separating the conifers into individual species difficult. The datasets mostly contains ponderosa pines, Douglas fir, Engelmann spruce and lodgepole pine but also includes more than one species in a vegetation class (e.g., North Pacific Dry-Mesic Silver Fir-Western Hemlock-Douglas-fir Forest) such as other firs, pines, spruces, hemlocks and cedars or were listed as mixed conifer.

The USFS climate change modeling was completed for individual species within the Other Conifer assemblage showing the current viability, viability at 2030 and 2060. Most of these models show the conifer species having severely reduced viability by the 2060 timeframe. Ponderosa pine was one outlier that caused some uncertainty by increasing its range into new locations at lower elevations.

4 Conceptual Model

A conceptual model of conifer ecosystems in the ecoregion is presented in Figure 4-1. Change agents of greatest importance to this conservation element are climate change, insects and diseases, wildfire and timber harvest. Climate change, in particular toward hotter and drier conditions, may alter the current distribution of coniferous forests and is thought to weaken the trees making them more vulnerable to insect attack. Insects that infest conifers include Tussock moths (*Euproctis similis)*, western spruce budworms (*Choristoneura occidentalis*) and mountain pine beetles (*Dendroctonus ponderosae*), and diseases that infect trees are wood-rot basidiomycete fungus and white pine blister rust fungus. Bark beetle population size have rapidly increased in recent years. An increase in temperatures at high elevations is thought to be the reason that allows these insects to survive and reproduce at higher elevations than previously known to occur (Bentz 2008). Douglas-fir can survive low intensity surface fires but are killed by moderate to high intensity fires and must regenerate from seed. Douglas-fir is somewhat shade tolerant and can encroach into the understory of forested habitats (e.g., aspen, other conifers). In contrast, lodgepole pine and Engelmann spruce require open habitat for regeneration and regenerate from seed after a wildfire. Fuel buildup in the understory is related to the cover of invasives, particularly knapweed (*Centaurea virgata*) and smooth brome (*Bromus inermis*) that invade conifer communities when openings exist. Fire frequency and intensity influences the cover of invasives. For example, smooth brome has been controlled with repeated, prescription burn treatments (Wilson and Stubbendieck 1997). Timber harvest, wildlife browsing, and windthrow events are also important change agents. Older trees are generally more vulnerable to windthrow events (Steil *et al.* 2009). Timber harvest may initially reduce conifer canopy cover, however if harvest is conducted using sustainable methods, tree canopy cover could increase. Wildlife and livestock browsing on resprouts, buds, needles and cambium may retard growth and regeneration.

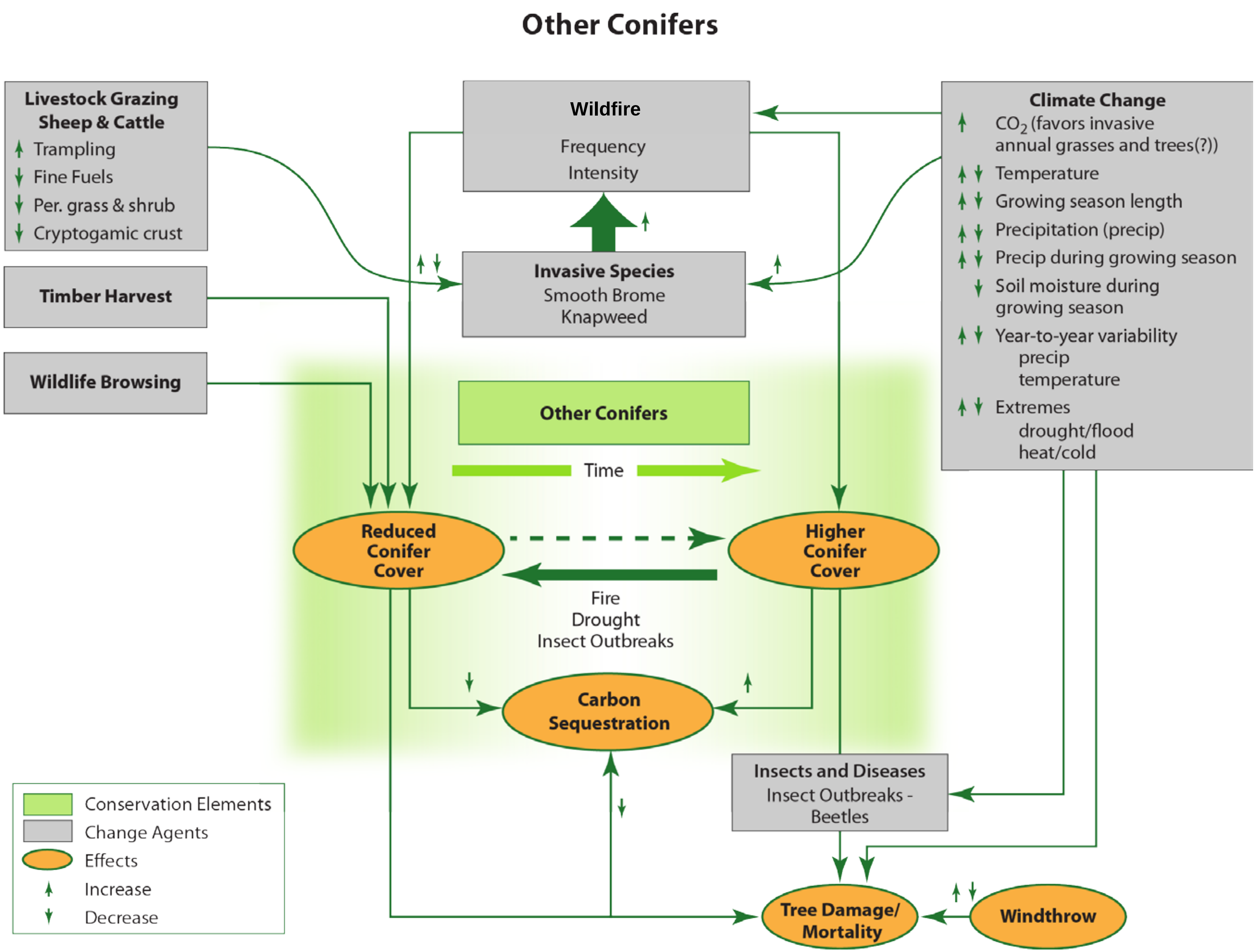

Figure 4-1. Other Conifer Conceptual Model

5 Management Questions

Where are the Other Conifer Stands?

Figure 5-1 shows the location of the assemblage called Other Conifer within the ecoregion. This assemblage of conifers mostly contains ponderosa pines, Douglas fir, Engelmann spruce and lodgepole pine but will also include other firs, pines, spruces, hemlocks and cedars. The vegetation classes within SW and NW ReGAP and LANDFIRE made separating the conifers into individual species difficult as most classes included more than one species (e.g. North Pacific Dry-Mesic Silver Fir-Western Hemlock-Douglas-fir Forest) or were listed as mixed conifer. As displayed in Figure 5-1, the majority of the other conifer coarse filter conservation element is located along the periphery of the ecoregion within National Forests such as Targhee, Payette, Boise, Sawtooth, Deschutes, Malheur, Freemont, Modoc, Lassen, and Plumas. Most of the Other Conifer conservation element exist above 6,000 ft (1,829 m) especially those within the National Forest but isolated patches occur at lower elevations such as along the east fork of the Bruneau River. Figure 5-2 shows the relative density of Other Conifer based on a moving window analysis. The densest locations of Other Conifers were within the Deschutes, Fremont and Malheur National Forests within Oregon and Payette and Targhee forests within Idaho and Wyoming.

Where do Other Conifer stands interact with Change Agents?

Development

The distance to development was determined by merging many types of development into one spatial layer and then determining the Euclidean distance to from Other Conifers to any type of development. The development spatial layer consisted of:

- Ski resorts,
- TIGER roads,
- Railroads,
- Mines,
- Agriculture,
- Developed areas,
- Ruby Pipeline (NV only),
- Land Treatments,
- Wind Turbines, and
- Transmission lines.

Figure 5-3 displays the results of determining the average distance by 4km grid from Other Conifers to one of the listed types of development. The most prominent type of development interacting with Other Conifers is roads. The TIGER Topologically Integrated Geographic Encoding and Referencing) roads spatial layer (US Census) is very detailed and includes some off highway vehicles, 4WD forest service roads, BLM routes along with urban roads and major highways. Ski resorts within the ecoregion range from small USFS recreation areas to large resorts with associated surrounding development such as Sun Valley on the northern edge of the ecoregion. Throughout most of the ecoregion Other Conifers are generally less than 300 m from development, though in the north and northeast there are conifers that are 300 – 1,000 m from development. Few conifer stands have development >1 km away.

Disease

The data source for disease or insects affecting Other Conifer was the USFS Aerial Disease Surveys. The main disease or insect identified and mapped by the Aerial Disease Surveys was pine bark beetle. Using the location of the Other Conifer infected stands, the Euclidean distance spatial operation was used to calculate the distance from Other Conifer stands. Figure 5-4 shows the average distance by 4km grid from an Other Conifer stand to a stand identified by Aerial Disease Surveys as being impacted by pine bark beetle or other insect and disease. The Malheur National Forest, western and east edges of the ecoregion appear to have the lowest distance between infected Other Conifer stands. The Other Conifer stands further from the edges of the ecoregion tend to have higher distances to diseased stands probably due to lower density of Other Conifer.

Wildfire

FSIM burn probability data was modeled by the USGS and USFS and was used to determine wildfire risk to Other Conifers within the ecoregion. Figure 5-5 shows the burn probability (low, moderate and high) for Other Conifer by the most common value within the 4km grid. It also includes the GeoMAC fire perimeters for the past two years to show where recent fire activity has occurred. The highest burn probability is Other Conifer areas within southern and northern Idaho (within ecoregion) from the southern edges of the Payette National Forest to the Boise National Forest northeast of Mountain Home. The areas with the lowest burn probability are on the periphery of the ecoregion within the National Forests except for Payette and Boise as previously mentioned. Most of the recent fire activity in the densest stands of Other Conifer, have been fairly small in size compared to the large fires that occurred in 2012 such as the Long Draw, Holloway and Rush. The Buck Creek (2011) fire in Oregon on the edges of the Deschutes National Forest was the largest fire in the last two years in the densest stands of Other Conifer (around 6,000 ac).

Grazing

Livestock grazing is common in the ecoregion and approximately 70 percent of the REA is under grazing allotments. Livestock browsing on buds, needles and cambium may retard growth and regeneration of conifers and consumption of preferred herbaceous species may affect the establishment dynamics of conifers.

How will Other Conifer be impacted by modeled Climate Change?

USFS Climate Modeling

The USFS Moscow Forestry Sciences Laboratory developed climate models for various tree species modeling the effects of climate change in various future scenarios. The climate change modeling uses three different global climate models (Canadian Center for Climate Modeling and Analysis [CGCM3], Geophysical Fluid Dynamics Laboratory [GFDLCM21] and Hadley Center/World Data Center [HADCM3] for a total of seven climate scenarios (Table 5-1). The seven scenarios were added together for the 2030 and 2060 future time frames to create an average climate scenario that can be used without having to the reader to pick a scenario. The models produce a viability that ranges from 0 – 1.0 with species with a viability below 0.5 having little chance of a species surviving (Crookston *et al*. 2010).

Table 5-1 Description of Climate Scenarios used in USFS Climate Modeling (Crookston et al. 2010)

Climate Scenario	Description
A2	High emissions, regionally diverse world, rapid growth
A1B	Intermediate emissions, homogeneous world, rapid growth
B1	Lower emissions, local environmental sustainability
B2	Lowest emissions, global environmental sustainability

The climate change modeling done by the USFS was completed for individual species while the Other Conifer assemblage covers many conifer species. Four example species will be presented (Douglas fir, Engelmann spruce, lodgepole pine and ponderosa pine) to show the predicted modeling for these species.

Figures5-6, 5-9, 5-12, and 5-15 shows the current viability for Douglas fir, Engelmann spruce, lodgepole pine and ponderosa pine within the NGB based on the modeling done by the USFS (Crookson *et al*. 2010). Figures 5-7, 5-10, 5-13, and 5-16 show the results of the average of the seven climate scenarios at the year 2030 timeframe. Figures 5-8, 5-11, 5-14, and 5-17 shows the average of the 2060 timeframe. Most of these models show the Other Conifers to be fairly impacted based on their modeling especially at the 2060 timeframe. One outlier is ponderosa pine that causes some uncertainty in the modeling as it is forecasted to become more viable in locations (lower elevation) where it currently doesn't exist.

An alternative climate change model developed by Hostetler *et al.* (2011 [provided in the Climate Change Package]), shows changes in precipitation particularly wetter winters and drier early fall. In particular precipitation increases in November to May and decreases in September and October. These changes in timing and frequency of rainfall may affect conifer survivorship.

Where are intact Other Conifer stands (minimally impacted by Human Activities)?

To derive where intact Other Conifer stands (minimally impacted by human activities) are located, the following three layers were classified and combined: Distance to Development, Burn Probability and Distance to Disease Stands. Using the values as classified in Figures 5-3, 5-4, and 5-5, the results were reclassified 1, 2 or 3 (e.g., 1 would be the highest burn probability, closest to development or closest to disease stand while 3 would be the lowest burn probability, furthest from development and furthest from a diseased stand). Using the raster calculator, the values were combined to derive a score from 3 to 9 and then averaged within an analysis unit (4 km grid). A stretched raster was used to show the range of values from the lowest 3 (orange) to the highest 9 (green).

Figure 5-18 shows a cumulative indicator score for Other Conifer, with the highest scoring areas being in the less dense interior sections of the ecoregion such as the Owyhee Mountains and Craters of the Moon National Monument. Certain National Forest along the periphery of the ecoregion such as Challis and Targhee also had some areas that were scoring high. Some of the lower scoring areas would be the Payette, Boise and Malheur National Forest. This portion of the analysis does not take into account climate change projections.

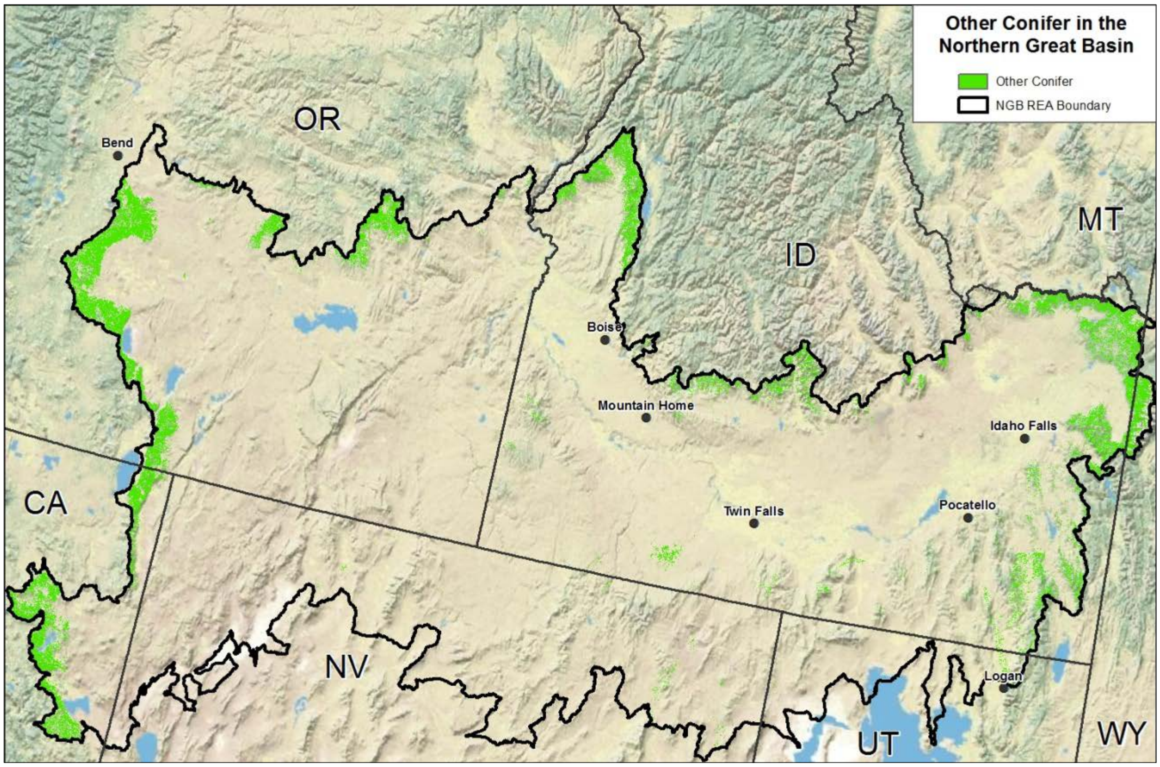

Figure 5-1. Other Conifer Locations within the NGB

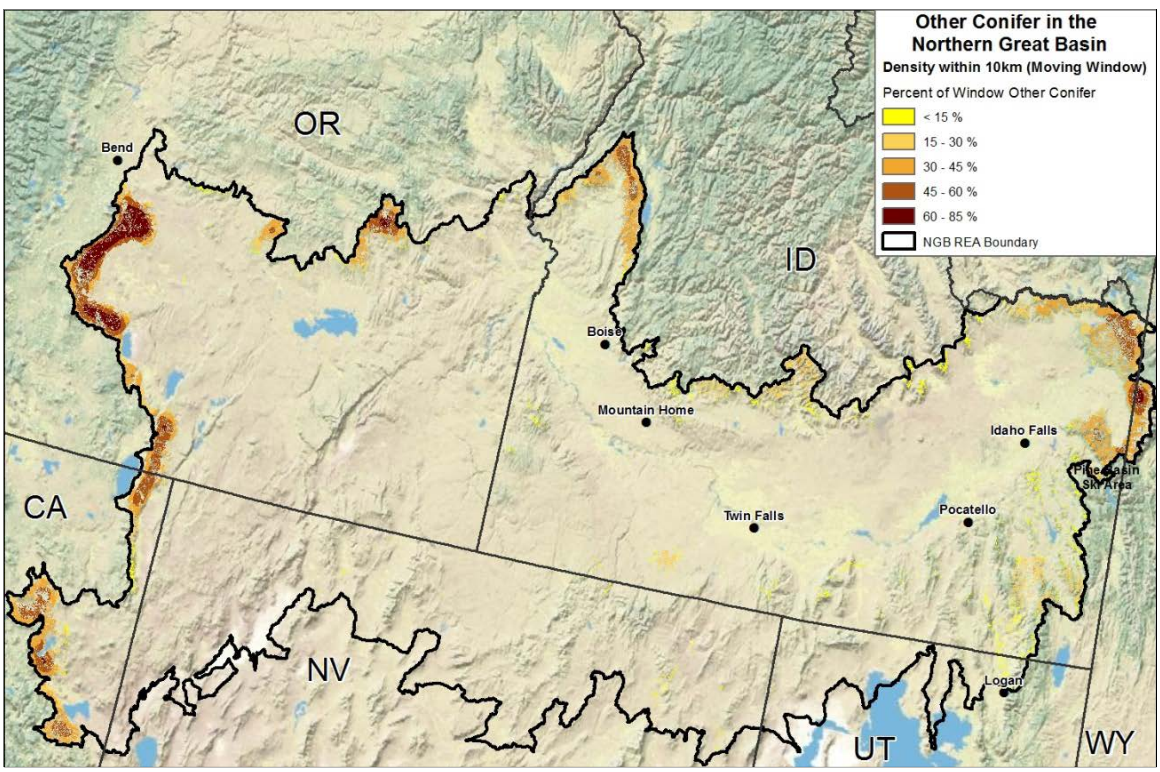

Figure 5-2. Density of Other Conifer within at 10km Moving Window Analysis

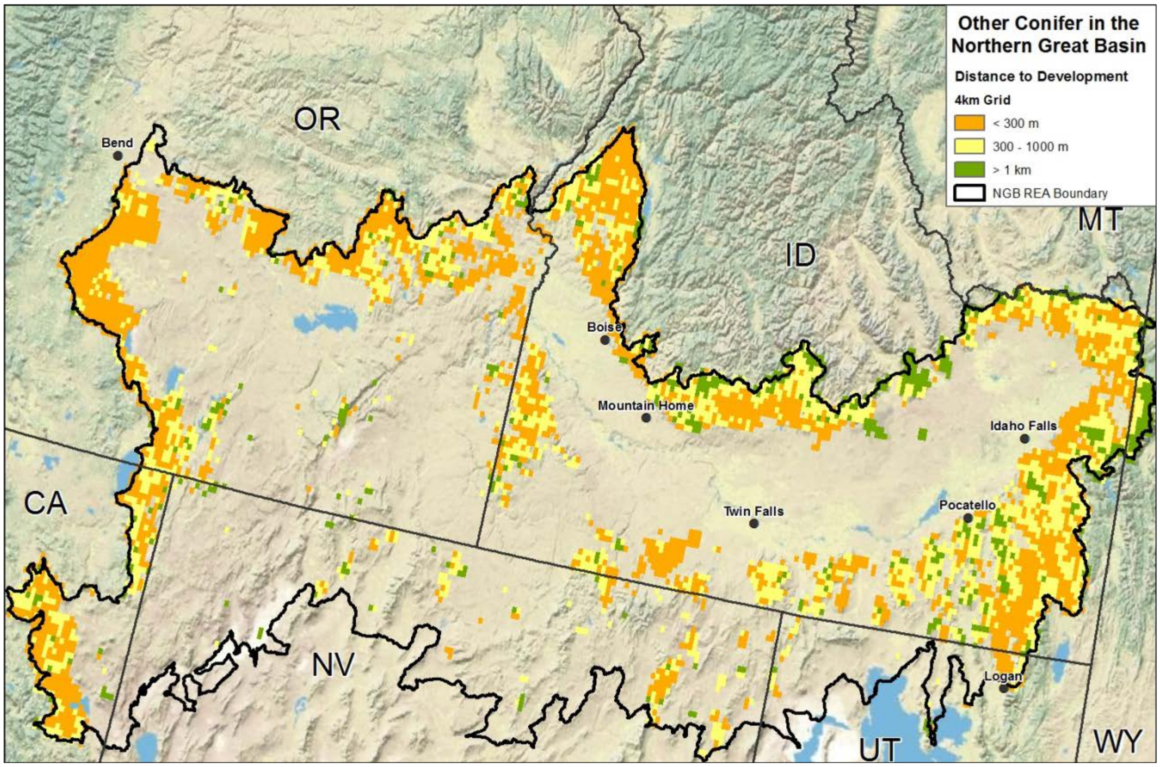

Figure 5-3. Distance to Development for Other Conifer within the NGB

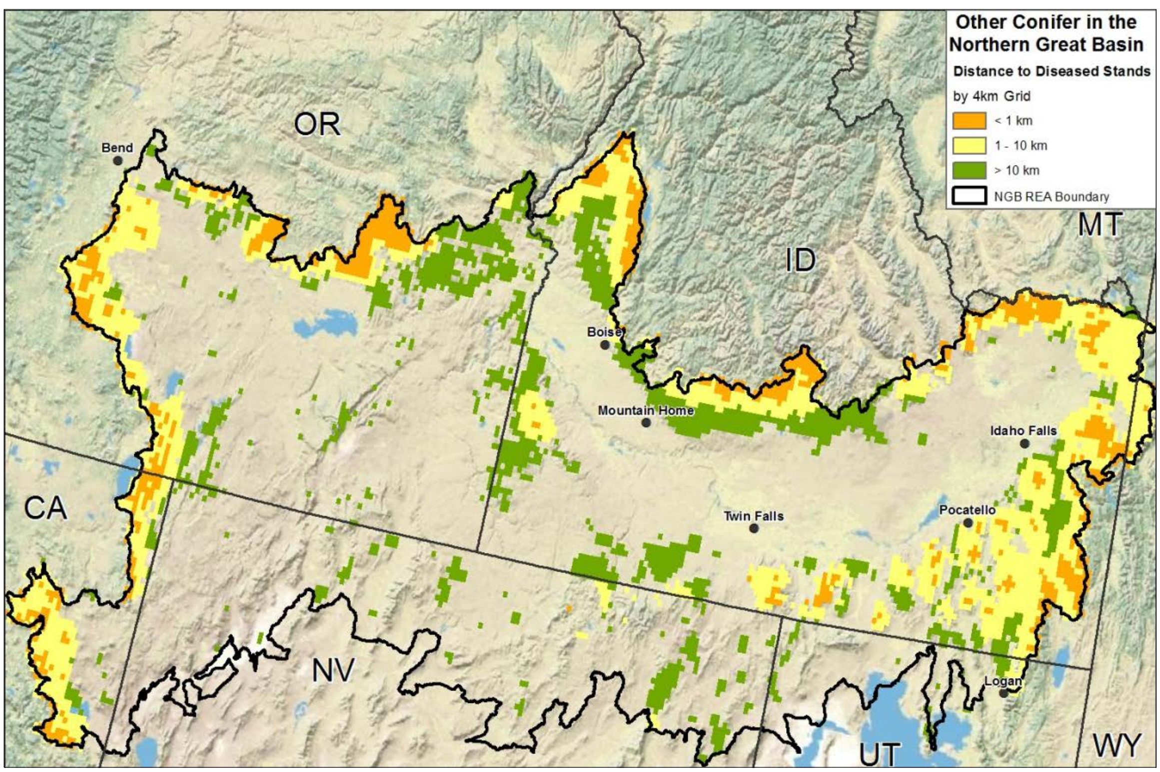

Figure 5-4. Distance to Disease/Insect Breakout in Other Conifer

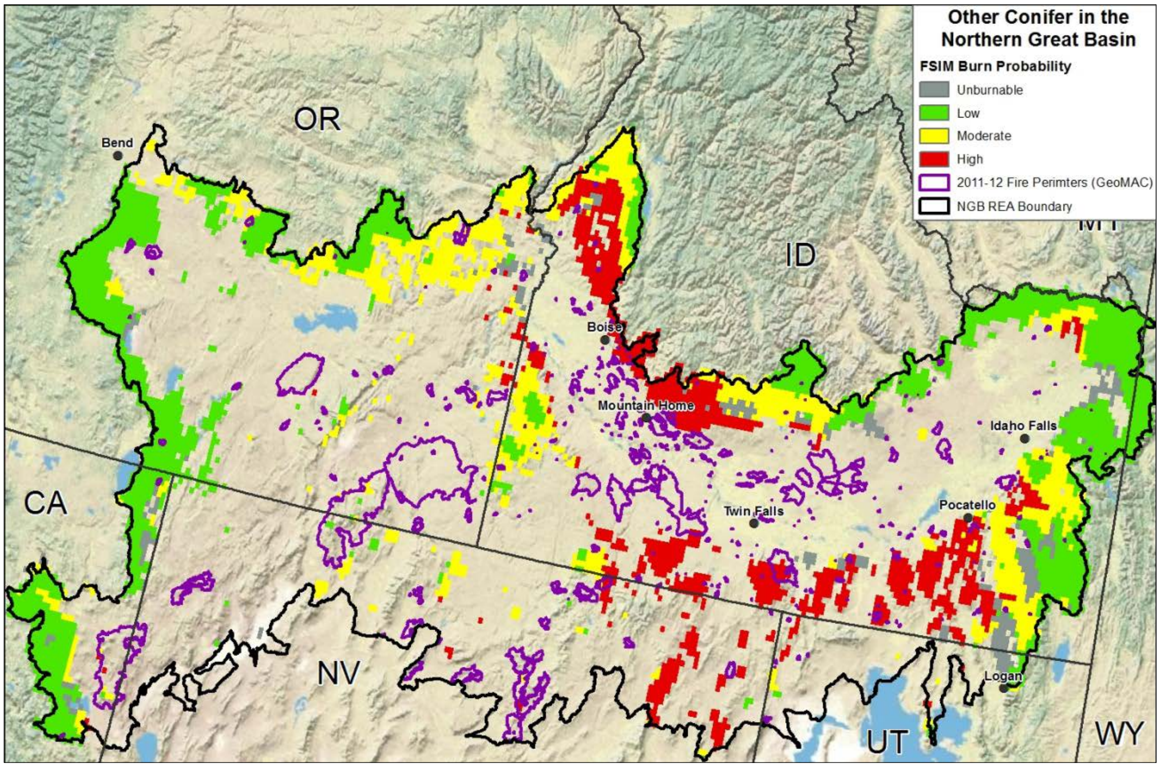

Figure 5-5. FSIM Burn Probability and Recent Fire Perimeters near Other Conifer

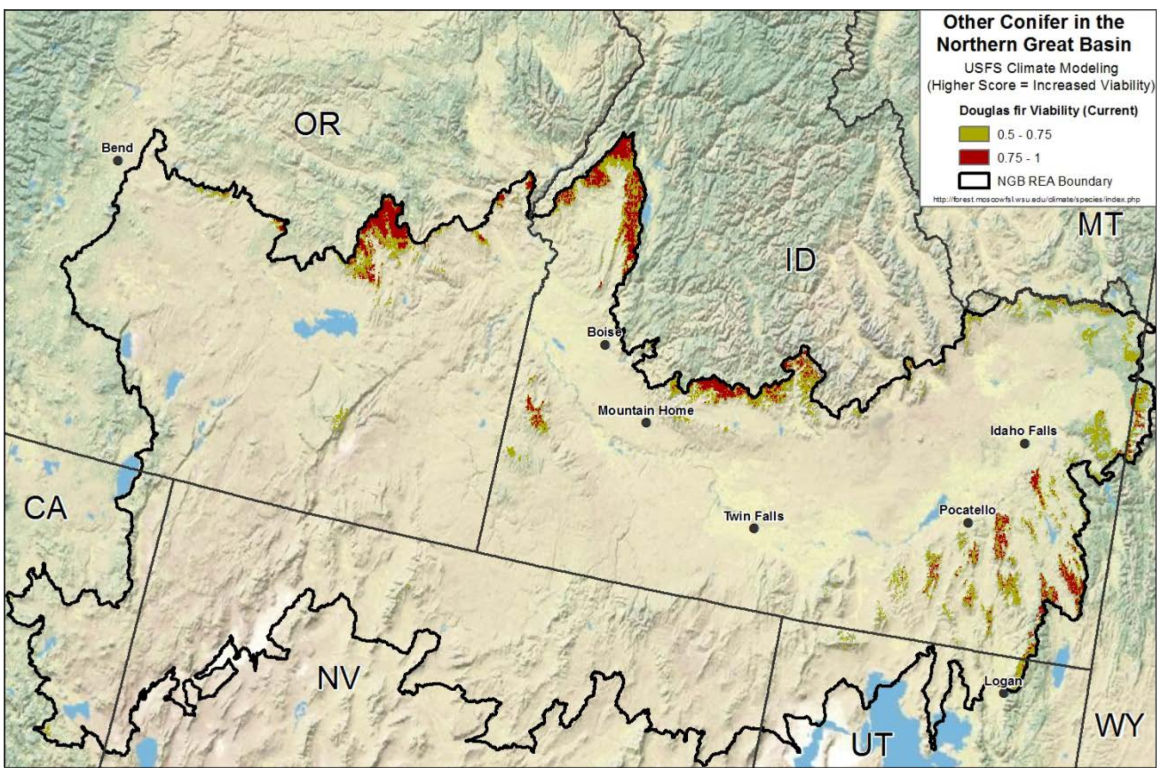

Figure 5-6. USFS Climate Modeling Douglas fir Current Viability

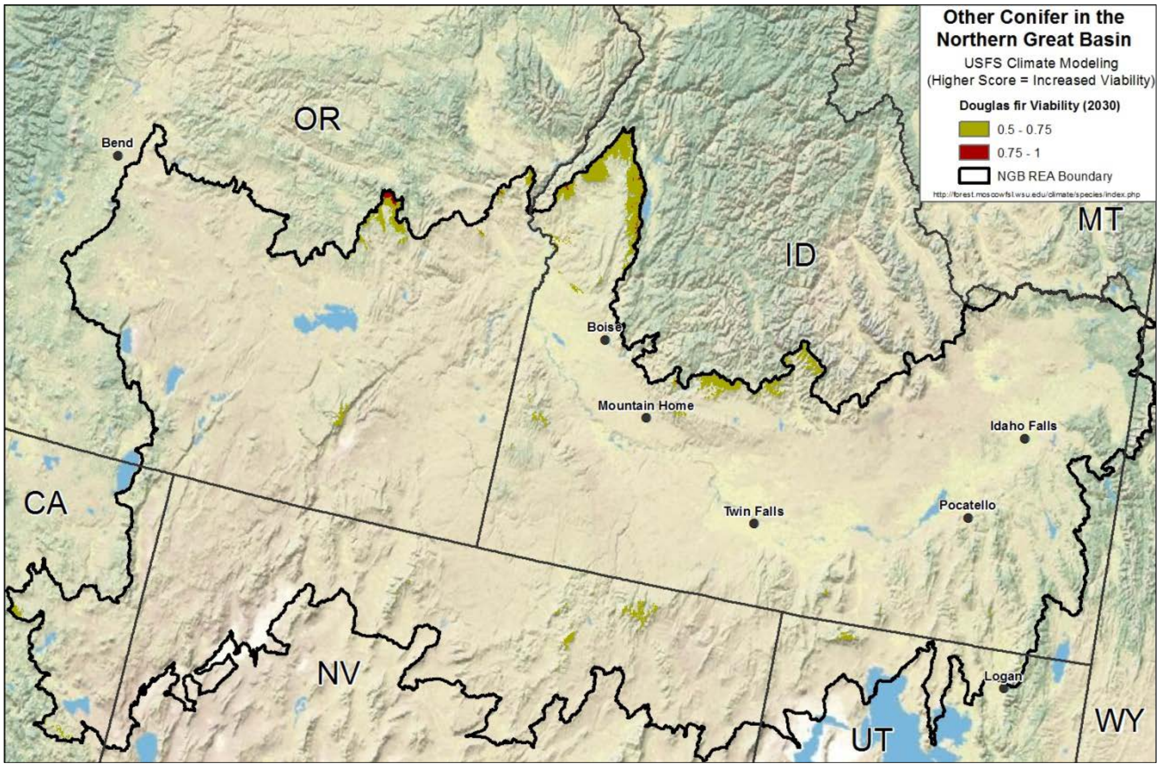

Figure 5-7. USFS Climate Modeling Douglas fir 2030 Viability

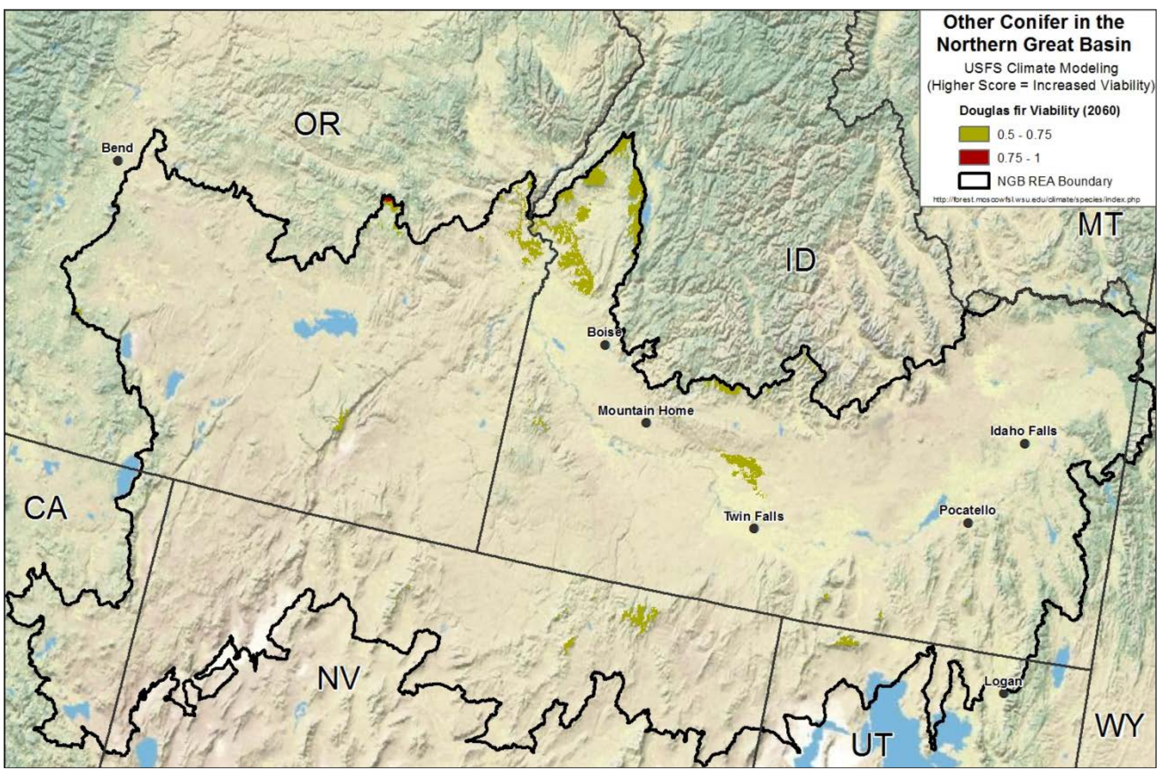

Figure 5-8. USFS Climate Modeling Douglas fir 2060 Viability

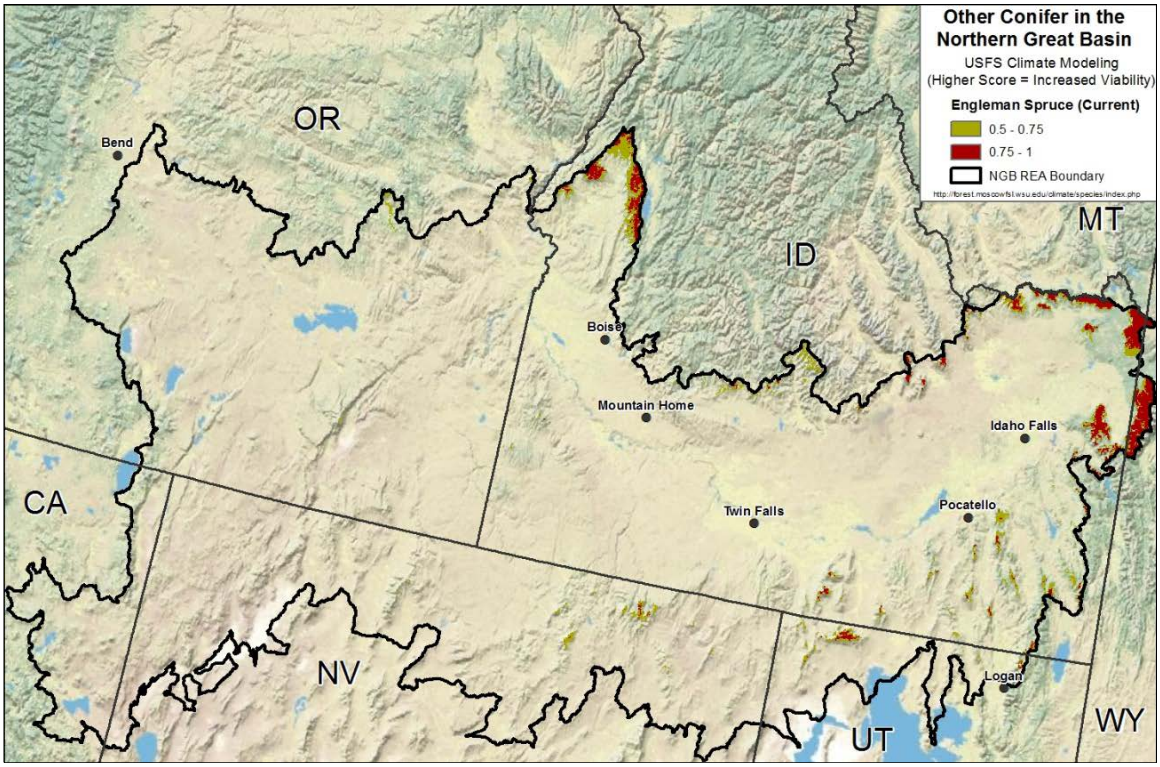

Figure 5-9. USFS Climate Modeling Engelmann spruce Current Viability

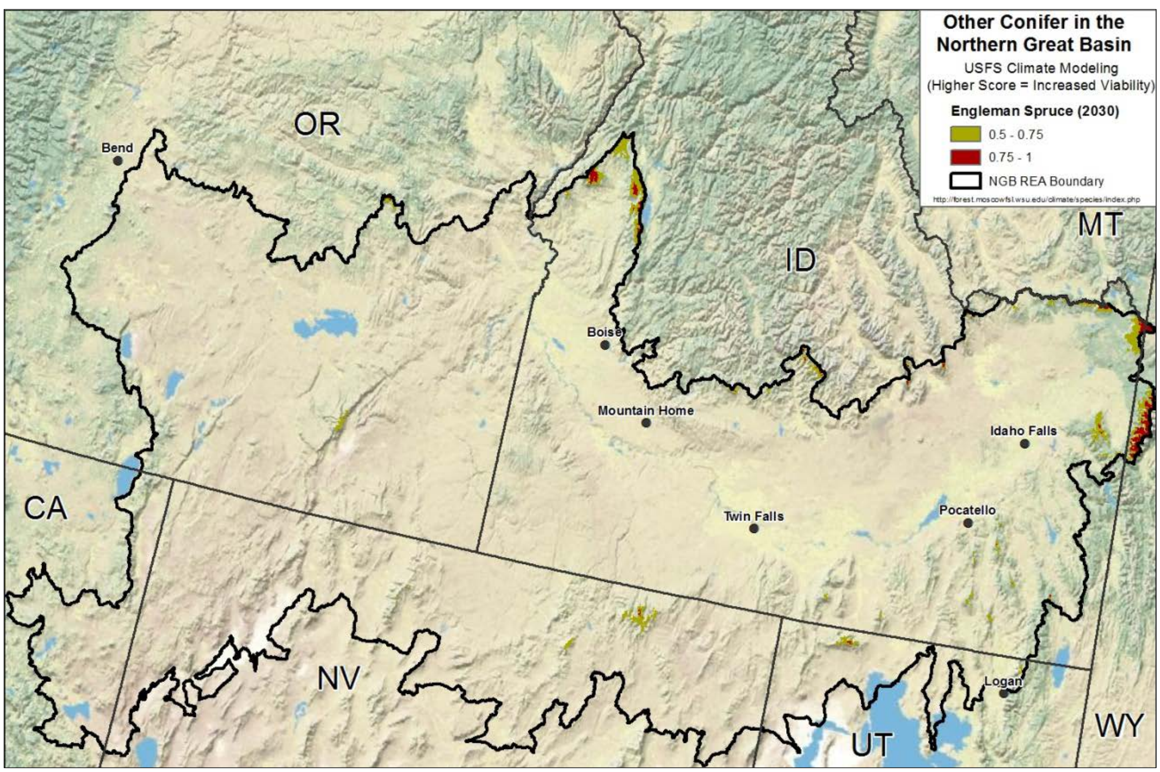

Figure 5-10. USFS Climate Modeling Engelmann spruce 2030 Viability

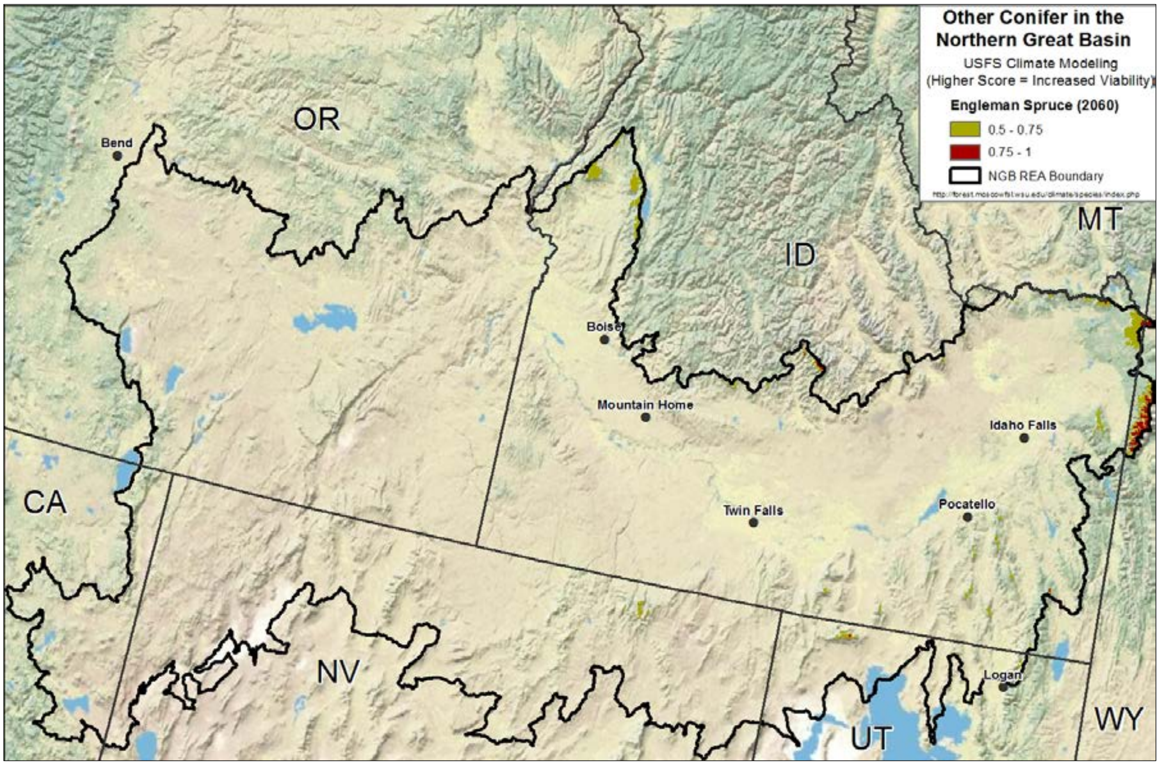

Figure 5-11 USFS Climate Modeling Engelmann Spruce 2060 Viability

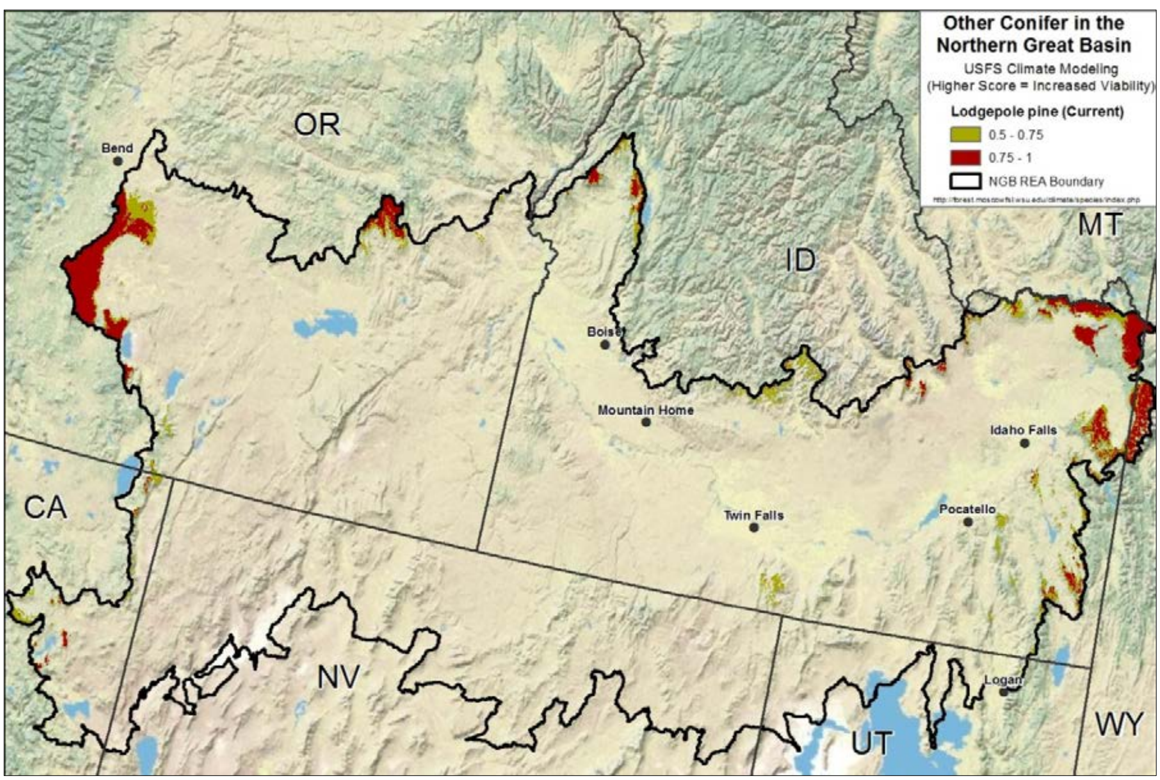

Figure 5-12. USFS Climate Modeling Lodgepole Pine Current Viability

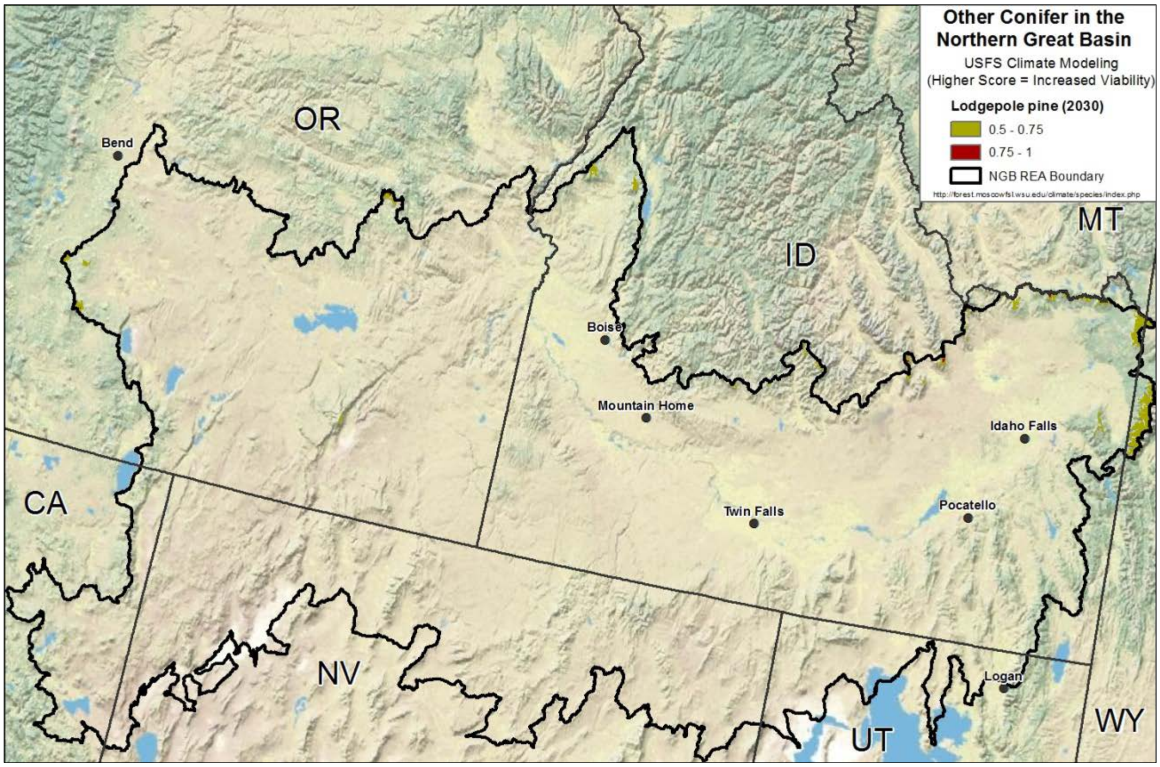

Figure 5-13. USFS Climate Modeling Lodgepole Pine 2030 Viability

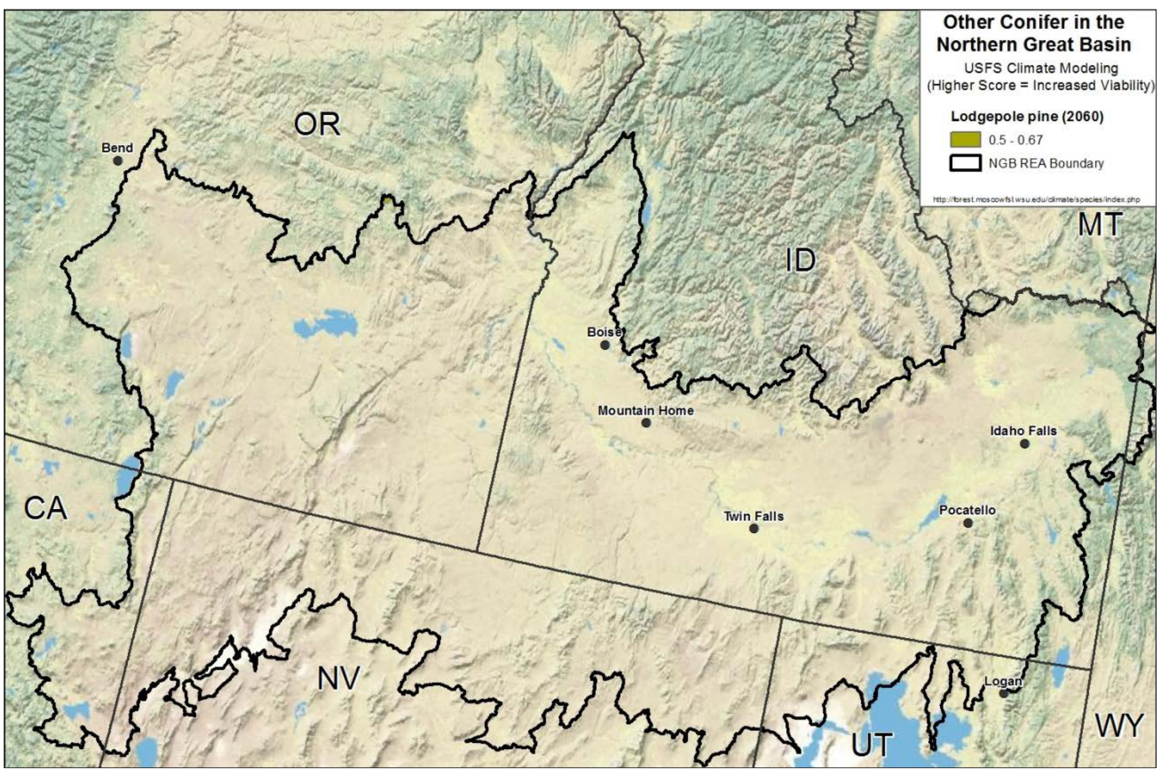

Figure 5-14. USFS Climate Modeling Lodgepole Pine 2060 Viability

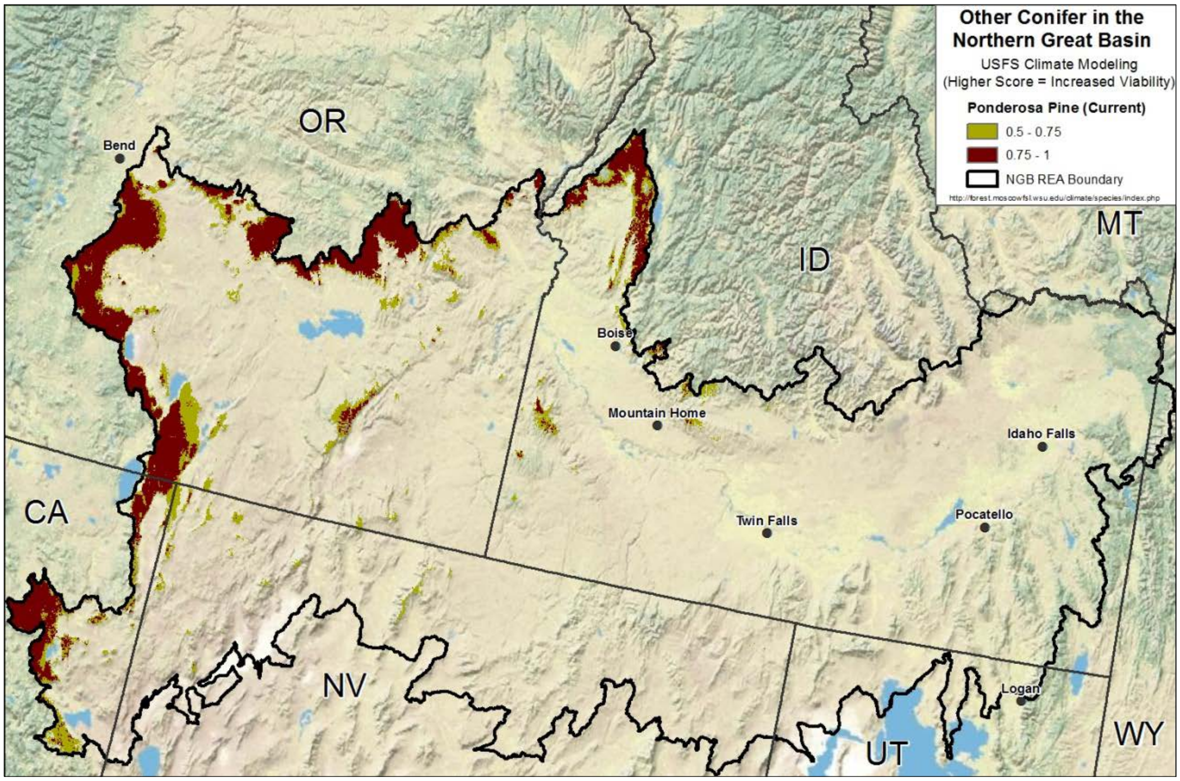

Figure 5-15. USFS Climate Modeling Ponderosa Pine Current Viability

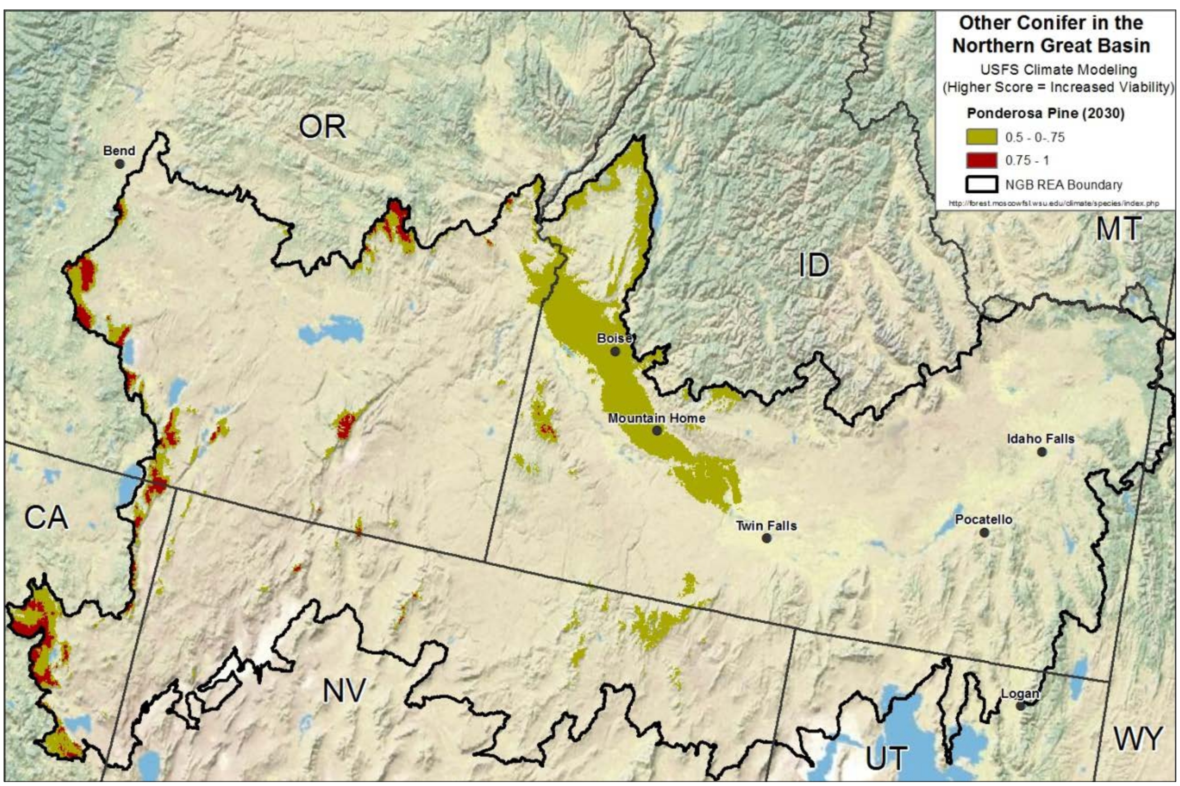

Figure 5-16. USFS Climate Modeling Ponderosa Pine 2030 Viability

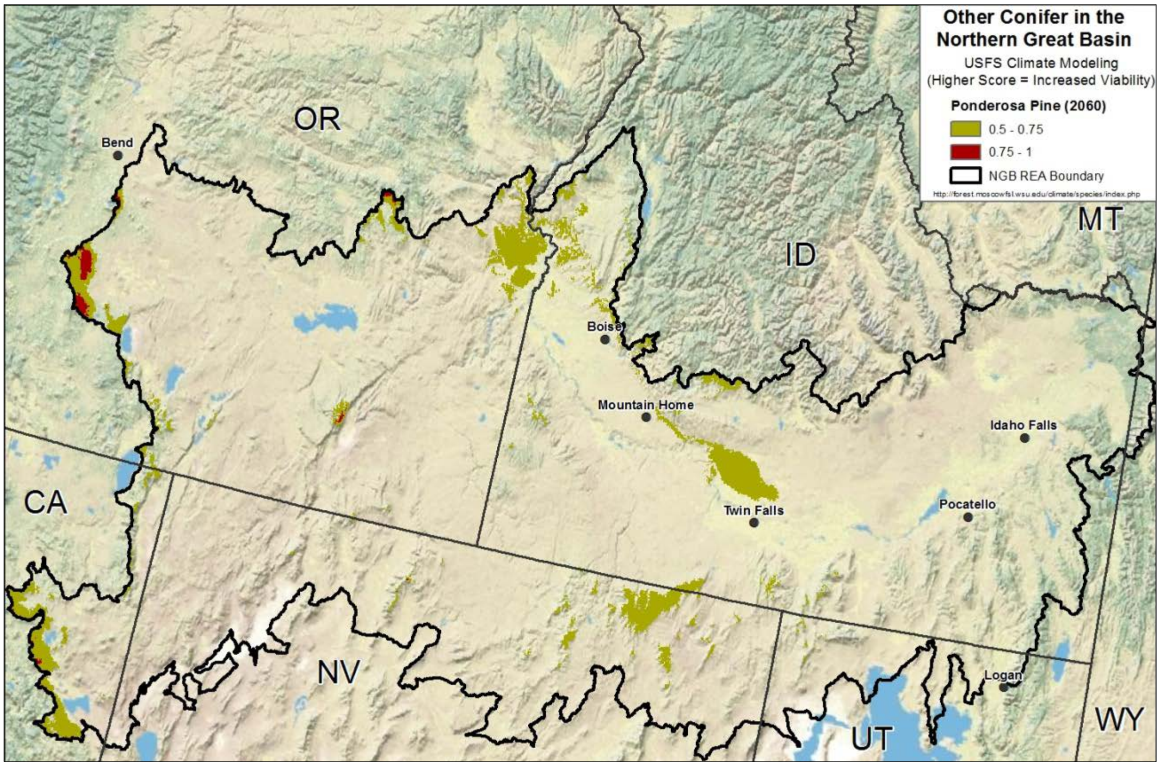

Figure 5-17. USFS Climate Modeling Ponderosa Pine 2060 Viability

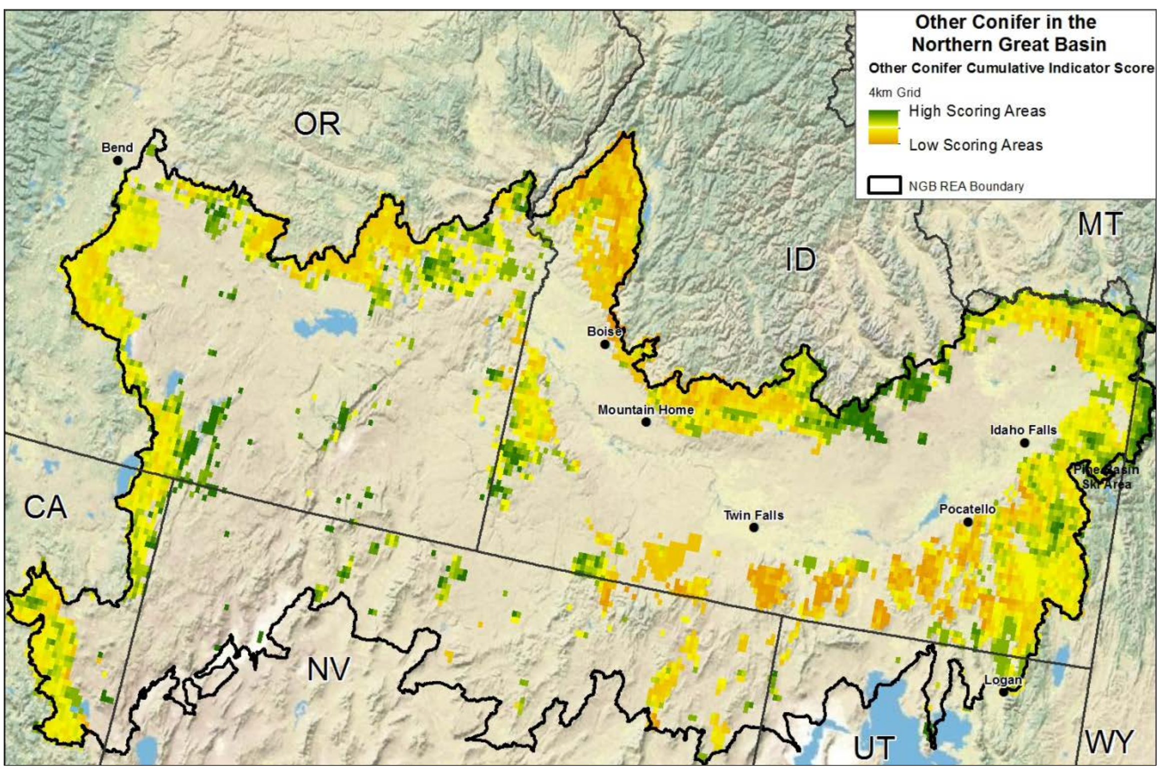

Figure 5-18. Cumulative Indicator Score for Other Conifer

6 Summary of Other Conifer in the NGB

Conifers are an integral component of forest communities at higher elevations in the NGB. Common dominant species are Douglas-fir (*Pseudotsuga menziesii*), lodgepole pine (*Pinus contorta*), ponderosa pine (*Pinus ponderosa*) and Engelmann spruce (*Picea engelmannii*). Conifer establishment is increasingly common and leads to new management decisions on existing stands and conifer expansion into sagebrush and aspen communities.

Multiple vegetation types were combined to make up one class for Other Conifer occurrence. This assemblage of conifers mostly contains ponderosa pines, Douglas fir, Engelmann spruce and lodgepole pine but will also include other firs, pines, spruces, hemlocks and cedars. Other Conifers are located along the periphery of the ecoregion generally above 6,000 feet (1829m) within National Forests such as Targhee, Payette, Boise, Sawtooth, Deschutes, Malheur, Freemont, Modoc, Lassen, and Plumas. Isolated conifer patches occur at lower elevations such as along the east fork of the Bruneau River. The densest locations of other conifers are within the Deschutes, Fremont and Malheur National Forests within Oregon and Payette and Targhee forests within Idaho and Wyoming.

The most prominent type of development interacting with Other Conifers is roads. Throughout most of the ecoregion Other Conifers are generally less than 300m from development though in the north and northeast there are conifers that are 300 – 1000m from development. Few conifer stands have development >1 km away.

When openings exists, invasive plant species particularly knapweed (*Centaurea virgata*) and smooth brome (*Bromus inermis*) invade conifer communities. The main disease or insect affecting conifers is the pine bark beetle. The Malheur National Forest, western and east edges of the ecoregion appear to have the lowest distance between infected Other Conifer stands. The Other Conifer stands further from the edges of the ecoregion tend to have higher distances to diseased stands, probably due to lower density of Other Conifers.

Conifers can vary in their tolerance for wildfire. Douglas-fir can survive low intensity surface fires but are killed by moderate to high intensity fires whereas lodgepole pine and Engelmann spruce require open habitat for regeneration and regenerate from seed after a wildfire. The highest burn probability is Other Conifer areas within southern and northern Idaho from the southern edges of the Payette National Forest to the Boise National Forest northeast of Mountain Home. The areas with the lowest burn probability are on the periphery of the ecoregion within the National Forests except for Payette and Boise as previously mentioned.

Livestock grazing is common in the ecoregion and approximately70 percent of the REA is under grazing allotments. Livestock browsing on buds, needles and cambium may retard growth and regeneration and consumption of preferred herbaceous species may affect the establishment dynamics of conifers.

Climate change, in particular toward hotter and drier conditions, may alter the current distribution of coniferous forests and is thought to weaken the trees making them more vulnerable to insect attack. USFS models show the Other Conifers to be negatively impacted by climate change especially in 2060 timeframe. One outlier is ponderosa pine that causes some uncertainty in the modeling as it is forecasted to become more viable in locations (lower elevation) where it currently doesn't exist.

In general, the most intact Other Conifer areas are the less dense interior sections of the ecoregion such as the Owyhee Mountains and Craters of the Moon National Monument. Certain National Forest along the periphery of the ecoregion such as Challis and Targhee also had some areas that had high intact scores. The less intact Other Conifer areas are the Payette, Boise and Malheur National Forest.

7 References

Bentz, B. 2008. Western U.S. Bark Beetles and Climate Change. (May 20, 2008). U.S. Department of Agriculture, Forest Service, Climate Change Resource Center. Available on internet at: http://www.fs.fed.us/ccrc/topics/bark-beetles.shtml

Steil, J.C., C.R. Blinn, and R. Kolka. 2009. Foresters' Perceptions of Windthrow Dynamics in Northern Minnesota Riparian Management Zones. North Journal of Applied Forestry 26: 76-82.

Willson, G.D. and J. Stubbendieck. 1997. Fire effects on four growth stages of smooth brome (*Bromus inermis* Leyss.). Natural Areas Journal 17(4)306-312. Northern Prairie Wildlife Research Center Online, available at: http://www.npwrc.usgs.gov/resource/habitat/brominer/index.htm (Version 02MAR98).

Wild Horse & Burro
Coarse Filter Conservation Element Package

1 Conservation Element Description

The BLM is the federal agency responsible for protecting, managing, and controlling populations of wild horses and burros under the authority of the Wild Free-Roaming Horses and Burros Act of 1971. Their mission is to ensure that sustainable herds thrive on healthy western public rangelands as directed by Congress. The BLM manages these iconic animals on 26.9 million acres of rangelands as part of their overall multiple-use mission across 245 million acres of public lands (BLM 2011a).

Wild horse and burro herds grow at a rate on average of 20 percent a year, which means herds can double in size every four years. As these populations grow at such a fast pace, there are many potential adverse impacts to public lands as a result of overpopulated herds. In response to herd growth, the BLM must remove thousands of wild horses and burros from the range each year to protect public rangelands from the environmental impacts of overgrazing and prevent horse deaths from starvation and dehydration. Currently, the western rangeland free-roaming population of approximately 40,000 horses and burros exceeds by nearly 13,000 the number that the BLM has determined can exist in balance with other public rangeland resources and uses. The health of ecosystems of public rangelands, which also provide the primary forage resources for livestock and habitat for wildlife and vegetation, is not sustainable and is not able to withstand the impacts resulting from rapidly growing wild horse and burro herds (BLM 2011h).

The BLM's goal is to maintain sustainable wild horse populations on healthy public lands. To do this, the BLM works to achieve what is known as the Appropriate Management Level – the point at which wild horse and burro herd populations are consistent with the land's capacity to support them. In the context of its multiple-use mission, Appropriate Management Level is the level at which wild horses and burros can thrive in balance with other public land uses and resources, including livestock grazing, vegetation, and wildlife (BLM 2011b).

There are 71 Wild Horse and Burro Herd Areas and 49 Wild Horse and Burro Herd Management Areas within the NGB ecoregion (USGS 2012).

2 Conservation Element 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 Conservation Element Distribution Mapping

3.1 Data Identification

The major datasets identified to map the distribution of the wild horse and burro conservation element was BLM's herd areas and herd management areas. The conservation element distribution datasets are further described in Table 3-1.

Table 3-1. Data Sources for the Wild Horse and Burro Coarse Filter Conservation Element Distribution Mapping for the NGB Ecoregion

Data Required	Dataset Name	Source Agency	Type/Scale	Status	Use in REA
Terrestrial Systems					
Occupied Ranges	Herd Areas	BLM	Polygon	Acquired	Yes
	Herd Management Areas	BLM	Polygon	Acquired	Yes
Land Condition	Rangeland Health Study	USGS 2011	Polygon	Acquired	Yes
	Land Treatment Digital Library	USGS - Boise	Polygon	Acquired	Yes

3.2 Distribution Mapping Methods

Wild horse and burro herd areas and herd management areas are spatial layers that were obtained from the BLM as the primary manager of this resource. Herd management areas are the primary locations where wild horse and burro are currently managed by BLM while Wild horse and burro herd areas are locations that were used by a herd as its habitat in 1971, when the Wild and Free Roaming Horses and Burros Act (43 CFR 4700.0-5(d)) was passed.. Both herd management areas and Wild horse and burro herd areas were analyzed as Wild horse and burro herd areas may provide a future possible location for wild horse and burros if deemed appropriate for use as a herd management areas. Since herd management areas and Wild horse and burro herd areas cross the ecoregion border, some of the analysis such as burn probability will only be available for portions that are within the ecoregion.

3.3 Data Gaps, Uncertainty and Limitations

The population data used for some of the figures was based off of the latest from individual state offices or from the BLM census for 2012 which can be found at http://www.blm.gov/wo/st/en/prog/whbprogram/herd_management/Data.html. Some of the population counts are based on prior year counts and can be several years old but are the latest that is available. Population counts in Wild horse and burro herd areas were mostly none existent or very old so population counts in Wild horse and burro herd areas were not used. The Appropriate Management Level is listed with the populations. Some states use a range of values (Low – High), in these cases the highest Appropriate Management Level was used when comparing populations to the Appropriate Management Level. When there were wild horses and burros present, their populations and Appropriate Management Levels were added together to arrive at a total population and total Appropriate Management Level.

4 Conceptual Model

There is no conceptual model for wild horse and burros.

5 Management Questions

Where are the current wild horse and burro Herd Management Areas? (MQ 21).

Figure 5-1 shows locations of wild horse and burro herd management areas within the ecoregion while Figure 5-2 shows herd areas herd management areas are actively managed by the BLM. The wild horse and burro herd areas should not contain populations but could be used in the future. Therefore they are included in the analysis. Figure 5-3 shows the current populations of the herd management areas. The population counts are up to date as of 2012 census, but the individual herd management areas are not counted every year so some counts may be from several years ago. Figure 5-4 shows the burro population within the herd management areas. Each herd management area has an Appropriate Management Level that measures what the occupancy of the herd management areas should be. Figure 5-5 shows the occupancy rate of each herd management areas based on the population and Appropriate Management Level. Herd management areas with both wild horses and burros had the population and Appropriate Management Level summed together and reported combined. If a range of Appropriate Management Levels were provided for an area, the higher Appropriate Management Level was used. The population counts for wild horse and burro herd areas were very out of date or unavailable and were not reported.

Where will Change Agents (excluding climate change) overlap herd management areas, under each time scenario? (MQ 22).

Development

Figure 5-6 shows the resulting distance to development (developed areas, agriculture and roads) for herd management areas in the ecoregion. Figure 5-7 show the distance for Wild horse and burro herd areas. Most herd management areas and Wild horse and burro herd areas scored moderately as road density seems to be fairly high in the TIGER roads being used in the analysis. This dataset includes 4WD and private ranch roads which can be at fairly high density within herd management areas and Wild horse and burro herd areas.

Wildfire

Figures 5-8 and 5-10 show the fire frequency and FSim burn probability for the herd management areas. The Saylor Creek herd management area seems to be the most vulnerable for combined fire frequency and burn probability. Most of the herd management areas in the eastern part of the ecoregion all have higher burn probabilities as well as the Twin Peaks herd management areas on the border of Nevada and California where the Rush wildfire occurred in 2012. Figures 5-9 and 5-11 show a similar pattern for Wild horse and burro herd areas.

Invasives

Figures 5-12 and 5-13 shows the dominance of cheatgrass within the ecoregion based on the Peterson (2005) study. This study covered about half of the ecoregion but left gaps in most of Idaho and Oregon and parts of California and Utah. The Invasives Rolling Review Team felt that this study was the best available for the ecoregion until a more recent study by USGS on cheatgrass mortality is released this year. The dominant locations of cheatgrass, based on this study, are the edge of the Snake River Plain along with isolated pockets in Nevada and Oregon mostly due to disturbance. The dominance of cheatgrass could convert typical fire return intervals from 60 – 110 years to 3 – 5 years and create a homogenous landscaped dominated by invasive species (Chambers and Pellant 2008). Herd management areas that appear to be have high amounts of cheatgrass cover would be those in Idaho such as Saylor Creek, Hardtrigger and Black Mountain as well as Jackies Butte in Oregon.

Grazing

The USGS conducted an inventory of grazing allotments and a determination of the rangeland health based on standards for each allotment. Figures 5-14 and 5-15 show the resulting assessment for herd management areas and Wild horse and burro herd areas in the ecoregion. There were several areas of uncertainty with this study that were identified such as that every state has different standards for rangeland health that makes comparison difficult. Another area of inconsistency was that not all field offices contributed data which created gaps in the dataset.

Where will herd management areas experience significant deviations from normal climate variation? (MQ 23.)

Reviewing the climate change package shows that precipitation is predicted to increase annually by 2060. The majority of that precipitation will arrive during the spring with a decrease in precipitation in the months of September and October. Less precipitation following the hottest summer months (July and August) may increase demands for water delivery as natural water sources may dry up, decrease forage regrowth and alter the Appropriate Management Level for the herd management areas and Wild horse and burro herd areas. Climate variability and frequency of floods and droughts is predicted to increase (Chambers and Pellant 2008). Since wild horse and burros are restricted from movement outside of their herd management areas, drought from climate change could be a significant challenge.

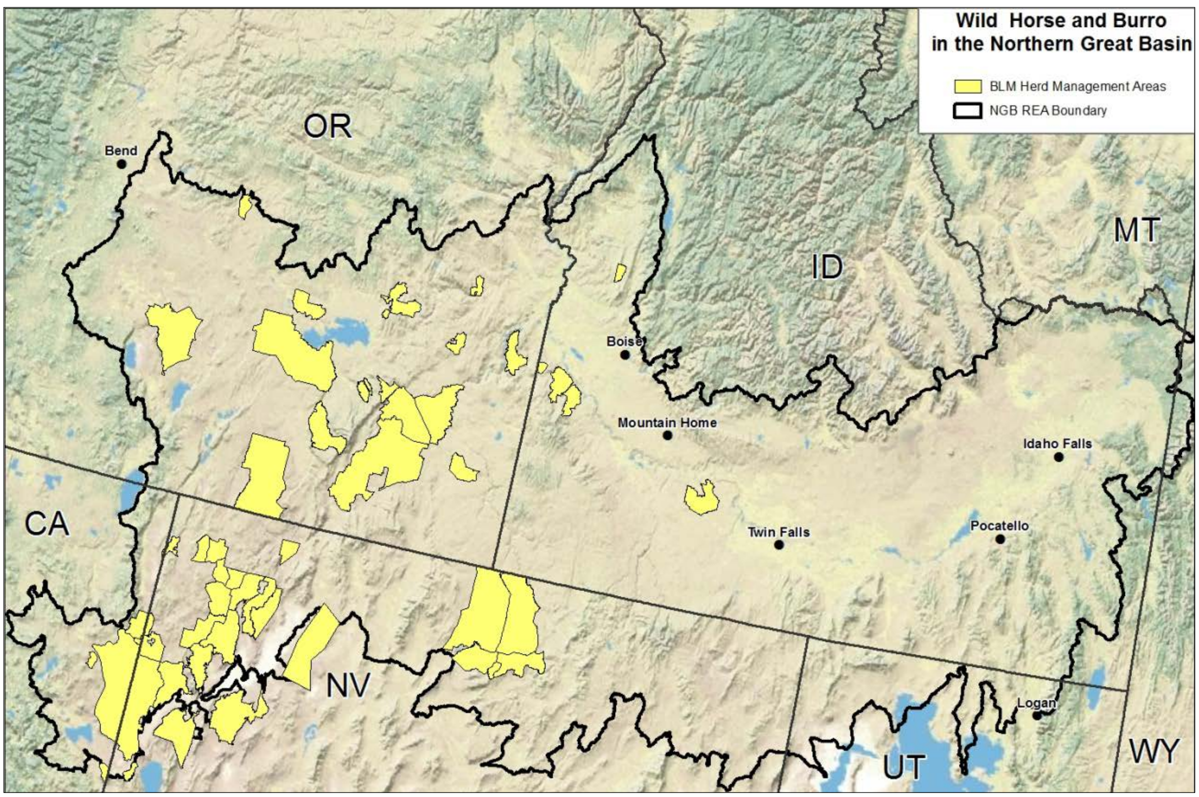

Figure 5-1. Location of Herd Management Areas within the NGB

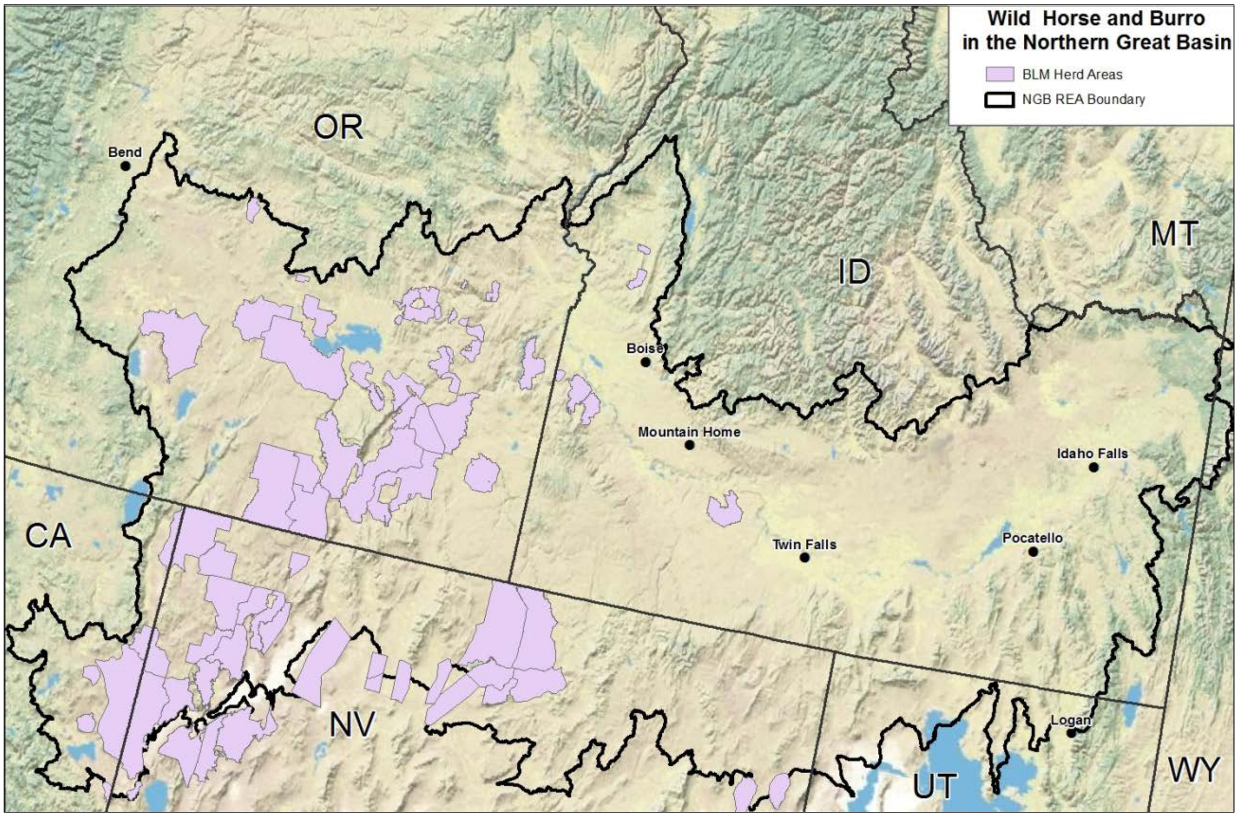

Figure 5-2. Location of Herd Areas within the NGB

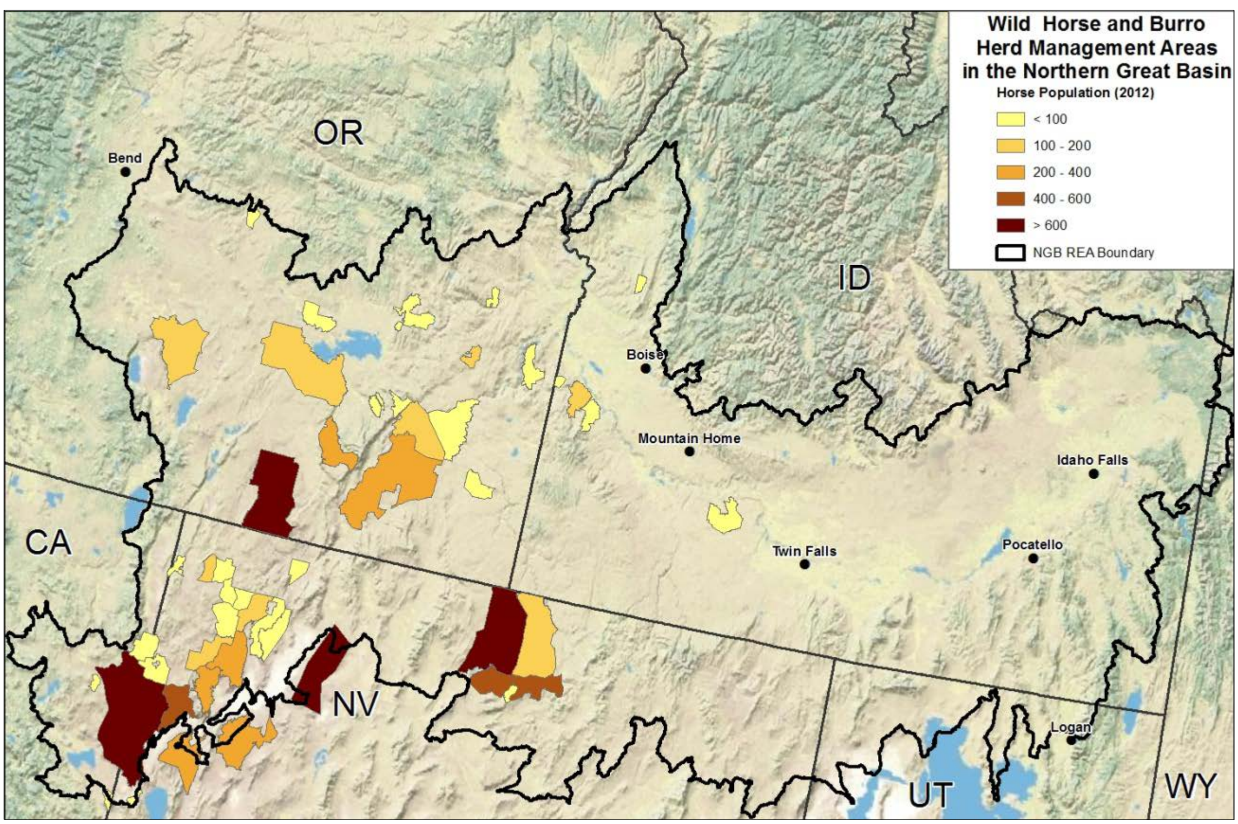

Figure 5-3. Wild Horse Population by Herd Management Area

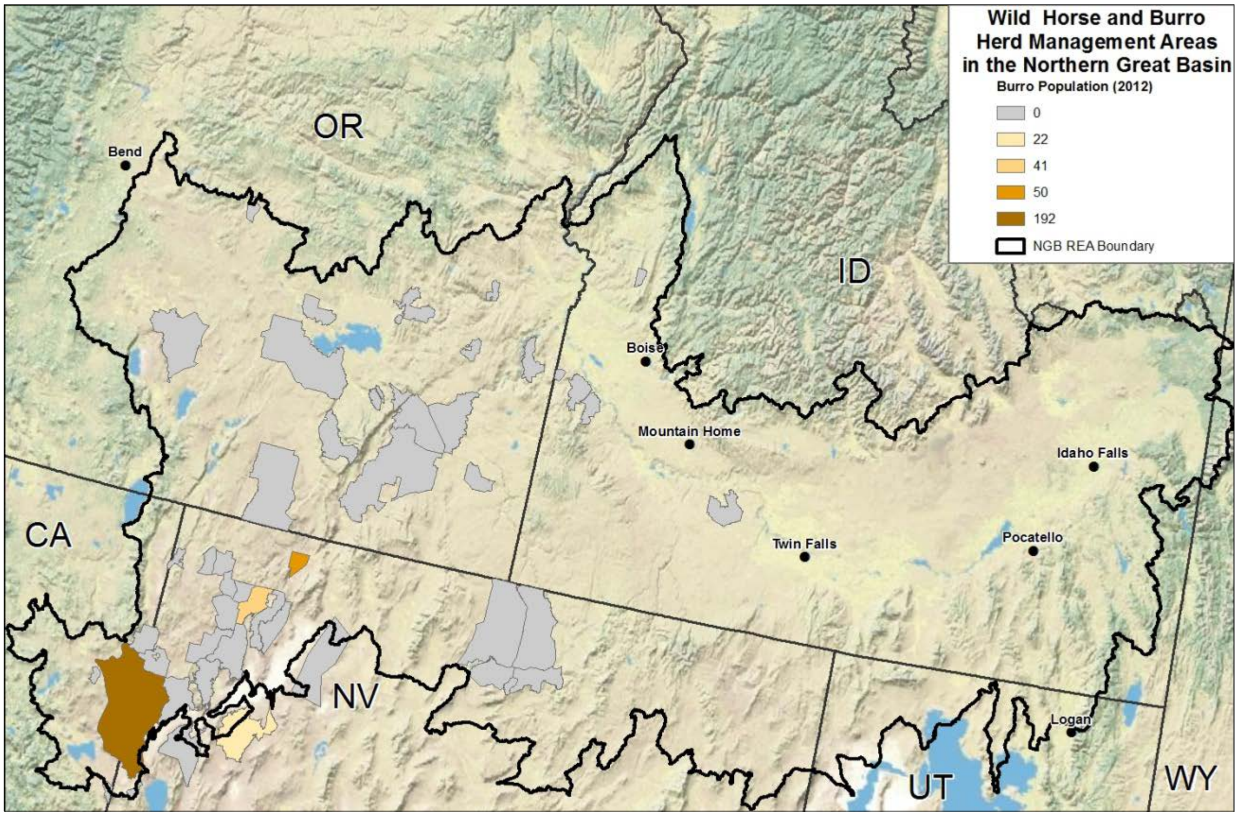

Figure 5-4. Burro Population by Herd Management Area

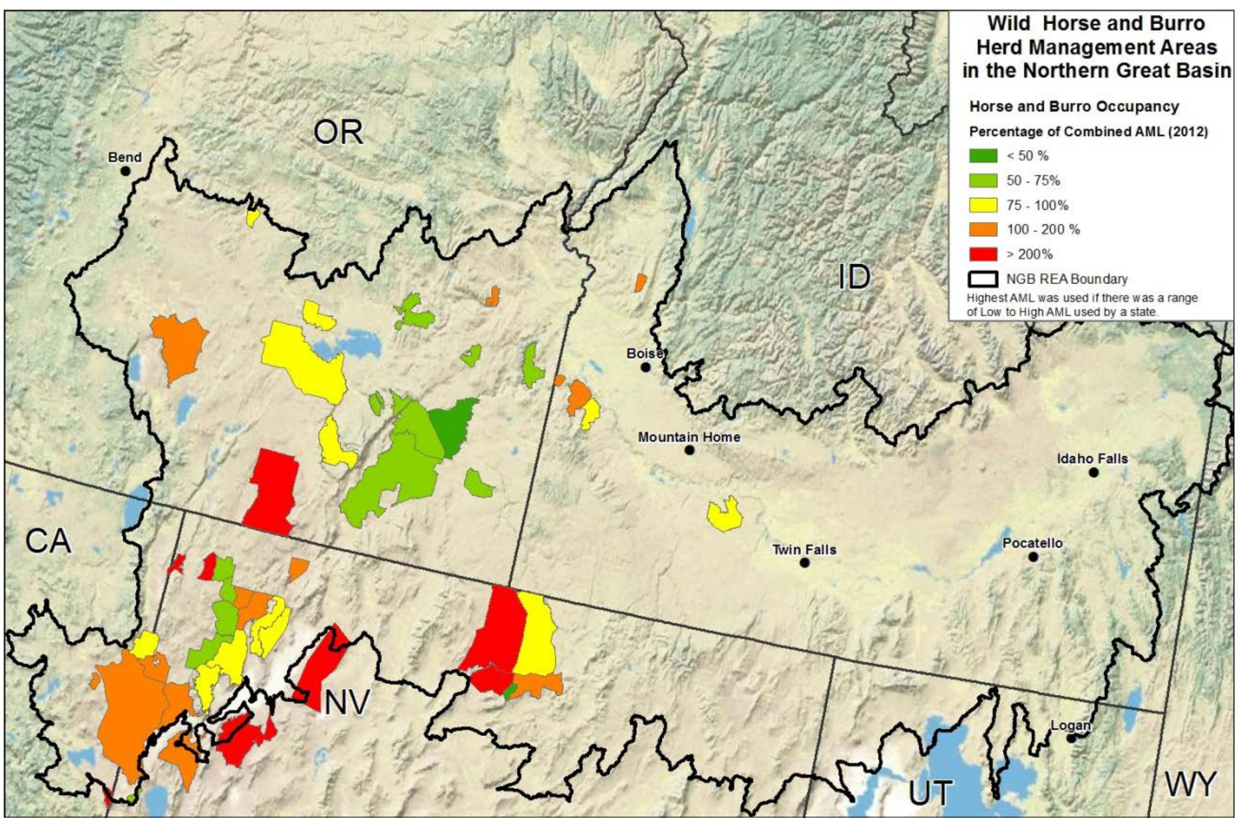

Figure 5-5. Percent of Appropriate Management Level within Herd Management Areas

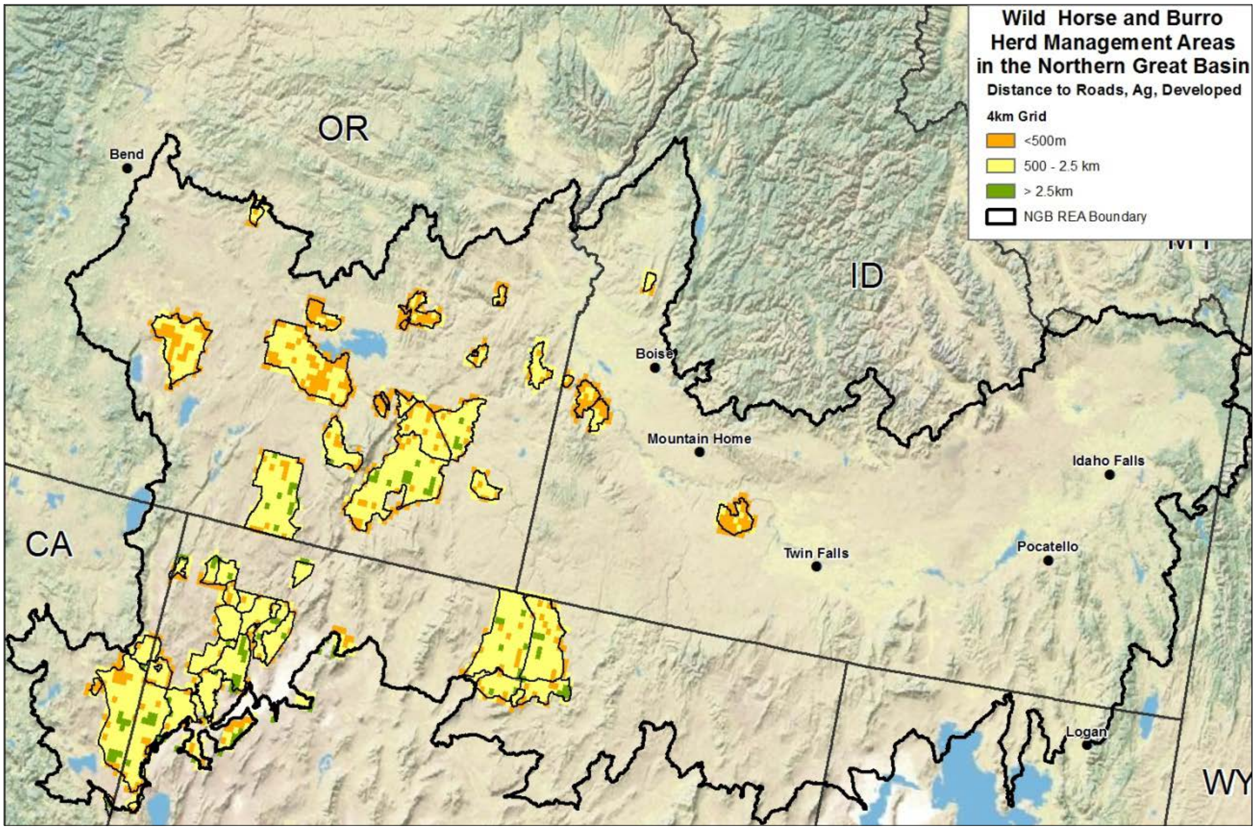

Figure 5-6. Distance to Developed for Wild Horse and Burro Herd Management Areas

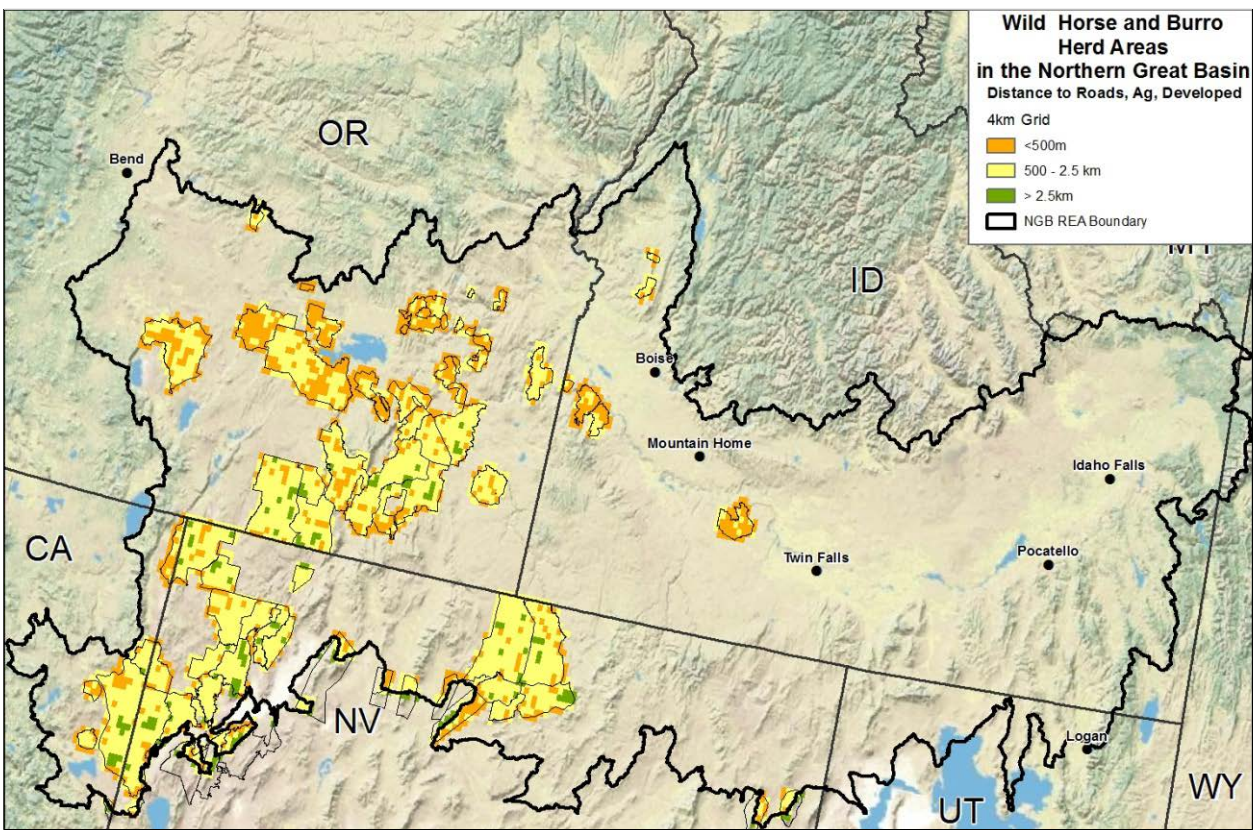

Figure 5-7. Distance to Developed for Wild Horse and Burro Herd Areas

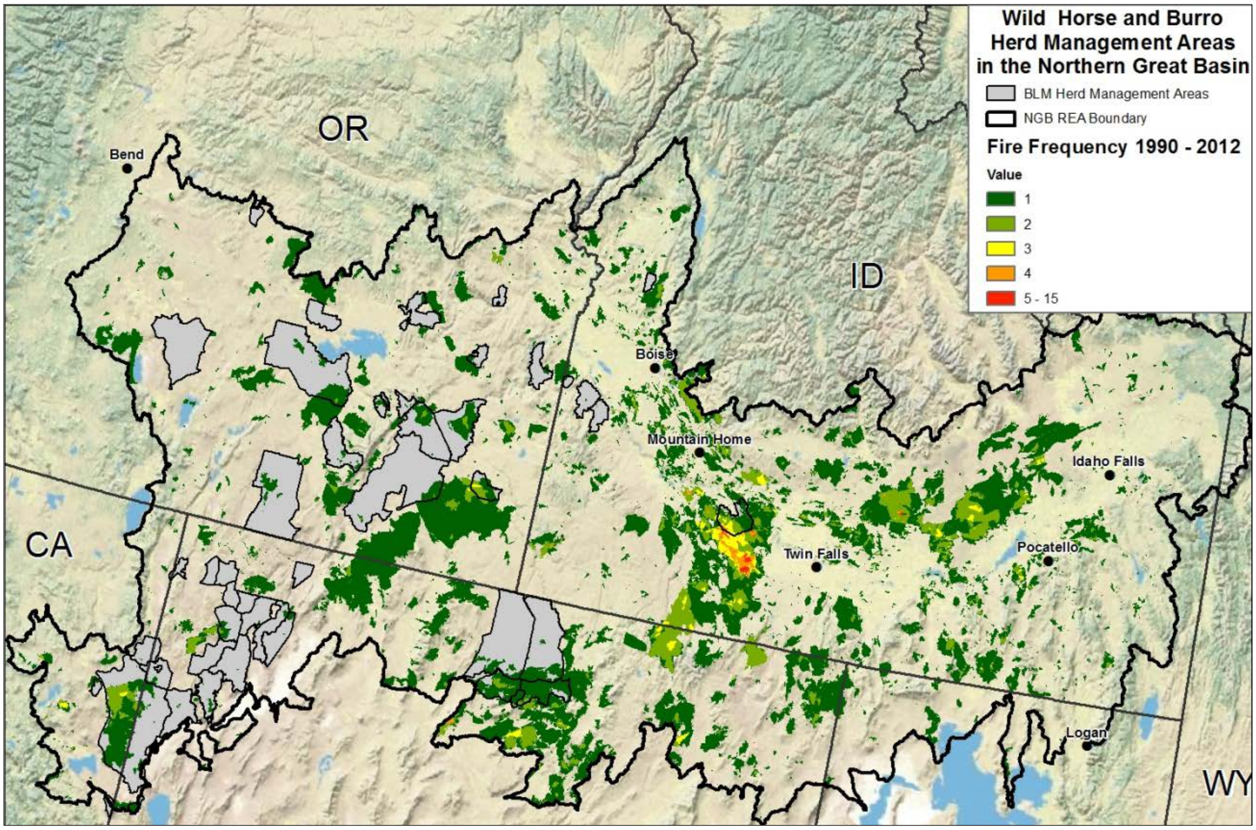

Figure 5-8. Fire Frequency (1990 – 2012) in Herd Management Areas

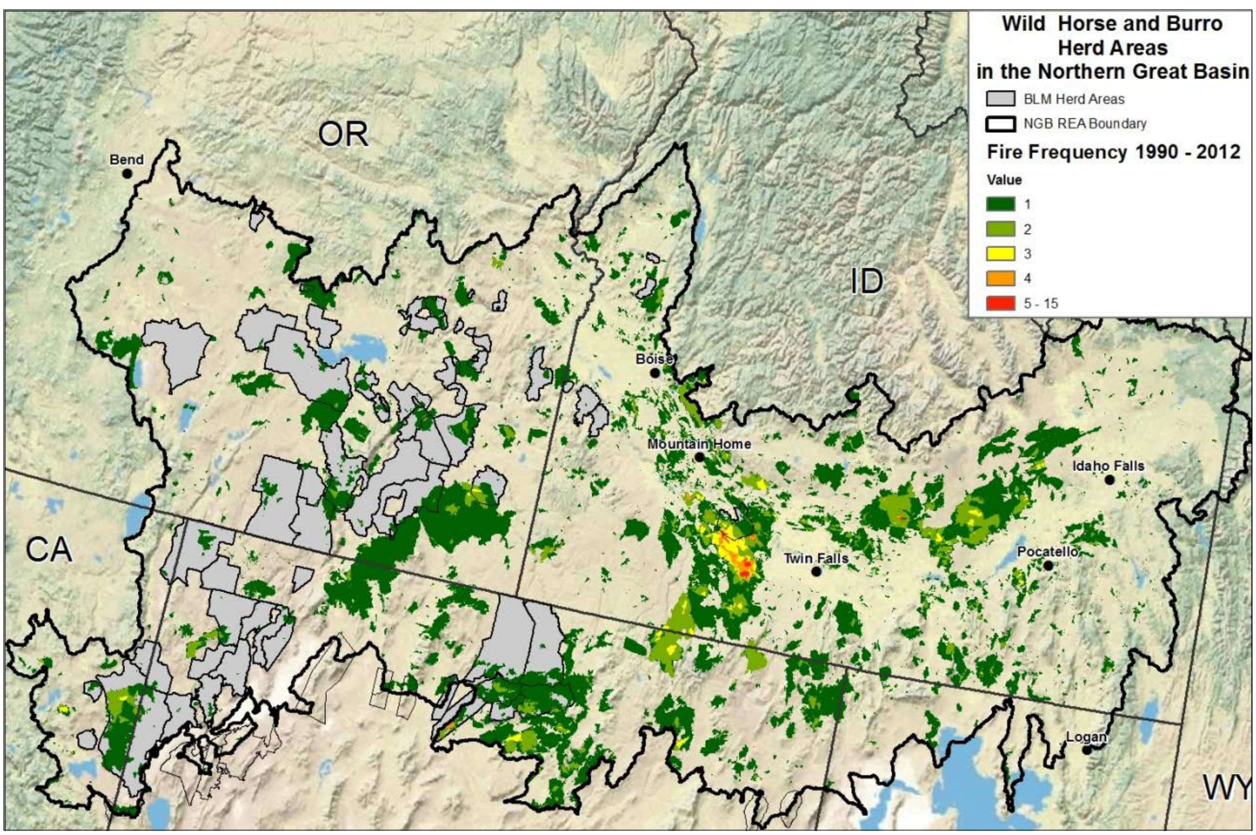

Figure 5-9. Fire Frequency (1990 – 2012) in Herd Areas

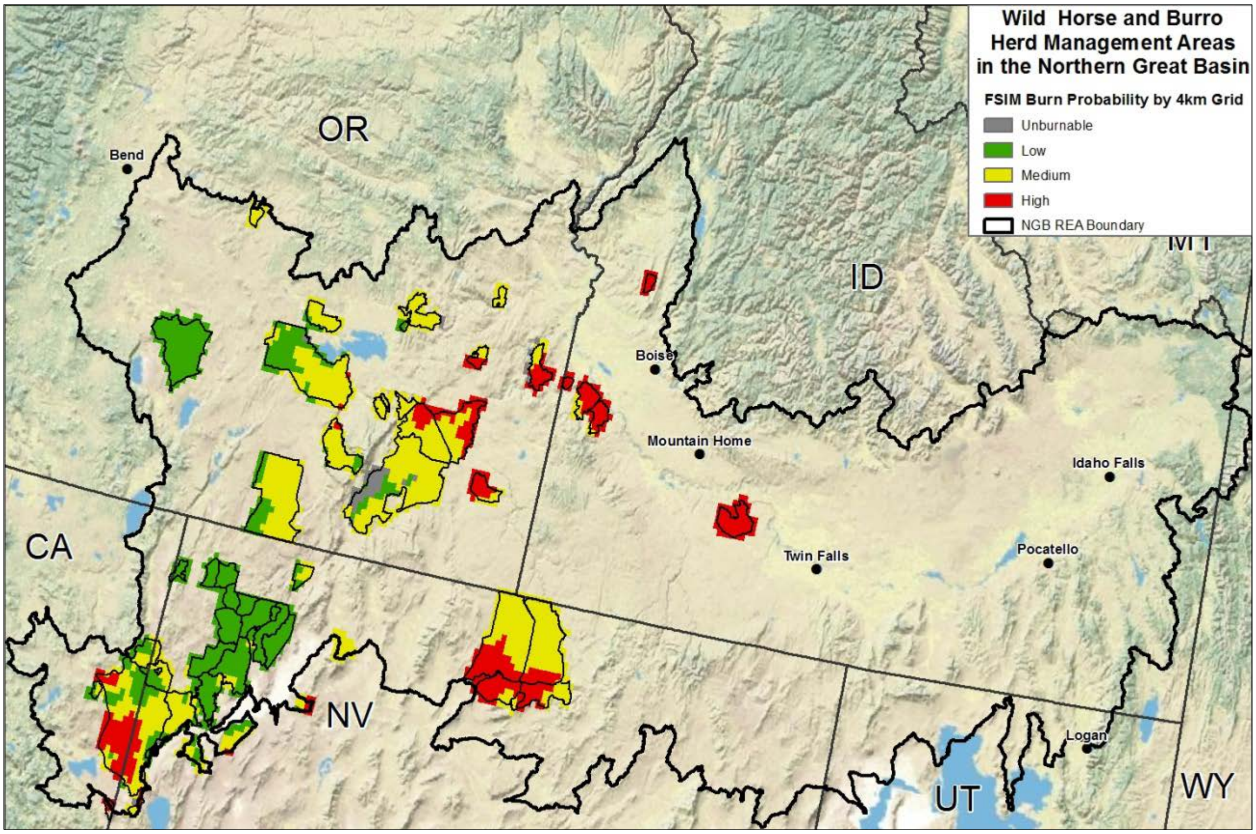

Figure 5-10. Burn Probability for Wild Horse and Burro Herd Management Areas

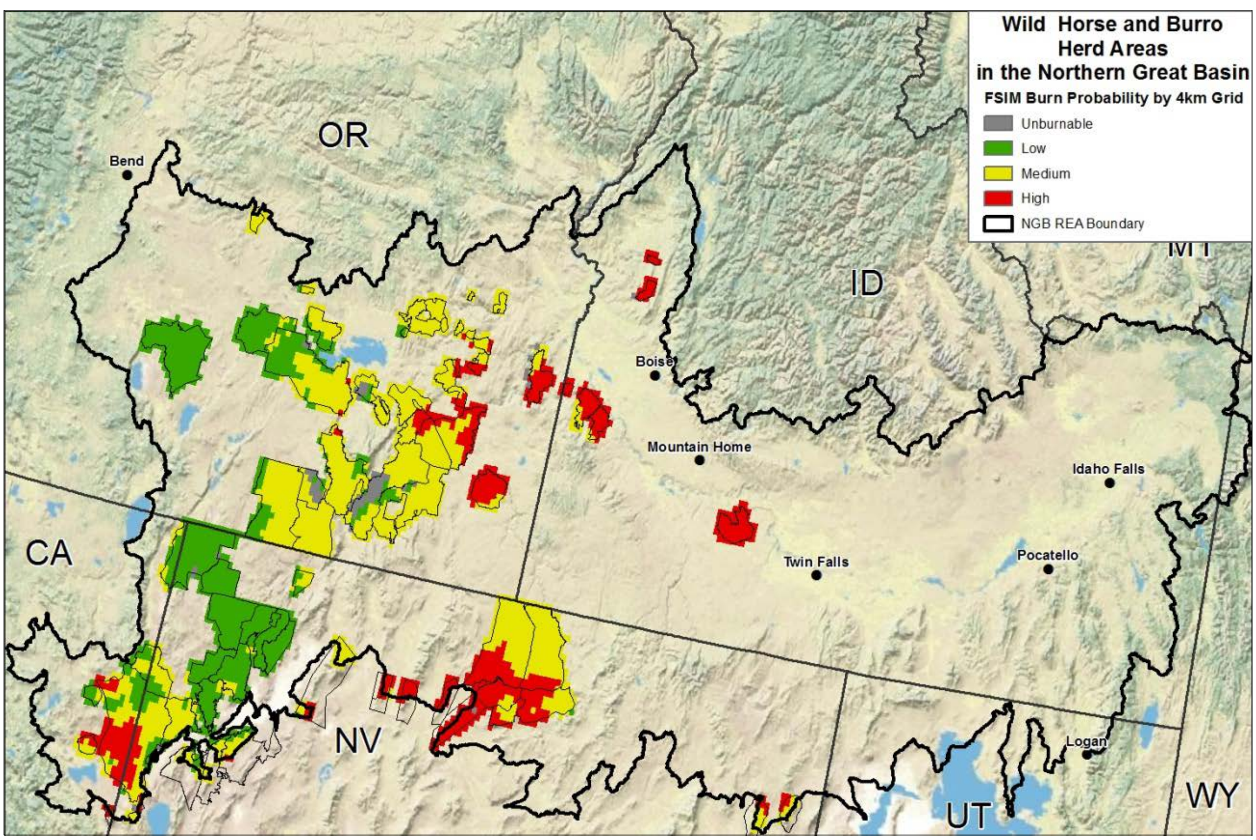

Figure 5-11. Burn Probability for Wild Horse and Burro Herd Areas

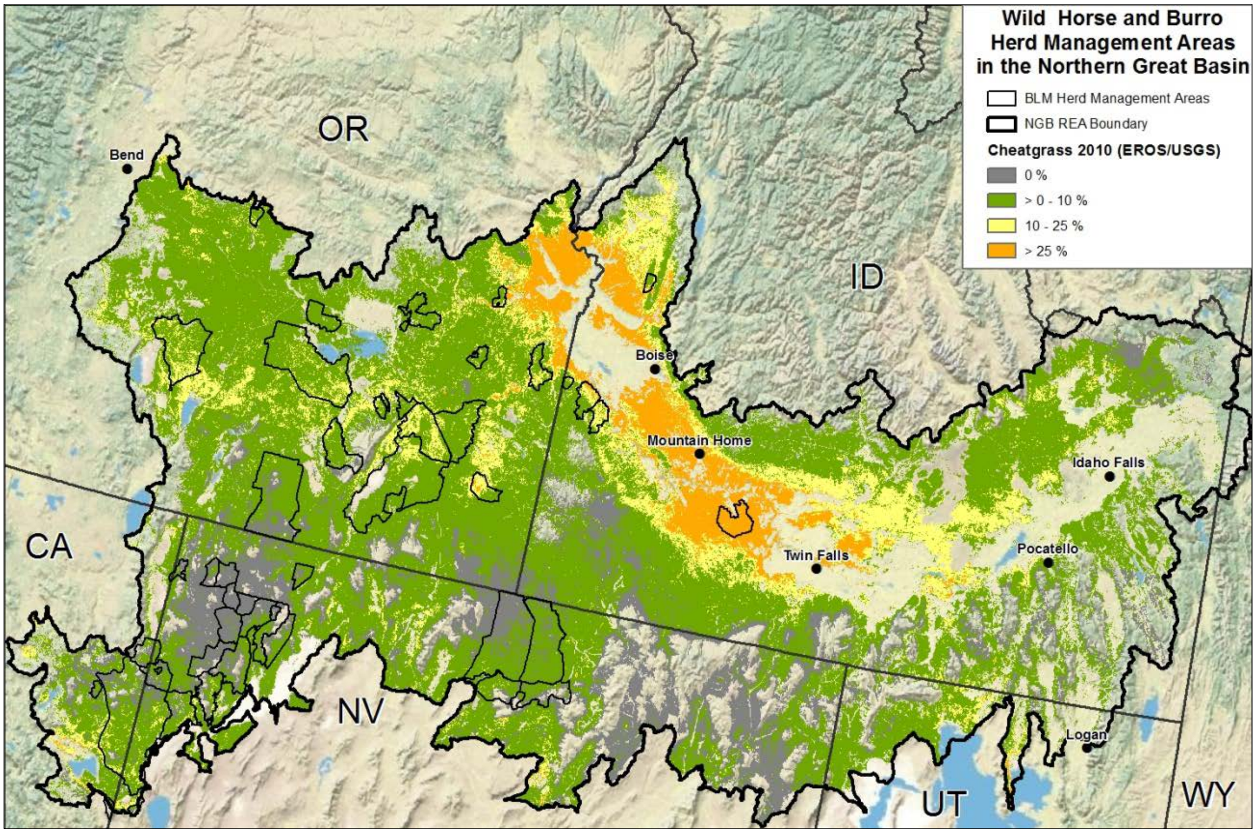

Figure 5-12. Cheatgrass within Wild Horse and Burro Herd Management Areas

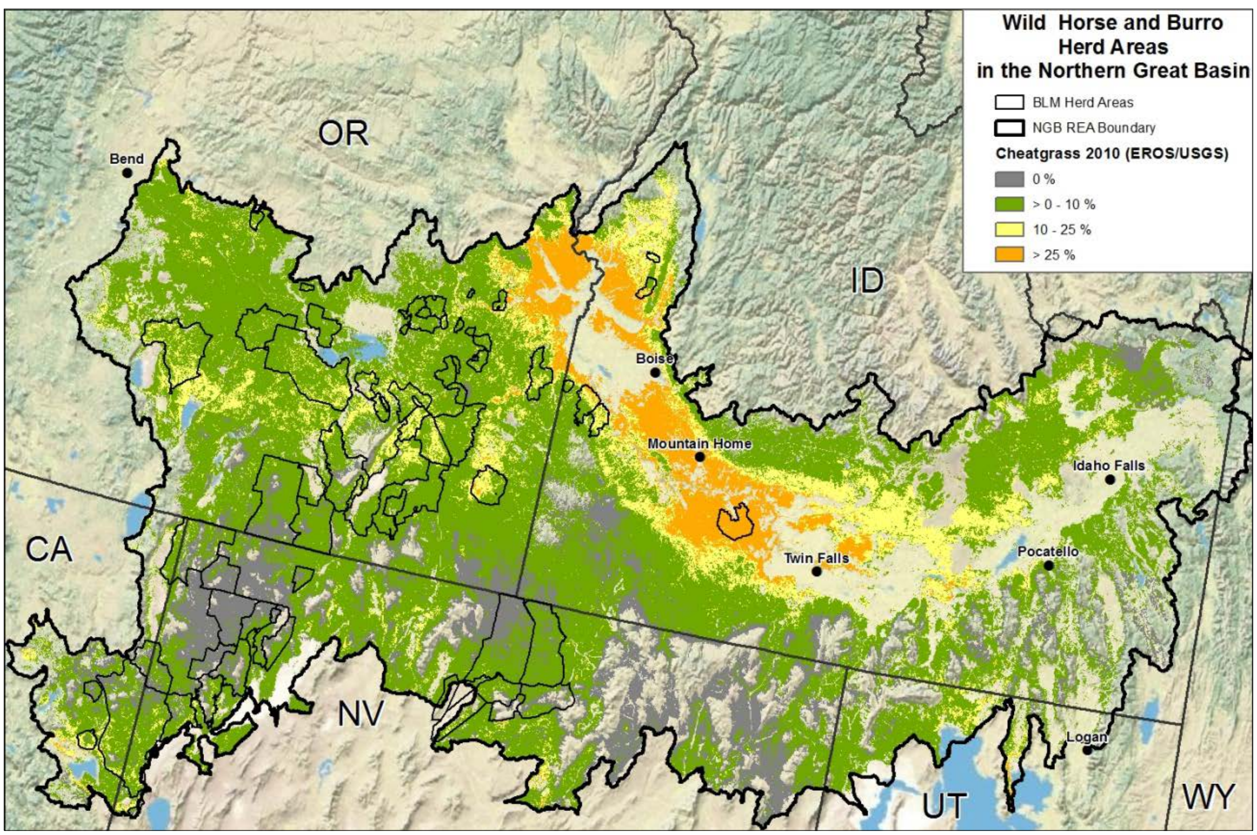

Figure 5-13. Cheatgrass within Wild Horse and Burro Herd Areas

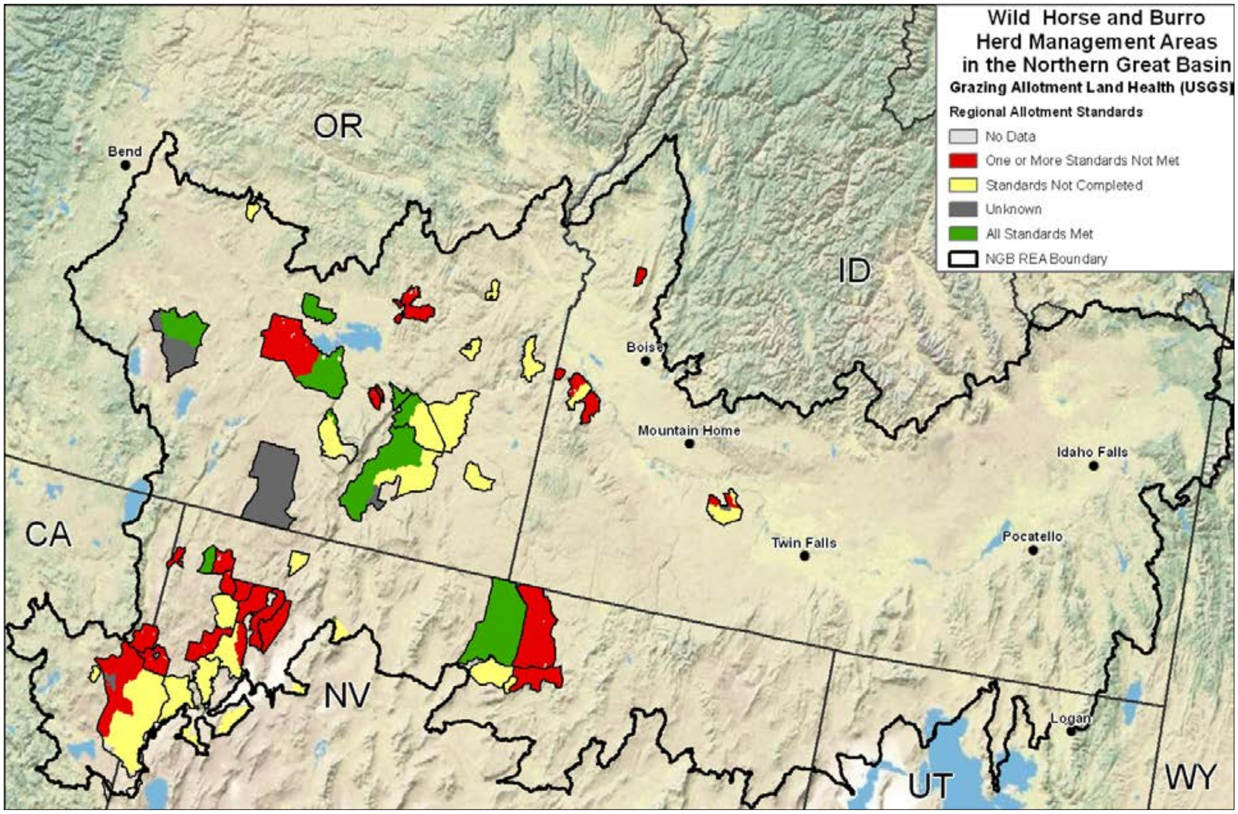

Figure 5-14. Rangeland Standards for Wild Horse and Burro Herd Management Areas

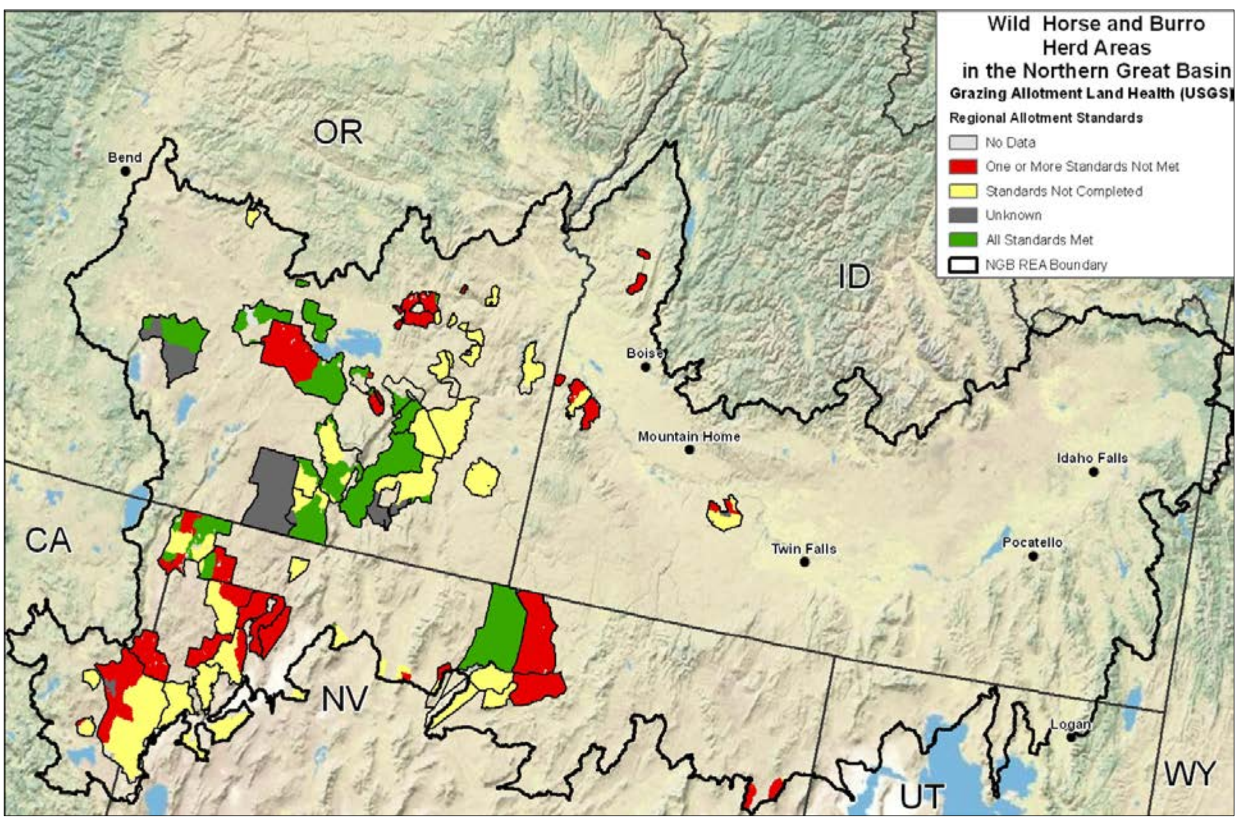

Figure 5-15. Rangeland Standards for Wild Horse and Burro Herd Areas

6 References

Bureau of Land Management (BLM). 2011a. Wild Horses and Burros, History and Facts, and Director's Message. Website available at: http://www.blm.gov/wo/st/en/prog/whbprogram/history_and_facts/director.html. Accessed February 2012.

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Specially Designated Areas
Coarse Filter Conservation Elements Package

1 Conservation Element Description

Specially Designated Areas (SDAs) are areas of natural and historic importance in the United States that have been, or have been proposed to be, designated by Congress to become federally protected entities, identified through land use planning, Presidential proclamation (National Monuments) or by states (for State Parks). SDAs require special management attention to protect and prevent irreparable damage to areas with historic, cultural, and scenic values as well as areas supporting fish, wildlife, or other natural resources or processes (BLM 2011). There are many different SDAs under a variety of agency jurisdictions that were considered within the NGB ecoregion. Table 1-1 below lists the SDAs considered for this Rapid Ecoregional Assessment (REA), their abundance, and approximate level of land management and protection required. BLM released a science strategy in 2007 to facilitate scientific understanding of BLM's National Landscape Conservation System units (BLM 2007). Science strategies have been assembled for individual units or established at a state level.

Table 1-1. Specially Designated Areas and Abundance within the NGB Ecoregion

Management/Land Protection:	Specially Designated Areas (SDAs)	Count	Source
High	Wilderness Areas	27	Wilderness.net[1]
	Wilderness Study Areas	54	PADS 1.2[2]
	Wild and Scenic Rivers	21	Rivers.gov[3]
	Wild and Scenic Study Rivers	2	Rivers.gov[3]
	National Conservation Areas	79	PADS 1.2[2]
	National Wildlife Refuges	11	PADS 1.2[2]
	ACECs	61	PADS 1.2[2]
	National Monuments	4	PADS 1.2[2]
	Wild Horse & Burro Herd Mgmt Areas	49	BLM
	State Parks	8	PADS 1.2[2]
Low	Historic Districts	43	PADS 1.2[2], NRHP[4]

Sources:
1. BLM 2012
2. USGS 2012
3. USFWS 2012
4. NPS 2011

2 Conservation Element 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 Conservation Element Distribution Mapping

3.1 Data Identification

The primary datasets for the SDAs are listed in Table 3-1. These may be supplemented by BLM data if any proposed wilderness area, ACEC, etc. is not in the Protected Areas Database.

Table 3-1. Data Sources for the Specially Designated Areas Coarse Filter Conservation Element Distribution Mapping for the NGB Ecoregion

Data Required	Dataset Name	Source Agency	Type/Scale	Status	Use in REA
Terrestrial Systems					
Specially Designated Areas	Protected Areas Database (PADS)	USGS	Polygon	Acquired	Yes
	Wild and Scenic Rivers	Rivers.gov - USFWS	Polyline	Acquired	Yes
	Wilderness Areas	Wilderness .net - BLM	Polygon	Acquired	Yes
	Wilderness Study Areas	BLM	Polygon	Acquired	Yes
	ACECs	BLM	Polygon	Acquired	Yes
	National Wildlife Refuge	BLM	Polygon	Acquired	Yes
	National Conservation Areas	BLM	Polygon	Acquired	Yes
	National Monuments	BLM	Polygon	Acquired	Yes
	Historic Districts	NPS	Polygon	Acquired	Yes
	State Parks	USGS	Polygon	Acquired	Yes

3.2 Distribution Mapping Methods

The SDAs within the ecoregion were extracted from the Protected Areas Database and other datasets containing their boundaries and all combined on one NGB ecoregional map.

4 Conceptual Model

There is no conceptual model for the SDA Conservation Element because management practices, restrictions and regulation of specially designated areas can vary greatly amongst each SDA.

5 Management Questions

Where are specially designated areas of ecological and/or cultural value? (MQ 20)

Since the NGB is made up predominantly of BLM and USFS land, there is a large number of SDAs within the ecoregion (Figure 5-1). Wilderness Areas (based on the Wilderness Act of 1964) are designated by Congress to permanently protect areas that have minimal human imprint, opportunities for unconfined recreation, areas greater 5,000 acres, and have educational, historic or scientific value. Wilderness Areas are the most protected from development of all the SDAs as they restrict motorized vehicles, structures and most types of development. There are currently 27 wilderness areas and 54 wilderness study areas that are classified as suitable to become wilderness areas in the future. The northwest corner of Nevada contains a large concentration of SDAs making it the most protected part of the ecoregion with ten wilderness areas, the large Charles Sheldon National Wildlife Refuge, eleven Wilderness Study Areas and nine Areas of Critical Environmental Concern. Steens Mountain in Oregon is another location within the ecoregion containing a concentration of SDAs. Wild and Scenic Rivers are prevalent in Oregon and Idaho with 21 stretches of river designated as wild and scenic.

Population Growth vs. SDAs

Figure 5-2 shows the estimated population growth using the Integrated Climate and Land Use Scenario at 2060 for counties within the ecoregion. The Integrated Climate and Land Use Scenario data provides different scenarios for modeling population growth such as fertility rates, migration, etc. but for the REA the baseline or base case was used rather than picking a particular scenario. Figure 5-2 shows that the three counties with the highest predicted population growth will be Canyon, and Ada Counties in Idaho and Washoe County in Nevada. Canyon and Ada Counties are near Boise, the largest city in the ecoregion. Washoe County is projected to grow the most out of all the counties but the most of that growth will probably occur around Reno which is out of the ecoregion (roughly ninety-minute drive). Cache County in Utah is another place with moderate growth predicted. Many of the counties in the ecoregion are predicted to have declining population at 2060. Note that the population increases are expressed as percentages and at the entire county level whereas the growth is most likely to occur near population centers within the county. However, despite a high growth percentage, a relatively smaller initial population may not involve a large absolute increase in population.

Populated Areas vs. SDAs

Figure 5-3 shows the travel time from urban areas (greater than 20,000 in population) to areas within two hours distance. Two hours was used based on earlier work by Idaho Department of Lands 2009 and their Idaho Forest Action Plan and represent a typical day-trip recreation event. A cost distance spatial operation was used to calculate the distance from urban areas within the ecoregion and 100 miles from the ecoregion. Figure 5-3 shows that the majority of Oregon, California and Nevada fall outside the two hour window from most of the urban areas. Bend, OR is the one exception for Oregon as it is a fairly large urban area just outside of the ecoregion. Idaho and the eastern part of the Utah have the most areas within two hours of an urban area.

SDAs within two hours of urban areas may see extra pressure from growing populations. However, most of the SDAs in the ecoregion are outside of these two hour windows. Of the SDAs within a two hour window, wilderness areas should be the least impacted since they are roadless areas where access and travel is most difficult such as the Oregon Badlands Wilderness. SDAs under increased pressure in Idaho could be ACECs or NCAs with few restrictions on them such as the Snake River ACEC and Snake River Birds of Prey.

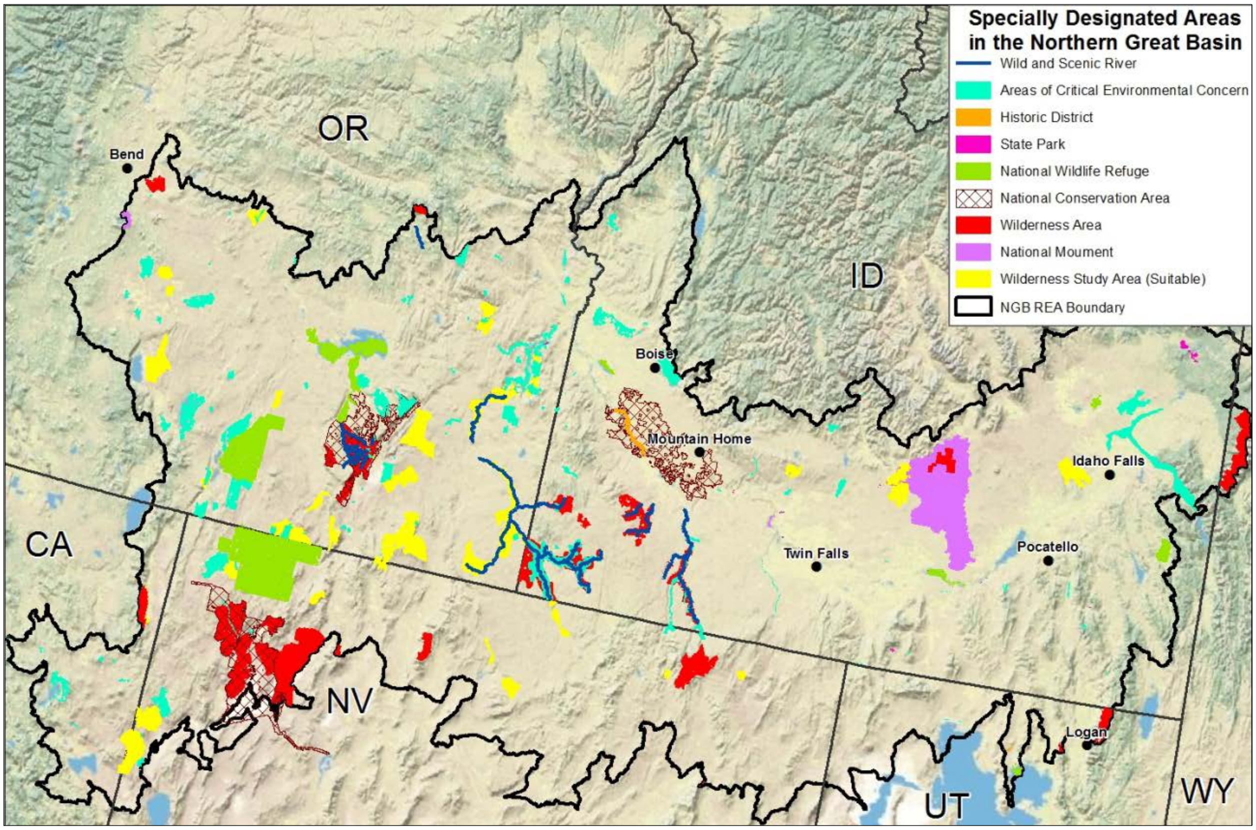

Figure 5-1. Specially Designated Areas in the NGB

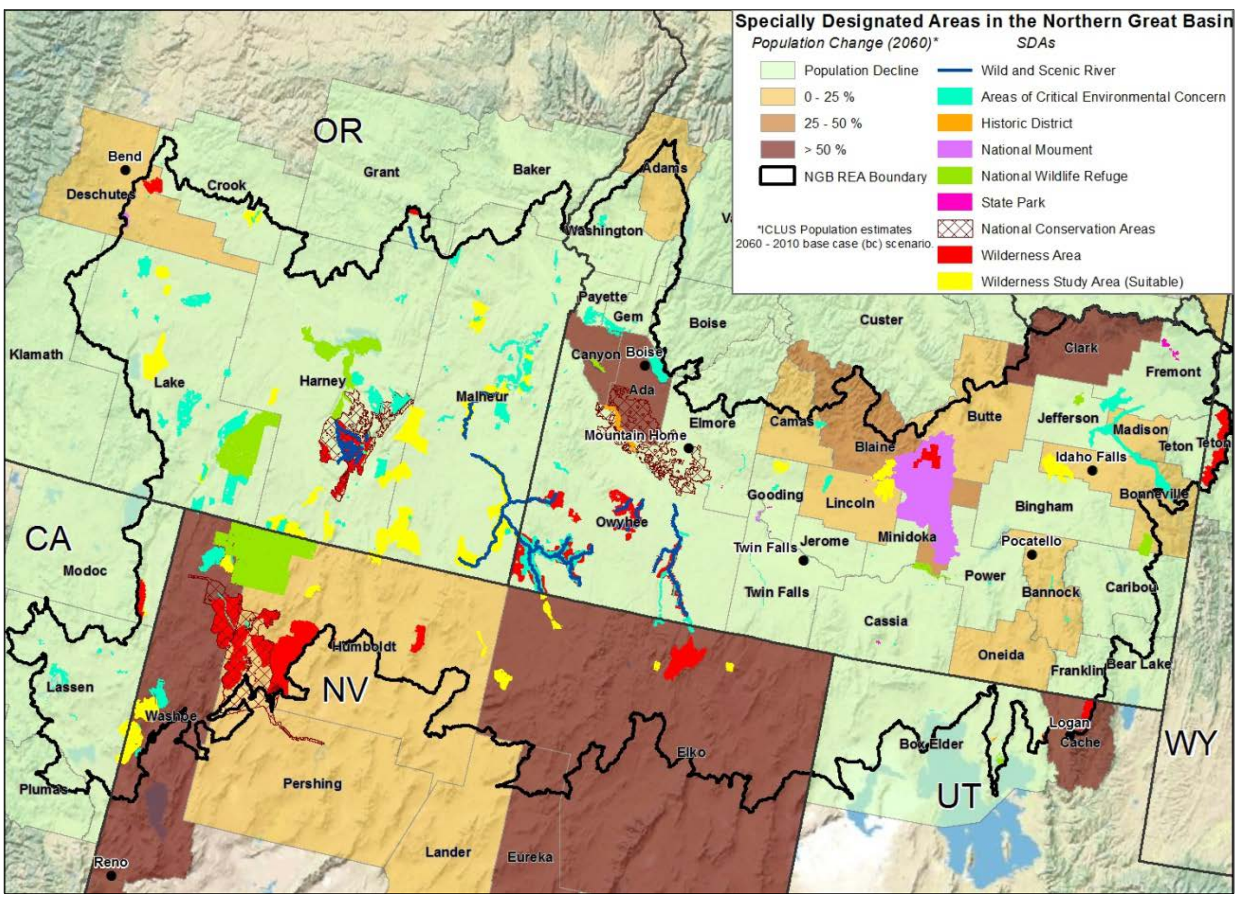

Figure 5-2. Specially Designated Areas and Population Growth at 2060

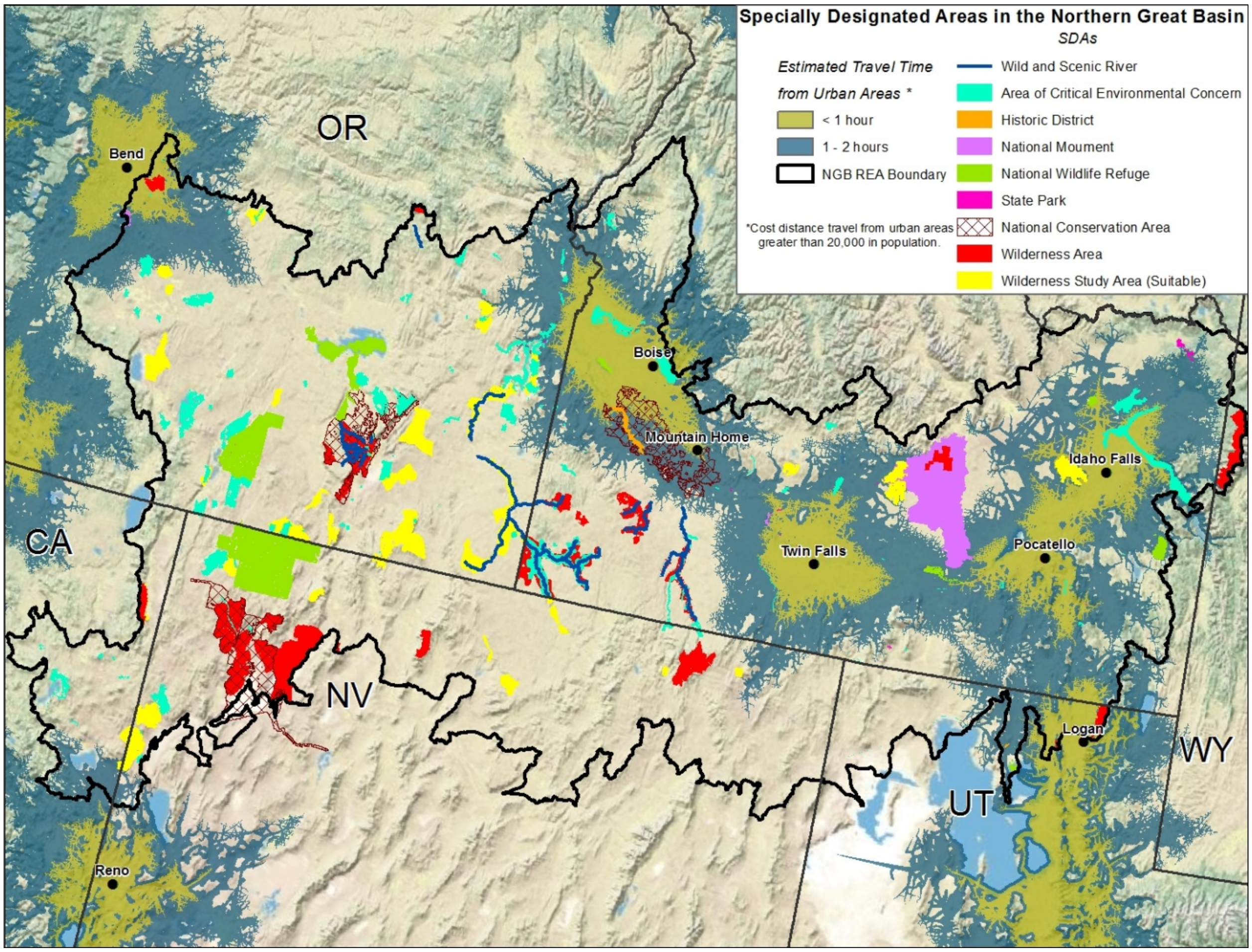

Figure 5-3. Travel Time from Urban Centers (> 20,000 in Population) to SDAs

6 References

Bureau of Land Management (BLM). 2007. National Landscape Conservation System Science Strategy: BLM/WO/GI-06/027+6100

Bureau of Land Management (BLM). 2011. Frequently Asked Questions. Web site at: http://www.blm.gov/ut/st/en/prog/more/acecs/faqs.html. Accessed January 2012.

Idaho Department of Lands. 2009. Idaho Forest Action Plan. Website at: http://www.idl.idaho.gov/bureau/ForestAssist/safr/May-2012_Idaho_FAP_part-1_Assessment.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).