A STRATEGY PLANNING TOOL FOR WESTERN CONSERVATION

THE WILLIAM AND FLORA HEWLETT FOUNDATION
ENVIRONMENT PROGRAM

MARCH 2011

Prepared by The William and Flora Hewlett Foundation
and Redstone Strategy Group

TABLE OF CONTENTS

SUMMARY 3

1. WHAT IS THE TOOL'S PURPOSE? 5
   - The tool suggests philanthropic investments 5
   - The suggestions are based on expected return estimates 6
   - These suggestions are one step in the planning process 6

2. WHAT IS THE FOUNDATION'S GOAL FOR THE WEST? 7
   - Ensuring ecological integrity from the Rockies to the Pacific 7
   - Ecological integrity has six main components 8
   - Targets are set for each component of ecological integrity 9

3. WHAT CHANGES ARE NEEDED TO REACH THE GOAL? 14
   - Integrity estimates take into account different levels of protection 14
   - Integrity is estimated based on intensity of human uses 15

4. HOW CAN THE FOUNDATION IMPROVE ECOLOGICAL INTEGRITY? 20
   - A number of possible investments are considered 20
   - Expected return estimates suggest the most effective investments 21
   - Published research and expert input are used to estimate expected return 23
   - Integer optimization identifies a straw-man portfolio of investments 24

5. WHAT ARE THE RESULTS AND HOW WILL THEY BE USED? 26
   - The suggested straw-man portfolio results in a mix of investments 26
   - Assumptions can affect the results, but the strategy is largely stable 27
   - The tool's suggestions are part of a multi-step planning process 29

6. HOW CAN THE FOUNDATION FURTHER IMPROVE THE TOOL? 31

APPENDIX 1: PARCELS, ECOSYSTEMS, AND SPECIES 33

APPENDIX 2: HUMAN USE INPUTS AND ASSUMPTIONS 50

APPENDIX 3: SENSITIVITY SCENARIOS 60

APPENDIX 4: SOURCES 61

SUMMARY

THIS DOCUMENT DESCRIBES A STRATEGY PLANNING TOOL USED BY the Hewlett Foundation to inform its Western conservation investments. The tool suggests specific philanthropic investments to help the Foundation achieve its Western conservation goals.

1. WHAT IS THE TOOL'S PURPOSE?

The strategy planning tool suggests a straw-man portfolio of philanthropic investments. It is used as a starting point for planning that also incorporates expert advice.

2. WHAT IS THE FOUNDATION'S GOAL FOR THE WEST?

The Foundation's goal is to ensure the ecological integrity of the West to benefit wildlife and people. The strategy planning tool includes targets for ecosystems, species, core areas, connectivity corridors, greenhouse gas emissions, and sustainable human uses. The specific targets are guided by scientific and other expert input and are updated as information improves.

3. WHAT CHANGES ARE NEEDED TO REACH THE GOAL?

Current integrity is estimated for ecosystems, species' ranges, core areas, and corridors through analysis of human uses. These integrity levels are then compared to the Foundation's targets to identify areas that can benefit from investments.

4. HOW CAN THE FOUNDATION IMPROVE ECOLOGICAL INTEGRITY?

The tool suggests specific philanthropic investments to improve ecological integrity in areas that are below the Foundation's targets. The tool estimates expected returns (ERs) to compare the likelihood-adjusted cost-effectiveness of the possible investments.

5. WHAT ARE THE RESULTS AND HOW WILL THEY BE USED?

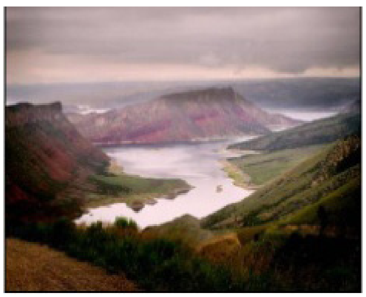
The tool suggests a mix of place-based and West-wide investments that are relatively stable with changes in assumptions. Beginning with this mix, the Foundation's investment decisions then incorporate internal discussion, expert input, and consultation with potential partner funders and grantees. The result is ambitious: it requires Hewlett to invest over many years and to partner with other funders and government entities.

6. HOW CAN THE FOUNDATION FURTHER IMPROVE THE TOOL?

The tool has already been significantly enhanced based on a peer review. Changing needs and data will no doubt result in furthur opportunities for improvement. This final chapter lists four changes that are likely to be valuable over time.

1

WHAT IS THE TOOL'S PURPOSE?



THE STRATEGY PLANNING TOOL SUGGESTS A STRAW-MAN PORTFOLIO of philanthropic investments. It is used as a starting place for planning that also incorporates expert advice.

The Hewlett Foundation has a strong tradition of work on Western conservation issues. Over more than thirty years of work, the Foundation has invested $215 million in the West. Currently, it spends about $25 million on the topic each year. In an effort to maximize these investments, the Foundation is undertaking a review of its strategy in the region. As one part of this review, the Foundation decided to examine quantitative tradeoffs between potential investments in the West. The Foundation developed a strategy planning tool to make approximate data-based comparisons of different investments that could serve as a starting place for detailed strategy planning. This chapter describes the tool and its intended contribution to the full strategy planning process.

THE TOOL SUGGESTS PHILANTHROPIC INVESTMENTS

The strategy planning tool suggests high-return investments to be included in the Foundation's plan for the West. It differs from conservation modeling tools, which are designed to suggest specific geographic priority areas with a high level of resolution. This tool identifies specific philanthropic investments to improve broad areas that are below conservation targets. The output of the tool is a straw-man portfolio of investments that could cost-effectively achieve all of the Foundation's goals in the West. Since the Hewlett Foundation achieves its aims through grantmaking, a specific portfolio of possible grantable activities is more valuable than a list of priority places.

The Foundation recognizes that the results of the tool are an approximation. A variety of simplifying assumptions were made to allow for comparisons and actionable recommendations at the scale of the entire West. The tool results are meant to be further refined and ground-truthed through a planning process involving the Foundation, outside experts, possible partner funders, and grantees to create a comprehensive conservation plan for the West.

An explicit conservation plan for the whole West is valuable for several reasons. It allows the Foundation to be sure that its investments are working together to achieve lasting success in the region. It also allows the Foundation to closely measure progress towards this overall goal. Lastly, a detailed strategic plan is useful internally and with other potential funders to make the case for additional funding.

THE SUGGESTIONS ARE BASED ON EXPECTED RETURN ESTIMATES

The portfolio of suggested investments is developed using expected return (ER) estimates. ER compares philanthropic investments based on their potential impact, likelihood of success, and expected cost. Based on a number of explicit assumptions, the tool suggests investments that appear to have high potential to cost-effectively achieve the Foundation's goals. This straw-man set of investments includes both place-based work that directly benefit priority regions and West-wide investments that improve large areas, including priority regions. Through an optimization process, a portfolio of possible high-expected return investments is suggested to achieve the Foundation's goals while minimizing cost.

THESE SUGGESTIONS ARE ONE STEP IN THE PLANNING PROCESS

The quantitative comparisons performed by the strategy planning tool are meant to inform the strategy planning process, not replace it. During the initial development of the tool, outside experts and Foundation staff were heavily involved in developing assumptions and evaluating preliminary outputs. These staff and outside experts are expected to continue their involvement as the tool is further refined. In addition, the portfolio of investments generated by the strategy planning tool was reviewed both internally and externally (Figure 1). Some of the suggested strategies have been changed or eliminated based on the experience and knowledge of experts in the field, conditions on the ground in priority areas, and other subtle factors that were not captured by the tool.

FIGURE 1 Strategy planning process

2

WHAT IS THE FOUNDATION'S GOAL FOR THE WEST?

THE FOUNDATION'S GOAL IS TO ENSURE THE ECOLOGICAL INTEGRITY of the West to benefit wildlife and people. The strategy planning tool includes targets for ecosystems, species, core areas, connectivity corridors, greenhouse gas emissions, and sustainable human uses. The specific targets are guided by scientific and other expert input and are updated as information improves.

Healthy biodiversity underlies the many ecological, economic, and aesthetic values created by the lands and waters of the West. The Foundation aims to protect these values by securing the long-term ecological integrity of the West. Specifically, the Foundation's goals are to conserve threatened ecosystems and species through increased protection; maintain a network of highly protected core areas and intact corridors between them; lessen greenhouse gas emissions and maximize adaptation to climate change; and encourage sustainable human uses of Western landscapes. This chapter describes these broad goals and the quantitative integrity targets that represent them in the strategy planning tool.

ENSURING ECOLOGICAL INTEGRITY FROM THE ROCKIES TO THE PACIFIC

The West, as defined by the Foundation, covers nearly 1.5 billion acres in the United States, Canada, and the Colorado River Delta in Mexico (Figure 2).

For the purposes of this tool, the study area was divided into approximately 12,000 smaller "parcels." To create these parcels, a roughly 25 x 32 kilometer rectangular grid was applied to the study area. Additionally, sections of major rivers (and the riparian areas around them) within each grid cell were treated as separate parcels. Smaller streams were not treated as separate parcels, but were included as part of each grid cell (for more details, see Appendix 1.1).

FIGURE 2 Study area

ECOLOGICAL INTEGRITY HAS SIX MAIN COMPONENTS

Ecological integrity, for the Foundation's purposes, means that natural systems function similarly to their cycles in the absence of human activity. This requires that sufficient habitat be protected to allow core ecological functions and key species to be sustained over time. Specifically, the Foundation has recognized six components of ecological integrity (Figure 3).

Quantitative targets were established for the first four components through the strategy planning tool, while the last two are being addressed through the judgment of Foundation staff in the later stages of strategy development. For the four components with specific targets (ecosystems, species, core areas, and corridors), the tool seeks the lowest cost set of investments to accomplish the minimum targets throughout the entire West.

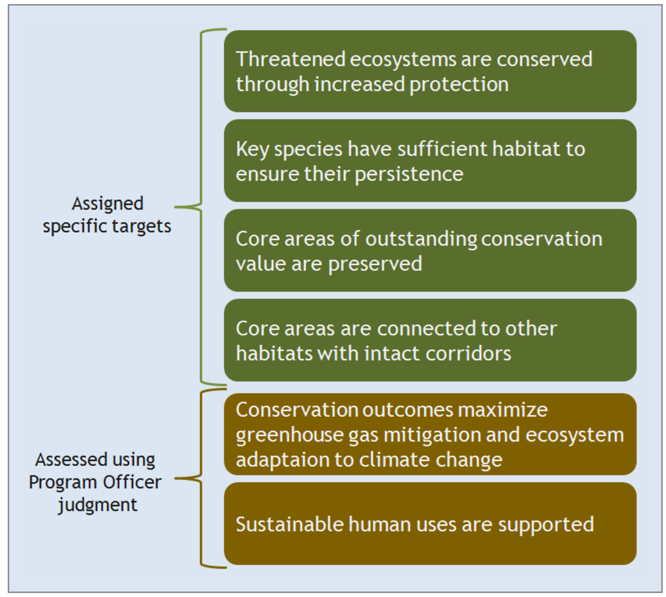


FIGURE 3 What is ecological integrity?

This section describes the components of ecological integrity. The last section in this chapter describes the specific quantitative targets that were selected for each component.

1. **Threatened ecosystems are conserved through increased protection.** In most cases, this means establishing a mosaic of protected and working lands with conservation value equivalent to placing a certain amount of an ecosystem in strict protection. As a simple example, to achieve 30% integrity, 60% of an ecosystem's total area could have been given protection 50% as valuable as strict protected areas, or 30% of the ecosystem could have been put into strict protected areas.[1] To attempt to explicitly address future climate change impacts, representation targets were increased for the ecosystems that may be most vulnerable to altered temperature and precipitation regimes (for example, Arctic ecosystems).

2. **Key species have sufficient habitat to ensure their persistence.** These species serve as surrogates for all species, as they represent the most sensitive and/or wide-ranging species in each terrestrial and freshwater ecosystem. Habitat representation for each species was estimated similar to ecosystem representation, taking both working lands and strict protected areas into account.

3. **Core areas of outstanding conservation value are preserved.** Large core areas of intact, wild lands (such as wilderness areas and national parks) are ecological strongholds, as well as iconic landscapes worthy of protection. While in many cases these areas are well protected, they may be threatened with fragmentation or degradation. The tool selected core areas from a set of intact wild lands. They are identified as areas to be monitored and protected if they are faced with significant, currently unforeseen human uses.

1 Subject to appropriate constraints on fragmentation and connectivity, as described in Section 3.

4. **Core areas are connected to other habitats by intact corridors.** Corridors between core areas allow for seasonal migrations of wide-ranging species, as well as longer-term shifts in species distributions in response to climate change and other global changes. The strategy planning tool identified specific corridors to be improved and/or maintained to meet minimum integrity targets.

5. **Conservation outcomes maximize greenhouse gas mitigation.** As a major source of energy for the United States and Canada—two of the world's largest carbon emitters—the West has a significant role to play in stabilizing global greenhouse gas emissions. With Foundation staff guidance, the strategies suggested by the tool include ancillary climate benefits wherever possible (e.g., reducing fossil fuel development on public lands).

6. **Sustainable human uses are supported.** The Foundation recognizes that the biodiversity and the human needs of the West are inextricably linked. The only way to achieve the Foundation's conservation objectives is to ensure that the long-term needs of Western communities are met as well. The strategies suggested by the tool intentionally seek to balance conservation with sustainable economic and recreational uses (for example, agriculture, tourism, and responsible mineral exploration where appropriate).

TARGETS ARE SET FOR EACH COMPONENT OF ECOLOGICAL INTEGRITY

The first step in translating the Foundation's broad vision into a measurable objective was to identify and set protection targets for the first four components of ecological integrity (ecosystems, species' ranges, core areas, and corridors). The Foundation relied on scientific literature for guidance in setting conservation targets. However, translating theoretical understanding of ecological processes into hard conservation targets is difficult and judgment-based. As the science of conservation improves, the tool will be updated.

The integrity targets are expressed as the percentage of each ecosystem, species, core area, or corridor that would have to be conserved in strict protected areas to meet the target. As explained earlier, and in detail in the following chapter, these goals can be met by joining together larger areas of partially protected lands (subject to constraints on fragmentation and connectivity), instead of investing only in strict protected areas.

The rest of this section describes the data used and targets set for ecosystems, species' ranges, core areas, and corridors.

Ecosystem Inputs and Targets

The ecosystems included in the tool were 53 terrestrial ecosystems, 53 riparian ecosystems, and 37 freshwater ecosystems (Figure 4). The data used to represent ecosystems were derived from various publicly-available data sets.

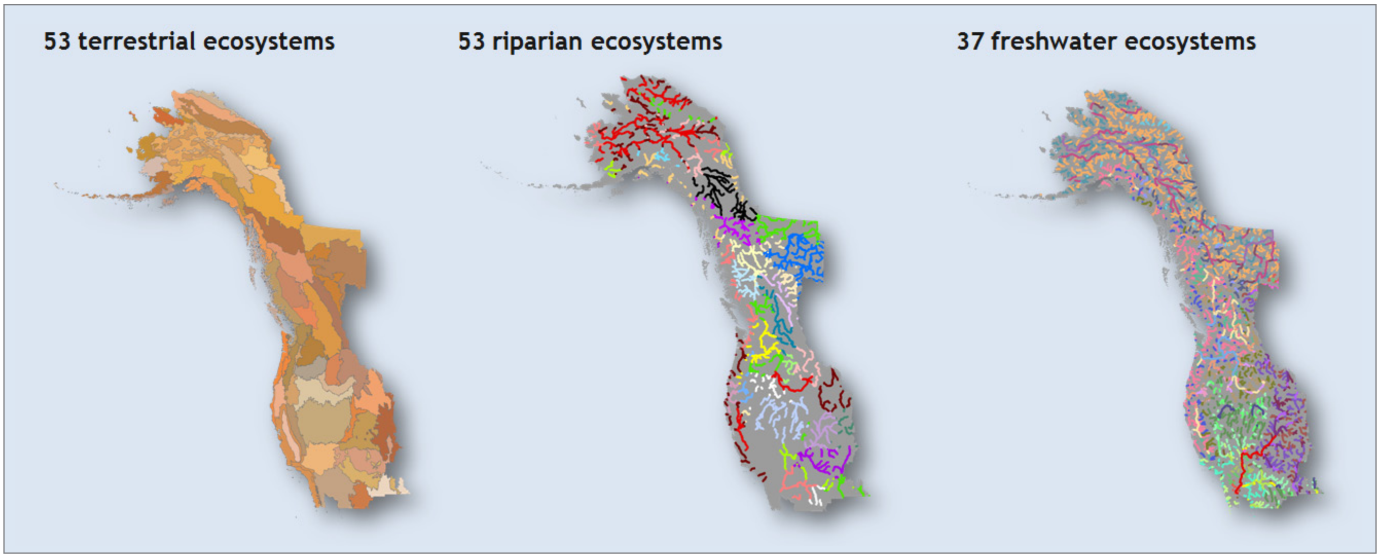


FIGURE 4 Ecosystems

Terrestrial ecosystems were defined based on the US EPA's Level III ecosystems.[2] Riparian ecosystems were defined by applying a half-kilometer buffer to rivers (Pfafstetter level 4 or larger) in each terrestrial ecosystem. Freshwater ecosystems were defined using a combination of WWF-defined freshwater biological regions and USGS data on stream gradient, size, and elevation (see details in Appendix 1.2). While these ecosystems are relatively detailed when comparig across the West, using smaller ecosystem boundaries would likely result in more below-target areas.

The integrity target for terrestrial and freshwater ecosystems was set at a baseline of 30% (Figure 5). In other words, each terrestrial and freshwater ecosystem should have a minimum level of protection equivalent to the protection afforded by placing 30% of the ecosystem's area into strict protected areas (again, subject to constraints on fragmentation and connectivity). This target was informed by published scientific studies of the rates at which species are lost to extinction as habitat area decreases. These species-area curve analyses suggest that for many ecosystems, conserving 30% of the total area in strict protected areas would be likely to protect healthy populations of most species.[3] This target is highly imperfect, but given the lack of a better alternative, and its common use by other planners, it serves as a useful baseline.[4] Given the importance of the targets in selecting regions and the amount of work required in those regions, exploring the implications of setting alternative targets could be a useful path for the Foundation to pursue.

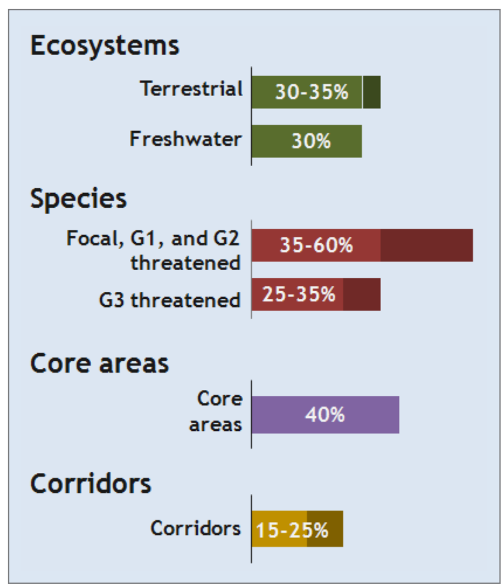


FIGURE 5 Ecological integrity targets

2 All ecosystems less than 10,000,000 acres (8 in total across the West) are clustered with their most ecologically similar neighbor.

3 Tear et al, 2005. "How Much is Enough? The Recurrent Problem of Setting Measurable Objectives in Conservation." *BioScience* 55:10.

4 Vander Schaaf et al, 2006. "Pacific Northwest Coast Ecoregion Assessment." Prepared by The Nature Conservancy, the Nature Conservancy of Canada, and the Washington Department of Fish and Wildlife.

These baseline targets were increased by up to 5% for ecosystems that may be particularly vulnerable to climate change impacts. For example, the target was increased for the Arctic Foothills terrestrial ecosystem, which is located at the northen tip of Alaska and is predicted to experience significant increases in temperature. The tool incorporates predicted changes in temperature and precipitation[5] and vegetation[6] to assess the possible climate change vulnerability of each ecosystem. (see details in Appendix 1.2.3). This consideration of climate impacts is a first approximation, since scientific understanding of climate vulnerability is still evolving.

In recognition of the important role of riparian habitats in the West, the riparian ecosystems mentioned earlier were given an additional target of 25% integrity (also increased by up to 5% based on possible vulnerability to climate change). This additional target was included to ensure that terrestrial conservation work placed an appropriate focus on riparian areas.

Species Inputs and Targets

Integrity targets were also set for individual species habitat, since some species may require specific protections within their ranges (in addition to ecosystem-level protection). The tool considered two sets of species: focal species and threatened and endangered species.

The focal species are 17 wide-ranging terrestrial and freshwater animals that are intended to serve as umbrella species for particular regions or habitat types, and/or demand specific protection because of their iconic nature (e.g., grizzly bear and Colorado cutthroat trout). The focal species include ten mammals, four birds, two fish groups, and one reptile ("herp"). The full list of focal species, which was based on expert input, and their range maps are provided in Appendix 1.3.1. Figure 6 shows the density of focal species throughout the study area.

Threatened and endangered species are vertebrate animals in the study area with the following global conservation statuses (as defined by NatureServe): critically imperiled (G1), imperiled (G2), or vulnerable to extirpation or extinction (G3)[7]. The terrestrial threatened and endangered species include 29 mammals, 57 amphibians and reptiles ("herps"), and 16 birds. Freshwater species include 100 fishes. The full list of threatened and endangered species is included in Appendix 1.3.2.

For both focal species and threatened and endangered species, occurrence data was collected from individual state Natural Heritage Programs and from NatureServe. Figure 6 shows the density of these species throughout the study area.

5 National Center for Atmospheric Research. 2007. "Community Climate System Model project." <http://www.gisclimatechange.org>. Accessed 19 September 2008. Note: the strategy planning tool used CCSM Model Run: Scenario A1B, Ensemble average 2000 to 2099.

6 Gonzalez, P., R.P. Neilson, and R.J. Drapek. "Climate Change Vegetation Shifts across Global Ecoregions." Ecological Society of America Annual Meeting Abstracts 90 (2005): 228.

7 http://www.natureserve.org/explorer/ranking.htm

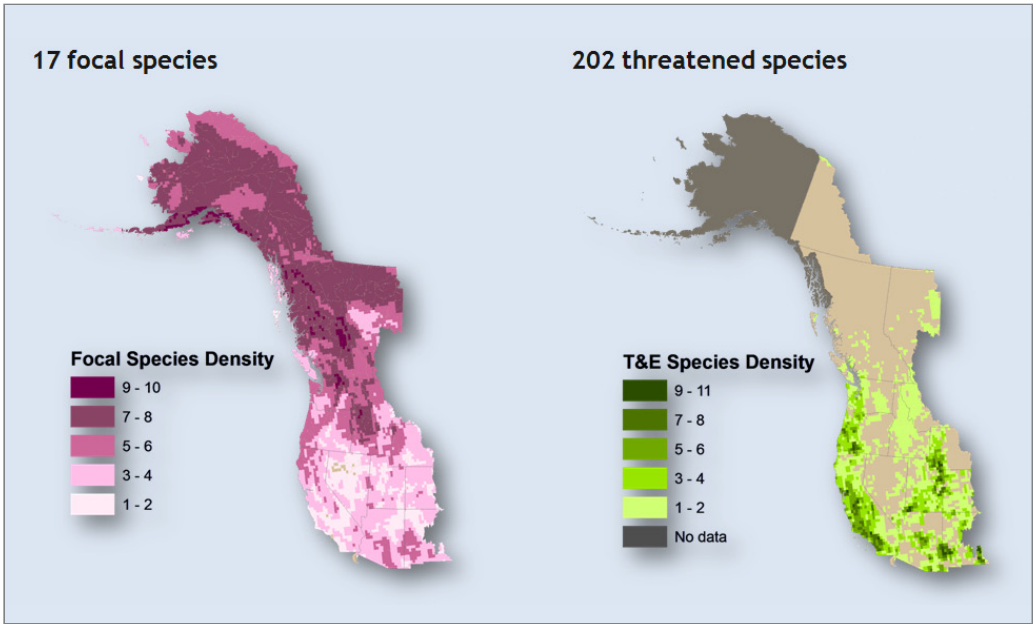


FIGURE 6 Species

Integrity targets for these species were set based on the best judgment of the Foundation and outside experts (Figure 5). For terrestrial species, all focal species and G1 and G2 threatened and endangered species were assigned an integrity target of 35% throughout their ranges. G3 terrestrial species were assigned an integrity target of 25%, representing their relatively lower (but still significant) level of threat. The one exception to these targets is the grizzly bear (a focal species), where experts suggested a target of 60% due to its high sensitivity to human disturbances.

Freshwater species targets were informed by a similar target-setting approach performed by The Nature Conservancy.[8,9] Integrity targets for all freshwater focal species and G1 and G2 threatened and endangered species were set at 60% throughout their ranges. G3 freshwater species targets were set at 35%. Freshwater targets were higher than terrestrial targets because of the higher sensitivity of freshwater species and because there was greater geographic specificity in the occurrence data for freshwater species than for terrestrial species.

Core Area Inputs and Targets

A set of core conservation areas was defined by selecting a subset of high-integrity national parks, wilderness areas, and inventoried roadless areas (Figure 7). These core areas are likely to be particularly important for species affected by even low levels of human use, such as grizzly bears. Since these areas are already relatively well-protected, specific integrity targets were not set for core

8 The Nature Conservancy. Colorado River Strategic Planning Effort. Completed June 2007.

9 Because of the analytical approach used by the strategy advisory tool, which extended The Nature Conservancy's model of the Colorado River region to cover the entire West, a relatively small number of freshwater species and ecosystems are identified as below-target. Increasing integrity targets or using a more localized unit of analysis (i.e., a smaller grid parcel size in the tool) would likely cause other freshwater ecosystems and species to be identified as below-target.

areas. However, more than 90% of core areas have integrity levels higher than 40%. These core areas will be monitored for new threats that could significantly degrade their currently high conservation value.

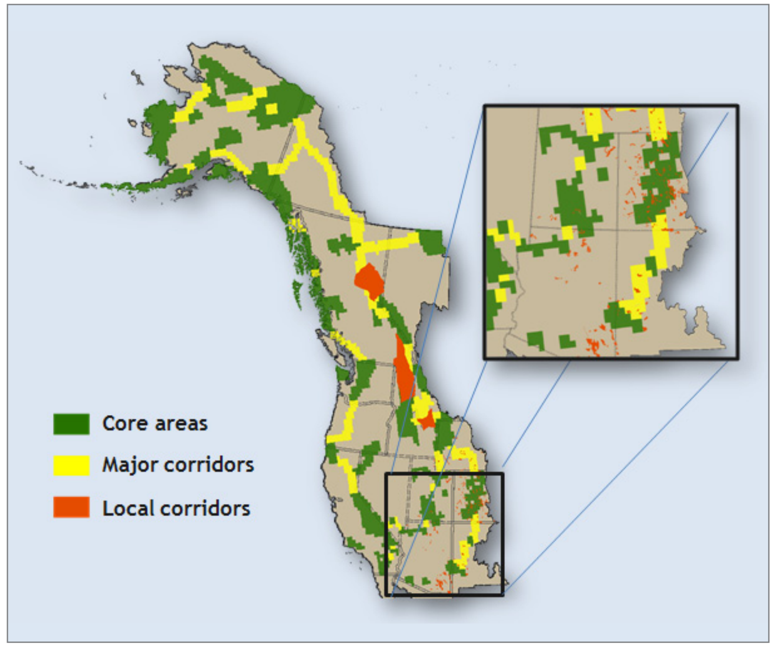


FIGURE 7 Core areas and corridors

Corridor Inputs and Targets

The tool also sought protection of corridors between core areas. Corridors allow for migrations of wide-ranging species, as well as longer-term shifts in species distributions in response to climate change and other global changes. Two types of corridors were defined: major corridors and local corridors. Protection targets were assigned separately for the two types (Figure 4).

Major corridors follow five main continental-scale ecological linkages: one near the Pacific Coast, one through the mountains in the middle of the continent, and three east-west linkages (one through the Canadian Boreal Forest, one in Alaska and the Northwest Territories, and one in the Southern Rockies).[10] The tool ensured connectedness along each of these major corridors by requiring a minimum 25 kilometer-wide (one grid parcel) corridor between core areas. Every individual parcel in the major corridors was required to have integrity equal to or greater than 25% (equivalent to the conservation value of BLM lands with moderate human use). This differs from the integrity-averaging approach applied for other targets in order to ensure that these long corridors provide essentially uninterrupted stretches of adequate habitat along their entire length.

Local corridors are intended to ensure protection for local migrations of wide-ranging animals.[11] Local corridors were assigned an integrity target of 15% (equivalent to the conservation value of agricultural land with no significant additional human uses). Local corridors were included for the intermountain West, where many large animals make seasonal migrations. Similar local corridor data were not readily available for other regions of the West.

As Wilcove and Turner point out in their review of this work, it is debatable as to how high a priority local corridors should receive given the lack of data, and the attention that big game species already receive from government agencies and other organizations.

Lastly, it may be worth including specific habitat for migratory birds, if reasonable data can be found. However, there is a question as to whether it is stop-over sites in the West, or wintering sites in the tropics.

10 These linkages are partly based on the continental-scale megalinkages proposed by the Wildlands Project and the Rewilding Institute.

11 Local corridors are based on the linkages developed by the Wild Utah Project and Southern Rockies Ecosystem Project.

3

WHAT CHANGES ARE NEEDED TO REACH THE GOAL?

THE TOOL SUGGESTS GEOGRAPHIC AREAS WHERE CHANGES CAN HELP achieve the Foundation's goal. Current integrity is estimated for ecosystems, species' ranges, core areas, and corridors through analysis of human uses. These integrity levels are then compared to the Foundation's targets to identify areas that can benefit from investments.

The goal for this part of the strategy planning tool was to identify ecosystems, species, core areas, or corridors that may not have sufficient levels of conservation protection. As explained in chapter 1, the tool is not intended to include a full-scale ecological model that identifies sites with a high level of spatial resolution. The goal is to find areas that may be particularly in need of conservation investment so that specific philanthropic investments can be suggested for these areas (as described in the next chapter). Foundation staff were involved throughout the development of this portion of the tool, evaluating the areas suggested by the tool and in some cases recommending changes when the areas suggested did not agree with their understanding of high-need areas in the West.

INTEGRITY ESTIMATES TAKE INTO ACCOUNT DIFFERENT LEVELS OF PROTECTION

The tool allows for different combinations of fully-protected and partially-protected landscapes to meet the integrity targets for each ecosystem, species, core area, and corridor. Relative conservation values are assigned to each parcel, and these values are averaged together for each ecosystem, species, core area, or corridor to estimate integrity (in this document, "conservation value" refers to individual parcels, while "integrity" refers the average of the conservation values of all parcels within a particular ecosystem, species, core area, or corridor). Thus, integrity is a percentage value that reflects the approximate level of protection relative to a perfectly-protected ecosystem, species' range, core area, or corridor.

This integrity-averaging approach has the advantage of accounting for the contributions of working lands and partially-protected landscapes. The approach is imprecise for several reasons. Scientific understanding of the exact conservation values of these lands is still being developed and the contributions of working and partially protected lands are different for different ecosystem components (e.g., agricultural fields may be just as good as nature reserves for some bird species, but may have relatively low habitat value for large, shy predators like grizzly bears). On average, however, the comparisons are valuable because they make it possible to consider different combinations of strict protected areas and working lands to meet the Foundation's ecological integrity goals. The Foundation relied on input from experts at conservation-focused NGOs to develop the best possible comparisons of different land types.

Another potential shortcoming of the integrity averaging approach is that it does not directly take into account habitat fragmentation. The Foundation addressed this issue by setting explicit targets for core areas and corridors (as explained in the previous chapter) and by clustering the investments suggested by the tool together into discrete regions (described in chapter 4).

Lastly, by applying the same methedology to assess the integrity of individual specieis' habitat as for the overall ecoystem, the tool is ignoring species-specific needs. While it would be unrealistic to include specific habitat characteristics for each species with over 200 species, there is some risk that the recommended investments either do not inclue the specific improvements necessary for an individual species, or are more extensive than what is needed for a particular species.

The rest of this chapter describes in detail how current integrity was assessed.

INTEGRITY IS ESTIMATED BASED ON INTENSITY OF HUMAN USES

Integrity was estimated through a three-step process (Figure 8). First, human use scores were assigned to each parcel based on the intensity of various human uses (e.g., oil and gas development, agriculture, municipal development). Second, each parcel's human use score was converted into a conservation value based on a "conservation value curve" that specified the approximate relative conservation values of lands with different levels of human use. Finally, the conservation values for each relevant parcel were averaged to estimate the integrity (i.e., overall level of protection) for each ecosystem, species range, core area, and corridor.

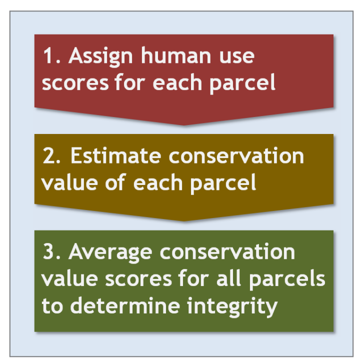


FIGURE 8 Process to estimate conservation values and integrity

1. Assigning Human Use Scores for Each Parcel

The first step, assigning human use scores, was accomplished using geographic data on the distributions of various human uses throughout the West. The conservation impacts of different human uses were estimated based on the best judgment of the Foundation staff and outside experts.

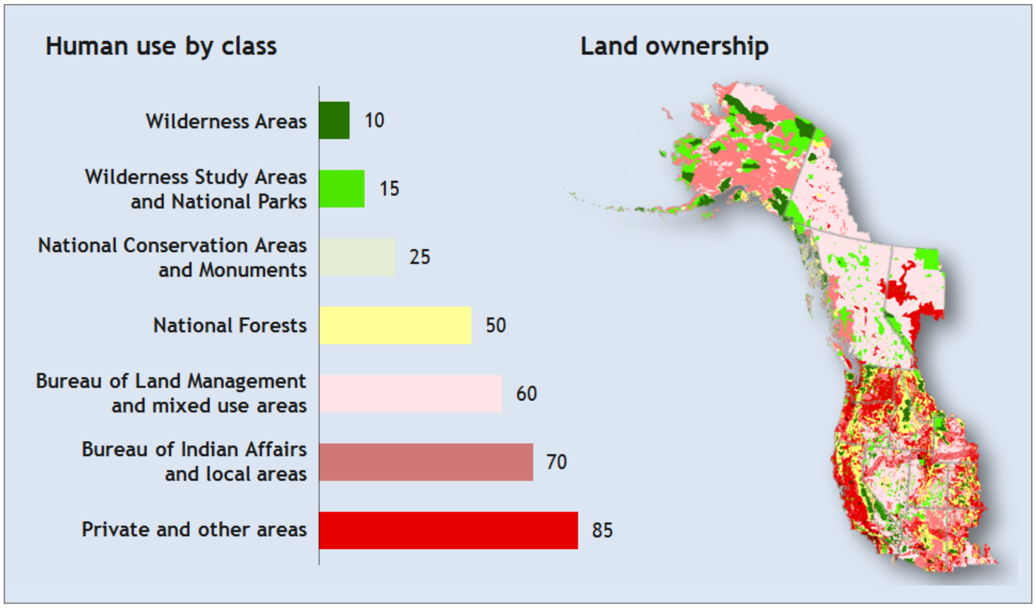


FIGURE 9 Land ownership human use scores

For terrestrial parcels (including riparian areas), ten human use factors were considered (Appendix 2.1). These impacts were weighted to reflect their relative importance to conservation. The most important terrestrial human use factor was land ownership class (Figure 9), which had a maximum score of 100. Land ownership class refers to the ownership and management regime applied to each parcel (e.g., national parks, national forests, private land). The rules associated with land ownership class determine the maximum amount of human use allowable on the land. For example, disturbance is heavily restricted in wilderness areas, while Bureau of Land Management lands are managed for multiple uses.

Seven major land ownership classes were identified.[12] The human use scores assigned to each ownership class were developed through a consensus exercise with ten experts from conservation NGOs, including The Wilderness Society, The Nature Conservancy, and Trout Unlimited. The low human use score assigned to wilderness areas represents a low level of alteration (i.e., a high level of protection), while the high human use score assigned to private lands represents a low level of protection.

In addition to land ownership, nine other terrestrial human use factors were considered. The majority of these uses were given maximum scores of 10, while a few of the less significant were given maximum scores of 5 or even 2.5. The specific score for each factor on each parcel depended on the intensity of the activity in the parcel. As an example, the derivation of human use scores for population growth is shown in Figure 10. Areas projected to have high future population growth were assigned a maximum use score of 10 to capture the effects of potential expanded urban development (areas with less than

12 These seven classes are a summary grouping of 54 individual land ownership types considered by the tool; see Appendix 2.1.1 for more details.

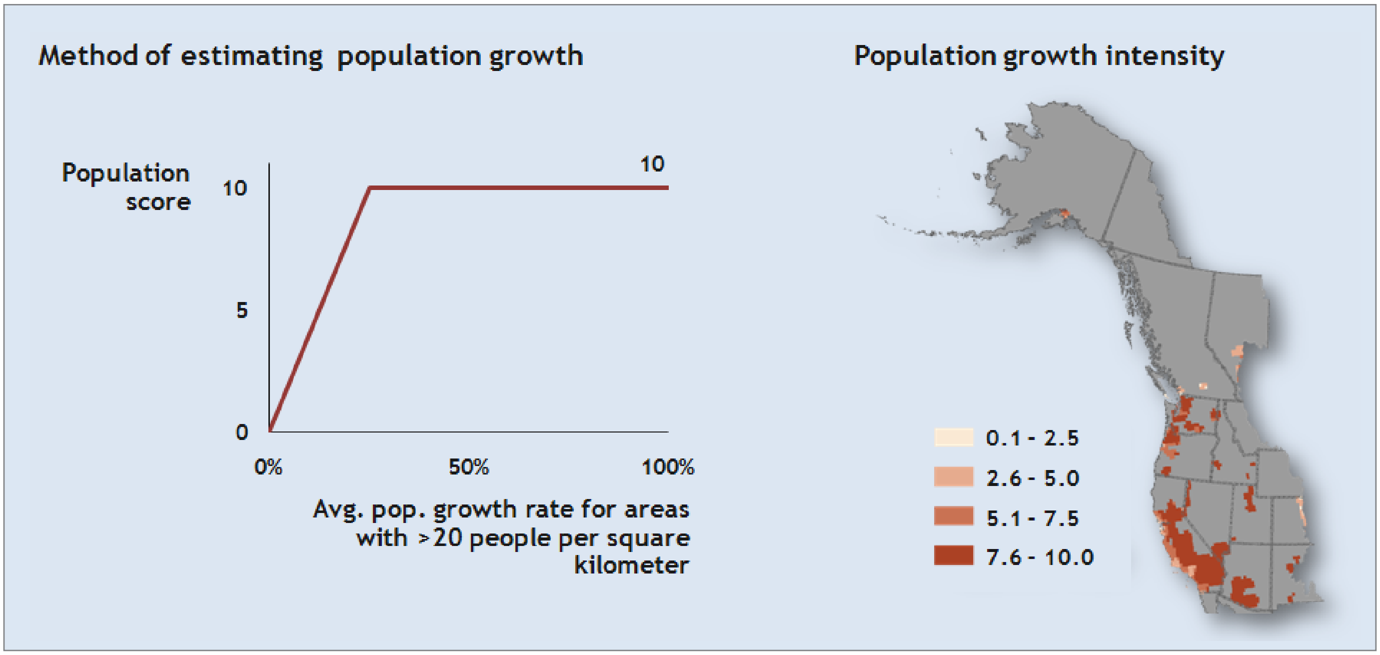


FIGURE 10 Population growth human use score

20 people per square kilometer were not assigned population growth scores regardless of projected growth rate). Population growth projections came from the individual states and provinces (see Appendix 2.1.2 for details). The full list of terrestrial human uses and the processes used to estimate scores are included in Appendix 2.1.

For freshwater parcels, nine human use factors were considered (see Appendix 2.2 for the full list). These are activities that consume water, disrupt the natural hydrograph, or affect water quality. Since rivers and streams are more affected by far-away human uses, such as dams and major pollution sources, than terrestrial systems, land ownership class is less important for freshwater systems. Therefore, land ownership was not included as a freshwater human use.

Total human uses were estimated for each parcel by adding the human use scores for all ten factors. While there is a theoretical risk that the high weight on land use could bias the results towards acquisition of private lands, the high cost associated with private land acquisition prevents this from happening. As it turns out, the cost estimates for private acquisition used in the tool are sufficiently high that it is generally an option of last resort.

2. Estimating the Conservation Value of Each Parcel

The second step, converting human use scores to conservation value scores, relied on non-linear conservation value curves. The purpose of the conservation value curves was to reflect the fact that incremental changes in human use have non-linear effects on the total conservation value of a given piece of land. Specifically, relatively intact habitats were assumed to be more degraded by additional human uses than habitats that were already highly degraded.

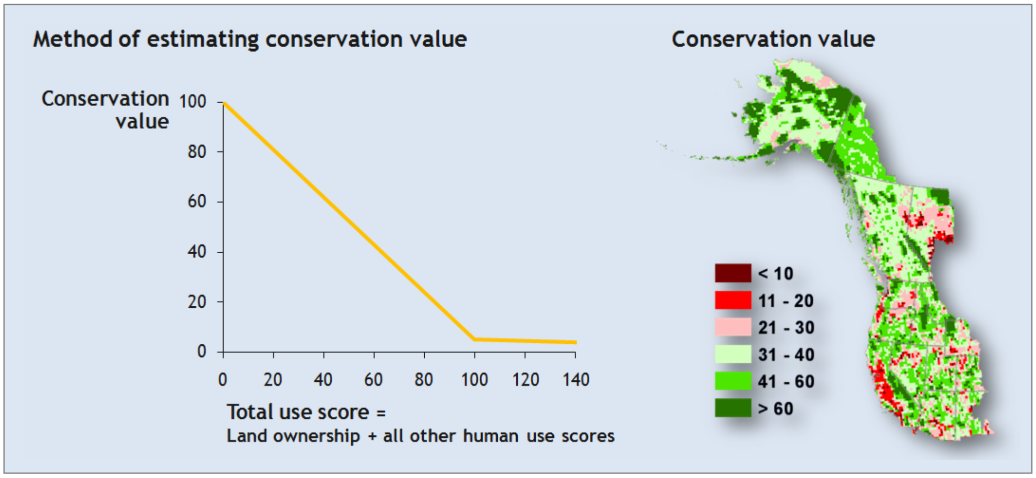


FIGURE 11 Terrestrial conversation value

Obviously, this simple assumption fails to capture some ecological dynamics (for example, well-preserved systems may be able to absorb some initial threat with little effect on integrity). However, practical computational constraints on the tool required a relatively simple integrity curve. Separate integrity curves were used for terrestrial and freshwater parcels. The differences in the curves reflect expert assessments that, while freshwater systems may be affected by a smaller number of human uses, the effects of each human use on conservation value may be greater than for terrestrial habitats.

On the conservation value curve, specific human use levels on the x-axis correspond to specific conservation value scores on the y-axis. Figure 11 shows the terrestrial conservation value curve and the estimated conservation value of each terrestrial parcel. Figure 12 shows the same information for freshwater parcels.

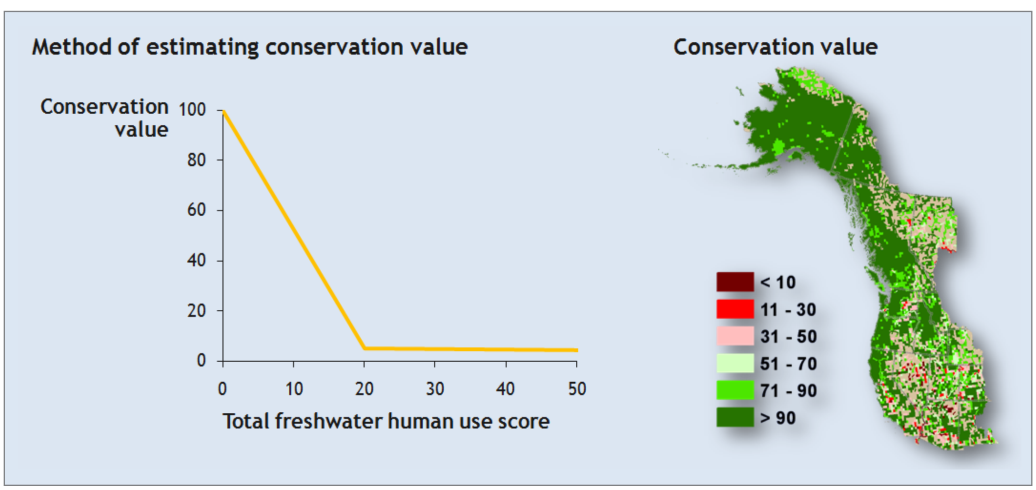


FIGURE 12 Freshwater conservation value

3. Averaging Conservation Values to Determine Integrity

The final step, where conservation values were averaged to estimate integrity values for individual ecosystems, species, core areas, and corridors, was carried out by calculating an area-weighted average of the conservation values of the individual parcels that make up each entity.

Figure 13 shows an example of the whole process for a specific ecosystem. The example ecosystem, the Ahklun and Kilbuck Mountains, is located in western Alaska. The ecosystem is home to the Togiak Wilderness Area and the southern portion of the Yukon Delta National Wildlife Refuge. Human uses are restricted to limited areas of roads and mining, so the human use scores for most parcels were relatively low. These low human use scores translated into high conservation values for the majority of the parcels in this ecosystem. When these parcels' conservation values were averaged together, the ecosystem received an integrity score of 60%, higher than its target of 34%. Therefore, according to the logic behind this tool, investment is not required to improve the overall conservation status of this ecosystem (although the Foundation may choose to work in this region for many other good reasons—for example, to take advantage of an opportunity to cheaply and quickly increase legal protection for Alaska state-owned lands).

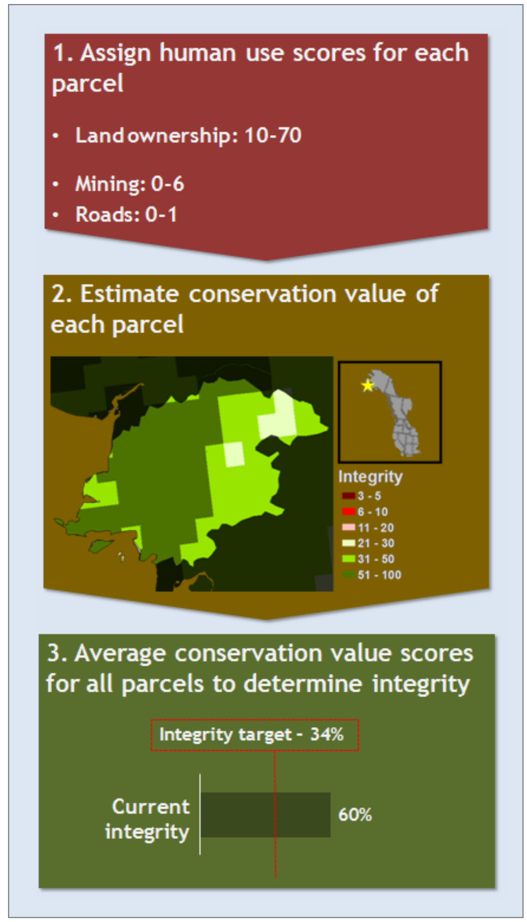


FIGURE 13 Integrity example: Ahklun and Kilbuck Mountains

4

HOW CAN THE FOUNDATION IMPROVE ECOLOGICAL INTEGRITY?

THE TOOL SUGGESTS SPECIFIC PHILANTHROPIC INVESTMENTS TO improve ecological integrity in areas that are below the Foundation's targets. The tool estimates expected returns (ERs) to compare the likelihood-adjusted cost-effectiveness of the possible investments.

The Foundation must choose from many different types of investments to achieve its goals in the West. The most important part of the tool is a rough comparison of the expected returns (ER) of different possible investments. ER estimates the approximate likelihood-adjusted cost-effectiveness of possible philanthropic investments. This ER estimation considered the potential benefits if investments were to succeed as planned, the likelihood that the investments would succeed, and the cost of the investments to the Foundation.

Once ER values were estimated, integer optimization was used to propose a strawman portfolio of investments that achieves the required improvements in integrity most cost-effectively. This output was used as a starting place for discussion among the Foundation staff. While selecting the actual portfolio of investments, Foundation staff then included real-world factors such as staff and grantee experience, conditions in the field, and other considerations not addressed by the simple strategy planning tool.

This chapter describes the investments considered, the process used to compare them, and a suggested portfolio of investments.

A NUMBER OF POSSIBLE INVESTMENTS ARE CONSIDERED

As a grantmaking foundation, the Hewlett Foundation achieves its aims by making investments in other organizations. Therefore, a main objective of the strategic planning process for the Foundation is to identify specific types of philanthropic investments that can drive change. Two major types of investments were considered in the tool: place-based work, and West-wide investments.

- **Place-based work** affects a relatively specific geography (a single parcel or a small group of parcels). Examples include purchasing agricultural water, changing management rules in a single BLM district or National Forest, or changing the management regime for a particular dam. Thirty-three possible place-based investments were considered, each of which could be applied in different geographies.

- **West-wide investments** are high-level investments that affect a broad area of the landscape (usually entire states/provinces or countries). Examples include educating policy makers and the public regarding specific state or federal policies, and supporting agency (e.g., BLM) management as it considers rules and practices at a national level. Twenty-four West-wide investments were considered. Note that West-wide investments can be related to legislation or legislative activity. In those cases, the Foundation supports public education, nonpartisan research and analysis and similar non-lobbying activities.

Table 1 includes a sample of place-based and West-wide investments, organized around land-, water-, and energy-related investments, as this is the framework that the Foundation uses to organize its investments.

EXPECTED RETURN (ER) ESTIMATES SUGGEST THE MOST EFFECTIVE INVESTMENTS

The tool sought the most cost-effective conservation strategies to achieve the overall Foundation goal using an expected return (ER) approach. ER is a method of cost-benefit estimate of the expected conservation improvement per dollar spent for potential investments. The basic equation behind ER multiplies the potential benefit of the investment by its rough likelihood of success (i.e. the expected benefit), and then divides by the probable cost, resulting in the expected benefit per dollar spent for a particular investment (Figure 14). The components of expected return are explained in more detail below.

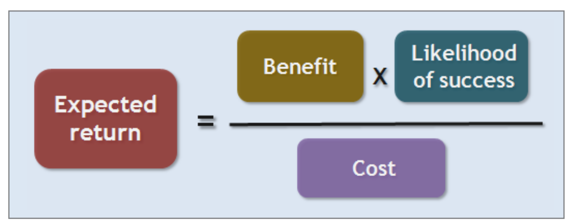


FIGURE 14 Components of expected return

- **Benefit:** Benefit is the progress towards the Foundation's overall goal that would be achieved if an investment were successful. In benefit estimates, both the number of acres with improved conservation value and the magnitude of improvement (i.e., the reduction in human use) were considered.

- **Likelihood of success:** Likelihood of success (LOS) is the approximate probability that an investment will achieve its stated goals. While some investments may have the potential for huge benefit, their success may not be guaranteed (for example, educating policy makers and the public related to national energy policy to restrict fossil fuel development). On the other hand, some investments with more moderate potential benefit are "safer" (for example, placing a conservation easement on a single large piece of land). Accounting for LOS allows the Foundation to compare the expected benefits of these different types of investments.

Type	Investment	Median Expected Return[13]	Total cost	Benefit (reduction in human impact)	LOS %
Land: West-wide	Educate policy makers and the public on the benefits of restoring full funding for the Land and Water Conservation Fund[14]	6,290	$5,000,000	40 for private non-urban, non-agriculture land use; 5 for agriculture, population, future urban development; 3 for roads, 2 for grazing, 1 for invasives and timber; applicable to a total of 0.6M possible acres of private non-agricultural lands where biodiversity targets are not being met	65%
Land: Place-based	Support improved planning and monitoring processes for a BLM district, including adaptive management	16,975	$500,000 + $2/acre	5 for BLM land use, 2 for all other terrestrial uses[15] and future urban development. Median BLM size was ~0.9M acres (ranging from <0.1 to 94M acres)	70%
Water: West-wide	Educate policy makers and the public on the benefits of linking ground and surface water use regulations to better manage groundwater use	1,515	$5,000,000 per state	1 for future urban development; 0.5 for freshwater agriculture; applicable just to river miles in Arizona	50%
Water: Place-based	Support improved management of an existing dam through re-operation or re-licensing	215	$5,000,000 per dam	5 for dam use	90%
Energy: West-wide	Pursue nonpartisan research and analysis to help define energy transmission corridors on public lands and streamline permitting for new facilities in order to promote renewables	106,535	$2,000,000	1 for BLM lands; 0.5 for oil and gas; applicable to a total of 10M possible acres of BLM lands with high wind or solar potential	60%
Energy: Place-based	Educate policy makers and the public on the benefits of strengthened rules for oil shale/ tar sands development in a BLM district	6,950	$800,000 + $2/acre	5 for BLM ownership, 5 for oil shale/tar sands. Median BLM size was ~0.6M acres (ranging from <0.1 to 2.2M acres)	70%

TABLE 1 Expected return examples

- Foundation of achieving a specific action or change. In some cases, the cost to Hewlett of a particular strategy may be less than the total cost. For example, increasing public funding for private lands by $1 billion has a total cost of $1 billion, but the cost to Hewlett is likely to be considerably lower.

13 Expected integrity-weighted improvement per dollar, sum of terrestrial and freshwater ER. Water interventions based on river miles normalized to be equivalent to acre-based interventions

14 Note that the Foundation does not expend funds or earmark its funding for prohibited attempts to influence legislation, but may engage in public education, nonpartisan research and analysis, or other permissible activities

15 Oil and gas, grazing, mining, agriculture, roads, invasive species, timber, oil shale, population

PUBLISHED RESEARCH AND EXPERT INPUT ARE USED TO ESTIMATE ER

The ER estimates relied on published scientific and socio-economic information as well as expert input. The published information and data used to create preliminary ER estimates for each intervention included GIS data, ecological studies, policy assessments, and NGO budgets and staffing plans.

Additionally, because published information was often highly specific to a given location or activity, the Foundation solicited the guidance of scientists and conservation experts in applying the information more broadly. Expert interviews were used to vet all initial assumptions. Eleven initial interviews were conducted near the beginning of the project. After reviewing the initial interview results, a more structured round of ER-specific interviews was carried out in the form of a two-stage Delphi process. In the first stage, at least one topic expert assessed the benefit, likelihood of success, and cost for a wide range of potential investments in each of these categories: public lands, private lands, freshwater and riparian areas, energy development, and lasting support. These assessments were then combined and presented to a group of West-wide experts, who reassessed the expected returns until there was general agreement within the group on the average expected returns of these investments.

The processes used to estimate each of the ER components are described below.

- **Benefit:** The number of acres improved by each investment was estimated using GIS data from various agencies and organizations. These data included the geographic distributions of human uses and conservation targets on the landscape. Thus, for example, it was possible to estimate the number of acres that would benefit from increasing the strictness of oil and gas development regulations in Utah.

  The magnitude of the improvement in conservation value from different investments was estimated based on scientific studies (e.g., the impacts of different intensities of oil and gas development on wildlife populations) and expert interviews.

- **Likelihood of success:** Likelihoods of success were estimated from 0% to 100% for each possible investment based on expert assessments. These "baseline" likelihoods of success were also varied by geographic region, to reflect the fact that some regions may be more welcoming of conservation than others. These regional adjustments were informed by expert interviews, but were also based on published data, particularly the scores for federal and state representatives provided by the League of Conservation Voters (LCV) in the US. LCV scores are based on an elected representative's voting record on conservation issues. To attempt to capture a wider perspective, LCV scores were averaged for each area's representatives during the 107^{th}, 108^{th}, and 109^{th} Congresses (2001–2007). A score of 100% represents a pro-conservation vote on every issue monitored by LCV. Because no comparable equivalent to LCV scores was available for Canada, likelihood of success was not varied by geography in Canada.

- **Cost:** Each investment was assigned either a cost per acre or a fixed cost, depending on the type of investment. For example, the cost to purchase land was estimated using cost per acre, while the cost to educate policy makers and the public regarding a state's instream flow policies was treated as a fixed cost. In both cases, the cost values assigned were based on a combination of research (e.g., examination of NGO staffing and budgets; historical land and easement prices) and expert interviews.

An example ER estimation for increasing grazing restrictions is provided in Figure 15. The specific investment is to educate land managers and support nonpartisan research and analysis on the effects of grazing in order to reduce or eliminate grazing on particularly ecologically valuable lands within a given BLM district or National Forest. The benefit of this investment was an eight-point (out of ten) reduction in the grazing impact intensity score on an example 1M acre parcel. The benefit was set at eight instead of ten because while this type of investment could greatly reduce grazing pressure, historical grazing impacts may mean that additional attention is required to fully restore the land. Because the investment is a relatively well-understood strategy, but one that may have some pushback in implementation, the baseline likelihood of success was set at 50%. However, as discussed, this baseline LOS was further adjusted by geography. The geographically-adjusted LOS for this investment ranged from 45% to 100% based on the receptiveness to conservation of the area under consideration (assessed roughly through LCV scores). Finally, the cost of $200 per acre was based on the approximate cost of buying out grazing rights. Specifically, the Multi-Use Conflict Resolution Act of 2005 proposed a payment of $175–220 per acre to grazing permittees who voluntarily relinquished their permits.[16] The resulting ER of the investment is shown in Figure 15.

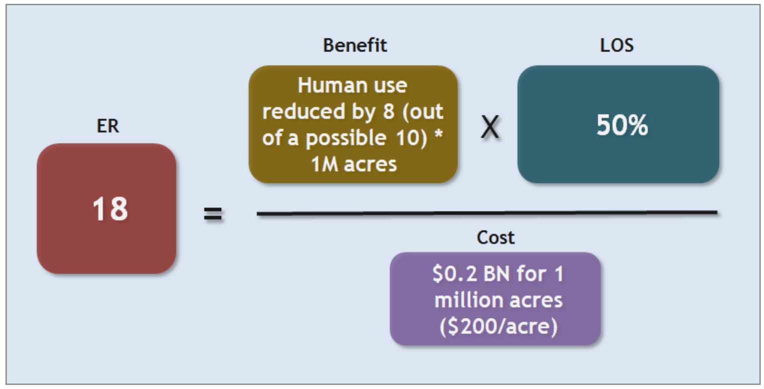


FIGURE 15 Example ER estimate: Grazing restrictions

In this document, ERs are reported as a range of values, representing the variation in ER for a single type of investment applied in different geographies or different situations (e.g., a place-based investment pursued in different BLM districts, or a West-wide investment pursued through different agencies or strategies).

INTEGER OPTIMIZATION IDENTIFIES A STRAWMAN PORTFOLIO OF INVESTMENTS

Once ER values were assigned to individual investments, integer optimization was used to identify a portfolio of investments. In each ecosystem, species'

16 Cost assumes 1–1.25 animal unit month (AUM) /acre, at $175 per AUM. Source: Public Lands Ranching. "Federal Livestock Grazing AUMs: B(u)y the Numbers." <http://www.publiclandsranching.org/htmlres/fs_buy_the_numbers.htm> Accessed September 2008.

range, core area, or corridor below the Foundation's targets, the optimization considered the possible investments relevant to that area, eventually building a portfolio of investments that could achieve all of the Foundation's goals while minimizing expected cost.

During the optimization, the tool attempted to aggregate investments geographically to decrease implementation costs and increase contiguity of protected areas. This was accomplished by assigning a "start-up cost" of $100,000 in each large watershed.[17] The initial investment assigned to each watershed was assessed this cost, but subsequent investments were not.

17 USGS HUC 4 watersheds were used for this step.

5

WHAT ARE THE RESULTS AND HOW WILL THEY BE USED?

THE TOOL SUGGESTS A MIX OF PLACE-BASED AND WEST-WIDE investments that are relatively stable with changes in assumptions. Beginning with this mix, the Foundation's investment decisions then incorporate internal discussion, expert input, and consultation with potential partner funders and grantees. The result is ambitious: it requires Hewlett to invest over many years and to partner with other funders and government entities.

The strategy planning tool suggestions are an important step in the Foundation's strategy planning process. By establishing clear goals and metrics and trading off between different investments, the tool has laid the groundwork for a more complete strategy development process. This chapter describes the straw-man portfolio suggested by the tool (and its sensitivity to changed assumptions) and also outlines the full strategy development process that will be informed by this work.

THE SUGGESTED STRAW-MAN PORTFOLIO RESULTS IN A MIX OF INVESTMENTS

The portfolio of investments suggested by the strategy planning tool to achieve the Foundation's goals is a mix of place-based and West-wide investments. Figure 16 shows the place-based work. In total, 75 place-based and 19 West-wide investments were recommended from a much longer list of possible investments. These results feed into the Program outcomes described in the strategic plan by aggregating the outcomes of individual activities, and accounting for overlaps in geographies.

Place-based work tended to cluster in well-defined regions because the tool sought to maximize environmental and cost efficiencies by combining place-based investments into contiguous areas when possible (Figure 16). Additionally, place-based investments that represented less than \$10,000 per parcel, \$10M for all work per region, or \$1M for targeted work per region[18] of required work were ignored in the portfolio of strategy suggestions in order to

18 Regions were defined manually by clustering together nearby areas of place-based work primarily based on watersheds.

focus the Foundation's work on the needs that were most significant at the scale of the entire West. Additionally, a proposed region of work in eastern Nevada was removed at the suggestion of Foundation staff and outside experts. The work was primarily for the benefit of only three freshwater species and carried a relatively high cost.

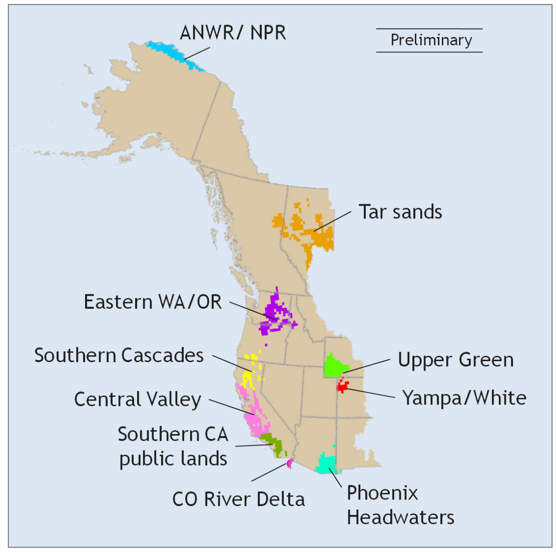


FIGURE 16 Place-based work

West-wide investments were suggested for 19 major issues related to land conservation policy, water use and riparian areas, and energy development. Some of these investments are at a federal level, while others are at the state-level (state-level investments were counted as one issue even if they are to be addressed in several states).

One result of the process followed is that the recommended activities tend to benefit areas that are degraded to some degree, rather than securing areas that are highly intact under a higher degree of protection. The tool can be tweaked to place greater emphasis on permanently securing intact lands if that becomes a greater priority for the Foundation.

One obvious implication is that protecting the ecological integrity of the entire West will require many years and the cooperation of multiple funders and government entities. Fortunately, partner funding seems likely to be available. The Foundation already shares significant co-funding with the Packard and Wyss Foundations, each of which contributes significant funding in the region, as well as the SeaChange, Wilburforce, Pew, Walton Family, and Rockefeller Brothers philanthropies. In addition, there are shared priorities with ClimateWorks around many of the energy-related investments in the West. While funding from other institutions does not overlap perfectly with Hewlett Foundation priorities, coordination is continuing to grow.

The costs described above include only the philanthropic costs to the Hewlett Foundation and other private funders. They exclude public costs, which are expected to be paid mostly by governments. For example, the policy development cost of encouraging full funding of the Land and Water Conservation Fund[19] is included, but the government cost to actually fund it, in the hundreds of millions of dollars per year, is excluded.

ASSUMPTIONS CAN AFFECT THE RESULTS, BUT THE STRATEGY IS LARGELY STABLE

While the Foundation sought to apply the best available science and expert knowledge in developing the strategy planning tool, the single set of suggested investments does not fully capture how various changes in the underlying assumptions could produce alternative results.

19 Note that the Foundation does not expend funds or earmark its funding for prohibited attempts to influence legislation, but may engage in public education, nonpartisan research and analysis, or other permissible activities

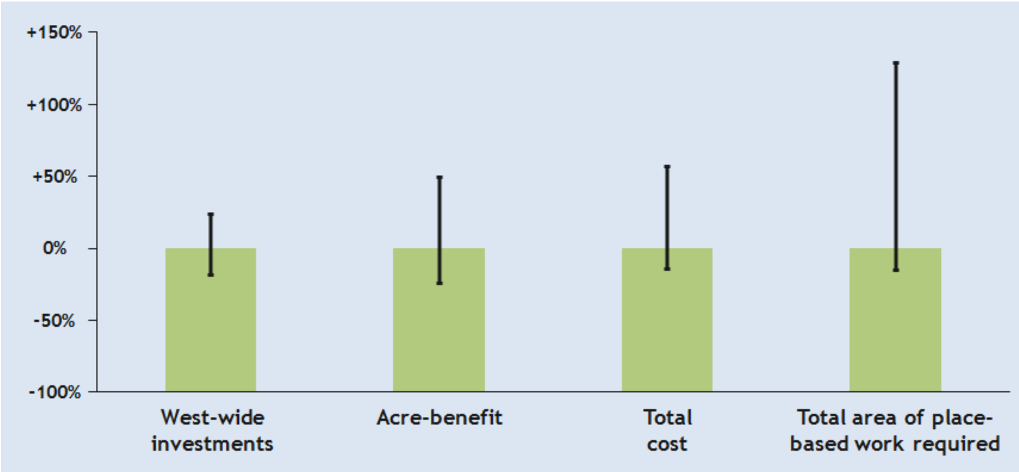


FIGURE 17 Variability of the suggested portfolio.
Maximum variation in all scenarios (black bars) vs. baseline scenario (green)

To gauge the effect of the model assumptions on the list of potential strategies suggested by the strategy planning tool, the Foundation performed a sensitivity analysis using nine scenarios, each of which varied certain assumptions of the tool (e.g., decreasing the assumed integrity of mixed-use public lands). These scenarios are described in Appendix 3.

For each scenario, the Foundation examined changes in four aspects of the advisory tool result. These four metrics were:

1. **Number of West-wide investments**[20]
2. **"Acre-benefit"** (the number of acres needing improvement throughout the West multiplied by the magnitude of the improvement required in each area)
3. **Total cost of the portfolio**[21]
4. **Total area of place-based work required**

Figure 17 shows the maximum variation in any scenario for each of these metrics. The most stable metric is the number of West-wide investments required to meet the Foundation's goals. Acre-benefit is also relatively stable.

The total cost of the strategy is also relatively stable as assumptions change. Depending on the assumptions used in the tool, the cost could be about 50% higher than the approximate value suggested by the tool. However, in seven of the nine scenarios examined, the cost varies less than 30%.

20 Investments for the same issue in multiple states are counted as one West-wide investment.

21 This metric excludes the cost of private land acquisition. Because of its large size relative to other costs, it dominates the comparisons between scenarios. The cost of private land acquisition shows a similar amount of variation.

While the total area of place-based work required varies significantly with changed assumptions, this generally reflects scenarios where there are more acres at lower cost.

The implication for the Foundation's work is that the tool's suggestions are stable enough to be used as a starting point for strategy development. The most important parts of the suggested portfolio—the investments that result in large integrity improvements—are stable. These investments are the ones that the Foundation would focus on in the next five years, since they drive the solution. Over time, additional areas needing small improvements in integrity can be identified with greater precision.

THE TOOL'S SUGGESTIONS ARE PART OF A MULTI-STEP PLANNING PROCESS

The straw-man portfolio provided by the strategy planning tool has served as a starting point in the Foundation's strategy development process. In order to convert these suggestions into a firm strategy for the West, and to identify a subset of that strategy to address in the next five years, the Foundation is engaged in a careful process of internal planning and external consultation and review (in addition to the external input that was included during the tool development process). These steps are summarized briefly below:

- **Internal planning:** In addition to active involvement and revision-making throughout the development of the tool, the Foundation's Environment Program staff continues to review the possible strategy suggestions produced by the tool. These discussions have already resulted in several changes to the strategy, including the possibility that some portion of the budget will be reserved for opportunistic investment in areas already above their ecological integrity goals.

- **External review and consultation:** 14 external experts were consulted during the development and application of the tool. Once the tool was developed, the Foundation shared the preliminary strategy suggestions with senior leaders at other foundations in the field. Additionally, the Foundation is conducting an expert review process to solicit feedback on the tool itself.

- **Board of Trustees input:** Foundation staff have reviewed the proposed plan with the Hewlett Foundation Board.

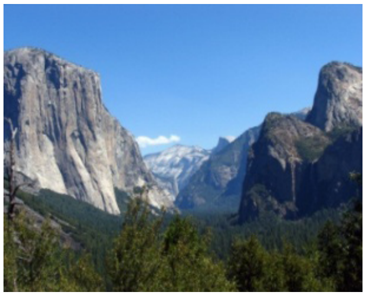
- **Consultations with additional partner foundations and major grantees:** The Foundation also plans to review its strategy with potential partner funders and major grantees (in addition to the many conversations that have already taken place during the tool's development). These discussions may be particularly important once the Foundation begins to implement its five-year strategy. The goal for these discussions will be to ground-truth possible strategies in specific places and seek alignment with the strategic priorities of other funders and organizations.

Finally, the tool generates a table of "irreplaceability" that allows program staff to pursue the next most attractive investment to achieve a specific goal if the tool's recommended investment is impractical. In practice, only a small number of investments in the straw man solution are relatively irreplaceable because existing alternatives have very high costs. For many investments, good alternatives exist, which provides program staff with substantial flexibility to deal with real world changes in feasibility or cost.

In summary, the Program's five-year plan is initially based on strategy planning tool results, but is (and will continue to be) adjusted for real-world conditions and subtle factors that are not captured by the tool.

6

HOW CAN THE FOUNDATION FURTHER IMPROVE THE TOOL?



THE TOOL HAS ALREADY BEEN SIGNIFICANTLY ENHANCED BASED ON a peer review. Changing needs and data will no doubt result in furthur opportunities for improvement. This final chapter lists four changes that are likely to be valuable over time.

Given the Foundation's changing needs, and changing data, there will be many opportunities to improve the tool over time. This chapter lists four such possible additions.

- **Incorporate more detailed data as it becomes available.** Several of the GIS datasets used inputs to the tool (e.g., land ownership, mining claims, and invasive species locations) that are imperfect or incomplete. While these datasets currently represent the best data that is available at a West-wide scale, including smaller locally-focused datasets and/or including new data as it becomes available could improve the tool.

- **Estimate interaction effects of investments.** Many of the possible investments that the Foundation could make will alter the potential benefit, cost, and LOS of other investments in later years. For example, funding an effort to support improved planning and monitoring processes for a BLM district could build capacity in a region that reduces the future costs and raises the future LOS of investments in the same region. The tool currently addresses this issue in a limited way by applying a start-up cost to the first investment in any region. These interactions could be addressed more comprehensively, although it would likely require a significant investment of time and funding to address these interaction effects comprehensively.

- **Improve the precision and geographic specificity of ER estimates by soliciting further expert input.** While this tool was developed based on input from some of the most knowledgeable and experienced experts on Western conservation, it is possible that further consultations could improve the estimates of the various components of expected return (benefit, LOS, cost). Additional interviews may be particularly useful for improving the geographic specificity of ER estimates.

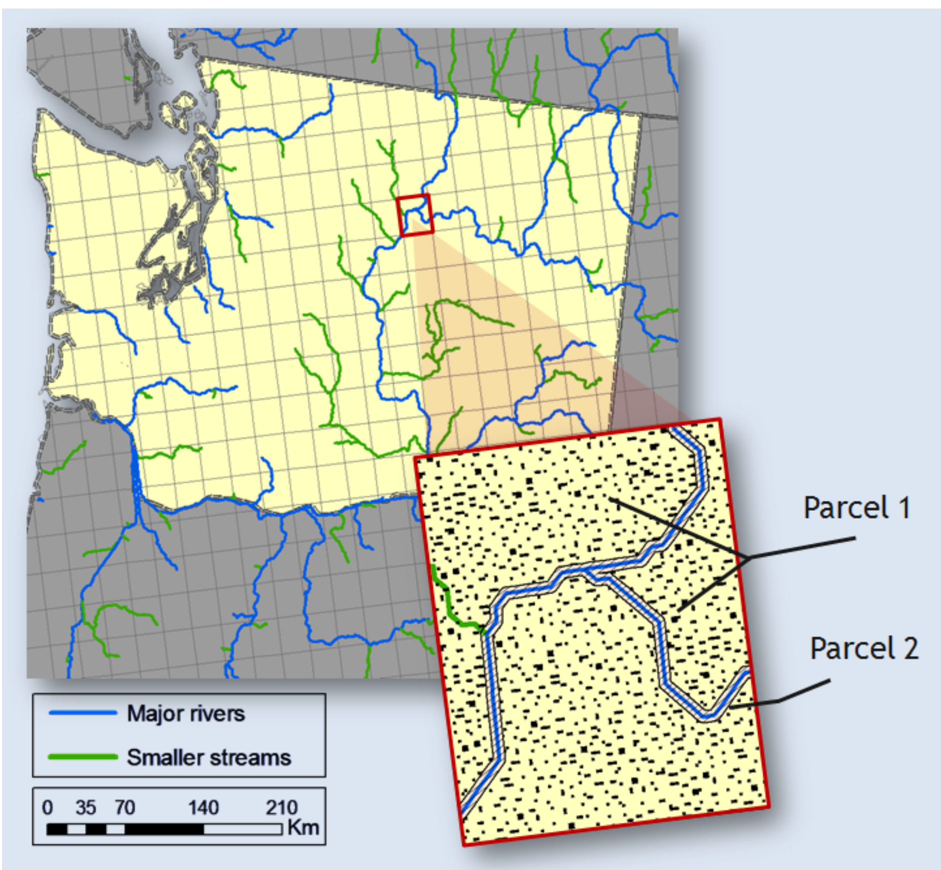
- **Explicitly consider changes over time in more key variables.** The tool currently incorporates forecasts of changes in climate and population density. Incorporating similar forecasts for changes in other key variables, such as land and easement prices, could improve the tool.

APPENDIX 1 PARCELS, ECOSYSTEMS, AND SPECIES

1.1 PARCELS

The study area was divided into approximately 12,000 "parcels." A roughly 25 x 32 kilometer rectangular grid was applied to the study area. All of the area in each grid cell that was not part of a major river or stream (stream segments in the USGS Hydro1K dataset with a Pfafstetter level of 4 or below) was treated as one parcel ("Parcel 1" in figure below). All of the major river and stream segments within each grid square were defined as one additional parcel ("Parcel 2" in figure below). Streams smaller than Pfafstetter level 4 were not assigned separate parcels. In the freshwater process, the small streams inside of each grid cell were addressed as a single unit.

Within each parcel, the actual area affected by different human uses (e.g., oil and gas development) and the area eligible to be affected by different investments (e.g., private land acquisition) were tracked in order to avoid overestimations of the different human use factors and investments.



Creation of parcels

1.2 ECOSYSTEMS

1.2.1 Terrestrial Targets and Current Integrity

The following table lists the integrity targets and current integrity for each of the 53 EPA level III ecosystems included in the tool[22]. Targets ranged from 30–35%, based on an ecosystem's possible vulnerability to climate change impacts (explained below).

Terrestrial Ecosystem	Target	Current integrity
Ahklun and Kilbuck Mountains	34%	60%
Alaska Peninsula Mountains	32%	65%
Alaska Range	34%	46%
Arctic Coastal Plain	35%	33%
Arctic Foothills	35%	41%
Arizona/New Mexico Mountains	30%	44%
Arizona/New Mexico Plateau	31%	35%
Blue Mountains	32%	40%
Bristol Bay-Nushagak Lowlands-Aleutian Islands	33%	50%
Brooks Range/Richardson Mountains	35%	68%
Canadian Rockies	33%	58%
Cascades	31%	51%
Central Basin and Range	32%	37%
Central California Valley	31%	15%
Chilcotin Ranges and Fraser Plateau	32%	41%
Clear Hills & Western Alberta Upland	32%	33%
Coast Range -Willamette Valley	31%	33%
Coastal Western Hemlock-Sitka Spruce Forests	32%	50%
Colorado Plateaus	32%	38%
Columbia Mountains/Northern Rockies	33%	41%
Columbia Plateau	31%	26%
Copper Plateau -Wrangell and St. Elias Mountains	33%	72%
Eastern Cascades Slopes & Foothills	31%	44%
Hay and Slave River Lowlands	32%	47%
Idaho Batholith	32%	59%
Interior Bottomlands-Yukon Flats	34%	54%
Interior Forested Lowlands & Uplands	34%	48%
Interior Highlands & Klondike Plateau	34%	47%
Klamath Mountains	31%	43%
Mackenzie and Selwyn Mountains	34%	29%
Madrean Archipelago	30%	31%
Mid-Boreal Uplands and Peace-Wabaska Lowlands	32%	50%
Middle Rockies	32%	46%
Mojave Basin and Range	31%	44%
Northern Basin and Range	31%	47%
Ogilvie Mountains	34%	53%
Pacific Coastal Mountains-Cook Inlet	33%	44%
Peel River and Nahanni Plateaus	33%	40%
Seward Peninsula	34%	52%
Sierra Nevada	31%	40%
Skeena-Omineca-Central Canadian Rocky Mountains	33%	34%
Snake River Plain	31%	33%
Sonoran Desert	31%	26%
Southern and Baja California Pine-Oak Mountains -California Coastal Sage, Chaparral, and Oak Woodlands	31%	41%
Southern Rockies	32%	37%
Strait of Georgia/Puget Lowland-Pacific and Nass Ranges	32%	61%
Subarctic Coastal Plains	34%	33%
Thompson-Okanogan Plateau	33%	40%

22 All Level III ecosystems under 10,000,000 acres (8 in total across the West) were clustered with their most ecologically similar neighbor.

Terrestrial Ecosystem	Target	Current integrity
Wasatch and Uinta Mountains	32%	42%
Watson Highlands	33%	29%
Wyoming Basin	32%	47%
Yukon-Stikine Highlands/Boreal Mountains and Plateaus	33%	47%

1.2.2 Riparian Targets and Current Integrity

Riparian ecosystems were defined by putting a 500 meter buffer on rivers (Pfafstetter level 4 or larger) in each terrestrial ecosystem. Targets ranged from 25–30%, based on an ecosystem's vulnerability to climate change impacts (explained below).

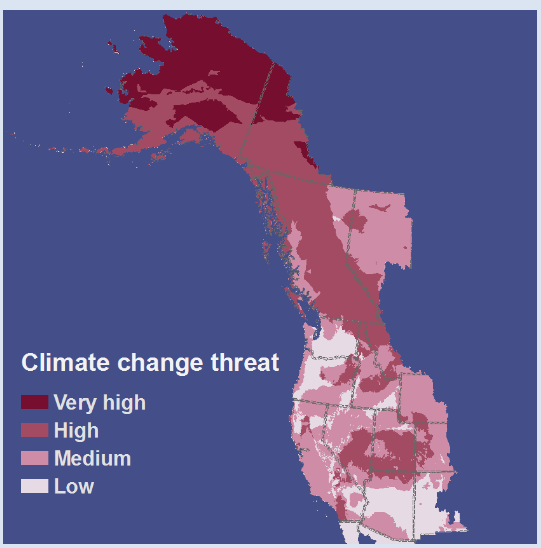
Terrestrial Ecosystem	Target	Current integrity
Ahklun and Kilbuck Mountains	29%	71%
Alaska Peninsula Mountains	27%	77%
Alaska Range	29%	34%
Arctic Coastal Plain	30%	30%
Arctic Foothills	30%	43%
Arizona/New Mexico Mountains	25%	48%
Arizona/New Mexico Plateau	26%	33%
Blue Mountains	27%	38%
Bristol Bay-Nushagak Lowlands-Aleutian Islands	28%	47%
Brooks Range/Richardson Mountains	30%	74%
Canadian Rockies	28%	50%
Cascades	26%	35%
Central Basin and Range	27%	27%
Central California Valley	26%	24%
Chilcotin Ranges and Fraser Plateau	27%	41%
Clear Hills & Western Alberta Upland	27%	32%
Coast Range -Willamette Valley	26%	19%
Coastal Western Hemlock-Sitka Spruce Forests	27%	80%
Colorado Plateaus	27%	35%
Columbia Mountains/Northern Rockies	28%	34%
Columbia Plateau	26%	26%
Copper Plateau -Wrangell and St. Elias Mountains	28%	56%
Eastern Cascades Slopes & Foothills	26%	38%
Hay and Slave River Lowlands	27%	48%
Idaho Batholith	27%	66%
Interior Bottomlands-Yukon Flats	29%	48%
Interior Forested Lowlands & Uplands	29%	47%
Interior Highlands & Klondike Plateau	29%	46%
Klamath Mountains	26%	40%
Mackenzie and Selwyn Mountains	29%	43%
Madrean Archipelago	25%	23%
Mid-Boreal Uplands and Peace-Wabaska Lowlands	27%	28%
Middle Rockies	27%	35%
Mojave Basin and Range	26%	40%
Northern Basin and Range	26%	40%
Ogilvie Mountains	29%	46%
Pacific Coastal Mountains-Cook Inlet	28%	42%
Peel River and Nahanni Plateaus	28%	51%
Seward Peninsula	29%	35%
Sierra Nevada	26%	42%
Skeena-Omineca-Central Canadian Rocky Mountains	28%	39%
Snake River Plain	26%	26%
Sonoran Desert	26%	20%
Southern and Baja California Pine-Oak Mountains -California Coastal Sage, Chaparral, and Oak Woodlands	26%	20%
Southern Rockies	27%	28%

Terrestrial Ecosystem	Target	Current integrity
Strait of Georgia/Puget Lowland-Pacific and Nass Ranges	27%	29%
Subarctic Coastal Plains	29%	56%
Thompson-Okanogan Plateau	28%	29%
Wasatch and Uinta Mountains	27%	27%
Watson Highlands	28%	42%
Wyoming Basin	27%	21%
Yukon-Stikine Highlands/Boreal Mountains and Plateaus	28%	54%

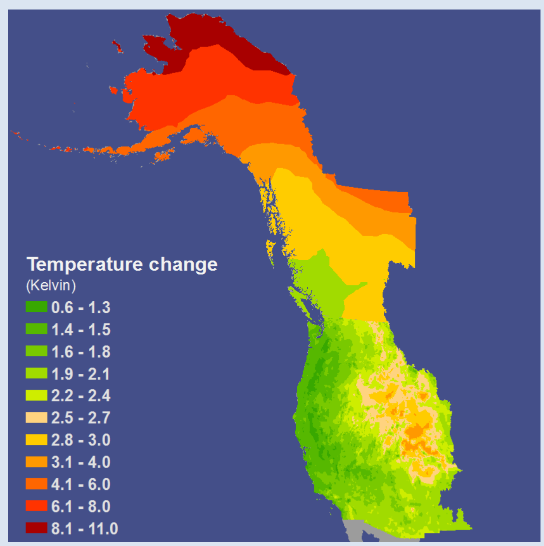
1.2.3 Climate Change Adjustments

Currently, the model incorporates NCAR forecasts (CCSM Model Run: Scenario A1B, Ensemble average 2000 to 2099[23]) of temperature and precipitation change and TNC forecasts of vegetation shifts.[24] This allows the model to direct work to areas considered most likely to change as climate varies. The Foundation recognizes that projections such as these are still evolving, and the Foundation's approach to climate adaptation should shift as the science improves.

Total climate change impact
is the sum of the three factors, weighted in the following way:
Temperature: 0.5, Precipitation: 0.25, Vegetation shift: 0.25



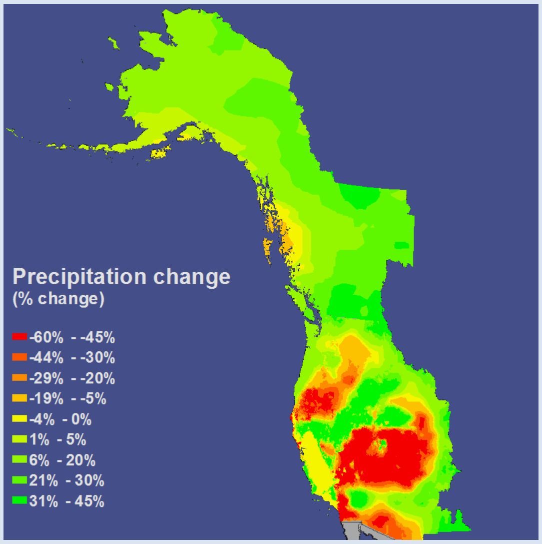
Temperature change
is estimated by taking the difference between the average predicted temperature in January between two time frames: 2000–2010 and 2090–2099



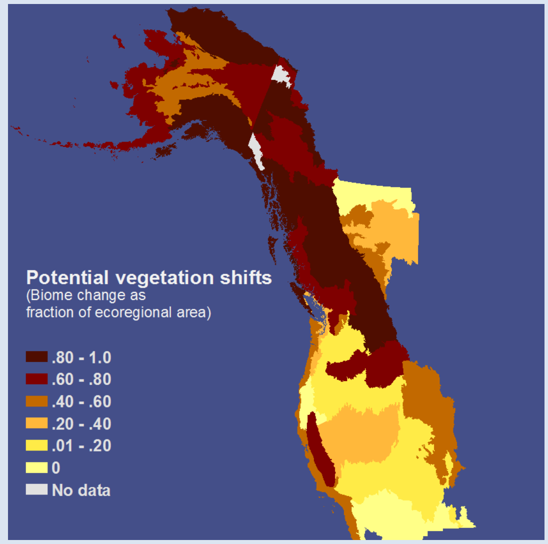
23 National Center for Atmospheric Research. 2007. "Community Climate System Model project." Accessed 19 September 2008. <http://www.gisclimatechange.org>.

24 Gonzalez, P., R.P. Neilson, and R.J. Drapek. "Climate Change Vegetation Shifts across Global Ecoregions." Ecological Society of America Annual Meeting Abstracts 90 (2005): 228.

Precipitation change
is the percent change between the average predicted precipitation in July for two time frames: 2000–2010 and 2090–2099



Potential vegetation shift
is the predicted biome change as fraction of ecosystem area between 1990 and 2100



1.2.4 Freshwater Targets and Current Integrity

The following table lists the integrity targets and current integrity for the 38 freshwater ecosystems:

Freshwater Ecosystem	Target	Current integrity
Arctic, high-flow, low-elevation, low-gradient	30%	95%
Arctic, med-flow, low-elevation, med-gradient	30%	89%
Arctic, med-flow, low-elevation, low-gradient	30%	92%
Arctic, low-flow, high-elevation, high-gradient	30%	97%
Arctic, low-flow, high-elevation, med-gradient	30%	96%
Arctic, low-flow, low-elevation, high-gradient	30%	95%
Arctic, low-flow, low-elevation, med-gradient	30%	93%
Arctic, low-flow, low-elevation, low-gradient	30%	93%
Endorheic/Xeric, med-flow, high-elevation, low-gradient	30%	62%
Endorheic/Xeric, med-flow, low-elevation, med-gradient	30%	43%
Endorheic/Xeric, med-flow, low-elevation, low-gradient	30%	47%
Endorheic/Xeric, low-flow, high-elevation, high-gradient	30%	78%
Endorheic/Xeric, low-flow, high-elevation, med-gradient	30%	67%
Endorheic/Xeric, low-flow, high-elevation, low-gradient	30%	75%
Endorheic/Xeric, low-flow, low-elevation, high-gradient	30%	76%
Endorheic/Xeric, low-flow, low-elevation, med-gradient	30%	79%

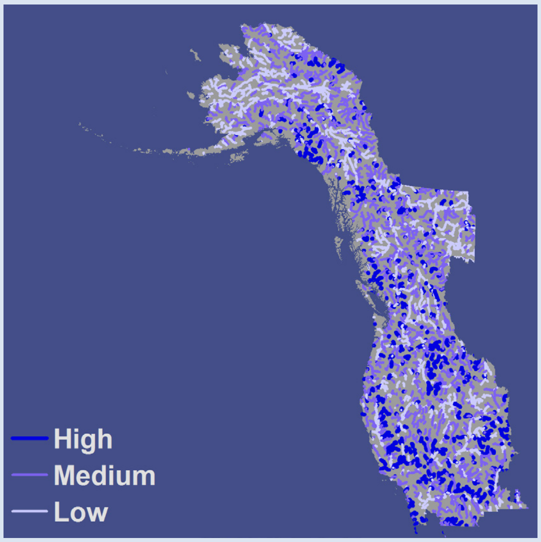
Freshwater Ecosystem	Target	Current integrity
Endorheic/Xeric, low-flow, low-elevation, low-gradient	30%	76%
Temperate Coastal, high-flow, low-elevation, low-gradient	30%	72%
Temperate Coastal, med-flow, high-elevation, med-gradient	30%	85%
Temperate Coastal, med-flow, low-elevation, med-gradient	30%	90%
Temperate Coastal, med-flow, low-elevation, low-gradient	30%	79%
Temperate Coastal, low-flow, high-elevation, high-gradient	30%	89%
Temperate Coastal, low-flow, high-elevation, med-gradient	30%	87%
Temperate Coastal, low-flow, high-elevation, low-gradient	30%	82%
Temperate Coastal, low-flow, low-elevation, high-gradient	30%	90%
Temperate Coastal, low-flow, low-elevation, med-gradient	30%	88%
Temperate Coastal, low-flow, low-elevation, low-gradient	30%	88%
Temperate, high-flow, low-elevation, low-gradient	30%	36%
Temperate, med-flow, high-elevation, med-gradient	30%	61%
Temperate, med-flow, high-elevation, low-gradient	30%	60%
Temperate, med-flow, low-elevation, low-gradient	30%	71%
Temperate, low-flow, high-elevation, high-gradient	30%	76%
Temperate, low-flow, high-elevation, med-gradient	30%	77%
Temperate, low-flow, high-elevation, low-gradient	30%	67%
Temperate, low-flow, low-elevation, high-gradient	30%	63%
Temperate, low-flow, low-elevation, med-gradient	30%	65%
Temperate, low-flow, low-elevation, low-gradient	30%	80%
Other	30%	73%

1.2.5 Creation of Freshwater Ecosystems

Freshwater ecosystems were created using four characteristics (based on an existing TNC approach):

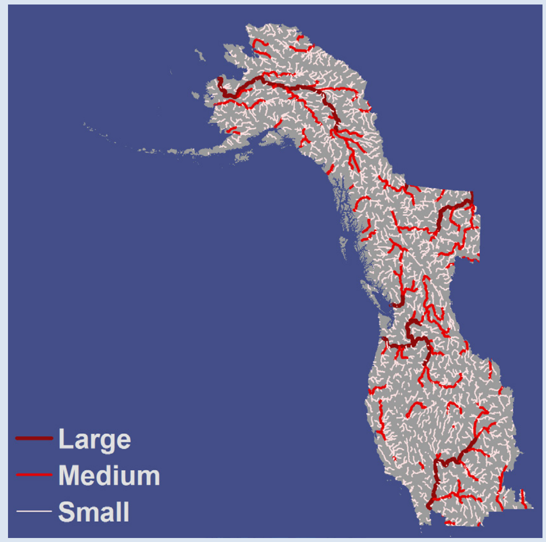
Gradient

Three classes based on USGS data[25] on short stream segments (beginning elevation–ending elevation, divided by length). Classes were defined as follows (units: m/m): High: .071-.006; Medium: .006-.002; Low: .002 -0.



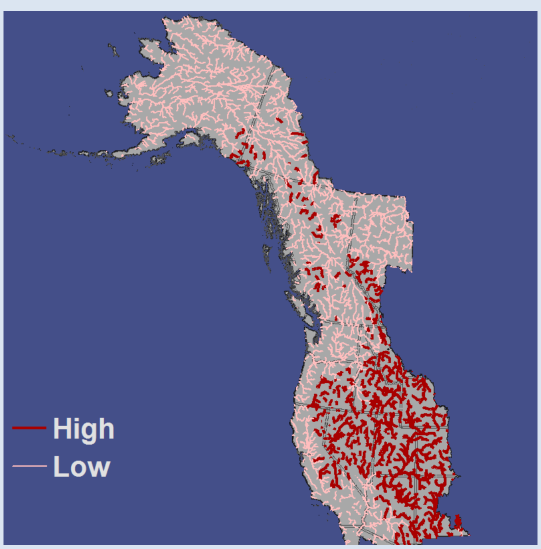
Size

Three classes based on USGS data on flow accumulation values, representing the upstream catchment area (in square kilometers). Ranges are as follows: Large: 1,350–175; Medium: 175–15; Small: 15–0.



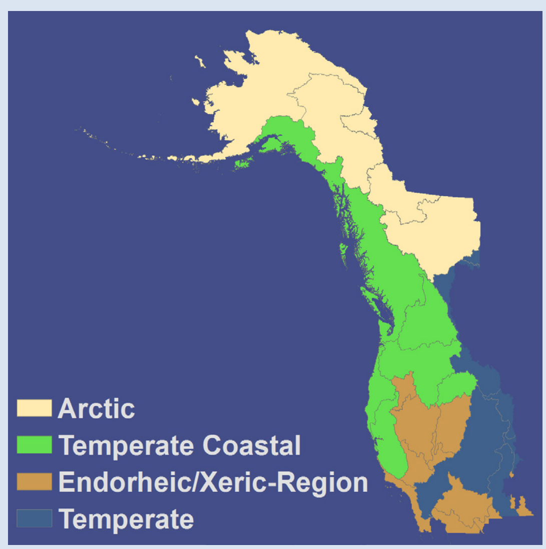
Elevation

Two classes based on USGS data (beginning elevation of the stream segment, in meters). Ranges are as follows: High: 2,800–1,000; Low: 1,000–0.



Major bio region

Four classes based on WWF's assessment[26] of the dynamics of freshwater ecological systems and patterns of species diversity.



25 "The North American HYDRO 1K dataset." US Geological Survey, 2000. <http://edc.usgs.gov/products/elevation/gtopo30/hydro/readme.html#DataLayers> Robin A. Abell, et al. Freshwater Ecoregions of North America: a Conservation Assessment. The World Wildlife Fund, 2000.

26 Robin A. Abell, et al. *Freshwater Ecoregions of North America: a Conservation Assessment*. The World Wildlife Fund, 2000.

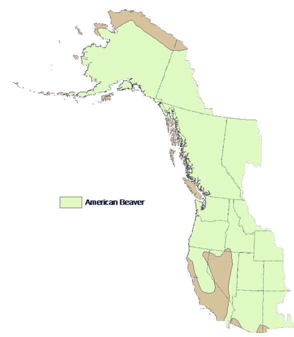
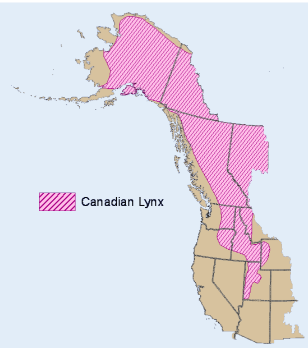
1.3 SPECIES

1.3.1 Focal Species

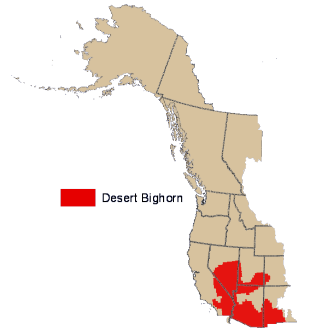
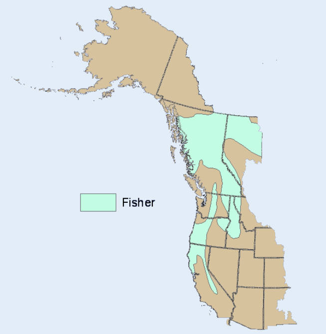
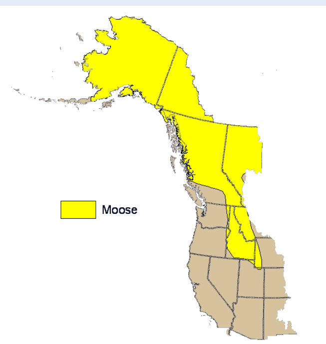
The focal species are 17 wide-ranging animals that may serve as umbrella species for particular regions or habitat types, and also demand specific protection because of their iconic nature.

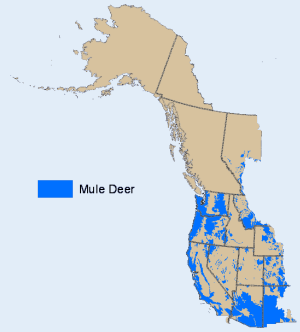
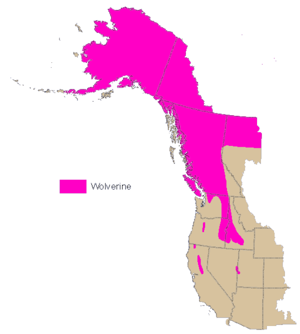
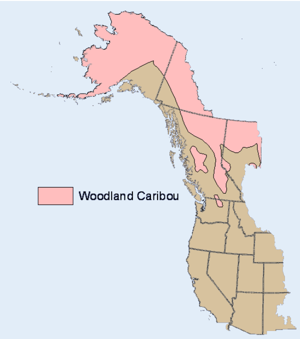
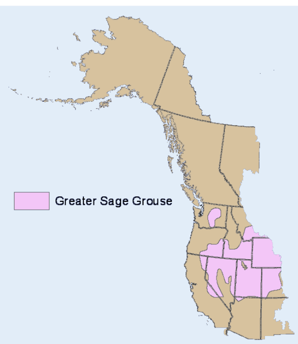
Characteristics used to select focal species include species with specialized habitat needs (whose habitat would therefore not be sufficiently protected under general ecosystem habitat protection), and to a lesser extent, species with extensive tracts, umbrella or indicator species, and iconic species. Focal species were also selected so that the full set would have a mix of types of species (mammals, birds, herps, fish) with a greater focus on mammals, and that the combined ranges of all the focal species generally covers all of the West.

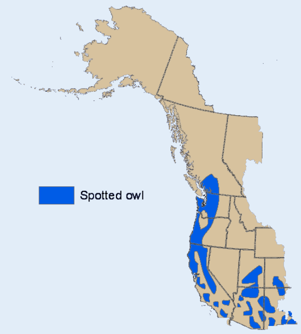
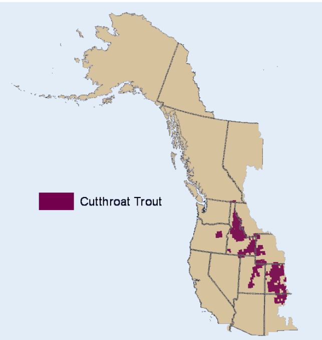
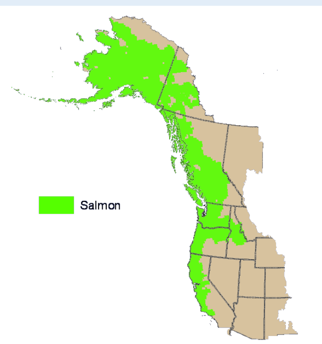
Using these criteria, the Foundation, in combination with peer feedback, selected 17 focal species (ten mammals, four birds, two fish groups, and one herp). The focal species are listed below:

Type	Common name	Scientific name	Notes	Range[27]
Mammal	American beaver	*Castor canadensis*	Links to riparian areas, critical status as a keystone engineer, specialized habitat, extensive tracts, vulnerable to climate change	
Mammal	Canadian Lynx	*Lynx Canadensis*	Extensive tracts, iconic	

27 NatureServe 2009 via http://www.natureserve.org/explorer. **Mammals:** Patterson, B.D., G. Ceballos, W. Sechrest, M.F. Tognelli, T. Brooks, L. Luna, P. Ortega, I. Salazar, and B.E. Young. 2003. Digital Distribution Maps of the Mammals of the Western Hemisphere, version 3.0. NatureServe, Arlington, Virginia, USA. **Birds:** Ridgely, R.S., T.F. Allnutt, T. Brooks, D.K. McNicol, D.W. Mehlman, B.E. Young, and J.R. Zook. 2003. Digital Distribution Maps of the Birds of the Western Hemisphere, version 3.0. NatureServe, Arlington, Virginia, USA. **Amphibians:** IUCN, Conservation International, and NatureServe. 2004. Global Amphibian Assessment. IUCN, Conservation International, and NatureServe, Washington, DC and Arlington, Virginia, USA.

Type	Common name	Scientific name	Notes	Range
Mammal	Desert Bighorn	*Ovis canadensis nelsoni*	Specialized habitat, extensive tracts, iconic	
Mammal	Fisher	*Martes pennanti*	Extensive tracts, iconic	
Mammal	Gray Wolf	*Canis lupus*	Extensive tracts, iconic	
Mammal	Grizzly Bear	*Ursus arctos*	Extensive tracts, iconic, concentrated range restricted to non-urban, high integrity areas	
Mammal	Moose	*Alces americanus*	Extensive tracts, iconic	

Type	Common name	Scientific name	Notes	Range
Mammal	Mule deer	*Odocoileus hemionus*	Extensive tracts	
Mammal	Wolverine	*Gulo gulo*	Specialized habitat, extensive tracts, iconic	
Mammal	Woodland caribou	*Rangifer tarandus caribou*	Represent tundra and taiga well, are iconic, require very large tracts, and are vulnerable to external stressors	
Bird	Common eider	*Somateria mollissima*	Fish and Wildlife Service focal migratory, specialized habitat	
Bird	Greater Sage Grouse	*Centrocercus urophasianus*	Specialized habitat, umbrella species, iconic	

Type	Common name	Scientific name	Notes	Range
Bird	Marbled murrelet	*Brachyramphus marmoratus*	Specialized habitat	
Bird	Spotted owl	*Strix occidentalis*	Species of common conservation concern, specialized habitat, umbrella species	
Herp	Desert Tortoise	*Gopherus agassizii*	Specialized habitat	
Fish	Cutthroat Trout: 5 subspecies (Colorado River, Greenback, Rio Grande, Westslope, Yellowstone)	*Oncorhynchus clarkii pleuriticus et al (O. clarkii stomias, O. clarkii virginalis, O. clarkii lewisi, O. clarkii bouvieri)*	Specialized habitat	
Fish	Salmon: 5 species (Chinook, Chum, Coho, Pink, Sockeye)	*Oncorhynchus tshawytscha et al (O. keta, O. kisutch, O. kisutch, O. gorbuscha, O. nerka)*	Specialized habitat, extensive tracts	

1.3.2 Threatened and Endangered Species

The table below lists all of the threatened and endangered species considered by the tool.

Rank	Common name	Scientific name	Taxonomic group
G1	California Condor	*Gymnogyps californianus*	Bird
G1	Gunnison Sage Grouse	*Centrocercus minimus*	Bird
G1	Whooping Crane	*Grus americana*	Bird
G1	Bear Lake Sculpin	*Cottus extensus*	Fish
G1	Bear Lake Whitefish	*Prosopium abyssicola*	Fish
G1	Bonneville Cisco	*Prosopium gemmifer*	Fish
G1	Bonneville Whitefish	*Prosopium spilonotus*	Fish
G1	Bonytail Chub	*Gila elegans*	Fish
G1	Borax Lake Chub	*Gila boraxobius*	Fish
G1	Chihuahua Chub	*Gila nigrescens*	Fish
G1	Colorado Pikeminnow	*Ptychocheilus lucius*	Fish
G1	Cowichan Lake Lamprey	*Lampetra macrostoma*	Fish
G1	Cui-Ui	*Chasmistes cujus*	Fish
G1	Cultus Pygmy Sculpin	*Cottus sp. 2*	Fish
G1	Delta Smelt	*Hypomesus transpacificus*	Fish
G1	Desert Dace	*Eremichthys acros*	Fish
G1	Desert Pupfish	*Cyprinodon macularius*	Fish
G1	Devils Hole Pupfish	*Cyprinodon diabolis*	Fish
G1	Enos Lake Benthic Stickleback	*Gasterosteus sp. 3*	Fish
G1	Enos Lake Limnetic Stickleback	*Gasterosteus sp. 2*	Fish
G1	Giant Black Stickleback	*Gasterosteus sp. 1*	Fish
G1	Humpback Chub	*Gila cypha*	Fish
G1	June Sucker	*Chasmistes liorus*	Fish
G1	Kern Brook Lamprey	*Lampetra hubbsi*	Fish
G1	Least Chub	*Iotichthys phlegethontis*	Fish
G1	Leatherside Chub	*Lepidomeda copei*	Fish
G1	Little Colorado Spinedace	*Lepidomeda vittata*	Fish
G1	Lost River Sucker	*Deltistes luxatus*	Fish
G1	Miller Lake Lamprey	*Lampetra minima*	Fish
G1	Moapa Dace	*Moapa coriacea*	Fish
G1	Modoc Sucker	*Catostomus microps*	Fish
G1	Owens Pupfish	*Cyprinodon radiosus*	Fish
G1	Paxton Lake Benthic Stickleback	*Gasterosteus sp. 5*	Fish
G1	Paxton Lake Limnetic Stickleback	*Gasterosteus sp. 4*	Fish

Rank	Common name	Scientific name	Taxonomic group
G1	Pecos Pupfish	*Cyprinodon pecosensis*	Fish
G1	Pygmy Longfin Smelt	*Spirinchus sp. 1*	Fish
G1	Quitobaquito Desert Pupfish	*Cyprinodon eremus*	Fish
G1	Razorback Sucker	*Xyrauchen texanus*	Fish
G1	Rio Grande Silvery Minnow	*Hybognathus amarus*	Fish
G1	Salish Sucker	*Catostomus sp. 4*	Fish
G1	Santa Ana Sucker	*Catostomus santaanae*	Fish
G1	Shortnose Sucker	*Chasmistes brevirostris*	Fish
G1	Vananda Creek Benthic Stickleback	*Gasterosteus sp. 17*	Fish
G1	Vananda Creek Limnetic Stickleback	*Gasterosteus sp. 16*	Fish
G1	Virgin River Chub	*Gila seminuda*	Fish
G1	Wall Canyon Sucker	*Catostomus sp. 1*	Fish
G1	Warner Sucker	*Catostomus warnerensis*	Fish
G1	White River Sculpin	*Cottus sp. 3*	Fish
G1	White River Spinedace	*Lepidomeda albivallis*	Fish
G1	White Sands Pupfish	*Cyprinodon tularosa*	Fish
G1	Woundfin	*Plagopterus argentissimus*	Fish
G1	Yaqui Chub	*Gila purpurea*	Fish
G1	Black Toad	*Bufo exsul*	Herp
G1	Blunt-Nosed Leopard Lizard	*Gambelia sila*	Herp
G1	Breckenridge Mountain Slender Salamander	*Batrachoseps sp. 1*	Herp
G1	Coachella Valley Fringe-Toed Lizard	*Uma inornata*	Herp
G1	Island Night Lizard	*Xantusia riversiana*	Herp
G1	Kings River Slender Salamander	*Batrachoseps regius*	Herp
G1	Limestone Salamander	*Hydromantes brunus*	Herp
G1	Owens Valley Web-Toed Salamander (Aka Oak Creek Salamander)	*Hydromantes sp. 1*	Herp
G1	Panamint Alligator Lizard	*Elgaria panamintina*	Herp
G1	Ramsey Canyon Leopard Frog	*Lithobates subaquavocalis*	Herp
G1	Relict Leopard Frog	*Rana onca*	Herp
G1	Scott Bar Salamander	*Plethodon asupak*	Herp
G1	Shasta Salamander	*Hydromantes shastae*	Herp
G1	Sierra Madre Yellow-Legged Frog	*Rana muscosa*	Herp
G1	Sierra Nevada Yellow-Legged Frog	*Rana sierrae*	Herp

Rank	Common name	Scientific name	Taxonomic group
G1	Black-Footed Ferret	*Mustela nigripes*	Mammal
G1	Guadalupe Fur-Seal	*Arctocephalus townsendi*	Mammal
G1	Salt-Marsh Harvest Mouse	*Reithrodontomys raviventris*	Mammal
G1	Utah Prairie-Dog	*Cynomys parvidens*	Mammal
G1	Vancouver Island Marmot	*Marmota vancouverensis*	Mammal
G2	Ashy Storm-Petrel	*Oceanodroma homochroa*	Bird
G2	Mountain Plover	*Charadrius montanus*	Bird
G2	Sparsely Flowered Jewelflower	*Streptanthus sparsiflorus*	Bird
G2	Tricolored Blackbird	*Agelaius tricolor*	Bird
G2	Alvord Chub	*Gila alvordensis*	Fish
G2	Arkansas River Shiner	*Notropis girardi*	Fish
G2	Arroyo Chub	*Gila orcuttii*	Fish
G2	Beautiful Shiner	*Cyprinella formosa*	Fish
G2	Gila Chub	*Gila intermedia*	Fish
G2	Headwater Chub	*Gila nigra*	Fish
G2	Little Colorado Sucker	*Catostomus sp. 3*	Fish
G2	Loach Minnow	*Tiaroga cobitis*	Fish
G2	Modoc Sucker	*Catostomus microps*	Fish
G2	Oregon Chub	*Oregonichthys crameri*	Fish
G2	Pecos Gambusia	*Gambusia nobilis*	Fish
G2	Railroad Valley Springfish	*Crenichthys nevadae*	Fish
G2	Relict Dace	*Relictus solitarius*	Fish
G2	Rough Sculpin	*Cottus asperrimus*	Fish
G2	Sacramento Splittail	*Pogonichthys macrolepidotus*	Fish
G2	Shoshone Sculpin	*Cottus greenei*	Fish
G2	Sonora Chub	*Gila ditaenia*	Fish
G2	Southern Leatherside Chub	*Lepidomeda aliciae*	Fish
G2	Spikedace	*Meda fulgida*	Fish
G2	Umpqua Chub	*Oregonichthys kalawatseti*	Fish
G2	Wood River Sculpin	*Cottus leiopomus*	Fish
G2	Yaqui Catfish	*Ictalurus pricei*	Fish
G2	Amargosa Toad	*Bufo nelsoni*	Herp
G2	Arizona Striped Whiptail	*Aspidoscelis arizonae*	Herp
G2	Arroyo Toad	*Bufo californicus*	Herp
G2	California Tiger Salamander	*Ambystoma californiense*	Herp
G2	Giant Garter Snake	*Thamnophis gigas*	Herp
G2	Inyo Mountains Slender Salamander	*Batrachoseps campi*	Herp
G2	Jemez Mountains Salamander	*Plethodon neomexicanus*	Herp

Rank	Common name	Scientific name	Taxonomic group
G2	Kern Canyon Slender Salamander	*Batrachoseps simatus*	Herp
G2	Kern Slender Salamander	*Batrachoseps robustus*	Herp
G2	Oregon Slender Salamander	*Batrachoseps wrightorum*	Herp
G2	Oregon Spotted Frog	*Rana pretiosa*	Herp
G2	Relictual Slender Salamander	*Batrachoseps relictus*	Herp
G2	San Gabriel Mtns Slender Salamander	*Batrachoseps gabrieli*	Herp
G2	Sand Dune Lizard	*Sceloporus arenicolus*	Herp
G2	Siskiyou Mountains Salamander	*Plethodon stormi*	Herp
G2	Tehachapi Slender Salamander	*Batrachoseps stebbinsi*	Herp
G2	Triploid Colorado Checkered Whiptail	*Aspidoscelis neotesselata*	Herp
G2	Yosemite Toad	*Bufo canorus*	Herp
G2	Giant Kangaroo Rat	*Dipodomys ingens*	Mammal
G2	Keen's Myotis	*Myotis keenii*	Mammal
G2	Mohave Ground Squirrel	*Spermophilus mohavensis*	Mammal
G2	Mount Lyell Shrew	*Sorex lyelli*	Mammal
G2	Nelson's Antelope Squirrel	*Ammospermophilus nelsoni*	Mammal
G2	Palmer's Chipmunk	*Neotamias palmeri*	Mammal
G2	Stephens' Kangaroo Rat	*Dipodomys stephensi*	Mammal
G2	Washington Ground Squirrel	*Spermophilus washingtoni*	Mammal
G2	Wyoming Pocket Gopher	*Thomomys clusius*	Mammal
G3	Abert's Towhee	*Pipilo aberti*	Bird
G3	American White Pelican	*Pelecanus erythrorhynchos*	Bird
G3	Eared Quetzal	*Euptilotis neoxenus*	Bird
G3	Le Conte's Thrasher	*Toxostoma lecontei*	Bird
G3	Lesser Prairie-Chicken	*Tympanuchus pallidicinctus*	Bird
G3	Marbled Murrelet	*Brachyramphus marmoratus*	Bird
G3	Piping Plover	*Charadrius melodus*	Bird
G3	Plain-Capped Starthroat	*Heliomaster constantii*	Bird
G3	Spotted Owl	*Strix occidentalis*	Bird
G3	Arkansas Darter	*Etheostoma cragini*	Fish
G3	Blue Chub	*Gila coerulea*	Fish
G3	Blue Sucker	*Cycleptus elongatus*	Fish
G3	Bull Trout	*Salvelinus confluentus*	Fish
G3	Desert Sucker	*Catostomus clarkii*	Fish
G3	Desert Sucker	*Catostomus clarki*	Fish
G3	Flannelmouth Sucker	*Catostomus latipinnis*	Fish
G3	Gila Topminnow	*Poeciliopsis occidentalis*	Fish

Rank	Common name	Scientific name	Taxonomic group
G3	Gila Trout	*Oncorhynchus gilae*	Fish
G3	Green Sturgeon	*Acipenser medirostris*	Fish
G3	Greenthroat Darter	*Etheostoma lepidum*	Fish
G3	Hardhead	*Mylopharodon conocephalus*	Fish
G3	Headwater Catfish	*Ictalurus lupus*	Fish
G3	Klamath Lake Sculpin	*Cottus princeps*	Fish
G3	Klamath Largescale Sucker	*Catostomus snyderi*	Fish
G3	Margined Sculpin	*Cottus marginatus*	Fish
G3	Mexican Stoneroller	*Campostoma ornatum*	Fish
G3	Nooksack Dace	*Rhinichthys sp. 4*	Fish
G3	Olympic Mudminnow	*Novumbra hubbsi*	Fish
G3	Owens Sucker	*Catostomus fumeiventris*	Fish
G3	Pit-Klamath Brook Lamprey	*Lampetra lethophaga*	Fish
G3	Rio Grande Chub	*Gila pandora*	Fish
G3	Rio Grande Shiner	*Notropis jemezanus*	Fish
G3	Rio Grande Sucker	*Catostomus plebeius*	Fish
G3	Roundtail Chub	*Gila robusta*	Fish
G3	Sacramento Perch	*Archoplites interruptus*	Fish
G3	Shortjaw Cisco	*Coregonus zenithicus*	Fish
G3	Slender Sculpin	*Cottus tenuis*	Fish
G3	Sonora Sucker	*Catostomus insignis*	Fish
G3	Tidewater Goby	*Eucyclogobius newberryi*	Fish
G3	Umpqua Dace	*Rhinichthys evermanni*	Fish
G3	Arizona Night Lizard	*Xantusia arizonae*	Herp
G3	Bezy's Night Lizard	*Xantusia bezyi*	Herp
G3	Big Bend Slider	*Trachemys gaigeae*	Herp
G3	Cascade Torrent Salamander	*Rhyacotriton cascadae*	Herp
G3	Cascades Frog	*Rana cascadae*	Herp
G3	Chiricahua Leopard Frog	*Lithobates chiricahuensis*	Herp
G3	Chiricahua Leopard Frog	*Rana chiricahuensis*	Herp
G3	Clouded Salamander	*Aneides ferreus*	Herp
G3	Colorado Desert Fringe-Toed Lizard	*Uma notata*	Herp
G3	Cope's Giant Salamander	*Dicamptodon copei*	Herp
G3	Flat-Tailed Horned Lizard	*Phrynosoma mcallii*	Herp
G3	Foothill Yellow-Legged Frog	*Rana boylii*	Herp
G3	Gray-Checkered Whiptail	*Cnemidophorus dixoni*	Herp
G3	Idaho Giant Salamander	*Dicamptodon aterrimus*	Herp
G3	Larch Mountain Salamander	*Plethodon larselli*	Herp

Rank	Common name	Scientific name	Taxonomic group
G3	Mount Lyell Salamander	*Hydromantes platycephalus*	Herp
G3	Sacramento Mountain Salamander	*Aneides hardii*	Herp
G3	Southern Torrent Salamander	*Rhyacotriton variegatus*	Herp
G3	Southwestern Toad	*Bufo microscaphus*	Herp
G3	Tarahumara Frog	*Rana tarahumarae*	Herp
G3	Two-Striped Garter Snake	*Thamnophis hammondii*	Herp
G3	Van Dyke's Salamander	*Plethodon vandykei*	Herp
G3	Western Pond Turtle	*Actinemys marmorata*	Herp
G3	Western Spadefoot	*Spea hammondii*	Herp
G3	Yuman Desert Fringe-Toed Lizard	*Uma rufopunctata*	Herp
G3	Allen's Big-Eared Bat	*Idionycteris phyllotis*	Mammal
G3	Arizona Shrew	*Sorex arizonae*	Mammal
G3	Black-Tailed Prairie Dog	*Cynomys ludovicianus*	Mammal
G3	Desert Pocket Gopher	*Geomys arenarius*	Mammal
G3	Gray-Footed Chipmunk	*Tamias canipes*	Mammal
G3	Inyo Shrew	*Sorex tenellus*	Mammal
G3	Jaguar	*Panthera onca*	Mammal
G3	Mexican Long-Nosed Bat	*Leptonycteris nivalis*	Mammal
G3	Northern Fur-Seal	*Callorhinus ursinus*	Mammal
G3	Northern Sea Lion	*Eumetopias jubatus*	Mammal
G3	Occult Myotis	*Myotis occultus*	Mammal
G3	Polar Bear	*Ursus maritimus*	Mammal
G3	Sonoma Tree Vole	*Arborimus pomo*	Mammal
G3	Swift Fox	*Vulpes velox*	Mammal
G3	White-Footed Vole	*Arborimus albipes*	Mammal

APPENDIX 2 HUMAN USE INPUTS AND ASSUMPTIONS

This appendix describes the formula used to estimate each human use factor and shows a map of the study area highlighting its severity.

2.1 TERRESTRIAL HUMAN USE FACTORS

The various human uses below can protect land and preserve its integrity, or degrade its integrity based on the intensity of each use. The range of intensity scores for each human use reflects the weight placed on that human use in the tool (e.g., a maximum possible score of 10 reflects a higher weighting than a maximum possible score of 5).

2.1.1 Land Ownership Class

(Range 10–85) Based on who owns the land (e.g. BLM, FS, private) and the type of management of that land (e.g. wilderness area, wilderness study area, public domain lands, private lands). In total there are 54 types of land management categorized into seven ownership classes. These categories are based on comparative analysis and expert interviews.

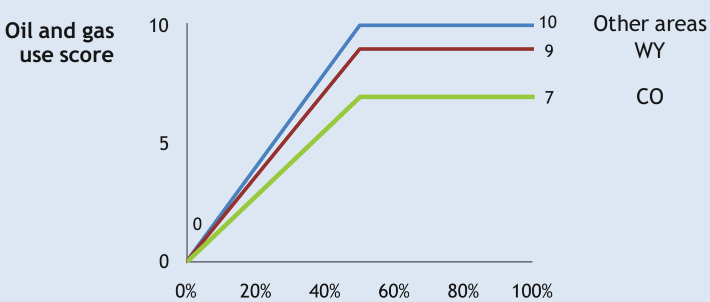
Ownership class	Specific land ownership/management
Wilderness areas	• BLM Wilderness Areas • FS Wilderness Areas • FWS Wilderness Areas • NPS Wilderness Areas • Wilderness Areas in Canada
Wilderness Study Areas and National Parks	• BLM Wilderness Study Areas • FS Wilderness Study Areas • FWS Wilderness Study Areas • FWS National Wildlife Refuges • FWS Wildlife Management Areas • NPS areas • NPS National Parks • NPS National Wild and Scenic Rivers • NPS Wilderness Study Areas • State parks • National parks and Wilderness Study Areas in Canada

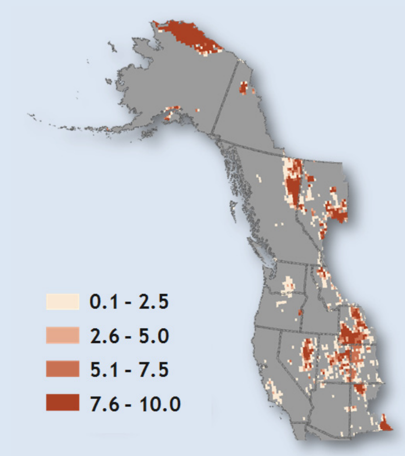
Ownership class	Specific land ownership/management
National Conservation Areas and Monuments	• BLM Forest Reserves • BLM National Conservation Areas • BLM National Monuments • FS National Monuments • FS National Scenic Areas • NPS National Monuments • NPS National Preserves • NPS National Reserves • Private conservation • Navajo-owned high sensitivity lands • Navajo-owned biological preserves • National monuments and conservation areas in Canada
National Forests	• FWS lands • FWS National Fish Hatcheries • FS lands • FS National Forests • FS National Recreation Areas • Fish and wildlife areas in Canada
BLM mixed use areas	• BLM lands • BLM National Recreation Areas • Bureau of Recreation lands • Department of Defense lands • Non-government organization lands • NPS National Memorials • NPS National Recreation Areas • NPS National Seashores • Recreation Areas • Navajo-owned moderate sensitivity lands • Navajo-owned recreational areas
BIA and local areas	• BIA lands • Indian reservations in Canada • Navajo-owned low sensitivity lands • Locally owned lands (e.g., City, County, State-owned lands)
Private and other areas	• Privately owned lands. Note that agricultural were assigned a lower private use score (80), and urban areas were assigned a higher private use score (95) • Department of Energy lands • USDA lands • Navajo-owned community development lands • Other (e.g., water)

2.1.2 Other Human Use Factors

Oil and gas

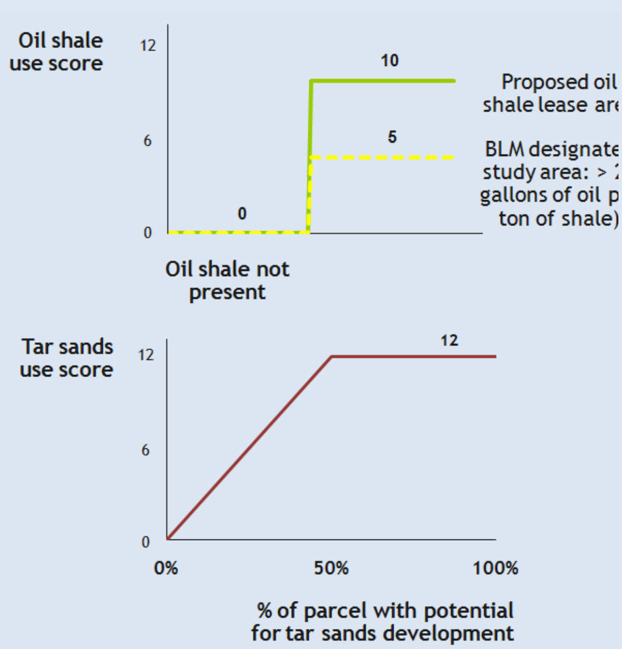
(Range 0–10) Based on oil and gas lease coverage (% land covered by authorized lease areas). Canadian areas were estimated based on number of wells per 3 square meters (1 well/3km2 = intensity of 10), and National Petroleum Reserve Alaska areas were considered level 10 intensity areas. Colorado and Wyoming were assigned lower maximum use scores because oil and gas operations are more restricted in these states (i.e., an acre of oil and gas development in Colorado is more controlled than the same acre in Utah).

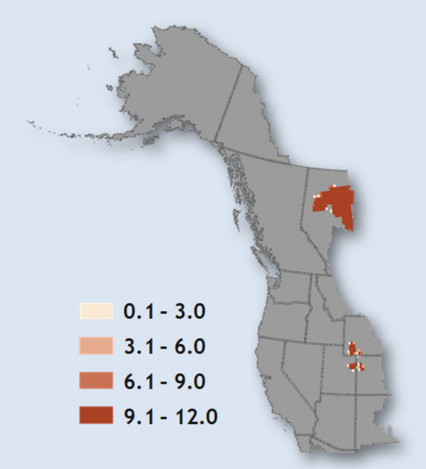




Oil shale/tar sands

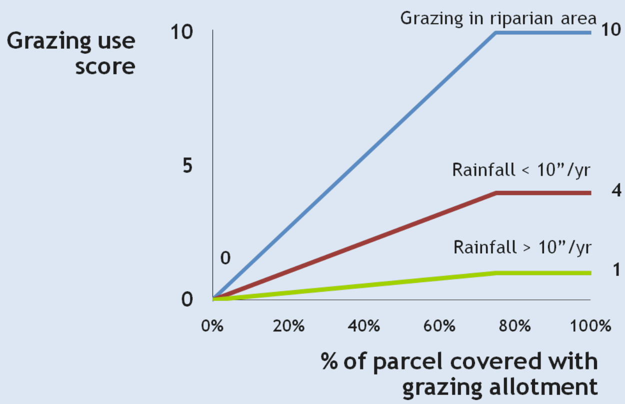
(Range 0–12) Based on area covered with BLM-proposed leases and areas with oil shale potential in the US and potential extent of tar sands in Canada.

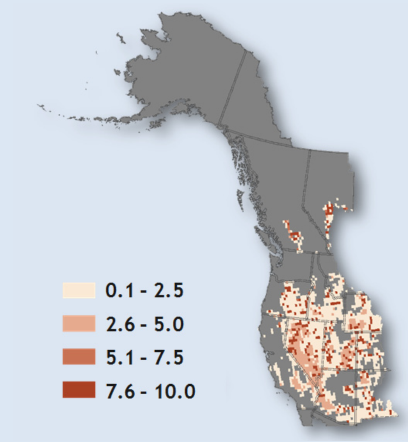




Grazing

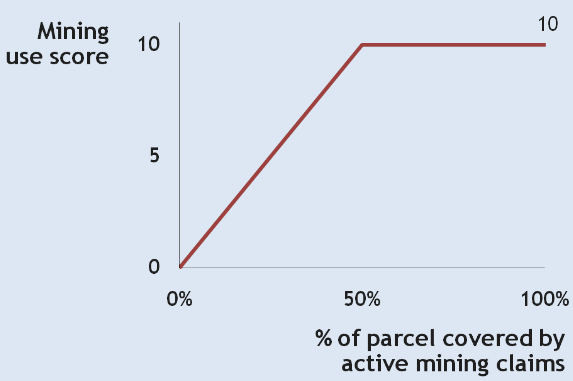
(Range 0–10) Based on area covered with grazing allotments, rainfall, and riparian status. Grazing in riparian areas was assigned the maximum use score of 10, due to the sensitivity of riparian areas to unregulated grazing practices. Grazing in non-riparian areas with less than ten inches of annual rainfall was given a maximum use score of 4, and grazing in non-riparian areas with higher levels of annual rainfall was assigned a maximum use score of 1.

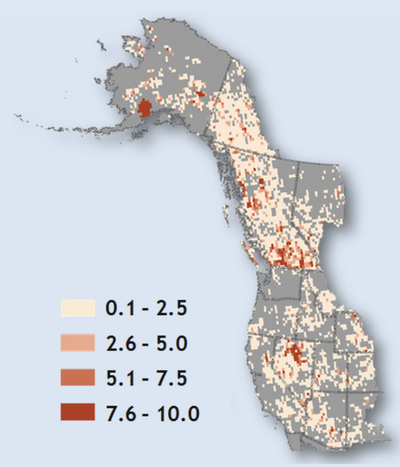




Mining

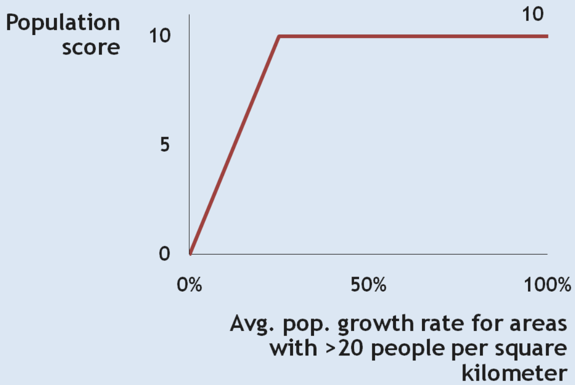
(Range 0–10) Based on density of active mining claims.

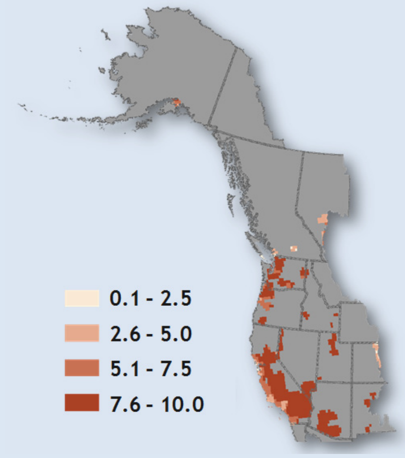




Population growth

(Range 0–10) Based on state projections of population growth by county, excluding low population density areas.

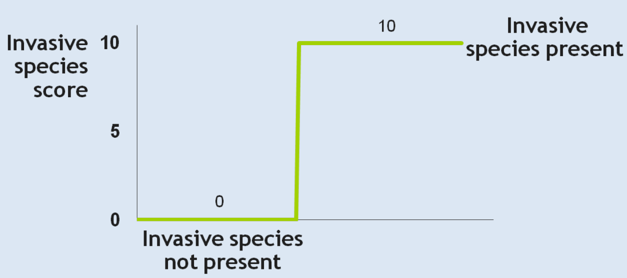




Invasive species

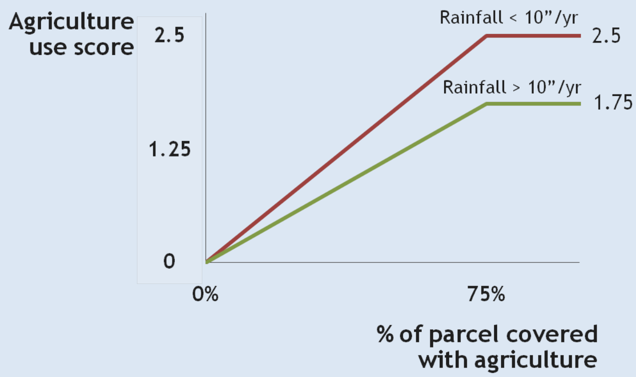
(Range 0–10) Based on presence of Tamarisk and other invasive species. Data on invasive species came from the National Institute of Invasive Species (NIIS) web-based global database. Species with greater than 10 occurrences in the data set that occur in the study area are listed below (listed by genus).

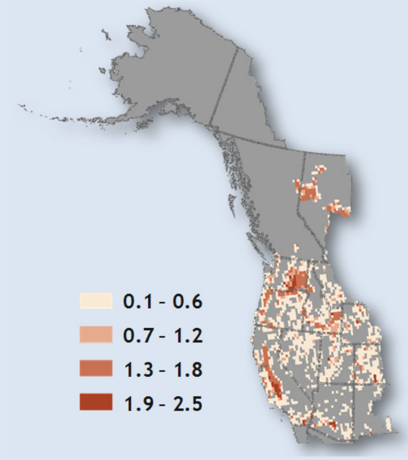
Tamarix	Carduus	Onopordum	Cardaria
Bromus	Centaurea	Potentilla	Lepidium
Linaria	Cynoglossum	Verbascum	Saponaria
Cirsium	Euphorbia	Acroptilon	Convolvulus



Agriculture

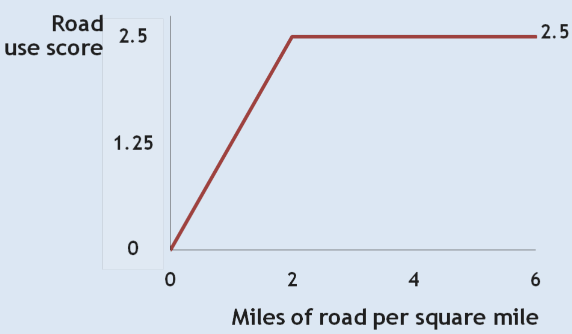
(Range 0–2.5) Based on satellite interpretations of land cover. Agriculture in areas with less than ten inches of annual rainfall was given a maximum use score of 2.5, and agriculture in areas with higher levels of annual rainfall was assigned a maximum use score of 1.75.

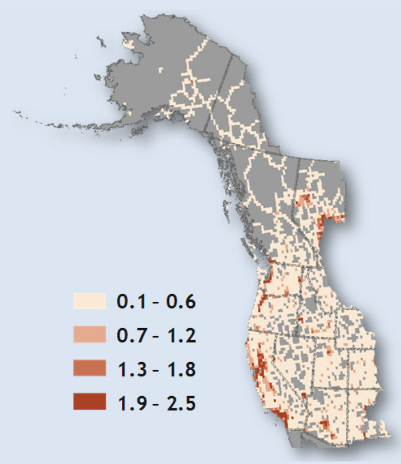




Roads

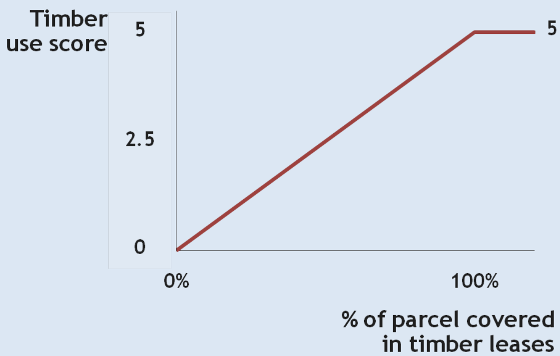
(Range 0–2.5) Based on miles of road per square mile, from data provided by ESRI.

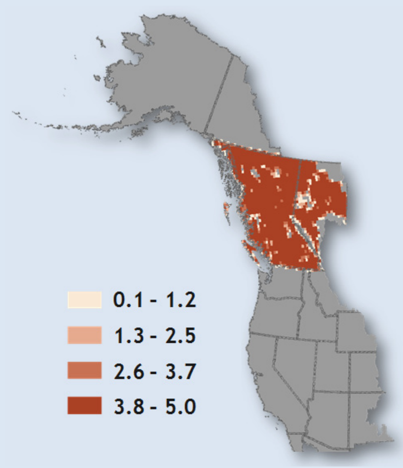




Timber

(Range 0–5) Based on potential for timber extraction in Canada.[28]





28 Unfortunately, comprehensive timber data were not readily available for the US

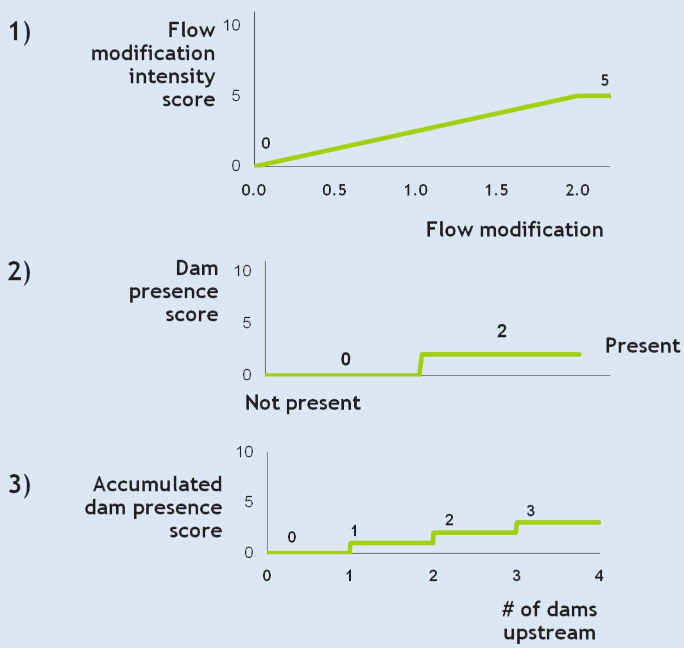
2.2 Freshwater Human Uses

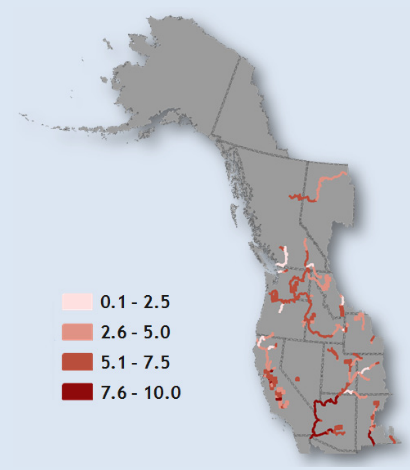
Freshwater human uses represent how flows and water quality in rivers and streams are affected by human use. River flow was estimated using USGS stream gauge data and Canada's hydrometric database (HYDAT). Each parcel was assigned the maximum flow that existed within the parcel's boundaries.

Dams

(Range 0–10) Based on three components: 1) the amount of water stored by a given dam on a stream segment relative to stream flow (defined as 'flow modification' and calculated for every segment with a dam's community), 2) whether dams are present anywhere on a stream segment and 3) the total number of accumulated dams upstream from a stream segment. For the first component, flow modification was defined by maximum dam storage [AF] divided by accumulated flow. A dam community was defined by the parcel in which the dam is present and every stream reach downstream until another dam is reached, or the stream flows into the ocean. Parcels with a dam receive a threat of 10.

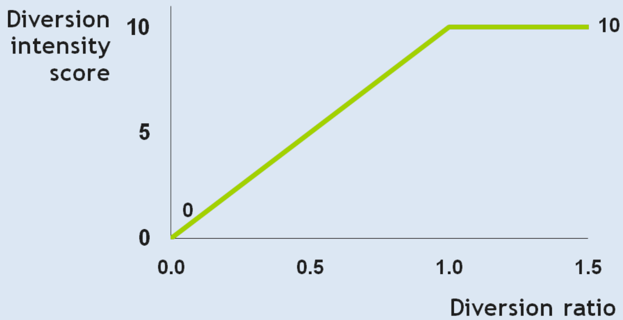
Components

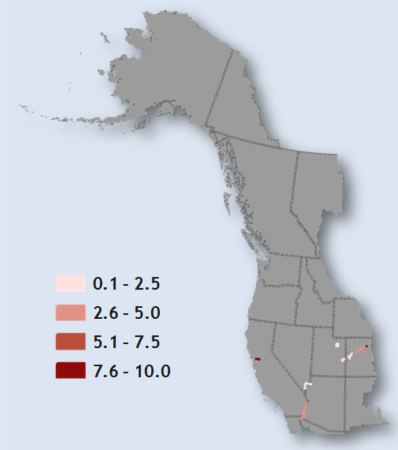




Diversions

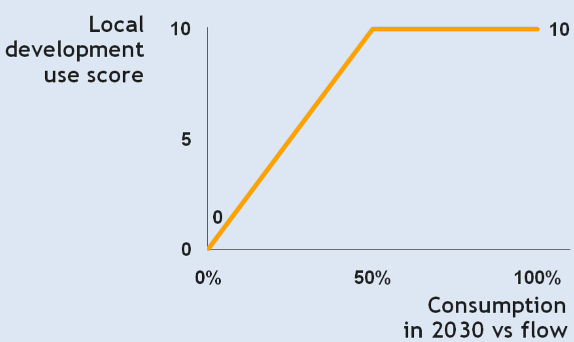
(Range 0–10) Based on amounts of major water diversions relative to stream flow. Diversion ratio is the diversion flow (AF/year) divided by the average flow (AF/year) within a given stream segment. Therefore, the diversion ratio decreases as one moves downstream to higher average flow values.

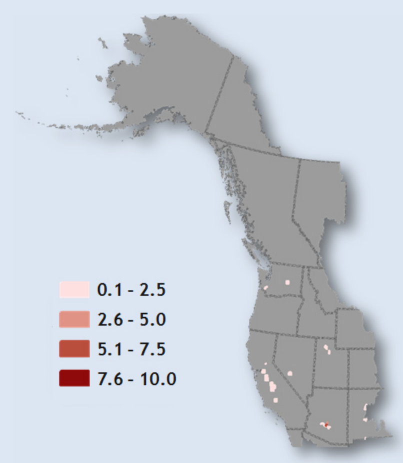




Local development

(Range 0–10) Predicted local municipal water consumption in 2030, relative to stream flow (Predicted consumption assumes 0.5 AF/household usage, 2 people per household, with 20% water consumption[29]).

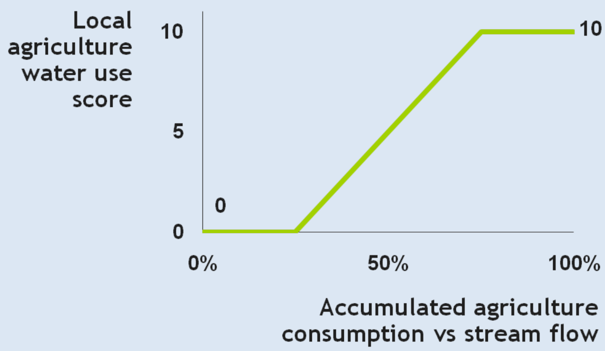


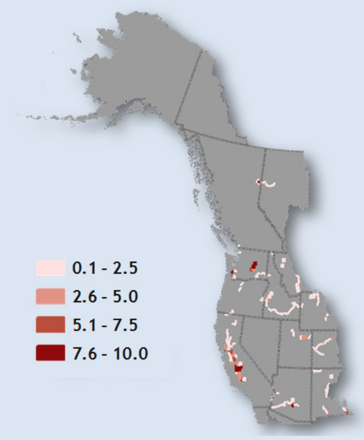


29 In other words, 20% of household water use is not returned to rivers

Local agriculture water use

(Range 0–10) Based on agricultural water withdrawals relative to stream flow. Assumptions: 4.5 AF/acre of agriculture, 50% consumption rate, 75% of agriculture is irrigated; AZ and NM: 6 AF/acre agriculture, 50% consumption rate, 90% of agriculture is irrigated.





Oil & gas

Same human use curve as terrestrial oil & gas, but with the maximum score capped at 5.

Oil shale

Same human use curve as terrestrial oil shale, but with the maximum score capped at 5.

Mining

Same human use curve as terrestrial mining, but with the maximum score capped at 5.

Invasive species

Same human use curve as terrestrial invasive species.

Agricultural (terrestrial)

Same human use curve as terrestrial agriculture, with the maximum score capped at 2 (representing quality alterations on local agriculture).

APPENDIX 3 SENSITIVITY SCENARIOS

Nine scenarios were examined in the sensitivity analysis.

Scenario name	Change
Public lands focus	Increase likelihood of success by 20 percentage points for all public lands investments
Public and policy maker education focus	Increase likelihood of success by 20 percentage points for efforts to educate the public and policy makers and pursue nonpartisan research and analysis
Poor private lands management	Decrease land ownership use score by 5 for all private lands with easement potential
Strong private lands management	Increase land ownership use score by 5 for all private lands with easement potential
Strong public lands management	Increase land ownership use score by 5 for all public lands other than Wilderness Areas or Wilderness Study Areas
Reduced ecosystem targets	Decrease all ecosystem protection targets by 3 percentage points
Increased ecosystem targets	Increase all ecosystem protection targets by 3 percentage points
Reduced focal species targets	Decrease all focal species protection targets by 5 percentage points
Increased focal species targets	Increase all focal species protection targets by 5 percentage points

The variation used in some of these scenarios may appear quite modest. However, the solution becomes infeasible in some highly degraded regions, like the Central Valley of California, making larger variations impossible to run. Modifications to the tool to make it able to handle partial infeasibility, could improve the ability to run alternative scenarios in the future.

APPENDIX 4 SOURCES

4.1 ARTICLES AND REFERENCES

Abell, Robin, et. al. "Freshwater Ecoregions of the World: A New Map of Biogeographic Unit for Freshwater Biodiversity Conservation." BioScience Vol. 58. No. 5 (2008). 403- 414.

Alaska Department of Natural Resources Division of Oil and Gas. "Alaska: Oil and Gas Report." Anchorage: 2007.

Amos, Adell Louise. "The Use of State Instream Flow Laws for Federal Lands: Respecting State Control While Meeting Federal Purposes." Environmental Law Vol. 36 (2006). 1237–1281.

Anderson, Mike. "A Decade of National Forest Roadless Area Conservation: Background Paper." The Wilderness Society, 2008.

Baker, David R. "Regulators Move to Curb Coal Plants." San Francisco Chronicle. 14 December 2006.

Baldassare, Mark. "PPIC Statewide Survey: Special Survey on the Environment." Survey. In collaboration with the William and Flora Hewlett Foundation, 2006.

Barringer, Felicity. "U.S. Rules Out Dam Removal to Aid Salmon." The New York Times. 1 December 2004.

Bartis, James T., Tom LaTourrette, Lloyd Dixon, D.J. Peterson, and Gary Cecchine. "Oil Shale Development in the United States: Prospects and Policy Issues." Arlington: RAND Corporation, 2005.

Bates, B.C., Z.W. Kundzewicz, S. Wu and J.P. Palutikof, Eds., "2008: Climate Change and Water." Technical Paper of the Intergovernmental Panel on Climate Change, IPCC Secretariat, Geneva: 210.

Beauvais, Gary, et. al. "Big Game Migration Corridors in Wyoming". University of Wyoming Open Spaces Initiative, 2004.

Boutin, Stan, Philip Lee, and Cheryl Smyth. "Quantitative Review of Riparian Buffer Width Guidelines from Canada and the United States." Journal of Environmental Management 70 (2004): 165–180

Bryer, Mark T., Jonathan V. Higgins, Mary L. Khoury, and Thomas W. Fitzhugh. "A Freshwater Classification Approach for Biodiversity Conservation Planning." Conservation Biology Vol. 19 No. 2 (2005): 432–445.

Cafferata, Pete, et. al. "Programs Assessing Implementation and Effectiveness of State Forest Practice Rules and BMPS in the West." Water, Air and Soil Pollution Focus 4 (2004): 143–169

Christensen, J.H., et. al. "2007: Regional Climate Projections." Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge and New York: Cambridge University Press, 2007.

COSEWIC. 2007. Canadian Species at Risk. Committee on the Status of Endangered Wildlife in Canada (2007): 84.

Commission for Environmental Corporation. "Ecological Regions of North America: Toward a Common Perspective." Quebec: Commission for Environmental Corporation, 1997.

_ _ _, "The North American Mosaic: A State of the Environment Report." Quebec: Commission for Environmental Corporation, 2001.

Culiver, Nada Wolff, Janice Thomson, and Mark Wilbert. “Analysis of habitat Fragmentation from Oil and Gas Development and Its Impact on Wildlife: A Framework for Public Land Management Planning.” The Wilderness Society, 2008.

Darin, Thomas F., and Travis Stills. “Preserving Our Public Lands: A Citizen’s Guide to Understanding and Participating in Oil and Gas Decisions Affecting Our Public Lands.” Boulder: Land and Water Fund of the Rockies, 2002.

Dobson, A. P., et al.” Geographic Distribution of Endangered Species in the United States.” Science 275 (1997): 550.

Donoso, Raquel, Rey Leon and Raquel Donoso. “New Voices for Change: Environmental Health Issues in Latino Communities of the San Joaquin Valley.” Latino Issues Forum, 2004.

Dunkel, Catherine A. “Oil and Gas Resources in the Pacific Outer Continental Shelf as of Jauary 1, 1999.” U.S. Department of the Interior, 2001.

Foreman, David. “Rewilding North America: Appendix A large Core complexes in the South to North MegaLinkages.” Wildlands Network. <http://www.wildlandsproject.org/cms/page1090.cfm>

Global Strategy Group. “2007 Environment Survey—Key Findings.” Survey, 2007.

Gonzalez, P., R.P. Neilson, and R.J. Drapek. “Climate Change Vegetation Shifts across Global Ecoregions.” Ecological Society of America Annual Meeting Abstracts 90 (2005): 228.

Green, Emily. “Not This Water.” Las Vegas Sun. 22 June 2008.

Ingerson, Ann. “Conservation Capital: Sources of Public Funding for Land Conservation.” Washington D.C.: The Wilderness Society, 2004.

_ _ _, “Conservation Capital: Sources of Private Funding for Land Conservation.” Washington D.C.: The Wilderness Society, 2004.

Jenkins, Matt. “Seeking the Water Jackpot.” High Country News. 17 March 2008.

Kiesecker, Joseph. “Energy by Design: Blending Landscape Level Planning and Mitigation Hierarchy.” The Nature Conservancy, 9 April 2008.

Konisky, David M. “Public Attitudes on the Environment.” University of Missouri, Institute of Public Policy Report 04–2008, 2008. <http://www.truman.missouri.edu/ipp/>

Land Trust Alliance. “2005 National Land Trust Census Report Executive Summary.” <http://www.protectprivateconservation.org/census/executive_summary.htm#_ftn1>

Lewis, Owen T. “Climate change, species-area curves and the extinction crisis.” Philosophical Transactions of the Royal Society B 361(2006): 163–171.

McFarlane, Susan. “On Tap: Urban Water Issues in Canada Discussion Paper.” Calgary: Canada West Foundation, 2003.

McKinnon, Shaun. “Utah Pipeline Cost Set at $1 Billion.” The Arizona Republic. 29 July 2008.

Noss, Reed. “Climate Change in the Northwest.” Fall 2007. <www.conservationnw.org>

Olson, David M, et. al. “Terrestrial Ecoregions of the World: A New Map of Life on Earth.” BioScience Vol. 51, No. 11 (2001). 933–938.

_ _ _, and Eric Dinerstein. “The Global 200: Priority Ecoregions for Global Conservation.” Annals of the Missouri Botanical Garden Vol. 89, No 2 (2002). 199–224.

Province of British Columbia. “Riparian Rights and Public Foreshore Use in the Administration of Aquatic Crown Land, Occasional Paper No. 5. “ Ministry of Environment, lands and Parks Lands Water Programs Branch, 2003. (Revised July 2008.)

Public Policy Institute of California. “Water Supply and Quality.” 2008.

Schoen, John and Erin Dovichin, eds. “The Coastal Forests and Mountain Ecoregion of Southeastern Alaska and the Tongass National Forest.” Anchorage: Audubon Alaska and The Nature Conservancy, 2007.

Sierra Club. "National Survey of Hispanic Voters on Environmental Issues." Survey. 2008.

Southwest Energy Efficiency Project. "The New Mother Lode: The Potential for More Efficient Electricity Use in the Southwest." Prepared for the Hewlett Foundation Energy Series, 2002. <www.swenergy.org>

Tear, Timothy, Kareiva, Peter et al. 2005. "How Much is Enough? The Recurrent Problem of Setting Measurable Objectives in Conservation." BioScience 55:10.

The Brookings Institute. "Mountain Megas: Americas Newest Metropolitan Places and a Federal Partnership to Help them Prosper." Metropolitan Policy Program, 2008.

The Nature Conservancy. "Conservation by Design, A Strategic Framework for Mission Success." 2006.

The Policy Project. "Measuring Political Commitment." 2000.

USDA. "Conservation Reserve Program: Summary and Enrollment Statistics." 2007.

Vincent, Carol Hardy. "Land and Water Conservation Fund: Overview, Funding History, and Current Issues." CRS Report for Congress, 2006.

Westerling, A. L. "Warming and Earlier Spring Increase Western U.S. Forest Wildfire Activity." Science 313 (2006): 940.

Western Resource Advocates. "A Balanced Energy Plan for the Interior West." Prepared for the Hewlett Foundation Energy Series, 2004. < http://www.westernresourceadvocates.org>

Young Voter Strategies and CIRCLE. "Young Voter Mobilization Tactics." George Washington University Graduate School of Political Management.

Zamora-Arroyo, Francisco, et. al. Conservation Priorities in the Colorado River Delta, Mexico and the United States. Prepared by the Sonoran Institute, Environmental Defense, University of Arizona, Pronatura Noroeste Dirección de Conservación Sonora, Centro de Investigación en Alimentación y Desarrollo, and World Wildlife Fund—Gulf of California Program, 2005.

4.2 GIS DATA SOURCES

Agricultural Land in the Western United States. US Geological Survey, 2008. <http://sagemap.wr.usgs.gov>

"Alaska DNR State Mining Claims." Alaska Department of Natural Resources—Land Records Information Section. 2008.

"BLM Colorado State Wide Geospatial Database." Bureau of Land Management, Colorado State Office, Geosciences Team, Dave Taylor (ed.), 2007. <http://www.blm.gov/co/st/en/BLM_Programs/geographical_sciences/gis/metadata.html>

"BLM Range Allotments." Dept of the Interior, Bureau of Land Management, 2006. <http://www.geocommunicator.gov/NILS-PARCEL2/map.jsp?MAP=GA>

"Bureau of Reclamation: Dataweb Homepage." US Bureau of Reclamation. <http://www.usbr.gov/dataweb/>

"Canadian Commercial Forest Tenures." Global Forest Watch Canada, 2004. <http://www.globalforestwatch.ca/datawarehouse/datawarehouse.htm>

"Canada_mines2008." Global Forest Watch Canada. 2007

"Central Arizona Project : Map Of System Operations." <http://www.cap-az.com/static/index.cfm?contentID=35>

"Dams in British Columbia." Government of British Columbia, Water Stewardship Division. <http://www.env.gov.bc.ca/wsd/public_safety/dam_safety/index.html>

"Ecological Regions of North America." Commission for Environmental Cooperation, 1997. <ftp://ftp.epa.gov/wed/ecoregions/cec_na/>

"Federal Mining Claims." Dept of the Interior, Bureau of Land Management. <http://www.geocommunicator.gov/NILS-PARCEL2/map.jsp?MAP=MC>

"Federal Oil and Gas Leasing." Dept of the Interior, Bureau of Land Management, 2006. <http://www.geocommunicator.gov>

"Generalized Land Status of Alaska NAD83." Bureau of Land Management—Branch of IRM, 2008. <http://sdms.ak.blm.gov/metadata/generalized_land_status_nad83.faq.html>

Gonzalez, P., R.P. Neilson, and R.J. Drapek. "Climate change vegetation shifts across global ecoregions." Ecological Society of America Annual Meeting Abstracts 90 (2005).: 228 <http://conserveonline.org/workspaces/climate.change/climate.change.vegetation.shifts/Gonzalez%20et%20al.%202005.pdf>

Government of Canada's hydrometric database (HYDAT), 2005. <http://www.wsc.ec.gc.ca/products/hydat/main_e.cfm?cname=hydat_e.cfm>

James Catlin. Personal communication. Wild Utah Project (incorportaing data from Southern Rockies Ecosystem Project, Heart of the West wildlands network designs, and Yellowstone-to-Yukon conservation initiative). 26 September 2008.

"Land Status Nevada (poly)." USDOI–BLM–Nevada State Office–Mapping Sciences, Reno, Nevada, 2007. <http://www.blm.gov/nv/st/en/prog/more_programs/geographic_sciences/gis/geospatial_data.html>

"Major Dams of the United States." National Atlas of the United States, 2006. <http://nationalatlas.gov/atlasftp.html?openChapters=chpwater#chpwater>

"Mineral Occurences Data." Yukon Geology Program, Indian and Northern Affairs Canada, Exploration and Geological Services Division, Yukon Territories. 2002

National Center for Atmospheric Research. 2007. "Community Climate System Model project." Accessed 19 September 2008. <http://www.gisclimatechange.org>.

"National Institute of Invasive Species (NIISS) web-based global database." US Geological Survey.

"Navajo Nation Department of Fish and Wildlife." <http://www.navajofishandwildlife.org/index.htm>

"New Mexico Federal Lands." Bureau of Land Management—New Mexico State Office, 2008. <http://www.blm.gov/nm/st/en/prog/more/geographic_sciences/statewide_map_files.html>

"Oil and Gas Well Surface Locations for British Columbia." British Columbia Oil & Commission, 2006. <ftp://www.ogc.gov.bc.ca/outgoing/OGC_Data/Wells/>

"Oil Shale and Tar Sands Information Center." Argonne National Lab, Bureaue of Land Management, 2007. <http://ostseis.anl.gov/>

"Oregon Surface Management Ownership (poly)." Bureau of Land Management, Oregon State Office, 2005. <http://www.blm.gov/or/gis/data.php>

Patterson, B. D., G. Ceballos, W. Sechrest, M. F. Tognelli, T. Brooks, L. Luna, P. Ortega, I. Salazar, and B. E. Young. 2007. "Digital Distribution Maps of the Mammals of the Western
Hemisphere, version 3.0." NatureServe, Arlington, Virginia, USA.

"Population and dwelling counts, for Canada and census divisions, 2006 and 2001 censuses." Statistics Canada. 2007. <http://www12.statcan.ca/english/census06/data/popdwell/Table.cfm?T=701&SR=1&S=0&O=A&RPP=9999&PR=0&CMA=0>

"Public Lands State of Washington (Polygon) Geographic NAD83." OR/WA BLM, Portland, OR, 2003. <http://www.blm.gov/or/gis/data.php>

Robin A. Abell, et al. *Freshwater Ecoregions of North America: a Conservation Assessment.* The World Wildlife Fund, 2000.

"Salmon Biodiversity by Watershed." State of the Salmon <http://www.stateofthesalmon.org/resources/sosdb.asp>

"State of Utah Surface Ownership." The State of Utah School and Institutional Trust Lands Administration, The Bureau of Land Management, Salt Lake City, UT, 2008

<http://www.blm.gov/ut/st/en/prog/more/geographic_information/gis_data_and_maps.html>

"Statewide Active Oil and Gas Lease Boundaries." Alaska Department of Natural Resources, Division of Oil & Gas, 2008. <http://www.dog.dnr.state.ak.us/oil/products/data/downloads/downloads.htm>

"Surface Management Agency for Idaho (Federal, State, and Private Lands)." U.S. Bureau of Land Management, Idaho State Office, Geographic Sciences, Boise, Idaho, 2008. <http://data.insideidaho.org/data/BLM/archive/statewide/landstatus_id_blm.tgz>

"Surface management by private, local, state, & federal government agencies."Arizona State Land Department, Arizona Land Resources Information System, Pheonix, Arizona, 2007. <http://www.blm.gov/az/gis/files.htm>

"Surficial Materials of the Athabasca Oil Sands (in Situ) Area, Northeast Alberta." Alberta Energy and Utilities Board, Alberta Geological Survey, Andriashek, Laurence, 2002. <http://www.ags.gov.ab.ca/publications/DIG/ZIP/DIG_2002_019.zip>

"The Canadian Vegetation and Land Cover." Geomatics Canada, L. St-Laurent, 1995.

"The North American HYDRO 1K dataset." US Geological Survey, 2000. <http://edc.usgs.gov/products/elevation/gtopo30/hydro/readme.html#DataLayers>

Tuhy, J.S., P. Comer, D. Dorfman, M. Lammert, J. Humke, B. Cholvin, G. Bell, B. Neely, S. Silbert, L. Whitham, and B. Baker. "A conservation assessment of the Colorado Plateau Ecoregion." Moab: The Nature Conservancy, Moab Project Office, 2002.

"Upper Mannville Oil and Gas Fields." Alberta Geological Survey, 2008. <http://www.ags.gov.ab.ca/publications/DIG/ZIP/DIG_2008_0266.zip>

United States Department of Agriculture. Census of Agriculture—State Data. National Agriculture Statistics Service (2002): 309–317.

"U.S. and Canada Major Roads." ESRI, 2007.

"U.S. Census Block Groups." ESRI, 2007.

"U.S. Census Urbanized Areas." ESRI, 2003.

"U.S. Rivers and Streams." ESRI, 2004.

"USGS Streamgages Linked to the Medium Resolution NHD." US Geological Survey, 2006. <http://water.usgs.gov/GIS/metadata/usgswrd/XML/Streamgage.xml>

"Yukon Oil and Gas Dispositions." Government of Yukon, 2005. <http://www.emr.gov.yk.ca/oilandgas/mapsdata.html#Oil_and_Gas_GIS_Data>

Species data was obtained through government websites or personal communication with the following contacts in each state:

- Arizona: Sabra Schwartz, Program Supervisor, AZ Heritage Data Management System, 2008.
- British Columbia: British Columbia Conservation Data Service, (http://www.env.gov.bc.ca/cdc/), 2008.
- California: Kristina Donat, Information Services Manager, CA natural Diversity Database, 2008.
- Idaho: George Stephens, At-risk Species Data Manager, ID Department of Fish and Game, 2008.
- Montana: Martin Miller, Data Assistant, MT Natural Heritage Program, 2008.
- Nevada: Eric Miskow, Data Manager, NV Department of Conservation and Natural Resources, 2008.
- New Mexico: Rayo McCollough, Data Services Manager, Natural Heritage New Mexico, 2008.
- Oregon: Lindsey Koepke, Assistant Information Manager, OR Natural Heritage Information Center, 2008.
- Utah: Utah Division of Wildlife Resources (http://wildlife.utah.gov/index.php), 2008.

- Washington: Washington Natural Heritage Program, (http://www.dnr.wa.gov/ResearchScience/Topics/NaturalHeritage/Pages/amp_nh.aspx), 2008.
- Wyoming: Melanie Arnett, Wyoming Natural Diversity Database, 2008.
- Yukon: Wildlife Key Areas, Yukon Department of Environment (http://www.environmentyukon.gov.yk.ca/geomatics/data/wildlife-key-area.html), 2008.

4.3 ANALYTICAL DATA SOURCES (EXPECTED RETURN ANALYSIS)

Alaska Conservation Voters. “24th Legislative Conservation Record.” Alaska Conservation Voters, 2005. <www.acvoters.org>

Alaska Division of Forestry and Department of Natural Resources. “Alaska Forest Resources and Practices Act.” Anchorage, 2007.

Alberta Sustainable Resource Development. “Alberta Timber Harvest Planning and Operating Ground Rules.” Alberta Sustainable Resource Development. Edmonton (1994): 57.

Arizona League of Conservation Voters. “Arizona Legislative Score Card 2007.” Arizona Conservation Voter Vol. 16 No. 3 (2007).

British Columbia Ministry of Forests. “Forest Practices Code-Riparian Management Area Guidebook.” British Columbia Ministry of Forests. Victoria (1995): 80.

BC Wild and Environmental Mining Council of BC. “Acid Mine Drainage: Mining and Water Pollution Issues in BC.” Victoria.

Board of Forestry and Fire Protection. “CDF Matrix of Salmonid Protection Measures.” Discussion for Board Meeting, 2006. <http://www.fire.ca.gov/CDFBOFDB/pdfs/Final2112RulesMatrix_v8.pdf>

California League of Conservation Voters. “California Environmental Scorecard: 2007 Legislative Year.” California League of Conservation Voters, 2007.

Colorado Conservation Voters. “Colorado Legislative Conservation Scorecard 2008.” Colorado Conservation Voters, 2008.

Colorado Mined Land Reclamation Board. “Regulations of the Colorado Mined Land Reclamation Board for Coal Mining.” Colorado Division of Minerals and Geology. Denver, 1980.

Colorado Oil and Gas Conservation Commission. “Complete Rules (100- 1100 Series). Colorado Department of Natural Resources, 2008. < http://cogcc.state.co.us/>

Colorado Timber Industry Association and Colorado State Forest Service. “Colorado Forest Stewardship Guidelines: BMPs for Colorado.” 1998.

Conservation Voters for Idaho. “2008 Legislative Scorecard.” Conservation Voters for Idaho, 2008.

Department of Natural Resources and Conservation. “Montana Guide to the Streamside Management Zone Law and Rules.” 1993.

Missoula, Montana. 35 p. Department of Natural Resources and Conservation, Department of Natural Resources and Conservation.

Energy Information Administration. “Updated State and Regional Level Greenhouse Gas Emission Factors for Electricity.” 2002. <http://www.eia.doe.gov/pub/oiaf/1605/cdrom/pdf/e-supdoc.pdf>

Idaho Department of Lands, et. al. “Forest Stewardship Guidelines for Water Quality.” Idaho Department of Lands, 2000.

Lands of America. “Rural Land for Sale.” 2008. 9 September 2008. <http://www.landsofamerica.com/america/land-for-sale/index.cfm?Searchit=&state_id=8&sqft=0&sqft=10000000&Price=0&Price=10000000000&GetRes=Search+for+Property>

Montana Conservation Voters. “Montana Legislative 2007 Scorecard.” Montana Conservation Voters, 2007.

Nevada Conservation League. "Nevada's 2007 Conservation Scorecard." Nevada Conservation League, 2007. <www.nevadconservationleague.org>

New Mexico Conservation Voters. "Legislative 2008 Scorecard." New Mexico Conservation Voters, 2008. <http://www.cvnm.org/index.html>

Province of Alberta. "Alberta Regulation 151/71: Oil and Gas Conservation Regulations." Queen's Printer for Alberta, 2008.

State Conservation Commission. "Best Management Practices Handbook." Carson City: State of Nevada, 1994.

The Trust for Public Lands. "Land Vote: All Measures 2008 by State." 2008. <http://www.conservationalmanac.org/landvote/cgi-bin/nph-landvote.cgi/000000A/https/www.quickbase.com/db/bbqna2qct>

Union of Concerned Scientists. "State Renewable Electricity Standards." 2008. <http://www.ucsusa.org/search/search.jsp?query=State+Minimum+Renewable+Electricity+Requirements&x=0&y=0 >

U.S. Census Bureau. "Energy Consumption—End-use Sector and Selected Source, by State." 2000. <http://www.census.gov/compendia/statab/cats/energy_utilities.html>

United States Department of Agriculture. "Agricultural Statistics 2005." Washington D.C.: United States Government Printing Office, 2005. (Table 12–13)

Washington Conservation Voters. "Legislative Scorecard 2007–2008." Washington Conservation Voters, 2008. <www.wcvoters.org>

Washington Forest Practices Board. "Washington Forest Practices Board Manual: Section 7 Guidelines for Riparian Management Zones." Olympia: Washington State Department of Natural Resources (2000): 44

Wildlands Project. "Continental Megalinkages Map: Reconnecting North America for Wildlife." Richmond: 2004. <http://www.wildlandsproject.org/cms/index.cfm?group_id=1134>

Wyoming Conservation Voters. "2007 Legislative Scorecard." Wyoming Conservation Voters, 2007.

Wyoming Department of Environmental Quality. "Silviculture Best Management Practices, Wyoming Non-point Source Management Plan." Cheyenne: Forestry Division, Wyoming Department of Environmental Quality (1997): 67.

Wyoming Oil and Gas Commission. "Rules and Statutes: Oil and Gas." 2008. <http://wogcc.state.wy.us/rules-statutes.cfm?Skip='Y'>

4.4 EXPERT INTERVIEWS

Chris Killingsworth, Wyss Foundation. 7 August 2008, 3 December 2008.

Courtney Cuff, Western Conservation Foundation. 7 August 2008, 25 September 2008.

Jim Martin, State of Colorado. 7 August 2008.

Felicia Marcus, Trust for Public Land. 12 August 2008.

Johanna Wald, Natural Resources Defense Council. 12 August 2008.

Mark Burgett, ClimateWorks Foundation. 9 September 2008 and 3 December 2008.

Ralph Cavanagh, Natural Resources Defense Council. 9 September 2008.

Michael Mantell, Resources Law Group. 15 September 2008.

Sam Tucker, Independent consultant. 15 September 2008.

Steve Kallick, Pew Charitable Trusts. 15 September 2008.

Ross McMillan. 26 September 2008.

Tim Sullivan. 21 November 2008.

Chris Wood. 21 November 2008.

Rhea Suh. 3 December 2008.

Walt Reid. 18 December 2008.

Hal Harvey. 19 December 2008.