March 15,2017

Trout Unlimited testimony on HB 5009-DOE budget

Co-chairs Frederic and Witt, and Committee members-

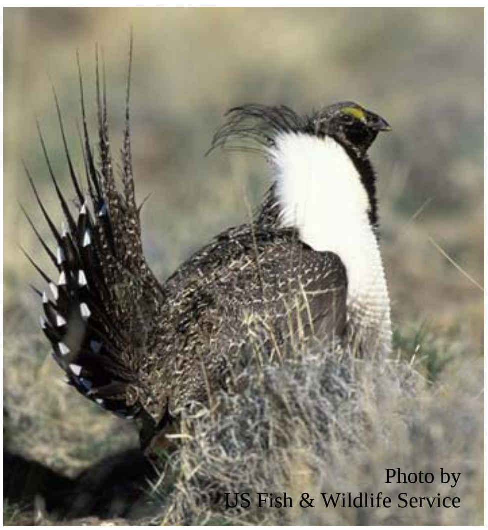
My name is Tom Wolf, here representing Trout Unlimited, a national coldwater conservation, composed of anglers and hunters. We have 3200 members here in Oregon and 155,000 nationwide, and many of our volunteers are very active in working to restore native wild coldwater fish populations. Trout Unlimited has sent me here today to state our support of HB 5009- the Department of Energy 2017-2019 proposed budget.

Trout Unlimited 's primary focus in the DOE budget is in the Energy Facility Siting program. We support the proposed budget for this part of DOE and POP 140, which provides staffing for energy facility siting.

As green energy like wind energy, solar power and other green energy sources are being developed across our nation, Trout Unlimited has become very concerned about how and where these facilities are being placed. Location and how they are sited has a very big impact. For example, the siting of wind energy towers can have a major impact on songbirds and sage grouse, both in mortality and disrupting their migration routes. The location of other energy facilities also will have a possible negative impact on both fish and wildlife. Therefore, it is so important that DOE have sufficient funding for energy facility siting in their budget proposal. I have attached, along with my testimony, a TU paper on our energy policy and facility siting importance. I hope you get an opportunity to read that paper-it is very well done and uses many documented scientific studies.

So, in conclusion, Trout Unlimited urges you to approve DOE proposed 2017-2019 proposed budget, and in particular the funding for energy facility siting, as well as POP 140. As we create more green energy, where we locate these facilities is very important to the future of our native fish and wildlife.

Broadscale Assessment of Renewable Energy Potential and the Human Footprint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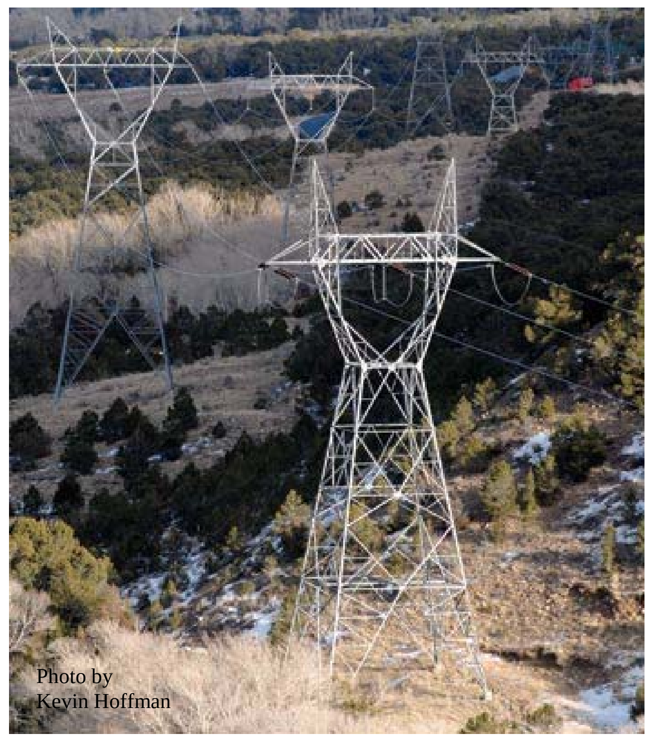
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EXECUTIVE SUMMARY

Rising temperatures and the increasing frequency and intensity of disturbance events due to climate change has created a sense of urgency to reduce greenhouse gas emissions and slow the nation's growing carbon footprint. A key component of this strategy is the development of renewable energy resources such as wind and solar power. However, not all areas capable of supporting renewable energy should be developed. Although development of these resources is important for mitigating climate change, it needs to be done in a deliberate and responsible manner that protects ecologically-significant natural communities and landscapes so that species and ecosystems retain the resilience and adaptive capacity necessary to persist in a rapidly changing environment. Degraded lands that provide minimal ecological value and have high renewable energy potential should be the focus for development.

The human footprint assessment characterizes the extent and intensity of anthropogenic impacts on the landscape, providing a surrogate for loss of biodiversity and altered ecological processes. Areas with minimal human influence are assumed to have retained a higher degree of ecological integrity than more degraded landscapes and therefore should not be developed. Concentrating energy development on lands within and immediately adjacent to highly altered landscapes will contain the human footprint and minimize detrimental effects to fish, wildlife, and ecosystem services. The human footprint assessment is based on the spatial integration of four factors: remoteness, fragmentation, degradation, and aquatic integrity. Each of these factors is analyzed independently and then the results are combined to create an intensity gradient of the human footprint across the western landscape.

Results of the human footprint assessment are combined with distribution data for native salmonids and sage-grouse to support a west-wide development suitability analysis. The suitability analysis distinguishes between lands where development should be avoided and areas that are potentially suitable based on current landscape conditions and relative importance to sage-grouse and native salmonids. Of the 758 million acres that comprise the 11 western states, just under one-half were classified as not suitable for development. About two-thirds of the lands found to be unsuitable for development based on environmental values are public lands and one-third are private. The ratio is reversed for the 51% of the land classified as potentially suitable with slightly less than one-third associated with public land and the remainder on private.

In order to specifically address the question of wind and solar power development, a capability assessment was performed for these resources. Siting criteria from the National Renewable Energy Laboratory on physical landscape features and existing infrastructure were used to identify areas capable of supporting large-scale commercial development of wind and solar energy. The results of the capability analyses were combined with the results of the suitability analysis to produce a coarse-scale regional framework for responsible energy development that allows for development while protecting areas with high ecological values important to fish and wildlife.

The final energy plan identifies 91 and 114 million acres of land capable of supporting wind and solar power, respectively. About 28% of the lands capable of supporting wind were classified as unsuitable due to high quality environmental values and 33% of the lands capable of supporting solar were similarly classified. Of the lands identified as potentially suitable, 32% and 25% of wind and solar, respectively, was considered to have high potential suitability while the remainder was classified as moderately suitable. Although the majority of the lands found to be either moderately or highly suitable for development are on private lands, 10% and 30% of the suitable sites for wind and solar respectively, are on public lands. This equates to approximately six million acres of potentially suitable public lands for wind energy and 22 million acres for solar. If only those lands given a high suitability rating are considered, this number drops to less than one million acres for wind and three million acres for solar on public lands. However, private lands could provide an additional 20 and 16 million acres of highly suitable wind and solar power potential, respectively.

When interpreting the results of this assessment, it is important to keep in mind that it is a coarse-scale assessment intended to provide regional guidance for responsible renewable energy development. Local conditions may exist that can alter the findings in either direction and therefore site-specific analyses should be conducted before any final development suitability determinations are made.

Project Background

Increasing global temperatures resulting from greenhouse gas emissions has generated a debate within the conservation community regarding the merits of investing limited resources in mitigation verses adaptation strategies (Becker 2009; Orr 2009). Mitigating climate change by reducing carbon emissions through conservation and the development of renewable resources is critically important. However, our sense of urgency to slow the accelerating pace of global warming should not override the need to develop renewable resources in a responsible manner. Responsible development should protect ecologically-significant natural communities and landscapes so that species and ecosystems retain the resilience and adaptive capacity necessary to persist in a rapidly changing environment. The purpose of the following assessment is to demonstrate the potential to promote both mitigation and adaptation strategies with a landscape scale vision for renewable energy development.

Development of renewable resources should be a deliberate process that seeks to minimize its impacts on the nation's land, water and fish and wildlife resources. Even the most seemingly benign energy resources such as solar can have an adverse effect on the environment including habitat degradation and fragmentation from the construction of roads and facilities, water consumption, and loss of virtually all vegetation beneath the panels. Keeping development out of currently protected lands (e.g., National Parks and designated Wilderness areas) is not enough. Recent studies have shown that our current system of protected areas does not adequately address the full array of the nation's biodiversity (Scott et al. 2001a; Scott et al. 2001b; Hazen and Anthamatten 2004). Accordingly, we should focus renewable energy development on degraded lands that provide minimal ecological value and have high renewable energy potential, while avoiding disturbance of landscapes with high ecological and fish and wildlife values.

Kiesecker and others make the case for integrating conservation planning with the 'mitigation hierarchy' of avoid, minimize, or mitigate environmental impacts from energy development (Kiesecker et al. 2010). This assessment provides regional guidance for application of the mitigation hierarchy to development of wind and solar resources based on the results of broadscale capability and suitability analyses. The capability assessment evaluates the potential for energy development based on physical landscape features and existing infrastructure while the suitability assessment answers the question of whether or not development is appropriate at a specific site given other resource values. The foundation of the suitability assessment is the human footprint which is modeled across the western landscape to characterize the extent and intensity of cumulative anthropogenic impacts on the land. Areas at the low-end of the intensity gradient can be assumed to have greater likelihood of supporting native biodiversity and ecological processes and should be avoided while areas at the high end of the intensity gradient may be suitable for development. The potentially suitable areas should be the starting point for site-specific analyses to identify local environmental and social values and determine whether or not the adverse effects of development can be minimized to an acceptable level.

Figure 1 illustrates the decision process for integration of the capability and suitability assessments with the mitigation hierarchy. Undisturbed lands capable of supporting energy resources may not be suitable for development because of their ecological values and should be avoided. In contrast, landscapes at the high end of the intensity gradient that are capable of supporting energy resources should undergo further review for potential development applying the 'minimize and mitigate' strategies. Given the inherent coarseness of broadscale assessments such as this, site-specific analyses should be conducted before making a final determination on development suitability. Areas with irreplaceable environmental values not identified in the coarse-scale suitability assessment should also be avoided. The restoration and protection of these areas could be used as off-site mitigation for unavoidable environmental impacts from development at a more suitable location.

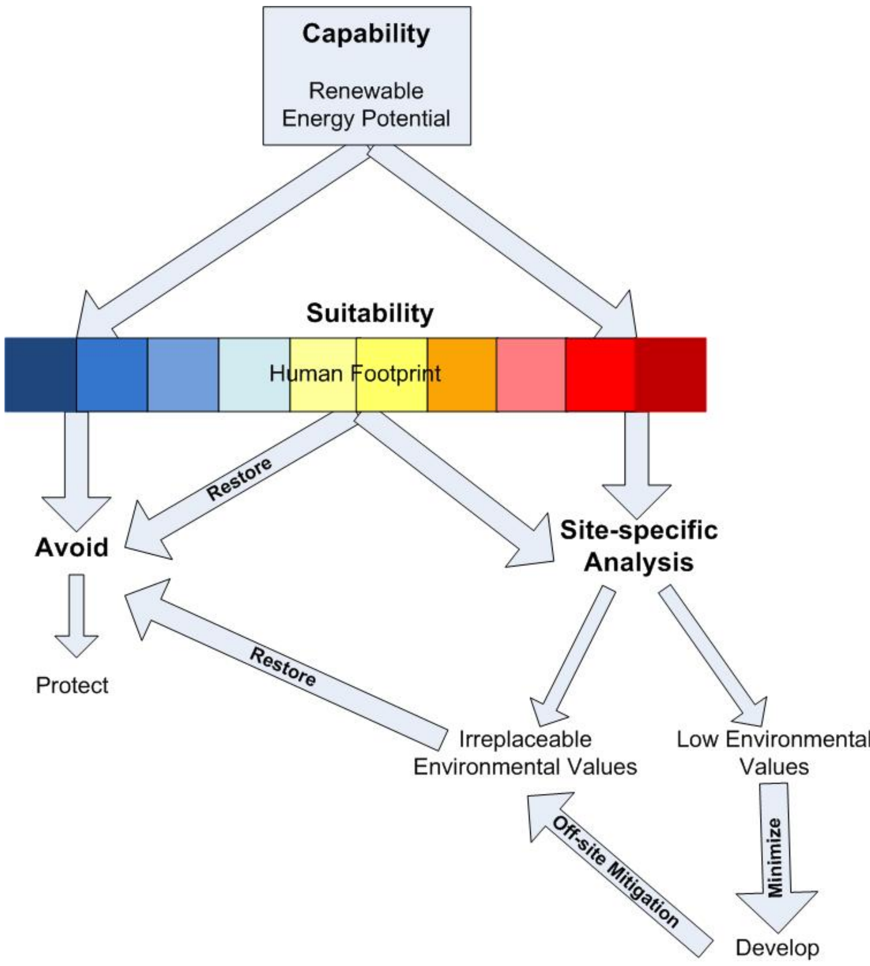

Figure 1. Decision process for the integration of the mitigation hierarchy with capability and suitability assessments. Degraded landscapes capable of supporting renewable energy are potentially the most suitable lands for development and should be the first priority for site-specific analyses.

Given the scale and geographic scope of these analyses, local features exist that may change the results of both the capability and suitability assessments in either direction. Therefore interpretation of results should be kept to the identification of regional patterns and trends and not used to support local decisions or site-specific planning.

Human Footprint

The goal of the human footprint analysis is to characterize the extent and intensity of anthropogenic impacts on the landscape as a surrogate for loss of biodiversity and altered ecological processes (Wackernagel and Rees, 1996). Numerous human footprint assessments have been completed at local, regional, and global scales (Sanderson et al. 2002; Haines et al. 2008; Leu et al. 2008) . While the underlying premise is the same, methods and data sets will vary depending on the scale and intended application of the results.

This assessment was designed to facilitate the siting of renewable energy projects at a regional scale such that conflicts between development interests and conservation interests are minimized. In addition to protected areas such as designated Wilderness and National Parks that do not currently allow development, unprotected lands with minimum anthropogenic impacts (i.e. a low intensity human footprint) are less suitable for development than areas exhibiting a greater intensity of human alterations. Concentrating energy development on lands within and immediately adjacent to highly altered landscapes rather than in the unprotected buffer zones around lands with high ecological integrity will help to contain the human footprint on the landscape and minimize detrimental effects to fish, wildlife and ecosystem services, such as the provision of clean water.

There are four modules that go into this assessment of the human footprint: remoteness, fragmentation, degradation, and aquatic integrity. Each is comprised of multiple data sets that are quantified in a spatially distributed model across the 11 western states. Before results of these discrete analyses can be combined, they must be converted to a common unit of measure by normalizing the raw values. Rather than default the upper limit of the normalized scale to the highest value measured, an upper threshold is defined based on either limits established in the literature or the 2^{nd} standard deviation of the results. This is done for two reasons. First is simply to eliminate the 'noise' that is inherent in any large-scale data set resulting in a small percentage of very high values that can skew a normalized scale to the high end while masking the variability present at the lower end of the continuum. The second reason is that for many of these elements there is a threshold beyond which increased intensity becomes irrelevant because the landscape has lost its resiliency.

Remoteness

The influence of human presence extends beyond the physical footprint of development to the surrounding landscape with areas of higher population densities having a greater influence across a larger region than more rural areas. Parks and Harcourt (2002) found that extinction of large mammals in protected areas of the western U.S. correlated with human density surrounding the reserve, emphasizing the influence of human presence on natural processes beyond the built environment. The remoteness module is intended to capture this more subtle effect of human presence.

Population data from the 2000 census was used to calculate population density across the eleven western states. A linear relationship was assumed between population density and human influence, recognizing that this relationship reaches an asymptote at some point in which further increases in density do not equate to increased effects. Although the point at which this occurs is uncertain, the threshold used by Sanderson et al. (2002) of 10 persons per km² was applied and all higher density values were reclassified to this upper limit. Population densities were then grouped into five categories (values ranging from 1-5) using the "natural breaks" classification (Jenks 1967) which identifies groupings that minimize variance within groups and maximizes variance among groups.

A moving window analysis was conducted on the reclassified data set to calculate the relative intensity of human presence within a 40 km quadrate (1600 sq km) based on distance from a population center weighted by population density. The results were reclassified into 21 classes with values ranging from 0-20 (Figure 2). The dark blue areas are indicative of those places least

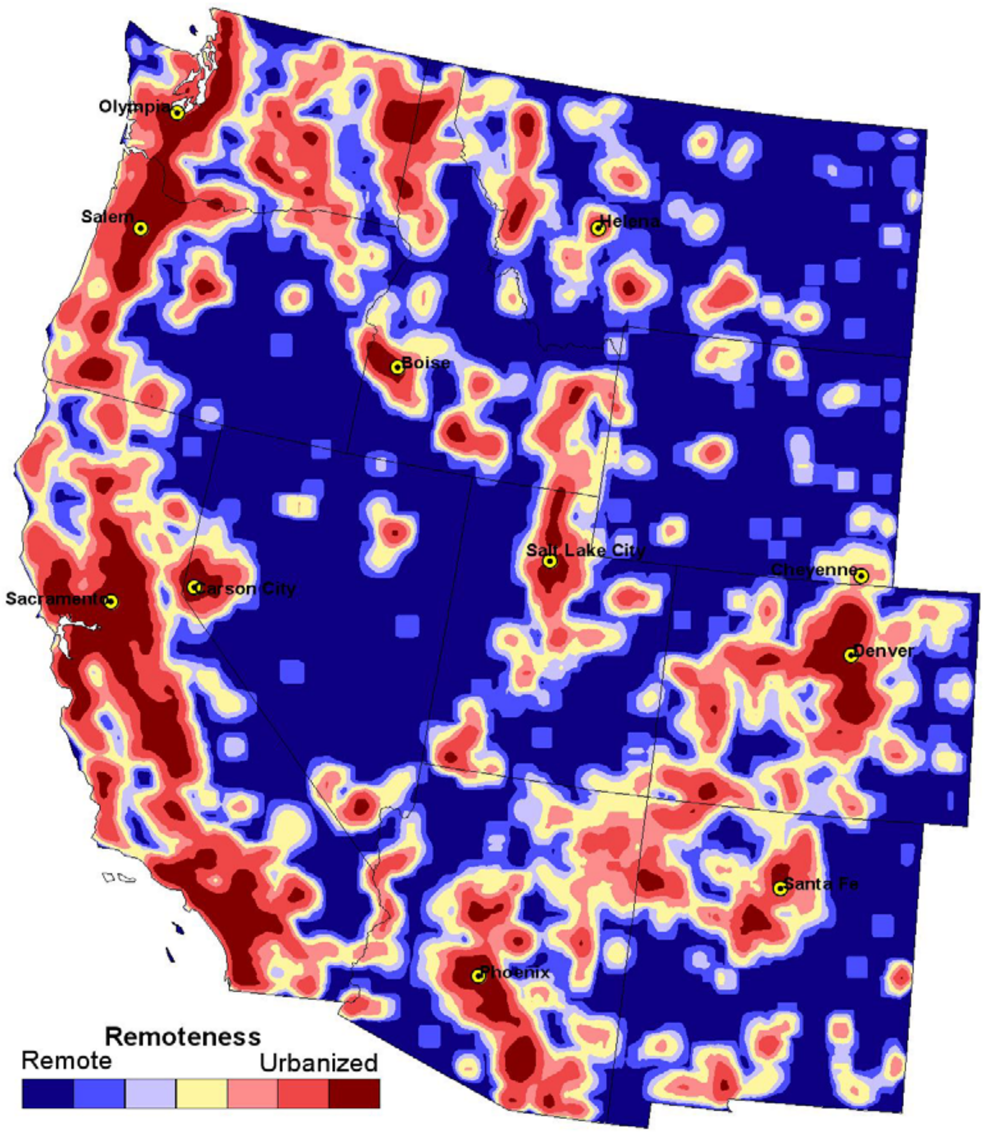

Figure 2. Remoteness as a function of distance from population centers weighted by population density.

likely to be influenced by human presence at any population density while the dark red areas represent urban centers. The light red to yellow regions correspond to undeveloped landscapes surrounding a highly urbanized area that experiences a greater human influence than lands at a similar distance from a rural community (light blue on map).

Fragmentation

Fragmentation of the natural landscape contributes both to the loss of biodiversity and diminishment of ecosystem functions (Noss and Csuti 1997). Although the minimum patch size necessary to support biodiversity and ecological processes is dependent on a variety of factors and subject to much debate within the conservation community, it can be assumed that larger patches have a higher likelihood of supporting landscape-scale species such as sage-grouse and natural processes such as wildfire.

Features that fragment the landscape not only impede wildlife movement but also create an edge effect that reduces the functional size of the remaining patch. Therefore, anthropogenic features used in the fragmentation assessment include elements such as powerline corridors that may not be complete barriers to wildlife but create a sharp edge, particularly in forest habitats where the forest cover is completely removed. The six data sets used in the fragmentation module include:

- Urban land use
- Agricultural land use
- All state and federal highways
- Railroads
- Powerlines
- Reservoirs greater than 50 ha.

These six data sets were combined into a single data layer so that the size of the patches between these features could be calculated. The largest patch, at over 4 million hectares, incorporated the wilderness and roadless areas of central Idaho while the mean patch size was 526,000 ha. Given the limited number of parcels larger than the mean (71 out of 36,200 patches), this was set as the upper limit for normalizing. All patches above the mean were given a value of 20 and everything below was scored proportionally. The dark blue patches in Figure 3 represent the largest remaining patches while the areas in red are small patches indicative of highly fragmented landscapes.

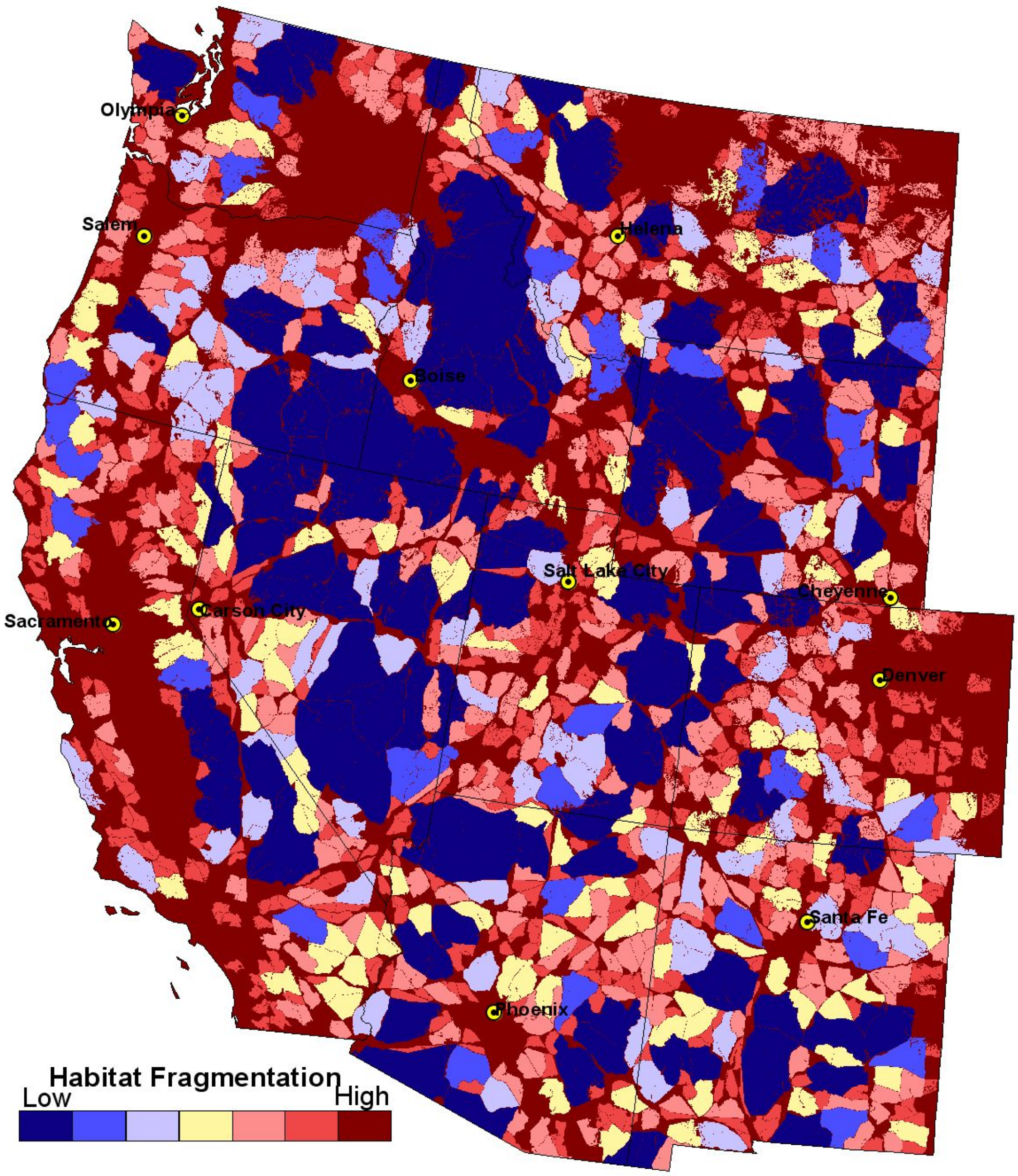

Figure 3. Habitat fragmentation from permanent anthropogenic features such as highways, and cities.

Degradation

The direct loss of habitat due to land conversion and degradation is one of the leading factors in the loss of biodiversity today (Wilson 1992, Noss et al. 1997). Degraded habitats frequently serve as conduits for the spread of invasive species and disease that displace local populations and alter natural processes important to maintaining ecosystem functions (Wilcove et al. 2000).

While converted lands are readily identifiable as cities, farmland, roads etc, degraded landscapes are more difficult to discern since they incorporate a change in the composition and/or structure of the dominant land cover but not necessarily a complete change in use. The degradation analysis incorporates both habitats that have been lost due to land conversion as well as habitats that have been degraded by resource utilization.

Given the lack of land cover data with sufficient detail to characterize degraded habitats, surrogates were used to evaluate the intensity of resource utilization under the assumption that greater development intensity equates to more degraded habitats. Non-consumptive uses such as recreation may also contribute to habitat degradation but in general this is to a lesser degree with intensity of use dispersing from population centers, a landscape feature captured in the remoteness module. The five components of the degradation analysis include logging, grazing, oil and gas development, mining, and converted land. Characterizing the relative intensity of development for each factor required separate assessments that were later combined to create a single data layer representing habitat degradation.

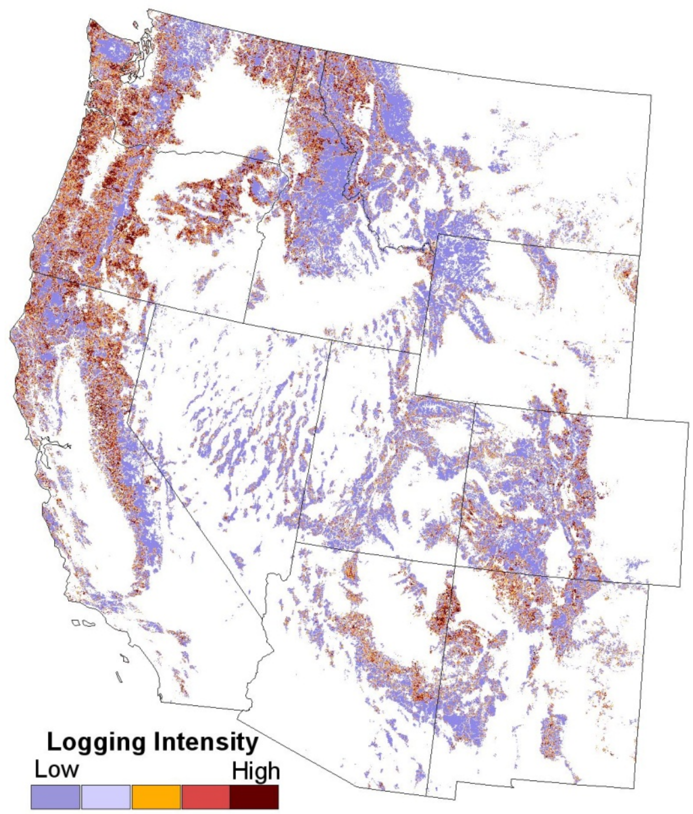

Figure 4. Logging intensity using road density on forested lands.

Logging. Data on harvest activities is not available westwide so the assessment of logging activity relied on forest road density as a surrogate. Potential commercial forest lands were identified using the Existing Vegetation Type (EVT; spatial resolution = 30 m) spatial data layer from the U.S. Forest Service and Department of the Interior's LANDFIRE program (e.g. www.landfire.gov). In order to eliminate small isolated patches of forest and urban forests, only areas that were at least 33% forested within a 1 km^2 moving window were classified as forest.

Road density was calculated using all roads not classified as a highway. Since the intent is to develop an intensity gradient, the standard deviation was calculated for road density on forested lands to establish an upper limit of intensity. The second standard deviation of 4.8 km/km^2 was used as the upper threshold for normalizing on a 0-10 scale. Figure 4 shows the results of this assessment. The dark red areas represent forested landscapes with the highest road densities and likely the most extensive logging activity.

Livestock Grazing. Although livestock grazing is ubiquitous across western public lands, there is very little landscape-scale spatial data on the effects of grazing so surrogates were used to identify those areas inherently more vulnerable to the adverse effects of livestock grazing. The goal of the grazing assessment is to develop a relative scale for likely impacts to natural plant communities from a history of livestock grazing rather than attempt to characterize the impacts in any single year given seasonal and annual variability in livestock management practices.

Biological soil crusts are critical to the preservation of native plant communities and soil stabilization in arid and semi-arid landscapes. These fragile crusts are easily destroyed by livestock trampling and may take years to rebuild after the disturbance has been removed while continual disturbance will prevent recolonization from occurring (Belnap 2003**)**. Given the sensitivity of these environments to even light stocking levels and the difficulty in restoring disturbed areas, precipitation was used as a surrogate for livestock impacts with the assumption that, over time, xeric environments are more vulnerable and less resilient to cumulative disturbances from livestock grazing than more mesic environments.

Average annual precipitation from 1970-2000 (PRISM 2007; spatial resolution = 800 m) was analyzed across all Bureau of Land Management grazing allotments. LANDFIRE vegetation data was used to delineate areas within the allotments that are dominated by non-native annuals. The average annual precipitation for these non-native grasslands (25.4 cm) was lower than the average precipitation across all of the allotments (30.48 cm).

Assuming that the presence of non-native annual grasslands as the dominant plant community is indicative of a vulnerable and non-resilient landscape, the precipitation analysis of these disturbed sites was used to establish the upper threshold of the intensity gradient. The second standard deviation below the mean was 12.7 cm of annual precipitation. This threshold was used to normalize precipitation values on a 0-10 scale for all grazing allotments analyzed. Recognizing that the presence of annual grasslands is indicative of a degraded landscape, the results of the precipitation analysis were further modified downward based on the density of non-native vegetation within a 10 km quadrate (100 sq km). Figure 5 shows the results of the assessment with the areas in dark red being the most vulnerable to grazing impacts.

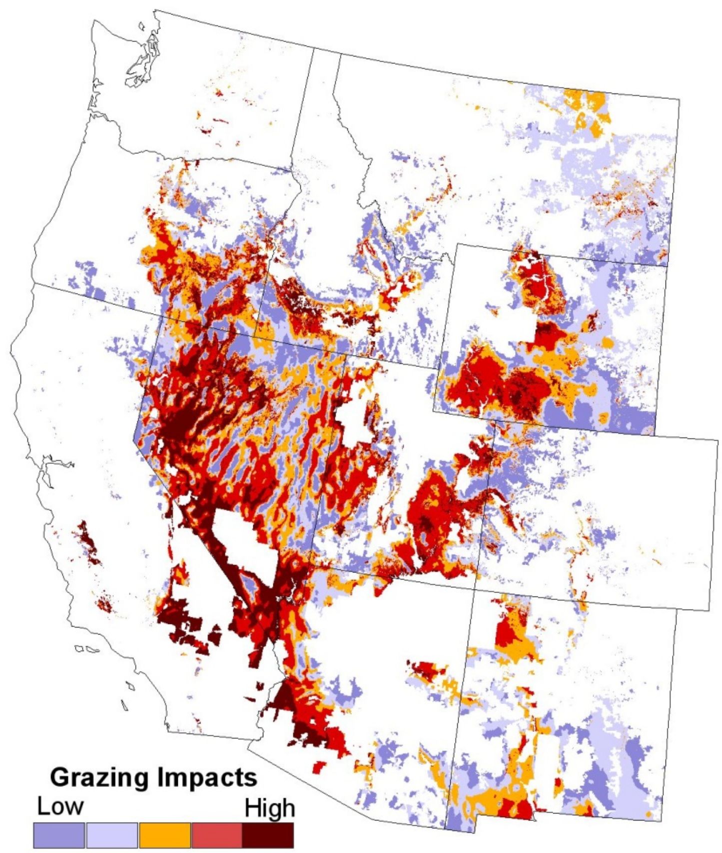

Figure 5. Grazing impacts using annual precipitation to characterize inherent landscape vulnerability.

Oil and Gas Development. The past decade has seen a proliferation of oil and gas wells across the western landscape with the associated infrastructure of roads, pipelines and other facilities. Spatial data available west-wide is limited to the location of the actual well pads and does not encompass the full extent of the land disturbances associated with development. However, Walker et al. (2007) found that the density of well pads is highly correlated with other development features and is a suitable index for evaluating the intensity of development. Wyoming Game and Fish Department has used well density to develop disturbance thresholds for fish and wildlife (Wyoming Game and Fish Department 2010).

The best available data on oil and gas wells was obtained for each state which varied from 2004 to 2007. All currently producing wells or those with an active drilling permit were used in the density calculation. Wyoming Game and Fish Department (2010) has assigned development thresholds to different species and habitats depending on the sensitivity of a species to disturbance. The middle value of the high impact range for aquatic resources of 10 wells/mile^2 (3.8 wells/km^2) was used to set the upper threshold. This was also within the high impact range for pronghorn and native non-game species while it was in the extreme impact category for species such as sage-grouse, elk, and mule deer.

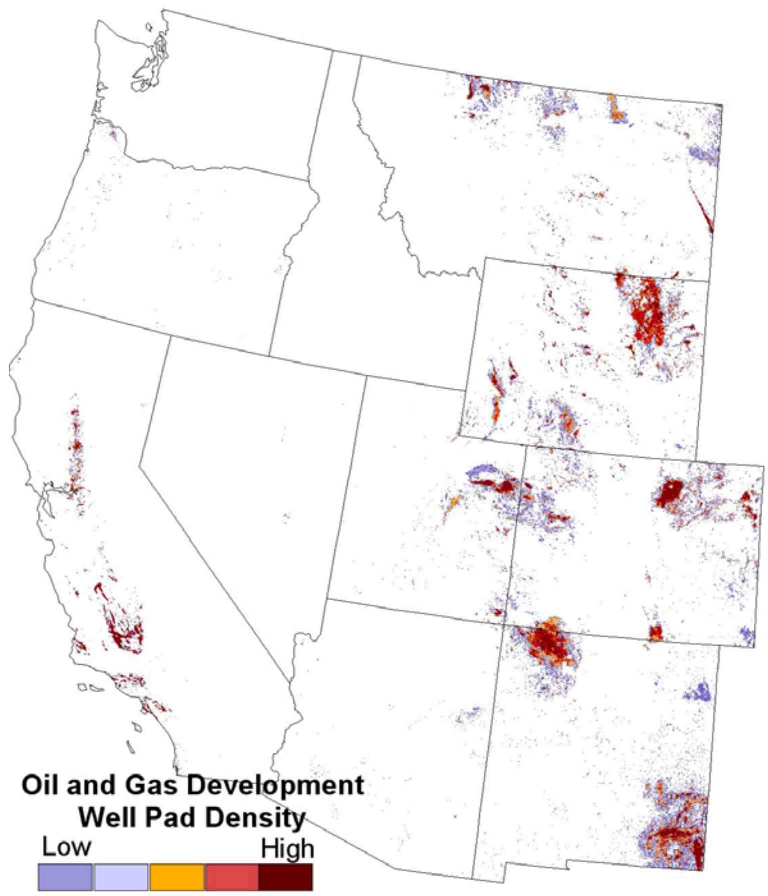

Figure 6. Oil and gas development intensity as indicated by well pad density.

Given the industrial nature of oil and gas development compared to logging and grazing, a scale of 0-20 was used for normalizing well density values rather than 0-10, giving additional weight to this element in the final degradation assessment. Figure 6 shows the results of this analysis. Areas in dark red have the highest density of active wells and therefore the greatest impact on fish, wildlife, and their habitats.

Mining. According to 2005 data from the U.S. Geological Survey Mineral Resources Data System, there are over 100,000 active and inactive mines across the western U.S. This data set includes the small 'mom and pop' operations as well as the industrial sites and all resource types from sand and gravel to uranium. Unfortunately this information is only available as point data and does not adequately define the geographic extent of a mining operation. However, the tabular data associated with the points provides information on production size and type of mine which was used to distinguish between the potential impacts of different operations.

Given the tendency for mining operations to have lingering environmental effects after the mine has been shut down, all current and past producers were included in the analysis. Each mine was weighted according to production size, status (i.e. current or past producer) and type of operation (i.e. sand and gravel, surface, or underground) with active, large surface mines being given the highest weighting. A moving window analysis was conducted which summed the values of the weighted points within a 1 km quadrate. The 2nd standard deviation of non-zero values was used to establish the upper limit for normalizing. As with oil and gas development, a 0-20 scale for normalizing was applied due to the severity of potential environmental impacts from mining as compared to logging and grazing. Figure 7 shows the results of this analysis. Although they are difficult to discern at this scale, the dark red areas represent the largest mines or an unusually high accumulation of small operators. The blue areas show the pervasiveness of small mines across the western landscape.

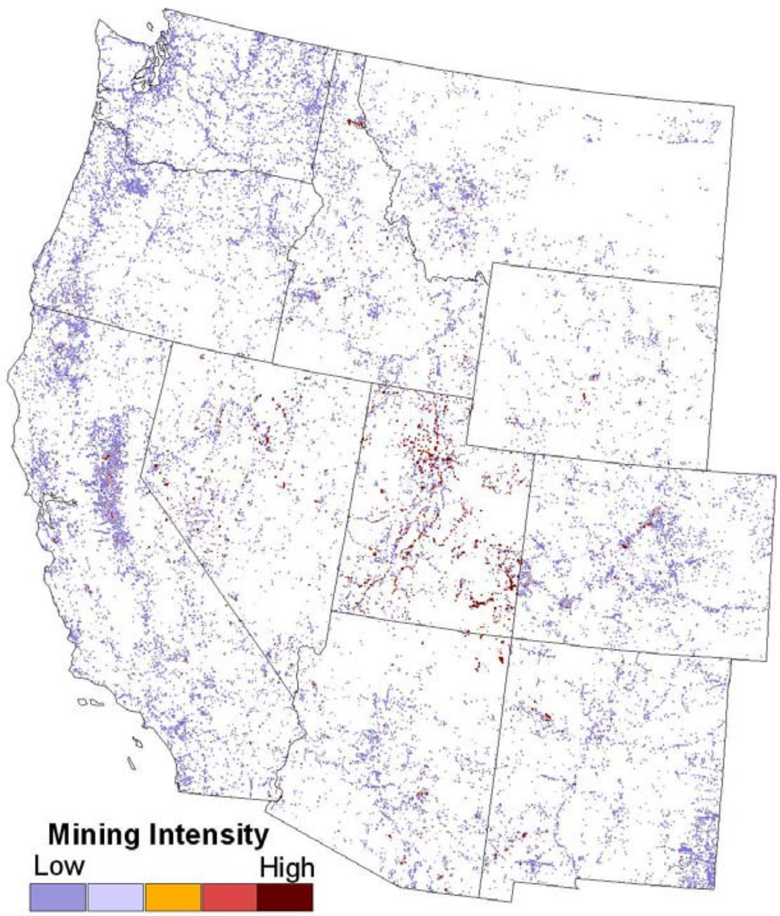

Figure 7. Mines by size and type of operation.

Converted Land. The final element in the degradation assessment is the identification of lands that have been converted to a different land use. These converted lands represent a permanent loss of habitat as well as a change in ecosystem functions.

For this analysis data layers on developed land, agriculture, and highways were combined to create a single data set of converted lands. In addition to the actual loss of the natural landscape, there is the potential for exacerbating effects when multiple anthropogenic features are located in close proximity to one another. For example a highway leaving Los Angeles will be more heavily traveled and likely to have a greater impact on the surrounding landscape than a highway running through the middle of Nevada. In order to capture these interactions a 20 km² moving window was applied and the percent of converted land was calculated within the quadrate. 75% was used as the upper threshold for normalizing on a 0-20 scale.

Figure 8 shows the results of the converted lands analysis. The dark red represents those places where converted lands account for 75% of the area within a 20 km ² window centered on that point. The light blue areas are typically associated with rural highways and towns.

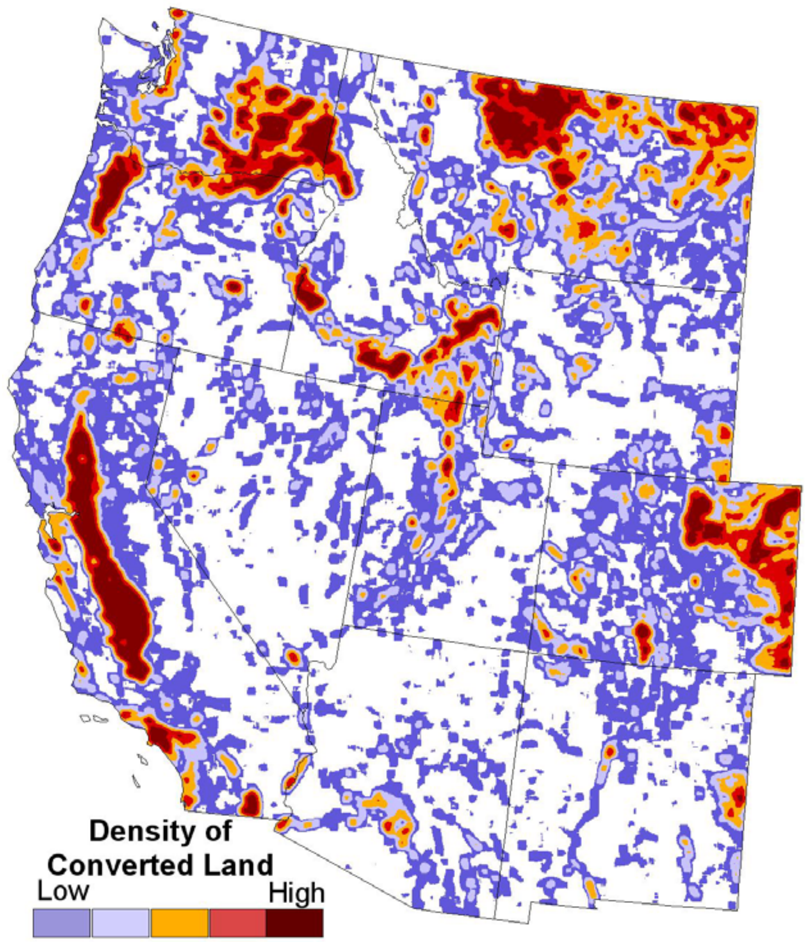

Figure 8. Concentration of converted lands within 20 km².

Degradation Assessment. The final step in developing the degradation module involved combining the results of the five analyses described above. Logging and grazing were each scored on a 0-10 scale while oil and gas development, mining, and converted lands were given a higher weight and scored on a scale of 0-20. The results are shown in Figure 9. The dark red represents those areas that are the most degraded or changed from natural conditions while the dark blue areas are the least affected.

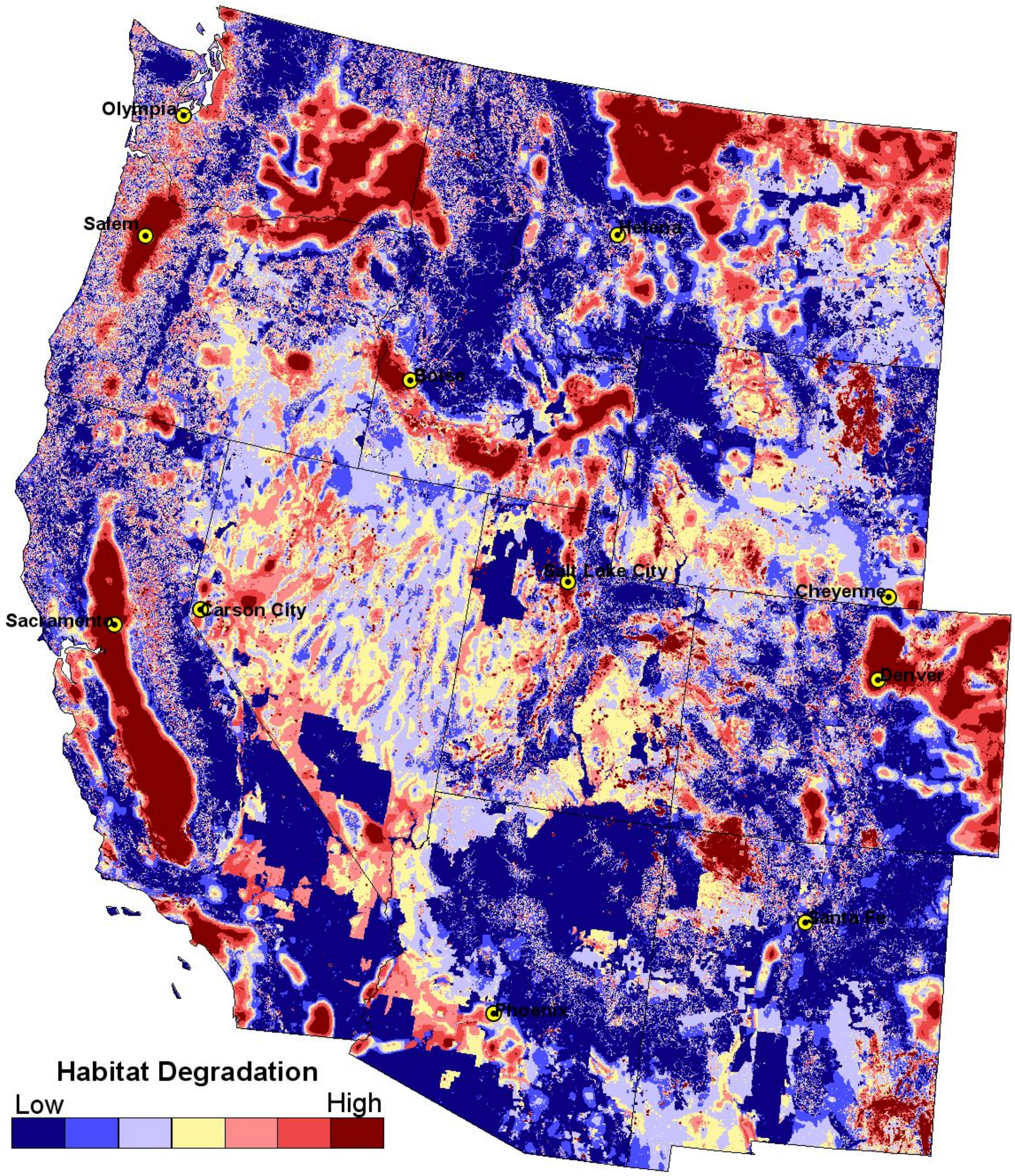

Figure 9. Habitat degradation from natural resource development (logging, mining etc) and land conversion.

Aquatic Integrity

Aquatic systems, due to their linear nature, respond differently to landscape disturbances than terrestrial systems. A disturbance event or change in land cover/use can affect aquatic habitats both upstream and downstream, extending well beyond the physical footprint captured in the previous analyses. Therefore, it is the intent of the aquatic integrity assessment to capture not only those features that directly affect aquatic habitat such as dams, but also the indirect effects of land use and landscape changes that may impair hydrologic processes at a watershed scale.

Unlike the previous assessments (remoteness, fragmentation, and degradation) which were conducted using a spatially continuous model, the aquatic integrity assessment relies on subwatersheds (6th code hydrologic unit) as the analysis unit. All of the data elements analyzed were summarized by subwatershed. Depending on the feature, results were tabulated as area weighted averages, percentages, or counts. Although many of the data sets used in the aquatic integrity analysis were used in the previous analyses, they are applied in a different context and thresholds defining upper limits of the intensity gradient are based on the cumulative effects within a subwatershed. Following is a description of each of the features captured in the aquatic integrity analysis and the upper limit of the intensity gradient used for normalizing. Each factor was normalized on a 0-10 scale.

- *Road density* was calculated for the subwatershed using all roads. The upper threshold for normalizing was set at 4.7 km/km^2 based on habitat integrity indicators in Trout Unlimited's Conservation Success Index (CSI) (Williams et al. 2007).
- *Percent urban land cover* was calculated for each subwatershed as a surrogate for impervious surface. Research suggests that aquatic systems are impaired when impervious surfaces exceed 10% of a watershed (Center for Watershed Protection 2003) so 10% was used as the upper limit.
- *Percent of agricultural land* was calculated for each subwatershed. Agriculture not only removes native vegetation but can be a significant source of pollution and sedimentation into a river system. The upper limit was set to 58% based on research by the Eastern Brook Joint Venture and habitat indicators used in the CSI (Hudy et al. 2006, Williams et al. 2007).
- *Percent of natural cover within riparian buffer* was calculated within a 100 meter buffer of all streams in the subwatershed using the LANDFIRE vegetation data. Less than 50% natural cover was used for normalizing values.
- *Kilomters of Roads* within a 100 meter stream buffer were summarized and used to calculate the percentage of stream kilometers with a road in the riparian corridor. An upper limit of 50% was used for normalizing (Williams et al. 2007).
- *Dams*, as identified in the National Inventory of Dams, are incorporated into the assessment both in terms of total number of dams within a watershed (5th code hydrologic unit) and storage capacity recognizing that dams impact both connectivity and flow of aquatic systems. The upper threshold for number of dams was based on the second standard deviation which was 11 dams within a watershed. Studies have found that dam storage per unit of watershed area is highly correlated with the degree of hydrologic impairment (Zimmerman and Lester 2006). The upper threshold for severe impacts of >100 $ac.ft/km^2$ established by FitzHugh (2005) was applied.
- *Kilomteres of Canals* within each watershed (HUC5) was calculated and the second standard deviation (2400 km) was used as the upper threshold.
- *Natural resource development* was calculated as an area-weighted average for each subwatershed using the normalized values for logging, mining, oil and gas, and livestock grazing computed in the degradation assessment. The values were summed and then normalized to a 0-10 scale.

After calculating and normalizing values for each feature, the results were then summed to provide a total subwatershed score. Figure 10 shows the results with dark blue areas being the least effected and dark red the most.

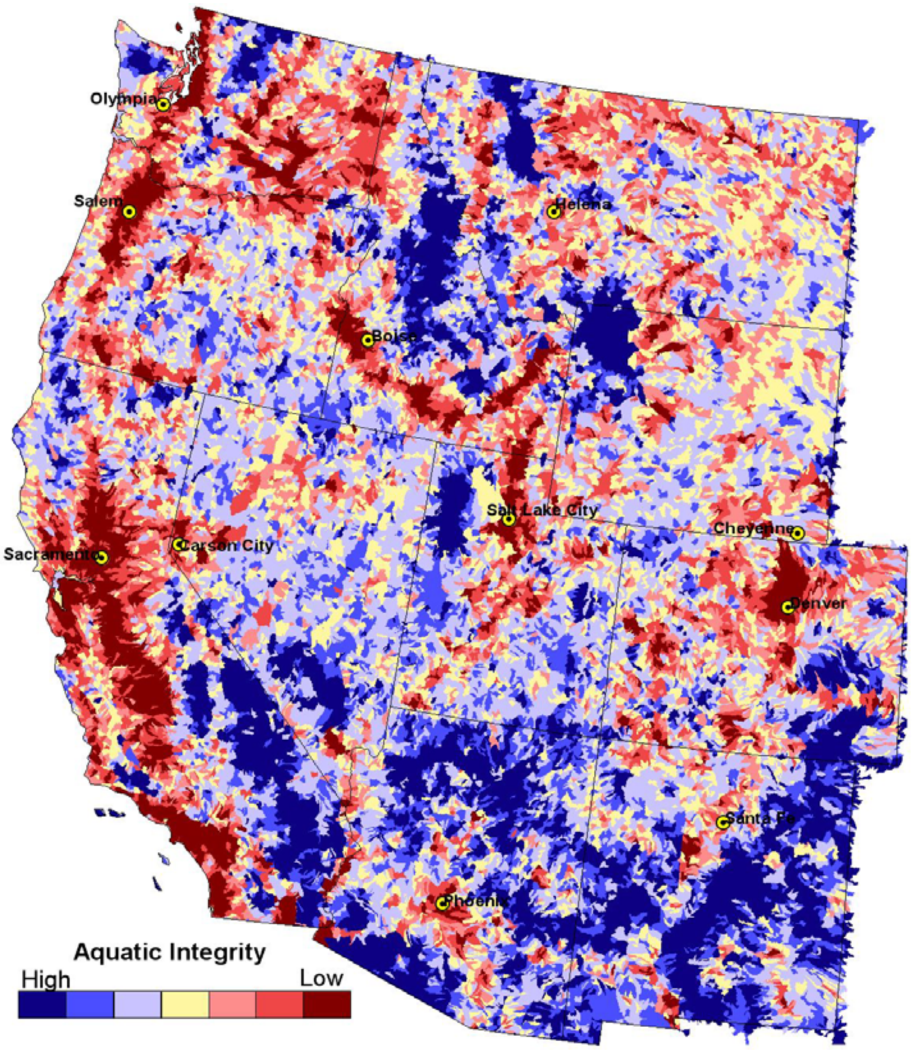

Figure 10. Aquatic integrity based on subwatershed effects from habitat conversion and degradation.

Cumulative Footprint

The cumulative human footprint is determined by combining the results of the four modules and reclassifying the results to a scale of 0 – 10. Recognizing that the intended use of this analysis is to identify potentially suitable landscapes for renewable energy development, an additional step was taken to insure the continued protection of special management areas. Not all areas with high environmental or social value are necessarily devoid of human alterations to the land. National parks, monuments, recreation areas and wildlife refuges typically contain roads, and may also have clusters of buildings or other developed amenities. However, this does not mean that these areas should be considered for energy development – their special status is indicative of higher social and environmental values that should be preserved.

Therefore, all special status lands greater than 400 ha (1000 acres) in size, including a 2 km buffer zone around each site, were classified as 0 in the final assessment and should be avoided when siting energy development projects . Figure 11 shows the final footprint assessment. Blue areas on the map are the least affected by human activities while red are the most intensively used.

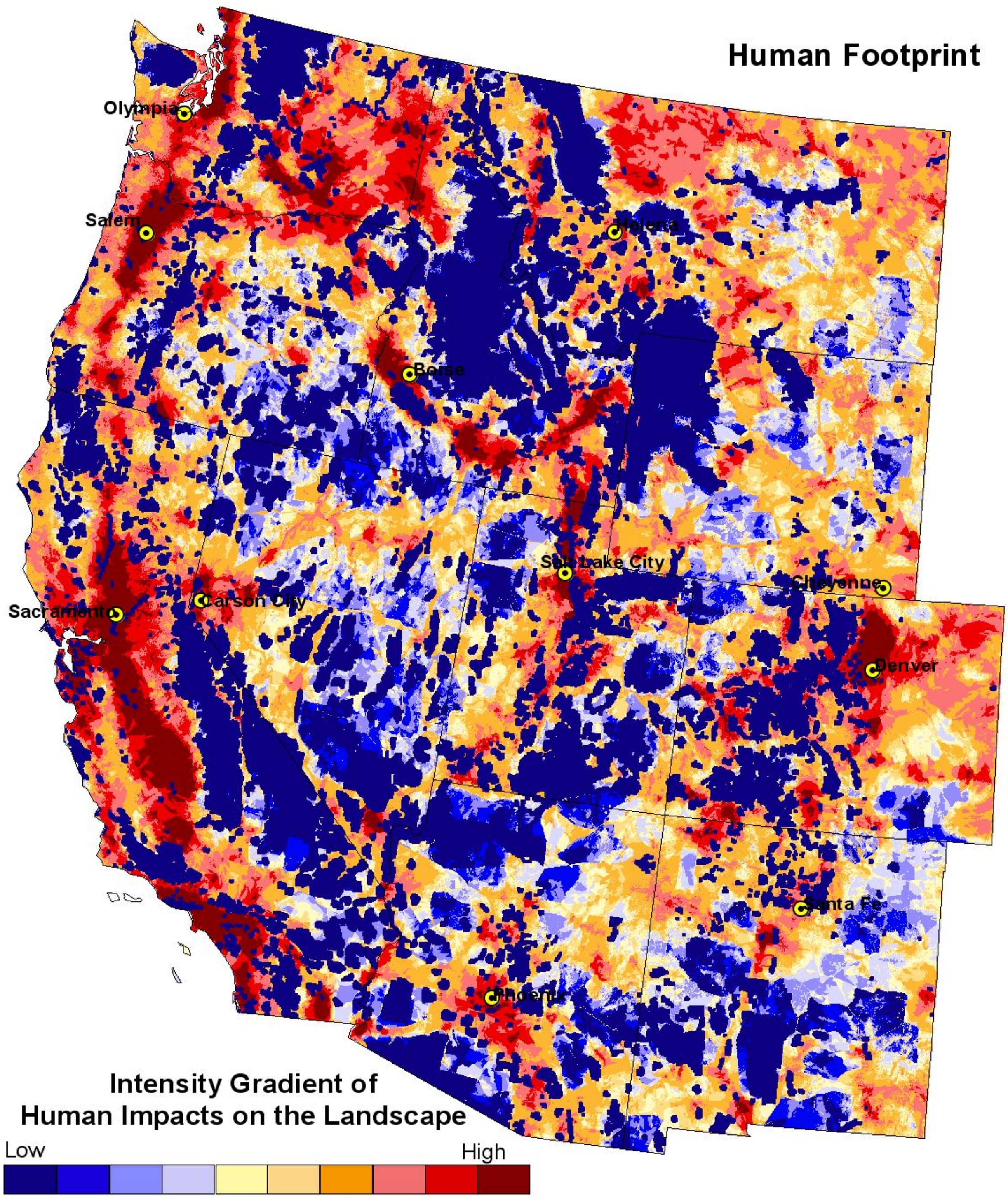

Figure 11. Human footprint based on remoteness, fragmentation, degradation, and aquatic integrity.

Fish and Wildlife Values

The human footprint provides a useful framework for assessing the intensity of anthropogenic influences on the landscape with the assumption that those areas least affected by man are the most apt to support healthy ecosystems and the ecological processes necessary to sustain them. Healthy ecosystems are typically of high biological value, supporting a diversity of native flora and fauna. However, the intent of the preceding analysis is not to imply that degraded landscapes are devoid of biological value but to highlight those areas that should not be developed and focus site-specific assessments on degraded landscapes that may be suitable for large-scale renewable energy development but not necessarily in all situations.

Species with narrow ranges such as reptiles and small mammals may spend their entire life cycle in degraded habitat because they are unable to relocate while migratory species such as elk and mule deer may move through degraded landscapes connecting seasonal habitats. Similarly wild fish may also be found in degraded aquatic systems but their presence may simply be the result of their inability to relocate. In any of these situations, native species occupying degraded habitats can be assumed to be under greater stress than those found in higher quality habitats. This is not only a function of the direct loss of food, water, and cover in a degraded or fragmented landscape, but also the indirect pressure of competition and/or predation by non-native species that may be better adapted to the altered habitat. Rather than increasing environmental stressors on local populations by developing energy resources, degraded habitats that support important life history stages such as calving areas, spawning habitat or migratory corridors, or that sustain populations of imperiled species should be considered for restoration as off-site mitigation for development done elsewhere.

The current distributions of native salmonids and sage-grouse are used to further the refine the results of the human footprint assessment. Degraded landscapes that lie within the current distributions of these sensitive species may be better suited for restoration than further development. While a similar argument can be made for the protection and restoration of habitats occupied by other sensitive species, it is not the intent of this analysis to incorporate all sensitive species but rather to demonstrate how information on species distributions can be used in conjunction with the results of the human footprint assessment to provide a spatial framework for responsible energy development.

Trout and Salmon

Native trout and salmon were selected for additional analysis because of Trout Unlimited's long-standing history in the conservation of coldwater resources and because virtually all native trout and salmon have experienced significant range contractions over the past 100 years, making them particularly vulnerable to further habitat losses. Many species and subspecies of trout and salmon are listed as endangered or threatened pursuant to the Endangered Species Act while others are managed as sensitive species by state and federal wildlife agencies. Their reliance on cold, high-quality, streams and lakes, free of nonnative salmonids makes them particularly sensitive to habitat degradation.

For this assessment, we combined the current distributions of many native trout and salmon found across the West. Given the overlap between ranges of different anadromous species we used winter steelhead which has the most extensive distribution to represent the coastal runs of southern Oregon and California and Chinook and sockeye salmon distributions for the Columbia basin. Distributions for all interior cutthroat subspecies were included as well as bull trout, Apache trout, Gila trout and endemic populations of California redband trout.
Figure 12 shows the combined extent of these distributions. The areas in blue represent currently occupied subwatersheds. Given the isolation of many populations and the need to extend and reconnect these isolates, unoccupied subwatersheds within occupied watersheds (green on map) and subbasins (beige on map) are also shown. It is important to consider downstream impacts and changes to hydrologic processes within these larger drainage areas both in terms of direct effects on existing populations as well as the loss of future restoration and reconnection alternatives.

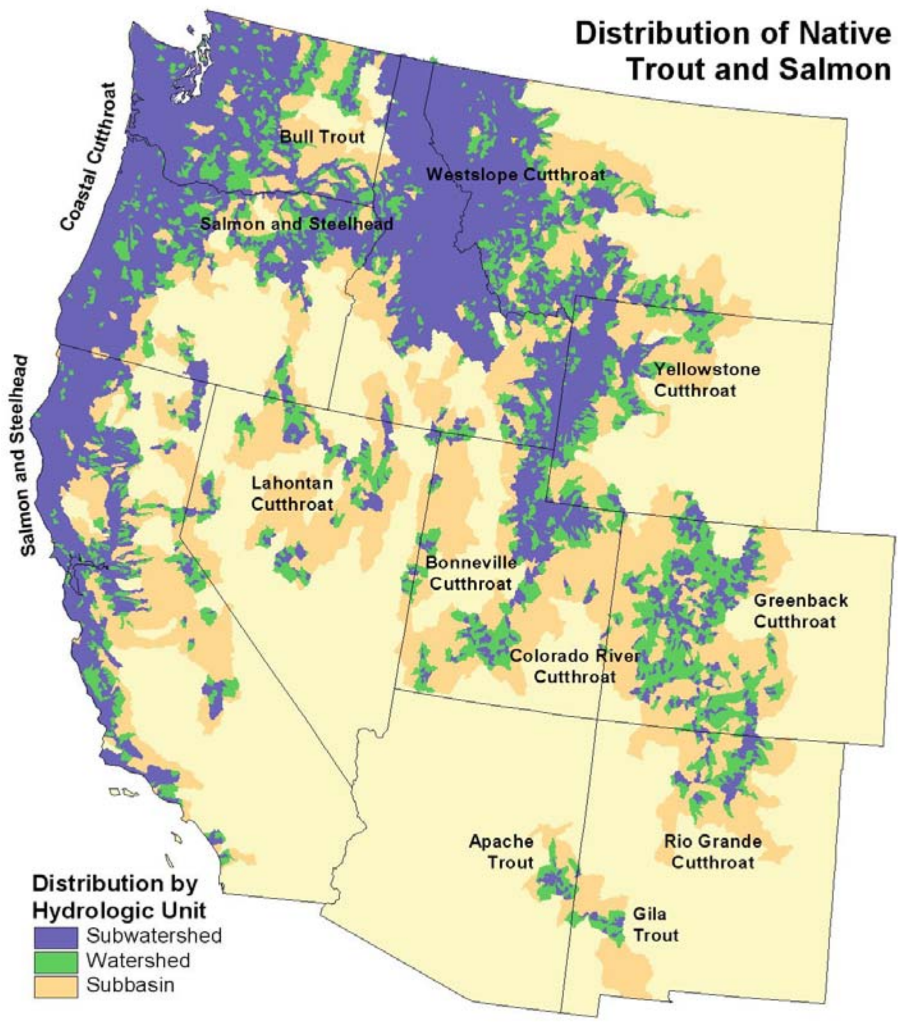

Figure 12. Distribution of native trout and salmon. Curently occupied subwatersheds are shown in blue.

Figure 13 shows the results of the human footprint assessment on occupied watersheds (blue and green areas shown in Figure 12). In order to simplify interpretation, the intensity gradient was reclassified to just five classes. Many of the interior populations of native trout are associated with high quality habitats (blue on map) because they have been isolated in high elevation headwater streams in order to protect them from hybridization with non-native salmonids such as rainbow trout. In contrast, anadromous species dependent on the coastal streams for a portion of their life history experience more degraded habitats (red on map) due to land conversion for agriculture and urban development, a well-developed road network, and the legacy of extensive logging activities.

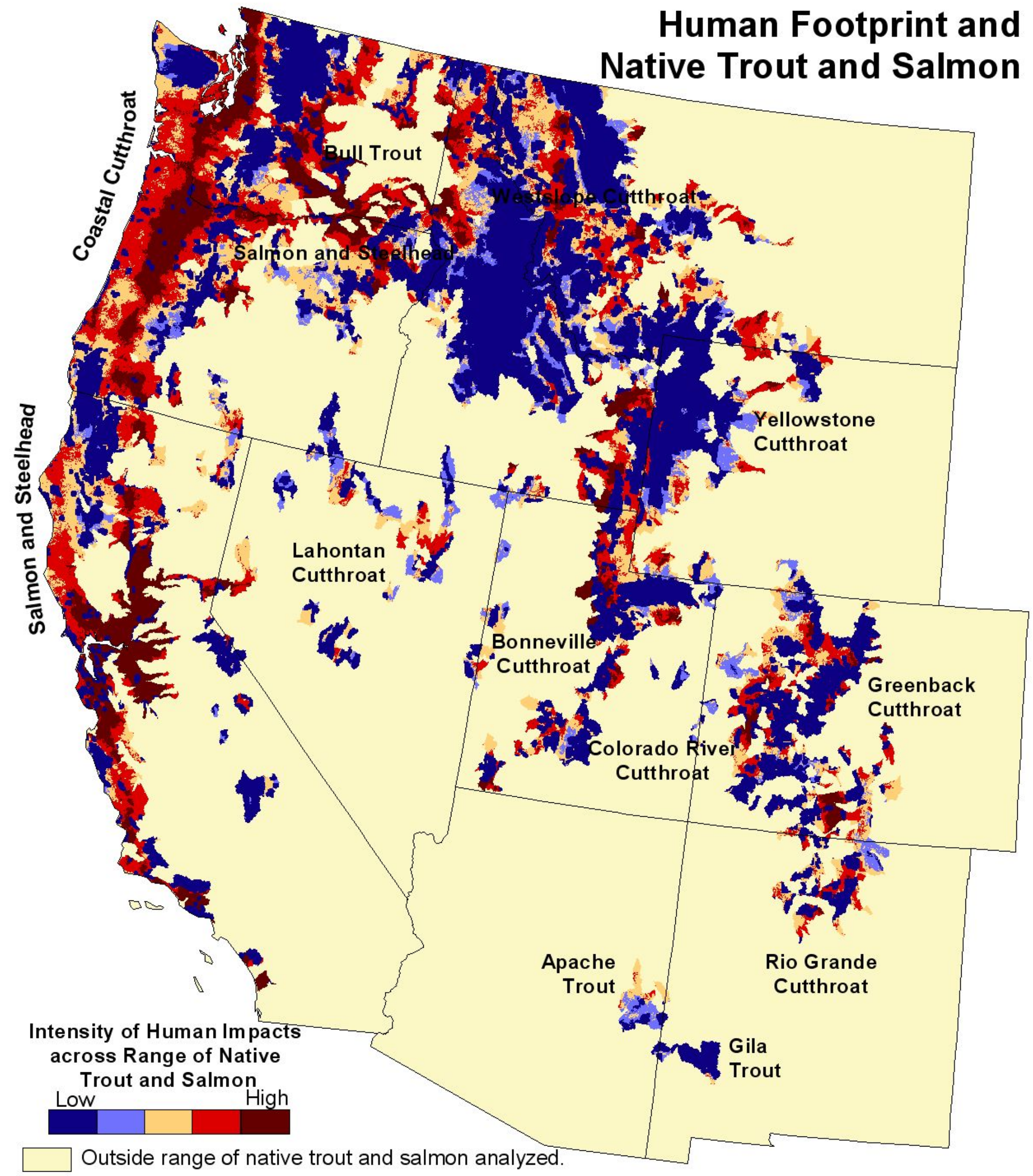

Figure 13. Human footprint of watersheds occupied by native trout and salmon species and subspecies.

Although the direct impacts from wind energy development on coldwater fish are minimal, indirect impacts associated with construction and transmission could have an adverse effect on fish due to increased sedimentation and removal of natural vegetation. New road construction, particularly at individual stream crossings, would likely have the greatest effect. After construction, new roads that allow for increased human access can also be problematic resulting in the unintentional introduction or spread of invasive species and/or increased fishing pressure.

In addition to the indirect effects on water quality associated with the construction of infrastructure discussed above relative to wind power, solar power may also impact water quantity. Solar power plants require large quantities of water for cooling, a scarce commodity in the arid southwest where development is concentrated. The potential discharge of liquids and effluents containing chemicals from the power plants is also cause for concern. The physical footprint of solar power development is significant since it requires the removal of all vegetation at the site. Depending on the size of the project, this can alter hydrologic processes at the watershed scale by increasing surface runoff and decreasing the capacity of the landscape to retain water. Given the highly vulnerable status of all of the southwest fishes and the risk of increasing drought and temperature through-out this region due to climate change (Williams et al. 2009, Haak et al. 2010), all of the occupied watersheds should be avoided. The potential to impact both water quality and quantity will exacerbate the effects of climate change and increase environmental stress on local populations of imperiled native trout that are already at risk of extinction.

Sage-grouse

Sage-grouse are an icon of the American West and the focal point for much of the conflict surrounding energy development in Wyoming, Montana, Colorado and Utah. A recent decision by the U.S. Fish and Wildlife Service found that the listing of sage-grouse under the Endangered Species Act was ‘warranted but precluded’. Sage-grouse have been extirpated from nearly half of their original range due to loss of habitat and populations are continuing to decline (Doherty et al. 2009). Figure 14 shows the historical (blue) and current (green) distributions of sage-grouse. Core areas containing population centers with high abundance as described in the recent sage-grouse assessment led by U.S.G.S. scientists (Marti 2009) are shown in red.

Figure 15 shows the results of the human footprint assessment across the current distribution of sage-grouse. Much of the occupied habitat is degraded, particularly along the eastern edge of its range where the past decade has seen a rapid expansion of oil and gas development. Sage-grouse have a very low tolerance for disturbance but are found in degraded habitats because few sagebrush landscapes remain intact (Connelly et al. 2004). Conversion of sagebrush habitats to agriculture and rural development and the degradation of native plant communities by inappropriate livestock grazing and resource development have contributed to the decline of the species, a situation more recently exacerbated by energy development.

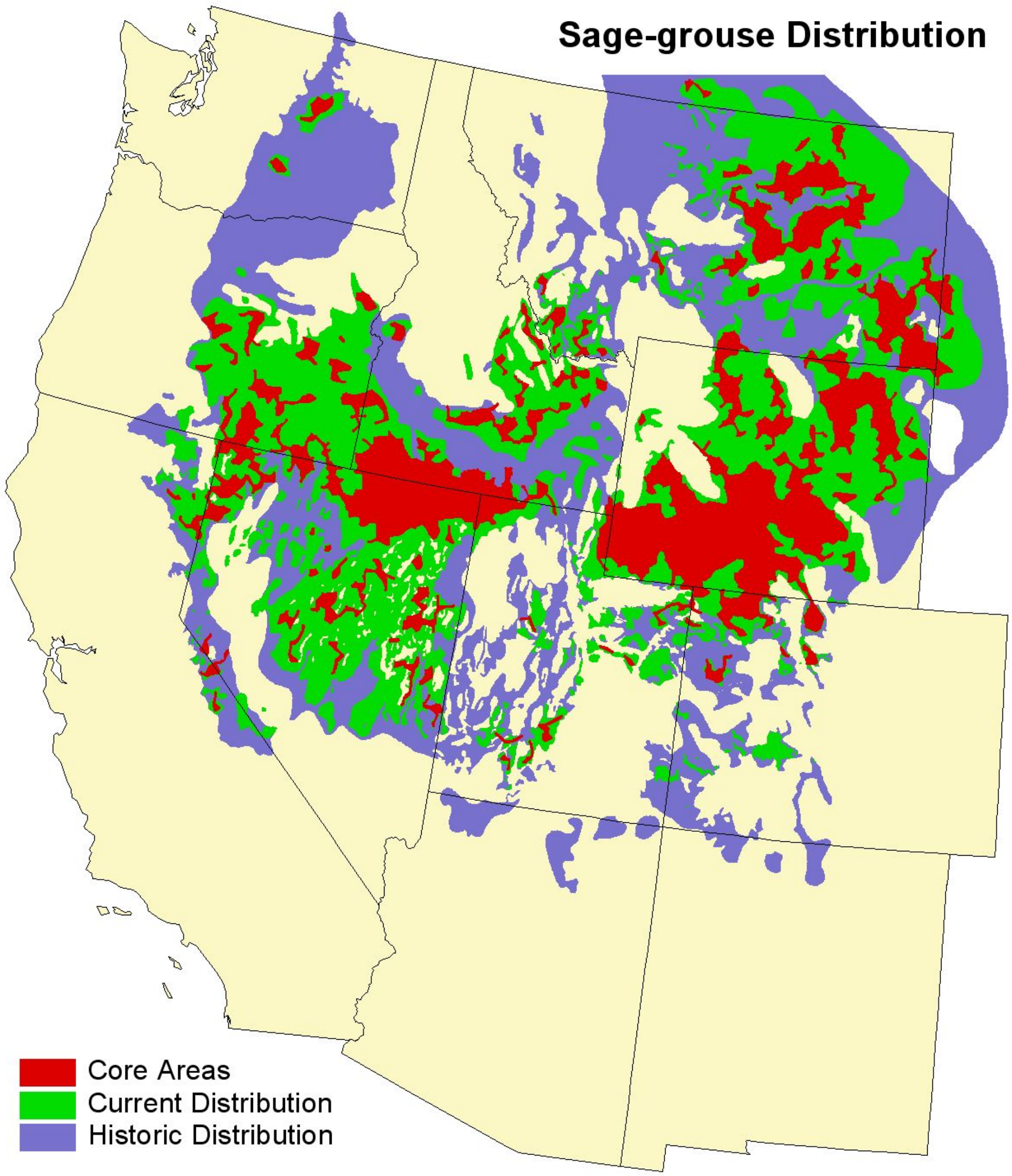

Figure 14. Current and historic distributions and core areas of high abundance for Greater Sage-Grouse. Data provided by USGS Snake River Field Station, Boise, Idaho.

Development of wind resources in sage-grouse habitat impacts local populations in several ways. New roads and transmission corridors fragment habitat and provide a conduit for invasive plant species such as cheatgrass that further degrade sagebrush habitats, displacing the native grasses and forbs on which sage-grouse depend. Given the low tolerance of sage-grouse to human disturbances, local populations may abandon development sites. This type of response has been observed around oil and gas developments where populations have declined (Walker et al. 2007). It is particularly a concern with regard to wind energy since sage-grouse avoid tall structures.

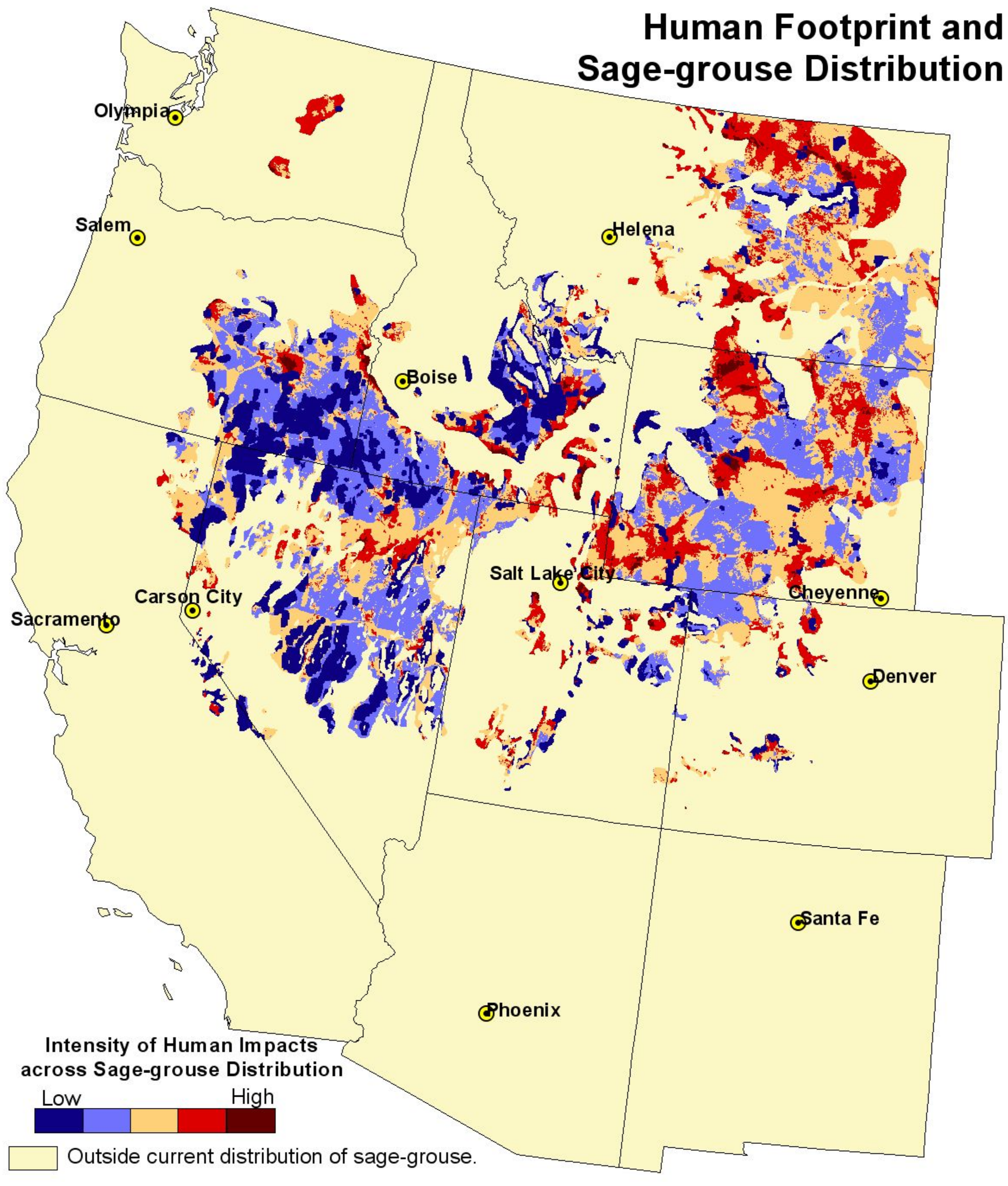

Figure 15. Human footprint across the current sage-grouse distribution.

Solar energy also poses a threat to sage-grouse populations from fragmentation and degradation of habitat. Removal of all vegetation beneath a solar facility renders the habitat useless to species such as sage-grouse that are dependent on sagebrush ecosystems. Given the high risk of sage-grouse abandoning habitats impacted by development, core areas or other population centers should be avoided. Degraded habitats with low sage-grouse abundance may be suitable for energy development, pursuant to the findings of a site-specific analysis.

Development Suitability Assessment

The suitability assessment addresses the question of whether or not development is appropriate for a particular area based on other values. For the purposes of this assessment, the other values of interest relate to ecological integrity and the relative importance of an area to fish and wildlife. We use the results of the human footprint analysis as a surrogate for ecological integrity with the assumption that the least altered landscapes have the highest overall integrity and are the least suitable for development. The current distributions of sage-grouse and native salmonids are also incorporated into the suitability assessment.

Other values not captured in this analysis such as cultural and visual resources and rare species occurrences may also render an area unsuitable for development. The characterization of an area as 'suitable' is intended to imply that, relative to other landscapes, certain areas are more suitable than others but a site-specific assessment of local conditions should be completed before any final suitability determinations are made.

The suitability assessment applied pre-defined decision criteria to distinguish between three suitability ratings: high, moderate, and not suitable. Figure 16 shows the decision matrix that was used in determining the suitability ratings. The boxes shown in gray represent the criteria for a determination of 'not suitable'. This includes all landscapes at the low end of the human footprint intensity gradient as well as all but the most disturbed landscapes within the sage-grouse core areas and subwatersheds currently occupied by interior species of native trout. For the purposes of the suitability assessment, a distinction was made between the anadromous species (i.e. salmon, steelhead, and sea-run cutthroat) and interior trout. Although all of these species are at risk, the interior species and subspecies were considered to be more vulnerable to local land disturbances due to their inability to relocate as a result of fragmented habitat and the subsequent loss of their migratory life history.

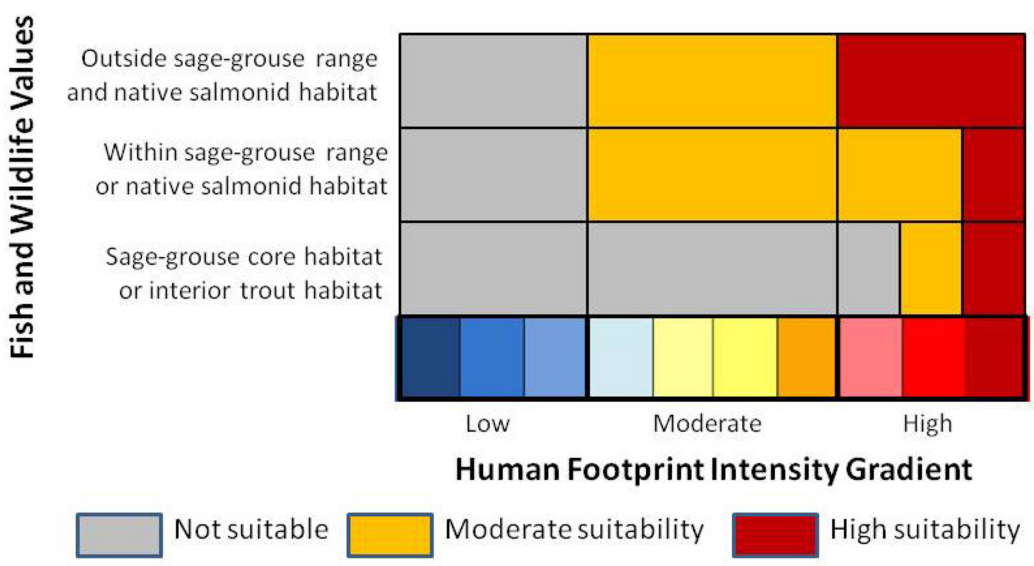

Figure 16. Decision matrix for suitability assessment.

The orange boxes in Figure 16 indicate the criteria used to identify landscapes classified as ‘moderate suitability’. This includes all landscapes with a moderate intensity human footprint that are outside of the core sage-grouse areas and interior trout habitat. It also encompasses lands within sage-grouse and trout habitat that have a high intensity footprint. Site-specific analyses are particularly important for lands with this suitability rating. Depending on the nature of the land disturbance and local environmental values, restoration may be more appropriate for some of these landscapes than development. Lands identified with a potentially ‘high suitability’ for development are primarily those areas with a high intensity of human disturbance, excluding sage-grouse habitat and subwatersheds currently occupied by native trout and salmon. The most altered landscapes within sage-grouse and salmonid habitat were also given a high suitability rating, although there were very few places where these features overlapped.

Figure 17 shows the results of the suitability assessment. The areas in gray are not suitable for development due to their ecological values and should be avoided. The areas in dark gray are public lands with special management designations (e.g. forest service roadless area, wilderness area, national park etc.) while the areas in light gray encompass a range of land ownerships from private to federal. The areas in orange are classified as ‘moderate suitability’ and represent lands with a moderate degree of human impacts that may still retain some important environmental values. The lands potentially the most suitable for development are shown in red and are those areas with the highest intensity of human disturbance.

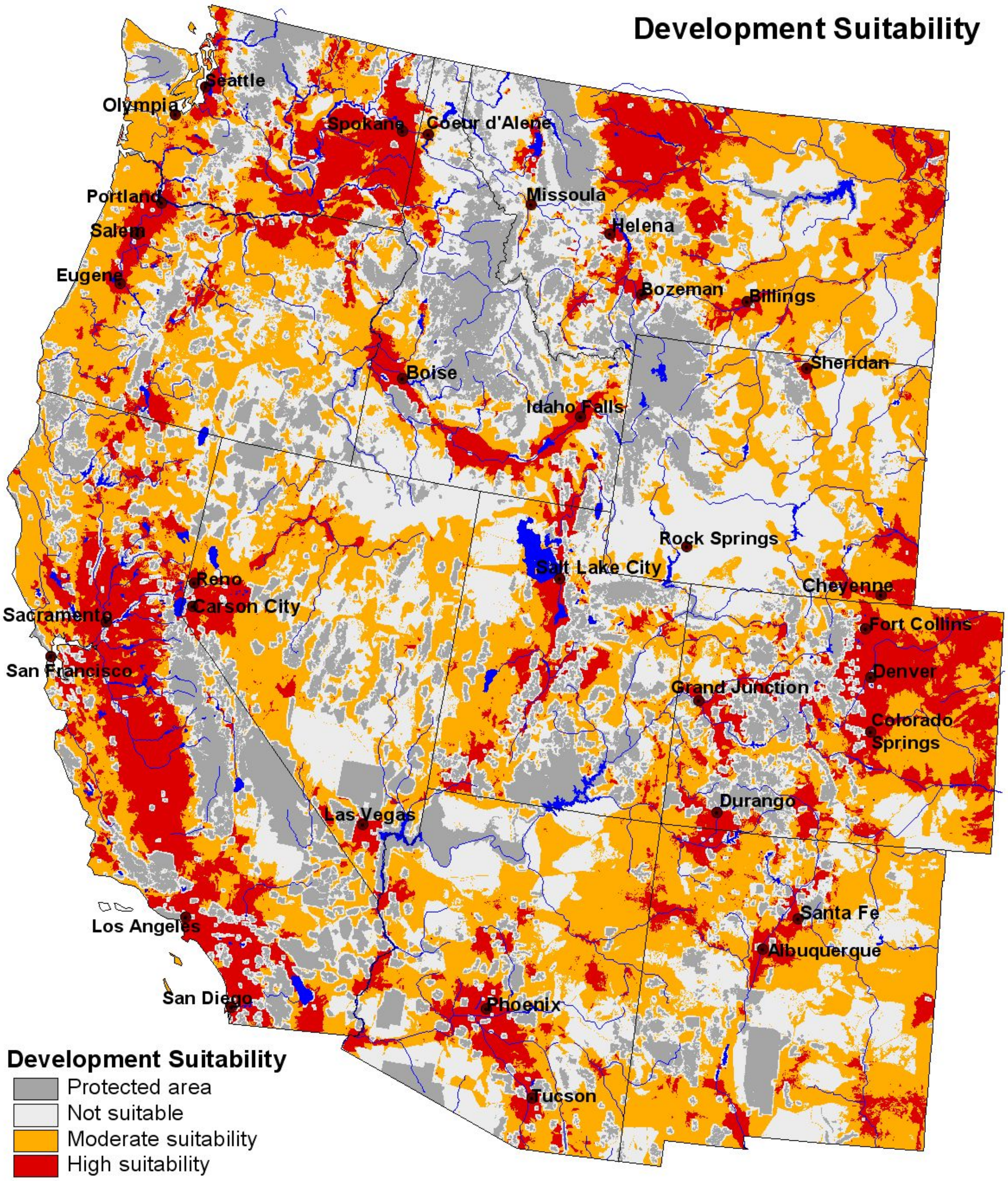

Figure 17. Development suitability based on the human footprint assessment and current distributions of sage-grouse and native salmonids.

Development Capability Assessment: Wind and Solar

There are many forms of renewable energy being developed today, but wind and solar power have seen the most significant expansion across the western landscape. Project scale for development of these resources can vary from residential applications to industrial complexes where more solar panels and wind turbines equate to more power generation and decreased unit costs for infrastructure. This assessment is concerned primarily with the siting of large complexes which have the greatest potential to adversely affect fish and wildlife resources through the fragmentation and degradation of habitats. There are additional opportunities for many small projects that are not discussed in this analysis due to scale.

Results of the development suitability assessment described in the previous section are combined with a capability assessment to identify those areas with the greatest potential for wind and solar power development on the least ecologically important landscapes. The capability assessment evaluates the potential for development based on energy supply and relevant landscape features as described in a 2003 report by the Bureau of Land Management and Department of Energy as modified by the National Renewable Energy Laboratory (NREL) in 2008. (www.nrel.gov)

Wind Energy Potential

The 2003 report by BLM and DOE defines screening criteria for wind energy development. These include physical landscape features, existing infrastructure, as well as economic and policy considerations. Only those factors that could be analyzed spatially were used in the capability assessment. This included the following:

- Wind class 3 or greater.
- Less than 14% slope.
- Elevation below 7,000 feet (2134 m).
- Within 25 miles (40.2 km) of a 69-345 kV transmission line.
- Within 50 miles (80.5 km) of a road or railroad.
- Contiguous parcel at least 1 square mile (2.6 km^2).

Of these six criteria, the most critical factor is wind power. Figure 18 shows wind class across the West based on data from Department of Energy's National Renewable Energy Laboratory. Wind power Class 3 is the minimum required for long-term power generation while Class 4 is necessary for short-term (NREL 2003). Figure 19 shows the results of the capability assessment by wind power class. Only those areas meeting all six of the criteria outlined are shown on the map.

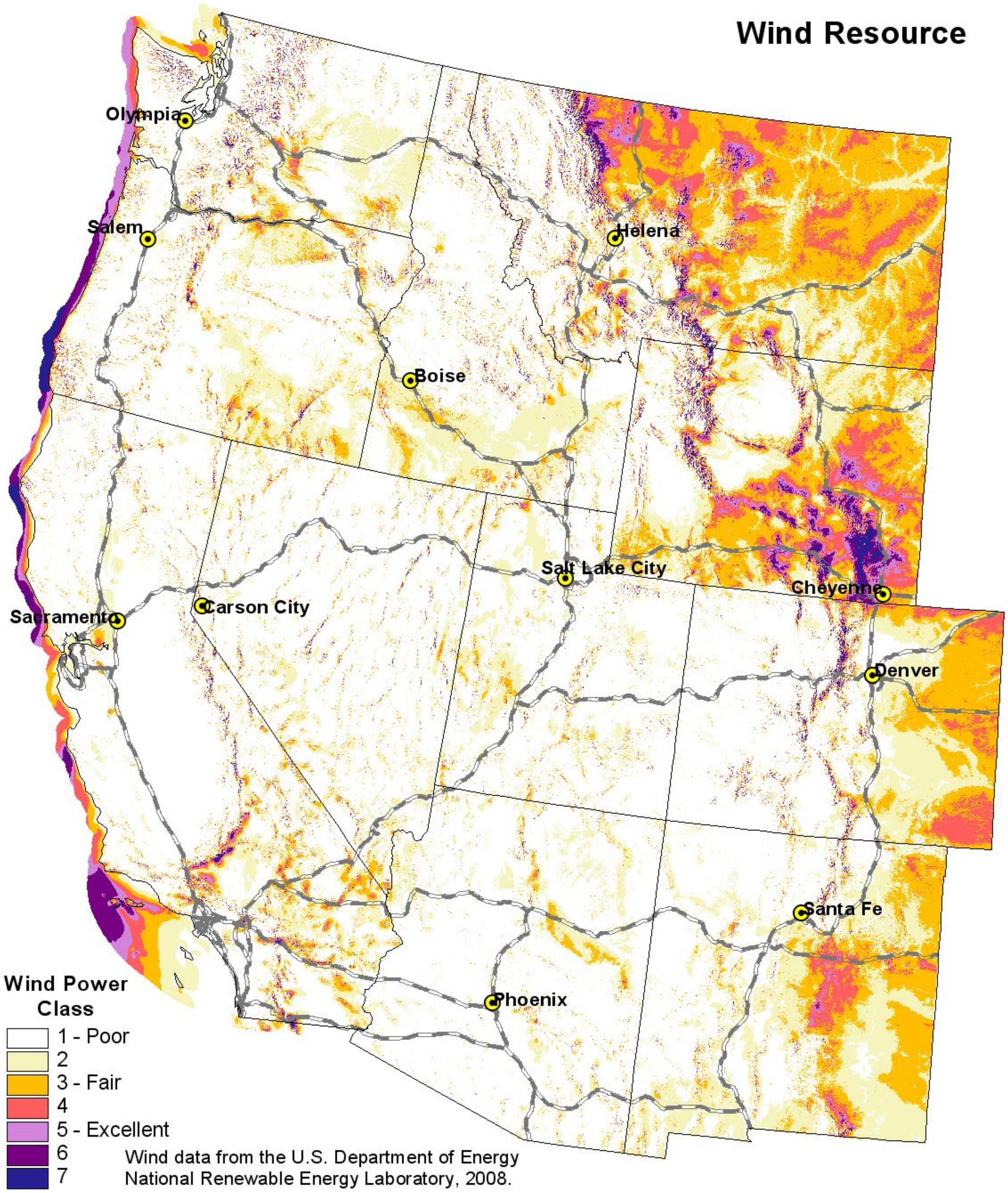

Figure 18. Available wind resources by wind power class. Class 3 or higher is considered suitable for wind energy development.

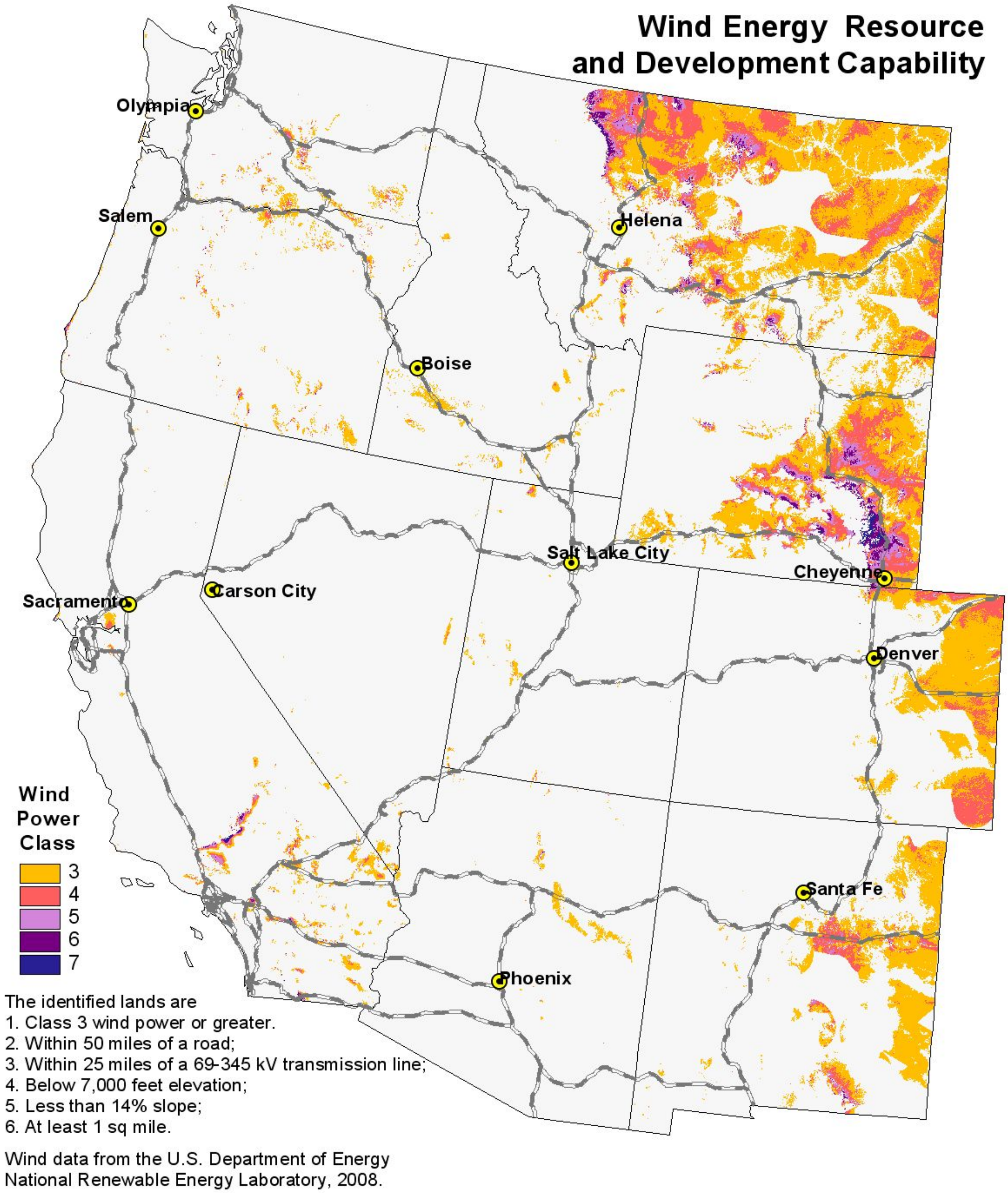

Figure 19. Land capable of supporting wind energy development shown by wind power class.

Lands identified as capable of supporting wind energy development were combined with the results of the suitability assessment. Figure 20 shows these results. Only those areas found to be capable of supporting wind energy development are shown. The dark red areas represent the most degraded landscapes and should be the highest priority areas for initial siting evaluations. The areas in orange may be suitable but more detailed environmental analyses are required in order to make a final determination. The areas in gray are lands capable of supporting wind energy but based on the suitability assessment they were found to have high ecological values and therefore should not be developed.

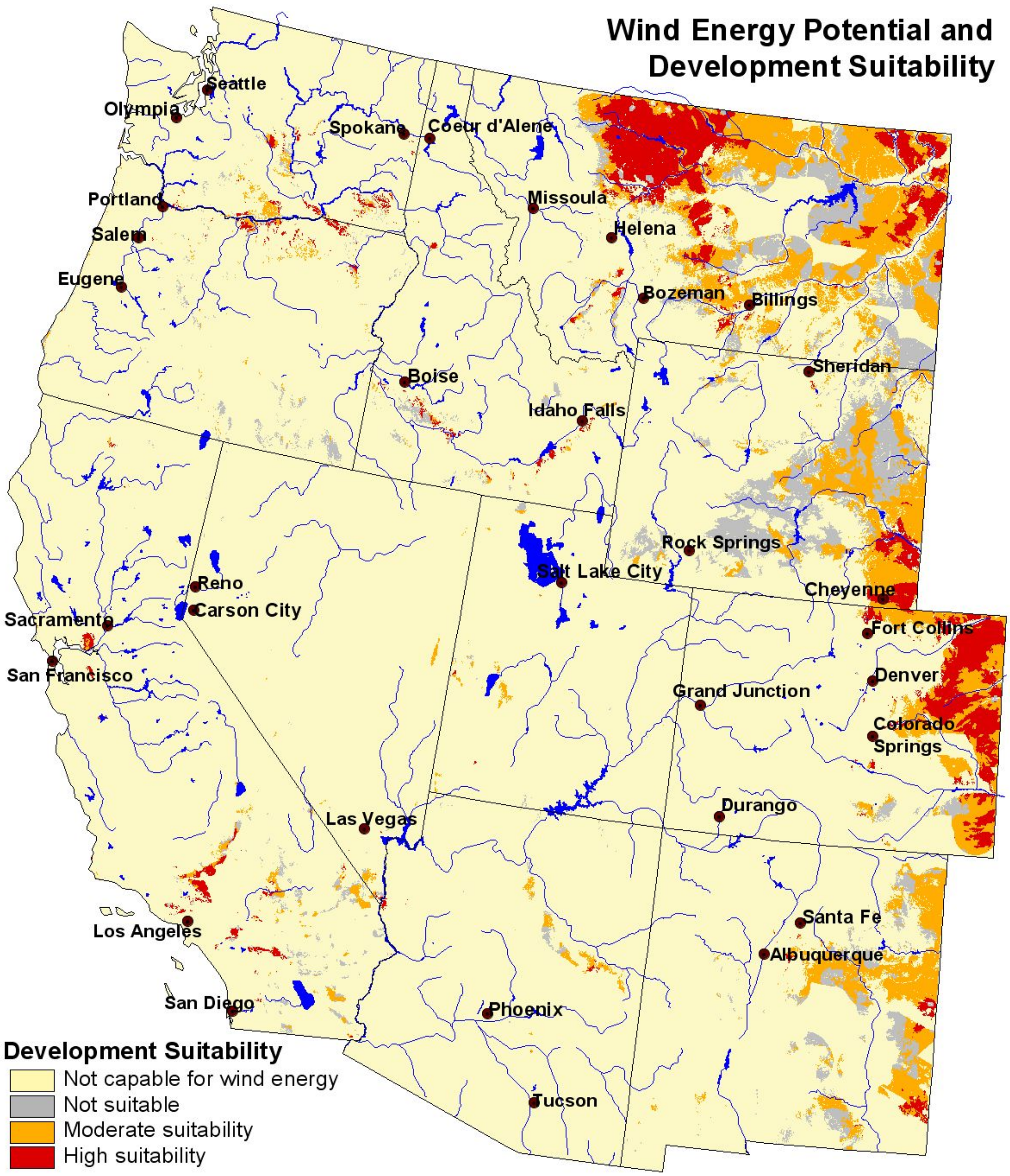

Figure 20. Areas satisfying all six criteria for wind energy development capability shown by suitability class.

Solar Power

The criteria used for assessing land capability for development of solar thermal systems was based on screening factors outlined in the 2003 report (NREL 2003). However, a more recent assessment of solar resources completed by NREL in 2008 modified some of the thresholds used to determine development potential and were used to modify the 2003 criteria where applicable. The five criteria analyzed are listed below with reference to the appropriate assessment.

- Direct solar resource at least 6 kWh/m2/day (NREL 2008).
- Less than 3% slope (NREL 2008).
- Within 80.5 km (50 miles) of 115-345 kV transmission line (NREL 2003).
- Within 80.5 km (50 miles) of a road or railroad (NREL 2003).
- Minimum continuous patch size of 1 km² (NREL 2008).

Figure 21 shows the direct solar resource across the West based on 2008 data from NREL with the greatest potential found in the southwest.

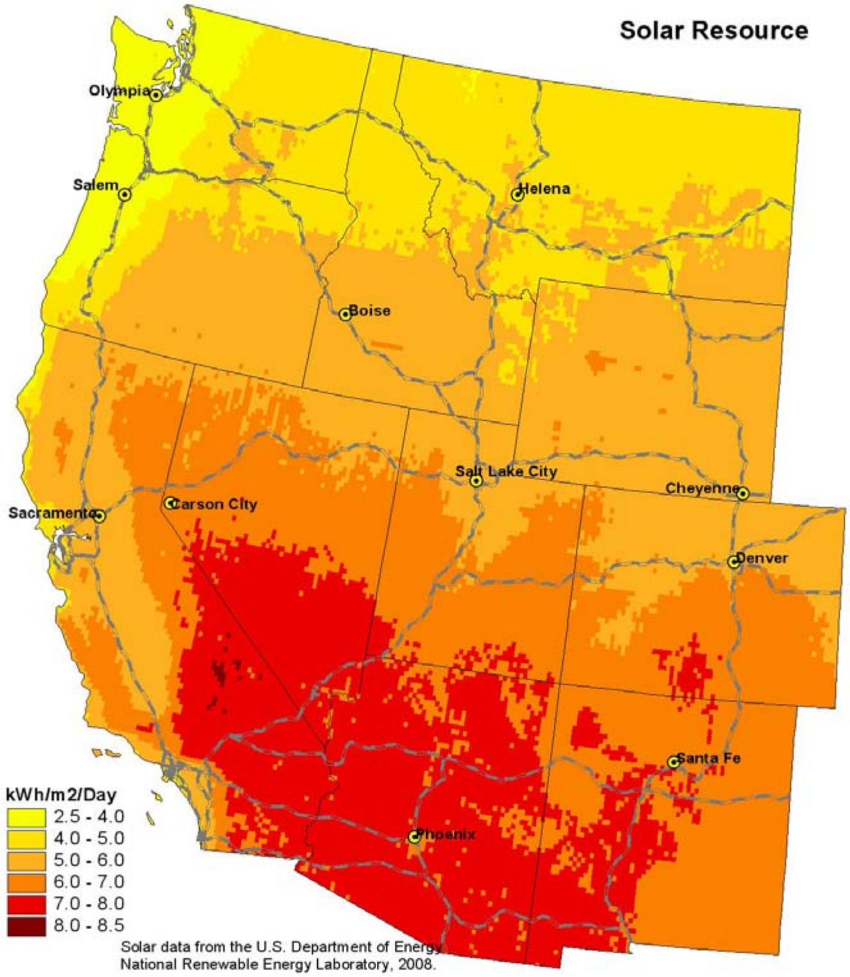

Figure 21. Available solar resources – a minimum of 6 kWh/m2/Day is required for development.

Figure 22 shows the lands capable of supporting large-scale solar energy development based on the five criteria specified. Figure 22 integrates these results with the results of the suitability assessment for identification of the potentially highest priority sites for solar development. The

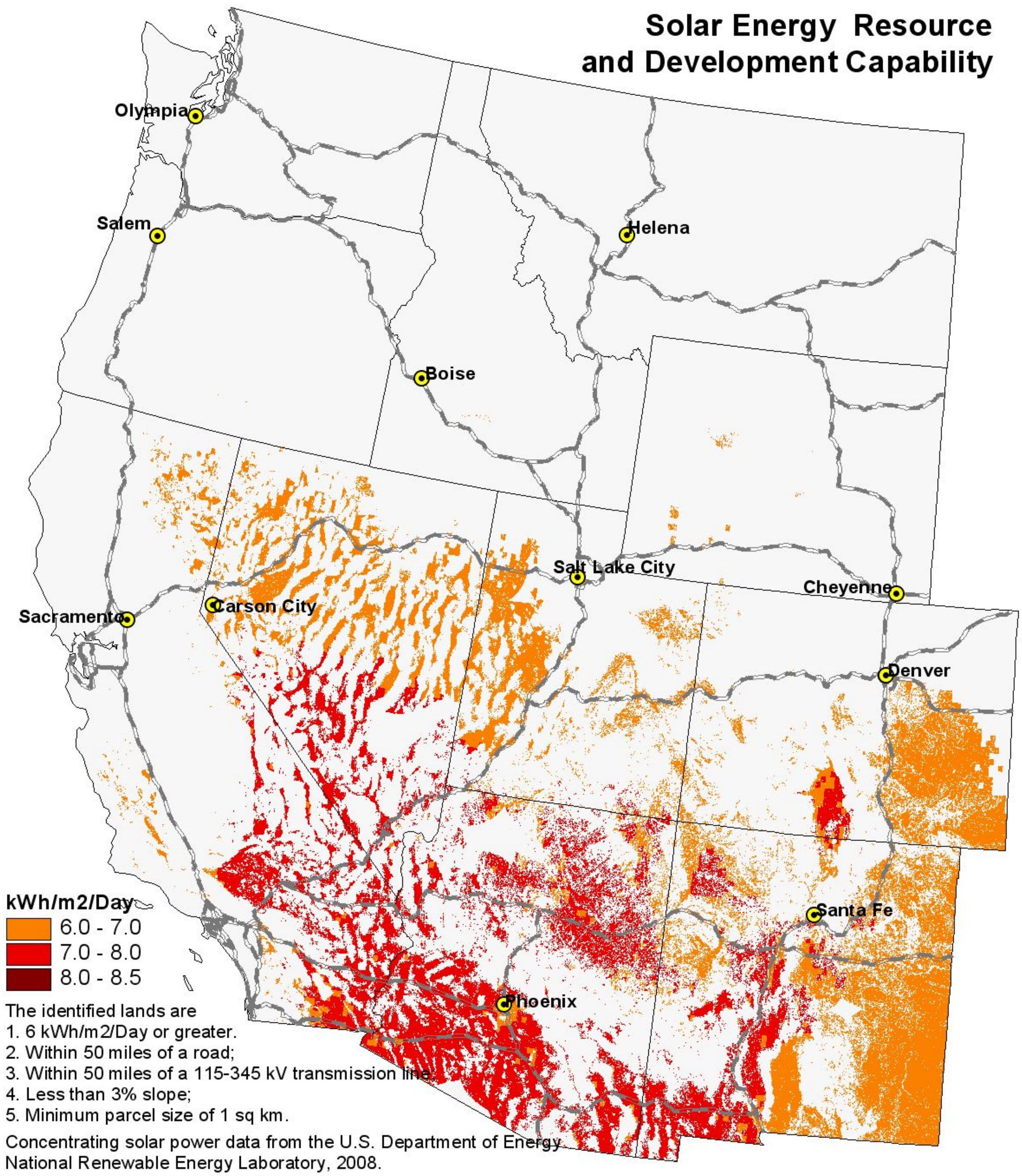

Figure 22. Lands capable of supporting development of solar energy resources.

dark red areas represent the areas that are potentially the most appropriate for development and should be the starting point for detailed site review while the gray areas should not be developed due to high ecological values.

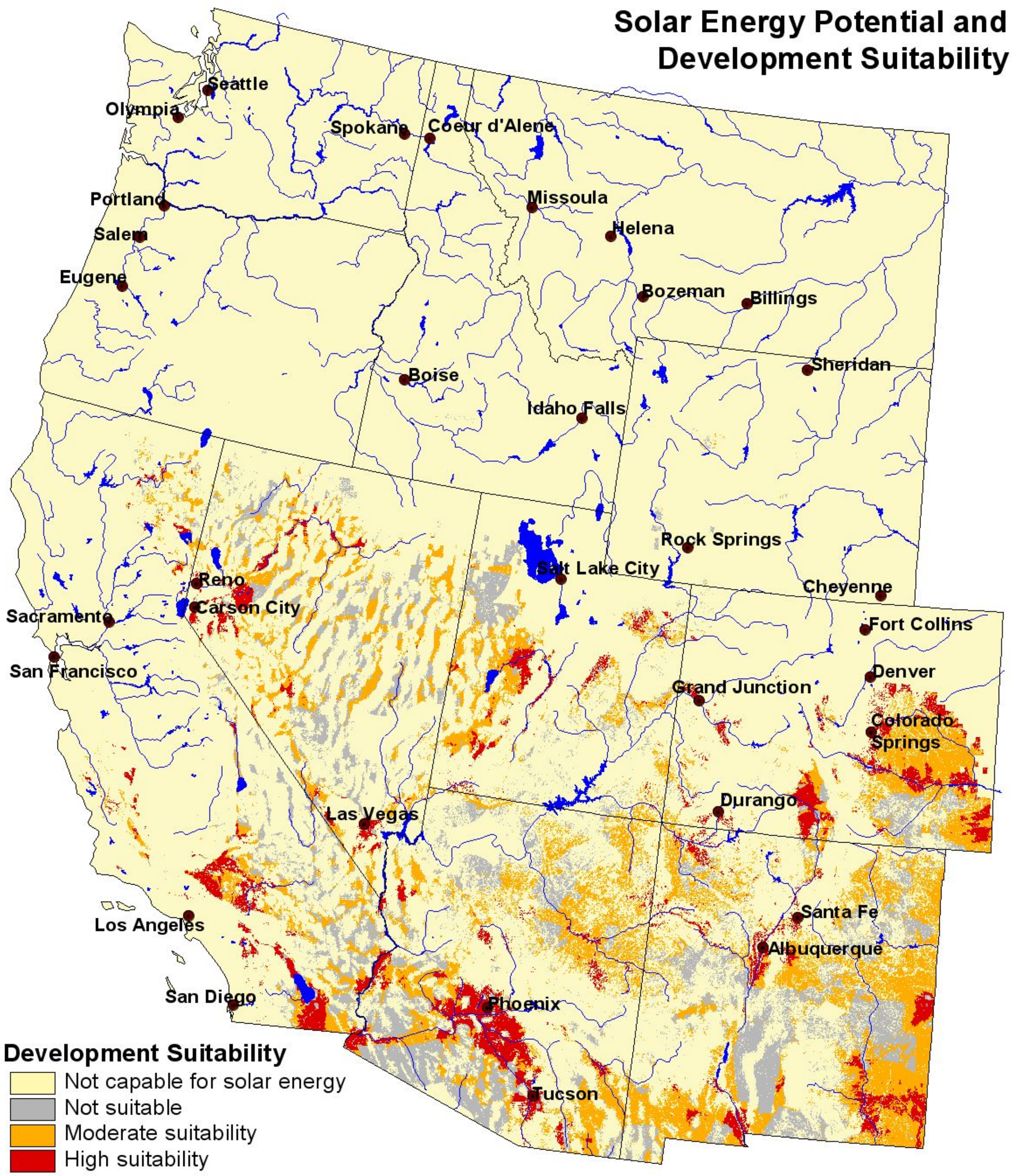

Figure 23. Lands satisfying the four criteria for solar energy development capability shown by suitability class.

Additional Renewable Energy Considerations

Although wind and solar power are the primary focus of this assessment, we would be remiss in our discussion of renewable energy if we did not also address hydropower development and energy transmission.   Due to issues of scale we have not completed broad-scale capability and suitability assessments for these developments but we have included a discussion with some preliminary spatial information that can be used to inform the debate over the siting of new hydropower projects and transmission corridors.

Hydropower

Hydropower has been an important source of energy in the West for decades and is experiencing a resurgence with the national push for development of 'clean' renewable energy. However, identification of 'clean' energy sources should not be limited to an assessment of greenhouse gases but should also encompass the cumulative effects on the environment of resource development. Hydroelectric projects have been devastating for the West's fisheries, resulting in the local extinction of native salmonids, particularly anadromous species, across large portions of their range.

Unlike wind and solar which may have very large physical footprints, the immediate disturbance area associated with a hydroelectric project is relatively small but the ecological footprint can extend for hundreds of kilometers upstream and downstream through-out a river basin. Application of the human footprint, as defined in this assessment, to hydropower is not appropriate for two reasons. First, the fine-scaled data required for even a cursory determination of hydroelectric capability is not readily available at a westwide scale. Second, the connectivity of hydrologic systems and complexity of adequately evaluating cumulative upstream and downstream effects to their full extent is also beyond the scope of this assessment. However, without conducting a spatially explicit analysis, it is still possible to provide a general overview of existing and possibly future hydroelectric projects within the context of minimizing environmental effects.

According to the National Inventory of Dams (U.S. Army Corps of Engineers, 2009) there are 11,700 dams across the eleven western states with a dam height of at least six feet. Although there are likely many more dams that do not meet this criteria but are still problematic from a fisheries perspective, this inventory captures the most significant sources of hydroelectric potential. Dams are built for a variety of reasons from water storage and flood control to fish and wildlife habitat and power generation. Of the dams inventoried in the West, only 560 currently generate electricity. Given the site-specific requirements for hydroelectric generation, many dams are not suitable for producing power. However, it is likely that some could be retrofitted to support hydroelectricity as an additional use. Opportunities for this type of development should be considered first, before identifying sites for new dam construction.

Figure 24 shows existing hydroelectric facilities (large red dots on map) as well as existing dams that do not currently produce power (small green dots on map). Small dams constructed to create fish ponds, stock water, or other fish and wildlife amenities as well as those built for tailings or debris control were excluded from consideration along with all dams built prior to 1960. This left over 3000 dams built primarily for recreation, flood control, and water supply that do not currently generate power. Several of these are quite large with a storage capacity in excess of one million acre-feet of water. Although many of these dams may not be suitable for power generation due to technical and environmental constraints, they should serve as the starting point for an assessment of the nation's hydropower resources before the construction of new sites.

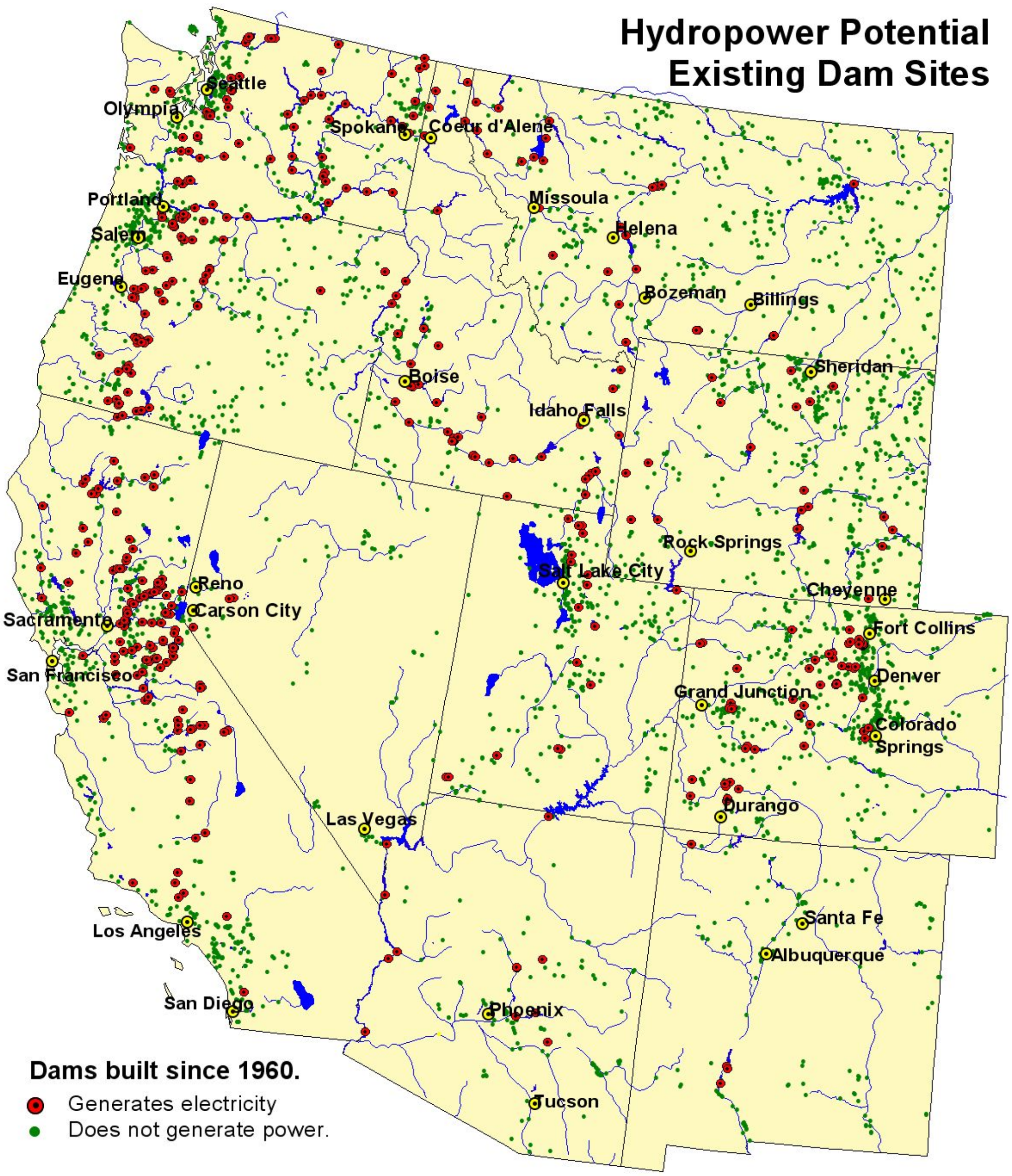

Figure 24. Existing hydroelectric projects and dams that do not produce power.

Transmission Corridors

Increased development of energy resources across the West necessitates a similar increase in transmission capacity to move energy from its source to population centers. Recognizing the need to upgrade and expand the existing power grid to support increased oil and gas development in the West, Congress directed the federal land management agencies to designate energy corridors on federal land in Section 368 of the Energy Policy Act of 2005 (U.S. Department of Energy and U.S. Department of the Interior 2008). These corridors were identified specifically for the transport of oil, gas, and hydrogen and electricity transmission from distribution facilities. Transmission demands from renewable resources such as wind and solar were not part of the original assessment so any new assessments can be expected to increase the number of corridors required to move energy from new facilities.

New transmission corridors may extend for hundreds of miles and have the potential to fragment landscapes as well as serve as a conduit for the spread of invasive plant species such as cheatgrass and increase human access into previously unroaded areas. However, unlike power generation facilities that must be sited in areas capable of producing energy, there is some flexibility in the siting of transmission corridors. Although they have specific connection points, their alignment between these points should be designed to minimize environmental impacts. Much of the West is already crossed by hundreds of thousands of miles of linear features. This includes over 300,000 miles of state and federal highways and nearly 200,000 miles of existing powerlines. When railroads, canals, and secondary roads are included the number is well over one million. These existing features should be followed whenever possible in order to minimize additional fragmentation of landscapes that are already too fragmented.

Figure 25 shows the location of the Section 368 corridors as well as the existing distribution system. It also shows areas identified in this assessment as being capable of supporting wind or solar power development (purple and red on map respectively). Development of these resources will require additional transmission corridors beyond those already identified. The Section 368 corridors are only on federal lands whereas much of the wind development is occurring on private lands so decisions on corridor alignments will involve a local land use planning process.

Figure 26 shows the proposed Section 368 corridors in relation to the development suitability assessment. Although it is difficult to discern specific impacts at this scale of analysis, there are several areas that could be problematic, particularly at the center of the western region which separates the supply along the eastern flanks from the demand along the coast. Areas with low population densities and generally small human footprints such as southeastern Oregon, southwestern Idaho, and Nevada are at risk of experiencing increased fragmentation and degradation of remaining wild lands as they are crossed by energy corridors. New energy corridors should follow existing alignments of highways, railroads, and other linear features rather than fragmenting landscapes that still retain a high level of ecological integrity.

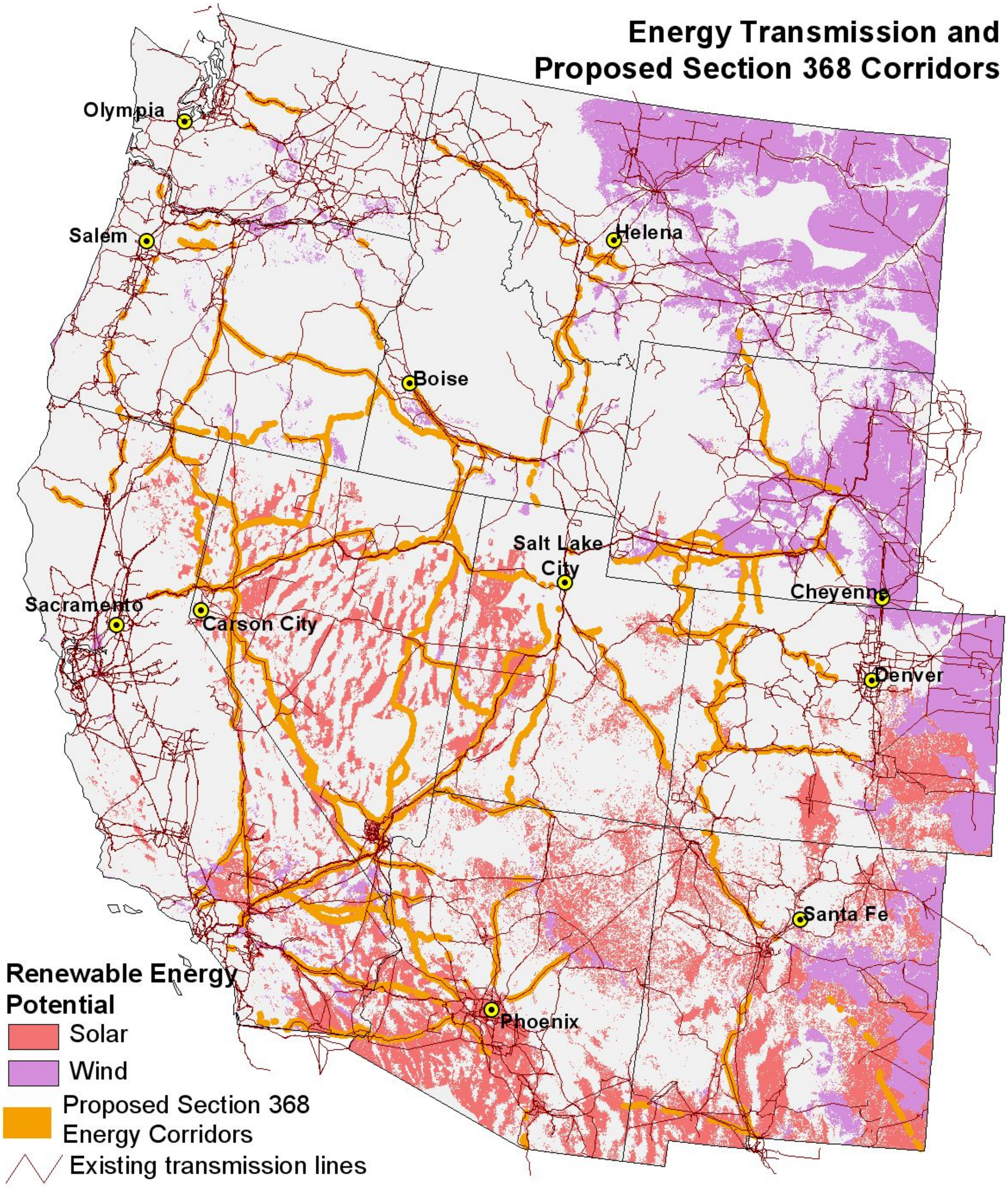

Figure 25. Proposed Section 368 energy corridors on federal land and existing powerlines. Lands capable of supporting wind and solar power are also shown in purple and red respectively.

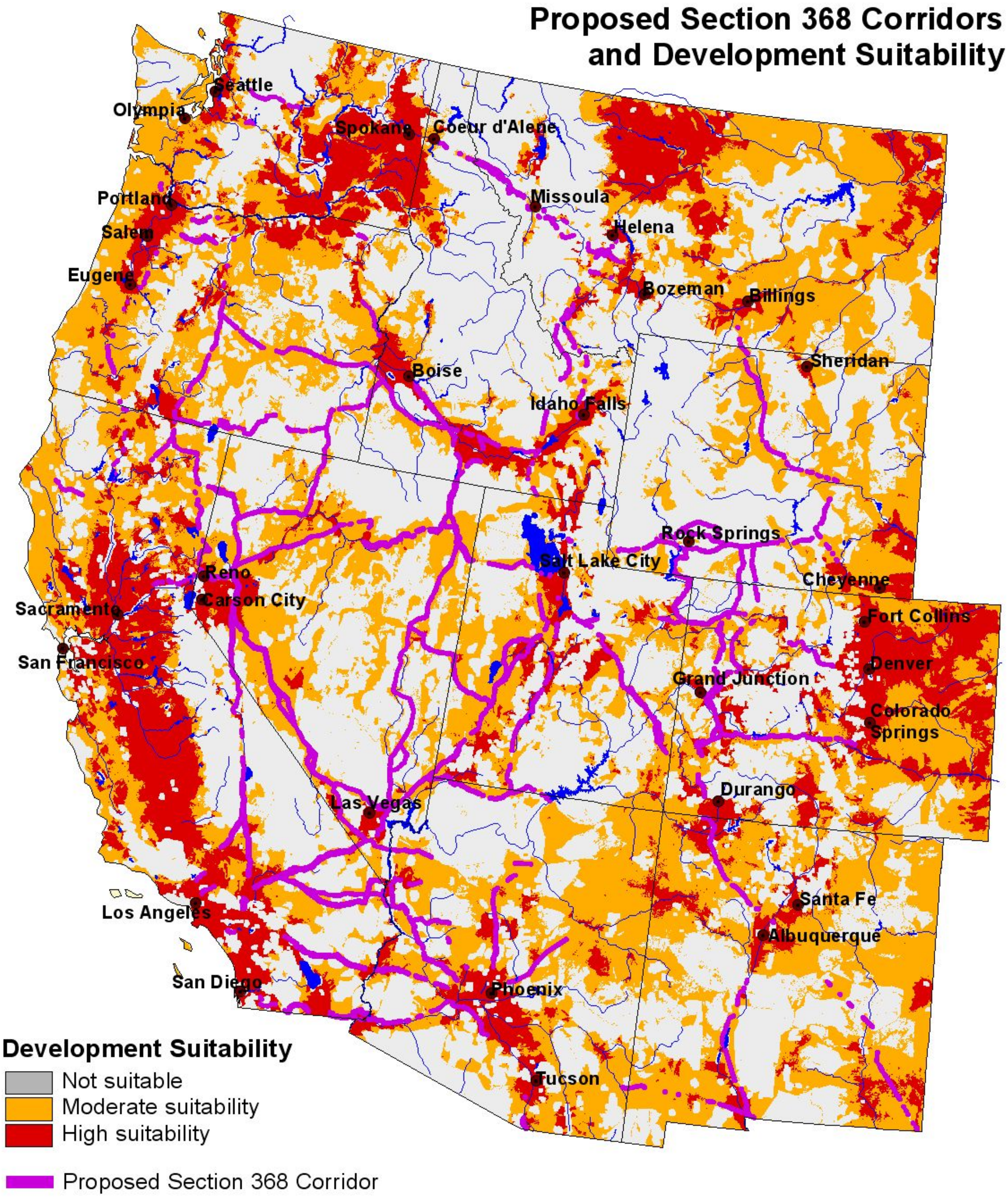

Figure 26. Proposed Section 368 corridors and results of the development suitability assessment.

Conclusion

The human footprint provides a useful foundation for the identification of lands that are potentially suitable for renewable energy development. Although it is a broadscale assessment it provides regional guidance for landscape planning that allows for development while minimizing environmental impacts on high value areas. Wind and solar power are important to the nation's energy portfolio as renewable resources that can help to reduce greenhouse gas emissions. However, development of these resources is not appropriate for all lands capable of producing power. This assessment demonstrates that even after excluding the highest quality habitats and areas supporting sensitive species (i.e. sage-grouse and native salmonids) there are still many places that are both capable and potentially suitable, for development. Table 1 provides acreage summaries from the suitability/capability assessment for both wind and solar power, distinguishing between public and private lands.

	Westwide (millions of acres)			Wind Capable (millions of acres)			Solar Capable (millions of acres)		
	Total	**Public**	**Pvt.**	**Total**	**Public**	**Pvt.**	**Total**	**Public**	**Pvt.**
Westwide	758	363	395	91	15	76	114	38	76
Mod. Suit.	273	98	175	45	5	40	57	19	38
High Suit.	114	15	99	21	1	20	19	3	16
Total Suit.	387	113	274	66	6	60	76	22	54

Table 1. Acreage summaries of results from the suitability and capability assessments, distinguishing between public and private lands.

Of the 758 million acres that comprise the western landscape, slightly over one-half were found to be potentially suitable for development. This includes 66 and 76 million acres of lands capable of supporting wind and solar power development respectively. If only those lands classified with a high suitability rating are considered, there are still 21 and 19 million acres available for wind and solar, respectively. These are the lands that should be considered first for development. Although there may be local site-specific issues that ultimately preclude development, by focusing initial siting studies on those places with lower ecological integrity the likelihood of implementing a successful project with minimal controversy increases.

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