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Decision Support for the Integrated Restoration and Protection Strategy of the Forest Service, Northern Region

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Abstract

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This report documents a decision-support process developed in the U.S. Department of Agriculture, Forest Service, Northern Region to assess management opportunities as part of an ecosystem-based approach to management that emphasizes ecological resilience. The decision-support system described in this work implements what is known as the Integrated Restoration and Protection Strategy and was developed to allow the region to assess ecosystem resilience using a more consistent, efficient, and effective process; to identify priority restoration opportunities; and to manage resources and ecosystem services being affected by various disturbance processes.

Keywords: Decision support, integrated resource restoration, natural resources, protection.

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Cover: Rocky Ridge, Lolo Motorway, Nez Perce Clearwater National Forest. Photo by Jerry Bauer.

Executive Summary

This report documents a decision-support process developed in the U.S. Department of Agriculture, Forest Service, Northern Region to assess management opportunities as part of an ecosystem-based approach to management that emphasizes ecological resilience. The decision-support system (DSS) described in this work implements what is known as the Integrated Restoration and Protection Strategy (IRPS) and was developed to allow the region to assess ecosystem resilience using a more consistent, efficient, and effective process; to identify priority restoration opportunities; and to manage resources and ecosystem services being affected by various disturbance processes.

In the late 1990s, the Northern Region regional forester tasked regional office staff with assessing the status of resources across the region. Consequently, the staff developed the Northern Region Overview (NRO) to determine the state of ecosystem health and recreation for selected forested and nonforested ecosystems to help establish restoration needs. Completed in 1998, the NRO included a summary of ecological conditions from broad-scale information contained in the Interior Columbia River Basin Assessment. The Northern Region initiated the IRPS assessment in 2005 and completed its current version in 2010. The IRPS was designed to provide a more spatially explicit understanding of ecological conditions and to assist national forest and grassland units with selection of opportunities for restoring ecological systems to more resilient conditions. The intent of the IRPS was also to identify areas where social infrastructure could be protected to the extent possible from uncharacteristic local disturbances affecting these social values.

As a prelude to describing the IRPS framework and results from the DSS, this report discusses the IRPS in the context of national restoration policy and guidance and the 2012 Planning Rule, as well as the relation of the IRPS to several other national initiatives.

A basic objective of DSS implementation was to identify where potentially high-priority multiple resource objectives could be met in the same location by integrating values at risk under a **theme**, which is a collection of similar resource concerns and objectives, as well as across themes. These values and objectives included social, ecological, and economic values or investments. The IRPS also provides information, along with approximately 50 geographic information system layers, for collaborating across administrative and other jurisdictional boundaries in projects such as the State Assessments and for identifying opportunities to restore or protect values that may be at risk to current or projected disturbance or other risk factors. The IRPS currently serves as a starting point, combined with local, more site-specific information, such as input from partners and collaborative groups, to identify and sequence priority integrated restoration proposals in the Northern Region. It provides information to help local units assess ecological conditions, assess risks to related ecosystem services, and identify and prioritize potential subwatersheds for accomplishing goals and objectives of forest and grassland management plans. The strategy is intended to assist local units in developing and prioritizing integrated projects addressing land and water restoration; community wildfire protection plans; and sustainable, resilient, and desired conditions as described in management plans. Finally, the IRPS provides resource information on values that may be vulnerable or at risk to specific agents of change, including disturbance agents, to help units develop integrated projects.

The IRPS addresses 19 key planning questions, derived from management concerns, and identifies opportunities and potential priorities for 19 associated resource **objectives** (scenarios) that may be at risk from current or projected disturbance and other agents of change. The themes and scenarios were identified and designed by staff specialists in an interdisciplinary fashion, then concurred on by regional leadership, which acted as a steering committee. Each scenario represents a resource objective in the DSS, and contributes to a potential spatial solution for IRPS opportunities. Each scenario was evaluated based on three primary decision criteria—values, risks, and feasibility—with values representing the current state of key resources. Staff specialists in the regional office weighted the primary criteria and the Regional Leadership Steering Committee, which included the regional forester's office, reviewed the criteria to express their perception of the relative opportunity to minimize or reduce the risk factors to restore a more resilient condition. The major themes covered by the IRPS include:

1. Restoration of forests, grasslands, and human communities to a more resilient condition.
2. Restoration and maintenance of wildlife habitats, including restoration of more resilient vegetation conditions where appropriate, to meet ecological and social goals.
3. Restoration and maintenance of resilient, high-value watersheds.
4. Restoration of high-value fisheries streams, developing more resilient habitat.
5. Restoration and protection of recreation sites and scenic vistas.
6. Protection of people, structures, and community infrastructure, highlighting current and projected mountain pine beetle and wildfire effects.

The overall architecture of the Northern Region IRPS DSS was designed as a three-tiered decision model. At the lowest level, data for each of the 19 scenarios were evaluated by scenario-specific decision models. At the next higher level of the three-tiered decision architecture, the 19 scenarios were organized into the

above six themes. A priority score for each theme was calculated for each theme-specific decision model at this level. Finally, at the highest level, an **overall** IRPS priority score was calculated, considering the contributions of the priorities of the six themes. Practical issues associated with the IRPS DSS implementation are discussed at some length.

This report presents maps of opportunity scores by subwatershed for each of the IRPS themes and scenarios. These maps provide a spatial representation of the key findings across the region. Analogous map products for each of four subregions were also created to show how opportunity scores change when evaluating against only those subwatersheds in a geographic subset of the region. The report also includes detailed information on how to use the DSS products and how to update them.

A final discussion section concludes this report with an introspective look at what worked well, some issues and caveats, opportunities for improving the IRPS DSS, and the potential role of the DSS in future applications such as strategic regional planning, forest planning, and an all-lands approach to management.

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Introduction

In the U.S. Department of Agriculture, Forest Service, land management plans (forest plans) completed in the 1980s concentrated on resources, suitable uses, commodity production, and resource conservation. Implementation of these plans without a unified **ecosystem** (bolded terms are defined in sidebars 1 through 5) management-based approach has resulted in considerable uncertainty about the effectiveness of treatments owing to increases in disturbances and inconsistent methods for assessing priorities. After various integrated program reviews were conducted on multiple national forests in 2004 and 2005, it was not clear how project-level proposed actions addressed the questions "why here?" and "why now?" Ecosystem management (Holling 1978, Walters 1986), which considers ecological, social, and economic **sustainability** (Reynolds 2005), including forest and grassland **resilience**, did not have the focus it has acquired since forest plans were initially developed. To look at short- and long-term resilience and at management of resources in an ecosystem-management-based approach, the Forest Service has developed new tools and **assessment** procedures. This report documents a decision-support process developed in the Forest Service's Northern Region to assess management opportunities emerging from this approach, with its emphasis on ecological resilience. One of the major goals of the Forest Service is managing National Forest System (NFS) lands for ecological resilience (Forest Service Manual 2020). In addition, in 2012, the Forest Service implemented a new planning rule under the National Forest Management Act that provides a new framework to assess, monitor, and revise forest plans. The decision-support process described in this report implements what is known as the Integrated Restoration and Protection Strategy (IRPS). We developed the IRPS using some of these evolving concepts and tools to enable the Northern Region to assess ecosystem resilience using a more consistent, efficient, and effective process; to identify priority restoration opportunities; and to manage resources and **ecosystem services** being affected by various disturbance processes.

Click bolded text to view definitions.

Sidebar 1
Ecosystem (FSM 2000).—A spatially explicit, relatively homogeneous unit of the earth that includes all interacting organisms and elements of the abiotic environment within its boundaries. An ecosystem is commonly described in terms of its (1) composition—the biological elements within the different levels of biological organizations, from genes and species to communities and ecosystems; (2) structure—the organization and physical arrangement of biological elements such as snags and down woody debris, vertical and horizontal distribution of vegetation, stream habitat complexity, landscape pattern, and connectivity; and (3) function—ecological processes, such as energy flow; nutrient cycling and retention; soil development and retention; predation and herbivory; and natural disturbances such as wind, fire, and floods that sustain composition and structure.

Decision-support tools in the Forest Service have been used at multiple levels, including the national, regional, forest, and grassland unit or multiunit, and project-watershed level. Assessments and decisionmaking at any of these levels need transparent and efficient tools to integrate a host of resource conditions (including past, current, and projected conditions), thus allowing a manager to understand issues and concerns about these conditions. The IRPS decision-support system (DSS) enabled a regionwide, unified assessment of ecological and social concerns related to the **composition**, **structure**, and **function** of ecosystems and many of the related ecosystem services upon which people of the region depend. The DSS integrates an array of assessment results into a process to help identify priority opportunity areas for **restoration** in a geographic information system (GIS) environment, assisting forest and grassland units with identifying priority proposed actions for project-level restoration treatments. The integration of resource information, concerns related to existing conditions, and assessment of both ecological and socioeconomic implications related to decisions concerning proposed treatments to restore resilience and protect human infrastructure will hopefully increase efficient choice among proposed actions and is facilitated by the IRPS DSS.

In this section, we provide some historical background on the IRPS, review national direction that provides context for it, describe its relation to other national and regional initiatives, and conclude with a description of IRPS goals and objectives.

Sidebar 2

Sustainability—Meeting the needs of the present generation without compromising the ability of future generations to meet their needs. Sustainability is composed of desirable social, economic, and ecological conditions or trends interacting at varying spatial and temporal scales, embodying the principles of multiple use and sustained yield (FSM 1900).

Resilience—The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change.

Assessment (FSM 1900)—An analysis and interpretation of the social, economic, or ecological characteristics of an area using scientific principles to describe existing conditions as they affect sustainability. Assessments provide the foundation of independent information upon which to build conservation strategies and management decisions, and against which alternative approaches can be evaluated and modified.

Restoration—The process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed. Ecological restoration focuses on establishing the composition, structure, pattern, and ecological processes necessary to facilitate terrestrial and aquatic ecosystem sustainability, resilience, and health under current and future conditions.

Subsequent sections describe implementation of IRPS in the Northern Region, the analytical framework used, initial results and a status report, and how to use and update IRPS products.

Historical Background

In the late 1990s, the regional forester tasked the staff of the regional office with assessing the status of resources across the region. Consequently, regional office staff developed the Northern Region Overview (NRO) to describe the state of ecosystem health and recreation for selected forested and nonforested ecosystems to determine their restoration needs. Completed in 1998, the NRO included a summary of ecological conditions from broad-scale information contained in the Interior Columbia River Basin Assessment (Quigley and Arbelbide 1997). A very broad-scale landscape simulation model, CRBSUM (Quigley and Arbelbide 1997), identified ecological departures from historical conditions compared to existing conditions and was the basis of the NRO broad-scale, nonspatial ecological assessment. This NRO assessment considered conditions with higher levels of ecological departure to be less resilient to future disturbance processes, and thus highlighted general ecological restoration opportunities.

To understand the various ecosystems of the Northern Region and sustain their biodiversity, some reference for assessing the potential productivity of the land, the natural diversity of relevant ecosystems, and what processes sustain this productivity and diversity is necessary. In the last two decades, ecologists have increasingly relied upon reconstructions of historical ecosystem structures and processes to gain ecological understanding. These historical reconstructions have come to be called the **historic range of variability** (HRV), and use the concept of historical/natural conditions and processes within some range (Brown et al. 2004, Dillon et al. 2005, Meyer et al. 2005, Nonaka and Spies 2005, Reynolds 2003, Tinker et al. 2003, Veblen 2003). The concept of ecosystem ranges of variability has been suggested as a framework for a coarse filter conservation strategy (Landres et al. 1999). Historical range of variability concepts were developed in part to better understand how disturbance, vegetation, and other ecosystem components interact, and, in turn, how interaction affects biophysical characteristics such as plants, animals, fish, and soil and water resources. Historical perspectives increase our understanding of the dynamic nature of landscapes and provide a frame of reference for assessing current patterns and processes (Swetnam et al. 1999). National forests in the Northern Region have followed this process in developing an HRV for vegetation and define it as the range of variability in spatial, structural, compositional, and temporal characteristics of ecosystem elements as affected by climatic fluctuations and disturbances. Major fluctuations in climate during the last 100 years have dramatically influenced vegetation. The HRV analysis in the Northern Region focused on forest composition, structure, landscape pattern, and processes

Sidebar 3

Adaptive management—A system of management practices based on clearly identified outcomes and monitoring to determine if management actions are meeting desired outcomes, and if not, to facilitate management changes that will best ensure that outcomes are met or reevaluated. Adaptive management stems from the recognition that knowledge about natural resource systems is sometimes uncertain (36 CFR 219.16; FSM 1900).

Monitoring—The collection and analysis of repeated observations or measurements to evaluate changes in condition and progress toward meeting a resource or management objective. A monitoring activity may include an information-needs assessment; planning and scheduling; data collection, classification, mapping, data entry, storage and maintenance; product development; evaluation; and reporting phases.

Evaluation—An appraisal and study of social, economic, and ecological conditions and trends relevant to a unit, or the analysis of monitoring data that produces information needed to answer specific monitoring questions. Evaluation may include comparing monitoring results with a predetermined guideline or expected norm that may lead to recommendations for changes in management, a land management plan, or monitoring plan. Evaluations provide an updated compilation of information for use in environmental analysis of future project and activity decisions.

Sidebar 4

Restoration is defined in Forest Service Manual 2020 (FSM 2000) as the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed. Ecological restoration focuses on establishing the composition, structure, pattern, and ecological processes necessary to facilitate terrestrial and aquatic ecosystem sustainability, resilience, and health under current and future conditions. To restore resilience, it is important to identify desired conditions, then try to optimize the components of resilience to achieve those end states.[1] Restoration can be viewed as the point at which resilience theory is transformed into practice and as such is the point at which the integration between ecological and social resilience is necessary (Walker et al. 2002).

[1] Carroll, M.; Cava, E.; Lawhon, J. 2010. Resilience in U.S. Forest Service policy: a report for the Defenders of Wildlife. New Haven, CT: Yale School of Forestry and Environmental Studies.

(disturbance and succession) and has been used to help determine desired conditions for the future. The concept of comparing current vegetation conditions to both historical and potential future conditions is described by Gartner et al. (2008). In summary, this approach is designed to provide insights into how ecosystems have changed, as well as how they may change in the future. The knowledge gained from this approach

Sidebar 5

Ecosystem services. Benefits people obtain from ecosystems, including:

1. **Provisioning services**—such as clean air and fresh water, as well as energy, fuel, forage, fiber, and minerals;
2. **Regulating services**—such as long-term storage of carbon; climate regulation; water filtration, purification, and storage; soil stabilization; flood control; and disease regulation;
3. **Supporting services**—such as pollination, seed dispersal, soil formation, and nutrient cycling; and
4. **Cultural services—**such as educational, aesthetic, spiritual and cultural heritage values, as well as recreational experiences and tourism opportunities.

can then be used to inform management decisions regarding how climate change may affect future landscape conditions (Hayward et al. 2012, Keane et al. 2008). Given these insights, strategies for adapting to climate change, such as fostering resistance and resilience in forest ecosystems, can be considered. A recent study by the Climate Impacts Group at the University of Washington (Snover 2013) noted that

> ... temperatures increased ~1.2 °F (0.7 °C) for maximum temperature and ~2.1 °F (1.2 °C) for minimum temperature averaged for Northern Rockies stations, 1916–2006. This is comparable to the U.S. national average of 1.1 °F (0.6 °C) for the same period. Seventy-seven percent of stations had increasing maximum temperature, and 94 percent of stations had increasing minimum temperature. The change in annual precipitation, averaged over the region, is an increase of +9.0 percent since 1916, slightly more than the U.S. national average of about 8.1 percent. Precipitation increased at 81 percent of stations, and the increase was primarily in spring, summer, and fall.

For projected trends, Snover (2013) observed that

> ...all global climate models (GCMs) project surface temperature warming in the Northern Rockies in all seasons regardless of uncertainties in modeling or greenhouse gas emissions. These projected temperature increases exceed observed 20th century year-to-year variability, generally by the 2040s **(fig. 1)**. Many climate models project increases in precipitation during the winter and decreases in summer; however, projected precipitation changes are comparable to 20th century variability. Beyond mid-century, climate change projections are less certain because they depend increasingly on greenhouse gas emission rates in the next few decades.

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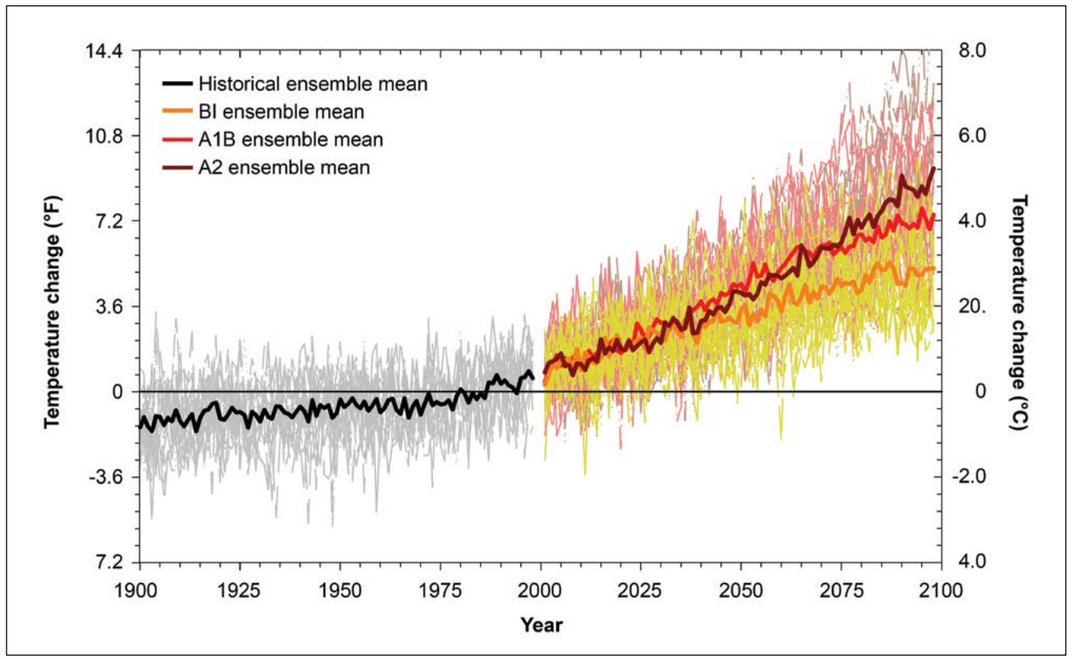


Figure 1—Projected temperature increases in the Northern Rockies, 2001–2099 (color). Heavy lines are ensemble (multiple climate model) averages for B1, A1B, and A2 emissions scenarios (see footnote 1).

A summary of departure of ecological conditions in the Northern Region shows significant departure of forest composition, density, size class, and pattern. Beginning with departure of composition on moist forests types, historically, western white pine (*Pinus monticola* Douglas ex D. Don) had an important ecological role in forests of the interior Northwest (Harvey et al. 1995, Monnig and Byler 1992). In the region, western white pine occurred on approximately 4.5 million acres in northern Idaho and western Montana. Especially important was the ability of this species to form a stable, relatively long-lived forest that was perpetuated by a combination of mixed-severity and stand-replacing wildfires.[2] Although fire occurred in this forest type fairly regularly, old-growth structures often persisted for several centuries. Across its range, the abundance of western white pine is now estimated to be less than 5 percent of what it was at the turn of the 20th century (Neuenschwander et al. 1999).

[2] Zack, A.C.; Morgan, P. 1994. Fire history on the Idaho Panhandle National Forests. Unpublished report. On file with: Idaho Panhandle National Forests, 3815 Schreiber Way, Coeur d'Alene, ID 83815. 44 p.

With the impact of white pine blister rust and the decrease in fire, the role of insects and pathogens as disturbance agents is growing and changing. White pine blister rust accounts for major changes in forest successional patterns, having removed more than 90 percent of two conifer species (white pine and whitebark pine) in the western portion of the region. Mortality caused by white pine blister rust and mountain pine beetle (*Dendroctonus ponderosae)* in whitebark pine has greatly accelerated in the past decade, decimating much of this forest type. These forests have been replaced by moist-site Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco), grand fir (*Abies grandis* (Douglas ex D. Don) Lindl.), and western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) forest types. With the absence of white pine in moist forests of western Montana and northern Idaho, and decreased amounts of ponderosa pine (*Pinus ponderosa* Lawson & C. Lawson) and larch (*Larix occidentalis* Nutt.) in those previously mixed white pine, ponderosa pine, and larch communities, root pathogens have transformed from thinning agents into major stand-changing agents in the Douglas-fir and true fir stands that have replaced white pine. Root pathogens now produce significant canopy openings on many sites. Depending upon the habitat type, root pathogens may either stall stands in a diseased shrub/sapling/open pole successional stage or strongly accelerate succession toward shade-tolerant species. Because of the large change in the composition of the forests in the area, it has been suggested that the genetic strategy of the dominant conifers may change (Rehfeldt 1994). In historical forests that were dominated by seral tree species, insect and diseases probably served as stabilizing agents, removing the maladapted late-seral and climax species early in stand development, which would preserve only the best climax trees and favor the dominance of the long-lived seral species (Harvey et al. 1999).

The two most significant native pathogens in the northern Rocky Mountains are Armillaria root disease and annosus root disease. Armillaria root disease kills conifers of all species when they are young, but is especially damaging to Douglas-fir, subalpine fir (*A. lasiocarpa* (Hook.) Nutt.), and grand fir because these species remain susceptible throughout their lives (Shaw and Kile 1991). In addition, they often affect canopy closure and create small openings (**fig. 2**). The effects of these root pathogens are long lasting; they persist on a site and affect multiple generations of trees. Armillaria and other root diseases influence forest species composition, structure, and successional trajectories, and they accelerate change to climax species or maintain stands in early-seral stages (Byler and Hagle 2000). At least 3.3 million acres (1 335 000 ha) in the northern Rocky Mountains have moderate to severe root disease, with up to 60 percent in the form of Armillaria root disease. On about 2 million acres (809 000 ha) of forest lands in Idaho and Montana in the Northern Region, shrub fields have replaced forest cover as a result of severe root disease.

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Barry Bollenbacher



Figure 2—Typical root disease centers of moderate severity. Note the dead standing trees, reduced stand density, loss of crown cover, and substantially lower productivity. Because these effects persist for long periods until disease-resistant tree species are able to occupy the site, root diseases limit forest carbon stocks and sequestration rates for longer periods than other disturbances.

Root disease has, on average, infected more than 14 million acres (5 670 000 ha), reducing forest canopy cover by 20 to 30 percent in the infected area. Significant reduction in productivity and carbon sequestration has been the result.

Native and nonnative pathogens are now responsible for a relatively much larger proportion of forest disturbance than they were historically. The impact of all these pathogens in the short run is to strongly accelerate succession toward late-seral, shade-tolerant tree species. An analysis of pathogen and insect impacts in northern Idaho and western Montana examined successional changes for the period 1935 to 1975. This analysis shows that, in 40 years, pathogens and insects changed forest cover types to more late-successional, shade-tolerant tree species on more than 80 percent of the area dominated by moist forest habitat types (Byler and Hagle 2000). The same analysis of insect and pathogen impacts also showed that almost 40 percent of the moist habitat type area analyzed was either stalled in small tree structures or was actually moving back toward the small tree structures as a result of the removal of the largest trees. Root diseases have a substantial, and perhaps the most significant, effect on forest carbon stocks and flux on forests of western Montana and northern Idaho. Thus, moderate- and high-severity root disease centers are a major source of forest mortality and a long-term constraint on forest carbon sequestration rates.

Very limited scientific information is available on the potential effects of climate variability and change on root diseases and white pine blister rust. In general, the available literature suggests that any climate variation or change-related increases in moisture stress of host trees could increase the incidence and spread of root diseases (Shaw and Kile 1991, U.S. Congress Office of Technology Assessment 1993, Wargo and Harrington 1991). Climate change could have a positive, negative, or no impact on individual pathogens. However, insufficient information is available to estimate those effects, according to Kliejunas et al. (2009), who prepared a literature review of climate change and forest diseases of western North America. It is generally believed that climate change will lead to reductions in tree health and will improve conditions for highly damaging pathogens such as root disease. Thus, on these sites of approximately 4.5 million acres, restoration of composition to reverse this departure, primarily western white pine, ponderosa pine, and western larch, is an urgent priority.

Moving to the dry forests types within the Northern Region that occur on approximately 3.5 million acres, we see that the effects of fire exclusion and densification of the ponderosa pine and dry Douglas-fir forests have experienced significant departures in forest density, from more open-grown forests that can cope with moisture stress and mixed-severity and nonlethal fire to forests prone to stand-replacing fire in an altered fire regime. As noted previously, models of future climate change predict that Northern Rockies forests will have longer, drier summers and warmer conditions as well. **Figure 3** illustrates the overall water balance within a forest as it changes over time. Overall soil-water balance determines which tree species can ultimately survive on a specific site. Pioneer (early-seral) species such as ponderosa pine have the unique ability to establish on bare soil surfaces where high surface temperatures (>150 °F) exclude other species. One of the adaptations of these seral species are deep rooting characteristics that allow the tree to find an adequate water supply and avoid extensive competition with shallow- and fibrous-rooted grasses and forbs. Because the shade from these species limits sun-loving grasses and forbs, shade-tolerant tree species establish and grow, and these species usually have a shallower rooting characteristic that allows them to gather soil water from the nutrient-rich soil.

Forest structure can play an important role in wildfire behavior and severity, especially during warm, dry climatic periods. Using ponderosa pine as an example, this species is often the only one that can colonize the hot, dry surface conditions of a disturbed site. Over time, as it matures, it provides a shaded environment in which less heat-tolerant Douglas-fir can establish. With frequent understory fires as part of the dominant low-severity fire regime, the thick-barked ponderosa pine survives and the thinner bark Douglas-fir or ponderosa pine seedlings do not. If frequent fires are sustained, the ponderosa pine forest can develop into large patches of open-grown,

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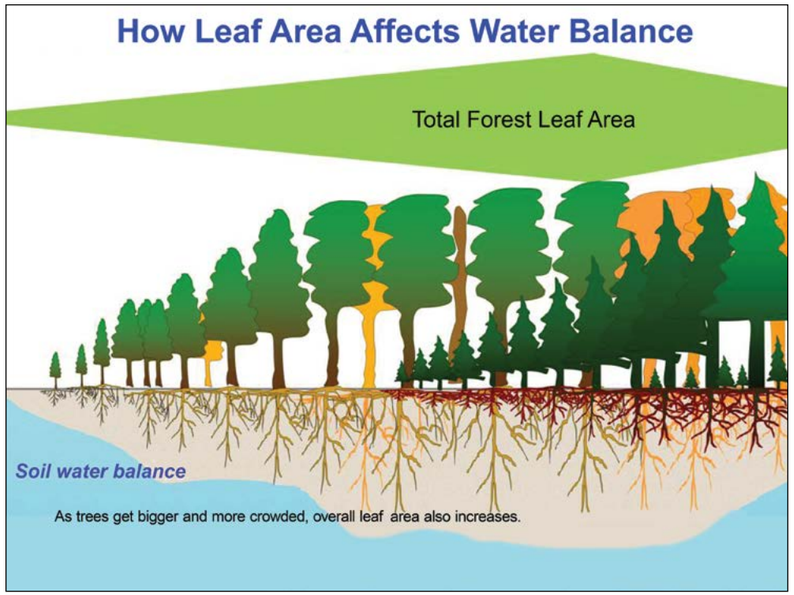


Figure 3—Generalized relation between leaf area and water balance in a forest stand. As trees get larger and more crowded, overall leaf area also increases. The greater the leaf surface area on a site, the greater the transpirational water loss, and thus water demand on soil water reserves. Also, higher leaf surface areas result in greater rain and snowfall interception, of which a large percentage evaporates back to the atmosphere, rather than being stored in the soil surface. In essence, the overall rooting structure becomes much more competitive as succession progresses. In addition, the overall leaf surface area that develops over time on a given site increases. Grass/forb and shrublands usually develop a maximum total leaf area of about 3 per 1 square foot of soil surface area. Forests can develop leaf areas in excess of 6 per 1 square foot of soil surface area. With increasing leaf area comes increased water transpiration that can deplete the soil water storage capacity needed to keep trees hydrated throughout the summer. The additional dense forest canopy interception of rain and snow, which directly evaporates back to the atmosphere (snow sublimation), further compounds this effect, reducing soil water recharge. The end result is a water-stressed forest that not only becomes more susceptible to insects and disease but also more prone to supporting severe wildfires, because live fuel moisture is relatively low.

old-growth structure intermixed with small openings that can persist for centuries, provided that moisture and temperature regimes do not dramatically change. During a cool, wet climatic period or through fire suppression, ponderosa pine forests will allow Douglas-fir or denser ponderosa pine to become established and, over a period of decades, may become dominated by this dense forest structure. The increased biomass and densification of the forest then allows fires to develop into large, active crown fires that bring the site back to the initial stand-establishment phase, or, if fire reburns these areas soon, may limit forest establishment owing to loss of seed source, limited soil moisture, and high surface soil temperature. This is a situation of concern for increasing temperatures and drier summers in overly dense dry forests in the Northern Region.

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A recent example from the Custer National Forest illustrates the possible effects of uncharacteristic succession into a dense forest structure not typical of the historical fire regime. Historically, these forests were more open-grown; however, lack of disturbance led to high-density stressed forests and a dramatic change in forest pattern after the Brewer Fire in 1988, then a reburn of the same area in the Kraft Springs Fire in 2002 (**figs. 4** and **5**). The pattern and structure of the forest, which once supported white-tailed deer (*Odocoileus virginianus*) and flammulated owls (*Otus flammeolus*), now has changed to mule deer habitat and a nonforest condition for many years (**fig. 6**).

In another ponderosa pine forest near Lake Koocanusa on the Kootenai National Forest in northwestern Montana, commercial thinning returned the forest to a density more typical of a low-severity fire regime (shown in fig. 7 on the right side of the road), leading to a subsequent surface-fire burn, as compared to the lethal crown fire that occurred to the left of the road (**fig. 7**) during the Camp 32 Fire in 2007.

Dry Douglas-fir communities, especially in eastern Montana, function in a way similar to ponderosa pine forests, where density management and moisture deficits are key issues in developing more resilient forests. These areas currently are too cool to support ponderosa pine; however, that could change in a warming climate. Thus, these dry forest types occurring on approximately 3.5 million acres also urgently need to be restored to a more historical density, particularly in the face of projected climate change in the Northern Rocky Mountains.

The remaining major departure from historical conditions in the Northern Region is the homogenization of size class and the pattern of those successional stages in the higher elevation lodgepole pine and whitebark pine forests, which comprise about 10 million acres in the region. The current pattern is one of uniformity—the forests tend toward a single size class (9 to 15” dbh), and one which is susceptible to mountain pine beetle infestation. Historically, only about one third of the forest would have been in that size class.

Projecting future trends in bark beetle population dynamics is complex, owing to numerous, often interacting, contributing factors. The two primary drivers of bark beetle outbreaks are (1) the distribution and susceptibility of host trees (Fettig et al. 2007), and (2) the effects of temperature and other climatic factors on the survival and development of bark beetle populations (Raffa et al. 2008). Future population trends for mountain pine beetle (MPB) and other bark beetles will be determined primarily by the distribution of susceptible host trees and climatic conditions conducive to rapid population growth (Bentz et al. 2009). Bark beetle outbreaks require large expanses of susceptible-aged and homogeneous forest. Past research has established relationships between stand characteristics and susceptibility to MPB attacks (Fettig et al. 2007). The current outbreak and severity of mortality linked to the pattern of susceptible host tree species is illustrated in **figure 8**.

Typical conditions prior to effective fire suppression. **Altered forest structure became much more dense.**

Barry Bollenbacher



Figure 4—Stand-level effects of uncharacteristic multiple disturbances within an altered fire regime in ponderosa pine in eastern Montana (Custer National Forest).

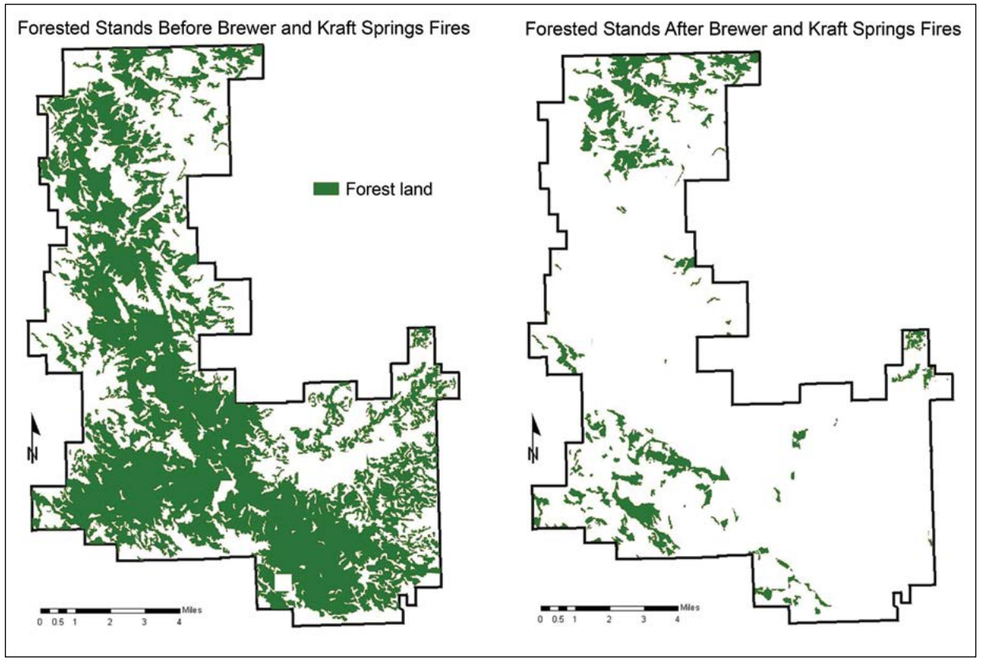


Figure 5—Forest-level effects of uncharacteristic multiple disturbances within an altered fire regime in ponderosa pine in eastern Montana (Custer National Forest).



Dennis Sandbak



Dennis Sandbak

Figure 6—Results of a double burn in ponderosa pine on the Custer National Forest have set the site back so severely that regeneration of the forest will take decades, reducing carbon sequestration and onsite water storage, and transforming traditional whitetail deer and flammulated owl habitat into mule deer (*Odocoileus hemionus*) habitat.



Megan Strom

Figure 7—Commercial thinning on the right side of the road returned the forest to a density more typical of a low-severity fire regime, leading to a surface-fire intensity, as compared to a lethal crown fire to the left of the road.

Climate variability and long-term trends will also influence the potential for large-scale outbreaks of MPB. Climate influences bark beetle populations in multiple ways, including over-winter survival, reproductive rate and success, dispersal ability, timing of egg and larval life stages, timing of adult emergence, and time required to complete a life cycle. Recently, entomologists have developed models of potential effects of climate change on population dynamics of the MPB. These models simulate the effects of climate projections on the probability of MPB over-winter survival (cold tolerance) and probability of adaptive seasonality. Adaptive seasonality combines several temperature-dependent life-history characteristics to describe MPB life-cycle timing that results in univoltism (complete life cycle within one year) and adult emergence during an appropriate window of time to facilitate mass attack on host trees (Bentz et al. 2009, Logan and Bentz 1999). A more detailed discussion of the effect of climate change on bark beetles in the Western United States is available at http://www.fs.fed.us/wwetac/projects/PDFs/RTA_Bark_Beetle.pdf.

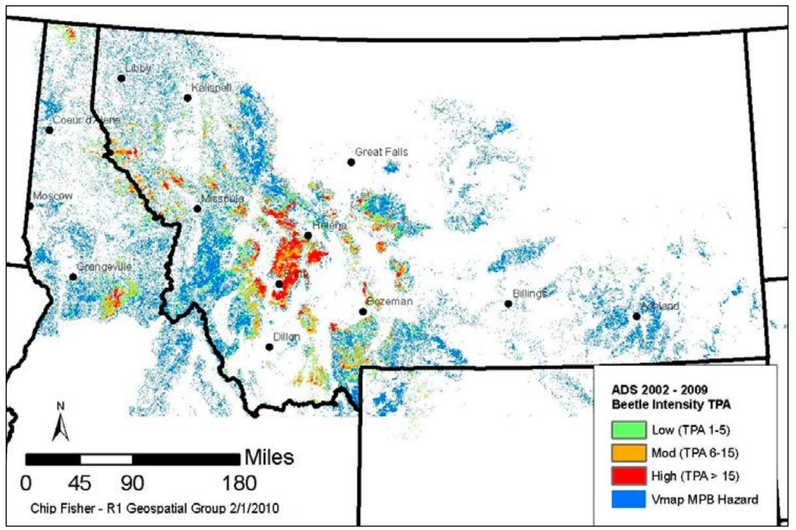


Figure 8—Spatial extent and severity of the current mountain pine beetle outbreak in the Northern Region, showing outbreaks mapped by aerial detection surveys (ADS) between 2002-2009 as well as areas with potential for outbreaks as estimated from the Northern Region's VMap vegetation mapping products.

Cold-tolerance models project that the probability of over-winter survival of MPB will increase over most of the Western United States throughout the 21st century, particularly at higher elevations (Bentz et al. 2009). A substantial increase in cold temperature survival probability, relative to the 1961–1990 period, is projected for Montana for the period 2001–2030. Cold-tolerance models project that at the end of the 21st century, most areas in the Western United States currently containing pine forests will have a moderate to high probability of cold temperature survival for MPB. Exceptions are the high elevations along the Continental Divide in Montana and portions of the Greater Yellowstone area. Adaptive seasonality models project a decrease in MPB outbreak potential in lower elevation forests and an increase in potential for higher elevation forests, including portions of northern Idaho, for the period 2001–2030 compared to 1961–1990 (Bentz et al. 2009).

Increasing the diversity of stand ages, size classes, and tree species in currently homogeneous landscapes can reduce the extent and continuity of highly susceptible stands at any one time, and thus the severity of bark-beetle-caused tree mortality during outbreaks in lodgepole-pine-dominated areas of central Montana (fig. 9) (Bentz et al. 2009, Fettig et al. 2007). Timber harvest, prescribed fire, and wildland fires managed for resource objectives are the most

commonly available tools for increasing landscape heterogeneity, reducing the departure from historical conditions, and promoting a more sustainable, resilient landscape pattern (Turner 2012).

As we consider past variability and add to that the suggested human influences, there may be significant changes occurring across the Northern Region forests owing to a changing water balance and the role of disturbances such as wildfire, insects, and disease. Whether invasive species (e.g., white pine blister rust), drought, uncharacteristic wildfires, elevated native insect and disease levels, unusually high forest densities, reductions in landscape heterogeneity, or some other agent or combination of agents are what serve to stress trees and forest ecosystems, recent research suggests that climate change will likely exacerbate those stressors, and that stress complexes will continue to manifest themselves (Littell et al. 2010, McKenzie et al. 2009, Turner 2012).

The NRO was specifically developed to address three areas:

1. Implement the natural resources agenda, which includes developing a process for including larger landscape assessments such as the Columbia River Basin (Quigley and Arbelbide 1997) and Northern Great Plains Assessments (USDA FS0 2000) in a region-wide assessment. In 1998, Chief Dombeck announced what would become known as the agency's Natural Resource Agenda (NRA). The NRA builds on this historical and legal foundation by making the maintenance and restoration of healthy ecosystems and watersheds a top priority. Based on sound science, the Forest Service is implementing policies and strategies for restoring, protecting, and maintaining healthy ecosystems at the watershed level. Some of the critical issues now facing the Nation's watersheds (and that informed the NRA) include invasion of exotic species, risk of severe and extensive wildfire, undesirable changes in vegetation, loss of species viability, degradation of aquatic ecosystems, excessive roading and poor road maintenance, air pollution, development on private land, and abandoned mines.
2. Communicate the situation in the Northern Region, based on the Forest Service Chief's review of the region in February 1998. A regional business plan conveying this information would be prepared, and the NRO would provide the basis for this plan.
3. Provide an umbrella assessment to be used by the national forests and grasslands within the region. The field units would use this as context for their forest plans and project-level analysis, and could further refine and enhance the information for their field units based on local data.

An initial NRO report was developed in 1998 and updated in 2006 with the first version of the IRPS, adding spatially explicit information to the assessment. Significant impacts of particular concern were invasive species and introductions of exotic species (e.g., nonnative fish and blister rust). Because the first stage of the NRO was developed without the spatial analysis tools now available, the Northern Region determined that a GIS-based spatial analysis and display tool should be part of the next version of the NRO, which then became IRPS version 1. The IRPS provides these new capabilities, and continues to build upon past NRO efforts.

The IRPS assessment was initiated in 2005 and the current version of the IRPS was completed in 2010, prior to any of the national initiative assessments, discussed below, concerning ecological conditions. The IRPS was designed to provide a more spatially explicit understanding of ecological conditions and to identify and assist forest and grassland units with selection of opportunities for restoring ecological systems to more resilient conditions, while also identifying areas where social infrastructure could be protected to the extent possible from uncharacteristic local disturbances affecting social values.

Amanda Milburn



Figure 9—Diversity of the pattern of size classes of lodgepole pine forests in the Helena National Forest, Montana, shows that not all stands are susceptible to mountain pine beetle mortality at the same time.

Click bolded text to view the text box.

Policy and Restoration Initiatives

A basic objective of the IRPS is to implement national direction as outlined in the National Restoration Policy and Guidance (box 1) and the 2012 Planning Rule (U.S. Government 2012) (**box 2**). The rule emphasizes identifying watersheds that are a priority for maintenance or restoration. However, the areas for analysis during an assessment should be defined by what is appropriate for the ecosystem components being assessed. In the case of vegetation in the IRPS, landscape units of approximately 400,000 acres were used to model past vegetation conditions to set up a comparison of existing conditions. Disturbance factors tend to influence and form patterns at that scale, whereas within fine-scale analysis units, there is a tendency to miss disturbance from adjacent areas. The use of IRPS to determine restoration priorities by subwatershed addresses the planning rule intent. Restoration of riparian areas is also a priority in the rule. Restoration can be accomplished through "passive management or may require active management, particularly in areas where disturbance such as fire or flooding have been excluded or where past management has altered function" (U.S. Government 2012). In other words, active restoration is encouraged. Timber harvest is also recognized in the rule as a valuable restoration tool. Specifically the rule states: "Today, harvest of timber on NFS lands occurs for many different reasons, including restoration of ecological resilience, community protection in wildland-urban interfaces, habitat restoration, and protection of municipal water supplies." Thus, the rule clarifies that timber harvest on lands suitable for timber production can also occur to meet restoration needs, along with community protection in the wildland-urban interface. Hazardous fuel reduction projects are already authorized under the Healthy Forests Restoration Act (HFRA).

At the national level in the Forest Service, there are several resource-specific priority-setting initiatives that use decision-support system technologies, including the Watershed Condition Framework (**box 3**), the Terrestrial Condition Assessment (**box 4**) (presently in development), the Cohesive Fire Strategy (**box 5**), the fuels-budget allocation system (Reynolds et al. 2009), and the Secretary of Agriculture's All-Lands Strategy (**box 6**). Each initiative uses some form of decision support to help identify restoration treatment opportunities or priorities, but none of these initiatives was deliberately designed for integration with the others. Particularly in these times of limited budgets, focusing on priority opportunities is important; however, doing so without integrating with other functionally similar efforts may not be the most efficient way to locate, prioritize, and design project activities. From the beginning, however, one of the goals of IRPS was to integrate restoration opportunities across the array of resource issues represented by boxes 3 to 6. In addition to the national initiatives mentioned above, IRPS was also designed to incorporate a regional one, the Whitebark Pine Range-Wide Restoration Strategy (**box 7**). It is

Box 1: National Restoration Policy and Guidance

In 2008, the National Restoration Policy and Guidance was finalized as Forest Service policy (FSM 2000). The manual provides direction for restoration on National Forest Systems (NFS) lands. It does not set program priorities, but rather provides the conceptual policy guidance for the agency. Specifically, the policy in Forest Service Handbook (2020.3) states:

1. All resource management programs have a responsibility for ecological restoration including, but not limited to, management of vegetation, water, wildland fire, wildlife, and recreation. Management activities may range from monitoring resource conditions to manipulation of terrestrial and aquatic ecosystems to regulation of human uses.
2. Establish ecological restoration goals and objectives in strategic plans to maintain the adaptive capacity of ecosystems—recognizing uncertainty related to climate change. Identify opportunities to sustain ecological refugia that may serve as vital sources of ecological diversity. Develop goals and objectives within the framework defined by laws, Indian treaties, regulations, collaboratively developed public and Indian tribal values and desires, historical conditions, current and likely future ecological capabilities, a range of climate change projections, the best available scientific information, and technical and economic feasibility—to achieve desired conditions (FSM 1900) for NFS lands.
3. Ecological restoration activities should be planned, implemented, monitored, and evaluated in consideration of current and desired conditions and the potential for future changes in environmental conditions, including climate change.
4. Where appropriate, integrate resource management programs and projects to achieve complementary or synergistic results contributing to ecological restoration.
5. Collaborate across ownerships and jurisdictions to achieve landscape restoration objectives.
6. Within existing authorities, revenue from commercial uses of natural resources may be used to help fund restoration activities.

In addition, the following direction is provided (FSM 2000):
Apply the following guiding principles when planning and implementing restoration projects:

7. Ecosystems are dynamic and change is inevitable.
8. Public involvement and consultation with Indian tribes is important in setting objectives for restoration.
9. Knowledge of past and current ecosystem dynamics, current and desired conditions, climate change projections, and human uses is fundamental to planning restoration activities.
10. Adaptive management, monitoring, and evaluation are essential to ecological restoration.

Click bolded text to view the text box.

also hoped that the IRPS framework will provide a useful starting point for regional collaboration with a broad range of other types of assessments (**box 8**). Figure 10 provides a simple conceptual framework that suggests ways in which the IRPS framework might interface with other initiatives and assessments.

Goals and Objectives of the IRPS

The basic goal of IRPS is captured in Forest Service Manual Chapter 2020 (FSM 2000): "The aim is to reestablish and retain ecological resilience of NFS lands and associated resources to achieve sustainable management and provide a broad range of ecosystem services. Healthy, resilient landscapes will have greater capacity to survive natural disturbances and large-scale threats to sustainability, especially under changing and uncertain future environmental conditions, such as those driven by climate change and increasing human uses."

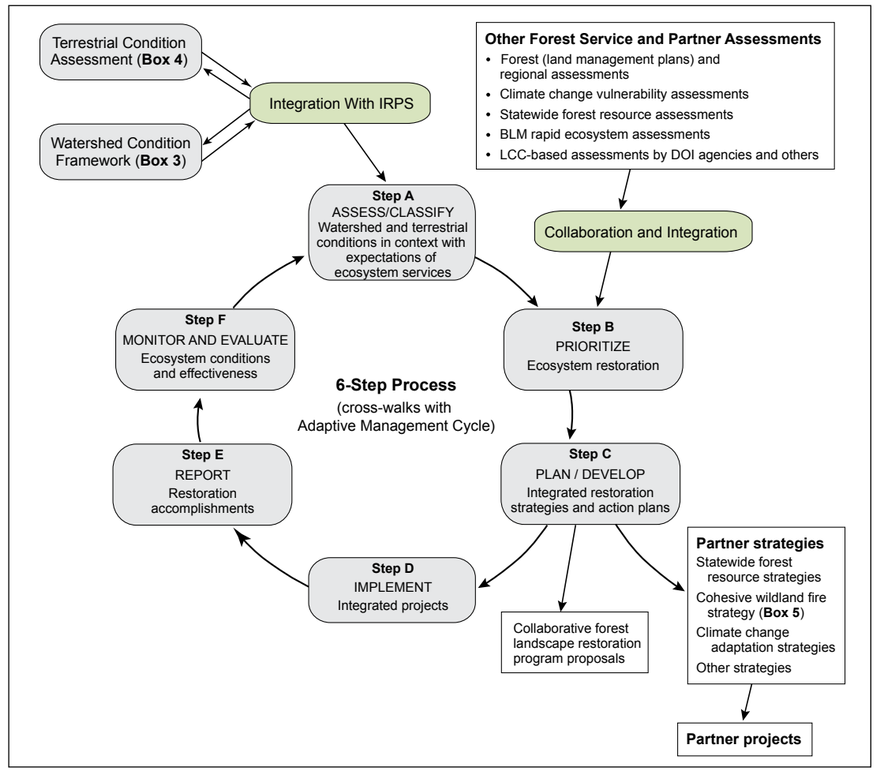


Figure 10—How the various national initiatives might integrate with Integrated Restoration and Protection Strategy and other assessments and strategies to achieve desired outcomes using an all–lands approach.

One of the objectives of the IRPS assessment was to summarize findings of ecological departure with tools being used in forest plan revision efforts within the region, such as the landscape simulation model SIMPPLLE. These analyses completed landscape simulation modeling at the approximate scale of a 4th-level hydrologic unit code (HUC)[3] (approximately 400,000 acres) to assist in the identification of ecological departure in vegetation (app. D2). A companion objective was to identify areas where departure of vegetation and aquatic systems might lead to increases in

Click the green underlined text to open Appendix D2.

Box 2: Planning Rule

The 2012 Planning Rule and associated directives explicitly address restoration of watersheds, ecosystems, and species of conservation concern.

The rule specifically references restoration in several sections. The Federal Register notice (February 14, 2011) on the 2012 planning rule states:

The proposed rule is more prescriptive about considering and facilitating restoration of damaged resources as well as improving resource capacity to withstand environmental risks and stressors (i.e., resilience), thereby providing greater capacity for sustaining local or rural economic opportunities to benefit from forest resources and ecosystem services, including recreation/tourism and water supply/watershed health as well as restoration based activities.

Refocusing the use of the term ''restoration'' to focus on recovery of resilience and ecosystem functions (instead of historical reference points) offers greater flexibility to develop plan components (e.g., desired conditions) that provide more feasible and adaptable direction for addressing damaged ecosystems.

Within the watershed context, the rule also directs forests and grasslands to develop plan components that "must provide for the maintenance or restoration of ecological conditions to contribute to the extent practicable, to maintaining a viable population of a species within its range." This is addressed by using both coarse-filter and fine-filter assessments. (Haufler 1994, Morgan et al. 1994, Roloff et al. 1997) The coarse-filter addresses departure of composition, structure, and ecological function, while the fine filter addresses those species that cannot be addressed by the coarse filter habitat assessment. Viability, a requirement in the planning rule, can be supported by the coarse filter in many cases, which is not a species approach as such.

[3] The hydrologic unit code (HUC) is a numbering system for watersheds. It was developed by the U.S. Geological Survey in cooperation with the U.S. Water Resource Council and the U.S. Department of Agriculture Natural Resources Conservation Service to provide a common coding system for state and federal agencies.

Box 3: Watershed Condition Framework

The Forest Service Watershed Condition Framework (USDA FS 2011) is a comprehensive approach to implementing integrated watershed restoration on all national forests and grasslands. It is a six-step outcome-based process for improvement of watershed conditions (fig. 11). The steps first provide a numeric condition against which future condition of the same watersheds can be compared in future years. National forests and grasslands are asked to determine priority watersheds for restoration based on local knowledge, ecological, social, and economic considerations, forest and grassland plans, and national and regional strategies and direction. These priorities should align with outside agency efforts and partnership opportunities. Watershed action plans are then developed and implemented, accomplishments are tracked, and monitoring is conducted to verify that treatments are implemented and are achieving anticipated restoration. If conditions change or results are not sufficient, further adaptation of restoration measures may be required.

To date, all 6th-level hydrologic units (hereafter, subwatersheds, approximately 10,000 to 40,000 acres) on national forests and grasslands have been given a numeric rating based on 24 questions in four categories (aquatic physical, aquatic biological, terrestrial physical, and terrestrial biological) and have been placed into one of three condition classes: functioning, functioning at risk, and impaired. Within the Northern Region, all forests have selected at least two priority subwatersheds in which essential restoration work is planned to be completed within a 5-year timeframe. The relatively small Dakota Prairie Grasslands has selected only one watershed. Each Forest Service region is anticipated to be assigned annual targets for the number of subwatersheds in which condition must be improved.

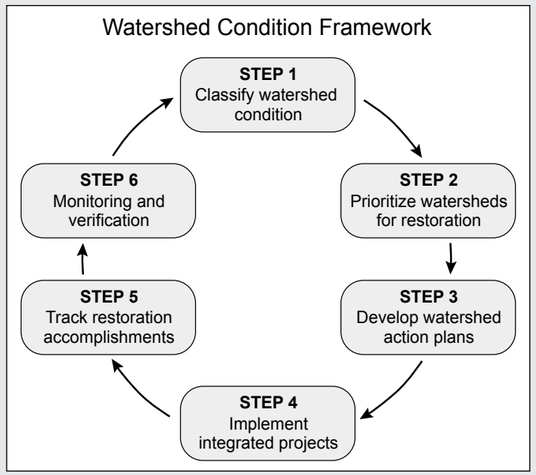


Figure 11—Basic steps in the Watershed Condition Framework.

Box 4: Terrestrial Condition Assessment

Under development is a national terrestrial condition assessment (TCA) designed to complement the watershed condition framework (WCF). This effort will facilitate integration of broad ecological conditions with the completed WCF. The information used in TCA is being compiled by a national core team of ecologists, silviculturists, and Forest Health Protection staff members. The TCA assesses similar information as contained in scenario 1B and 1C in the Integrated Restoration and Protection Strategy (IRPS) but is not integrated with other national initiatives at this time. Information from IRPS can help supplement the developing TCA when implemented. Both frameworks, IRPS and TCA, use Ecosystem Management Decision Support methodology design principles to access priorities. This methodology is described in the "General Description of Decision Support" section of this report. Once the TCA is fully developed, it will be integrated into the WCF with 6th-level hydrologic unit codes being reporting units. As an integrated approach, IRPS will assist in the priority selection or sequencing of restoration watersheds, thereby taking advantage of integration completed in the Northern Region IRPS.

Box 5: National Cohesive Wildland Fire Management Strategy (Cohesive Strategy)

The Cohesive Strategy is a collaborative process with active involvement of all levels of government and nongovernmental organizations, as well as the public, to seek national, all-lands solutions to wildland fire management issues. It addresses the Nation's wildfire problems by focusing on three key areas: resilient landscapes, fire-adapted communities, and responses to wildfire (fig. 12).

The Cohesive Strategy is being implemented in three phases, allowing stakeholders to systematically develop a dynamic approach to planning for, responding to, and recovering from wildland fire incidents. This phased approach is designed to promote dialogue between national, regional, and local leadership. The strategy can be strengthened by integration with other program areas.

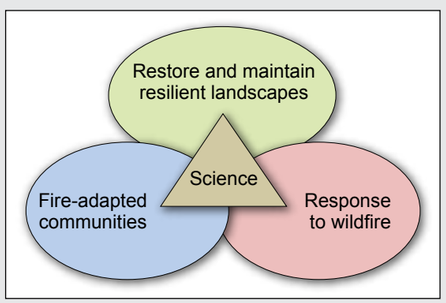


Figure 12—Elements of a National Cohesive Wildland Fire Management Strategy.

Box 6: All-Lands Strategy

U.S. Department of Agriculture (USDA) Secretary Tom Vilsack and U.S. Forest Service Chief Tom Tidwell have initiated an all-lands approach to conservation that recognizes the value of all forests and trees—rural and urban, public and private—in all states and U.S. territories. It was recognized that public benefits as well as forest threats cross boundaries, and are best addressed through integrated partnerships and infrastructure (markets, resource professionals, and information). Threats facing National Forest System (NFS) lands, such as fire, insects and disease, air pollution, and drought, do not recognize property boundaries, nor do many of the species dependent on NFS lands, or the benefits coming from them such as water and clean air.

A legacy of fire suppression, coupled with climate change, has created increasing ecosystem stresses that exacerbate existing threats and put at risk such benefits as clean water and air quality. To better respond to management needs, an all-lands approach to planning is being pursued to help understand the unique role that each land ownership jurisdiction plays (ecologically, socially, and economically) within the broader landscape, how threats and resources are crossing boundaries, how pressures and management of surrounding lands may affect resources or activity on NFS lands, and how each ownership's management could be revised or amended as a result. The all-lands approach to assessment features collaboration engaging the public early and often to build a common understanding of the roles, values, and contributions of NFS lands within the broader landscape. Implementation of this approach does not, however, mean that NFS managers would seek to direct or control management of non-NFS lands, nor does it mean that NFS managers would conform management to meet non-NFS goals.

disturbance probability that might put at risk social infrastructure such as structures, municipal water quality, developed and dispersed recreation sites, power transmission lines, and related human developments that could be concerns for public safety. Another important objective of the IRPS was to assess the relative restoration opportunities in an integrated way to assist national forests and grasslands with selection or sequencing of high-priority integrated restoration projects. The integrative reporting unit for the IRPS is the 6th-level HUC, and helps provide a way to prioritize, in a consistent way, possible integrated restoration projects. To assist in accomplishing this objective, a DSS was developed to integrate information related to current condition, and current and probable future threats to desired conditions.

Box 7: Whitebark Pine Rangewide Restoration Strategy

A rangewide restoration strategy for whitebark pine (*Pinus albicaulis*) has been developed (Keane et al. 2012), consisting of a set of principles coupled with associated actions to guide the design, planning, and implementation of restoration activities throughout the range of whitebark pine (Schoettle and Sniezko 2007, Schwandt 2006). The guiding principles represent broad areas of emphasis that should be addressed when restoring whitebark pine. They were taken from a number of sources and represent the most current research in whitebark pine conservation (Aubry et al. 2008, Elderd et al. 2008, Fins et al. 2001, McKinney 2004, Schoettle and Sniezko 2007, Schultz 1989, Schwandt et al. 2006, Sniezko et al. 2004, Waring and O'Hara 2005). The principles include (1) promoting rust resistance by facilitating and accelerating natural selection for blister rust-resistant genotypes in stands; (2) conserving broad genetic diversity by collecting and archiving seeds, and growing and planting genetically diverse seedlings; (3) saving seed sources by protecting mature, seed-producing, rust-resistant whitebark pine trees in areas that are experiencing rapid decline; and (4) employing restoration treatments in areas where whitebark pine forests are declining owing to insects, disease, or advanced succession.

Proactive restoration includes (1) managing the spread of blister rust by controlling alternate hosts, (2) using fire in successionally advanced communities to encourage whitebark pine regeneration, (3) thinning and reducing competing vegetation to increase the vigor of trees and reduce the likelihood of mountain pine beetle attacks, (4) planting rust-resistant seedlings to accelerate the effects of selection, and (5) promoting natural regeneration and diverse age-class structures to maintain ecosystem function and provide large populations for selection for rust resistance. The ultimate goal is to create diverse age-class structures that facilitate the selection process for rust-resistance (Schoettle and Sniezko 2007).

Box 8: Other Forest Service and Partner Assessments

- Forest land management planning and regional assessments
- Climate change vulnerability assessments
- Statewide forest resource assessments
- Bureau of Land Management Rapid Ecosystem Assessments
- Landscape Conservation Cooperative based assessments by Department of the Interior agencies et al.

Click bolded figure text to view the figure.

The IRPS currently serves as a starting point, combined with local, more site-specific information such as input from partners and collaborative groups, to identify and sequence priority integrated restoration proposals. This has occurred within Collaborative Forest Landscape Restoration Program (CFLRP) areas on multiple forests, and has occurred forest-wide on several forest units. One unforeseen application is that the IRPS is also being used to help inform national functional initiative assessment tools such as the national Watershed Condition Class assessment, the national Terrestrial Condition Assessment, and the national Cohesive Fire Strategy (**fig. 10**), developed after the IRPS was completed, with more local data.

A final objective of DSS implementation was to identify where potentially high-priority multiple-resource objectives could be met in the same location by integrating values at risk under a **theme**, which is a collection of similar resource concerns and objectives, and across themes. This strategy also provides information, along with approximately 50 GIS layers, to collaborate across administrative and other jurisdictional boundaries in projects such as the state assessments (**fig. 10**), to restore or protect values that may be at risk to current or projected disturbance or other risk factors.

Implementing IRPS in the Northern Region

The focus of the Northern Region IRPS is to provide spatially explicit GIS and landscape simulation modeling information using SIMPPLLE, reported at a sub-watershed scale (6th-level HUC) to help forests and grasslands manage and restore resilience with a more integrated approach in the context of current and projected risks. Overarching questions in the past, related to where we invest in the highest priority areas for restoration, have been "why here?" and "why now?" Restoration requires the manipulation of ecosystem elements and processes, and thus requires specific definitions of the components to be managed in the system, as well as desired conditions of restoration, i.e., restoring the resilience "of what," "to what," "for what," and "for how long."

As an example, one of the individual resource attributes assessed in the IRPS is the desired condition of resilient forest ecosystems, in which the forest contains, for the local biophysical setting, a specifically defined diversity of composition, size, density, and pattern (of what) that enables it to be resilient to changing disturbance processes (to what). These attributes were evaluated for each of 55 landscapes (averaging 380,000 ac) using the SIMPPLLE landscape simulation model, and were evaluated in terms of historical, compared to current, condition to help identify restoration opportunities. Important compositional changes included significant reductions in aspen, western white pine, whitebark pine, western larch, and ponderosa pine tree species forest types. (See app. D2 forest vegetation departure spreadsheets for specific desired condition and current condition metrics.) These forest ecosystems, once restored, should be able to maintain their capacity to provide various ecosystem services such as wildlife habitat in the short and long term. This approach is considered to be a coarse-filter assessment to inform desired conditions for restoration. The approach provides for a range of species habitat conditions at a variety of spatial scales over the long term and offers the best possibility of maintaining biological diversity for the vast majority of species (Committee of Scientists 1999, Hunter 1990). An understanding of past, current, and projected future disturbance regimes and their influence on the composition, structure, and spatial arrangement of vegetation is critical to conserving biological diversity at broad spatial scales (Haufler 1999). With climate change considerations, one needs to identify assumptions for the future and hypotheses to monitor. In this case, the departure (loss) of fire-adapted tree species intolerant to shade and other disturbance-adapted forest types such as those previously mentioned are key to future resilience and capacity to provide such things as sustained wildlife habitat. Some important assumptions about future trends are:

- Expect warmer temperatures, similar precipitation, with dryer summers, resulting in increasing moisture deficits (Littell et al. 2009, Snover 2013).
- Expect increase in fire severity, number, and size (Dillon et al. 2011, Keane et al. 2008, Keeling and Sala 2012, Littell et al. 2010, Turner 2012).
- Expect increasing bark beetle activity (Bentz 2009).
- Expect tree species that are intolerant to shade to cope more effectively with possible future climate compared to tolerant species (Chmura et al. 2011).

Considering these assumptions, a hypothesis for restoration to more resilient forest conditions includes:

- Restoring a higher proportion of shade-intolerant tree species that are more drought resistant such as ponderosa pine, western larch, and western white pine that should enable the forests to cope more effectively with climate change and increasing disturbance and have a greater capacity to persist compared to shade-tolerant species (Chmura et al. 2011).
- Reducing forest density should help the forest cope with increasing moisture deficits and severe fire (Bollenbacher 2013).
- Restoring size- and age-class diversity of forest patches and the pattern of those conditions should assist in limiting disturbance in any one time-step and encourage forest regeneration (Turner 2012).
- Anticipating the potential for persistent shifts in vegetation composition, structure, and functional type (Loehman et al. 2011, Marlon et al. 2012, Westerling et al. 2011).

A monitoring program, using a combination of Forest Inventory and Analysis (FIA) vegetation grid plots and change detection using satellite imagery to assess changes in pattern, is now being implemented in the Northern Region to allow broad-scale effectiveness monitoring over time. Specific project-level implementation monitoring is being completed by the evaluation of posttreatment conditions.

During 2010–2011, resource specialists in the Northern Region updated the IRPS (first completed in 2006), paralleling DSS methods implemented in the Ecosystem Management Decision Support System (EMDS) (Reynolds et al. 2003, Reynolds 2006). The goal of this strategy was to provide a consistent, transparent, and reproducible approach to identifying and prioritizing restoration opportunities by subwatershed across the region, forests and grasslands, and districts. Similarly, the Watershed Condition Framework (**box 3**) and the Terrestrial Condition Assessment (**box 4**) are national initiatives using DSS technology and nationally derived GIS layers that have been developed since the IRPS. The IRPS has more precise, and in many cases, more accurate local data in the regional GIS layers, and is being used to modify the national input layers for the Northern Region in those initiatives. Additionally, the strategy sets the context for collaboration in an all-lands approach (**box 7**) that, as we implement treatments, will lead to more resilient terrestrial and aquatic ecosystems.

Click bolded text to view the text box.

The Northern Region IRPS now provides information to help local units assess ecological conditions, assess risks to related ecosystem services, and identify and prioritize potential subwatersheds for accomplishing goals and objectives of forest and grassland plans. It is intended to assist local units in developing and prioritizing integrated projects that address land and water restoration; community wildfire protection plans; and sustainable, resilient, and desired conditions as described in forest and grassland management plans. It provides resource information on values that may be vulnerable or at risk to specific agents of change, including disturbance agents, to help units develop integrated projects.

The IRPS assessment used more than 50 GIS layers to address 19 different management concerns. The management concerns were selected by staff specialists and the leadership oversight committee, including the regional forester's office, as those representing currently important regionwide concerns to be addressed. These management concerns were grouped into six themes to organize the assessment more efficiently, and included the current departure and resilience of forested and nonforest vegetation communities, wildlife habitats in short supply or threatened by potential disturbance, water quality concerns, rare or declining fish habitat, recreation, and public safety concerns.

This DSS provides:

- Context for integrated, rather than mitigated, projects;
- Increased efficiency through bundling functional dollars to accomplish multiple objectives;
- A consistent information source and approach to collaborating with other landowners to prioritize restoration across jurisdictional boundaries;
- Identification of opportunities to use stewardship contracting to perform restoration forestry while providing revenue to complete other restoration work that is not historically well-funded;
- A framework and platform for our adaptation strategy for climate change; and
- An opportunity to add local data to address more issues including information related to the space and time feasibility of potential opportunities.

The IRPS Analytical Framework

The IRPS addresses 19 key planning questions, derived from management concerns, and identifies opportunities and potential priorities for 19 associated resource objectives (called **scenarios**) that may be at risk from current or projected disturbance and other agents of change. Throughout the remainder of this report, we refer to the evaluation of each resource value as a scenario, and the 19 scenarios are stratified into six **themes**. The themes and scenarios were identified and designed by staff specialists in an interdisciplinary fashion, then concurred on by regional leadership that acted as a steering committee. Each scenario represents a resource objective in the DSS, and contributes to a potential spatial solution for IRPS opportunities. The scenarios are likely to change over time, so the decision-support framework must be flexible enough to address various questions with the same data or new information as needed.

Each scenario was evaluated based on three primary decision criteria: values, risks, and feasibility, with values representing the current state of key resources. Primary criteria were weighted by staff specialists in the regional office and reviewed by the Regional Leadership Steering Committee, which included the regional forester's office, to express their perception of the relative opportunity to minimize or reduce the risk factors to restore a more resilient condition. This cross-checking with management validated perceptions of relative importance to management, and how important various elements are to the management decisionmaking process for how to sequence opportunities. Although each scenario included a feasibility criterion, in application at the regional scale, we found that information relevant to assessing feasibility was not readily available at the broad scale. So, without the feasibility criteria

in the regional model, model outcomes should be considered potential restoration opportunities to be verified with local feasibility factors. Hence, feasibility becomes a very important factor at finer scales for locating actual project areas. There are many examples of feasibility factors or criteria such as, but not limited to, forest plan standards, management area direction, accessibility, partnership opportunities, local emphasis in other land ownerships to do similar work across land ownership boundaries, collaborative interest, and social license to implement restoration projects in controversial areas.

Themes and Scenarios

The primary resource objectives (scenarios) and associated themes addressed in the IRPS are described in this section. For each scenario, we state the associated planning question that motivates the scenario design. Narrative links under each theme provide additional background information on the scenarios.

Theme 1: Restoration of forests, grasslands, and human communities to a more resilient condition—
Within this theme, three resource objectives, or scenarios, are assessed by using a planning question to address the issue:

Click the green underlined text to open The associated appendix..

Scenario 1a—Community fire resilience (see narrative in app. D1).
Question: Which human community areas are most critical to improve fire resilience owing to burn probability or insect and disease risk?

Scenario 1b—Vegetation resilience and current departure from desired conditions in forested areas addressing resilience and vulnerability (see narrative in app. D2).
Question: Which forest areas offer the best opportunities to improve vegetation resilience to meet forest plan desired condition owing to high departure from historical conditions, or crown fire burn probability, or insect and disease risk?

Scenario 1c—Ecosystem resilience and vulnerability in nonforested areas (see narrative in app. D3).
Question: Which nonforested areas offer the best opportunities to improve nonforest ecosystem resilience owing to composition of nonforest types with noxious weed risk, or departure from historical fire regime (lack of fire), or grazing risk?

Theme 2: Restoration and maintenance of wildlife habitats, including restoration of more resilient vegetation conditions where appropriate, to meet ecological and social goals—
The narratives for scenarios under theme 2 are presented in appendix D4.

Scenario 2a—Restoration of whitebark pine ecosystems.
Question: Which forest areas offer the best opportunities to restore whitebark pine and associated habitats, considering the high level of mortality from white pine blister rust and mountain pine beetle (MPB), and high levels of wildfire burn probability in many areas resulting from succession to climax vegetation such as spruce-subalpine fir?

Scenario 2b—Low-elevation dry forest communities.
Question: Which forest areas offer the best opportunities to restore resilience of composition and density of dry forest communities and associated habitats, given current and projected insect and disease and high levels of wildfire burn probability in many areas because of uncharacteristically high forest density?

Scenario 2c—Dry shrublands (low-elevation sagebrush).
Question: Which low-elevation sagebrush areas offer the best opportunities to restore resilience of composition and density and associated habitats, given current levels of conifer encroachment and high levels of wildfire burn probability?

Scenario 2d—Aspen communities.
Question: Which aspen habitat areas offer the best opportunities to restore resilience of composition, density, and associated habitats, given current levels of conifer encroachment and high levels of wildfire burn probability?

Scenario 2e—Woody draw communities.
Question: Which woody draw habitat areas offer the best opportunities to restore resilience of composition, density, and associated habitats, given current levels of conifer encroachment and grazing, and high levels of wildfire burn probability?

Scenario 2f—Mixed-grass prairie.
Question: Which mixed-grass prairie habitat areas offer the best opportunities to restore resilience of composition, density, and associated habitats, given current levels of conifer encroachment and grazing and high levels of wildfire burn probability?

Scenario 2g—Riparian, wetlands, and seeps.
Question: Which riparian and wetland areas offer the best opportunities to restore resilience of composition, density, and associated habitats, given current levels of noxious weed hazard, grazing, and motorized access, and high levels of wildfire burn probability?

Scenario 2h—Big-game winter range.
Question: Which big-game winter range areas offer the best opportunities to restore resilience of composition, density, and associated habitats, given current levels of noxious weed hazard, current vegetation composition and structure vulnerability to disturbance agents, grazing, and motorized access, and high levels of wildfire burn probability?

Scenario 2i—Threatened and endangered (T&E) core grizzly bear habitat.
Question: Which core grizzly bear habitat areas offer the best opportunities to provide increased security, considering their current open road and motorized trail access and other human disturbance potential?

Theme 3: Restoration and maintenance of resilient, high-value watersheds—

Scenario 3—Watershed quality (sediment) (see narrative in app. D5)
Question: Which subwatersheds are best to restore because of municipal watershed use, section 303(d) listings, or the presence of multiple risk factors?

Theme 4: Restoration of high-value fisheries streams developing more resilient habitat—

Click the green underlined text to open The associated appendix..

Scenario 4—Threatened, endangered, and sensitive fish species (see narrative in app. D6).
Question: Which watersheds are best to restore owing to forest plan revision, aquatic species priority, or multiple risk factors?

Theme 5: Restoration and protection of recreation sites and scenic vistas—
See the narratives in appendix D7 for additional information on scenarios in theme 5.

Scenario 5a—Safety.
Question: Which areas are most important to protect or restore because of high concentrations of use with existing or potential hazard trees resulting from insects and disease and in areas with high burn probability?

Scenario 5b—Investment protection.
Question: Which areas are most important to protect from an investment perspective (e.g., high-investment areas that are at risk of damage)?

Scenario 5c—Recreation setting restoration.
Question: Which recreation settings are priority areas for restoration (e.g., high-use dispersed recreation areas in vulnerable subwatersheds)?

Scenario 5d—Scenic integrity restoration.
Question: Which areas are most important to restore or enhance (e.g., high-visibility areas with low or very low scenic integrity)?

Scenario 5e—Scenic integrity protection.
Question: Which areas are most important to protect from degradation (e.g., highly visible areas with very high or high existing scenic integrity)?

Theme 6: Protection of people, structures, and community infrastructure (roads, trails, bridges, power corridors, recreational developments, etc.) highlighting current and projected MPB and wildfire effects—
To consider public safety and protection of infrastructure, this theme uses scenarios 1a, 5a, and 5b a second time, based on current regional priorities.

Question: Which community areas are most critical to improve fire resilience owing to burn probability or insect and disease risk? (scenario 1a).

Question: Which areas are most important to protect or restore owing to high concentrations of use? (scenario 5a).

Question: Which areas are most important to protect from an investment perspective? (scenario 5b).

Decision Model Design

The overall architecture of the Northern Region IRPS DSS was designed as a three-tiered decision model.

At the lowest level, data for each of the 19 scenarios were evaluated by scenario-specific decision models (e.g., fig. 13). Initial prototypes of decision models for scenarios were designed in Criterium DecisionPlus,[4] [5] (a DSS tool for multicriteria decision analysis (Saaty 1992). However, for operational purposes, mathematically equivalent models ultimately were coded in Excel® spreadsheets. Definitions of data fields used in all decision models are documented in appendix A, and decision models for all scenarios are documented in appendix B. Each team of specialists working on a specific scenario assigned relative weights to subcriteria (e.g., level 2 in fig. 13) such that they summed to a value of 1 when summed over all subcriteria, thus indicating the relative importance of the contribution of each subcriterion with respect to restoration priority as perceived by the specialist team. Weight assignments are also documented in appendix B for each scenario. In connection with the use of weighting in the IRPS DSS, it is important to acknowledge at this point that, although decision models provide a formal framework for reasoning more critically about choices in a decision process (e.g., which subwatersheds should receive the

Click bolded figure text to view the figure.

[4] The use of trade or firm names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.

[5] InfoHarvest, Inc., P.O. Box 25155, Seattle WA 98165-2055. http://www.infoharvest.com/.

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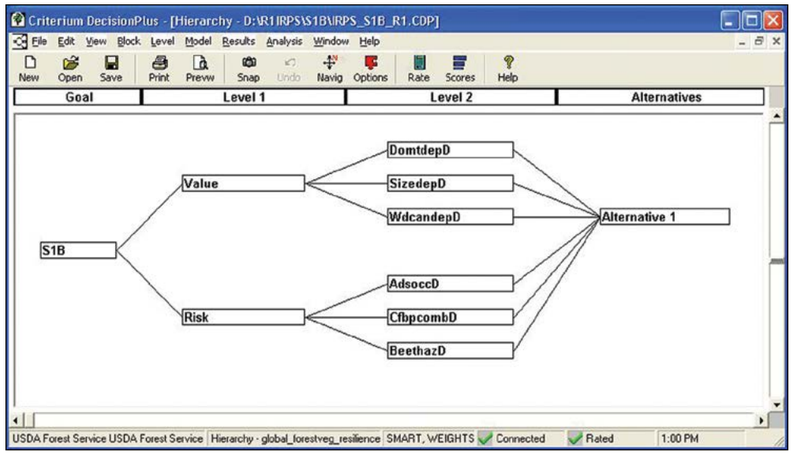
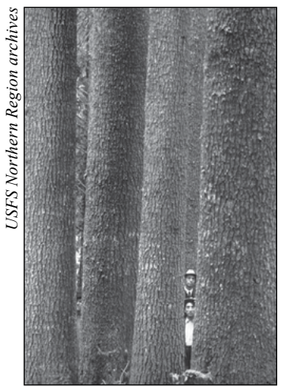


Figure 13—An example of the decision model for scenario S1b that addresses resilient forest vegetation condition relative to desired condition. Subcriteria considered under the value criterion include departure of dominance type (similar to forest cover type) relative to desired conditions (DomtdepD, fig. 14), departure of size class relative to desired conditions (SizedepD, fig. 15), and departure of forest density relative to desired condition (WdcandemD, fig. 16). Areas where density is departed can be restored using tools such as fire (**fig. 17**), resulting in a closer approximation of desired conditions (**fig. 18**).

USFS Northern Region archives





Art Zack

Figure 14—Example of departure of dominance type (similar to forest cover type) relative to desired conditions (DomtdepD in fig. 13). The western white pine type typical of historical conditions (left), has largely been lost and replaced by root disease-affected Douglas-fir and grand fir types today (right). These moist forests were characteristically dense, but have experienced major compositional changes.

Amanda Milburn





Canadian Forest Service

Figure 15—Example of departure of size class relative to desired conditions (SizedepD in fig. 13). Photo on the left illustrates how size class diversity has led to fewer beetle-susceptible landscape components in any one time period; on the right we see homogenization of forest size class with a lack of diversity leading to widespread, simultaneous susceptibility to disturbance agents such as mountain pine beetle.

Barry Bollenbacher



Figure 16—Example of increasing forest density (WdcandemD in fig. 13) and the susceptibility to uncharacteristic disturbance in dry forest environments. This photo depicts historical, more open forest conditions in ponderosa pine with a developing mid-story that may allow for uncharacteristic crown fire that will replace typical old-forest communities.



Ray Shearer



Mick Harrington

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Figure 17—In this example from the Lolo and Flathead National Forests (related to the WdcandepD factor in **fig. 13**), western larch forests have experienced uncharacteristic increasing forest density in dry to moderately moist sites in western Montana. Reduction of density is a tool to increase resilience to uncharacteristic wildfire.

Barry Bollenbacher



Figure 18—Walking with the Giants in Girard Larch Grove, Seeley Lake Ranger District, Lolo National Forest, after restoration treatments of harvest and prescribed burning.

highest priority for restoration) and documenting that reasoning (Saaty 1992), decisionmaking is necessarily a relatively subjective process on at least two levels. First, the specialists responsible for each scenario had to decide what attributes (or lowest-level criteria) were relevant to the scenario, which requires a judgment call. Second, they had to decide on the relative importance of the contributions of those attributes to the scenario-level priority score. Somewhat as a counterpoint to the inherently subjective nature of decision models, however, the formal model framework also provides a context for a reasoned discussion among model developers, especially when the design is a collaborative process. In the case of the IRPS, in particular, project reviews provided an opportunity for multiple levels of management to engage in the design process, so that, ultimately, many perspectives were brought to the table.

At the next higher level of the three-tiered decision architecture, the 19 scenarios were organized into the six themes described in the previous section. A priority score for each theme was calculated for each theme-specific decision model at this level (e.g., fig. 19).

In the current version of the DSS, the priority score for a theme was simply calculated as the average priority score over all scenario components of the theme, meaning that all scenario priorities in a theme are equally weighted, and therefore contribute equally to the priority score for the theme. However, more generic decision models for theme priorities could easily be designed, allowing for differential weights on component scenario priorities, if this were ever desired by managers. Decision models for all themes are similarly documented in appendix B.

Finally, at the highest level of the three-tiered decision model, an overall IRPS priority score is calculated, considering the contributions of the priorities of the six themes (**fig. 20**).

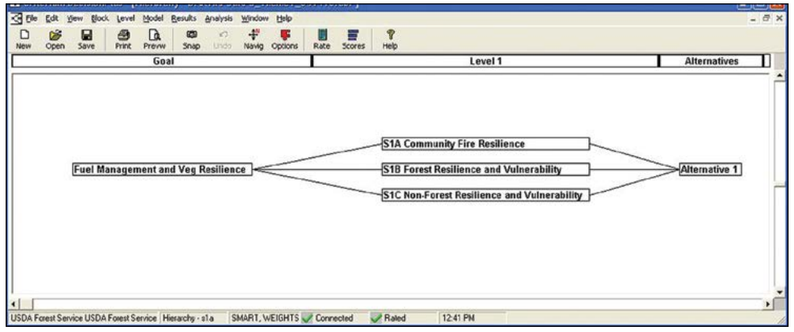


Figure 19—Decision model for priorities under theme 1 (restoration of forests and grasslands, directly adjacent human communities, to a more resilient condition). The goal object refers to the theme itself. Criteria at level 1 of the model, and prefaced by S1A, S1B, and S1C, refer to the three scenarios under the theme.

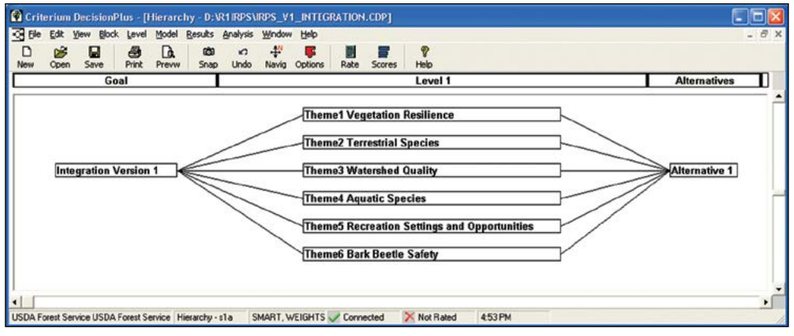


Figure 20—Top-level Integration and Restoration Strategy decision model, integrating across all themes. See Themes and Scenarios (app. C) for definitions of all scenarios under each theme.

The overall IRPS decision model addresses the question: Where in the Northern Region do all the identified multiple values at risk show potential priority opportunities for restoration or protection of values to identified risk factors? (See opportunity map for all themes integrated.) The contributions of theme priority scores to the **overall** decision score were equally weighted. An alternative a priori approach to weighting themes would be to weight each by the number of scenarios in the theme, a technique known as structural adjustment (Saaty 1992). The effect of structural adjustment is to ensure that all scenarios contribute equally to the final overall priority score. In other words, the contribution of any particular scenario is not diluted by belonging to a theme with a large number of scenarios. After carefully weighing the weighting options during a mid-project review, the equal weight option was selected, in part, to give equal emphasis to all themes, and, in part, to avoid overemphasis on theme 2, which has a relatively large number of scenarios related to vegetation conditions (app. D4).

Implementation

In the design phase, the three-tiered decision-model concept was developed with 19 resource-specific scenarios at the lowest level. During the design phase, specialists proposed value, risk, and feasibility inputs for each scenario, along with decision-model weights to be assigned to each input. In the implementation phase, a bottom-up approach was followed whereby scenario value, risk, and feasibility input sources were developed first, and then were summed to scenario, theme, and overall opportunity scores. At various steps in the process, several critical decisions had to be made, such as selection of analysis units, identification of data sources, and determination of methods to calculate summary statistics for input values per analysis unit. During implementation, by far the most time and effort were spent

developing scenario input data sources and summarizing them by analysis unit. In contrast, it took very little time to generate and view scenario, theme, and overall scores. Figure 21 outlines the process flow for IRPS.

The first implementation decision was the selection of subwatersheds as the spatial units of analysis based on historical and multiscale use of the data. The first Northern Region IRPS (completed in 2006) used subwatersheds to identify priority restoration areas. Regional leadership thought it was important to maintain that level of spatial resolution so that forests could compare the updated IRPS analysis with the first version. There was discussion with regional and forest staff about using 5th-level watersheds, especially because Montana was using them for its 2010 statewide assessment (Rogers 2010). The problem was that although 5th-level watersheds worked for a regional or statewide planning process, they were not considered to be of fine-enough scale for forest planning. Subwatershed assessments could be aggregated to a 5th-level HUC for collaboration with state and other

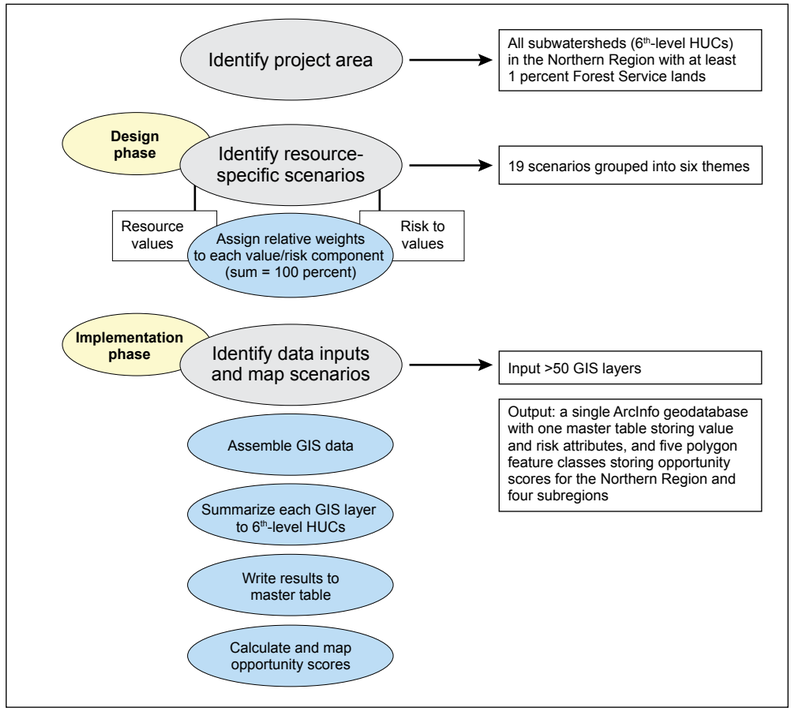


Figure 21—Process flow for the Integrated Restoration and Protection Strategy (IRPS). Resource specialists and geographical information system (GIS) analysts worked through the often-iterative IRPS process together. HUC= hydrologic unit code.

agencies, and still be used for forest-level planning. During the implementation phase, restricting the analysis to subwatersheds with 10, 5, and 1 percent Forest Service lands was considered. The regional leadership team decided to include subwatersheds with at least 1 percent Forest Service lands, because the National Watershed Condition assessment (USDA FS 2011) was being performed at that level of national forest ownership, and because the Community Fire Resilience (S1A) and Safety (S5A) scenarios were significantly different with inclusion of these subwatersheds.

Selection of scenario (input) data sources was done using a prototyping process that involved working with regional and forest specialists to identify potential data that represented value, risk, and feasibility factors, and then mapping them to subwatersheds to evaluate coverage and consistency issues. Initially, more than 120 scenario data sources were identified. During the design phase, several scenario data sources were identified for use in multiple scenarios. For example, the spatial data for bark beetle risk were used in six scenarios. In the implementation phase, scenarios with very similar inputs from different data sources were evaluated to simplify them to a single data source when possible, thus reducing redundancy. The prototyping process was used to evaluate how much influence these multiple inputs had at the theme or overall level. This process reduced the number of data sources from over 120 to 65, and substantially reduced GIS processing work. The evaluation of scenario data sources to identify important differences and similarities across all scenarios was perhaps the most important implementation step.

The evaluation of scenario data sources to identify important differences and similarities across all scenarios was perhaps the most important implementation step.

The Northern Region encompasses more than 26 million acres, so it was not always possible to find data sources with continuous coverage across all lands. Consequently, some scenario inputs were based on data sets covering only Forest Service lands or parts of Forest Service lands. These data sets lacked complete coverage across subwatersheds with extensive non-NFS lands. However, many important resource issues such as bark beetle potential mortality have only Forest Service lands coverage. LANDFIRE vegetation types (Rollins 2009) were used for several inputs instead of local forest vegetation data because of better coverage across all lands. In this case, local spatial or thematic resolution was given up to gain better regional coverage. (Note, however, that if future, more localized assessments are undertaken, the IRPS framework allows for forests to use better data where available.)

A few scenario inputs had consistency problems across the region because data were compiled from different sources. Some national forest data sets were collected following local criteria, based on forest assessment needs. When no other data source was available, these local data sets were compiled into a regional layer. Some data sets were from modeled data, based on small analysis areas that were compiled into a regional layer. For example, the crown fire, forest surface fire, and nonforest surface fire burn probabilities were based on Fire Program Analysis (FPA) assessments. The FPA burn probabilities had different data ranges and, in one case, slightly different criteria in the model. An attempt was made to normalize these data sets when they were compiled into regional layers, but there were still noticeable differences when mapped. In this case, local spatial or thematic resolution was gained at the expense of regional consistency.

A wide range of data formats was proposed as input to the scenarios, including single-feature GIS layers (vector and raster), modeled raster data from multiple sources, modeled vector data from multiple sources, FIA data summaries, tabular data summaries, and categorical or binary data. The wide range of data types presented unique challenges for characterizing values of scenario inputs to analysis units. In the end, all subwatershed scenario input summaries were written to and stored in a single data table. In the first implementation step, a subwatershed GIS layer with all subwatersheds meeting the 1-percent Forest Service lands requirement was created. A summary table was created from the GIS layer based on the HUC6_CODE attribute, and an attribute was added for every scenario input summary value. As each scenario input summary was calculated, the table was filled in for every subwatershed. This created a simple spreadsheet approach, in which all scenario inputs were located together, and scenario opportunity scores could be calculated from the table, an important consideration for later processing steps.

A fundamental issue in the analysis concerned choosing between use of area, linear, or counting sums (e.g., total miles of roads in a subwatershed) versus using percentile or density measures (e.g., density of roads in miles per square mile). In the course of the prototyping process, decisions were made to use direct sums for some scenario inputs and to use percentile or densities for others. This decision was based on the resource issue a scenario input was addressing, or if the measure enhanced relative differences among subwatersheds. For example, in the Watershed Quality Scenario (S3A), the number of dams in a subwatershed was used, because any dam was considered significant. Conversely, the percentage of dry shrublands in a subwatershed was used because it enhanced relative differences among subwatersheds. In general, if a data source had coverage across all lands, or if a layer had consistency issues, a percentage or density measure was used.

The Forest Vegetation Resilience Scenario (S1B) used FIA data summaries to compare current forest vegetation conditions either to forest plan desired conditions (for forests that have undergone plan revision) or HRV ranges in order to identify areas with significant departure. The FIA data summaries could not be performed

on subwatersheds because there were insufficient plots within them, and the vegetation metric (departure from forest vegetation desired condition) was not meaningful at that scale. Consequently, the FIA data were summarized across forest planning area or landscape areas called S1B analysis areas (about the size of a 5th-level HUC watershed). The forest vegetation departure index measures were then applied equally to all subwatersheds within them. This presented a problem for comparison of subwatersheds adjacent to each other, but worked well for comparison of subwatersheds across entire national forests.

Most value and risk inputs had continuous data ranges, but several scenario data sources were based on categorical data. These were generally binary data (yes or no), such as municipal or 303D-listed subwatersheds, or aquatic priority subwatersheds determined by previous regional assessments. Concerns were raised that these all-or-nothing inputs might unduly influence the analysis, but these concerns were addressed by adjusting their weights in the scenario opportunity-score calculation.

Several scenario inputs were originally derived from NetWeaver logic models (Miller and Saunders 2002) that interpreted and synthesized information from multiple data sources to produce a composite result. However, concerns were raised about the complexity of the logic models and the software. During the prototyping process, scenario inputs using NetWeaver logic models were simplified from multi-data-source logic models to single data sources. Scenario inputs that could not be simplified to single data sources were simplified to summaries of multiple data sources. An example is the road risk criterion in the Watershed Quality Scenario (S3A) that had three inputs: miles of roads, miles of road within 60 m (66 yards)of streams, and number of stream crossings. To simplify the process, an attribute was added to the value and risk input table for each of the road risk components and then a formula was used to combine the three inputs into a single road risk input:

$$\text{road risk} = (\text{road density} \times 0.2) + (\text{riparian road density} \times 0.4) + (\text{stream crossings} \times 0.4)$$

in which the three input fields were each first normalized to a standard [0, 1] range (see below). All scenario inputs with multiple components similarly had their attributes added to the value and risk input table so they could be recalculated if necessary.

Once all scenario inputs (app. A) were assembled into the value and risk table, an opportunity score for the scenario was generated using a decision model (app. B).

Many decision models employ a general formula of normalizing inputs, multiplying each input by a weight, and then summing the results to obtain an overall decision score. Because the value and risk inputs had different data types and ranges, they were normalized into a [0, 1] range so they could be summed (Kamenetsky 1982). A minimum-maximum normalization process was used for all scenario inputs. The minimum and maximum range for each scenario input is based on the range of data values over all subwatersheds in the analysis. To meet time constraints and to simplify the process, the scenario opportunity scores were calculated in ArcMap using the following general formula:

$$\text{Scenario Score} = ((\text{value1} - \text{value1}_{min}) / (\text{value1}_{max} - \text{value1}_{min}) \times \text{weight}_{value1})) + (\text{value2}\ldots) + (\text{risk1}\ldots) + \ldots$$

in which value1 … value*n* and risk1 … risk*n* indicate subcriteria of the value and risk criteria that vary by scenario.

During scenario prototyping, decision-model weights for scenario inputs could be changed, and the results viewed in ArcMap in a manner analogous to EMDS. This allowed regional and national forest staff to try several versions of scenario inputs and decision-model weights to test the reasonableness of model outputs.

The method for generating theme scores and an overall score was decided during a draft IRPS update meeting of the Regional Leadership Team. Theme scores were generated using a simple averaging technique in which all scenario scores were equally weighted. Similarly, the overall score was generated using a simple averaging technique in which all theme scores were equally weighted. The rationale for equal weighting at these two levels of the decision architecture could be thought of as a default weighting scheme in which no theme or scenario has a priori precedence over any other. However, weights at either level can easily be altered to reflect different areas of management emphasis with major changes in regional or national policy direction over time. After the draft IRPS update meeting, all scenarios went through the prototyping process again to review and update any value, risk, or feasibility inputs. All scenario and theme opportunity scores were recalculated and a final overall score was calculated.

After the scenarios and themes were finalized, four subregional areas were separately analyzed. During the draft IRPS update, it was noted that several scenarios had significant differences across the Northern Region owing to ecological or resource issues. The full Northern Region was spatially partitioned into the Northern Idaho (Idaho Panhandle, Clearwater, and Nez Perce National Forests), Western Montana (Kootenai, Flathead, Lolo, and Bitterroot National Forests), Eastern Montana (Beaverhead-Deerlodge, Lewis-Clark, Helena, and Gallatin National Forests, and the Beartooth Ranger District of the Custer National Forest), and Plains (Ashland and Sioux Ranger Districts of the Custer National Forest and the Dakota Prairie Grasslands) subregions. In this case, only subwatersheds within a subregion were used to generate the minimum and maximum reference values for each value and risk input during normalization. The intent behind adjusting normalization

with change in spatial extent (e.g., from region to subregion) was to make modeled results more relevant to a specific subregion. Thus, there is both a regional perspective that would be more relevant to regionwide planning, and a subregional perspective more relevant to smaller-scale planning. Both perspectives are useful, and each is equally valid. In the wildlife theme, some scenarios were excluded from the theme score if the resource did not occur in the subregion.

The final step of implementation was building the IRPSv102 database and associated documentation (fig. 22). The IRPSv102 database (an ArcGIS file geodatabase) had five subwatershed feature classes (Regional, Northern Idaho, Western Montana, Eastern Montana, and Plains), and the value and risk input table for all subwatersheds. Each feature class had attributes for scenario and theme opportunity scores, and an overall score, along with a subwatershed identification number (HUC6 code) that was used to join the value and risk input table to each feature class. Documentation included metadata for all database elements and a user manual and overview document of this process. Appendix A contains the data dictionary of all value, risk, and feasibility inputs, and appendix B has the scenario opportunity-score formulas used for in the implementation. More information on individual scenarios can be found in the narratives: appendix D1 (scenario 1a), appendix D2 (scenario 1b), appendix D3 (scenario 1c), appendix D4 (scenarios 2a–2i), appendix D5 (scenario 3), appendix D6 (scenario 4), and appendix D7 (scenarios 5a–5e).

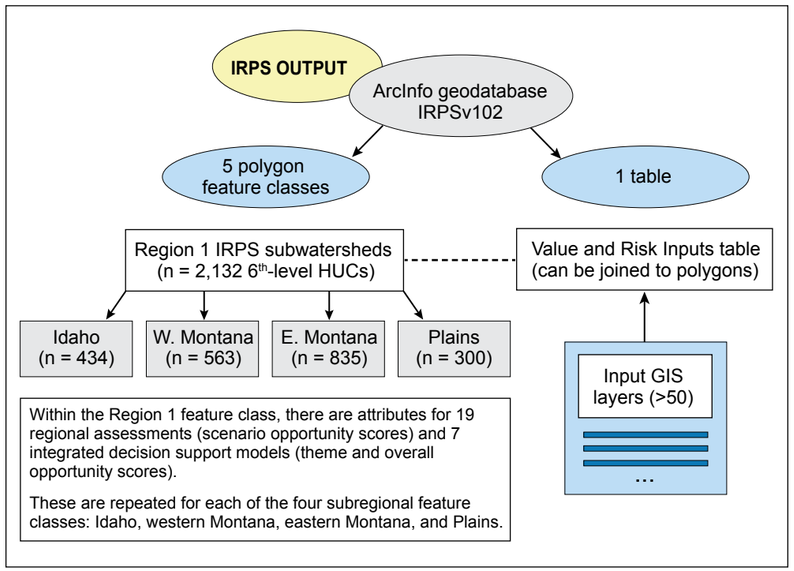


Figure 22—Outputs of the Integrated Restoration and Protection Strategy process are stored in an ArcInfo geodatabase.

Initial IRPS Results and Status Report

For each scenario, values, risks, and feasibility were assessed for every subwatershed in the Northern Region analysis area (n = 2,132). Formulas (app. B) were used to calculate opportunity scores for each subwatershed. Higher opportunity scores indicate greater potential opportunity for restoration or protection of a given resource.

Some **key findings** from the assessment for restoration and protection are:

1. Significant departure from desired forest conditions has resulted in less than desired resilience of forest vegetation as identified in theme 1, which emphasizes the need to
   a. Prioritize restoration of tree composition of western white pine, whitebark pine, western larch, aspen, and ponderosa pine (see spreadsheet for specific findings by analysis area);
   b. Reduce forest density on dry forest types (ponderosa pine and Douglas-fir) (see spreadsheet); and
   c. Reduce invasive species affecting native ecosystems.
2. Theme 2 emphasizes that priority restoration of wildlife habitat in short supply.
3. Theme 3 highlights the need for restoration of watershed function, including reduction of sedimentation and chemical contamination, and protection or restoration of municipal and watershed water quality.
4. Theme 4 demonstrates the need for restoration of key fish species habitat.
5. Themes 5 and 6 emphasize protection of people associated with social infrastructure, and providing for scenic landscapes.

Map products for each of the 19 management concerns display the relative priority of potential opportunity to restore aquatic and terrestrial ecosystems, and to protect or sustain many ecosystem services. When scenario assessments were aggregated into the six themes, then integrated into a single IRPS model across all themes, potential watersheds with priorities associated with multiple resources in the same areas were identified, suggesting that these might be areas where the agency could pursue actions that can meet multiple objectives.

We produced maps (see links below) and histograms (fig. 23 and links within maps) of opportunity scores by subwatershed for each of the IRPS themes and scenarios. These maps provide a spatial representation of the key findings above across the Northern Region. Analogous map products for each of the four subregions were also created to show how opportunity scores change when evaluating against only those subwatersheds in a geographic subset of the region. Maps of opportunity scores for Idaho, western Montana, eastern Montana, and Plains subwatersheds can be found here.

Click on each scenario to view its corresponding map.

Theme 1: Restoration of forests, grasslands, and human communities to a more resilient condition

- **Scenario 1a**: Community fire resilience
- **Scenario 1b:** Vegetation resilience and current departure from desired conditions in forested areas addressing resilience and vulnerability
- **Scenario 1c:** Ecosystem resilience and vulnerability in nonforested areas

Theme 2: Restoration and maintenance of wildlife habitats, including restoration of more resilient vegetation conditions where appropriate, to meet ecological and social goals

- **Scenario 2a:** Whitebark pine ecosystems
- **Scenario 2b**: Low-elevation dry forest communities
- **Scenario 2c:** Dry shrublands (low-elevation sagebrush)
- **Scenario 2d:** Aspen
- **Scenario 2e:** Woody draws
- **Scenario 2f:** Mixed-grass prairie
- **Scenario 2g:** Riparian, wetlands, and seeps
- **Scenario 2h:** Big-game winter range
- **Scenario 2i:** T&E core grizzly bear habitat

Theme 3: Restoration and maintenance of resilient, high-value watersheds (single scenario)

- **Scenario 3:** Watershed quality (sediment)

Theme 4: Restoration of high-value fisheries streams developing more resilient habitat (single scenario)

- **Scenario 4:** Threatened, endangered, and sensitive fish species

Theme 5: Restoration and protection of recreation sites and scenic vistas

- **Scenario 5a:** Safety
- **Scenario 5b:** Investment protection
- **Scenario 5c:** Recreation setting restoration
- **Scenario 5d**: Scenic integrity restoration
- **Scenario 5e:** Scenic integrity protection

Theme 6: Protection of people, structures, and community infrastructure

Overall integrated score, themes 1–6

Histograms (fig. 23) show a wide variety of distributions for scenario opportunity scores, reflecting their various input sources. As a rule, distributions for theme scores tend to become more normal than those for the scenarios from which they are derived. The majority of the scenario distributions are skewed to the left, indicating a relatively large number of subwatersheds with low opportunity scores. Two distributions, Scenario 2I and Theme 4, are bimodal; these can be explained by their 0/1 value inputs (either a subwatershed is grizzly core habitat or not, an aquatic priority watershed or not).

The decision model for each scenario is a linear model, primarily expressed in terms of value and risk criteria (app. B), but see exceptions in footnotes to table 1. A linear model is most appropriate when its components are uncorrelated. We tested this condition for the 19 scenarios by computing Pearson's correlation coefficient (r) and associated R^2 value between value and risk for each scenario (table 1). Although correlations were generally low to very low for most scenarios, all but one were significant ($\alpha = 0.01$) owing to the very large sample size ($n = 2{,}132$). However, the R^2 value also shows that the variance in value explained by risk was almost uniformly very low (table 1), the one major exception being scenario 1C. Thus, despite significant correlations between value and risk criteria for almost all scenarios, the two criteria can be considered independent factors in the decision models for practical purposes.

Owing to the additive nature of the decision models for scenarios, it is also possible to sum value and risk scores to the theme level to assess correlations between value and risk by theme (table 2). Note that the highest R^2 value at the theme level is 0.097 for theme 5, so correlations at the theme level are even less of an issue.

Staff at the region, forest, or district levels will also find it informative to examine the contributions of value and risk scores to restoration priority scores for specific subwatersheds when planning restoration activities. This is most easily accomplished in a GIS system, so a table containing the value and risk scores for all subwatersheds in the regional analysis has been generated and included within the output geodatabase (included on this disc).

In the context of the goals and objectives of the IRPS, the DSS product is currently being used as a starting point, to be combined with local, more site-specific information such as input from partnerships and collaborative groups, to identify and sequence priority integrated restoration proposals. This has occurred within Collaborative Forest Landscape Restoration Program (CFLRP) areas on multiple forests, and has occurred forestwide on several forest units. One unforeseen application is that the IRPS is also being used, with more local data, to help inform national functional initiative tools developed after the IRPS was completed.

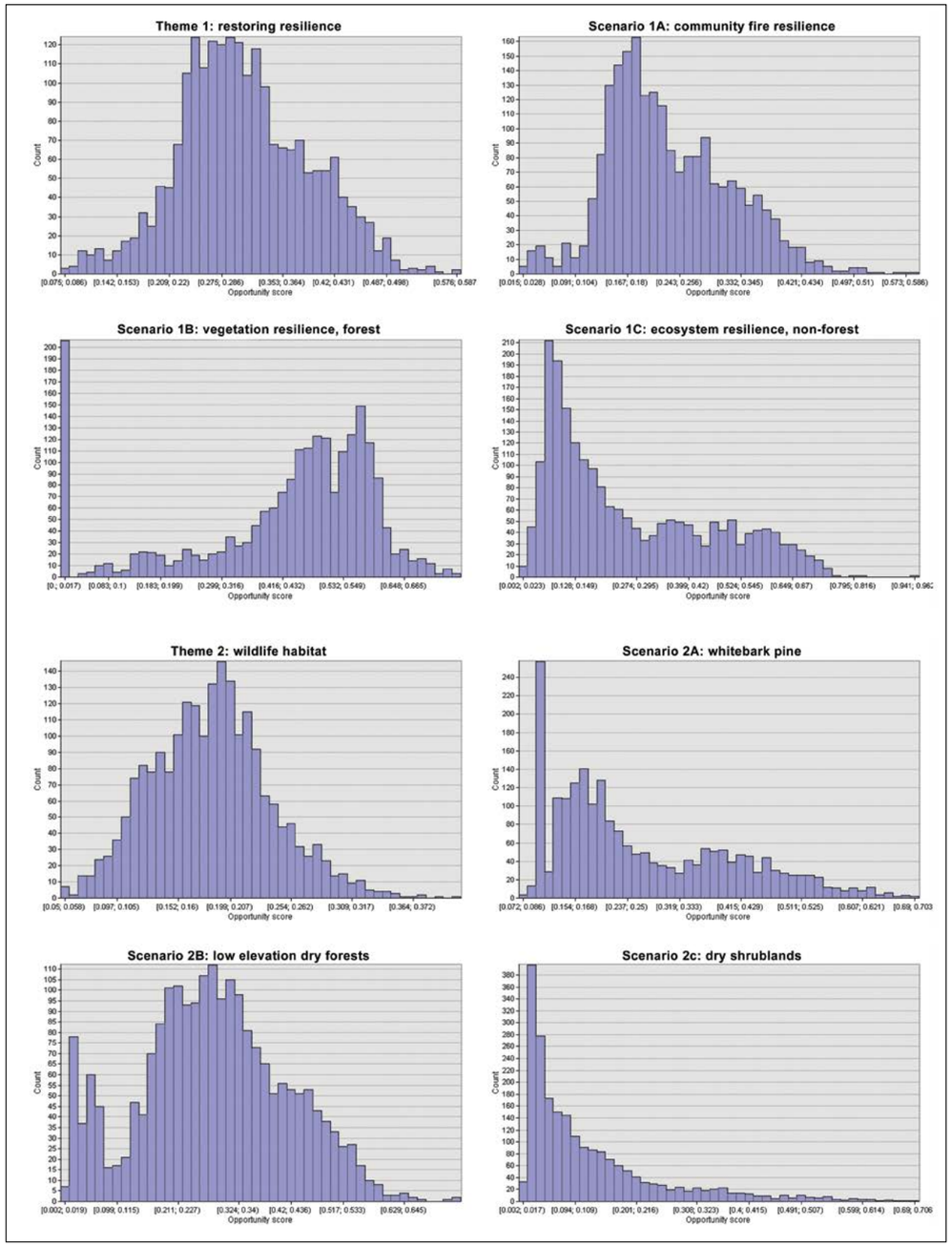


Figure 23—Histograms of opportunity scores by theme and scenario.

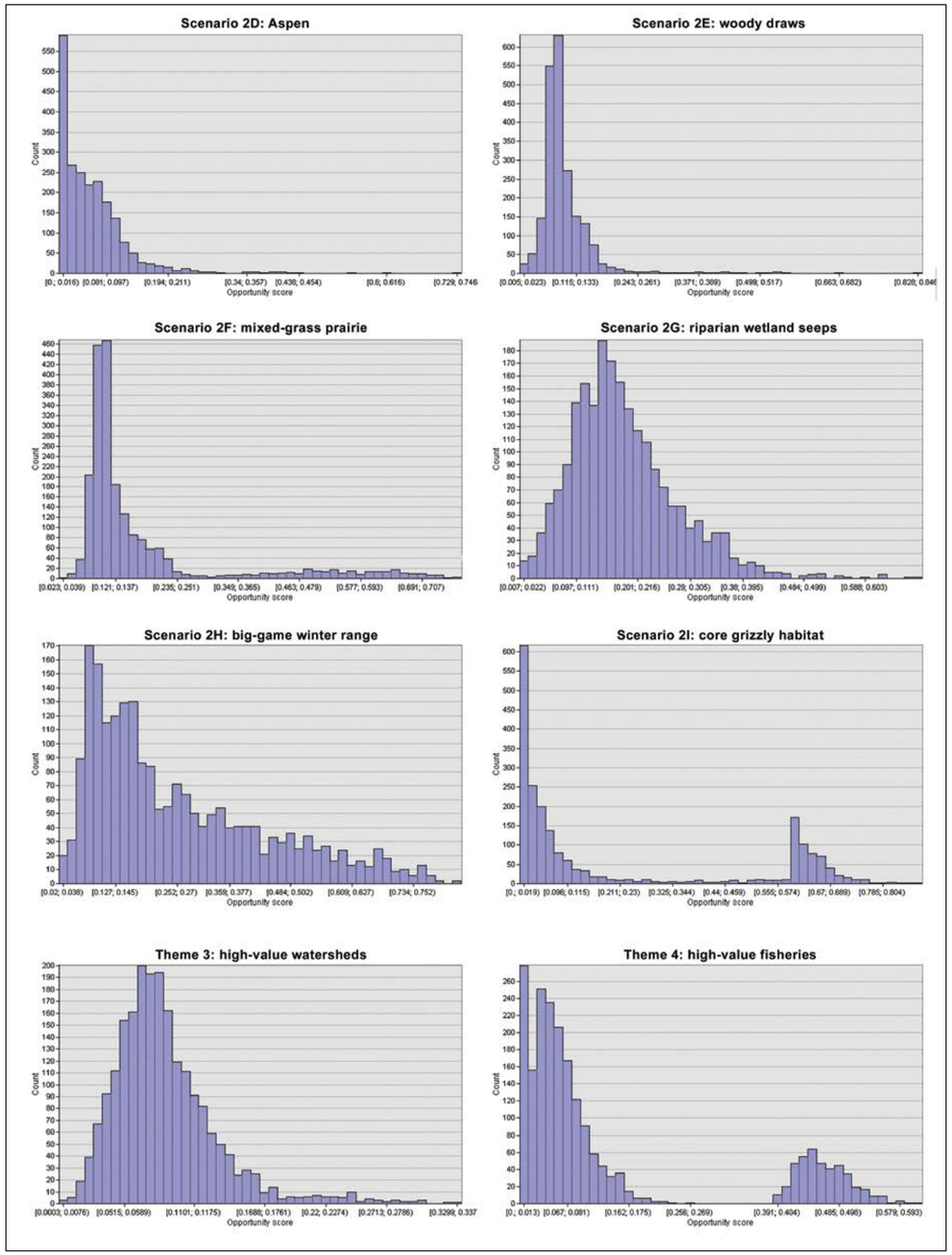


Figure 23 continued—Histograms of opportunity scores by theme and scenario.

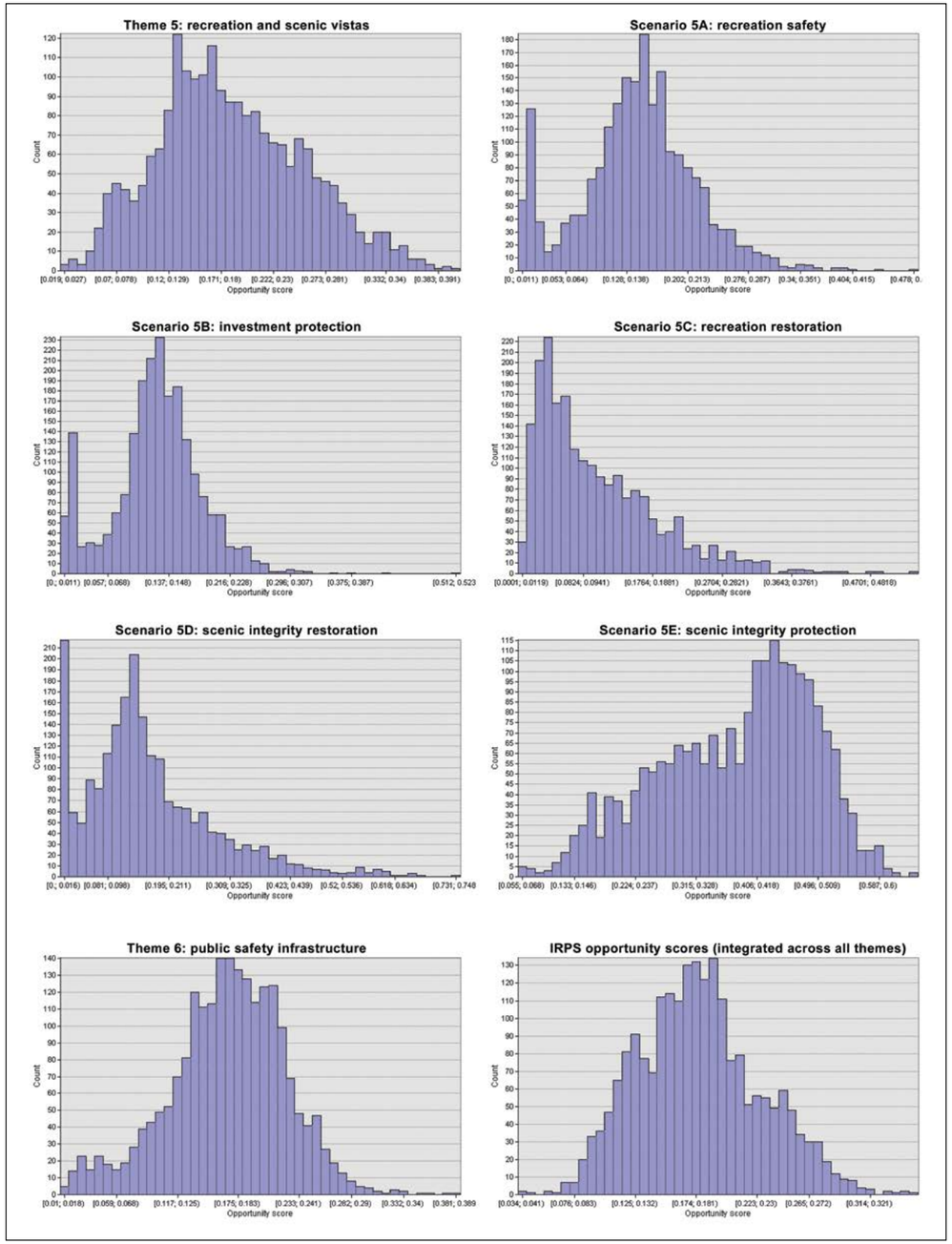


Figure 23 continued—Histograms of opportunity scores by theme and scenario.

Table 1—Pearson correlation coefficient (*r*) and associated R^2 value for correlations between value and risk criteria by Integrated Restoration and Protection Strategy scenario

Scenario	Pearson r^a	R^2
S1a	-0.329 *	0.108
S1b	0.445*	0.198
S1c	0.759*	0.576
S2a[b]	0.299	0.089
S2b	0.35*	0.123
S2c	0.494*	0.244
S2d	0.398*	0.158
S2e	0.240*	0.058
S2f	0.221*	0.049
S2g	-0.007	0.000
S2h	0.235*	0.055
S2i	0.074*	0.005
S3a	0.089*	0.008
S4a	0.116*	0.013
S5a	0.357*	0.127
S5b	0.129*	0.017
S5c	0.353*	0.125
S5d[c]	—	—
S5e	0.056*	0.003

[a] An asterisk (*) indicates that the correlation is significant at α = 0.01.
[b] Scenario S2a included a feasibility criterion whose value was added to the risk value for purposes of this analysis.
[c] Scenario S5d did not include a risk criterion.
— = not applicable.

Table 2—Pearson correlation coefficient (r) and associated R2 value for correlations between value and risk criteria by IRPS theme

Theme	Pearson r^a	R^2
1	-0.154*	0.024
2	0.130*	0.017
3	0.089*	0.008
4[b]	0.116*	0.013
5	0.312*	0.097

[a] An asterisk (*) indicates that the correlation is significant at α = 0.01.

Using and Updating IRPS Products

The IRPS update analysis and IRPSv102 database were designed to be updated and used by regional and national forest staff. The subregional subwatershed layers may provide a better starting point for forest-scale analysis owing to more specific treatment of local ecological or resource issues. In the implementation section above, it was noted that the most time-intensive process is identifying and calculating the values of scenario value, risk, and feasibility inputs. The implementation section also discussed the importance of a prototyping process in which the scenario value, risk, and feasibility inputs were explored and modified. Generating scenario and theme opportunity scores takes only minutes, but working on value, risk, and feasibility inputs can take days or months. Appendix E provides an overview of how to use the IRPSv102 database, and appendix A contains a data dictionary of scenario inputs. Understanding the scenario inputs and how to view and recalculate scenario opportunity scores are covered in these two appendixes.

Discussion

What Worked Well

Addressing the questions—

The overall approach in the design of the IRPS required that key resource objectives (as reflected in scenario values) be initially identified by resource specialists. However, it was important that managers (line officers, in the case of the Forest Service) were critical participants in the process to validate that these were the important issues to address in the Northern Region IRPS. The overall assessment of IRPS priorities was designed to respond to planning questions related to the particular resource values. Identification of the associated objectives gave the strategy team a more integrated perspective of restoration and protection objectives.

Design of the 19 scenarios followed a consistent approach of evaluating values, risks, and feasibilities identified for each scenario. This allowed the diverse group of resource specialists to, in effect, think and communicate in the same language, and complete the individual assessments in a comparable way. This approach led to a more consistent and transparent understanding of how the assessment was completed in responding to the assessment planning questions. This worked well for understanding linkages between planning questions, the factors involved in each assessment, and the data needed and used to support the overall assessment of IRPS priorities. It also led to a much better, more consistent understanding of why potential restoration priorities for the various scenarios came out the way they did, because the methodology was applied in a very consistent manner.

The IRPS required a large volume of data and GIS layers because of the number of planning questions tackled in the assessments. This situation had both positive and negative implications. On the negative side, the data sets were time-consuming and expensive to develop. However, once developed, the data sets, in aggregate, were seen as a very valuable and powerful asset for the Northern Region, providing context for finer scale evaluations. These default data sets were highly consistent across the entire regional landscape, and can subsequently be augmented with local data to be much more effective at identifying actual project opportunities in the context of regional landscape conditions.

This regional evaluation required weighting of the various factors within the assessments, and across the assessments when implemented in a DSS. It is important to note that line officers were the leadership who validated or established the final model weights, because the individual assessments were used as a decision-support tool. This was a very appropriate role for regional leadership, and their engagement in the process provided leadership legitimacy to the IRPS.

One key finding, after completing the IRPS at the regional scale, was that potential opportunity areas provided a useful starting point for discussions and also provided a useful context for developing feasible project-opportunity areas. Key ingredients for developing useful solutions for final opportunity areas are locally determined feasibility factors, because these are not always readily available at the regional scale. When locally determined feasibility factors are combined with a consistent identification of value and risk factors, it results in identification of local project areas ripe for consideration. In addition to the 19 regional scale resource assessments, others may be added at the local level to better address questions such as “why here?” and “why now?”

One potential additional use for the IRPS information is as a starting point to help identify future CFLRP areas. This will have some of the limitations of the existing framework (e.g., feasibility factors developed at local scale), but may become a good framework for developing additional CFLRP areas.

How the assessment was received by forests—

At least initially, there has been mixed reaction to the assessment and DSS by forest and grassland units. This mixed reaction was based on differences in local interpretation of how the assessment was intended to be used. Those units that see it as a consistent methodology, to which additional items (such as feasibility factors) can be added, see it as a useful starting point and as a consistent framework that can be applied at finer scales. This was indeed a primary purpose of the IRPS, as well as providing an assessment that can be shared with other landowners adjacent to Northern Region lands, and as a method to integrate a diverse set of complex objectives around resource

assessment. The overall approach presented here offers the opportunity to integrate at least some of the other assessments related to major national initiatives at the regional and finer scales, for example, by integrating those assessments as new scenarios to be included in an overall opportunity assessment to support forest planning or identification of project-opportunity areas. On the other hand, those units that interpreted the IRPS as a final solution for priority opportunities, or were concerned that this framework had direct and immediate implications for budget allocation to units, were intent on showing why it was not, or should not be, a final solution. This latter perspective was actually useful feedback to the regional office insofar as it raised legitimate concerns about how the IRPS approach will in fact interface with decisions on budget allocation. Although detailed discussion of the latter issue is beyond the scope of this report, it is worth noting that the IRPS priorities generated by the assessment were primarily based on biophysical considerations. Consequently, an additional stage of budget analysis, starting from the IRPS priorities, will certainly be needed.

Issues and Caveats

In February 2011, the Geospatial Group of the Northern Region reviewed the process and products of the Northern Region IRPS DSS, and raised a number of issues. In some cases, the issue raised is a legitimate concern, and it is discussed here as a caveat of which users of the DSS should be aware. In the following, each issue is highlighted in bold, and our response follows.

- **There has been little, if any, independent and external review of what has been done and how it is being proposed to be used.**
  This publication was produced with the intent of providing comprehensive documentation on use and maintenance of the DSS for end users. However, in the process of preparation for publication, the report received external technical review from a diverse panel, including scientists, field biologists, and other technical specialists (see "Acknowledgments"), thus substantially addressing this issue. Moreover, field biologists from diverse fields, and representing various forests within the Northern Region, were integral members of the development team, particularly with respect to input on design of decision models for the scenarios. Lastly, an early prototype of the final system was documented by Jensen et al. (2009).

- **As a regional model, the current IRPS model is cumbersome and complex … and inhibits transparency.**
  An overarching objective behind IRPS DSS development was to provide a consistent framework for restoration planning across the entire Northern Region that also was as comprehensive and integrated as possible with respect to addressing natural resource issues. The overall design involves six themes that decompose into 19 scenarios, and the result is a system that, at least at first glance, admittedly appears to be rather large and complex. However, upon close review of this report, readers should note the following:

  - All 19 scenarios use a simple and consistent design for a decision model, which is based on values relevant to the specific scenario and risks to those values, and is the basis for setting priorities at the level of each individual scenario.
  - Scenarios are grouped into six themes, representing the major resource areas addressed by the IRPS. The theme-level priority score for a subwatershed is simply the average priority score of the scenarios in the theme.
  - Themes 2 and 5 evaluate 9 and 5 scenarios, respectively, and thus are somewhat large and complex in terms of the number of scenarios. On the other hand, themes 1, 3, 4, and 6 only consider 3, 1, 1, and 3 scenarios, respectively, and thus are relatively simple.
  - The overall, integrated priority score for a subwatershed is simply its average theme priority.

  The overall architecture of the DSS design is thus relatively simple. It starts with decision models for computing priorities of subwatersheds for individual scenarios, followed by a simple summarization to the theme level, and a subsequent summarization to an overall, integrated priority score. In other words, the DSS is really a three-tiered system of decision models. Moreover, transparency is really not a problem. Starting from the overall priority score for a subwatershed, a user can examine the next lower theme level to understand the derivation of the overall score, and similarly, the derivation of theme-level scores is easily understood in terms of scenario scores at the next lower level.

- **It is unclear how the regional results will "inform" subregional or unit analyses.**
  The IRPS DSS is designed to inform restoration planning at multiple spatial scales from subwatersheds up to the Northern Region, in the process providing an integrated multiscale perspective. It is true that the initial report, an earlier iteration of the present publication on which this comment is based, did not elaborate on how results from the IRPS DSS could inform planning decisions at the subregional and unit scales. However, based on this comment, and those of several external reviewers, the sense in which the DSS informs planning at these multiple scales is now laid out in a general way in several of the earlier sections, and more specifically in the results section. Results presented in this report represent a broad, regionwide perspective that

considers all scenarios and spans all subregions and forests of the Northern Region. At this scale, the objectives are twofold: (1) to provide a broad overview of the region that can inform decisions on broad programmatic issues of interest to the regional office, and (2) to provide a regionally consistent framework for setting priorities at subregion and forest scales. One difficulty with the regional view is that not all scenarios are relevant to all subregions or forests. For example, certain vegetation types considered in theme 2 are not represented in all subregions. However, it is expected that, for purposes of guiding management direction at finer spatial scales, the DSS framework will be adapted for use at these scales by ignoring scenarios that are not relevant in a specific context. This clearly suggests some degree of incompatibility between the regional view and that at finer scales. The apparent problem with informing finer scales is an artifact of the way in which the IRPS DSS was initially built and delivered, but the problem is easily resolved. In particular, in operational use, information flow will proceed from the bottom up, as opposed to from the top down. In other words, the forest scale would inform the subregion scale, which would in turn inform the regional scale. There is still a minor issue insofar as there will be local variants of the DSS implementation based on its geographic context, but the basic objective is met for a regionwide approach that is as consistent as possible.

- **The current system mixes quantitative and qualitative elements by including weights at multiple stages within the model.**
  More correctly, the IRPS DSS mixes objective data inputs and subjective weights. This is entirely appropriate because the DSS is, as already noted, a three-tiered decision model, and weighting in decision models is a very conventional and well-accepted practice (Saaty 1992). At the level of the scenarios, weighting choices were dependent on expert judgment. However, weights on themes in the top-level decision model were determined more mechanistically. In particular, all themes and scenarios within themes were equally weighted. This choice of weighting was determined by a subset of the Regional Leadership Team with deputy regional forester input.

- **The summarization unit of 6th-level HUCs is problematic for many of the input variables.**
  All data inputs to the DSS were initially summarized at their appropriate scales (app. A). However, all data were then attributed to subwatersheds, and this is indeed problematic. For example, all estimates of vegetation cover used in theme 1, scenario 1B were calculated for 55 Forest Planning Landscape Geographic Areas across the region that are similar in size to a 4th-level HUC. This was done for two primary reasons: (1) to link the Forest Planning Geographic Areas to the IRPS, and (2) to use the FIA data to show current condition and have in place a set of plots to monitor the trends toward desired condition in each of these geographic areas as a result of restoration activities and natural disturbance processes (see app. D2 for Scenario S1B narrative that discusses methodology). These estimates were then attributed to all subwatersheds contained within a geographic area. This is obviously a problem because vegetation cover within a geographic area varies across subwatersheds. Unfortunately, the sampling density of FIA vegetation plots required that vegetation cover be estimated at a scale larger than a subwatershed, in this case, the geographic areas, and there is no statistical basis for estimating variability in cover across subwatersheds. As a practical matter, the Northern Region has been committed to use of FIA data as its corporate database for vegetation inventory and monitoring purposes. The region has developed a coarse-scale vegetation cover map (VMAP, via supervised classification of satellite data), but accuracy of this information at the fine scale of a subwatershed may be equally unsatisfactory because it was developed, and has an accuracy assessment, at a much coarser resolution than a subwatershed.

- **There is very little detail on how and where IRPS and the underlying data to support it will be managed and made available to end users.**
  Currently, updates to the IRPS project are being funded by the Resource Information Management (RIM) board of the Northern Region. This is a year-to-year funding process, with no long-range funding guarantees. Therefore, it is essential that this funding be used to develop automated updating processes, to harvest real-time data from corporate data sources. One way this can be maintained is through the development of Geospatial Interface (GI) tools, an opportunity developed by the Forest Service Geospatial Service and Technology Center. Development of these tools would allow a data steward to quickly and efficiently update data layers periodically, using updates generated by forest-level personnel. The IRPS project is currently distributed to forests and the public through an internally maintained web site. This Web site is maintained with RIM funding, with no long-term maintenance plans. The possibility may exist to develop tools that facilitate maintenance, such as those tools that automatically update data accessed by the links on the Web site. Further investigation into maintenance possibilities will have to be conducted to develop a minimum-effort maintenance plan.

Feasibility—
This release of IRPS does not contain information about the feasibility of employing restoration activities to the ground. There is an outstanding data need for a regionally consistent data set that describes what treatments might be applied on the ground. Ideally, one would use the IRPS product to begin restoration implementation not only in areas where there is an opportunity for restoration work to be conducted, but also in areas where it is practical (i.e., economical, physically possible, etc.) to do so. Work to develop a data set that describes the feasibility opportunity is currently under way, but has not been completed at the time of publication.

Opportunities for Improvement

Capturing locally available data—
We anticipate that the data sets and model will be improved and modified with locally available data. The regionally derived data will serve as a baseline, or default, for units to use initially in their assessments. Likewise, the analysis process, weighting schemes, and scenario compositions will serve as a default process for units to have an initial look at their forest for possibilities, but will also allow the units to determine their own weighting schemes, and construct their own scenarios, based on the issues important to the forest and project.

Improvements identified as a result of working with these teams will be incorporated into the larger IRPS product, which is then transferrable to other units in the region.

Sensitivity analysis—
The IRPS can be analyzed to determine the importance of the information data sets included in the analysis as well as the weights. Mathematically, the influence of each resource information data set included in the analysis can be analyzed to determine how much it contributes to the overall score of the resulting prioritization. The most influential data sets should be reviewed to determine whether they accurately represent the management situation on the ground. Concurrently, the weights of the individual data sets or scenarios can be rapidly changed to determine the sensitivity of weights to the different scenarios. More time and attention should be given to those weights that have the greatest impact on overall scenario score. Additionally, this type of analysis can be used in a collaborative setting to allow collaborators to explore and understand the implications of the assumptions in the model on the resulting opportunity scores.

Continuous feedback—
Most data sets used in the Northern Region IRPS analysis are in a constant state of flux. New information becomes available to bolster the existing data, catastrophic disturbance events occur, roads are built and decommissioned, and watershed restoration work is implemented. These are but a few of the changes that occur and cause the data to become obsolete shortly after they are obtained. Therefore, if one could capture this information in an efficient manner, the data sets and model process could be updated periodically to assist with making current, informed decisions.

Future use of EMDS—
The methods described in this report are the same data processing methods as EMDS, but IRPS does not actually use the EMDS software to calculate scenario values. However, newer versions of EMDS are anticipated to be released in the near future. When this occurs, they should be investigated to determine whether they provide sufficient technological benefits to warrant full or partial adoption for the analysis process. For example, future versions may facilitate development of Web-based applications that would allow internal users and external partners easy access to the data sets and assumptions of the IRPS product, or allow them the ability to quickly and transparently modify some of the assumptions to assess the implications of alternate management schemes.

Future Applications

All-lands assessment—
The data sets for the IRPS are region-wide in spatial extent, and include subwatersheds in which at least 1 percent of the land area is managed by the Forest Service. This results in a data set that, while not complete in coverage, includes a significant portion of the land mass in Montana and northern Idaho. Within these subwatersheds, the condition of the land owned and administered by the Forest Service is known, and in some cases, the condition of the non-Forest Service land is known as well.

Most appropriately, analyses can be conducted at the Forest Service ownership level and on a scale that covers the entire region. Issues common to all ownerships across the entire region, such as water quality, can be assessed to determine the key subwatersheds within the region that could benefit from concentrated restoration activity.

In the case of issues for which the IRPS data sets include the condition of all lands within watersheds, including both federal and nonfederal land, it may be appropriate to conduct analyses in cooperation with partners administering those lands. For instance,

Montana may be interested in assessing opportunities for joint ventures in subwatersheds involving multiple ownerships with common goals and restoration needs can achieve measurable, meaningful results. Especially in landscapes with multiple ownerships and high restoration needs, such collaborative efforts may be able to achieve restoration results that could not be achieved by agencies working independently.

The IRPS data sets may be used to inform other external assessments designed to include all lands within a specific geographic extent. For instance, Montana was required to conduct an all-lands assessment (Rogers 2010) to fulfill the requirements of the 2008 Farm Bill. In this instance, the Forest Service provided ownership-level data that were included to help establish national priorities for private forest conservation.

Strategic planning at the forest level—
National forests create and maintain a 5-year program of work, which details the anticipated projects to be analyzed and completed on the forest during that timeframe. Ideally, these projects would occur in those areas that had the greatest need for, or potential for, effective management activities that best met the goals and objectives of the forest plan. Those areas with the greatest need, potential, or opportunity would of course be scheduled first.

The IRPS framework creates a platform on which future-year planning can occur. At least three additional steps should be taken, however, for this to occur. First, the data sets should be updated to include better locally maintained data where appropriate. Second, the scenarios may need to be reformulated to describe the issues that the planning effort should address. For instance, if the primary goal of the plan is to schedule timber activities from which revenues will be used to improve deteriorated stream crossings, it may not make sense to include information about oil and gas wells. Third, an additional feasibility criterion should be developed by the forests to describe where it is possible for activities to occur. This could be timber feasibility, opportunities for prescribed burning, etc., but ultimately should be aligned with the goals of the planning exercise. Without knowing where it is feasible to do the desired activities, the decision is unlikely to be fully informed.

Forest plan and partner input at the project scale—
The Northern Region recognizes that the plan components of each unit are unique, which likely will result in different priorities among the units. Again, the system is therefore flexible to include data sets that are not currently part of the IRPS product, exclude those elements that do not pertain to the unit, and change the weights and scenario compositions to best respond to the issues and forest plan direction associated with each unit.

Furthermore, the IRPS product will facilitate work with partners and collaborators, especially in working meetings. The product can be rapidly modified for live, in-person updates that can be displayed in live meetings. This facilitates immediate analysis of a number of differing ideas, where the effects of different weighting schemes, scenario compositions, etc., can be displayed and evaluated with a group of collaborators.

Link to the planning rule—
The current version of the Forest Service planning rule requires a plan component to "Identify watershed(s) that are a priority for maintenance and restoration" (219.7(f)(1)(i)). The IRPS framework described here is a tool that may be used to explicitly address this planning rule component for forests that revise their plans under this rule. At the time of this publication, however, we acknowledge that the directives guiding the application of the planning rule have not been finalized and may suggest specific, alternative methods to this process. The possibility of using IRPS to assist with forest plan revision should be investigated after all components of the planning rule have been released in their finalized state.

Conclusions

Use of EMDS analysis methods enabled evaluation of multiple resource values in a transparent manner and produced output maps that displayed high-priority treatment areas. The weighting used for the scenarios can be modified as our knowledge base increases or to meet changing needs. A byproduct of this work was the development of a consistent set of region-wide data themes that have been added to the regional spatial data library for subsequent use in planning efforts. The result of this work provides consistent interpretations of ecosystem status for future monitoring of current and desired conditions.

Acknowledgments

We would like to thank the following groups and individuals for contributing to the development and implementation of this project:

- The Fire Laboratory in Missoula, for developing and supplying the burn probability layers.
- The Geospatial Group in the Regional Office Engineering Department, for critiquing the IRPS product to identify areas for needed improvement and ongoing maintenance.
- The Regional Board of Directors, for their input on weighting the themes. This resulted in a useful product for region-level decisions.
- We would also like to extend special recognition to Dr. Mark E. Jensen, who initiated and supported this project until his untimely death in 2010.

The current state of the Northern Region IRPS assessment owes much to the vision, expertise, and determination that Mark brought to the challenge of creating a rigorous and transparent DSS process for the region.

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Appendix A: Geographic Information System (GIS) Layers and Data Dictionary for Integrated Restoration and Protection Strategy Inputs

Background and Terminology

The Northern Region's Integrated Restoration and Protection Strategy (IRPS) is a broad-scale assessment of the region's resources and opportunities for their restoration and protection. IRPS is organized by resource **themes**, which are further divided into resource **scenarios.** As an example, theme 2 represents terrestrial species. Within that theme, Scenario S2A attempts to highlight opportunities for restoration and protection of whitebark pine by identifying resource **values**—in this case, whitebark pine and grizzly bear range—and **risks** to those values—here, the probability of crown fire, blister rust damage, and insect occurrence from aerial detection surveys in the past 5 years. A few scenarios, including whitebark pine, also address the **feasibility** of working in a given area. For each scenario, weights are assigned to each value, risk, and feasibility input, with the totals summing to 100 percent.

For each scenario, values, risks, and feasibility were assessed for every **subwatershed** (6th-code hydrologic unit, or HUC6) in the Northern Region analysis area (n = 2,132). Formulas were then used to calculate **opportunity scores** for each subwatershed. Higher opportunity scores indicate greater potential opportunity for restoration or protection of a given resource.

A number of geographic information system (GIS) inputs were needed to assess all of the values and risks identified in IRPS' six themes and 19 scenarios. This document provides an overview of these inputs and the attributes derived from them.

The information in this document is summarized in two ways. First, we provide a list of the project's **input GIS layers**, or the raw GIS data (table A1). Second, we provide a more detailed list of the **attributes** calculated for each subwatershed in IRPS from their associated input GIS layers (table A2). The attributes store (in one data table) the results of overlays of the input GIS layers with the subwatershed layer. Attributes store information such as the **percentage of area** within a subwatershed occupied by whitebark pine, the **number** of campgrounds in a subwatershed, or **miles per square mile** of roads in a subwatershed. These attributes are used to calculate opportunity scores.

Where to Find IRPS Data and Documentation

Forest Service access—

The current corporate version of IRPS data is stored in SDE, and can be accessed via layer files found in the T:\FS\Reference\GIS\r01\LayerFile\IRPS\IRPS_v102 directory.

Forest Service users can also access the data via a series of base maps stored as ArcGIS project files at T:\FS\NFS\R01\Collaboration\IRPS\GIS\MXD.

Working versions of the GIS data and value and risk attributes can be found at T:\FS\NFS\R01\Collaboration\IRPS\GIS\Data.

For more information on how to use IRPS data, please see How_to_use_IRPSv102_GIS_dataset_March2011.docx. For an overview of the project, please see IRPS_Brief_overview_with_maps_March2011.pdf. These files are housed with all other IRPS project documentation at: T:\FS\NFS\R01\Collaboration\IRPS\GIS\Documentation**.**

Public access—

The IRPS output geodatabase is available to the public at the following online linkage: https://fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5370182.zip

Table A1—Integrated Restoration and Protection Strategy (IRPS) input geographic information system (GIS) layers in the geodatabase irpsv102_input_layers.gdb

Input layer	Description	Metadata Select to View
Aquatic feature data set:		
barriers	Points representing barriers for aquatic species	○
BT_priorityHUCs	Priority watersheds for bull trout (western Montana)	○
Cutthroat_PriorityHUCs	Priority watersheds for cutthroat trout (eastern Montana)	○
DPG_priorityRest_HUC	Priority and restoration watersheds for Dakota Prairie Grasslands	○
ID_priorityRest_HUC	Fish Restoration Priority watersheds for Idaho	○
nhd_strms	1:24,000 National Hydrography Data set (NHD) streams for Region 1	○
Transportation feature data set:		
road_adsbb_own_irpshucs	Roads from the R1 transportation layer (maintenance level 3, 4, and 5) intersected with Aerial Insect and Disease Detection Survey (ADS) bark beetle polygons (2002–2009); to identify roads used in analyses, query ADSBARKBEETLE = 1	○
roadsTIGER	TIGER roads for Region 1	○
trails_adsbb_own_irpshucs	Trails from the R1 transportation layer intersected with ADS bark beetle polygons (2002–2009); to identify trails used in analyses, query ADSBARKBEETLE = 1	○
transmission_adsbb_own_irpshucs	Transmission lines intersected with ADS bark beetle polygons (2002–2009). To identify transmission lines used in analyses, query ADSBARKBEETLE = 1	○
Adminsites	Point locations for administrative sites within R1 national forests.	○
alp_own	Automated Lands Program (ALP) administrative national forest boundaries	○
Aspen	Aspen from Landfire existing vegetation type data	○
aspen_frcc	Departure from historical conditions in aspen based on Landfire fire regime condition class and existing vegetation type data	○
beetleint0209	Bark beetle occurrence/intensity from ADS polygons from 2002 to 2009	○
biggame_wr	Big-game winter range as represented by elk winter range in Idaho/Montana, and bighorn sheep areas on Dakota Prairie Grasslands	○
Blisterrust	Percentage of blister rust infection in whitebark pine at 1 km resolution	○
cfpfor_052010	Mean crown fire burn probability	○
dams_id	Idaho dams	○
dams_mt	Montana dams	○
dams_nd	North Dakota dams	○
dams_sd	South Dakota dams	○
decid_encro	Conifer succession (encroachment) in deciduous forest based on Landfire biophysical settings and existing vegetation type data	○
DispersedRecreation	Dispersed recreation use on national forest lands in five classes (1 = very low use, 2 = low use, 3 = moderate use, 4 = high use, 5 = very high use)	○

Metadata view

Input layer	Description	Metadata Select to View
Dryshrub	Dry shrublands from Landfire existing vegetation type data	○
electronic_sites	Cellular radiotelephone service sites	○
fote_popd2000	*Forests on the Edge* 2000 housing density per square mile in three classes: RURAL1 (0to 16), RURAL2 (16 to 65), and URBAN (65+)	○
fote_popd2030	*Forests on the Edge* 2030 housing density per square mile in three classes: RURAL1 (0 to 16), RURAL2 (16 to 65), and URBAN (65+)	○
Grizgrid	Grizzly bear distribution areas and recovery zones	○
grshr_encro	Conifer succession (encroachment) in grasslands/shrublands based on Landfire biophysical settings and existing vegetation type data	○
hucnfweedcomb	Grid combining three data layers: 6th-code hydrologic unit codes (HUCs), nonforest vegetation, and weed risk	○
ledf	Low-elevation dry forest communities from Landfire existing vegetation type data	○
mgprairie	Mixed grass prairie from Landfire existing vegetation type data	○
mtbs00_08	Monitoring Trends in Burn Severity (MTBS) for 2000–2008	○
municipal_watersheds062_r1	Surface water supplies that occur on national forest lands within Region 1, represented by subwatersheds	○
nffrcc30	Departure from historical conditions in nonforest vegetation based on Landfire fire regime condition class and existing vegetation type data	○
oilgas_wells	Oil and gas wells within the Region 1 boundary (including nonforest lands)	○
problem_mines	Point locations of problem mines in Montana and Idaho	○
R1_305b_Strms0	NHD streams that have been listed as 303d or 305b in Integrated Water Quality Monitoring and Assessment Reports in Montana, Idaho, North Dakota, and South Dakota	○
R1_RFA_Sites_data	Points representing developed recreation sites on national forest lands	○
ripwet	Riparian and wetland habitats from Landfire existing vegetation type data	○
ROS	Recreation Opportunity Spectrum (ROS) settings in six classes: 1 = urban, 2 = roaded natural, 3 = semiprimitive motorized, 4 = semiprimitive non-motorized, 5 = primitive, 6 = wilderness	○
ScenicIntegrity	Existing scenic integrity in four classes: 2 = low, 3 = moderate, 4 = high, 5 = very high	○
sfpfor_052010	Mean forest ground-fire burn probability	○
sfpnf_052010	Mean nonforest ground-fire burn probability	○
SkiAreas	Point locations of special use permit ski areas on national forest lands	○
wdraw_frcc	Departure from historic conditions in woody draws based on Landfire fire regime condition class and existing vegetation type data	○
weedrisk90	Weed risk in three classes: 1 = low, 2 = moderate, 3 = high	○
whitebark	Whitebark pine distribution, 1 km resolution	○
woodydraw	Woody draws from Landfire existing vegetation type data	○
x_IRPS_Active_Allot	Active range allotments for national forests in Region 1; associated tables for each forest contain animal unit month (AUM) data	○

Metadata view

Table A2—Data dictionary for IRPS input attributes in IRPSv102_ ScenarioValueRiskInputs table[1]

Forest Service ownership

Attribute: FSOWND Input layer: alp_own

Percentage of land managed by the USDA Forest Service within a subwatershed based on 2009 Automated Lands Program (ALP) data.

Population density, 2000

Value in S1A, S3A, S5E

Attribute: POPDEN2000 Input layer: fote_popd2000

Specialist: Catherine Stewart, Fire Ecologist/Assistant Fuels Planner

Percentage of subwatershed with high housing density based on the *Forests on the Edge* (FOTE) 2000 housing density model. The FOTE 30 m raster data had three classes of housing density per square mile: RURAL1 (0–16), RURAL2 (16–65), and URBAN (65+). Percentages of the subwatershed for each class were calculated and then the following formula was applied: POPDEN2000 = RURAL1 × .33 + RURAL2 × .66 + URBAN.

Oil and gas wells

Value in S1A,S3A

Attribute: OGWELLS Input layer: oilgas_wells

Specialist: Catherine Stewart, Fire Ecologist/Assistant Fuels Planner

Number of active oil or gas wells on Forest Service lands. Only the Dakota Prairie Grasslands had active oil or gas wells on Forest Service lands.

Forest dominance type, current departure

Value in S1B

Attribute: DOMTYPEDEP Input layer: n/a (FIA data query)

Specialist: Barry Bollenbacher, Regional Silviculturist

Current departure from desired condition or historical range of variability (HRV) for forest dominance types. Current condition of forest dominance types (mean percentage occurrence) was calculated based on Forest Inventory and Analysis (FIA) data queries. Owing to the limited number of base FIA grid data per 6th-code subwatershed, the queries were done by Forest Planning/Landscape areas (the S1B_AA attribute contains the query area). Desired condition ranges or HRV for forest dominance types were based on forest plan revision or SIMMPPLE modeling (http://www.fs.fed.us/rm/missoula/4151/SIMPPLLE/). In the analysis, each forest dominance type's mean percentage of occurrence was compared to the desired condition or HRV percentage range. Absolute departure from the range was calculated for each forest dominance type within a Forest Planning/Landscape area and then summed into a total departure.

For example, in the Kootenai-Idaho Panhandle National Forests planning area (S1B_AA = 101), the forest dominance types were: ponderosa pine, Douglas-fir, lodgepole pine, white pine, larch/whitebark pine, mixed cool mesic/mountain hemlock, mixed warm mesic/grand fir, and hardwoods. Ponderosa pine had a mean percentage of occurrence of 3.2 percent, a desired condition range of 4 to 10 percent, and a departure of 4 to 3.2 = 0.8 percent. Douglas-fir had a mean percentage of occurrence of 9.3 percent, a desired condition range of 11 to 25 percent, and a departure of 11 to 9.3 = 1.7 percent. Lodgepole pine had a mean percentage of occurrence of 5.8 percent, a desired condition range of 3 to 6 percent, and a departure of 0 percent (within range). White pine had a mean percentage of occurrence of 3.2 percent, a desired condition range of 10 to 39 percent, and a departure of 10 to 3.2 = 6.8 percent. Larch/whitebark pine had a mean percentage of occurrence of 14.0 percent, a desired condition range of 10 to 22 percent, and a departure of 0 percent (within range). Mixed cool mesic/mountain hemlock had a mean percentage of occurrence of 17.9 percent, a desired condition range of 10 to 20 percent, and a departure of 0 percent (within range). Mixed warm mesic/grand fir had a mean percentage of occurrence of 41.3 percent, a desired condition range of 5 to 12 percent, and a departure of 41.3 to 12 = 29.3 percent. Hardwoods had a mean percentage of occurrence of 0.4 percent, a desired condition range of 0 percent, and a departure of 0.4 to 0 = 0.4 percent. The total forest dominance type departure for this analysis area was: 0.8 + 1.7 + 0 + 6.8 + 0 + 0 + 29.3 + 0.4 = 39.0 percent.

For west-side forests, departure is based on draft revised forest plans and is subject to change as forests complete their revisions. For east-side forests, departure is based on a 2001 HRV analysis and is also subject to forest plan revision changes. Departure values were calculated by analysis area, and each subwatershed within a given analysis area has the same value.

[1] Attributes are listed here in the order in which they appear in the data table **IRPSv102_ ScenarioValueRiskInputs**, stored in the output geodatabase **RestorationOpportunityAreas_R1_v102.gdb**. (This table is also available in DBF format.) In general, resource values are listed first, followed by risks; attributes are also organized by scenario, starting with Scenario 1A. For each attribute, we provide its name and the name of the input GIS layer(s) used to calculate it. We also indicate the scenarios for which an attribute was used, and whether the attribute represents a value or a risk (or, in a few cases, a feasibility measure). The resource specialist who worked on the scenario or who knows the most about that attribute is also listed. Finally, we provide a brief description of the attribute and what it represents, how it was calculated, and any assumptions or special concerns of which users should be aware.

Forest tree size class, current departure

Value in S1B

Attribute: TREESIZDEP Input layer: n/a (FIA data query)

Specialist: Barry Bollenbacher, Regional Silviculturist

Current departure from desired condition or HRV for forest tree size class groups. This attribute was calculated following the same process as the DOMTYPEDEP attribute above. The tree size class groups were: sapling 0 to 4.9 in diameter at breast height (DBH), pole 5 to 9.9 in DBH, medium 10 to 14.9 in DBH, and large 15+ in DBH. Current condition (mean percentage occurrence) of tree size class groups was calculated based on FIA data queries. Desired condition ranges or HRV for tree size class groups were based on forest plan revision or SIMMPPLE modeling. In the analysis, each tree size class group's mean percentage of occurrence was compared to the desired condition or HRV percentage range and departure was calculated.

For example, in the Kootenai-Idaho Panhandle National Forests planning area (S1B_AA = 101), the sapling group had a mean percentage of occurrence of 6.5 percent, a desired condition range of 14 to 28 percent, and a departure of 14 to 6.5 = 7.5 percent. The pole group had a mean percentage of occurrence of 26.3 percent, a desired condition range of 9 to 18 percent, and a departure of 26.3 to 18 = 8.3 percent. The medium group had a mean percentage of occurrence of 28.8 percent, a desired condition range of 12 to 27 percent, and a departure of 28.8 to 27 = 1.8 percent. The large group had a mean percentage of occurrence of 33.6 percent, a desired condition range of 31 to 61 percent, and a departure of zero (within range). The total tree size class group departure was: 7.5 + 8.3 + 1.8 + 0 = 17.6 percent.

For west-side forests, departure is based on draft revised forest plans and is subject to change as forests complete their revisions. For east-side forests, departure is based on a 2001 HRV analysis and is also subject to forest plan revision changes. Departure values were calculated by analysis area, and each subwatershed within a given analysis area has the same value.

Warm dry forest canopy, current departure

Value in S1B

Attribute: WDCANOPDEP Input layer: n/a (FIA data query)

Specialist: Barry Bollenbacher, Regional Silviculturist

Current departure from desired condition or HRV for warm dry forest type canopy closure (density). The forest plan revisions did not have a desired condition range for density of the dry forest type at the time of this analysis. For this assessment, we used FVS and FFE (http://www.fs.fed.us/fmsc/fvs/description/model.shtml) to look at a range of basal areas that would result in reduced crown fire behavior and lower bark beetle hazard. A range of 55 to 75 square feet of basal area was used on west-side forests, and a range of 40 to 70 square feet of basal area was used on east-side forests as a desirable density to achieve these objectives. For this analysis, a desired condition range of 40 to 60 percent of the dry forest type that met the density objective was used. The FIA data by Forest Planning/Landscape area (S1B_AA) were first classified into "dry forest type" or "not dry forest type" and the percentage of dry forest type calculated. Then the dry forest type FIA data were classified into "met density objective" or "did not meet density objective" and the percentage of dry forest type that met the density objective was calculated. The final step compared that result to the desired condition range of 40 to 60 percent.

For example, in the Kootenai-Idaho Panhandle National Forests planning area (S1B_AA = 101), 8.9 percent of the FIA data were classified as dry forest type. Within the dry forest type, 22.5 percent met the density objective. The percentage of departure was 40 to 22.5 = 17.5 percent. In general, much of the warm dry type FIA data had basal area above the density objective, and thus had higher risk of crown fire or bark beetle infestation.

For west-side forests, departure is based on draft revised forest plans and is subject to change as forests complete their revisions. For east-side forests, departure is based on a 2001 HRV analysis and is also subject to forest plan revision changes. Departure values were calculated by analysis area, and each subwatershed within a given analysis area has the same value.

Nonforest vegetation types with weed risk

Value in S1C

Attribute: NFWRCOMP Input layer: hucnfweedcomb

Specialist: Steve Shelly, Regional Botanist/Research Natural Areas/Invasive Species

Percentage of subwatershed with nonforest types that have weed risk. This attribute is a compilation of nonforest types from Landfire existing vegetation type (EVT) groups and a regional weed risk layer. First, Landfire nonforest EVT 30 m raster data were resampled to 90 m and reclassified into 11 EVT groups: dry grass, wet grass, mixed grass, tall grass, alpine, sage, deciduous shrub, mixed high-elevation shrub, riparian, woody draw, and exotic species. Then the percentage of each EVT group was calculated per subwatershed. The EVT grouped raster data were combined with a regional weed risk 90 m raster layer (see weed risk attribute below). The percentage of each EVT group by low, moderate, and high weed risk was calculated. From that, a total weed risk per EVT group was calculated: (percent EVT group with low weed risk × .33) + (percent EVT group with mod weed risk × .66) + (percent EVT group with high weed risk × 1). Then the following general formula was used to calculate

a combined EVT group and weed risk value: (percent EVT group × EVT group weight) + (EVT group total weed risk percent × EVT group weed risk weight). In the final step, all of the combined EVT group and weed risk values were summed.

For example, the dry grass EVT group had 28 percent occurrence in a subwatershed. There was 12 percent in low weed risk, 10 percent in moderate weed risk, and 6 percent in high weed risk. The total dry grass weed risk was (12 × 0.33) + (10 × 0.66) + (6 percent × 1) = 16.56. The dry grass EVT group had a weight of 0.6 and the dry grass EVT group weed risk had a weight of 0.4. The combined dry grass EVT group and weed risk value was (28 × 0.6) + (16.56 × 0.4) = 23.424. The final combined nonforest with weed risk value used weights to account for different levels of risk caused by invasive weeds in different nonforest types.

Note: this is based on a composite weed risk layer that varies across the region and should be revised when feasible.

Whitebark pine

Value in S2A

Attribute: WHITEBARK Input layer: whitebark

Specialist: Eric Tomasik, Wildlife Program Leader

Whitebark pine distribution. Input data layer is a blister rust map provided by Bob Keane (Rocky Mountain Research Station Fire Sciences Lab) on 3/6/2009. All blister rust values were recoded to 1 to represent the overall whitebark pine distribution (as per email from Bob Keane, forwarded by Barry Bollenbacher, which indicates this is the best available distribution map with a 90 percent accuracy rate). An ArcGIS model (HUC_RASTER_PERC) was then used to calculate the percentage of each subwatershed in whitebark pine. Note that the source data are at 1 km resolution, which is coarser than most other inputs.

Grizzly bear range

Value in S2A, S2I

Attribute: GRIZRANGE Input layer: grizgrid

Specialist: Eric Tomasik, Wildlife Program Leader

Grizzly bear range as represented by input data set GrizzlyBear.gdb, provided by Kim Foiles on 9/30/09. Grizzly bear distribution areas/recovery zones were converted to a grid, and an ArcGIS model (HUC_RASTER_PERC) was used to calculate the percentage of each subwatershed that falls within the grizzly's distribution.

Dry forest communities

Value in S2B

Attribute: DRYFORCOMM Input layer: ledf

Specialist: Eric Tomasik, Wildlife Program Leader

Dry forest communities as represented by Landfire Rapid Refresh (LF_1.0.1) EVT data. Landfire data were queried to extract eight types identified by Mary Manning et al. as belonging to dry forest communities. An ArcGIS model (HUC_RASTER_PERC) was then used to calculate the percentage of each subwatershed in dry forest communities. The eight Landfire types are:

- 2045 Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest
- 2049 Rocky Mountain Foothill Limber Pine-Juniper Woodland
- 2053 Northern Rocky Mountain Ponderosa Pine Woodland and Savanna
- 2054 Southern Rocky Mountain Ponderosa Pine Woodland
- 2117 Southern Rocky Mountain Ponderosa Pine Savanna
- 2165 Northern Rocky Mountain Foothill Conifer Wooded Steppe
- 2179 Northwestern Great Plains-Black Hills Ponderosa Pine Woodland and Savanna
- 2227 *Pseudotsuga menziesii* Forest Alliance

Dry forest type with large trees

Value in S2B

Attribute: DRYFORLGTR Input layer: n/a (FIA data query)

Specialists: Eric Tomasik, Wildlife Program Leader; Barry Bollenbacher, Regional Silviculturalist

Percentage of dry forest type with large trees based on a query of FIA data. The FIA data query was run using the same Forest Planning/Landscape analysis areas as the DOMTYPEDEP, TREESIZDEP, and WDCANOPYDEP attributes; although each subwatershed is assigned a value, every subwatershed within an analysis area will have that same value. The FIA data by analysis area (S1B_AA) were first classified into "dry forest type" or "not dry forest type" and the percentage of dry forest type calculated. Then the percentage of "dry forest type" FIA plots in the "large tree size" class (15+ in DBH) was determined.

Dry shrublands

Value in S2C

Attribute: DRYSHRUB Input layer: dryshrub

Specialist: Eric Tomasik, Wildlife Program Leader

Dry shrublands as represented by Landfire Rapid Refresh (LF_1.0.1) EVT data. Landfire data were queried to extract 10 types identified by Mary Manning et al. as

belonging to dry shrublands. An ArcGIS model (HUC_RASTER_PERC) was then used to calculate the percentage of each subwatershed in dry shrubland. The 10 Landfire types are:

- 2072 Wyoming Basins Dwarf Sagebrush Shrubland and Steppe
- 2079 Great Basin Xeric Mixed Sagebrush Shrubland
- 2080 Inter-Mountain Basins Big Sagebrush Shrubland
- 2081 Inter-Mountain Basins Mixed Salt Desert Scrub
- 2085 Northwestern Great Plains Shrubland
- 2124 Columbia Plateau Low Sagebrush Steppe
- 2125 Inter-Mountain Basins Big Sagebrush Steppe
- 2126 Inter-Mountain Basins Montane Sagebrush Steppe
- 2127 Inter-Mountain Basins Semi-Desert Shrub-Steppe
- 2220 *Artemisia tridentata* ssp. *vaseyana* Shrubland Alliance

Aspen

Value in S2D

Attribute: ASPEN Input layer: aspen

Specialist: Eric Tomasik, Wildlife Program Leader

Aspen as represented by Landfire Rapid Refresh (LF_1.0.1) EVT data. Landfire data were queried to extract five types identified by Mary Manning et al. as belonging to aspen. An ArcGIS model (HUC_RASTER_PERC) was then used to calculate the percentage of each subwatershed in aspen. The five Landfire types are:

- 2009 Northwestern Great Plains Aspen Forest and Parkland
- 2011 Rocky Mountain Aspen Forest and Woodland
- 2061 Inter-Mountain Basins Aspen-Mixed Conifer Forest and Woodland
- 2301 Boreal Aspen-Birch Forest
- 2331 Eastern Great Plains Tallgrass Aspen Parkland

Woody draws

Value in S2E

Attribute: WOODYDRAW Input layer: woodydraw

Specialist: Eric Tomasik, Wildlife Program Leader

Woody draws as represented by Landfire Rapid Refresh (LF_1.0.1) existing vegetation type data. Landfire data were queried to extract one type identified by Mary Manning et al. as representing woody draws. An ArcGIS model (HUC_RASTER_PERC) was then used to calculate the percentage of each subwatershed in woody draws. The single Landfire type is:

2385 Western Great Plains Wooded Draw and Ravine

Note: an assumption inherent to each of these Landfire-based attributes is that the distribution mapped by Landfire adequately represents a given land cover type on the ground. This assumption seems to be least applicable to woody draws, a type notoriously difficult to map from satellite imagery: woody draws in the Northern Region, particularly in southeastern Montana, do not appear to be especially well represented by Landfire.

Mixed-grass prairie

Value in S2F

Attribute: MGPRAIRIE Input layer: mgprairie

Specialist: Eric Tomasik, Wildlife Program Leader

Mixed-grass prairie as represented by Landfire Rapid Refresh (LF_1.0.1) EVT data. Landfire data were queried to extract six types identified by Mary Manning et al. as belonging to mixed-grass prairie. An ArcGIS model (HUC_RASTER_PERC) was then used to calculate the percentage of each subwatershed in mixed-grass prairie. The six Landfire types are:

- 2132 Central Mixed Grass Prairie
- 2141 Northwestern Great Plains Mixed Grass Prairie
- 2147 Western Great Plains Foothill and Piedmont Grassland
- 2148 Western Great Plains Sand Prairie
- 2149 Western Great Plains Shortgrass Prairie
- 2150 Western Great Plains Tallgrass Prairie

Riparian/wetland

Value in S2G

Attribute: RIPWETLAND Input layer: ripwet

Specialist: Eric Tomasik, Wildlife Program Leader

Riparian/wetland as represented by Landfire Rapid Refresh (LF_1.0.1) existing vegetation type data. Landfire data were queried to extract 10 types identified by Mary Manning et al. as belonging to riparian/wetland. An ArcGIS model (HUC_RASTER_PERC) was then used to calculate the percentage of each subwatershed in riparian/wetland. The 10 Landfire types are:

- 2154 Inter-Mountain Basins Montane Riparian Systems
- 2159 Rocky Mountain Montane Riparian Systems
- 2160 Rocky Mountain Subalpine/Upper Montane Riparian Systems
- 2161 Northern Rocky Mountain Conifer Swamp
- 2162 Western Great Plains Floodplain Systems
- 2469 Eastern Great Plains Floodplain Systems
- 2482 Great Plains Prairie Pothole

- 2488 Eastern Great Plains Wet Meadow-Prairie-Marsh
- 2493 Central Interior and Appalachian Shrub-Herbaceous Wetland Systems
- 2495 Western Great Plains Depressional Wetland Systems

Big game winter range

Value in S2H, risk in S2D

Attribute: BIGGAMEWR Input layer: biggame_wr

Specialist: Eric Tomasik, Wildlife Program Leader

Big-game winter range as represented by elk winter range in Idaho and Montana, and bighorn sheep management areas in the Dakota Prairie Grasslands. Input data set is big_game_wr.shp, provided by Jim Barber on 5/24/10 and used in IRPS version 1. This shapefile was converted to geodatabase, and then multipart features were converted to singlepart. An identity was performed with the subwatershed feature class to determine the percentage of each subwatershed in big game winter range.

Municipal watersheds

Value in S3A

Attribute: MUNICWSHD Input layer: municipal_watersheds062_r1

Specialist: Bruce Sims, Regional Hydrologist

Surface water sources for communities that occur on National Forest System lands in the Northern Region, as depicted by the subwatersheds in which these sources reside. Each subwatershed is coded either 1 (yes) or 0 (no) to indicate whether or not it is a municipal watershed. The shapefile municipal_watersheds062_nfs_r1.shp is the original data source.

303(d) or 305(b) impaired streams

Value in S3A

Attribute: D303 Input layer: R1_305b_Strms

Specialist: Bruce Sims, Regional Hydrologist

Indicates whether the subwatershed has impaired stream reaches listed under sections 303(d) or 305(b) of the federal Clean Water Act. For an overview of 303(d) and 305(b) listings, please see the Environmental Protection Agency (EPA) fact sheet: http://www.epa.gov/owow/tmdl/results/pdf/aug_7_introduction_to_clean.pdf.

To match the Watershed Condition Class Assessment, all stream reaches that have a 303(d) (both total maximum daily load [TMDL] and non-TMDL) or 305(b) listing were considered. Lacking specific direction, all listed stream segments independent of their status (perennial, intermittent, etc.) were considered. Three layers were downloaded for Montana, Idaho, and North Dakota/South Dakota, then appended and intersected with watersheds and Forest Service ownership. Attribute D303 contains the miles of 303(d)/305(b) streams on Forest Service lands per subwatershed.

Future analyses should consider (a) whether to use all streams regardless of permanency throughout the year; (b) whether to include streams without TMDLs in place, or assign different weight to streams with TMDLs in place; and (c) how streams will be rated according to different sources of disturbance/use/pollution.

Aquatic Priority Watersheds

Value in S4A

Attribute: AQUATPRIOR Input layers: see below

Specialist: Scott Spaulding, Fish Program Manager

Aquatic Priority Watershed based on Idaho forest plan revision, western Montana bull trout, central-eastern Montana west-slope cutthroat or Yellowstone cutthroat, and Eastern Montana/Dakota prairie grassland IRPS V062 (1 = yes and 0 = no). Please refer to the files Map_1_ID_restPriority.pdf, Map_2_WMt_restPriority.pdf, Map_3_East_MT_restPriority.pdf, and Map_4_DPG_restPriority.pdf. Four corresponding input layers are stored in the aquatic feature data set: BT_priorityHUCs, Cutthroat_PriorityHUCs, DPG_priorityRest_HUC, and ID_priorityRest_HUC.

Developed recreation use

Value in S5A

Attribute: DEVRECUSE Input layer: R1_RFA_Sites_data

Specialist: Lis Novak, Regional Landscape Architect

Weighted sum of number of developed recreation sites based on:

6. Occupancy rate (low <20 percent; moderate 20 to 40 percent; high >40 percent);
7. Total annual visitation (low <500; moderate 500 to 2,500; high >2,500); and
8. Duration of use (low = THs, Boat, interp-minor, observ. sites, docum. sites; moderate = day use, picnic, fishing, winter, swimming; high = cabins, campgrounds/areas, interp-admin&major).

Developed recreation points were created from latitude/longitude fields in the source file R1_RFA_Sites.xls (received from Lis Novak) and attributed from the same source. Occupancy rate is based on the field "average_daily," total annual visitation is based on the field "ann_estimate," and duration of use is based on the field "site_type." The weighted sum was calculated using: [(occurate-low × .1 + occurate-mod × .3 + occurate-high × .6) + (totvis-low × .1 + totvis-mod × .3 + totvis-high × .6) + (duruse-low × .1 + duruse-mod×.3 + duruse-high × .6)]. All three inputs are assumed to be equally important; low classes are assumed to have low impact, and high classes have high impact.

High and very high dispersed recreation use

Value in S5A, S5C

Attribute: DISPRECHVH Input layer: DispersedRecreation

Specialist: Lis Novak, Regional Landscape Architect

Percent area of high + very high dispersed recreation use. Dispersed recreation use was modeled across the region to identify likely areas of concentrated overnight use. The model assumes that (1) dispersed recreation areas need to be accessible (preferably by motorized transportation), (2) campers need water, and (3) campers prefer flat areas and likely avoid steep terrain. The model has three inputs:

1. ROS as a measure of access or travel corridors (RN = roaded natural and SPM = semi primitive motorized). For more information, see the entry for the RECOPSPEC attribute below.
2. Proximity to water (400-m buffer of NHD water bodies and streams).
3. Slope classes based on a 30-m raster (H = 0 to 7 percent, high likelihood of dispersed recreation in flat areas; M = 7–15 percent; L >15 percent, low likelihood of dispersed recreation in steeper areas).

These layers were overlaid and landscapes were categorized into very high, high, moderate, low, and very low dispersed recreation use as follows:

- VERY HIGH: slope = H (flat, 0 to 7 percent), ROS setting = RN (easiest access by car), within 400 m of lake.
- HIGH: slope = M, ROS = RN, and within 400 m of lake; OR slope = H, ROS = RN, within 400 m of stream.
- MODERATE: slope = M, ROS = RN, within 400 m of stream; OR slope = H, ROS = SPM, within 400 m of lake or stream.
- LOW: slope = M, ROS = SPM, within 400 m of lake or stream.
- VERY LOW: slope = L; ROS = RN, within 400 m of lake or stream; OR slope = L, ROS = SPM, within 400 m of lake or stream.

All other areas were considered unsuitable for dispersed recreation use. Water body polygons were excluded from area calculations.

Recreation residences

Value in S5A, S5B

Attribute: RECRESID Input layer: DevRec_r1_residences

Specialist: Lis Novak, Regional Landscape Architect

Number of special-use permit recreation residence cabins in subwatershed.

Ski areas

Value in S5A, S5B

Attribute: SKIAREAS Input layer: SkiAreas

Specialist: Lis Novak, Regional Landscape Architect

Number of special use permit ski areas in subwatershed. The ski area point file was created from lat/long information found in R1SkiAreas_Lat_Long_Formatted12_09.XLS (from Lis Novak).

Roads within 150 feet of mapped insect/disease

Value in S5A

Attribute: ADSROADS Input layer: road_adsbb_own_irpshucs

Specialist: Lis Novak, Regional Landscape Architect

Miles of Forest Service System roads in Operational Maintenance class 3/4/5 that are within 150 feet of an Aerial Insect and Disease Detection Survey (ADS) polygon from survey years 2002–2009. Input layer is stored in the transportation feature data set.

This analysis is based on layers at different scales: the ADS polygons are mapped at a coarser scale than the roads. Results probably do not capture all roads affected by bark beetle infestation.

Trails within 150 feet of mapped insect/disease

Value in S5B

Attribute: ADSTRAIL Input layer: trails_adsbb_own_irpshucs

Specialist: Lis Novak, Regional Landscape Architect

Miles of Forest Service System trails in that are within 150 feet of an Aerial Insect and ADS polygon from survey years 2002–2009. Input layer is stored in the transportation feature data set.

This analysis is based on layers at different scales: the ADS polygons are mapped at a coarser scale than the trails. Results probably do not capture all trails affected by bark beetle infestation.

Developed recreation investment

Value in S5B

Attribute: DEVRECINV Input layer: R1_RFA_Sites_data

Specialist: Lis Novak, Regional Landscape Architect

Weighted sum of the number of developed recreation sites based on:

- Development scale (low <3; moderate = 3; high >3);
- Replacement value (low <$25,000; moderate $25,000 to $100,000; high >$100,000); and

- Site type (low = THs, swimming, winter; moderate = picnic, boating, fishing, interp-minor, observ. sites, docum. sites; high = cabins, campgrounds/areas, horse camps, Interp-admin&major).

Developed recreation points were created from latitude/longitude fields from the source file R1_RFA_Sites.xls (received from Lis Novak) and attributed from the same source. Development scale is based on the field "dev_scale," replacement value is based on the field "curr_repl," and site type is based on the field "site_type." The weighted sum was calculated using: [(devscal-low × .1 + devscal-mod × .3 + devscal-high × .6) + (replacval-low × .1 + replacval-mod × .3 + replacval-high ×.6) + (sitety-low × .1 + sitety-mod×.3 + sitety-high × .6)]. All three inputs are assumed to be equally important; low classes are assumed to have low impact, and high classes have high impact.

Utility lines within 150 feet of mapped insect/disease

Value in S5B

Attribute: ADSUTILITY **Input layer: transmission_adsbb_own_irpshucs**

Specialist: Lis Novak, Regional Landscape Architect

Miles of high voltage utility lines that are within 150 feet of an Aerial Insect and Disease Detection Survey (ADS) polygon from survey years 2002–2009. Input layer is stored in the transportation feature data set.

This analysis is based on layers at different scales: the ADS polygons are mapped at a coarser scale than the utility lines. Results probably do not capture all utility lines affected by bark beetle infestation.

Electronic sites

Value in S5B

Attribute: ELECTSITES **Input layer: electronic_sites**

Specialist: Lis Novak, Regional Landscape Architect

Number of electronic sites (e.g., cellular or radio towers) in the subwatershed.

Administrative sites

Value in S5B

Attribute: ADMINSITES **Input layer: adminsites**

Specialist: Lis Novak, Regional Landscape Architect

Number of Forest Service administrative sites (e.g., ranger district headquarters or work centers) that are in the subwatershed.

Low and moderate scenic integrity

Value in S5D

Attribute: SCENICINTL **Input layer: ScenicIntegrity**

Specialist: Lis Novak, Regional Landscape Architect

Percent area of low and moderate scenic integrity. Scenic integrity was conceptualized as forest lands with little evidence of human disturbance such as roads, ski areas, mining, oil and gas development, and utility corridors. It was modeled using:

1. Recreation Opportunity Spectrum categories;
2. Visual impact polygons from the R1 past vegetation treatment data (FACTS);
3. 400-m buffers around oil and gas development sites;
4. 400-m buffers around ski areas;
5. 400-m and 800-m buffers around inactive and active mines, respectively; and
6. 70-m buffer around utility corridors.

The layers were overlaid and landscapes were classified into very high, high, moderate, and low scenic integrity as follows:

- Very high = ROS settings of P (primitive).
- High = ROS settings of SPNM (semiprimitive nonmotorized), OR ROS settings of SPM (semiprimitive motorized) or RN (roaded natural) that do not overlap with visual impacts or buffers on oil/gas, ski areas, mines, or utility corridors.
- Moderate = ROS settings of SPM or RN that overlap with visual impact polygons coded 1, but not with any of the above buffers.
- Low = ROS settings of SPM or RN that overlap with any disturbance (visual impacts coded 2, or any of the above buffers).

Recreation Opportunity Spectrum

Value in S5D, S5E

Attribute: RECOPSPEC **Input layer: ROS**

Specialist: Lis Novak, Regional Landscape Architect

Percentage of area of the subwatershed covered by ROS categories urban (UR), RN, and SPM. ROS categories were modeled following the National ROS Inventory Mapping Protocol (Dec. 2003) using the rosto8.aml provided by Lis Novak. Input data had to be converted to ArcInfo coverages to run the AML; also, the AML had to be run on each forest individually because of software limitations when buffering roads. Source data included:

1. Forest Service boundaries (R1 Geospatial Library);
2. Wilderness and other special designated areas (R1 Geospatial Library);

3. R1 travel routes geodatabase (R1 Geospatial Library); and
4. TIGER 2000 roads data.

The travel routes line data were joined with the core attribute data (both roads and trails), and using the attribute oper_maint_level (for roads) or design_ use (for trails), roads and trails were categorized into nonmotorized, primitive, or better-than-primitive. In some cases, we used the attribute object_maint_level, or we double-checked assignments with R1 library visitor maps. TIGER roads had to be used mainly for areas outside the Forest Service areas (up to 3 miles from Forest Service lands because of aml buffers), where travel route information was unavailable. For TIGER roads, CFCC of A5 was categorized motorized primitive; A1-4 and A6 were better than primitive; and A71, A72 were nonmotorized. Some TIGER roads were added on Forest Service lands because they were federal, state, or county roads missing in the R1 travel routes database (checked against visitor maps).

After the travel routes data were prepared, the rosto8.aml was run. Results then had to be checked for small polygons and assigned a final category based on neighbors (according to the above National Protocol). Small Forest Service ownerships near towns were categorized urban. Results for individual forests were unioned and edge-matched; in areas of overlap, the lowest category was assigned to the polygon. One problem in the travel routes database was "dangling" motorized road or trail segments surrounded by closed roads or nonmotorized trails. These dangles tended to produce isolated motorized polygons in the middle of nonmotorized polygons; these isolated polygons were reclassified to the surrounding category.

High and very high scenic integrity

Value in S5E

Attribute: SCENICINTH Input layer: ScenicIntegrity

Specialist: Lis Novak, Regional Landscape Architect

Percent area of high and very high scenic integrity. Scenic integrity was conceptualized as forest lands with little evidence of human disturbance such as roads, ski areas, mining, oil and gas development, and utility corridors. It was modeled using:

1. Recreation Opportunity Spectrum categories;
2. Visual impact polygons from the R1 past vegetation treatment data (FACTS);
3. 400-m buffers around oil and gas development sites;
4. 400-m buffers around ski areas;
5. 400-m and 800-m buffers around inactive and active mines, respectively; and

6. 70-m buffer around utility corridors.

The layers were overlaid and landscapes were classified into very high, high, moderate, and low scenic integrity as follows:

- Very high = ROS settings of P (primitive).
- High = ROS settings of SPNM (semiprimitive nonmotorized), OR ROS settings of SPM (semiprimitive motorized) or RN (roaded natural) that do not overlap with visual impacts or buffers on oil/gas, ski areas, mines, or utility corridors.
- Moderate = ROS settings of SPM or RN that overlap with visual impact polygons coded 1, but not with any of the above buffers.
- Low = ROS settings of SPM or RN that overlap with any disturbance (visual impacts coded 2, or any of the above buffers).

Burn probability

Risk in S1A, S2E, S5A, S5B, S5E

Attribute: BURNPROB Input layers: see below

Specialist: Catherine Stewart, Fire Ecologist/Assistant Fuels Planner

Combined crown fire and ground fire burn probability based on Large Fire Simulator (FireSim) runs. Most of the Region (west of Billings, Montana) was performed in one FireSim run during the fall of 2009. The eastern part of the region was filled in from the Billings and North Dakota 2009 FPU analysis FireSim runs. The output of the FireSim runs were 270-m raster grids with burn probability estimates for six flame length classes: 0 to 2, 2 to 4, 4 to 6, 6 to 8, 8 to 12, 12+ feet. The burn probability estimates were collapsed into two flame length classes: 0 to 6 and 6+ feet. Landfire Tree Canopy data with Value ≥ 10 percent Forest Canopy was used to create a "forest type" mask for the region. Any burn probability pixel with a probability > zero in the 6+ feet class and falling in a "forest type" pixel was placed into a crown-fire burn probability 270-m raster layer. Any burn probability pixel with a probability > zero in the 0 to 6 feet class and falling in a "forest type" pixel was placed into a forest ground-fire burn probability 270-m raster layer. Any remaining burn probability pixels with any probability value > 0 (in either flame length class) were placed into a nonforest ground-fire burn probability 270-m raster layer.

The subwatershed layer was intersected with the three burn probability grids, and mean crown-fire burn probability, forest ground-fire burn probability, and nonforest ground-fire burn probability values were calculated. Additionally, the area of crown-fire burn probability, forest ground-fire burn probability, and nonforest ground-fire burn probability were calculated. The burn probability mean values and area values were used to calculate combined fire risk for crown-fire, forest ground-fire, and

nonforest ground-fire (CRNFIRECOM, FOGNFIRCOM, and NFGNFIRCOM). An overall fire risk attribute (BURNPROB) was calculated by normalizing each of the three attributes above and multiplying by a weight. In the BURNPROB formula, crown-fire and forest ground-fire had twice as much weight as nonforest ground-fire:

(([CRNFIRECOM]/0.7) × 0.3) + (([FOGNFIRCOM]/0.8) × 0.3) + (([NFGNFIRCOM]/0.9) × 0.1).

Subwatersheds with higher BURNPROB values are assumed to have more risk of wildfire. Input layers are cfpfor_052010, sfpfor_052010, and sfpnf_052010 (see the following three attributes).

We made use of burn probability knowing that it was a product scheduled for revision, and that future versions would use data from many weather stations and have fewer edge-matching problems. The version we used is a hybrid layer pasted together from three sources as outlined above: the western, forested part of the region was run using data from one weather station; most of the remainder of the region was mapped using FPA runs of the FireSim model; and North Dakota was extrapolated from surrounding areas. Note that burn probability is not conditional; chance of fire this year does not change the fuel model (or fire) for the next year. There are also no long-term vegetation interactions, drought influence, or fires spreading into the area from outside the edges of the map. Many factors result in fire probabilities on the lower end of the scale.

Crown fire burn probability

Risk in S1B, S2A, S2B, S2G, S3A; part of BURNPROB

Attribute: CRNFIRECOM Input layer: cfpfor_052010

Specialist: Catherine Stewart, Fire Ecologist/Assistant Fuels Planner

Crown-fire burn probability based on Large Fire Simulator (FireSim) runs (see BURNPROB attribute description above). Subwatersheds with higher CRNFIRECOM values are assumed to have more risk of crown fire. Assumptions and caveats outlined above for burn probability apply here as well.

Forest ground fire burn probability

Not used directly—part of BURNPROB

Attribute: FOGNFIRCOM Input layer: sfpfor_052010

Specialist: Catherine Stewart, Fire Ecologist/Assistant Fuels Planner

Forest ground-fire burn probability based on FireSim runs (see BURNPROB attribute description above). Subwatersheds with higher FOGNFIRCOM values are assumed to have more risk of forest ground fire. Assumptions and caveats outlined above for burn probability apply here as well.

Nonforest ground fire burn probability

Risk in S2C, S2F; part of BURNPROB

Attribute: NFGNFIRCOM Input layer: sfpnf_052010

Specialist: Catherine Stewart, Fire Ecologist/Assistant Fuels Planner

Nonforest ground fire-burn probability based on FireSim runs (see BURNPROB attribute description above). Subwatersheds with higher NFGNFIRCOM values are assumed to have more risk of nonforest ground-fire (e.g., Dry Shrubland Scenario). Conversely, subwatersheds with lower NFGNFIRCOM values are assumed to lack nonforest ground-fire activity (e.g., Mixed Grass Prairie Scenario). Assumptions and caveats outlined above for burn probability apply here as well.

Bark beetle occurrence from ADS surveys, 2002-2009

Risk in S1A, S1B, S2B, S3A, S5A, S5B

Attribute: ADSBBOCC Input layer: beetleint0209

Specialist: Barry Bollenbacher, Regional Silviculturist

Percentage of bark beetle occurrence based on Aerial Insect and Disease Detection Survey (ADS) polygons from survey years 2002–2009. A bark beetle occurrence 30-m raster layer was created by modeling 2002–2009 ADS bark beetle "trees per acre" data into three classes: low, moderate, and high. First each year's ADS feature class polygon data was queried for: "DCA1" IN (11002, 11006, 11007, 11009, 11015, 11029, 11049, 11050) AND "TPA1" ≥ 1 and a 30 m raster layer was created based on the "TPA1" attribute. The yearly ADS bark beetle "trees per acre" raster layers were combined using a sum function into a "total bark beetle occurrence" raster layer. The "total bark beetle occurrence" raster layer was then reclassified into three classes based on: low (SUMTPA 1–5), mod (SUMTPA 5–15), and high (SUMTPA 15+). The percentage of each bark beetle occurrence class was determined, and the following formula was applied: ADSBBCC = (% low × 0.33) + (% mod × 0.66) + (% high × 1).

Note: ADS data are mapped at a coarse scale and were not designed to capture cumulative beetle mortality.

Bark beetle hazard

Risk in S1A, S1B, S2B, S5A, S5B, S5E

Attribute: BBHAZ Input layer: n/a (FIA data query)

Specialist: Barry Bollenbacher, Regional Silviculturist

The probability of pine stands being susceptible to bark beetle attack based on an FIA data query by 5th-code watershed. All 6th-code subwatersheds within a 5th-code watershed have the same value for this attribute.

Nonforest fire regime condition class, high vegetation departure

Risk in S1C

Attribute: NFFRCC Input layer: nffrcc30

Specialist: Steve Shelly, Regional Botanist/Research Natural Areas/Invasive Species

Departure from historical conditions in nonforest vegetation types as represented by Landfire (LF_1.0.0) Fire Regime Condition Class (FRCC) data. FRCC data were downloaded and intersected with Landfire Nonforest EVT Groups (see NFWRCOMP attribute description) to determine the fire regime condition class for each nonforest pixel. From this, the percentage of FRCC class 3, high vegetation departure, was calculated for the subwatershed.

Grazing

Risk in S1C, S2B, S2C, S2D, S2E, S2F, S2G, S2H, S3A, S4A

Attribute: GRAZCOMB Input layers: see attributes below

Specialist: Eric Tomasik, Wildlife Program Leader

Combination of two attributes: active allotment area per subwatershed (ACTALLOT) and the number of animal unit months (AUM) in a subwatershed. Each input was normalized and multiplied by equal weights and then summed: (([ACTALLOT]/100) × 0.5) + (([AMU]/18972) × 0.5).

Active grazing allotments

Not used directly - part of GRAZCOMB

Attribute: ACTALLOT Input layer: x_IRPS_Active_Allot

Specialist: Eric Tomasik, Wildlife Program Leader

Percent of subwatershed with active allotments based on forest allotment layers and 2009 allotment status reports.

Animal unit months

Not used directly - part of GRAZCOMB

Attribute: AMU Input layers: see below

Specialist: Eric Tomasik, Wildlife Program Leader

Number of AUMs based on 2009 allotment status reports. Source data are: xBD_Aum_Frequency, xBITT_Aum_Frequency, xCLW_Aum_Frequency, xCUS_Aum_Frequency, xDPG_Aum_Frequency, xFLH_Aum_Frequency, xGAL_Aum_Frequency, xHEL_Aum_Frequency, xIP_Aum_Frequency, xKOOT_Aum_Frequency, xLC_Aum_Frequency, xLOLO_Aum_Frequency, xNEZ_Aum_Frequency.

Whitebark pine blister rust

Risk in S2A

Attribute: WBPBLISTRU Input layer: blisterrust

Specialist: Eric Tomasik, Wildlife Program Leader

Whitebark pine blister rust as represented by a blister rust map provided by Bob Keane (RMRS Fire Sciences Lab) on 3/6/2009. Percentage blister rust was broken into 3 classes: Low (0 to 30, Moderate (>30 to 60), and High (>60 to 100). An ArcGIS model (HUC_RASTER_HAZSUM) was then run to determine the percentage of each subwatershed in each of the three classes, and the following formula was used to derive a single summary attribute: WBPBLISTRU = (rustLD × 0.33) + (rustMD × 0.66) + rustHD. Note that the source data are at 1-km resolution, which is coarser than most other inputs.

Monitoring Trends in Burn Severity, 2000-2008, moderate and high severity

Risk in S2A, S3A

Attribute: MTBSMODHI Input layer: mtbs00_08

Specialist: Eric Tomasik, Wildlife Program Leader

Percentage of moderate or high fire burn severity. The 2000–2008 Monitoring Trends in Burn Severity (MTBS) 30-m raster data were combined (note: only the moderate and high classes were included) using a maximum function. Percentages of moderate and high burn severity were calculated and the following formula was used to combine them: (% moderate × 0.6) + (% high × 1).

Weed risk

Risk in S2B, S2C, S2F, S2G, S2H

Attribute: WEEDRISK Input layer: weedrisk90

Specialist: Eric Tomasik, Wildlife Program Leader, and Steve Shelly, Regional Botanist/Research Natural Areas/Invasive Species

Percentage of modeled weed risk in subwatershed. A regionwide modeled weed risk layer was assembled from three separate raster sources: Mantas 2003 weed risk for 28 exotic species in northern Idaho and west-central Montana, Ashland and Sioux Ranger Districts weed risk, and Dakota Prairie Grassland weed risk. The 2009 Region 1 Invasives layer was also used in the creation of the three weed risk inputs. All three raster layers had low, moderate, and high weed risk classes. Percentages of low, moderate, and high weed risk were calculated per subwatershed and then the following formula was applied: (% low weed risk × 0.33) + (% mod weed risk × 0.66) + (% high weed risk × 1).

The weed risk layer is a composite of three data sources, none of which is an ideal representation of weed risk across the landscape. This layer represents the best available data, but should be revisited and revised as necessary.

Conifer succession in grasslands/shrublands

Risk in S2C

Attribute: GRSHRENCRO Input layer: grshr_encro

Specialist: Eric Tomasik, Wildlife Program Leader

Conifer succession (encroachment) in grasslands/shrublands as represented by a simple, pixel-based comparison of existing and potential vegetation. Conifer succession was assessed by: (1) downloading Landfire (LF_1.0.0) Biophysical Settings (BPS) data, extracting grass and shrub types based on groupings in the metadata and online tables, and creating a 0/1 grid where all grass/shrub types were coded 1; (2) creating a 0/1 grid from Landfire Rapid Refresh existing type data where all conifer types were coded 1; and (3) adding the two grids together. Pixels with a score of 2 were counted as areas where conifer succession has occurred in grass/shrub types. An ArcGIS model (HUC_RASTER_PERC) was then used to calculate the percentage of each subwatershed where conifer succession has occurred.

Conifer succession in deciduous forest

Risk in S2D

Attribute: DECIDENCRO Input layer: decid_encro

Specialist: Eric Tomasik, Wildlife Program Leader

Conifer succession (encroachment) in deciduous forest as represented by a simple, pixel-based comparison of existing and potential vegetation. Conifer succession was assessed by: (1) downloading Landfire (LF_1.0.0) Biophysical Settings (BPS) data, extracting deciduous forest types based on groupings in the metadata and online tables, and creating a 0/1 grid where all deciduous forest types were coded 1; (2) creating a 0/1 grid from Landfire Rapid Refresh existing type data where all conifer types were coded 1; and (3) adding the two grids together. Pixels with a score of 2 were counted as areas where conifer succession has occurred in deciduous forest types. An ArcGIS model (HUC_RASTER_PERC) was then used to calculate the percentage of each subwatershed where conifer succession has occurred.

Aspen fire regime condition class

Risk in S2D

Attribute: ASPENFRCC Input layer: aspen_frcc

Specialist: Eric Tomasik, Wildlife Program Leader

Departure from historic conditions in aspen as represented by Landfire (LF_1.0.0) Fire Regime Condition Class (FRCC) data. FRCC data were downloaded and intersected with the aspen grid to determine the fire regime condition class for each aspen pixel as follows: aspen_frcc3rr = con([aspen] = 1 and [frcc_4_irs] le 3, [frcc_4_irs]). The output grid had values for each of the three FRCC classes: 1 = low vegetation departure; 2 = moderate vegetation departure; and 3 = high vegetation departure. An ArcGIS model (HUC_RASTER_HAZSUM) was then run to determine the percentage of each subwatershed in each of the three classes, and the following formula was used to derive a single summary attribute: ASPENFRCC = (0.33 × [aspen_frccLD]) + (0.66 × [aspen_frccMD]) + [aspen_frccHD].

Woody draw fire regime condition class

Risk in S2E

Attribute: WOODRWFRCC Input layer: wdraw_frcc

Specialist: Eric Tomasik, Wildlife Program Leader

Departure from historic conditions in woody draws as represented by Landfire (LF_1.0.0) Fire Regime Condition Class (FRCC) data. FRCC data were downloaded and intersected with the woodydraw grid to determine the fire regime condition class for each woodydraw pixel as follows: wdraw_frcc3rr = con([woodydraw] = 1 and [frcc_4_irs] le 3, [frcc_4_irs]). The output grid had values for each of the three FRCC classes: 1 = low vegetation departure; 2 = moderate vegetation departure; and 3 = high vegetation departure. An ArcGIS model (HUC_RASTER_HAZSUM) was then run to determine the percentage of each subwatershed in each of the three classes, and the following formula was used to derive a single summary attribute: WOODRWFRCC = (0.33 × [wdraw_frccLD]) + (0.66 × [wdraw_frccMD]) + [wdraw_frccHD].

Scenario 1B opportunity score

Risk in S2H

Attribute: S1BOS Input layer: n/a (scenario output score)

Specialist: Barry Bollenbacher, Regional Silviculturist

Forest vulnerability index based on high Scenario S1B opportunity scores. Subwatersheds with higher forest departure from desired conditions with high risk factors are assumed to be more vulnerable.

Scenario 1C opportunity score

Risk in S2H

Attribute: S1COS Input layer: n/a (scenario output score)

Specialist: Steve Shelly, Regional Botanist/Research Natural Areas/Invasive Species

Nonforest vulnerability index based on high Scenario SCB opportunity scores. Subwatersheds with higher nonforest risk factors are assumed to be more vulnerable.

Open road and motorized trail density

Risk in S2I

Attribute: MOTORROUTE Input layer: TravelRoutesR1.gdb**

Specialist: Eric Tomasik, Wildlife Program Leader

Density (miles/square mile [mi/mi^2]) of open roads and motorized trails per subwatershed. Within TravelRoutesR1.gdb, feature class R1_TravelRoutes_Roads was queried to select out roads that are not closed ("OPER_MAINT_LEVEL" <> '1 – BASIC CUSTODIAL CARE (CLOSED)'). Additionally, because the Idaho Panhandle's data are stored in a separate field in R1_TravelRoutes_Roads (OPER_MAINT instead of OPER_MAINT_LEVEL), the Idaho Panhandle's closed roads were queried out ("OPER_MAINT" = '1 - BASIC CUSTODIAL CARE (CLOSED)', then Select by Location was used to remove from the currently selected set in R1_TravelRoutes_Roads features that were identical to the currently selected in Idaho_Panhandle_Rd. The selected features were then exported to a new feature class, R1_Roads_not_closed. To select out motorized trails, feature class R1_TravelRoutes_Trails was queried ("DESIGNED_USE" = 'ATV – ALL TERRAIN VEHICLE' OR "DESIGNED_USE" = 'MTRCYCL – MOTORCYCLE' OR "DESIGNED_USE" = 'SNOMO – SNOWMOBILE') and selected features were exported to R1_Trails_motorized. Identity and summary statistics were then used to calculate miles of open road per square mile in each subwatershed; the process was repeated to calculate miles of motorized trail per square mile in each subwatershed, and the two fields were added to come up with a final number.

NOTES: (1) In R1_TravelRoutes_Roads, a number of road features had null values for OPER_MAINT_LEVEL; these roads were included in calculations of open road density. (2) The Idaho Panhandle had no attributes to determine whether or not trails are motorized, so no trails on that forest were included in calculations of motorized trail density. (3) No data were available in R1_TravelRoutes_Road for the Dakota Prairie and Sheyenne National Grasslands, thus no motorized route density was calculated.

**Because roads data receive constant updates and thus quickly become outdated, the inputs used here are not included in the project geodatabase.

Developed recreation sites

Risk in S3A

Attribute: DEVRECSITE Input layer: R1_RFA_Sites_data

Specialist: Bruce Sims, Regional Hydrologist/Lis Novak, Regional Landscape Architect

Developed recreation sites (number of points per square mile) per subwatershed. Points were created from latitude/longitude fields from R1_RFA_Sites.xls (received from Lis Novak) and attributed from that same source.

Problem mines

Risk in S3A, S4A

Attribute: MINES Input layer: problem_mines

Specialist: Bruce Sims, Regional Hydrologist

The number of problem mines per square mile. Mines that were attributed with a "1" in the "PROBLEM" attribute were selected from the Region 1 Mines (Abandoned and Inactive) databases for northern Idaho and Montana (metadata: http://www.fs.fed.us/r1/gis/thematic_data/mines_abandoned_inactive_n_id.htm, and http://www.fs.fed.us/r1/gis/thematic_data/mines_abandoned_inactive_mt.htm).

Total road density

Not used directly - part of ROADCOMB

Attribute: ROADTOTDEN Input layer: roadsTIGER

Specialist: Bruce Sims, Regional Hydrologist/Scott Spaulding, Fish Program Manager

Total road density (mi/mi^2) for the subwatershed. Source: 2000 TIGER roads for Montana, Idaho, Wyoming, South Dakota, and North Dakota.

Road density in riparian areas

Risk in S2G and part of ROADCOMB

Attribute: ROADRIPDEN Input layers: nhd_strms, roadsTIGER

Specialist: Bruce Sims, Regional Hydrologist/Scott Spaulding, Fish Program Manager

Road density in riparian areas (mi/mi^2) per subwatershed. Riparian area was created by buffering the 1:24,000 NHD streams by 60 m on either side; riparian area was then intersected with TIGER roads and lengths were summarized.

Number of stream crossings

Not used directly—part of ROADCOMB

Attribute: ROADSTRMXC Input layers: nhd_strms, roadsTIGER

Specialist: Bruce Sims, Regional Hydrologist/Scott Spaulding, Fish Program Manager

Number of stream crossings per stream mile per subwatershed. The 2000 TIGER roads layers and 2008 NHD stream layer were intersected to determine the number of road/stream crossings and miles of streams.

Combined road risk

Risk in S3A, S4A

Attribute: ROADCOMB Input layers: nhd_strms, roadsTIGER

Specialist: Bruce Sims, Regional Hydrologist/Scott Spaulding, Fish Program Manager

Combined road risk based on total road density (ROADTOTDEN), road density in riparian area (ROADRIPDEN), and the number of stream crossings (ROADSTRMXC). Road density in riparian areas and number of stream crossing

inputs were considered more important than the total road density input. Each input was normalized and multiplied by an input weight, and then the three inputs were summed: (([ROADTOTDEN] / 6.41) × 0.2) + (([ROADRIPDEN] / 9.06) × 0.4) + (([ROADSTRMXC] / 3.27) × 0.4).

- ROADTOTDEN = Total road density in miles per square mile for the watershed. Source: 2000 TIGER roads for Montana, Idaho, Wyoming, South Dakota, and North Dakota.
- ROADRIPDEN = Road density in riparian areas in miles per square mile per subwatershed. Riparian area was created by buffering the 1:24,000 NHD streams by 60 m on either side, intersecting TIGER roads and riparian area, and summarizing lengths.
- ROADSTRMXC = Number of stream crossings per stream mile per subwatershed. The 2000 TIGER roads layers and 2008 NHD stream layer were intersected to determine the number of road/stream crossings and miles of streams.

For both ROADRIPDEN and ROADSTRMXC, the scale at which each was digitized is important. The number of stream crossings might be skewed because the wiggly streams might or might not cut into the seemingly more generalized/straighter tiger roads. Positional accuracy also plays a greater role in calculating road density within the relatively narrow "riparian" corridor.

Dams

Risk in S3A, S4A

Attribute: DAMS **Input layers: dams_id, dams_mt, dams_nd, dams_sd**

Specialist: Bruce Sims, Regional Hydrologist/Scott Spaulding, Fish Program Manager

Number of dams per stream mile. Dams were assembled based on the water rights website of each state and the 2008 NHD stream data (nhd_strms). Sources:

1. Montana: http://nris.mt.gov/nsdi/nris/shape/dams.zip;
2. Idaho: http://www.idwr.idaho.gov/GeographicInfo/GISdata/gis_data.htm. An active dam sites coverage was generated from Sonny Hornbaker's database of Active Dams and was updated Nov 2005.
3. South Dakota: ftp://ftp.state.sd.us/denr/WR/UTEL water rights point file from Ken Buhler, Natural Resources Engineering Specialist, SD DENR-Water Rights Program. Only "Dams" (under 'DIVERSION1' attribute) were extracted, and 'status' codes CA, IL, DF, DN were excluded.
4. North Dakota: http://mapservice.swc.state.nd.us/ dams layer from water resource folder.

Fish barriers

Risk in S4A

Attribute: STRMBARR **Input layers: nhd_strms, barriers**

Specialist: Scott Spaulding, Fish Program Manager

Number of barriers to fish passage per stream mile in a subwatershed. NHD 1:24,000 streams were used as the stream mile base. Barrier points were extracted from the culverts_apr06.shp (provided by Erin Nock); only points labeled "red", "orange", and "total" in either or both of the Adult and Juvenile columns counted as a barrier. In future, it would be useful to have fish passage barriers by stream order; 3rd-order (or higher) stream barriers likely have the greatest proportional impact on life-history interruption.

Dispersed recreation (all levels)

Risk in S4A

Attribute: DISPRECALL **Input layer: DispersedRecreation**

Specialist: Scott Spaulding, Fish Program Manager/Lis Novak, Regional Landscape Architect

Weighted sum of percent area of very high, high, moderate, low, and very low dispersed recreation use (0.2 × VeryLow + 0.4 × Low + 0.6 × Moderate + 0.8 × High + Very High). Dispersed recreation use was modeled as described above for the DISPRECHVH attribute. This attribute, DISPRECALL, was included to represent risk to priority fish populations; its weighting assumes that high levels of dispersed recreation have greater impact on priority fish populations.

Scenario 3A opportunity scores

Risk in S5C

Attribute: S3AOS **Input layer: n/a (scenario output score)**

Specialist: Bruce Sims, Regional Hydrologist

Opportunity score for scenario 3 (watershed quality). Watersheds with high opportunity scores for watershed restoration indicate vulnerable watersheds that may need restoration for recreation settings. Thus the watershed quality scenario feeds into the recreation setting restoration scenario.

Calculated using the formula: S3AOS = ([MUNICWSH] × 0.15) + ([D303] × 0.15) + (([MINES] / 0.774278) × 0.1) + (([ROADCOMB] / 0.811284) × 0.1) + (([MTBSMODHI] / 72.882448) × 0.1) + (([GRAZCOMBCOMB] / 0.832034) × 0.1) + (([CRNFIRECOM] / 0.696285) × 0.06) + (([ADSBBOCC] / 100) × 0.06) + (([DAMS] / 0.312665) × 0.06) + (([POPDEN2000] / 58.9825) × 0.04) +(([DEVRECSITE] / 2.703567) × 0.04) + (([OGWELLS] / 46) × 0.04).

Projected population density, 2030

Risk in S5E

Attribute: POPDEN2030 Input layer: fote_popd2030

Specialist: Lis Novak, Regional Landscape Architect

Percentage of subwatershed with high housing density based on the *Forests on the Edge* (FOTE) 2030 housing density model. The FOTE 30-m raster data had three classes of housing density per square mile: RURAL1 (0 to 16), RURAL2 (16 to 65), and URBAN (65+). Percentages of the subwatershed for each class were calculated and then the following formula was applied: POPDEN2030 = RURAL1 × 0.33 + RURAL2 × 0.66 + URBAN.

Nonwilderness

Feasibility in S2A

Attribute: NONWILDER Input Layer: see below

Specialist: Eric Tomasik, Wildlife Program Leader

Percent of the subwatershed that is nonwilderness. This is a feasibility input for the whitebark pine scenario based on increased planning opportunities in nonwilderness areas. Automated Lands Program (ALP) wilderness data (1:24,000) were used in an identity performed with the subwatershed feature class to determine the percentage of each subwatershed in wilderness, and then that percentage was subtracted from 100 to determine the percentage of nonwilderness. The input layer is Surface Ownership (ALP) for Forests/Grasslands in Region 1 (2010); ALP_OwnershipBoundariesR1.zip was downloaded from the Northern Region geospatial library on 8/9/2010.

Human developments

Risk in S2I

Attribute: HUMANDEV Input layers: see below

Specialist: Eric Tomasik, Wildlife Program Leader

Combined measure of recreation residence cabins, developed recreation sites (R1_RFA), and ski areas in the subwatershed. A series of spatial joins were performed to determine the number of recreation residence cabins, etc., in the subwatershed. The count per subwatershed was then divided by the total area of the subwatershed to come up with a relative figure; because the output numbers were so small, results were multiplied by 10,000. Those results were then summed for the three feature types (recreation residence cabins, developed recreation sites, and ski areas) to come up with a single number per subwatershed. Input layers are DevRec_r1_residences, R1_RFA_Sites_data, and SkiAreas.

Appendix B: Opportunity-Score Formulas for Integrated Restoration and Protection Strategy (IRPS) Scenarios

These formulas were used in ArcGIS Field Calculator to calculate opportunity scores per scenario. Formulas were built to replicate the formulas used in Criterion Decision Plus, a part of Ecosystem Management Decision Support (EMDS) software. Opportunity scores for the entire region have attributes ending in "OS"; opportunity scores for subregions have attributes ending in "OS_ID", "OS_WMT", "OS_EMT", and "OS_PLNS".

Theme 1. Vegetation resilience

Community Fire Resilience

Clicking on the variable name will bring up a description of that variable on the opposite page.

S1AOS = (([POPDEN2000] / 58.99) × 0.5) + (([OGWELLS] / 46) × 0.2) + (([BURNPROB] / 0.587) × 0.2) + (([ADSBBOCC] / 100) × 0.05) + (([BBHAZ] / 1) × 0.05)

S1AOS_ID = (([POPDEN2000] / 50.25) × 0.5) + ([OGWELLS] × 0.2) + ((([BURNPROB] – 0.038) / (0.587 – 0.038)) × 0.2) + (([ADSBBOCC] / 100) × 0.05) + (([BBHAZ] / 1) × 0.05)

S1AOS_WMT = (([POPDEN2000] / 58.99) × 0.5) + ([OGWELLS] × 0.2) + ((([BURNPROB] – 0.107) / (0.565 – 0.107)) × 0.2) + (([ADSBBOCC] / 73.7) × 0.05) + (([BBHAZ] / 1) × 0.05)

S1AOS_EMT = (([POPDEN2000] / 49.375) × 0.5) + ([OGWELLS] × 0.2) + ((([BURNPROB] – 0.043) / (0.587 – 0.043)) × 0.2) + (([ADSBBOCC] / 100) × 0.05) + (([BBHAZ] / 1) × 0.05)

S1AOS_PLNS = (([POPDEN2000] / 35.39) × 0.5) + (([OGWELLS] / 46) × 0.2) + (([BURNPROB] / 0.372) × 0.2) + (([ADSBBOCC] / 0.209) × 0.05) + (([BBHAZ] / 0.8) × 0.05)

Vegetation Resilience and Current Departure from Desired Conditions in Forested Areas Addressing Resiliency and Vulnerability

S1BOS = (([DOMTYPEDEP] / 75.1) × 0.25) + (([TREESIZDEP] / 56.11) × 0.05) + (([WDCANOPDEP] / 39.39) × 0.4) + (([ADSBBOCC] / 100) × 0.15) + (([CRNFIRECOM] / 0.696285) × 0.1) + (([BBHAZ] /1) × 0.05)

S1BOS_ID = ((([DOMTYPEDEP] – 1.6) / (75.1 – 1.6)) × 0.25) + (([TREESIZDEP] / 35.4) × 0.05) + (([WDCANOPDEP] / 36.3) × 0.4) + (([ADSBBOCC] / 99.627893) × 0.15) + (([CRNFIRECOM] / 0.696285) × 0.1) + (([BBHAZ] / 1) × 0.05)

Variable description

S1BOS_WMT = ((([DOMTYPEDEP] – 4) / (64.1 – 4)) × 0.25) + ((([TREESIZDEP] / 35.9) × 0.05) + ((([WDCANOPDEP] / 39.4) × 0.4) + ((([ADSBBOCC] / 73.700989) × 0.15) + ((([CRNFIRECOM] / 0.641392) × 0.1) + ((([BBHAZ] / 1) × 0.05)

S1BOS_EMT = ((([DOMTYPEDEP] – 7.1) / (66.8 – 7.1)) × 0.25) + ((([TREESIZDEP] / 56.1) × 0.05) + ((([WDCANOPDEP] / 30.1) × 0.4) + ((([ADSBBOCC] / 100) × 0.15) + ((([CRNFIRECOM] / 0.625202) × 0.1) + ((([BBHAZ] / 1) × 0.05)

S1BOS_PLNS = ((([DOMTYPEDEP] / 49.1) × 0.25) + ((([TREESIZDEP] / 1.5) × 0.05) + ((([WDCANOPDEP] / 26) × 0.4) + ([ADSBBOCC] × 0.15) + ((([CRNFIRECOM] / 0.235013) × 0.1) + ((([BBHAZ] / 0.8) × 0.05)

Ecosystem Resilience and Vulnerability in Nonforested Areas

S1COS = ((([NFWRCOMP] / 87.93) × 0.7) + ((([NFFRCC] / 71.34) × 0.15) + ((([GRAZCOMB] / 0.832034) × 0.15)

S1COS_ID = ((([NFWRCOMP] – 0.249) / (50.34 – 0.249)) × 0.7) + ((([NFFRCC] – 0.23) / (47.032 – 0.23)) × 0.15) + ((([GRAZCOMB] / 0.523742) × 0.15)

S1COS_WMT = ((([NFWRCOMP] – 1.9) / (49.7 – 1.9)) × 0.7) + ((([NFFRCC] – 0.93) / (48.43 – 0.93)) × 0.15) + ((([GRAZCOMB] / 0.513033) × 0.15)

S1COS_EMT = ((([NFWRCOMP] – 3.7) / (84.9 – 3.7)) × 0.7) + ((([NFFRCC] – 2.6) / (61.33 – 2.6)) × 0.15) + ((([GRAZCOMB] / 0.642118) × 0.15)

S1COS_PLNS = ((([NFWRCOMP] – 8.365) / (87.93 – 8.365)) × 0.7) + ((([NFFRCC] – 4.39) / (71.33 – 4.39)) × 0.15) + ((([GRAZCOMB] – 0.005729) / (0.832034 – 0.005729)) × 0.15)

THEME1OS = ([S1AOS] + [S1BOS] + [S1COS]) / 3

THEME1OS_ID = ([S1AOS_ID] + [S1BOS_ID] + [S1COS_ID]) / 3

THEME1OS_WMT = ([S1AOS_WMT] + [S1BOS_WMT] + [S1COS_WMT]) / 3

THEME1OS_EMT = ([S1AOS_EMT] + [S1BOS_EMT] + [S1COS_EMT]) / 3

THEME1OS_PLNS = ([S1AOS_PLNS] + [S1BOS_PLNS] + [S1COS_PLNS]) / 3

Variable description

Theme 2. Terrestrial species

Whitebark Pine

Clicking on the variable name will bring up a description of that variable on the opposite page.

S2AOS = ((([WHITEBARK] – 0) / 100) × 0.30) + ((([GRIZRANGE] – 0) / 100) × 0.20) + ((([CRNFIRECOM] – 0) / 0.696285) × 0.15) + ((([WBPBLISTRU] – 0) / 77.507754) × 0.10) + ((([ADSBBOCC] – 0) / 100) × 0.10) + ((([NONWILDER] – 0) / 100) × 0.10) + ((([MTBSMODHI] – 0) / 72.882448) × 0.05)

S2AOS_ID = ((([WHITEBARK] – 0) / 56.571944) × 0.30) + ((([GRIZRANGE] – 0) / 100) × 0.20) + ((([CRNFIRECOM] – 0) / 0.696285) × 0.15) + ((([WBPBLISTRU] – 0) / 48.775023) × 0.10) + ((([ADSBBOCC] – 0) / 99.627893) × 0.10) + ((([NONWILDER] – 0) / 100) × 0.10) + ((([MTBSMODHI] – 0) / 49.054094) × 0.05)

S2AOS_WMT = ((([WHITEBARK] – 0) / 72.467653) × 0.30) + ((([GRIZRANGE] – 0) / 100) × 0.20) + ((([CRNFIRECOM] – 0) / 0.641392) × 0.15) + ((([WBPBLISTRU] – 0) / 71.788833) × 0.10) + ((([ADSBBOCC] – 0) / 73.700989) × 0.10) + ((([NONWILDER] – 0) / 100) × 0.10) + ((([MTBSMODHI] – 0) / 72.882448) × 0.05)

S2AOS_EMT = ((([WHITEBARK] – 0) / 100) × 0.30) + ((([GRIZRANGE] – 0) / 100) × 0.20) + ((([CRNFIRECOM] – 0) / 0.625202) × 0.15) + ((([WBPBLISTRU] – 0) / 77.507754) × 0.10) + ((([ADSBBOCC] – 0) / 100) × 0.10) + ((([NONWILDER] – 0) / 100) × 0.10) + ((([MTBSMODHI] – 0) / 51.928066) × 0.05)

Low-Elevation Dry Forest Communities

S2BOS = ((([DRYFORCOMM] – 0) / 83.419964) × 0.4) + ((([DRYFORLGTR] – 0) / 47.9) × 0.2) + ((([CRNFIRECOM] – 0) / 0.696285) × 0.22) + ((([BBHAZ] – 0) / 1) × 0.06) + ((([WEEDRISK] – 1.095319) / (98.975642 – 1.095319)) × 0.06) + ((([GRAZCOMB] – 0) / 0.832034) × 0.06)

S2BOS_ID = ((([DRYFORCOMM] – 0) / 78.942845) × 0.4) + ((([DRYFORLGTR] – 0.5) / (47.9 – 0.5)) × 0.2) + ((([CRNFIRECOM] – 0) / 0.696285) × 0.22) + ((([BBHAZ] – 0) / 1) × 0.06) + ((([WEEDRISK] – 1.095319) / (57.363703 – 1.095319)) × 0.06) + ((([GRAZCOMB] – 0) / 0.523742) × 0.06)

S2BOS_WMT = ((([DRYFORCOMM] – 0) / 80.150964) × 0.4) + ((([DRYFORLGTR] – 0.6) / (23.6 – 0.6)) × 0.2) + ((([CRNFIRECOM] – 0) / 0.641392) × 0.22) + ((([BBHAZ] – 0) / 1) × 0.06) + ((([WEEDRISK] – 2.773894) / (63.39186 – 2.773894)) × 0.06) + ((([GRAZCOMB] – 0) / 0.513033) × 0.06)

Variable description

S2BOS_EMT = ((([DRYFORCOMM] – 0.098264) / (83.419964 – 0.098264)) × 0.4) + ((([DRYFORLGTR] – 0) / 13) × 0.2) + ((([CRNFIRECOM]–0) / 0.625202) × 0.22) + ((([BBHAZ] – 0) / 1) × 0.06) + ((([WEEDRISK] – 2.329092) / (81.212349 – 2.329092)) × 0.06) + ((([GRAZCOMB] – 0) / 0.642118) × 0.06)

S2BOS_PLNS = ((([DRYFORCOMM] – 0) / 46.36846) × 0.4) + ((([DRYFORLGTR] – 0) / 12) × 0.2) + ((([CRNFIRECOM] – 0) / 0.235013) × 0.22) + ((([BBHAZ] – 0) / 0.8) × 0.06) + ((([WEEDRISK] – 3.759667) / (98.975642 – 3.759667)) × 0.06) + ((([GRAZCOMB] – 0.005729) / (0.832034 – 0.005729)) × 0.06)

Dry Shrublands (Low-Elevation Sagebrush)

S2COS = ((([DRYSHRUB] – 0) / 92.740152) × 0.6) + ((([GRSHRENCRO] – 0) / 7.665211) × 0.18) + ((([WEEDRISK] – 1.095319) / (98.975642 – 1.095319)) × 0.09) + ((([GRAZCOMB] – 0) / 0.832034) × 0.09) + ((([NFGNFIRCOM] – 0) / 0.896802) × 0.04)

S2COS_ID = ((([DRYSHRUB] – 0) / 23.440346) × 0.6) + ((([GRSHRENCRO] – 0) / 3.945029) × 0.18) + ((([WEEDRISK] – 1.095319) / (57.363703 – 1.095319)) × 0.09) + ((([GRAZCOMB] – 0) / 0.523742) × 0.09) + ((([NFGNFIRCOM] – 0.033254) / (0.632276 – 0.033254)) × 0.04)

S2COS_WMT = ((([DRYSHRUB] – 0) / 27.631625) × 0.6) + ((([GRSHRENCRO] – 0) / 2.739066) × 0.18) + ((([WEEDRISK] – 2.773894) / (63.39186 – 2.773894)) × 0.09) + ((([GRAZCOMB] – 0) / 0.513033) × 0.09) + ((([NFGNFIRCOM] – 0.047446) / (0.651329 – 0.047446)) × 0.04)

S2COS_EMT = ((([DRYSHRUB] – 0.003758) / (92.740152 – 0.003758)) × 0.6) + ((([GRSHRENCRO] – 0) / 7.092342) × 0.18) + ((([WEEDRISK] – 2.329092) / (81.212349 – 2.329092)) × 0.09) + ((([GRAZCOMB] – 0) / 0.642118) × 0.09) + ((([NFGNFIRCOM] – 0.067013) / (0.896802 – 0.067013)) × 0.04)

S2COS_PLNS = ((([DRYSHRUB] – 0) / 39.813746) × 0.6) + ((([GRSHRENCRO] – 0) / 7.665211) × 0.18) + ((([WEEDRISK] – 3.759667) / (98.975642 – 3.759667)) × 0.09) + ((([GRAZCOMB] – 0.005729) / (0.832034 – 0.005729)) × 0.09) + ((([NFGNFIRCOM] – 0) / 0.884038) × 0.04)

Aspen

S2DOS = ((([ASPEN] – 0) / 21.428781) × 0.6) + ((([GRAZCOMB] – 0) / 0.832034) × 0.12) + ((([BIGGAMEWR] – 0) / 100) × 0.10) + ((([DECIDENCRO] – 0) / 2.068026) × 0.09) + ((([ASPENFRCC] – 0) / 11.034032) × 0.09)

Variable description

S2DOS_ID = ((([ASPEN] – 0) / 2.982946) × 0.6) + ((([GRAZCOMB] – 0) / 0.523742) × 0.12) + ((([BIGGAMEWR] – 0) / 100) × 0.10) + ((([DECIDENCRO] – 0) / 0.314455) × 0.09) + ((([ASPENFRCC] – 0) / 1.455367) × 0.09)

S2DOS_WMT = ((([ASPEN] – 0) / 1.967653) × 0.6) + ((([GRAZCOMB] – 0) / 0.513033) × 0.12) + ((([BIGGAMEWR] – 0) / 99.705688) × 0.10) + ((([DECIDENCRO] – 0) / 0.414538) × 0.09) + ((([ASPENFRCC] – 0) / 1.298651) × 0.09)

S2DOS_EMT = ((([ASPEN] – 0) / 21.428781) × 0.6) + ((([GRAZCOMB] – 0) / 0.642118) × 0.12) + ((([BIGGAMEWR] – 0) / 100) × 0.10) + ((([DECIDENCRO] – 0) / 2.068026) × 0.09) + ((([ASPENFRCC] – 0) / 11.034032) × 0.09)

S2DOS_PLNS = ((([ASPEN] – 0) / 0.287612) × 0.6) + ((([GRAZCOMB] – 0) / 0.832034) × 0.12) + ((([BIGGAMEWR] – 0) / 57.386193) × 0.10) + (0 × 0.09) + ((([ASPENFRCC] – 0) / 0.129363) × 0.09)

Woody Draws

S2EOS = ((([WOODYDRAW] – 0) / 27.445381) × 0.6) + ((([WOODRWFRCC] – 0) / 14.22642) × 0.14) + ((([GRAZCOMB] – 0) / 0.832034) × 0.14) + ((([BURNPROB] – 0) / 0.586931) × 0.12)

S2EOS_EMT = ((([WOODYDRAW] – 0) / 5.053928) × 0.6) + ((([WOODRWFRCC] – 0) / 3.054094) × 0.14) + ((([GRAZCOMB] – 0) / 0.642118) × 0.14) + ((([BURNPROB] – 0.042793) / (0.586931 – 0.042793)) × 0.12)

S2EOS_PLNS = ((([WOODYDRAW] – 0) / 27.445381) × 0.6) + ((([WOODRWFRCC] – 0) / 14.22642) × 0.14) + ((([GRAZCOMB] – 0.005729) / (0.832034 – 0.005729)) × 0.14) + ((([BURNPROB] – 0) / 0.37204) × 0.12)

Mixed Grass Prairie

S2FOS = ((([MGPRAIRIE] – 0) / 96.177379) × 0.6) + ((([GRAZCOMB] – 0) / 0.832034) × 0.18) + ((([WEEDRISK] – 1.095319) / (98.975642 – 1.095319)) × 0.11) + ((([NFGNFIRCOM] – 0.896802) / (0 – 0.896802)) × 0.11)

S2FOS_EMT = ((([MGPRAIRIE] – 0) / 66.61403) × 0.6) + ((([GRAZCOMB] – 0) / 0.642118) × 0.18) + ((([WEEDRISK] – 2.329092) / (81.212349 – 2.329092)) × 0.11) + ((([NFGNFIRCOM] – 0.896802) / (0.067013 – 0.896802)) × 0.11)

S2FOS_PLNS = ((([MGPRAIRIE] – 0) / 96.177379) × 0.6) + ((([GRAZCOMB] – 0.005729) / (0.832034 – 0.005729)) × 0.18) + ((([WEEDRISK] – 3.759667) / (98.975642 – 3.759667)) × 0.11) + ((([NFGNFIRCOM] – 0.884038) / (0 – 0.884038)) × 0.11)

Clicking on the variable name will bring up a description of that variable on the opposite page.

Variable description

Riparian, Wetland and Seeps

S2GOS = ((([RIPWETLAND] – 0.016649) / (21.987018 – 0.016649)) × 0.6) + ((([GRAZCOMB] – 0) / 0.832034) × 0.2) + ((([WEEDRISK] – 1.095319) / (98.975642 – 1.095319)) × 0.09) + ((([ROADRIPDEN] – 0) / 9.063564) × .09) + ((([CRNFIRECOM] – 0) / 0.696285) × 0.02)

S2GOS_ID = ((([RIPWETLAND] – 0.030273) / (20.400666 – 0.030273)) × 0.6) + ((([GRAZCOMB] – 0) / 0.523742) × 0.2) + ((([WEEDRISK] – 1.095319) / (57.363703 – 1.095319)) × 0.09) + ((([ROADRIPDEN] – 0) / 6.388504) × .09) + ((([CRNFIRECOM] – 0) / 0.696285) × 0.02)

S2GOS_WMT = ((([RIPWETLAND] – 0.016649) / (21.987018 – 0.016649)) × 0.6) + ((([GRAZCOMB] – 0) / 0.513033) × 0.2) + ((([WEEDRISK] – 2.773894) / (63.39186 – 2.773894)) × 0.09) + ((([ROADRIPDEN] – 0) / 5.919286) × .09) + ((([CRNFIRECOM] – 0) / 0.641392) × 0.02)

S2GOS_EMT = ((([RIPWETLAND] – 0.077199) / (21.475871 – 0.077199)) × 0.6) + ((([GRAZCOMB] – 0) / 0.642118) × 0.2) + ((([WEEDRISK] – 2.329092) / (81.212349 – 2.329092)) × 0.09) + ((([ROADRIPDEN] – 0) / 7.775854) × .09) + ((([CRNFIRECOM] – 0) / 0.625202) × 0.02)

S2GOS_PLNS = ((([RIPWETLAND] – 0.258703) / (12.74041 – 0.258703)) × 0.6) + ((([GRAZCOMB] – 0.005729) / (0.832034 – 0.005729)) × 0.2) + ((([WEEDRISK] – 3.759667) / (98.975642 – 3.759667)) × 0.09) + ((([ROADRIPDEN] – 0) / 9.063564) × .09) + ((([CRNFIRECOM] – 0) / 0.235013) × 0.02)

Big-Game Winter Range

S2HOS = ((([BIGGAMEWR] – 0) / 100) × 0.6) + ((([S1BOS] – 0) / 0.765) × 0.09) + ((([S1COS] – 0.00247) / (0.96216– 0.00247)) × 0.09) + ((([WEEDRISK] – 1.095319) / (98.975642 – 1.095319)) × 0.11) + ((([GRAZCOMB] – 0) / 0.832034) × 0.11)

S2HOS_ID = ((([BIGGAMEWR] – 0) / 100) × 0.6) + ((([S1BOS] – 0.131035) / (0.765– 0.131035)) × 0.09) + ((([S1COS] – 0.000006) / (0.850146 – 0.000006)) × 0.09) + ((([WEEDRISK] – 1.095319) / (57.363703 – 1.095319)) × 0.11) + ((([GRAZCOMB] – 0) / 0.523742) × 0.11)

S2HOS_WMT = ((([BIGGAMEWR] – 0) / 99.705688) × 0.6) + ((([S1BOS] – 0.0263) / (0.846533– 0.0263)) × 0.09) + ((([S1COS] – 0.000294) / (0.851628– 0.000294)) × 0.09) + ((([WEEDRISK] – 2.773894) / (63.39186 – 2.773894)) × 0.11) + ((([GRAZCOMB] – 0) / 0.513033) × 0.11)

Variable description

S2HOS_EMT = ((([BIGGAMEWR] – 0) / 100) × 0.6) + ((([S1BOS] – 0.040286) / (0.871005– 0.040286)) × 0.09) + ((([S1COS] – 0.001791) / (0.886344– 0.001791)) × 0.09) + ((([WEEDRISK] – 2.329092) / (81.212349 – 2.329092)) × 0.11) + ((([GRAZCOMB] – 0) / 0.642118) × 0.11)

S2HOS_PLNS = ((([BIGGAMEWR] – 0) / 57.386193) × 0.6) + ((([S1BOS] – 0) / 0.780197) × 0.09) + ((([S1COS] – 0.01866) / (0.960201 – 0.01866)) × 0.09) + ((([WEEDRISK] – 3.759667) / (98.975642 – 3.759667)) × 0.11) + ((([GRAZCOMB] – 0.005729) / (0.832034 – 0.005729)) × 0.11)

T&E Core Grizzly Bear Habitat

Clicking on the variable name will bring up a description of that variable on the opposite page.

S2IOS = ((([GRIZRANGE] – 0) / 100) × 0.6) + ((([MOTORROUTE] – 0) / 5.177427) × 0.3) + ((([HUMANDEV] – 0) / 0.010438) × 0.1)

S2IOS_ID = ((([GRIZRANGE] – 0) / 100) × 0.6) + ((([MOTORROUTE] – 0) / 3.995461) × 0.3) + ((([HUMANDEV] – 0) / 0.005018) × 0.1)

S2IOS_WMT = ((([GRIZRANGE] – 0) / 100) × 0.6) + ((([MOTORROUTE] – 0) / 5.177427) × 0.3) + ((([HUMANDEV] – 0) / 0.004919) × 0.1)

S2IOS_EMT = ((([GRIZRANGE] – 0) / 100) × 0.6) + ((([MOTORROUTE] – 0) / 3.432214) × 0.3) + ((([HUMANDEV] – 0) / 0.010438) × 0.1)

THEME2OS = ([S2AOS] + [S2BOS] + [S2COS] + [S2DOS] + [S2EOS] + [S2FOS] + [S2GOS] + [S2HOS] + [S2IOS]) / 9

THEME2OS_ID = ([S2AOS_ID] + [S2BOS_ID] + [S2COS_ID] + [S2DOS_ID] + [S2GOS_ID] + [S2HOS_ID] + [S2IOS_ID]) / 7

THEME2OS_WMT = ([S2AOS_WMT] + [S2BOS_WMT] + [S2COS_WMT] + [S2DOS_WMT] + [S2GOS_WMT] + [S2HOS_WMT] + [S2IOS_WMT]) / 7

THEME20S_EMT = ([S2AOS_EMT] + [S2BOS_EMT] + [S2COS_EMT] + [S2DOS_EMT] + [S2EOS_EMT] + [S2FOS_EMT] + [S2GOS_EMT] + [S2HOS_ EMT] + [S2IOS_EMT]) / 9

THEME2OS_PLNS = ([S2BOS_PLNS] + [S2COS_PLNS] + [S2DOS_PLNS] + [S2EOS_PLNS] + [S2FOS_PLNS] + [S2GOS_PLNS] + [S2HOS_PLNS]) / 7

Variable description

Theme 3. Watershed Management

Watershed Quality (Sediment)

S3AOS = ([MUNICWSHD] × 0.15) + (([D303]/73.174) × 0.15) + (([MINES] / 0.774278) × 0.1) + (([ROADCOMB] / 0.83621) × 0.1) + (([MTBSMODHI] / 72.882448) × 0.1) + (([GRAZCOMB] / 0.832034) × 0.1) + (([CRNFIRECOM]/0.696285) × 0.06) + (([ADSBBOCC] / 100) × 0.06) + (([DAMS] / 0.312665) × 0.06) + (([POPDEN2000] / 58.9825) × 0.04) +(([DEVRECSITE] / 2.703567) × 0.04) + (([OGWELLS] / 46) × 0.04)

S3AOS_ID = ([MUNICWSHD] × 0.15) + (([D303]/73.174) × 0.15) + (([MINES] / 0.319371) × 0.1) + (([ROADCOMB] / 0.582136) × 0.1) + (([MTBSMODHI] / 49.054094) × 0.1) + (([GRAZCOMB] / 0.523742) × 0.1) + (([CRNFIRECOM] / 0.696285) × 0.06) + (([ADSBBOCC] / 100) × 0.06) + (([DAMS] / 0.146796) × 0.06) + (([POPDEN2000] / 50.24745) × 0.04) + (([DEVRECSITE] / 1.29955) × 0.04) + ([OGWELLS] × 0.04)

S3AOS_WMT = ([MUNICWSHD] × 0.15) + (([D303]/ 28.351334) × 0.15) + (([MINES] / 0.147355) × 0.1) + (([ROADCOMB] / 0.598575) × 0.1) + (([MTBSMODHI] / 72.882448) × 0.1) + (([GRAZCOMB] / 0.513033) × 0.1) + (([CRNFIRECOM] / 0.641392) × 0.06) + (([ADSBBOCC] / 73.700989) × 0.06) + (([DAMS] / 0.163958) × 0.06) + (([POPDEN2000] / 58.9825) × 0.04) +(([DEVRECSITE] / 1.273964) × 0.04) + ([OGWELLS] × 0.04)

S3AOS_EMT = ([MUNICWSHD] × 0.15) + (([D303]/ 42.680207) × 0.15) + (([MINES] / 0.774278) × 0.1) + (([ROADCOMB] / 0.791438) × 0.1) + (([MTBSMODHI] / 51.928066) × 0.1) + (([GRAZCOMB] / 0.642118) × 0.1) + (([CRNFIRECOM] / 0.625202) × 0.06) + (([ADSBBOCC] / 100) × 0.06) + (([DAMS] / 0.197954) × 0.06) + (([POPDEN2000] / 49.375428) × 0.04) +(([DEVRECSITE] / 2.703567) × 0.04) + ([OGWELLS] × 0.04)

S3AOS_PLNS = ([MUNICWSHD] × 0.15) + (([D303]/ 12.212963) × 0.15) + (([MINES] / 0.144339) × 0.1) + (([ROADCOMB] / 0.83621) × 0.1) + (([MTBSMODHI] / 24.12789) × 0.1) + (([GRAZCOMB] – 0.005729) / (0.832034 – 0.005729) × 0.1) + (([CRNFIRECOM] / 0.235013) × 0.06) + (([ADSBBOCC] / 0.208613) × 0.06) + (([DAMS] / 0.312665) × 0.06) + (([POPDEN2000] / 35.385658) × 0.04) + (([DEVRECSITE] / 0.068782) × 0.04) + (([OGWELLS] / 46) × 0.04)

THEME3OS = S3AOS

THEME3OS_ID = S3AOS_ID

Variable description

THEME3OS_WMT = S3AOS_WMT

THEME3OS_EMT = S3AOS_EMT

THEME3OS_PLNS = S3AOS_PLNS

Theme 4. Aquatic Species

Threatened, Endangered, and Sensitive Fish Species

Clicking on the variable name will bring up a description of that variable on the opposite page.

S4AOS = ([AQUATPRIOR] × 0.4) + (([STRMBARR] / 13.068695) × 0.12) + (([ROADCOMB] / 0.83621) × 0.14) + (([GRAZCOMB] / 0.832034) × 0.12) + (([MINES] / 0.774278) × 0.1) + (([DISPRECALL] / 57.485944) × 0.04) + (([DAMS] / 0.312665) × 0.08)

S4AOS_ID = ([AQUATPRIOR] × 0.4) + (([STRMBARR] / 12.668319) × 0.12) + (([ROADCOMB] / 0.582136) × 0.14) + (([GRAZCOMB] / 0.523742) × 0.12) + (([MINES] / 0.319371) × 0.1) + (([DISPRECALL] / 36.753851) × 0.04) + (([DAMS] / 0.146796) × 0.08)

S4AOS_WMT = ([AQUATPRIOR] × 0.4) + (([STRMBARR] / 13.068695) × 0.12) + (([ROADCOMB] / 0.598575) × 0.14) + (([GRAZCOMB] / 0.513033) × 0.12) + (([MINES] / 0.147355) × 0.1) + (([DISPRECALL] / 51.039823) × 0.04) + (([DAMS] / 0.163958) × 0.08)

S4AOS_EMT = ([AQUATPRIOR] × 0.4) + (([STRMBARR] / 10.076321) × 0.12) + (([ROADCOMB] / 0.791438) × 0.14) + (([GRAZCOMB] / 0.642118) × 0.12) + (([MINES] / 0.774278) × 0.1) + (([DISPRECALL] / 30.14474) × 0.04) + (([DAMS] / 0.197954) × 0.08)

S4AOS_PLNS = ([AQUATPRIOR] × 0.4) + (([STRMBARR] / 10.076321) × 0.12) + (([ROADCOMB] / 0.83621) × 0.14) + (([GRAZCOMB] – 0.005729) / (0.642118 – 0.005729) × 0.12) + (([MINES] / 0.144339) × 0.1) + (([DISPRECALL] / 57.485944) × 0.04) + (([DAMS] / 0.312665) × 0.08)

THEME4OS = S4AOS

THEME4OS_ID = S4AOS_ID

THEME4OS_WMT = S4AOS_WMT

THEME4OS_EMT = S4AOS_EMT

THEME4OS_PLNS = S4AOS_PLNS

Variable description

Theme 5. Recreation settings and opportunities

Safety

S5AOS = (([DEVRECUSE] / 46.24) × 0.2) + (([DISPRECHVH] / 51.04) × 0.15) + (([RECRESID] / 127) × 0.1) + (([SKIAREAS] / 1) × 0.1) + (([ADSROADS] / 24.62) × 0.1) + (([ADSTRAIL] / 56.17) × 0.05) + (([BURNPROB] / 0.587) × 0.1) + (([BBHAZ] / 1) × 0.1) + (([ADSBBOCC] / 100) × 0.1)

S5AOS_ID = (([DEVRECUSE] / 46.24) × 0.2) + (([DISPRECHVH] / 36.75) × 0.15) + (([RECRESID] / 127) × 0.1) + (([SKIAREAS] / 1) × 0.1) + (([ADSROADS] / 22.34) × 0.1) + (([ADSTRAIL] / 45.62) × 0.05) + ((([BURNPROB] – 0.038) / (0.587 – 0.038)) × 0.1) + (([BBHAZ] / 1) × 0.1) + (([ADSBBOCC] / 100) × 0.1)

S5AOS_WMT = (([DEVRECUSE] / 24.25) × 0.2) + (([DISPRECHVH] / 51.04) × 0.15) + (([RECRESID] / 44) × 0.1) + (([SKIAREAS] / 1) × 0.1) + (([ADSROADS] / 19.245) × 0.1) + (([ADSTRAIL] / 26.358) × 0.05) + ((([BURNPROB] – 0.107) / (0.565 – 0.107)) × 0.1) + (([BBHAZ] / 1) × 0.1) + (([ADSBBOCC] / 73.7) × 0.1)

S5AOS_EMT = (([DEVRECUSE] / 32.52) × 0.2) + (([DISPRECHVH] / 30.145) × 0.15) + (([RECRESID] / 62) × 0.1) + (([SKIAREAS] / 1) × 0.1) + (([ADSROADS] / 24.62) × 0.1) + (([ADSTRAIL] / 56.17) × 0.05) + ((([BURNPROB] – 0.043) / (0.587 – 0.043)) × 0.1) + (([BBHAZ] / 1) × 0.1) + (([ADSBBOCC] / 100) × 0.1)

S5AOS_PLNS = (([DEVRECUSE] / 5.58) × 0.2) + (([DISPRECHVH] / 43.86) × 0.15) + ([RECRESID] × 0.1) + ([SKIAREAS] × 0.1) + (([ADSROADS] / 0.885) × 0.1) + ([ADSTRAIL] × 0.05) + (([BURNPROB] / 0.372) × 0.1) + (([BBHAZ] / 0.8) × 0.1) + (([ADSBBOCC] / 0.209) × 0.1)

Investment Protection

S5BOS = (([DEVRECINV] / 44.54) × 0.3) + (([RECRESID] / 127) × 0.1) + (([SKIAREAS] / 1) × 0.1) + (([ADSUTILITY] / 14.07) × 0.1) + (([ELECTSITES] / 105) × 0.05) + (([ADMINSITES] / 2) × 0.05) + (([BURNPROB] / 0.587) × 0.1) + (([BBHAZ] / 1) × 0.1) + (([ADSBBOCC] / 100) × 0.1)

S5BOS_ID = (([DEVRECINV] / 44.54) × 0.3) + (([RECRESID] / 127) × 0.1) + (([SKIAREAS] / 1) × 0.1) + (([ADSUTILITY] / 6.59) × 0.1) + (([ELECTSITES] / 37) × 0.05) + (([ADMINSITES] / 2) × 0.05) + ((([BURNPROB] – 0.038) / (0.587 – 0.038)) × 0.1) + (([BBHAZ] / 1) × 0.1) + (([ADSBBOCC] / 100) × 0.1)

Variable description

Clicking on the variable name will bring up a description of that variable on the opposite page.

S5BOS_WMT = (([DEVRECINV] / 23.59) × 0.3) + (([RECRESID] / 44) × 0.1) + (([SKIAREAS] / 1) × 0.1) + (([ADSUTILITY] / 10.209) × 0.1) + (([ELECTSITES] / 105) × 0.05) + (([ADMINSITES] / 2) × 0.05) + ((([BURNPROB] – 0.107) / (0.565 – 0.107)) × 0.1) + (([BBHAZ] / 1) × 0.1) + (([ADSBBOCC] / 73.7) × 0.1)

S5BOS_EMT = (([DEVRECINV] / 39.45) × 0.3) + (([RECRESID] / 62) × 0.1) + (([SKIAREAS] / 1) × 0.1) + (([ADSUTILITY] / 14.07) × 0.1) + (([ELECTSITES] / 82) × 0.05) + (([ADMINSITES] / 2) × 0.05) + ((([BURNPROB] – 0.043) / (0.587 – 0.043)) × 0.1) + (([BBHAZ] / 1) × 0.1) + (([ADSBBOCC] / 100) × 0.1)

S5BOS_PLNS = (([DEVRECINV] / 7.97) × 0.3) + ([RECRESID] × 0) + ([SKIAREAS] × 0) + (([ADSUTILITY] / 0.214) × 0.1) + (([ELECTSITES] / 9) × 0.05) + (([ADMINSITES] / 1) × 0.05) + (([BURNPROB] / 0.372) × 0.1) + (([BBHAZ] / 0.8) × 0.1) + (([ADSBBOCC] / 0.209) × 0.1)

Recreation Setting Restoration

S5COS = (([DISPRECHVH] / 51.04) × 0.5) + ([S3AOS] × 0. 5)

S5COS_ID = (([DISPRECHVH] / 36.75) × 0.5) + ([S3AOS] × 0.5)

S5COS_WMT = (([DISPRECHVH] / 51.4) × 0.5) + ([S3AOS] × 0.5)

S5COS_EMT = (([DISPRECHVH] / 30.145) × 0.5) + ([S3AOS] × 0.5)

S5COS_PLNS = (([DISPRECHVH] / 43.86) × 0.5) + ([S3AOS] × 0.5)

Scenic Integrity Restoration

S5DOS = (([SCENICINTL] / 82.96) × 0.5) + (([POPDEN2000] / 58.99) × 0.25) + (([RECOPSPEC] / 100) × 0.25)

S5DOS_ID = (([SCENICINTL] / 82.96) × 0.5) + (([POPDEN2000] / 50.25) × 0.25) + (([RECOPSPEC] / 100) × 0.25)

S5DOS_WMT = (([SCENICINTL] / 68.8) × 0.5) + (([POPDEN2000] / 58.99) × 0.25) + (([RECOPSPEC] / 100) × 0.25)

S5DOS_EMT = (([SCENICINTL] / 49.74) × 0.5) + (([POPDEN2000] / 49.28) × 0.25) + (([RECOPSPEC] / 100) × 0.25)

S5DOS_PLNS = (([SCENICINTL] / 34.3) × 0.5) + (([POPDEN2000] / 35.4) × 0.25) + (([RECOPSPEC] / 100) × 0.25)

Variable description

Scenic Integrity Protection

S5EOS = (([SCENICINTH] / 100) × 0.3) + (([POPDEN2000] / 58.99) × 0.15) + (([RECOPSPEC] / 100) × 0.15) + (([BURNPROB] / 0.587) × 0.15) + (([BBHAZ] / 1) × 0.1) + (([POPDEN2030] / 81.44) × 0.15)

S5EOS_ID = (([SCENICINTH] / 100) × 0.3) + (([POPDEN2000] / 50.25) × 0.15) + (([RECOPSPEC] / 100) × 0.15) + ((([BURNPROB] – 0.038) / (0.587 – 0.038)) × 0.2) + (([BBHAZ] / 1) × 0.1) + (([POPDEN2030] / 67.04) × 0.15)

S5EOS_WMT = (([SCENICINTH] / 100) × 0.3) +(([POPDEN2000] / 58.99) × 0.15) + (([RECOPSPEC] / 100) × 0.15) + ((([BURNPROB] – 0.107) / (0.565 – 0.107)) × 0.15) + (([BBHAZ] / 1) × 0.1) + (([POPDEN2030] / 81.44) × 0.15)

S5EOS_EMT = (([SCENICINTH] / 100) × 0.3) + (([POPDEN2000] / 49.28) × 0.15) + (([RECOPSPEC] / 100) × 0.15) + ((([BURNPROB] – 0.043) / (0.587 – 0.043)) × 0.15) + (([BBHAZ] / 1) × 0.1) + (([POPDEN2030] / 66.54) × 0.15)

S5EOS_PLNS = (([SCENICINTH] / 94.2) × 0.3) + (([POPDEN2000] / 35.4) × 0.15) + (([RECOPSPEC] / 100) × 0.15) + (([BURNPROB] / 0.372) × 0.15) + (([BBHAZ] / 0.8) × 0.1) + (([POPDEN2030] / 35.13) × 0.15)

THEME5OS = ([S5AOS] + [S5BOS] + [S5COS] + [S5DOS] + [S5EOS]) / 5

THEME5OS_ID = ([S5AOS_ID] + [S5BOS_ID] + [S5COS_ID] + [S5DOS_ID] + [S5EOS_ID]) / 5

THEME5OS_WMT = ([S5AOS_WMT] + [S5BOS_WMT] + [S5COS_WMT] + [S5DOS_WMT] + [S5EOS_WMT]) / 5

THEME5OS_EMT = ([S5AOS_EMT] + [S5BOS_EMT] + [S5COS_EMT] + [S5DOS_EMT] + [S5EOS_EMT]) / 5

THEME5OS_PLNS = ([S5AOS_PLNS] + [S5BOS_PLNS] + [S5COS_PLNS] + [S5DOS_PLNS] + [S5EOS_PLNS]) / 5

Theme 6. Public Safety and Infrastructure Protection

THEME6OS = ([S1AOS] + [S5AOS] + [S5BOS]) / 3

THEME6OS_ID = ([S1AOS_ID] + [S5AOS_ID] + [S5BOS_ID]) / 3

THEME6OS_WMT = ([S1AOS_WMT] + [S5AOS_WMT] + [S5BOS_WMT]) / 3

THEME6OS_EMT = ([S1AOS_EMT] + [S5AOS_EMT] + [S5BOS_EMT]) / 3

THEME6OS_PLNS = ([S1AOS_PLNS] + [S5AOS_PLNS] + [S5BOS_PLNS]) / 3

Variable description

Final Integration

IRPSOS = ([THEME1OS] + [THEME2OS] + [THEME3OS] + [THEME4OS] + [THEME5OS] + [THEME6OS]) / 6

IRPSOS_ID = ([THEME1OS_ID] + [THEME2OS_ID] + [THEME3OS_ID] + [THEME4OS_ID] + [THEME5OS_ID] + [THEME6OS_ID]) / 6

IRPSOS_WMT = ([THEME1OS_WMT] + [THEME2OS_WMT] + [THEME3OS_WMT] + [THEME4OS_WMT] + [THEME5OS_WMT] + [THEME6OS_WMT]) / 6

IRPSOS_EMT = ([THEME1OS_EMT] + [THEME2OS_EMT] + [THEME3OS_EMT] + [THEME4OS_EMT] + [THEME5OS_EMT] + [THEME6OS_EMT]) / 6

IRPSOS_ PLNS = ([THEME1OS_PLNS] + [THEME2OS_PLNS] + [THEME3OS_PLNS] + [THEME4OS_PLNS] + [THEME5OS_PLNS] + [THEME6OS_PLNS]) / 6

Appendix C:
IRPS Resource Themes and Scenarios

This document describes the themes and scenarios used in the Region 1 USDA Forest Service Integrated Restoration and Protection Strategy (IRPS). Themes represent overall restoration and protection opportunities by resource area. Each of the six main themes has at least one, and usually several, scenarios. A sixth theme was added to identify integration opportunities within current bark beetle health and safety work. Scenarios represent specific objectives for restoration and protection within a resource area. Each scenario has value, risk, and feasibility criteria with weights assigned to them. In the scenario analyses, subwatersheds (6th-hydrolic unit code (HUCs) had measurements of each criterion (percentage area, number points, etc.) rescaled to [0, 1], multiplied by its weight, and summed to determine a scenario score. Subwatersheds with a high scenario score represent the best opportunity to meet the scenario objective. Scenario scores were averaged to produce theme scores, and theme scores were averaged to determine subwatersheds with the best overall opportunities for integrated restoration and protection.

Theme 1—Vegetation Resilience

Scenario 1a*:* ***Community fire resilience***

Scenario 1b*:* ***Vegetation resilience and current departure from desired conditions in forested areas addressing resiliency and vulnerability***

Scenario 1c: ***Ecosystem resilience and vulnerability in nonforested areas***

Theme 2—Terrestrial Species

Scenario 2a: ***Whitebark pine***

Scenario 2b: ***Low-elevation dry forest communities***

Scenario 2c: ***Dry shrublands (low-elevation sagebrush)***

Scenario 2d: ***Aspen***

Scenario 2e: ***Woody draws***

Scenario 2f: ***Mixed grass prairie***

Scenario 2g: ***Riparian, wetland, and seeps***

Scenario 2h: ***Big-game winter range***

Scenario 2i: ***Threatened and endangered core grizzly bear habitat***

Theme 3—Watershed Management

Scenario 3*:* ***Watershed quality (sediment)***

Theme 4—Aquatic Species

Scenario4*:* ***Threatened, endangered, and sensitive fish species***

Theme 5 – Recreation Settings and Opportunities

Scenario 5a: ***Safety***

Scenario 5b: ***Investment protection***

Scenario 5c: ***Recreation setting restoration***

Scenario 5d: ***Scenic integrity restoration***

Scenario 5e: ***Scenic integrity protection***

Theme 6—Public Safety and Infrastructure Protection

Scenario 1a*:* ***Community fire resilience***

Scenario 5a: ***Safety***

Scenario 5b: ***Investment protection***

Theme 1. VEGETATION RESILIENCE

Scenario 1a: Community fire resilience

Question: Which community areas are best to improve fire resilience owing to burn probability or insect and disease risk?

(70)	Value:	Population density (50 percent)
		Oil and gas wells (20 percent)
(30)	Risk:	Crown-and ground-fire burn probability (20 percent)
		Insect occurrence from Aerial Insect and Disease Detection Survey (ADS) over multiyear period (5 percent)
		Bark beetle hazard from Forest Inventory Analysis (FIA) data by HUC5 (5 percent)
(0)	Feasibility:	Response to wildland fire

Scenario 1b: Vegetation resilience and current departure from desired conditions in forested areas addressing resiliency and vulnerability

Question: Which forest areas are best to improve vegetation resilience to meet forest plan desired condition owing to high departure and/or crown fire burn probability or insect and disease risk?

(70)	Value:	Current departure from desired condition for forested areas:
		Dominance type departure (25 percent)
		Tree size departure (5 percent)
		Warm dry conifer type canopy departure (40 percent)
(30)	Risk:	Insect occurrence from ADS over multiyear period (15 percent)
		Crown-fire burn probability (10 percent)
		Bark beetle hazard from FIA data by HUC5 (5 percent)
		Root Disease risk (future analysis 5 percent weight and decrease value by 5 percent)
(0)	Feasibility:	Forest Service ownership

Scenario 1c: Ecosystem resilience and vulnerability in nonforested areas

Question: Which nonforest areas are best to improve nonforest ecosystem resilience owing to composition of nonforest types with noxious weed risk or departure from historical fire regime (lack of fire) or grazing risk?

(70)	Value	Composition of nonforest types with noxious weed hazard
(30)	Risk	Departure from historical fire regime of nonforest types (15 percent)
		Grazing (15 percent)
(0)	Feasibility	FS ownership

Theme 2. TERRESTRIAL SPECIES

Unique Wildlife Habitats, Connectivity and Linkage Areas, Core T&E Species Habitat

Scenario 2a: Whitebark Pine

(50)	Value:	Whitebark pine composition, percent HUC6 (30 percent)
		Grizzly bear species range (20 percent)
(35)	Risk:	Crown-fire burn probability (15 percent)
		Blister rust damage map (10 percent)
		Insect occurrence from ADS over multiyear period (10 percent)
(15)	Feasibility:	Nonwilderness (10 percent)*
		Monitoring Trends in Burn Severity (MTBS) moderate/high burn severity (5 percent)

Primary treatment: prescribed burning, or wildland fire for resource benefits to promote dispersal by Clark's nutcrackers (*Nucifraga columbiana*) and regeneration, and to reduce crown-fire potential. Planting in some areas.

*Current policy interpretation does not allow for many opportunities for planting in wilderness

Scenario 2b: Low-Elevation Dry Forest Communities

(60)	Value:	Dry forest composition, percentage HUC6 (40 percent)
		Large size class forest in Douglas-fir/ponderosa pine setting (20 percent)
(40)	Risk:	Crown-fire burn probability (22 percent)
		Bark beetle hazard from FIA data by HUC5 (6 percent)
		Noxious weed hazard (6 percent)
		Percentage of active grazing allotment (6 percent)

Primary treatments: thinning and prescribed burning to reduce fuels; also treatment of noxious weeds.

Scenario 2c: Dry Shrublands (Low-Elevation Sagebrush)

(60)	Value:	Dry shrubland composition, percentage HUC6 (60 percent)
(40)	Risk:	Conifer succession in dry shrublands (18 percent)
		Noxious weed hazard (9 percent)
		Percentage of active grazing allotment (9 percent)
		Ground-fire burn probability (4 percent)

Primary treatments: slashing conifers, prescribed burning, noxious weed treatment, improved grazing management

Scenario 2d: Aspen

(60) Value: Aspen composition, percentage HUC6
(40) Risk: Percentage of active grazing allotment (12 percent)
Herbivory by wildlife (10 percent)
Conifer succession in aspen/deciduous forest (9 percent)
Departure from historical fire regime in aspen (9 percent)

Primary treatments: prescribed and wildland fire, conifer removal, improved grazing management.

Scenario 2e: Woody draws

(60) Value: Woody draw composition, percentage HUC6
(40) Risk: Departure from historical fire regime in woody draws (14 percent)
Percentage of active grazing allotment (14 percent)
Crown-and ground-fire burn probability (12 percent)

Primary treatments: Remove conifers from deciduous woody draws, reintroduce fire to conifer woody draws, treat noxious weeds.

Scenario 2f: Mixed-grass prairie

(60) Value: Mixed-grass prairie composition, percentage HUC6
(40) Risk: Percentage of active grazing allotment (18 percent)
Noxious weed hazard (11 percent)
Low ground-fire burn probability (11 percent)
Fire exclusion (future?)

Primary treatments: improve livestock grazing, treat noxious weeds, reintroduce fire.

Scenario 2g: Riparian, wetland and seeps

(60) Value Riparian, wetland, and/or spring/seep composition, percentage HUC6
(40) Risk Percentage of active grazing allotment (20 percent)
Noxious weed hazard (9 percent)
Motorized routes in riparian (9 percent)
Fire behavior (2 percent)

Primary treatments: Improved livestock grazing management, noxious weed treatment, management/relocation/closure/obliteration of roads and other motorized routes, occasionally prescribed fire to be evaluated on a case-by-case basis. Variable riparian systems exist across the region (e.g., cedar/hemlock forest, willow, sedge, etc.). Treatments, particularly fire and vegetation would have to be tailored to the area. We would not want the negative effects of a treatment to outweigh the beneficial in a particular circumstance.

Scenario 2h: Big-game winter range

(60) Value: Big-game winter range map from version 1, percentage HUC6
(40) Risk: Vulnerability index (18 percent)
Noxious weed hazard (11 percent)
Percentage of active allotment (grazing) (11 percent)
Lack of security (future)
Fire exclusion (future)

The vulnerability index is essentially the results from scenarios 1b and 1c, which is a measure of how vulnerable the vegetation is to uncharacteristic disturbance, such that it would limit the ability of the landscape area to cope with disturbance or achieve a resilient desired condition. A cool Pacific Decadal Oscillation (PDO) from 1940 through 1980 in conjunction with fire exclusion helped develop a forest density not characteristic prior to this period. Climate change could make the forest even more vulnerable to disturbance.

Primary treatments: thinning and prescribed burning, slashing conifers, treatment of noxious weeds, improved livestock grazing management, management of motorized routes and recreation to improve security, and rehabbing motorized routes.

Scenario 2i: T&E core grizzly bear habitat

(60) Value Species core habitat, percentage HUC6
(40) Risk Open road and motorized trail density (30 percent)
Human developments (campgrounds, cabins) (10 percent)

Primary treatments: Provide security, closure of motorized routes, rehabilitation of motorized routes.

Scenario 2j: Connectivity and linkage areas (HOLD)

(60) Value Connectivity or linkage area (yes/no)
(40) Risk Motorized routes (28 percent)
Developments (recreation and access sites) (6 percent)
Loss of hiding cover (6 percent)
- Vegetation treatments
- Bark beetle hazard
- Insect occurrence (ADS)
- Crown-fire burn probability

This scenario is on hold until Montana Fish, Wildlife, and Parks completes its connectivity mapping efforts; once that product is available for review, it will be evaluated for its suitability for inclusion in this scenario. We will wait for this evaluation before determining whether a different product is necessary to address this scenario.

The intent is to maintain connectivity and linkage areas for migration and dispersal of all native species in the Northern Region. Often, areas identified by this

scenario as high priorities will be areas we want to exclude from vegetation treatment, and where restoration efforts may focus on road and motorized trail removal. This scenario might also be used to determine areas that should be avoided when selecting areas for human developments such as campgrounds. In rare circumstances, vegetation treatments might be used to maintain or protect connectivity and linkage areas.

Scenario 2k: Threatened, Endangered, and Sensitive Wildlife Species (HOLD)

(70) Value: Threatened, Endangered, and Sensitive Wildlife Species Ranges
Larger Strategies for Species Conservation and Recovery (e.g., recovery plans, conservation strategies, forest plans, state wildlife conservation plans)

(25) Risk: As identified in the aforementioned strategies

(5) Feasibility: Partners (yes/no) (5 percent)

This is a placeholder for species conservation and recovery plans, conservation strategies, and other similar products, for many of which the Forest Service has legal obligations.

Theme 3. WATERSHED MANAGEMENT

Scenario 3: Watershed Quality (Sediment)

Question: Which watersheds are best to restore owing to municipal watershed use, D303 listings, and/or have multiple risk factors?

(30) Value: Municipal watershed—yes/no (15 percent)
D303 (15 percent)

(70) Risk: Mines (10 percent)
Roads—road density, road density in riparian, stream crossing (10 percent)
MTBS—moderate/high burn severity (10 percent)
Grazing—allotment area and number animal unit months (10 percent)
Crown-fire burn probability (6 percent)
Insect occurrence—ADS (6 percent)
Flow—Dams (6 percent)
Forests on the Edge population density (4 percent)
Recreation sites (4 percent)
Oil and gas interface (4 percent)

(0) Feasibility: Forest Service ownership

Potential treatments: road treatments to reduce sediment, riparian and lake-shore treatments to reduce sediment, legacy mine site treatments to reduce contaminants, managing fire to allow for a more natural fire regime.

Theme 4. AQUATIC SPECIES

Scenario 4: Threatened, Endangered, and Sensitive Fish Species

Question: Which watersheds are best to restore owing to forest plan revision or aquatic species priority, or have multiple risk factors?

(40) Value: Aquatic priority watersheds based on:
Idaho forest plan revision aquatic priority watersheds,
Western Montana bull trout (*Salvelinus confluentus*)aquatic priority watersheds,
Central Montana west-slope cutthroat (*Oncorhynchus clarki; lewisi*) and Yellowstone cutthroat (*O. c.; bouvieri*) priority watersheds, and eastern Montana/Dakota IRPS v062 priority watersheds

(60) Risk: Fish passage (12 percent)
Roads (14 percent)
Grazing (12 percent)
Mining (10 percent)
Dispersed recreation (4 percent)
Dams (8)

(0) Feasibility: Partners (yes/no) (0 percent)
FS (0 percent)

Theme 5. RECREATION SETTINGS AND OPPORTUNITIES

Scenario 5a: Safety

Question: Which areas are most important to protect/restore owing to high concentrations of use? High use areas with existing/potential hazard trees owing to insects and disease and in areas with high burn probability

(70) Value: Recreation Use Areas:
Developed recreation sites—capacity/occupancy, total visits, duration of use (20 percent)
Dispersed recreation areas (15 percent)
Recreation Special Use:
Recreation residences (10 percent)
Ski areas (10 percent)
Travel Routes:
Roads—maintenance levels 3–5 (10 percent)
Trails—all trails including snow routes (5 percent)

(30) Risk: Crown-and ground-fire burn probability (10 percent)
Insect occurrence from ADS (10 percent)

Bark beetle hazard from FIA data (10 percent)

(0) Feasibility: FS ownership

Potential treatments: Fuels reduction treatments, hazard tree removal, thinning, planting.

Scenario 5b: Investment Protection

Question: Which areas are most important to protect from an investment perspective? High-investment areas that are at risk of damage.

(70) Value: Developed recreation sites—development scale, replacement value, site type (30 percent)
Recreation Special Use:
Recreation residences (10 percent)
Ski areas (10 percent)
Interface Investments:
Utility lines (10 percent)
Electronic sites (5 percent)
Administrative sites (5 percent)

(30) Risk: Crown-and ground-fire burn probability (10 percent)
Bark beetle hazard from FIA data (10 percent)
Insect occurrence from ADS last 5 years (10 percent)

(0) Feasibility: FS ownership

Primary treatments: fuels reduction treatments, hazard tree removal, etc.

Scenario 5c: Recreation Setting Restoration

Question: Which recreation settings are priority areas for restoration? High-use dispersed recreation areas in vulnerable water sheds.

(50) Value: Dispersed Recreation Settings (high + very high)

(50) Risk: Low Watershed Condition rating/Watersheds at risk (50 percent)
Soil erosion potential (not available at this time)

(0) Feasibility: FS ownership

Primary treatments: dispersed site hardening, restoration, rehabilitation or closure, road/trail obliteration/restoration/closure.

Scenario 5d: Scenic Integrity Restoration

Question: Which areas are most important to restore/enhance? High-visibility areas with low/very low scenic integrity

(100) Value: Current condition Low/Very Low scenic integrity (50 percent)
High-visibility areas:
Forests on the Edge population density (25 percent)
Recreation Opportunity Settings—roaded natural (RN), semiprimitive motorized (SPM) and Urban (25 percent)

(0) Risk: note: Conditions already in need of change.

(0) Feasibility: FS ownership

Primary treatments: prescribed burning, mechanical vegetation treatments, erosion control, road/trail decommissioning or hardening, planting, vista clearing, mining reclamation, planting, etc.

Scenario 5e: Scenic Integrity Protection

Question: Which areas are most important to protect from degradation? Highly visible areas with very high to high existing scenic integrity

(60) Value: High / Very High Existing Scenic Integrity (30 percent)
High-visibility areas:
Forests on the Edge population density (15 percent)
Recreation Opportunity Settings—RN, SPM and urban (15 percent)

(40) Risk: Crown-and ground-fire burn probability (15 percent)
Bark beetle hazard (10 percent)
Forests on the Edge population density 2030 (15 percent)

(0) Feasibility: FS ownership

Primary treatments: fuels reduction treatments, planting, etc.

Theme 6. PUBLIC SAFETY AND INFRASTRUCTURE PROTECTION

(note: this theme uses scenarios S1a, S5a, and S5b a second time based on current regional priorities)

Scenario 6a: Community Fire Resilience

Question: Which community areas are best to improve fire resilience due to burn probability or insect and disease risk?

(70) Value: Population density (50 percent)
Oil and gas wells (20 percent)

(30) Risk: Crown- and ground-fire burn probability (20 percent)
Insect occurrence from ADS past 5 years (5 percent)
Bark beetle hazard from FIA data by HUC5 (5 percent)

(0) Feasibility: Response to wildland fire

Scenario 6b: Safety

Question: Which areas are most important to protect/restore owing to high concentrations of use? High-use areas with existing/potential hazard trees due to insects and disease and in areas with high burn probability.

(70) Value: Recreation Use Areas:
Developed recreation sites—capacity/occupancy, total visits, duration of use (20 percent)
Dispersed recreation areas (15 percent)
Recreation Special Use:
Recreation residences (10 percent)
Ski areas (10 percent)
Travel Routes:
Roads—maintenance levels 3–5 (10 percent)
Trails—all trails including snow routes (5 percent)

(30) Risk: Crown-and ground-fire burn probability (10 percent)
Insect occurrence from ADS (10 percent)
Bark beetle hazard from FIA data (10 percent)

(0) Feasibility: FS ownership

Potential treatments: Fuels reduction treatments, hazard tree removal, thinning, planting.

Scenario 6c: Investment Protection

Question: Which areas are most important to protect from an investment perspective? High-investment areas that are at risk of damage.

(70) Value: Developed recreation sites—develop. scale, replacement value, site type (30 percent)
Recreation Special Use:
Recreation residences (10 percent)
Ski areas (10 percent)
Interface investments:
Utility lines (10 percent)
Electronic sites (5 percent)
Administrative sites (5 percent)

(30) Risk: Crown-and ground-fire burn probability (10 percent)
Bark beetle hazard from FIA data (10 percent)
Insect occurrence from ADS last 5 years (10 percent)

(0) Feasibility: FS ownership

Primary treatments: Fuels reduction treatments, hazard tree removal, etc.

Appendix D1:
Narrative for Scenario 1A, Community Fire Resiliency

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Theme 1 Vegetation Resilience

Scenario 1a Community Resiliency to Wildfire

Specialist Cathy Stewart, Regional Fire Ecologist

IRPS date March 2011

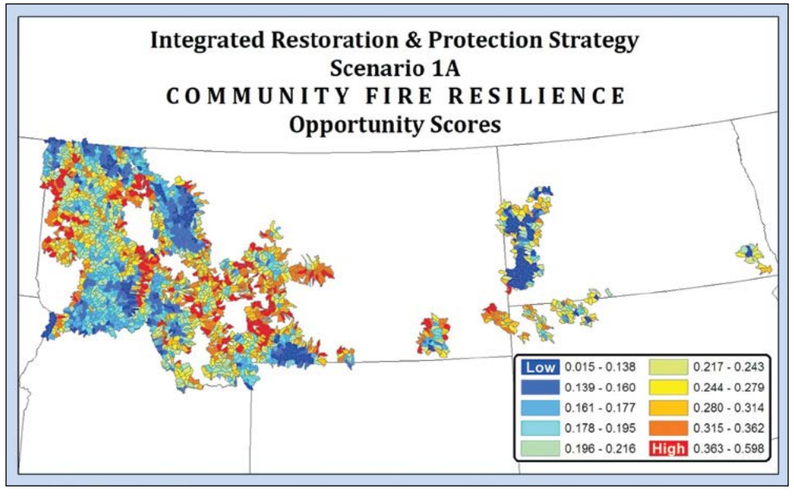
Question: Which community areas are best candidates for improving fire resilience as a result of their burn probability or insect and disease risk?

Model (weights in parentheses)

(70) Value: Population density (50 percent)
Oil and gas wells (20 percent)

(30) Risk: Crown- and ground-fire burn probability (20 percent)
Insect occurrence from Aerial Insect and Disease Detection Survey (ADS), past 5 years (5%)
Bark beetle hazard from Forest Inventory Analysis (FIA) data by 5th hydrological unit code or HUC5 (5%)

(0) Feasibility: Response to wildland fire



Scenario 1A Output. Here, opportunity scores are displayed in 10 quantiles, meaning that subwatersheds scoring in the top 10 percent are shown in red and the bottom 10 percent in dark blue.

Scenario 1A indirectly assesses the risk to communities (or population density) by wildfire and displays potential to reduce that risk by fuel treatments and fire managed for multiple objectives in the vicinity.

Scenario assumptions—
Communities at risk are better represented by population density than by community or wildland-urban interface (WUI) boundaries.

- Oil and gas wells are a community resource meriting protection.
- Insect occurrence/hazard increases burn probability.



source: mt.gov

Scenario inputs—

Population density was used to represent communities at risk instead of community boundaries, which can be variable in size, or WUI, which is also highly variable. Population density data estimates were computed from the U.S. Department of Commerce Census Bureau's block group and block data for 2000 and refined for 2000 data and projected for 2030 (Stein et al. 2007). (http://www.fs.fed.us/pnw/publications/gtr728/gtr728b.pdf)

For each 6th-code HUC, population densities for 2000 and 2030 are summarized in three classes:

- Rural I, **lands with 16 or fewer housing units per square mile.**
- Rural II, **17 to 64 housing units per square mile.**
- Exurban/urban, **65 or more housing units per square mile.**

Oil and gas wells are represented simply by the number of active oil or gas wells on Forest Service lands. Note that in Region 1, only the Dakota Prairie Grasslands had active oil or gas wells.

Insect occurrence was represented by the percentage of bark beetle occurrence based on ADS polygons from survey years 2002–2009. A 30-m raster layer was created by modeling 2002–2009 ADS bark beetle "trees per acre" data into three classes: low, moderate, and high. First, each year's ADS feature class polygon data were queried for "DCA1" IN (11002, 11006, 11007, 11009, 11015, 11029, 11049, 11050) AND "TPA1" ≥ 1, then a 30-m raster layer was created based on the "TPA1" attribute. The yearly ADS bark beetle "Trees Per Acre" raster layers were combined using a sum function into a "Total Bark Beetle Occurrence" raster layer, which was then broken into three classes: low (SUMTPA 1-5), moderate (SUMTPA 6-15_, and high (SUMTPA >15). The percentage of each bark beetle occurrence class was determined per HUC6, and a summary attribute was calculated: ADSBBOCC = (% low × 0.33) + (%mod × 0.66) + (%high × 1).

Bark beetle hazard was represented by the probability of pine stands being susceptible to bark beetle attack based on an FIA data query by 5th-code watershed. All 6th-code HUCs within a 5th-code watershed have the same bark beetle hazard.

Burn probability was used to estimate risk from wildfire by identifying areas with higher chances of crown fire relative to surrounding areas. The burn probability map is a product of Mark Finney's Large Fire Simulator FSim. FSim consists of modules for weather generation, modeling fire occurrence, fire growth, and fire suppression (Finney et al. 2011). It simulates occurrence and growth for thousands of fires over thousands of years in order to estimate average burn probabilities and distribution of fire sizes. Outputs result in simulations of fire line intensity and fire probability by cell.

Data inputs—Data required for input to the simulation process include geographic information system (GIS)-format fuels and topography (from LandFire Rapid Refresh), daily historical weather data from 10 to 20 years and historical ignition date and locations. All fires reported and available through FAMWEB (http://fam.nwcg.gov/fam-web/) for U.S. Forest Service, Fish and Wildlife Service, and National Park Service lands (no private) within the landscape were used to develop a regression based on energy reliance component (ERC) and to the number of large fires and multiple fire days. All fires greater than 300 acres (121 ha) were considered large fires. The spatial data set used is rapid refresh data updated for fires up to and through 2007 that was reprojected to a local projection. Runs were processed on the super computers at the fire lab.

The forest part of the region (from the Custer National Forest westward) was modeled as one modeling unit. This was due to edge-matching problems when smaller portions of the Region were run separately. This run used weather data from only one weather station in Missoula, owing to limitations of the model at that point in development. Future runs on the newer version of the model will enable the use of data from many weather stations.

For the rest of the Region, FPA (Fire Planning Analysis) runs of the FSim model were used. These runs were made using local weather stations in each FPU (Fire Planning Unit). There were edge-matching problems with these runs. The runs for North Dakota were not available at the time of data acquisition, so were extrapolated from data in surrounding areas. There have been subsequent updates to the FSim model that will accommodate more weather station data.

Data outputs—The output from these runs created a table of flame lengths, which were then manipulated to create classes of surface fire and crown fire. We overlaid the flame length grid with the crown cover layer of the landscape file. Areas with any crown cover >10 percent, fuel models >160 **and** flame lengths ≥2 m were classified as crown fire probability. All other flame lengths were designated as surface fire. The crown fire probability was averaged for each 6th-code HUC and the percentage of the HUC area in the crown fire class was calculated. The same procedure was followed for Ground Fire with forest and Ground Fire without forest.

The probabilities (not predictions or forecasts) are annual probabilities of a fire occurring and are additive. We can add up the probabilities for the years. But we **must** qualify that the probabilities are on average. So you can say that with 2 percent probability per year over 10 years you have a 20 percent chance of burn **on average**.

The probability is not conditional; chance of fire this year does not change the fuel model (or fire) for the next year. We would have to update the landscape spatial data (.lcp) file to reflect that and rerun the model to capture that impact. There are also no long-term vegetation interactions or influence of drought. There are no fires spreading into the area from outside the edges of the map. Many factors result in fire probabilities on the lower end of the scale.

Burn probability and fire behavior—Map outputs for burn probability represent an estimate of the spatial variability in probability of burning from large fires. Highest burn probabilities are found at the low elevations because grass fuels dominate in these locations. Expected flame lengths are relatively low in these fuel types. Areas of conifer forests and at high elevation tend to have lower burn probabilities because timber fuels have lower spread rates. However, expected flame lengths in these fuel types are higher, because they are more likely to burn as crown fires under the weather circumstances that allow them to burn.

Spatial locations of large fires are assumed to be random, but if data were available, they would be spatially variable. Once started, large-fire growth was simulated using the sequence of daily values of fuel moisture and windspeed from the synthetic weather stream (starting with the date of occurrence). The duration of fire growth was entirely determined by the sequence of weather days in the artificial time series following the day of ignition (i.e., not set a priori) and by a suppression model (see below). A Minimum Travel Time (MTT) algorithm performs the fire growth by searching for the shortest fire travel times among cells on a landscape. This method is computationally efficient in simulating fire growth under complex environmental conditions. It calculates fire behavior at each "cell" (e.g., flame length) on a landscape, which is necessary for determining fire effects.

Large-fire suppression—A statistical model of large-fire suppression was developed that relies on historical large-fire records. This model predicts the probability of containment as a function of time periods of fire activity (series of days on which the fire grew versus those on which it stayed relatively constant). Containment was found to be more likely when the fire grew slowly, after an increasing number of time periods of slow fire growth, and in nontimber fuels. Containment probability produced by the model was included in the simulation system and was applied to the daily sequence of weather events. For each period in a weather sequence, a containment probability produced by the model is used by the prototype to stochastically estimate the reduced number of days that fire growth occurs. This limits the sizes of most fires, but fires that started near the end of the seasons will be little influenced by suppression whereas fires beginning early in the season were probably greatly affected.

Data caveats—

Burn probability is a hybrid layer pasted together from three sources, as outlined above: the western, forested part of the region was run using data from one weather station; most of the remainder of the region was mapped using FPA runs of the FSim model; and North Dakota was extrapolated from surrounding areas. Future runs will enable the use of data from many weather stations, and should have fewer edge-matching problems. As outlined above, burn probability is not conditional; chance of fire this year does not change the fuel model (or fire) for the next year. There are also no long-term vegetation interactions, drought influence, or fires spreading into the area from outside the edges of the map. Many factors result in fire probabilities on the lower end of the scale.

Future Work

As the burn probability data are updated, Scenario 1A should be updated as well.

Future runs also could address feasibility through adjacency to Community Wildland Fire Protection Plans (CWPPs) and Response to Wildland Fire. CWPPs are created by each county. Where CWPPs are completed, there are greater chances of accomplishing fuel treatments owing to greater funding opportunities for CWPP projects. This increased chance for funding opportunities is projected as increased feasibility that fire risk, or burn probability, can be reduced in areas adjacent to CWPPs.

Unplanned ignitions managed for multiple objectives also have the potential to provide fire breaks or reduced fuel or fire severity. This has the potential to reduce fire risk to adjacent communities. The Response to Wildland Fire areas are tied to the individual forest land management plan direction and response guides. These areas have the potential for wildfire management decisions that can positively influence the feasibility that fire risk can be reduced. These areas are mapped according to individual forest plan allowances and summarized by 6th-code HUCs. The benefits can be ecological, based on desired conditions for wildlife habitat, hydrology, soils, etc. reflected in the forest plan (see Scenario 1B). Fuel reduction can also help reduce the severity of fire impacts on other resources. When overlaid with other habitat features, the benefits can be quantified.

Literature Cited

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Finney, M.A.; McHugh, C.W.; Grenfell, I.C.; Riley, K.L.; Short, K.C. 2011. A simulation of probabilistic wildfire risk components for the continental United States. Stochastic Environmental Research and Risk Assessment. 25: 973–1000.

Appendix D2: Narrative for Scenario 1B, Forest Resiliency, Vulnerability, and Departure From Desired Conditions

Barry L. Bollenbacher

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This scenario compares forest desired conditions (DC) with current conditions to represent factors that contribute to ecosystem diversity and vulnerabilities to disturbance agents likely to impede a trajectory toward achieving those desired conditions. These DCs and the departure from the DCs represent our current view of forest resiliency, or lack thereof in some cases, under current climatic conditions.

Value: Forest resiliency:

The value section of S1B included an analysis of departure from desire vegetation conditions for:

- Forest trees species composition (groups of species in some cases)
- Forest tree size class
- Forest density on the dry forest type (habitat type groupings were used to stratify this)

This analysis takes advantage of all of the studies documented in the Region 1 planning records, and comprehensive evaluation reports (CER) concerning how the historical range of variability (HRV) of forest vegetation helped to **inform** DCs for forest vegetation in the draft forest plans for the Nez Perce, Clearwater, Idaho Panhandle, Kootenai, Flathead, Lolo, and Bitterroot National Forests, and the DC, Goals and Objectives from the revised forest plan for the Beaverhead-Deerlodge National Forest. Information and analysis completed as part of the East-Side Analysis of the Management Situation (AMS 1998) in terms of HRV modeled for 21 Geographic Areas using the landscape simulation model SIMPPLLE (**http://www.fs.fed.us/rm/missoula/4151/SIMPPLLE/)** was used to approximate a reasonable estimate of DC for those areas within the Helena, Lewis and Clark, Gallatin, and Custer National Forests, as these forests have not begun forest plan revision. Methods papers regarding how HRV was determined are available here for the Idaho Panhandle, Kootenai, Nez Perce, Clearwater, Flathead, Lolo, and Bitterroot National Forests, and for the east-side forests.

These evaluations were then completed on 55 Analysis Areas similar to Baily's Subsections, and were modified to fit watershed and state boundaries for ease of analysis in the Ecosystem Management Decision Support (EMDS) model. Desired conditions were taken directly from the draft or revised forest plans located at:

Nez Perce-Clearwater National Forests
http://www.fs.fed.us/cnpz/forest/documents/draft_fp_ex/march07/clearwater/070306_clw_chapt_1.pdf
http://www.fs.fed.us/cnpz/forest/documents/draft_fp_ex/march07/nezperce/070306_nez_chapt_1.pdf

Flathead National Forest
http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev3_053829.pdf

Lolo National Forest
http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev3_053883.pdf

Bitterroot National Forest
http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev3_053878.pdf

Idaho Panhandle National Forest 2006 (same as current draft revision DCs)
http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsm91_056321.pdf

Kootenai National Forest 2006 (same as current draft revision DCs)
http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsm91_056306.pdf

Beaverhead-Deerlodge National Forest
http://fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5052767.pdf

Current conditions were evaluated using the periodic FIA plot data located within each of the 55 S1B Analysis Areas. **Vegetation attributes** contained in the DCs and the current condition include primary **dominance types in terms of species composition, size classes of the forest, and density of the dry forest portion of each landscape**. The Dominance Types and the Size Class Desired Conditions were taken directly from the draft or revised forest plans.

The draft forest plans, at the time of this assessment, did not have specific DC for density for the dry forest type, the most vulnerable in terms of departure of any biophysical forested site. For this assessment we used Forest Vegetation Simulator (FVS) and Forest Fuels Extension (FFE) to look at a range of basal areas that would result in reduced crown-fire behavior and lower bark beetle hazard (see appendix for examples) A range of 55 to 75 square feet of basal area was used on west-side forests as a desirable density to achieve these objectives, while 40 to 70 square feet of basal area (BA) was used in the analysis on east-side forests. A range of 40 to 60 percent of the dry forest type for these densities, on each forest, was used as a DC for density of the dry forest type until more specific information becomes available during the planning process.

The means for each of the three attributes were used to evaluate how close to DC (departure) an attribute currently is. These data are available in spreadsheets that also contain the evaluation of confidence interval with the lower bound, mean, and upper bound. This information allows the user to determine how confident we are in the estimates of current condition. In some cases the confidence interval may span outside the DC while the mean is within the DC. In this case, we would be less certain that the true mean is within the DC and we may be less certain how departed an attribute actually is if the true mean were known. One limitation of using the periodic data is that these plots for the most part were measured during the 1990s, prior to significant bark beetle outbreaks and fires from 2000 to present. Annualized FIA plot data for the last 5 years were not yet available for this analysis, but will be used to update this evaluation as soon as they become available. This should provide a reasonable monitoring opportunity in terms of changes resulting from disturbance.

Risks:
Current and projected hazards, risks, and probabilities of disturbance agents were identified spatially including:

- **Current bark beetle infestation (Aerial Detection Survey [ADS])**
- **Future bark beetle hazard (bark beetle hazard models in FVS)**
- **Crown fire burn probability (as in scenario 1A)**

These were evaluated for those risks to further impeding progress, or providing progress toward DCs in the decision model for this S1B scenario.

A departure quantity was calculated using the DC and current condition information, then evaluated against the these known insect and disease disturbance since 2000 from the **ADS**, and the future disturbance probabilities or risks that included crown-fire burn probability, and bark beetle hazard calculated from bark beetle hazard models in FVS using FIA data. Each S1b Analysis Area was then given a relative number or "vulnerability index" to represent the vegetation DC values at risk, to enable comparison across the region or subregion (northern Idaho, western Montana, eastern Montana, and Dakota Prairie Grasslands). The higher the index, the higher priority it might be to direct management actions to reduce vulnerability and further make progress toward DCs.

One limitation of this analysis is that it does not include the influence that the spatial pattern of compositions, size classes, and density classes may have on the resiliency of the forest. A DC for pattern within an Analysis Area or landscape would be a helpful addition to further assess forest resiliency. This can be evaluated using a landscape simulation model (such as SIMPPLLE), such as been completed for the evaluation of HRV for forest plan revision. An assessment of this type has been done for the Northern Rockies ecological section, Flathead National Forest; supporting documents are available here.

Feasibility factors:
Feasibility factors are important to consider in this model. Local factors are critical to add at the local level where they are known to exist to better reflect a sense of ripeness of opportunities.

Metadata including links to basis for DCs, Spatial GIS map of the S1B Analysis Areas, and evaluation spreadsheets are available with the details of the evaluation.

Literature references are contained in the individual methods papers concerning HRV.

Example evaluation of the effect of density on fire and bark beetle hazard

Silviculture prescription narrative Rx A: slash trees less than 7 inches DBH
This treatment is replicated in stands that have ladder fuels that do not have enough stocking in trees over 7 inches DBH to effectively commercial thin at this time, and is intended to reduce all ladder fuels in the less-than-7-inch-diameter class, to reduce crown-fire potential. The treatment will slash all trees less than 7 inches and hand pile and burn the slash. Ten percent of the areas will not be slashed to promote wildlife habitat diversity. The stands will be prescribed burned every 10 years through year 30 to reduce canopy bulk density as well as ladder fuels and ground fuels to produce a resilient stand that does not have a characteristically high potential for crown fire. Ponderosa pine will be favored for leave in all treatments owing to their ability to withstand low-severity fire.

Silviculture prescription narrative Rx B: commercial thinning
This treatment is replicated in stands that have ladder fuels and that do have enough stocking in trees over 7 inch DBH to effectively commercial thin at this time. This is intended to reduce all ladder fuels in the less-than-3-inch-diameter class by slashing and piling, while commercial thinning from below to a residual basal area of 60 square feet to reduce crown-fire potential. Tops will be removed during whole-tree yarding, as will all trees from 3- to 7-inch DBH, and piled and burned at the landing. The stands will be prescribed burned immediately after this commercial thinning to reduce ground fuels. The stands will be prescribed burned every 10 years (years 10 and 20 from year of commercial thinning), and beginning in year 30, a commercial thin reducing stand stocking down to 60 square feet of basal area will be completed to reduce canopy bulk density as well as ladder fuels and ground fuels to produce a resilient stand that does not have a characteristically high potential for crown fire. Prescribe burn after this commercial thin. Ponderosa pine will be favored for leave in all treatments owing to their ability to withstand low-severity fire. A variation will be tested for this prescription that reduces BA to 40 for commercial thin treatments.

Silviculture prescription narrative Rx C: commercial thinning
This treatment is replicated in stands that have ladder fuels and that do have enough stocking in trees over 7 inches DBH to effectively commercial thin at this time. This is intended to reduce all ladder fuels in the less-than-3-inch-diameter class through slashing and piling, while commercial thinning from below to a residual basal area of 60 square feet to reduce crown-fire potential. Tops will be removed during whole-tree yarding, as will all trees from 3 to 7 inches DBH, and utilized as biomass. The stands will be prescribed burned immediately after this commercial thinning to reduce ground fuels. The stands will be prescribed burned every 10

years (years 10 and 20 from year of commercial thinning), and beginning in year 30, a commercial thin reducing stand stocking down to 60 square feet of basal area will be completed to reduce canopy bulk density as well as ladder fuels and ground fuels to produce a resilient stand that does not have a characteristically high potential for crown fire. Prescribe burn after this commercial thin. Ponderosa pine will be favored for leave in all treatments owing to their ability to withstand low-severity fire. A variation will be tested for this prescription that reduces BA to 40 for commercial thin treatments.

Fire Modeling

Fire modeling to test crown-fire potential at various stages including **after each prescribed burn** for all prescriptions, and in addition in the case of the slashing treatment, after the initial slashing hand pile and burn were completed with the assumptions in the table above.

The summary of results of the analysis are included in the following graphs:

Interpretation

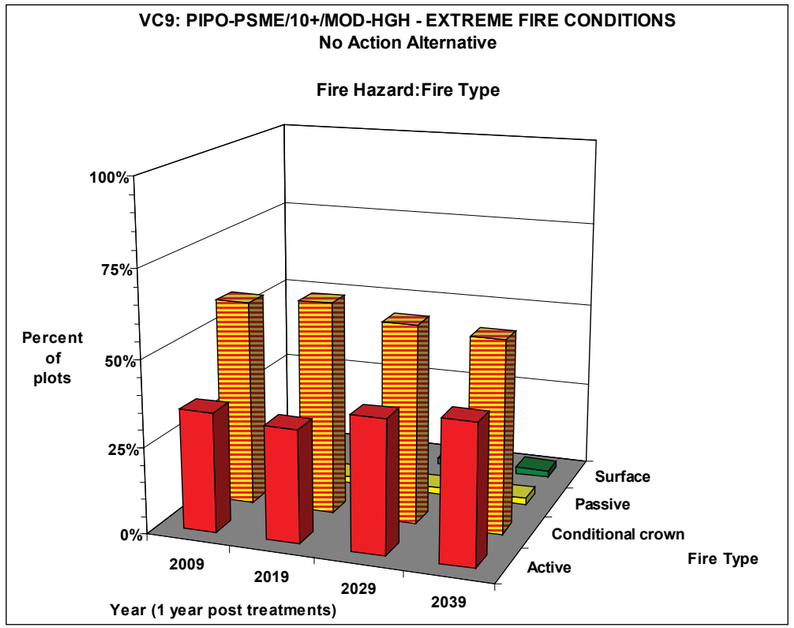
The FVS along with the FFE and bark beetle hazard model extensions were used to predict effects in terms of resilience to fire and bark beetle hazard for each scenario.

Fire

Action alternatives produce much more ground fire and passive fire because of the reduction of ground fuels, ladder fuels, and canopy bulk density through commercial thinning. Slashing is not as effective because crown fuels are not reduced enough to as effectively reduce the crown-fire potential.

Assumptions used in fire models to predict fire severity based on weather and fuel moisture

	Low fire ×	Medium × fire	Average fire	Bitterroot pocket card	Extreme fire
20- foot windspeed	0	5-10	15	20	40
Temperature	70	75	75	>85, RH<20%	90
Percent fuel moisture:					
1 hour (0-1/4 inch)	12-15	8-10	6		4
10 hour (1/4-1 inch)	12	10	8		6
100 hour (1-3 inch)	14	12	10		7
1000 hour (3 inch+)	30	20	15		12
Duff	150	100	100		65
Live	150	100	90	<100	60



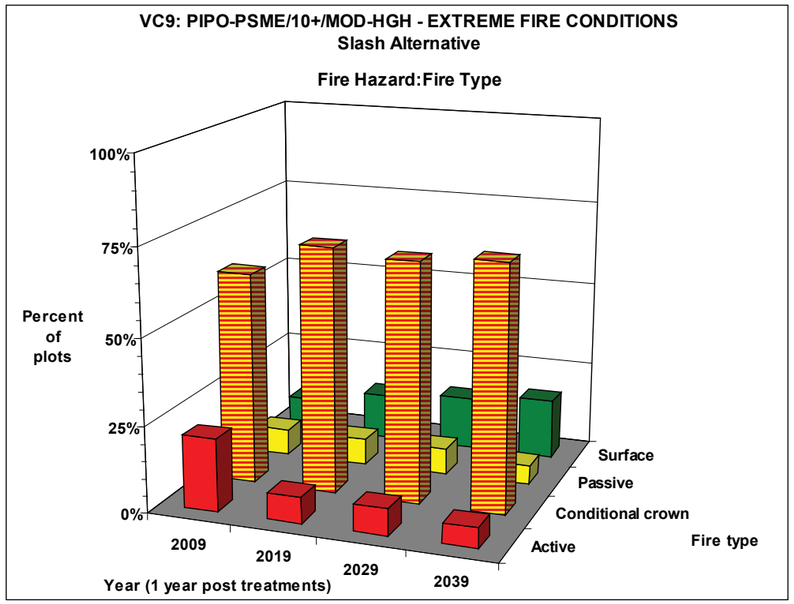
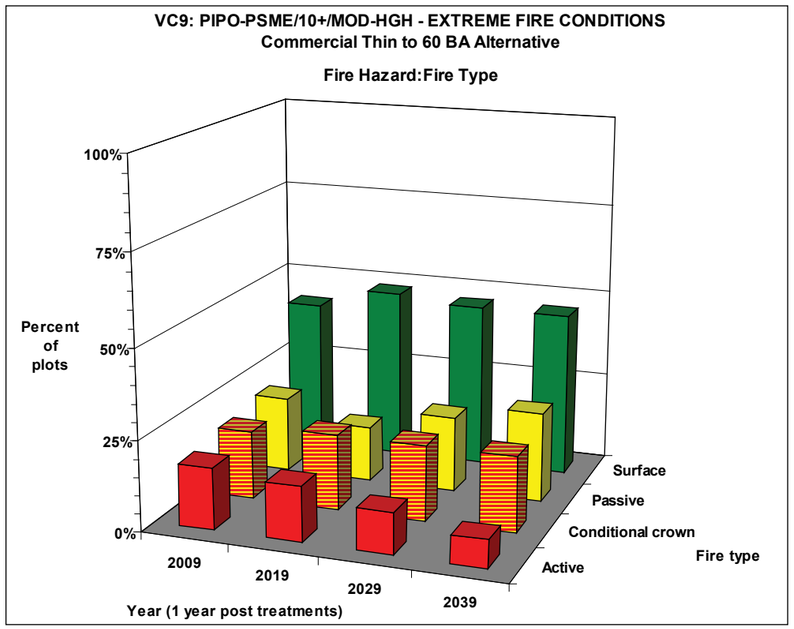


Figure D2-1— Predicted fire behavior in ponderosa pine/Douglas-fir 10"+ dbh forests for (a) no action taken, (b) slashing understory, (c) commercial thinning down to 60 sq ft basal area, and (d) commercial thinning down to 40 sq ft basal area.

C



D

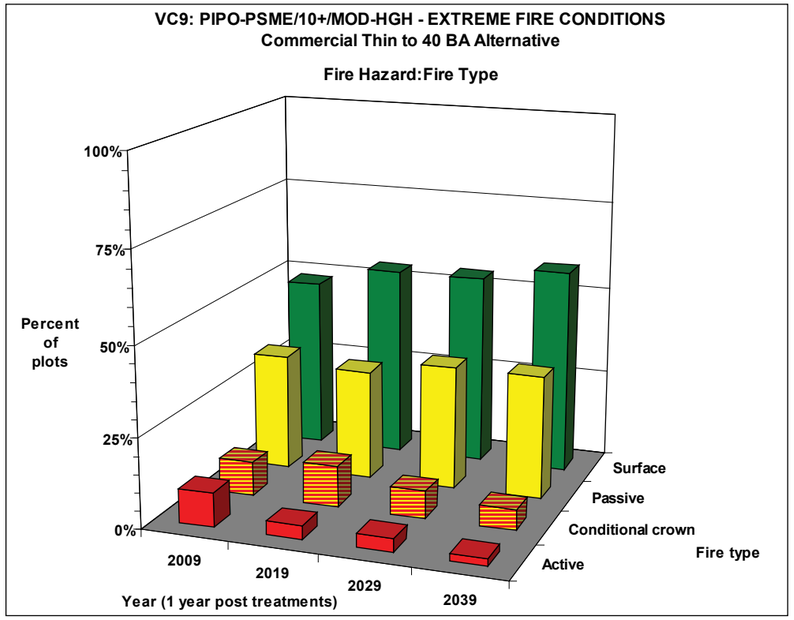
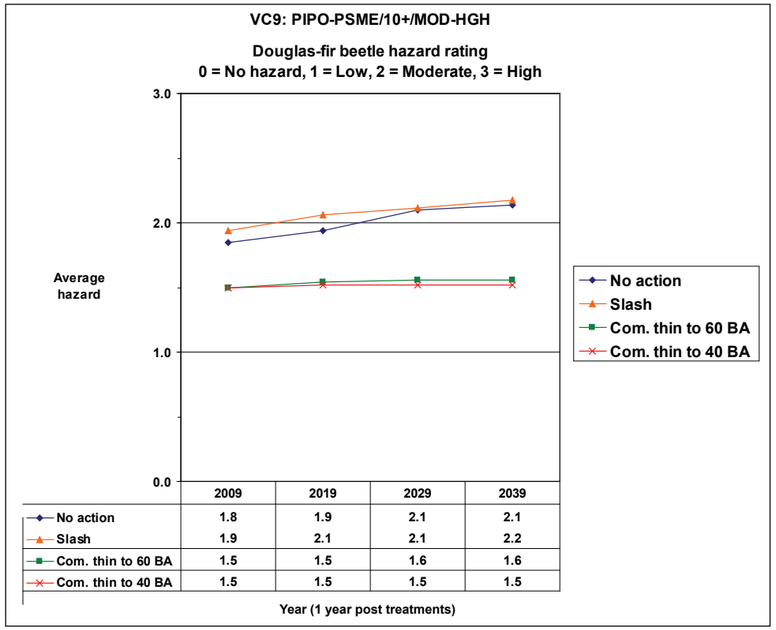


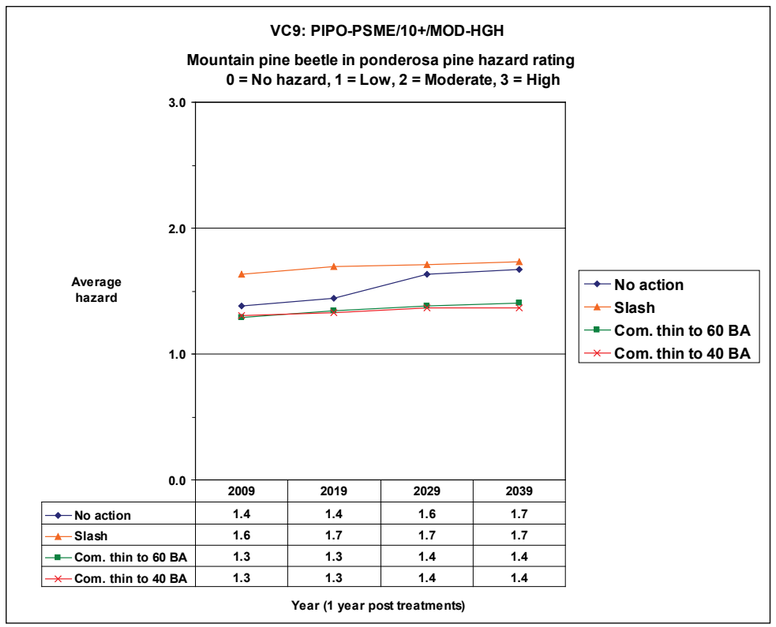
Figure D2-1 (continued)—Predicted fire behavior in ponderosa pine/Douglas-fir 10"+ dbh forests for (a) no action taken, (b) slashing understory, (c) commercial thinning down to 60 sq ft basal area, and (d) commercial thinning down to 40 sq ft basal area.

A



	2009	2019	2029	2039
No action	1.8	1.9	2.1	2.1
Slash	1.9	2.1	2.1	2.2
Com. thin to 60 BA	1.5	1.5	1.6	1.6
Com. thin to 40 BA	1.5	1.5	1.5	1.5

B



	2009	2019	2029	2039
No action	1.4	1.4	1.6	1.7
Slash	1.6	1.7	1.7	1.7
Com. thin to 60 BA	1.3	1.3	1.4	1.4
Com. thin to 40 BA	1.3	1.3	1.4	1.4

Figure D2-2—Predicted result of the four alternatives (no action, slashing understory, commercial thinning down to 60 sq ft basal area, and commercial thinning down to 40 sq ft basal area) on (a) Douglas-fir beetle hazard, and (b) mountain pine beetle hazard in ponderosa pine.

Bark beetle hazard

The plot data used were not initially high hazard to bark beetle mortality; however, the treatments do show a continuation of a low to moderate hazard. So perpetuation of the current low hazard through treatments over time help to maintain resilient stand conditions related to beetle hazard.

Resilience

When considered together, the treatments in these stands produce more resilient composition and structure in terms of both potential fire effects and beetle hazard over time compared to the no-action alternative for the time period in the analysis.

Summary

This analysis using FVS with extensions for fire and fuels and bark beetles can be completed on any projects having plot-level data taken with common stand exam procedures.

This analysis provides an example of how the issue of forest resilience can be addressed in this dry forest type. One limitation of a stand-level effects analysis is that the landscape context may produce conditions for crown fire or large-scale beetle outbreaks that may influence stand-level mortality, especially if the treatments were randomly located rather than strategically placed. Strategic placement of treatment units (pattern) needs to be evaluated as well as stand-level effects.

Specifics of any given stand to be evaluated at the project level will vary, so analysis results between alternatives may show other differences not apparent with the stand data in this example analysis. However, the approach used can be completed for project-level effects analyses for a variety of proposed actions.

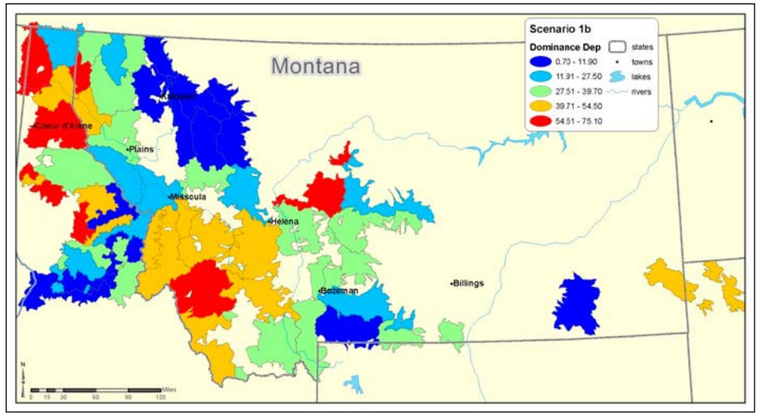


Figure D2-3—For 55 analysis areas in the Northern Region, departure from historic conditions for (a) dominance types in terms of tree species composition, (b) size classes of the forest, and (c) density of the dry forest portion of each landscape.

Appendix D3: Narrative for Scenario 1C, Nonforested Vegetation Types—Resiliency, Vulnerability, and Departure From Desired Conditions

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Mary Manning, Regional Vegetation Ecologist

To be as consistent as possible with the forested vegetation scenario, this scenario compares nonforested vegetation desired conditions (DC) to current conditions. This is done to represent the factors that contribute to ecosystem function, resiliency, and vulnerability to disturbance agents likely to limit these communities from moving toward and achieving those DCs. These DCs and the departure from the DCs represent our current view of nonforested vegetation resiliency, or lack thereof in some cases, under current climatic conditions. Adaptation strategies will need to be assessed, and DCs may need to be modified as we learn more about the influence of climate change on these communities and the various processes that affect their composition, structure, resiliency and landscape pattern. **Originally feasibility was considered during the ratings, as shown below.**

Scenario 1c: *Ecosystem resilience and vulnerability in nonforested areas*

(70)	Value	Composition of nonforest types with noxious weed hazard**
(20)	Risks	Departure from historical fire regime of nonforest types (10 percent)**
		Grazing (10 percent)**
(10)	Feasibility	Forest Service ownership

* Suggested weights in parentheses

** NetWeaver model in place

However, it was determined that we could drop feasibility and just use value and risk. In addition, risk was further refined to show the proportion of each impact. The Dakota Prairie subregion is not shown because the Dry Grass Ecological System is not represented in this subregion.

Subregion: western Montana

Vegetation type: Dry grass

Value: 60 percent
This type is somewhat rare in western Montana. It is declining and/or is highly susceptible to invasives, then conifer encroachment resulting from fire exclusion, and then grazing.

Risk: 40 percent
- Invasives: 20
- Fire exclusion: 12
- Grazing/herbivory: 8

Subregion: eastern Montana

Vegetation type: Dry grass

Value: 50 percent
This type is more common east of the divide. It is highly susceptible to invasives, then conifer encroachment.

Risk: 50 percent
- Invasives: 25
- Fire exclusion: 10
- Grazing/herbivory: 15

Subregion: northern Idaho

Vegetation type: Dry grass

Value: 50 percent
This is a rare type in northern Idaho. It has been converted to agriculture or highly altered by grazing and invasives, combined.

Risk: 50 percent
- Invasives: 30
- Fire exclusion: 5
- Grazing/herbivory: 15

A tabulation showing the value and risk of each nonforested vegetation type by subregion was then used in the Ecosystem Management Decision Support model:

EVG	N.ID V/R*	W. MT V/R	E.MT V/R	DPG V/R
Dry grass	40/60	40/60	40/60	n/a
Moist grass	60/40	60/40	60/40	n/a
Mixed grass prairie	n/a	n/a	50/50	50/50
Tall grass prairie	n/a	n/a	n/a	60/40
Sagebrush/xeric shrub	60/40	60/40	50/50	50/50
Mixed high-elevation shrub	70/30	70/30	70/30	n/a
Deciduous shrub	50/50	60/40	70/30	60/40
Alpine	80/20	80/20	80/20	n/a
Riparian/wetland	70/30	70/30	70/30	70/30
Woody draw	50/50	60/40	60/40	60/40
Exotic	10/90	10/90	10/90	10/90
Early seral herb	20/80	20/80	20/80	20/80

EVG = existing vegetation group, N.ID V/R = Northern Idaho value/risk, W.MT V/R = Western Montana value/risk, E.MT V/R = Eastern Montana value/risk, DPG V/R = Dakota Prairie Grasslands value/risk
* V = value, R = risk n/a = nonapplicable.

Approach Used to Describe the Vegetation Types (Value)

Because there are no readily available Forest Inventory and Analysis data describing nonforested vegetation types, we used NatureServe's Ecological Systems to describe current conditions.

NatureServe defines them as follows:

> Ecological systems represent recurring groups of biological communities that are found in similar physical environments and are influenced by similar dynamic ecological processes, such as fire or flooding. They are intended to provide a classification unit that is readily mappable, often from remote imagery, and readily identifiable by conservation and resource managers in the field.
>
> Terrestrial ecological systems are specifically defined as a group of plant community types (associations) that tend to co-occur within landscapes with similar ecological processes, substrates, and/or environmental gradients. A given system will typically manifest itself in a landscape at intermediate geographic scales of tens to thousands of hectares and will persist for 50 or more years. This temporal scale allows typical successional dynamics to be integrated into the concept of each unit. With these temporal and spatial scales bounding the concept of ecological systems, we then integrate multiple ecological factors—or diagnostic classifiers—to define each classification unit. The multiple ecological factors are evaluated and combined in different ways to explain the spatial co-occurrence of plant associations.

The approach used for forested vegetation was applied to nonforested vegetation, with modifications. The focus was on intact, functional vegetation types that had most native species present in adequate amounts. Invasive weeds were strongly considered in terms of their presence and amount (relative to the native species). Other factors considered were fire exclusion and resulting conifer reestablishment, and grazing (both domestic and native ungulates). In addition, the nonforested vegetation types for terrestrial species were described using ecological systems. They were assessed based upon wildlife habitat criteria and as such, the ratings may differ from those in this scenario.

Appendix D4:
Narrative for Theme 2, Terrestrial Species

Theme 2 Terrestrial Species

Specialist *Eric Tomasik*

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October 2010

Wildlife species and issues of concern across the region are many and highly variable. Theme 2 scenarios are not intended to capture all of these species or issues. Units will need to add scenarios to capture pertinent issues and information. Here, we have tried to capture issues deserving emphasis while working within constraints of broad-scale applicability and regionwide data availability.

Scenario 2a Whitebark Pine

Model (weights in parentheses)

(50)	Value:	Whitebark pine composition, % HUC6 (30%)
		Grizzly bear species range (20%)
(35)	Risk:	Crown-fire burn probability (15%)
		Blister rust damage map (10%)
		Insect occurrence from ADS, past 5 years (10%)
(15)	Feasibility:	Nonwilderness (10%)
		Monitoring Trends in Burn Severity (MTBS) moderate/high burn severity (5%)

Primary treatments: prescribed burning or wildland fire to promote dispersal by Clark's nutcrackers and regeneration, and to reduce crown-fire potential. Planting in some areas (*current policy interpretation does not allow many opportunities for planting in wilderness).

The intent is to retain existing whitebark pine of good cone-producing age and restore whitebark pine in areas where it has declined. Treatments should not result in contributing to substantial losses of healthy, mature trees, but small-scale impacts on a few of these large, mature trees are acceptable if they contribute to restoration at a larger scale for the species.

Whitebark pine seeds can be an important food item for grizzly bears; thus, the species' range is an input to the scenario in terms of resource value. Healthy, mature stands of whitebark pine are increasingly rare, and fire and vegetation treatments in these stands should account for their retention. Risks to whitebark pine, as modeled in the scenario, include the extent of blister rust damage, as mapped by Bob Keane at the Fire Lab; probability of crown fires (to account for the likelihood of fire killing mature, cone-producing whitebark pine); and insect outbreaks as mapped in the past 5 years' aerial detection surveys (ADS).

Treatment considerations and management approaches

Species composition

Stands dominated by lodgepole pine, subalpine fir, and spruce are the highest priority for treatment. The goal is to reduce these species in the understory and overstory, and increase whitebark pine. Burning will promote the regeneration of whitebark pine, thin stands, and reduce the competition from subalpine fir, lodgepole pine, and spruce.

Stocking or crown closure

Whitebark pine seeds are dispersed by Clark's nutcrackers and regenerate successfully when crown closure is 30 percent or less. Opening up whitebark pine stands to a maximum of 30 percent closure (or <175 square feet/acre basal area) with openings ~0.5 acre will aid in the regeneration of seedlings. Ideal structure would be open conditions with clumps of mature, immature, or sapling whitebark pine with seedlings eventually filling in openings, with reduced surface fuels and mineral soil exposed.

Burn conditions

Moderate years (when fire severity conditions are not extreme) have great potential to create the desired conditions described. Examples of moderate conditions might include shorter seasons, a trend of low energy release components for the season or where seasonal severity indicators are acceptable based on risk assessment. Often, a heavy frost in late summer/early fall will kill and dry out fine fuels, facilitating fire spread.

Resource benefit fire areas

The map on the linked site (ftp://ftp.r1.fs.fed.us/pub/open/Whitebark_Pine_Fire/) shows those areas where fire for resource benefits is allowed with pertinent operational details identified in Fire Management Plans or elsewhere. The light green areas do not yet have operational details documented, but may have potential for the future.

Blister rust

Where blister rust has caused extensive mortality of whitebark pine, burning will be essential to promote rust-resistant whitebark over other species. Areas with >50 percent whitebark pine mortality over a majority of an area are the highest priority for burning. However, if there are possible rust-resistant trees (pole-size or greater whitebark pine survivors of blister rust), use caution to avoid killing them. Regeneration from these individuals is essential—it is critical that this important genetic resource not be completely lost to fire. There are also cone collection plus trees

(see map) that are important to protect. In addition, fires in lower elevations below whitebark pine areas can create a landscape mosaic of fuel breaks to help protect rust-resistant stands, as well as expand its current range.

Mountain pine beetle
Where mortality due to mountain pine beetle is high in the southern part of White bark pine (WBP) range, complete stand replacement by fire is acceptable.

Fire history
Recent fires could provide fuel breaks for adjacent whitebark pine areas in need of fire. Fire history maps could also help identify and prioritize areas in need of fire. Those areas without fire in the past two decades and in spruce and subalpine fir habitats types will be a higher priority for fire.

Pure stands of whitebark pine versus mixed-species stands
Stands mixed with spruce, lodgepole pine, and subalpine fir (where whitebark pine has been a seral species) are good candidates for stand-replacing or mixed-severity fire to increase desired regeneration. Areas of pure, live whitebark pine are less in need of stand-replacing fire, but can benefit immensely from surface fire to reduce fuels.

Scenario 2b Low-Elevation Dry Forest Communities

Model (weights in parentheses)		
(60)	Value:	Dry forest composition, % HUC6 (40%)
		Large size class forest in Douglas-fir/ponderosa pine setting (20%)
(40)	Risk:	Crown-fire burn probability (22%)
		Bark beetle hazard from FIA data by HUC5 (6%)
		Noxious weed hazard (6%)
		% Active grazing allotment (6%)

Primary treatments: thinning and prescribed burning to reduce fuels; treatment of noxious weeds.

The intent is to restore relatively large-diameter forests with historically frequent fire intervals to a condition where they can again withstand understory fires and be less susceptible to insect outbreaks. Typical treatments will include reduction of ladder fuels and encroaching understory and midstory trees, and will include the retention of the large trees, replacement trees, and snags within the treatment area.

Scenario 2c Dry Shrublands (Low-Elevation Sagebrush)

Model (weights in parentheses)		
(60)	Value:	Dry shrubland composition, % HUC6 (60%)
(40)	Risk:	Conifer succession in dry shrublands (18%)
		Noxious weed hazard (9%)
		% Active grazing allotment (9%)
		Crown-and ground-fire burn probability (4%)

Primary treatments: slashing conifers, prescribed burning, noxious weed treatment, improved grazing management.

The intent is to retain high-density mature sagebrush. Larger contiguous blocks are generally favored, and at a planning unit scale, to be retained in proportions within the historical range of variation. Proactive treatments might include removing encroaching conifers and noxious weeds. Additionally, retention should be considered when planning prescribed fires and permitting livestock grazing. Considerations should be made at the local level for types of brush species, differential responses to fire, and ecosystem management.

Scenario 2d Aspen

Model (weights in parentheses)		
(60)	Value:	Aspen composition, % HUC6 (60%)
(40)	Risk:	% Active grazing allotment (12%)
		Herbivory by wildlife (10%)
		Conifer succession in aspen/deciduous forest (9%)
		Departure from historic fire regime in aspen (9%)

Primary treatments: prescribed and wildland fire, conifer removal, and improved livestock grazing management.

The intent is to restore mature, self-sustaining stands of aspen well-distributed across their historical range. In many cases, the low level of aspen in conifer stands is not detectable using remote sensing or standard vegetation inventory plots. This situation is very common, with this low level of aspen providing a regeneration opportunity after disturbance. Treatments might include removal of conifers, prescribed burning, and fencing out livestock and/or wild ungulates. New science continues to emerge on this issue. Livestock grazing often has a negative effect, and this should be carefully considered during reissuing of livestock permits.

Scenario 2e Woody Draws

Model (weights in parentheses)

(60)	Value:	Woody draw composition, % HUC6 (60%)
(40)	Risk:	Departure from historic fire regime in woody draws (14%)
		% Active grazing allotment (14%)
		Crown-and ground-fire burn probability (12%)

Primary treatments: removal of conifers from deciduous woody draws, reintroduction of fire to coniferous woody draws, and treatment of noxious weeds.

Woody draws can be a very limited habitat in eastern parts of the Northern Region. Treatments may differ depending on whether the woody draw is coniferous or deciduous. In some places, conifers are encroaching into draws where deciduous trees and shrubs should be retained. Other woody draws do not have a substantial deciduous component, and conifers would be retained. Treatments may include removal of conifers in deciduous woody draws, and understory burning and fuels reduction in coniferous woody draws. During livestock permitting, the effects primarily on deciduous woody draws should be considered.

Scenario 2f Mixed Grass Prairie

Model (weights in parentheses)

(60)	Value:	Mixed grass prairie composition, % HUC6 (60%)
(40)	Risk:	% Active grazing allotment (18%)
		Noxious weed hazard (11%)
		Low ground-fire burn probability (11%)

Primary treatments: improved livestock grazing management, treatment of noxious weeds, reintroduction of fire.

The intent is to retain native mixed grass prairies and their role in an intact ecosystem. Treatments could include noxious weed treatment and prescribed fire. Livestock grazing has a great potential to have a negative effect on this system; thus, timing and stocking levels should be carefully considered.

Fire exclusion is a potential risk factor to be considered for inclusion in future analyses.

Scenario 2g Riparian, Wetlands, and Seeps

Model (weights in parentheses)

(60)	Value:	Riparian, wetland, and/or spring/seep composition, % HUC6 (60%)
(40)	Risk:	% Active grazing allotment (20%)
		Noxious weed hazard (9%)
		Motorized routes in riparian (9%)
		Fire behavior (2%)

Primary treatments: Improved livestock grazing management, noxious weed treatment, management/relocation/closure/obliteration of roads and other motorized routes, and occasionally prescribed fires to be evaluated on a case-by-case basis. Variable riparian systems exist across the region (e.g., cedar/hemlock forest, willow, sedge, etc.). Treatments, particularly fire and vegetation, would have to be tailored to the area. We would not want the negative effects of a treatment to outweigh the benefits in a particular circumstance.

In some wetter parts of the region, generally in the western portion, running water can be quite common; in other portions, generally towards the east, riparian areas can be relatively rare and disproportionately important on the landscape. The value of this system to wildlife reaches far beyond its geographic extent. Although it occupies only a small fraction of the landscape, many birds, mammals, reptiles, amphibians, and invertebrates are dependent on this system for all or part of their life-history requirements. Livestock grazing probably has the greatest impact of all Forest Service management activities on this system, particularly moving east across the region. In some places, noxious weeds and potential for high burn severity may need to be addressed.

Scenario 2h Big Game Winter Range

Model (weights in parentheses)		
(60)	Value:	Big game winter range map from IRPS version 1, % HUC6 (60%)
(40)	Risk:	Vulnerability index (18%)
		Noxious weed hazard (11%)
		% Active grazing allotment (11%)

Primary treatments: thinning and prescribed burning, slashing conifers, treatment of noxious weeds, improved livestock grazing management, management of motorized routes and recreation to improve security, and rehabilitation of motorized routes.

The vulnerability index is essentially the results from scenarios 1b and 1c, which is a measure of how vulnerable the vegetation is to uncharacteristic disturbance, such that it would limit the ability of the landscape area to cope with disturbance and/or achieve resilient desired condition. A cool PDO from 1940 to 1980 in conjunction with fire exclusion helped develop a density of the forest that was not characteristic prior to this period of time. Climate change could make the forest even more vulnerable to disturbance.

The intent is to maintain high-quality winter range for big-game species. Currently, the only species mapped in the scenario is elk and additional species on the Dakota prairie grasslands; ideally, however, other big game (such as moose, bighorn sheep, and mule deer) should also be included in future rounds. What constitutes high-quality winter range varies greatly across the geography and ecosystems of the region, as well as by species. In some places and for some species, snow capture by forested canopy can be a limiting factor; in other places, forage availability and quality on low-elevation, south-facing slopes, and windblown areas may be a limiting factor. In other circumstances, shrubfields may be high-quality winter range. Treatments will vary by species and location. Treatments might include removing encroaching conifers, noxious weed treatment, rehabilitating motorized routes, and managing livestock grazing. Coordination with state fish and game agencies should occur during treatment design.

Lack of security of the animals and fire exclusion are potential risk factors to be considered for inclusion in future analyses.

Scenario 2i Threatened and Endangered Core Grizzly Bear Habitat

Model (weights in parentheses)		
(60)	Value:	Species core habitat, % HUC6 (60%)
(40)	Risk:	Open road and motorized trail density (30 %)
		Human developments (campgrounds, cabins) (10%)

Primary treatments: Provide security, closure of motorized routes, rehabilitation of motorized routes.

This scenario will help the region meet the objectives of grizzly bear recovery plans and management, including such things as open road density by subunit. In future iterations, this scenario should be fleshed out by the 28. Regional Threatened, Endangered, and Sensitive Species Program Leader and National Carnivore Program Leader.

Scenarios planned for future versions of Integrated Restoration and Protection Strategy (IRPS)

Scenario 2j Connectivity and linkage areas
(to be incorporated in future analyses)

Model (weights in parentheses)		
(60)	Value	Connectivity or linkage area (yes/no)
(40)	Risk	Road density (28%)
		Developments (recreation and access sites) (6%)
		Loss of hiding cover (6%)
		Bark beetle hazard
		Insect occurrence (ADS)
		Crown-fire burn probability

For IRPS version 10.2, this scenario is a placeholder until Montana Fish, Wildlife, and Parks completes its connectivity mapping effort or a similar product is available. Once that product is available for review, it will be evaluated for its suitability for inclusion in this scenario. We will wait for this evaluation before determining whether a different product is necessary to address this scenario.

The intent is to maintain connectivity and linkage areas for migration and dispersal of all native species in the Northern Region. Often, areas identified by this scenario as high priorities will be areas we want to exclude from vegetation treatment, and where restoration efforts may focus on road and motorized trail removal.

This scenario might also be used to determine areas that should be avoided when selecting areas for human developments such as campgrounds. In rare circumstances, vegetation treatments might be used to maintain or protect connectivity and linkage areas. This scenario could be particularly relevant to trying to account for climate change.

Scenario 2j **Threatened, Endangered, and Sensitive Wildlife Species**
(to be incorporated in future analyses)

Model (weights in parentheses)		
(70)	Value:	Threatened, Endangered, & Sensitive Wildlife Species Larger Strategies for Species Conservation and Recovery (e.g., Recovery Plans, Conservation Strategies, Forest Plans, State Wildlife Conservation Plans)
(25)	Risks:	As identified in the aforementioned strategies
(5)	Feasibility:	Partners (yes/no) (5%)

This is a placeholder for species conservation and recovery plans, conservation strategies, and other similar products, for many of which the Forest Service has legal obligations.

Appendix D5:
Narrative for Scenario 3, Water Quality Priority for Sediment

Bruce Sims, Chip Fisher

This scenario uses multiple parameters to determine the relative risk of erosion and sedimentation.

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Value: Water Quality and Watershed Resiliency
This scenario uses multiple parameters to determine the relative risk of erosion and sedimentation from each 12-digit watershed scale (watersheds 10,000 to 40,000 acres) within the Northern Region of the USDA Forest Service. Watersheds used for municipal water supplies and watersheds listed on Environmental Protection Agency's 303d list of waters where quality does not meet beneficial use criteria were given the highest value. A total of 10 indicators were used to identify watersheds at risk. This scenario was used as one component of the Northern Region's Integrated Restoration and Protection Strategy (IRPS) to provide information to forests and grasslands to assist in identifying priority restoration and protection work in an integrated and efficient manner.

Risk Determination: Addresses which watersheds are best to restore due to municipal watershed use, 303d listings, and/or have multiple risk factors?
The analysis was divided in two sections, values and risks. Though there are many factors that could be identified, this analysis was limited to factors available in spatial databases that could be displayed on maps. Key values identified were watersheds with known water quality impairment and those where surface water is used for municipal supplies. Risks were identified that could adversely affect water quality. These indicators were used to develop a relative watershed quality rating using the Ecosystem Management Decision Support (EMDS) model (http://cwam.ucdavis.edu/pdfs/EMDS.pdf).

Values—30 percent—The presence or absence of either 303d listed waters or municipal watersheds was used as a weighting factor in the model, each providing 15 percent to the score if present.

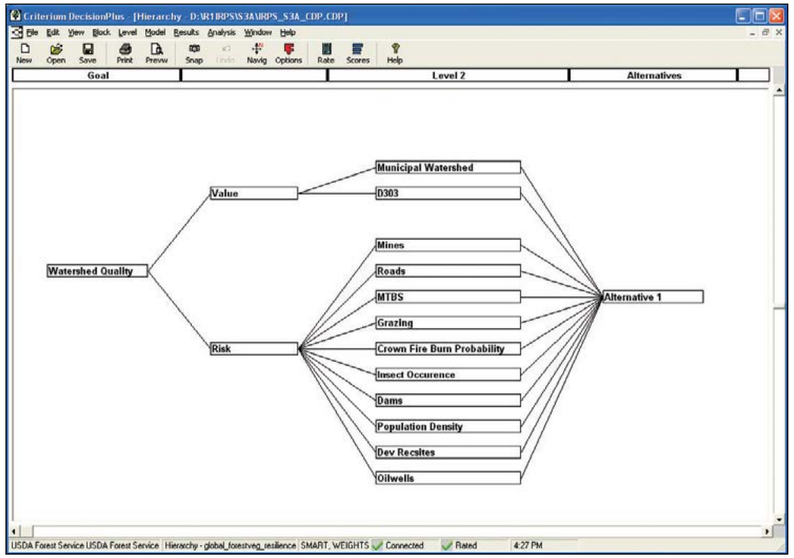
1. Watersheds with 303d listed water bodies (y/n)—15%
2. Municipal watersheds that are a priority for restoration (y/n)—15%

Risks—0 percent—Ten major risk factors were selected for the analysis. Factors used were limited to those that had spatial data available to allow geopgraphic information systems applications. The following condition factors were used:

1. Number of mines (10 percent)
2. Road densities in the watersheds, in riparian areas, and number of stream crossings (10 percent)
3. Acres of recent mod/high-severity fires from Monitoring Trends in Burn Severity (MTBS) (10 percent)

4. Acres of active grazing allotments and number of Animal unit months (10 percent)
5. Crown fire burn probability (6 percent)
6. Acres of insect infestation (ADS 2002–2009)
7. Number of dams (6 percent)
8. Acres of high population density adjacent to national forests (4 percent)
9. Number of developed recreation sites (4 percent)
10. Number of active oil or gas wells (4 percent)

These indicators were used to develop a relative watershed quality rating using the EMDS model (http://cwam.ucdavis.edu/pdfs/EMDS.pdf). The following chart illustrates how the model is organized.



Primary Treatments

Roads are long-term sources of chronic sediment input to stream systems. Reduction in road density and improvement in both drainage features and surfacing will result in decreased management-related sediment delivery. Treatments include:

- Road decommissioning
- Road storage
- Well-maintained roads
- Properly sized culverts and bridges with appropriate length and height above the stream
- Appropriate running surface for the road use
- Establishment of vegetation on road cut and fill slopes
- Moving road routes away from stream corridors

Riparian and lakeshore management are critical areas to protect owing to their proximity to water and ecological values. Some treatments and management actions include:

- Recreation
  - Fencing
  - Law enforcement
  - Signing
  - Travel management maps
  - Public education
  - Establishment of protective vegetation on disturbed sites
- Range Management
  - Fencing
  - Range administration
  - Herding
  - Education
  - Public agency and private coordination
  - Establishment of protective vegetation on disturbed sites
  - Water source development away from streams

Legacy mine sites can yield long-lasting acute or chronic concentrations of contaminants to stream systems. Some treatments to mitigate impacts include:

- Developing repositories with impermeable membranes for mine waste material
- Recontouring and establishing vegetation
- Liming
- Draining groundwater away from contaminated materials
- Water treatment plants

Managing fire to allow for a more natural fire regime. Fire suppression has allowed tree stands to become more dense and thereby increase the risk of large-scale high-intensity fire that have severe effects on vegetation and soils and may increase the likelihood of downstream flooding and debris torrents. Some treatments and management actions include:

- Use of prescribed fire
- Allowing natural fires to burn where human safety, resource, and property values allow
- Thinning of dense forest stands with highest priority being the urban interface
- Salvaging stands of trees killed by insects

Appendix D6: Narratives for Theme 4, Scenarios 4.1, and 4.2a and 4.2b; Aquatic Threatened, Endangered and Sensitive Species: Condition and Conservation and Restoration Opportunities

Scott Spaulding, Regional Fisheries Program Leader

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This scenario is intended to display aquatic conservation and restoration priority areas and opportunities at the 6th-field hydrologic unit code scale (6th-Field HUC) for use in the Northern Region Integrated Restoration and Protection Strategy (IRPS). Regionally consistent landscape risk information are used in conjunction with "value" data to help identify areas that may be good investments to help advance aquatic restoration and conservation, to reduce risk of further degradation, and to increase watershed and fish population resiliency. This scenario does not consider in any depth the effect of projected climate change trends. Future watershed vulnerability assessments that contemplate potential climate change effects will identify potential intervention and resiliency strategies that can be "added-on" to this analysis.

This aquatic theme presents outcome priorities from three different scenarios, in which the value information changes among scenarios (see fig. 1), described below. Following is a description of the value portions of those scenarios and how these will interact with the risk components.

Values (vary among scenarios 4.1, 4.2a and 4.2b) and data used—The value polygons based on the varying fish population or restoration HUC information used to inform a scenario is assessed an overall weight of 40 percent of the scenario total. This is to downplay these areas as important in IRPS if the associated risks (described below) are low. These areas would tend to fall out toward more of a conservation location rather than active restoration.

Scenario 4.1 uses the restoration priority HUCs from the initial round of IRPS as values (R1 Priority HUCs in fig. 1). Priorities among forest units across the region were developed independently and typically without consistency.

Scenario 4.2.a captures two new sources of information by subregions. First is the bull trout conservation strategy information for western Montana **(**or **West MT BT restoration priorities** in **fig. 1)**. These data were generated by the Western Montana Level One Team, a federal interagency team that addresses consultation, conservation, and recovery planning efforts for the ESA-listed bull trout. This value information is summed at the 6th-code HUC scale and aggregated up to represent bull trout local populations. These data are included for the Flathead, Kootenai, Lolo, Bitterroot, and west of the Continental Divide portions of the Helena and Beaverhead-Deerlodge National Forests. Nested within these priority HUCs is another scale of priority. These are areas deemed to be the best place for aquatic-focused restoration based on population status, landscape condition, and feasibility. These are the areas carried forward under the value portion of this scenario for western Montana. Outside of these restoration priorities, differentiation between conservation HUCs and restoration HUCs is not defined. The intersection of value with risks will help separate this out, to some extent. That is, there may be high-value areas that have risk factors that need to be addressed, which may fit nicely with some form of integrated treatments. The utility of using the bull trout conservation strategy information is from the restoration detail it contains. That is, each local population and contained 6th-code HUC will have descriptions of a given population's strengths, vulnerabilities, and restoration potential. Beyond that, the conservation strategy provides specific remedies and feasibilities of making both habitat condition and population improvements.

The **second set of data** used in this scenario is conservation population information generated from rangewide status assessments for two regional sensitive species: the west-slope (WCT) and the Yellowstone cutthroat trout (YCT) (or **YCT, WCT CP for ID and E MT** in **fig. 1**). These assessments produced spatial distribution maps for each species, their genetic status, and identification of conservation populations. These data are used for the Nez Perce (WCT) and Clearwater (WCT) National Forests west of the divide, and the Helena (WCT), Lewis and Clark (WCT), Beaverhead-Deerlodge (WCT), Gallatin (WCT and YCT), and Custer (YCT) National Forests east of the divide. We use the priority HUCs from Scenario 4.1.a for the Dakota Prairie Grasslands for all scenarios.

Scenario 4.2.b is essentially the same as scenario 4.2.a except we give priority restoration to HUCs identified in recent past forest plan revision for the Idaho national forests (Nez Perce, Clearwater, and Idaho Panhandle) (or **ID FPR Restoration Watersheds** in **fig. 1**). This is done to narrow down the priority areas in Idaho. The WCT rangewide conservation information used in the previous scenario creates such a large network of conservation streams and HUCs that it appears to be of little value in prioritizing restoration landscapes in Idaho.

Risks for all scenarios—

Risk data receive a higher overall weight (60 percent) in the aquatic scenarios because it is assumed to be a more important place to focus treatment emphasis. For instance, disturbance factors on the landscape affect both watershed condition and stream channel habitat and connectivity which in turn affect fish population status and resilience. An important note, however, is that larger risk factors nonfederal lands sometimes may play a more dominant role in controlling the status of fish populations. Examples of this could include lower Clark Fork River dams, county roads and crossings, and private and industrial timber land development. This emphasizes the importance of local fish biologist expertise and partnerships to help better frame areas of restoration and partnership development, especially on lands off-forest.

Risk data are used to overlap with priority fish population or restoration priority information (or values), summarize aquatic values at risk. This in turn helps look within an aquatic scenario for restoration opportunity and priority. The risks are classified into six major categories (and weighted):

- Roads (23 percent),
- Fish passage barriers (20 percent),
- Grazing (20 percent),
- Mines (17 percent),
- Dams (13 percent), and
- Dispersed recreation (8 percent) (fig. 1).

Road data are subdivided into risk categories that include total road density, riparian road density (roads within 300 feet of a stream channel) and stream crossings. These are separated into low, medium, and high categories based on percentile splits and weighted accordingly (0.1, 0.3, and 0.6). We intended to break out fish passage barriers by stream order, but only had these data for western Montana. The rationale is that barriers on 3rd-order and greater streams are likely to have the greatest proportional impact on fish passage and life-history interruption. Currently, this risk is taken from the number of barriers per stream mile per subwatershed. The grazing risk factor integrates both allotment amounts within a HUC and intensity based on animal unit months (AUM). Mines, dams, and dispersed recreation risk factors are further described in the Watershed Management Theme (mines and dams) and the Recreation Opportunities and Settings themes (dispersed recreation).

Data outputs—

The output for the aquatic scenarios includes a gradation of 6th-field HUCs identified as restoration priorities, from low to high based on balancing important population values with landscape risks. The assignment of relative importance between value and risk is assigned 40 percent to the values and 60 percent to the risks (fig. 1). Conservation areas for aquatic species (those areas best left alone from active management) should be identified to some degree in this analysis because they often occur in landscapes with the least amount of legacy or existing disturbance, thus a low priority for active management treatment. These would be areas that aquatic specialists would not advance the concept of integrated restoration. Other areas with greater risks that overlap with high-value populations are likely to be highlighted as restoration opportunities. However, caution should also be used in interpreting areas that are identified as aquatic restoration priorities. These areas should become the focus for interdisciplinary discussion at the forest unit. Discussion should focus on the merit and risk of entering an area for (1) unilateral aquatic and or aquatic and wildlife restoration, or (2) consideration of a more integrated restoration approach that may or may not be amenable to using tools such as stewardship contracting or agreements.

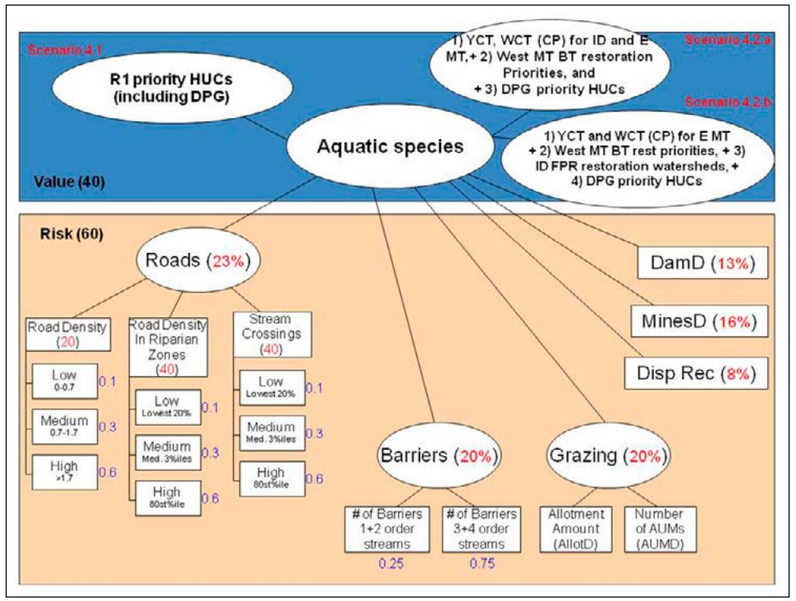


Figure D6-1—Conceptual diagram of the aquatic theme, its three scenarios, and risk values

Primary treatments—
Based on the risk factors identified above, some of the largest value treatments expected for the Aquatic Theme are as follows:

1. Large-scale roads analysis (over the scale of one to several 6th-code HUCs, up to 5th-code HUC scale) with the intent of identifying a minimum road system commensurate with a balancing of future needs and with deference to key resource priorities for a given landscape. This is intended to lead to meaningful road-density reductions, riparian road removal or relocation, fish passage barrier removal or remedy, and dispersed recreation site rehabilitation. It could also lead to priority best management practices on high-risk roads, road fill stabilization via riparian planting improvements, and large woody debris placement for eliminated habitat complexity.
2. Improved grazing management that includes infrastructure such as fencing or timing of animals on an allotment.
3. Application of fire for resource benefits as a tool to help reverse influences of fire exclusion.
4. Abandoned mine site reclamation.
5. Expansion of population patch size via nonnative fish treatments and/or isolation from invasion where this is a concern, and population reintroduction. This will mainly be a tool for the cutthroat trout subspecies.

Appendix D7:
Narrative for Scenario 5a, Visitor Safety

Lis Novak 6/1/2012

Click here to go back to your previous location.

This scenario assesses the relative risk to recreationists from both fire and hazard trees. Those watersheds containing high levels of use in areas prone to fire and containing hazard trees are ranked higher than those with lower use and risks. The scenario addresses the question: ***Where do we need to focus treatments to protect recreating visitors from fire and/or hazard trees*?**

Value: Recreating visitors

Recreation Opportunity Spectrum (ROS) settings were used as the framework for establishing broad distinctions between recreation use levels across the region. Recreation settings were classified into six distinct categories: Urban (U), Roaded Natural (RN), Semi-Primitive Motorized (SPM), Semi-Primitive Non-Motorized (SPNM), and Primitive (P). Because the majority of the region's use occurs along and adjacent to roads, the ROS system provided an initial division between High-, moderate-, and low-use areas based on where roaded and unroaded settings occur. Mapping procedures followed nationally established definitions and protocols, including the National ROS Inventory Mapping Protocol (December 2003; http://www.fs.fed.us/eng/ros.htm). Source data included:

- Region 1 library forest service boundaries,
- Region 1 library R1 travel routes geodatabase,
- Tiger2000 roads data, and
- R1 library Wilderness and other specially designated areas.

The travel routes line data were joined with the core attribute data (both roads and trails), and using the attribute "oper_maint_level" (roads) or "design_use" (trails).

- Roads and trails were then categorized as:
- Motorized trails,
- Primitive roads, and
- Better-than-primitive roads.

Verification of the above route assignments was done by cross referencing the Region 1 library visitor maps, and with data contained in the "TravelRoutesR1" geo-database. Tiger data were used to verify non-Forest Service routes (i.e., state highways or county roads) that often surround, and sometimes occur within, forest system lands. Tiger data were utilized primarily for routes adjacent to forest system lands (up to 3 miles from Forest Service lands). "CFCC" of A5 and A74 was categorized motorized primitive, A1–4, and A6 were better than primitive.

It was beyond the scope of this project to correct inaccuracies of the travel routes database. Because the aml only used buffers in the modeling process, any apparent route duplications would not affect the map product. Small Forest Service ownerships near towns were categorized urban. Some Tiger roads were added inside the Forest Service lands because they were federal, state, or county roads missing in the R1 travel routes database (checked against visitor maps). The aml results were checked for small polygons and assigned a final category based on adjacent ROS setting designations and consistent with protocols of the National ROS Mapping Protocol. Individual forest results were united and edge-matched.

The regional ROS layer was then visually checked for isolated motorized polygons that resulted from errors in the travel routes database. The most common error was when a motorized trail was surrounded by closed roads. Such areas were reclassified as nonmotorized. The polygon feature class was then converted to a raster data set.

Note: For future analysis, the regional ROS has been refined using a roughness model. The model utilizes topography to refine buffering boundaries. Reference the R1 Library ROS layer (McMorran 2010).

Using ROS settings as the foundation, P and SPNM ROS settings were assigned a "low" use level. Roaded ROS settings (U, R, RN and SPM) required additional data to better ascertain variations in use levels. Three types of recreation use areas were mapped and analyzed within each of the roaded ROS polygons:

- developed recreation sites
- areas of concentrated dispersed use
- recreation special use areas (ski areas and recreation residences)

In addition to the number and concentration of recreation sites and areas within each roaded ROS polygon, site-specific data were used to weight the use levels of each recreation site and area. Data and assumptions used in weighting use levels within specific sites and areas are outlined below.

Developed recreation sites (development scale 3–5) were mapped using latitude/longitude information extracted from INFRA. Each site in the point file was then attributed with information from both INFRA and forest-level Recreation Facilities Analysis (RFA) data. Both the amount of use and the duration of use were used in differentiating the concern for public safety at each recreation site. The criteria and weighting are listed below.

Occupancy was weighted and categorized as:

High ≥40 percent
Moderate = 20 to 40 percent
Low ≤20 percent

Annual Visitation was weighted and categorized as:

High ≥2,500
Moderate = 500 to 2,500
Low ≤500

Duration of Use was weighted and categorized using site types:

High = Cabins and campgrounds
Moderate = Picnicking, fishing, winter use, and swimming day-use areas
Low = Trailheads, boat launches, and minor interpretive sites

Each developed recreation site was then assigned a high, moderate, or low rating based on the collective score of all three values (occupancy, visitation, and duration).

Dispersed recreation use constitutes more than 80 percent of the region's recreation visitation (National Visitor Use Monitoring, round 2). As such, it was extremely important to recognize this type of use and attempt to geographically display where this use occurs. Because there was no inventoried or mapped dispersed recreation information, a predictive model was developed. The product of the model displays the relative likelihood of concentrated dispersed use across the region. Data used in mapping predicted dispersed use areas included topography, proximity to water, and access. Similar criteria have been used by archeologists in predicting the location of cultural sites. Human use continues to occur in these easily accessed landscapes that are relatively flat and near water. The predictive model used the following assumptions, measures, and associated ranking:

Slope (DMT): High = 0 to 7 percent
Moderate = 7 to 15 percent
Low ≥15 percent

Access: Very high to high = Roaded natural (RN) ROS settings
Moderate to Low = semi-primitive motorized (SPM) ROS setting

Access to water: Very High = RN ROS setting within 400 m of a lake
High = RN ROS setting within 400 m of river/stream
Moderate = SPM ROS setting within 400 m of a lake
Low = SPM ROS setting within 400 m of a river/stream

NOTE: The region has developed a Primitive Site Inventory Protocol (http://fsweb.wo.fs.fed.us/rhwr/ibsc/rs-prim-sites.shtml) to locate and assess the impacts of dispersed recreation use. Although the baseline inventory is not complete, units should supplement the predictive model with inventoried site data. Dispersed recreation site data collected (using the protocol) are stored in the recreation sites module of INFRA. Query development scale 0 to 2 sites.

Recreation special use areas were mapped using the data stored in the Special Uses Data Base (SUDs). Two types of special use areas were included: ski areas and recreation residences.

Ski areas were mapped as points, using latitude and longitude information in SUDs. Locations were verified using Google Earth and missing ski areas were added.

Recreation residences were also mapped using SUDs data. The information was supplemented with some forest information but is not considered complete.

NOTE: More accurate information on the location of recreation residences is now available.

Layers and metadata (Feb. 2012, Jillian Jurica, University of Montana, Rural Institute, Montech) are filed in the Region 1 geographical information system library.

Both ski areas and recreation residences were assigned a "high" use value. Ski areas have high numbers of recreation visitors, and recreation residences have consistent and long-duration use.

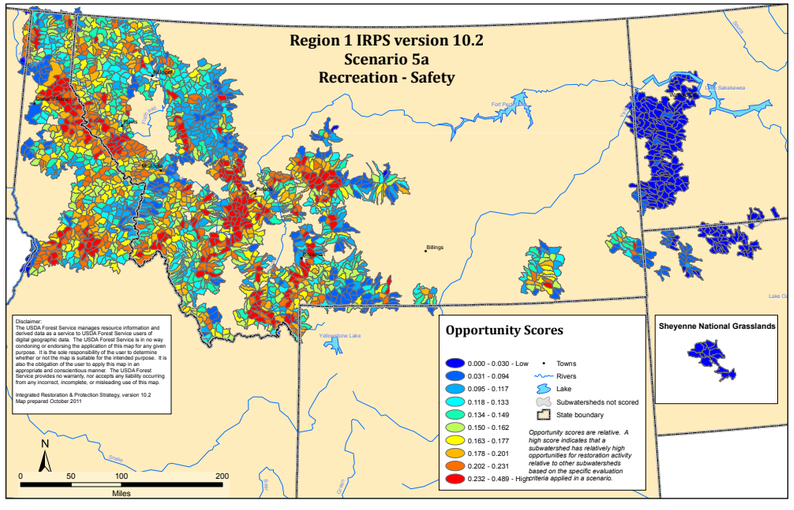
Risks: Crown-fire burn probability
Forest ground-fire probability
Non-forest ground fire probability
Bark beetle hazard from Forest Inventory and Analysis data
Insect occurrence from Aerial Detection Survey

Feasibility: Forest Service ownership

Potential management activities: Fuels reduction treatments, hazard tree removal, thinning

PRIORITIES FOR VISITOR SAFETY IRPS

SCENARIO 5a



Description of Scenario 5b, Recreation Investment Protection

Lis Novak 6/1/2012

This scenario assesses the relative risk to recreation infrastructure from both fire and hazard trees. Watersheds containing extensive infrastructure and prone to fire and falling trees are ranked higher than those with less infrastructure and containing lower risks. The scenario answers the question: ***Where do we focus our efforts to protect recreation infrastructure and investments?***

Value: Recreation infrastructure
Using ROS settings (see scenario 5a for mapping procedure) as the foundation, primitive and semi-primitive non-motorized ROS settings were assigned "low" investment levels. SPM settings were as ranked having "moderate" levels of investment. Although primitive and semiprimitive settings typically contain very few recreation structures or facilities, they often contain: trails, signs, and other minor investments. Remaining roaded ROS settings (U, R, RN) required additional data to better ascertain variations in investment levels.

Note: For future analysis, the Regional ROS has been refined using a roughness model. The model uses topography to refine buffering boundaries. Reference the Region 1 Library ROS layer (McMorran 2010).

Recreation facilities were mapped and weighted using both INFRA and SUDS data. Recreation facilities included recreation sites, ski areas, and recreation residences. Each type of recreation facility was then weighted to differentiate the amount of infrastructure/investment at each site. Criteria and weighting for each of the recreation facilities are outlined below.

Recreation Sites: The following criteria and associated values were assigned to recreation sites:

Development scale:	High	≥3
	Moderate	= 3
	Low	≤3
Replacement value:	High	≥$100,000
	Moderate	= $25,000 to 100,000
	Low	≤$25,000
Site type:	High	= Cabins, campgrounds, horse camps, major interpretive sites
	Moderate	= Picnicking, boating, minor interpretive sites,
	Low	= Trailheads, swimming sites, winter use sites

Recreation special uses: Both ski areas and recreation residences were assigned a "high" investment rating due to the amount of infrastructure associated with these types of facilities.

NOTE: More accurate information on the location recreation residences is now available.

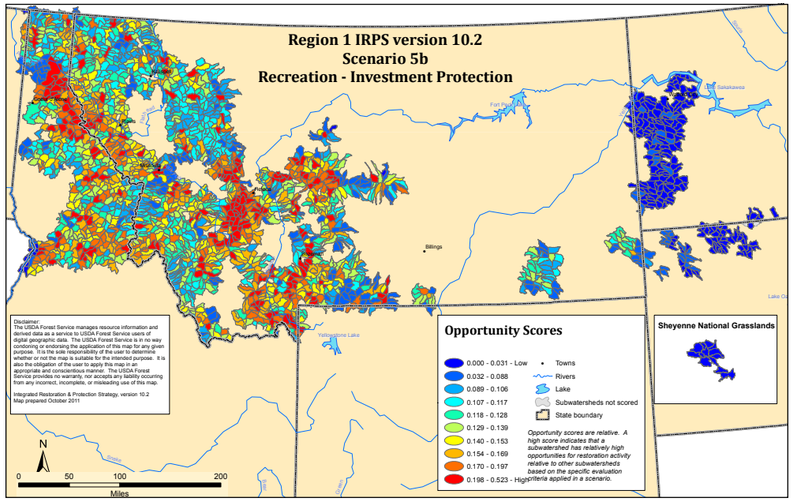
Layers and metadata (Feb. 2012, Jillian Jurica, University of Montana, Rural Institute, Montech) are filed in the Region 1 GIS library.

Risks: Crown-fire burn probability
Ground-fire probability
Bark beetle hazard from Forest Inventory and Analysis data
Insect occurrence from Aerial Detection Survey last 5 years

Feasibility: Forest Service ownership

Potential Management Activities: Fuels reduction treatments, hazard tree removal, thinning

PRIORITIES FOR RECREATION INVESTMENT PROTECTION
IRPS SCENARIO 5b



Description of Scenario 5c, Recreation Setting Restoration

Lis Novak 6/1/2012

This scenario assesses which recreation settings are at risk of degradation owing to the occurrence of unmanaged recreation. The analysis considers where concentrations of dispersed recreation use occur and the ability of individual watersheds to sustain that use. Those watersheds with high levels of dispersed recreation use and low watershed quality were rated as a high priority for restoration. Those watersheds in good condition and containing little dispersed use were rated as a low priority for restoration. The scenario answers the question: ***Which recreation settings are priorities for restoration activities?***

Value: Recreation Settings

Recreation settings were mapped usuing Recreation Opportunity Spectrum (ROS) definitions and protocols. The Forest Service ROS Inventory Mapping Protocol (December 2003, http://www.fs.fed.us/eng/ros.htm) was used to map six distinct ROS settings: Urban (U), roaded natural (rn), semiprimitive motorized (spm), semiprimitive nonmotorized (spnm), and primitive (p). Reference scenario 5a for additional information on how the regional ros layer was developed and its use in the predictive model for mapping dispersed recreation use.

Note: For future analysis, the regional ROS has been refined using a roughness model. The model usues topography to refine buffering boundaries. Reference the Region 1 Library ROS layer (McMorran, 12/2010).

Dispersed recreation use constitutes more than 80 percent of the region's recreation visitation (National Visitor Use Monitoring, round 2). As such, it was extremely important to recognize this type of use and attempt to geographically display where this use occurs. Reference Scenario 5a for more detail on the predictive model used in mapping dispersed recreation use.

Note: Region 1 has developed a Primitive Site Inventory Protocol (http://fsweb.wo.fs.fed.us/rhwr/ibsc/rs-prim-sites.shtml) to locate and assess the impacts of dispersed recreation use. Although the baseline inventory is not complete, units should supplement the predictive model with inventoried sites. Dispersed recreation site data collected (using the protocol) are stored in the recreation sites module of INFRA. Query dev. scale 0 to 2 sites.

Risk: Watershed vulnerability (watershed condition ratings)

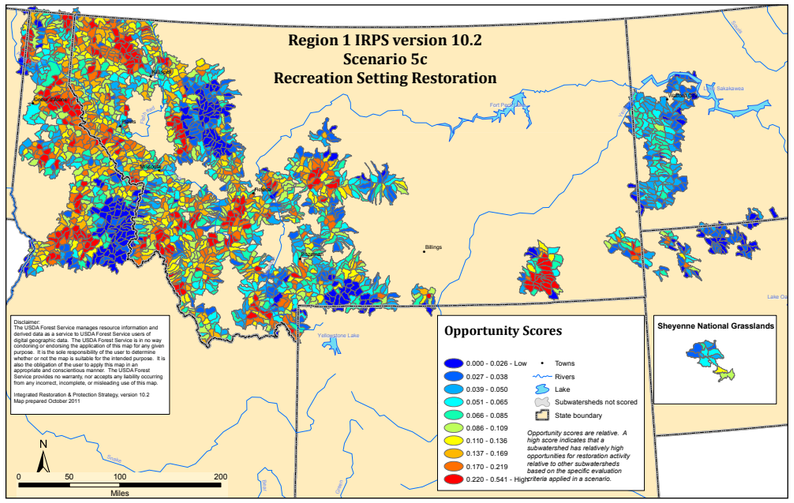
Note: Future analysis should include soil types (not a regional coverage at this time). By assigning various soil types with an erosion potential value, the watershed's ability to sustain dispersed recreation use could be more accurately assessed.

Feasibility: Forest Service ownership

Potential management activities: dispersed recreation management (site hardening, restoration, rehabilitation, and/or closure); travel route hardening, obliteration, restoration and/or closure; signing; education.

PRIOIRITIES FOR RECREATION SETTING RESTORATION

IRPS SCENARIO 5c



Description of Scenario 5d, Scenic Resource Restoration

Lis Novak 6/1/2012

This scenario assesses the existing condition of the region's scenic resources and the relative visibility of landscapes to prioritize future restoration. Scenic integrity was mapped using the region's ROS layer (reference scenario 5a), past management activities, and ecological conditions (reference scenario 1b—Forest resiliency). Areas with low existing scenicintegrity and high visiblity were rated as a priority for restoration. Those landscapes seldom seen and in good condition were rated as a low priority for restoration. The scenario answers the question: ***Where should we focus our efforts to restore the scenic integrity of landscapes across the region?***

Value: Scenic Resources

Two criteria were used in determining priority areas for restoration or enhancement of the region's scenic resources:

- Existing scenic integrity
- Visibility of the region's landscapes.

Existing scenic integrity was mapped using the regional ROS map and information about past management activities. The development of the regional ROS map is described under scenarios 5a. ROS settings were used to coarsely distinguish between landscapes likely to exhibit little visual evidence of past management activities from those likely exhibiting extensive evidence of past management.

Those settings without roads or motorized access were assigned scenic integrity ratings of:

Very high = Primitive (P) ROS settings; and

High = Semi-primitive nonmotorized (SPNM) ROS settings.

Additional data were necessary to determine the degree of visual contrast evident in roaded landscapes (U, R, RN, and SPM ROS settings). The data, along with associated assumptions, are documented below.

Past vegetation treatments were taken from the FACTS database and categorized to reflect varying levels of visual impact. Treatments were categorized as:

- 0 = no impact (treatments such as low-intensity prescribed burns)
- 1 = some impact (thinning, selection cuts, liberation cuts, and sanitation salvages)
- 2 = significant impact (fuel breaks, clearcuts, shelterwood and seed tree cuts, and overstory removal)

Other management activities were also mapped to depict impacts on scenery. They included:

400-m buffers around oil and gas development sites
400-m buffers around ski areas
400-m around inactive mines
800-m buffers around active mines
70-m buffer around utility corridors

The location and density of the above management activities were then merged with ROS settings. Existing Scenic Integrity was categorized into four classes:

Very High (5)	= Primitive
High (4)	= Semi Primitive Non-motorized = RN or SPM with no past vegetation or other management activities
Moderate (3)	= RN or SPM with some past vegetation treatments but no other management activities
Low (2)	= RN or SPM with significant vegetation treatments and/or other past management activities

Scenic integrity also reflects whether ecological conditions are healthy and resilient. Scenario 1b (Forest Resiliency, Vulnerability, and Departure from Desired Conditions) was used in conjunction with the above ratings to assign a final Existing Scenic Integrity rating.

Visibility: The relative visibility the regions landscapes was also a factor in prioritizing which landscapes warranted higher priority for restoration than others. Visibility was mapped using available information: of areas including roaded ROS settings and population centers.

NOTE: For future regional analysis, utilize the regional visibility mapping (McMorran 2010) at:

http://www.fs.usda.gov/detailfull/r1/landmanagement/gis/?cid=stelprdb5355199&width=full#

By overlaying the two maps (existing scenic integrity and visibility), landscapes were assigned a “High,” “Moderate,” or “Low” priority for restoration. Areas with low existing scenic integrity and highl visibility were rated as a priority for restoration. Those landscapes seldom seen and in good condition were rated as a low priority for restoration.

Risks: Further degradation of scenic integrity could be caused by management activities and/or disturbance regimes outside the historic range of variability (HRV). Indicators of disturbance regimes outside HRV include:

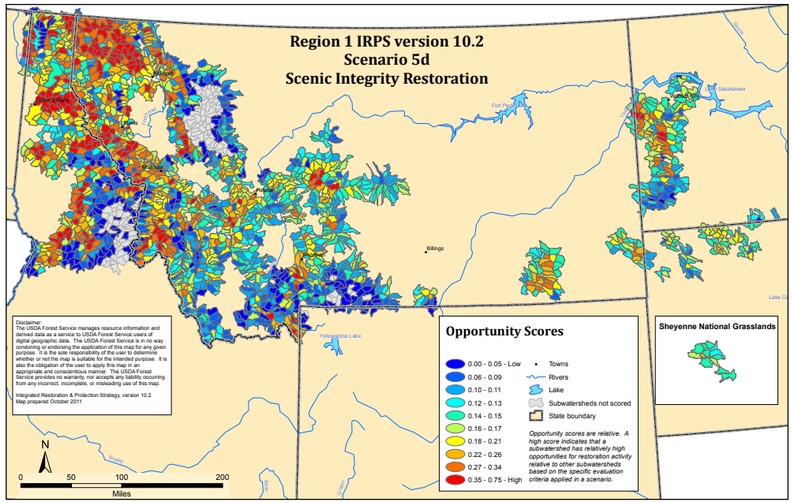
Crown-fire burn probability
Ground-fire probability
Bark beetle hazard from Forest Inventory and Analysis data
Insect occurrence from Aerial Detection Survey last 5 years

Feasibility: Forest Service ownership

Potential management activities: prescribed burning, mechanical vegetation treatments, erosion control, road/trail decommissioning or hardening, planting, vista clearing, mining reclamation, planting. The objective of future management activities should include objectives to reduce visual impacts of past management activities; create patterns and mosaics that mimic natural disturbance regimes; or ensure that potential future disturbance regimes occur within the HRV.

PRIORITIES FOR SCENIC RESOURCE RESTORATION

IRPS SCENARIO 5d



Description of Scenario 5e, Scenic Resource Protection

Lis Novak 6/1/2012

This scenario assesses which landscapes need treatment to protect their scenic character. Highly visible landscapes with high or very high scenic integrity were rated as a high priority for protection. Landscapes which are seldom seen and exhibiting low scenic integrity were rated as a lower priority for protection measures. The scenario was designed to answer the question: ***Where do we focus our efforts to maintain or protect the scenic integrity of landscapes across the region?***

Value: high-quality scenic resources
Existing scenic integrity and visibility (reference scenario 5d) were used to rank the condition and value of scenery across the region.

Risks: Degradation of scenic integrity could result from management activities and/or disturbance regimes outside the historic range of variability (HRV). Data predicting future management activities were not available. To assess risks from disturbance regimes outside HRV, the following data were used:

Crown-fire burn probability
Ground-fire probability
Bark beetle hazard from Forest Inventory and Analysis data
Insect occurrence from Aerial Detection Survey last 5 years

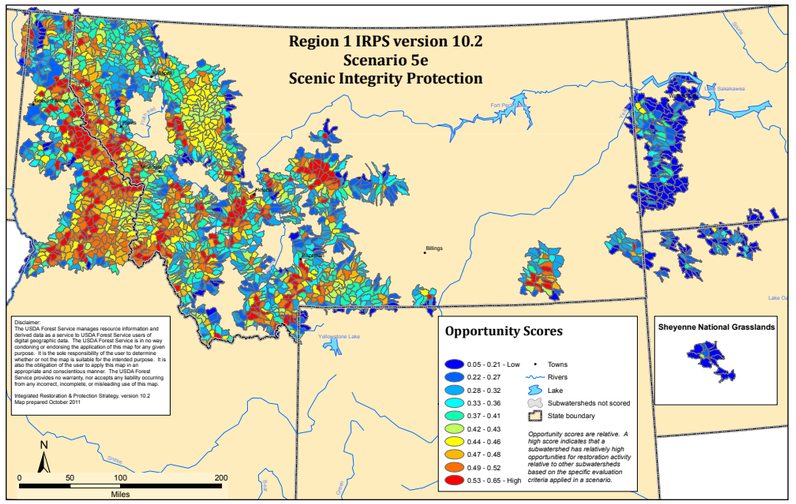
Note: Units should consider usuingforest-level data pertaining to predicted future management activities. Data may be available through monitoring and assessments and forest plan revisions. Mining, oil and gas, and predicted changes in urban interface are some of the risks and trends to be considered at the forest scale.

Feasibility: Forest Service ownership

Potential management activities: vegetation treatments (i.e., thinning, planting, spraying, etc.), fuels reduction treatments, planting, conservation easements, integration with community/Forest Open Space Strategy, etc. The objectives of future management activities should include: maintaining diversity, patterns, and mosaics that mimic natural disturbance (within the HRV) and prevent the occurrence of disturbance regimes that are outside the HRV.

PRIORITIES FOR SCENIC RESOURCE PROTECTION

IRPS SCENARIO 5e



Appendix E: How to Use the Integrated Restoration and Protection Strategy (IRPSv102) Geographic Information System data sets

This document describes what the IRPSv102 GIS data set is and how to use it to identify integrated restoration opportunity watersheds. The IRPSv102 GIS data set consists of a Region 1-wide 6th-code watershed polygon feature class, four subregion watershed polygon features classes (subsets of the region wide feature class), and a table with scenario value, risk, and feasibility inputs for each watershed. This document describes the regionwide watershed layer and associated scenario inputs table first, and then describes the subregion watershed layers.

Regionwide Watershed Layer With Scenario, Theme, And Overall Restoration Opportunity Scores

The IRPSv102 analysis is based on resource specific scenarios that measure resource values, risks to those values, and feasibility criteria. The base assumption of the analysis is watersheds with high value, risk, or feasibility inputs have higher restoration opportunities for that scenario resource. The IRPSv102 analysis has 19 resource scenarios evaluated for all watersheds. For example the whitebark pine scenario (S2A) has two value inputs: percentage of whitebark pine habitat and percentage of grizzly bear species range; and three risk inputs: crown-fire burn probability, blister rust damage, and insect occurrence based on Aerial Detection Surveys from 2002 through 2009. The value and risk inputs are summed in an equation and a whitebark pine restoration opportunity score (oppscore) is calculated for every watershed. All scenario restoration opportunity scores fall between zero and one, and watersheds with scores closer to one have higher restoration opportunities for that scenario.

In the map display below, whitebark pine scenario (S2A) restoration opportunity scores are shown. Notice how the Bob Marshall Wilderness and Greater Yellowstone Area both have higher scores because those areas have both whitebark pine and grizzly bear species range value inputs.

The next step in the IRPSv101 analysis was to integrate resource specific scenarios into six major themes. For example the whitebark pine scenario is part of the Terrestrial Species Theme (theme 2) that integrates nine unique wildlife habitat, connectivity, or threatened and endangered species issues. Watersheds with higher Theme 2 scores have greater restoration opportunities for multiple wildlife issues. The nine terrestrial species scenario restoration opportunity scores are averaged into a Theme 2 restoration opportunity score using equal weights:

(S2AOS + S2BOS + S2COS + S2DOS + S2EOS + S2FOS + S2GOS + S2HOS + S2IOS) / 9 = THEME2OS

How To Display Scenario Or Theme Restoration Opportunity Scores

- Bring up the IRPSv102 watershed properties window in ArcMap and select the Symbology tab.
- In the Symbology tab, select Quantities and then select the Scenario/Theme restoration opportunity score to display. By default, ArcMap displays quantities using five classes with Natural Breaks; another way of displaying oppscores that allows direct side-by-side comparison of different scores is to select Quantile breaks with 5 or 10 classes. Quantiles not only facilitate comparison, they allow users to identify watersheds in the top (or bottom) 10 or 20 percent.

List of scenarios by theme group

(Note: three scenarios are used a second time in Theme 6 based on current regional priorities for bark beetle projects)

Theme 1—Vegetation Resilience

Scenario 1a*:* *Community fire resilience*
Scenario 1b*:* *Vegetation resilience and current departure from desired conditions in forested areas addressing resiliency and vulnerability*
Scenario 1c: *Ecosystem resilience and vulnerability in nonforested areas*

Theme 2—Terrestrial Species

Scenario 2a: *Whitebark pine*
Scenario 2b: *Low-elevation dry forest communities*
Scenario 2c: *Dry shrublands (low-elevation sagebrush)*
Scenario 2d: *Aspen*
Scenario 2e: *Woody draws*
Scenario 2f: *Mixed-grass prairie*
Scenario 2g: *Riparian, wetland, and seeps*
Scenario 2h: *Big game winter range*
Scenario 2i: *Threatened and endangered core grizzly bear habitat*

Theme 3—Watershed Management

Scenario 3*:* *Watershed quality (sediment)*

Theme 4—Aquatic Species

Scenario4*:* *Threatened, Endangered, and Sensitive Fish Species*

Theme 5—Recreation Settings and Opportunities

Scenario 5a: *Safety*
Scenario 5b: *Investment protection*
Scenario 5c: *Recreation setting restoration*
Scenario 5d: *Scenic integrity restoration*
Scenario 5e: *Scenic integrity protection*

Theme 6—Public Safety and Infrastructure Protection

Scenario 1a: *Community fire resilience*
Scenario 5a: *Safety*
Scenario 5b: *Investment protection*

The final step in the IRPSv101 analysis was to integrate all six theme restoration opportunity scores into an overall integrated restoration opportunity score (IRPSOS). Note: all theme and overall integrated restoration opportunity scores fall between zero and one, and watersheds with scores closer to one have greater restoration opportunities. The six theme restoration opportunity scores were averaged into an overall score: (THEME1OS + THEME2OS + THEME3OS + THEME4OS + THEME5OS + THEME6OS) / 6 = IRPSOS.

Display of Region One 6th-code watershed polygon feature class showing overall integrated restoration opportunity scores using 10 quantiles

Scenario value, risk, and feasibility inputs table

As mentioned in the introduction, value, risk, and feasibility inputs were used to calculate scenario restoration opportunity scores. A table with scenario inputs (over 50 of them) was created that could be joined to the IRPSv102 watershed layers. The scenario input table can be used to spatially view value, risk, or feasibility input distributions across watersheds. The table can also be used to recalculate scenario restoration opportunity scores by changing the scenario input weights. The scenario input values in the table could be updated with local forest data and scenario restoration opportunity scores recalculated based on the updated input values. Another option would be adding a new value, risk, or feasibility input for a scenario and then recalculating scenario restoration opportunity scores.

Joining the scenario input table to IRPSv102 watershed layers to display value, risk, or feasibility input data

- Join using the HUC_12 attribute in both tables.
- Set symbology to quantities and select value, risk, or feasibility field to display.

How to recalculate a scenario restoration opportunity score

Scenario input values are normalized from 0 to 1 using min-max values. This allows scenario inputs with different units to be summed (e.g., combining percentage of big-game hiding cover with miles of open roads). The general outline of a scenario oppscore formula is:

(((<input attribute1> – min1) / (max1 – min1)) × weight1) + (((<input attribute2> – min2) / (max2 – min2)) × weight2) + …

- Remove any table joins to the scenario input table.
- Open the scenario input table.
- Open the scenario input table metadata file (right click on table, select data->view metadata)
- In the scenario input table scroll to the last column. called OPPSCORE.
- Right-click on the OPPSCORE column header and select field calculator.
- In the metadata, copy and paste (use mouse) the scenario opportunity score formula into the field calculator window (scenario opportunity score formulas are also in app. B).

  *** Adjust scenario input weights and/or attribute min and max values in the formula as needed.
- Click ok in the field calculator.
- Join the scenario input table to the watershed layer (use HUC_12 attribute in both tables).
- Use the field calculator to update the watershed layer scenario oppscore attribute from the OPPSCORE attribute.
- Use the field calculator to update the Theme oppscore attribute using updatedscenario oppscores.

Example of Community Fire Resilience oppscore formula:

S1AOS = ((([POPDEN2000] – 0)/(58.99 – 0)) × 0.5) + ((([OGWELLS]–0)/(46-0)) × 0.2) + ((([BURNPROB] – 0)/(0.587 – 0)) × 0.2) + ((([ADSBBOCC] – 0)/(100 – 0) × 0.05) + ((([BBHAZ] – 0)/(1 – 0)) × 0.05)

Subregion watershed layers with scenario, theme, and overall restoration opportunity scores

As mentioned in the introduction, there are four subregion watershed layers that are subsets of the IRPSv101 regionwide watershed layer. The four subregions are based on Ecological and General Forest Planning Zones and include: northern Idaho (Idaho Panhandle, Clearwater, and Nez Perce National Forests), western Montana

(Kootenai, Flathead, Lolo, and Bitterroot National Forests), eastern Montana (Beaverhead-Deerlodge, Helena, Lewis-Clark, and Gallatin National Forests; Beartooth Ranger District, Custer National Forest), and Plains (Ashland and Sioux Ranger Districts, Custer National Forest; Dakota Prairie Grasslands). Watershed restoration opportunity assessments are more meaningful at the subregional scale than across the entire region. Some of the scenario resource concerns only occur across subregional areas and thus watershed comparisons between northern Idaho and North Dakota are not practical. The subregional layers have the same scenario, theme, and overall integrated restoration opportunity scores described in the regionwide watershed layer. **All of the scenario restoration opportunity scores were calculated using scenario input ranges across subregional watersheds only.** Revised theme and overall integrated restoration opportunity scores were also calculated. The subregional analysis is considered a starting point for Forest Planning Zones. The regional office anticipates working with Forest Planning Zones to adjust scenario input weights and possibly adding new inputs specific to subregional analysis.

Appendix F: List of Project Participants

Northern Regional Office, Missoula, Montana

- Barry Bollenbacher, Regional Silviculturist
- Scott Spaulding, Regional Fisheries Biologist
- Lis Novak, Regional Landscape Architect/Recreation Planning
- Mary Manning, Regional Vegetation Ecologist
- Eric Tomasik, Regional Wildlife Program Manager
- Cathy Stewart, Regional Fire Ecologist
- Bruce Sims, Regional Hydrologist
- Steve Shelly, Regional Botanist
- Ann Carlson, Regional Aquatic Ecologist
- Beth Hahn, Regional Wildlife Ecologist
- Meredith Webster, Regional Soil Scientist
- Chip Fisher, Regional Remote Sensing Biologist
- Erin Nock, GIS Analyst
- Eric Henderson, Region 1 Planning Analyst

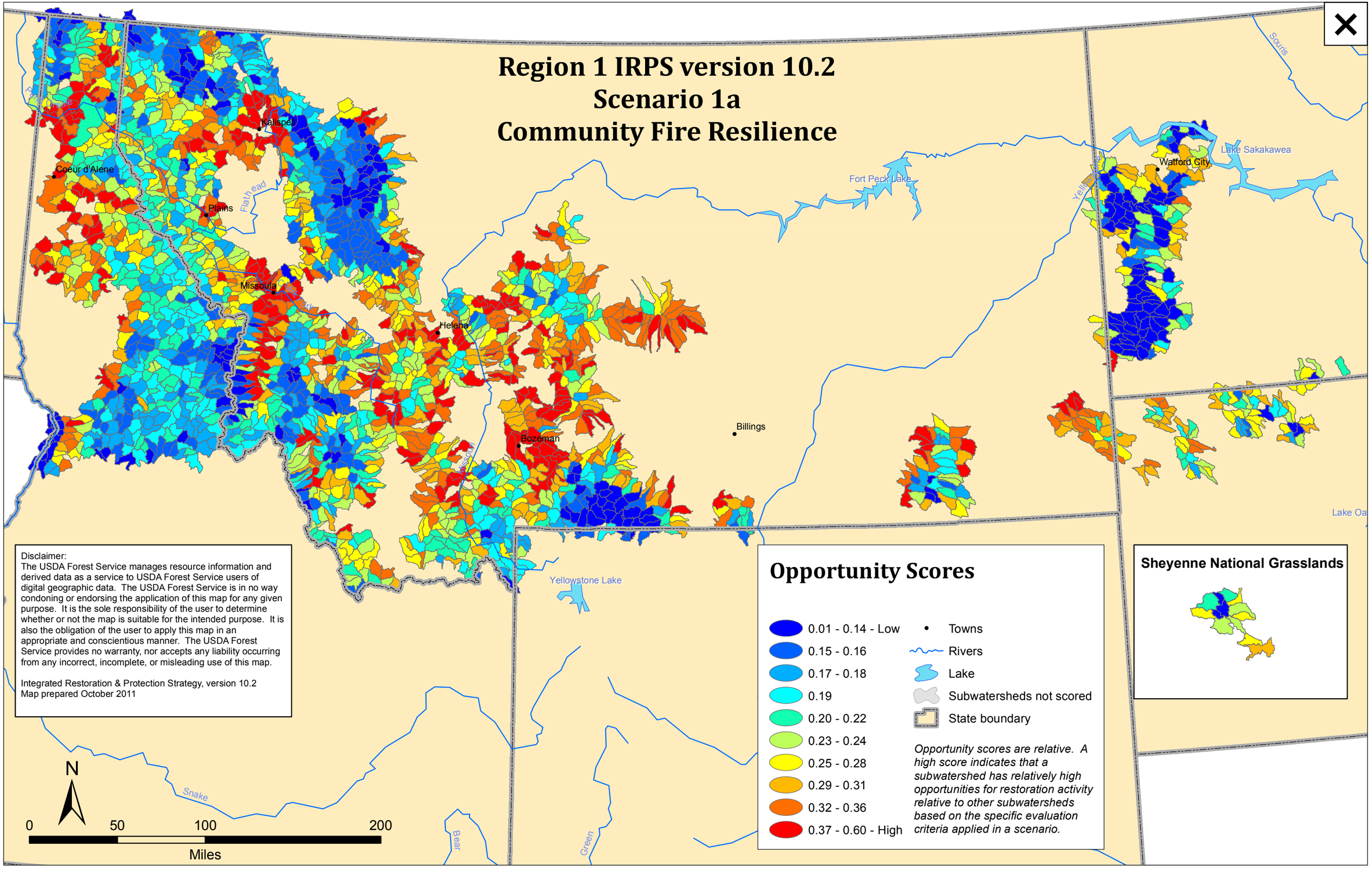
Pacific Northwest Research Station, Corvallis, Oregon

- Keith Reynolds, Research Forester

Montana Natural Heritage Program, Spatial Analysis Lab, The University of Montana, Missoula

- Melissa Hart, GIS Analyst/Ecologist
- Ute Langner, GIS Analyst/Ecologist
- Linda Vance, Senior Ecologist/Spatial Analysis Lab Director

Region 1 IRPS version 10.2
Scenario 1a
Community Fire Resilience



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Integrated Restoration & Protection Strategy, version 10.2
Map prepared October 2011

Opportunity Scores

- 0.01 - 0.14 - Low
- 0.15 - 0.16
- 0.17 - 0.18
- 0.19
- 0.20 - 0.22
- 0.23 - 0.24
- 0.25 - 0.28
- 0.29 - 0.31
- 0.32 - 0.36
- 0.37 - 0.60 - High

- Towns
- Rivers
- Lake
- Subwatersheds not scored
- State boundary

Opportunity scores are relative. A high score indicates that a subwatershed has relatively high opportunities for restoration activity relative to other subwatersheds based on the specific evaluation criteria applied in a scenario.

Sheyenne National Grasslands

Region 1 IRPS version 10.2
Scenario 1b
Resilience - Forested Areas

Kalispell
Coeur d'Alene
Plains
Missoula
Helena
Bozeman
Billings
Watford City
Fort Peck Lake
Lake Sakakawea
Yellowstone Lake
Flathead
Clark Fork
Yellowstone
Missouri
Snake
Bear
Green
Souris

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Integrated Restoration & Protection Strategy, version 10.2
Map prepared October 2011

N

0 50 100 200

Miles

Opportunity Scores

- 0.04 - 0.27 - Low
- 0.28 - 0.38
- 0.39 - 0.43
- 0.44 - 0.47
- 0.48 - 0.49
- 0.50 - 0.52
- 0.53 - 0.55
- 0.56 - 0.58
- 0.59 - 0.60
- 0.61 - 0.76 - High

- Towns
- Rivers
- Lake
- Subwatersheds not scored
- State boundary

Opportunity scores are relative. A high score indicates that a subwatershed has relatively high opportunities for restoration activity relative to other subwatersheds based on the specific evaluation criteria applied in a scenario.

Sheyenne National Grasslands

Region 1 IRPS version 10.2
Scenario 1c
Resilience - Nonforested Areas

Kalispell
Coeur d'Alene
Plains
Flathead
Missoula
Helena
Bozeman
Billings
Yellowstone Lake
Fort Peck Lake
Watford City
Lake Sakakawea
Souris
Yellowstone
Lake Oa
Snake
Bear
Green

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Map prepared October 2011

N

0 50 100 200

Miles

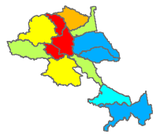
Opportunity Scores

- 0.00 - 0.07 - Low
- 0.08 - 0.09
- 0.10 - 0.12
- 0.13 - 0.15
- 0.16 - 0.20
- 0.21 - 0.26
- 0.27 - 0.37
- 0.38 - 0.48
- 0.49 - 0.59
- 0.60 - 0.96 - High

- Towns
- Rivers
- Lake
- Subwatersheds not scored
- State boundary

Opportunity scores are relative. A high score indicates that a subwatershed has relatively high opportunities for restoration activity relative to other subwatersheds based on the specific evaluation criteria applied in a scenario.

Sheyenne National Grasslands



Region 1 IRPS version 10.2
Scenario 2a
Whitebark Pine

Kalispell
Coeur d'Alene
Plains
Flathead
Missoula
Helena
Bozeman
Billings
Fort Peck Lake
Lake Sakakawea
Watford City
Souris
Yellowstone Lake
Snake
Bear
Green
Lake Oa

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Map prepared October 2011

N

0 50 100 200

Miles

Opportunity Scores

- 0.07 - 0.10 - Low
- 0.11 - 0.14
- 0.15 - 0.17
- 0.18 - 0.19
- 0.20 - 0.22
- 0.23 - 0.27
- 0.28 - 0.35
- 0.36 - 0.41
- 0.42 - 0.48
- 0.49 - 0.70 - High

- Towns
- Rivers
- Lake
- Subwatersheds not scored
- State boundary

Opportunity scores are relative. A high score indicates that a subwatershed has relatively high opportunities for restoration activity relative to other subwatersheds based on the specific evaluation criteria applied in a scenario.

Sheyenne National Grasslands

Region 1 IRPS version 10.2
Scenario 2b
Low Elevation Dry Forests

Kalispell
Coeur d'Alene
Plains
Missoula
Helena
Bozeman
Billings
Watford City
Fort Peck Lake
Lake Sakakawea
Yellowstone Lake
Flathead
Clark Fork
Yellowstone
Missouri
Souris
Snake
Bear
Green

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Map prepared October 2011

N

0 50 100 200

Miles

Opportunity Scores

- 0.00 - 0.08 - Low
- 0.09 - 0.18
- 0.19 - 0.21
- 0.22 - 0.25
- 0.26 - 0.28
- 0.29 - 0.32
- 0.33 - 0.35
- 0.36 - 0.41
- 0.42 - 0.47
- 0.48 - 0.74 - High

- Towns
- Rivers
- Lake
- Subwatersheds not scored
- State boundary

Opportunity scores are relative. A high score indicates that a subwatershed has relatively high opportunities for restoration activity relative to other subwatersheds based on the specific evaluation criteria applied in a scenario.

Sheyenne National Grasslands

Region 1 IRPS version 10.2
Scenario 2c
Dry Shrublands

Kalispell
Coeur d'Alene
Plains
Flathead
Missoula
Helena
Bozeman
Billings
Fort Peck Lake
Watford City
Lake Sakakawea
Souris
Yellowstone Lake
Snake
Bear
Green

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Integrated Restoration & Protection Strategy, version 10.2
Map prepared October 2011

N

0 50 100 200

Miles

Opportunity Scores

- 0.00 - 0.02 - Low
- 0.03
- 0.04
- 0.05 - 0.06
- 0.07 - 0.08
- 0.09 - 0.11
- 0.12 - 0.15
- 0.16 - 0.19
- 0.20 - 0.31
- 0.32 - 0.71 - High

- Towns
- Rivers
- Lake
- Subwatersheds not scored
- State boundary

Opportunity scores are relative. A high score indicates that a subwatershed has relatively high opportunities for restoration activity relative to other subwatersheds based on the specific evaluation criteria applied in a scenario.

Sheyenne National Grasslands

Region 1 IRPS version 10.2
Scenario 2d
Aspen

Kalispell
Coeur d'Alene
Plains
Missoula
Helena
Bozeman
Billings
Watford City
Lake Sakakawea
Fort Peck Lake
Yellowstone Lake
Flathead
Yellowstone
Missouri
Snake
Bear
Green
Souris

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Integrated Restoration & Protection Strategy, version 10.2
Map prepared October 2011

N

0 50 100 200

Miles

Opportunity Scores

- 0.000 - 0.003 - Low
- 0.004 - 0.011
- 0.012 - 0.022
- 0.023 - 0.036
- 0.037 - 0.048
- 0.049 - 0.062
- 0.063 - 0.079
- 0.080 - 0.096
- 0.097 - 0.123
- 0.124 - 0.746 - High

Towns
Rivers
Lake
Subwatersheds not scored
State boundary

Opportunity scores are relative. A high score indicates that a subwatershed has relatively high opportunities for restoration activity relative to other subwatersheds based on the specific evaluation criteria applied in a scenario.

Sheyenne National Grasslands

Region 1 IRPS version 10.2
Scenario 2e
Woody Draws

Kalispell
Coeur d'Alene
Plains
Flathead
Missoula
Helena
Bozeman
Billings
Fort Peck Lake
Lake Sakakawea
Watford City
Souris
Yellowstone Lake
Snake
Bear
Green
Lake Oa

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Integrated Restoration & Protection Strategy, version 10.2
Map prepared October 2011

N

0 50 100 200
Miles

Opportunity Scores

- 0.005 - 0.059 - Low
- 0.060 - 0.069
- 0.070 - 0.074
- 0.075 - 0.080
- 0.081 - 0.086
- 0.087 - 0.092
- 0.093 - 0.100
- 0.101 - 0.117
- 0.118 - 0.146
- 0.147 - 0.846 - High

Towns
Rivers
Lake
Subwatersheds not scored
State boundary

Opportunity scores are relative. A high score indicates that a subwatershed has relatively high opportunities for restoration activity relative to other subwatersheds based on the specific evaluation criteria applied in a scenario.

Sheyenne National Grasslands

Region 1 IRPS version 10.2
Scenario 2f
Mixed Grass Prairie

Kalispell
Coeur d'Alene
Plains
Missoula
Helena
Bozeman
Billings
Watford City
Lake Sakakawea
Fort Peck Lake
Yellowstone Lake
Flathead
Clark Fork
Yellowstone
Missouri
Souris
Snake
Bear
Green
Lake Oa

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Integrated Restoration & Protection Strategy, version 10.2
Map prepared October 2011

N

0 50 100 200

Miles

Opportunity Scores

- 0.023 - 0.086 - Low
- 0.087 - 0.095
- 0.096 - 0.103
- 0.104 - 0.108
- 0.109 - 0.116
- 0.117 - 0.128
- 0.129 - 0.154
- 0.155 - 0.202
- 0.203 - 0.469
- 0.470 - 0.773 - High

- Towns
- Rivers
- Lake
- Subwatersheds not scored
- State boundary

Opportunity scores are relative. A high score indicates that a subwatershed has relatively high opportunities for restoration activity relative to other subwatersheds based on the specific evaluation criteria applied in a scenario.

Sheyenne National Grasslands

Region 1 IRPS version 10.2
Scenario 2g
Riparian/Wetlands

Kalispell
Coeur d'Alene
Plains
Missoula
Helena
Bozeman
Billings
Watford City
Fort Peck Lake
Lake Sakakawea
Yellowstone Lake
Flathead
Yellowstone
Missouri
Snake
Bear
Green
Lake Oa

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Integrated Restoration & Protection Strategy, version 10.2
Map prepared October 2011

N

0 50 100 200

Miles

Opportunity Scores

- 0.01 - 0.09 - Low
- 0.10 - 0.11
- 0.12 - 0.13
- 0.14 - 0.15
- 0.16 - 0.17
- 0.18 - 0.19
- 0.20 - 0.22
- 0.23 - 0.25
- 0.26 - 0.31
- 0.32 - 0.69 - High

- Towns
- Rivers
- Lake
- Subwatersheds not scored
- State boundary

Opportunity scores are relative. A high score indicates that a subwatershed has relatively high opportunities for restoration activity relative to other subwatersheds based on the specific evaluation criteria applied in a scenario.

Sheyenne National Grasslands

Region 1 IRPS version 10.2
Scenario 2h
Big Game Winter Range

Kalispell
Coeur d'Alene
Plains
Flathead
Missoula
Helena
Bozeman
Billings
Fort Peck Lake
Watford City
Lake Sakakawea
Souris
Yellowstone Lake
Snake
Bear
Green

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Integrated Restoration & Protection Strategy, version 10.2
Map prepared October 2011

N

0 50 100 200

Miles

Opportunity Scores

- 0.02 - 0.08 Low
- 0.09 - 0.10
- 0.11 - 0.14
- 0.15 - 0.17
- 0.18 - 0.20
- 0.21 - 0.26
- 0.27 - 0.33
- 0.34 - 0.42
- 0.43 - 0.55
- 0.56 - 0.84 - High

- Towns
- Rivers
- Lake
- Subwatersheds not scored
- State boundary

Opportunity scores are relative. A high score indicates that a subwatershed has relatively high opportunities for restoration activity relative to other subwatersheds based on the specific evaluation criteria applied in a scenario.

Sheyenne National Grasslands

Region 1 IRPS version 10.2
Scenario 2i
Core Grizzly Bear Habitat

Kalispell
Coeur d'Alene
Plains
Flathead
Missoula
Helena
Bozeman
Billings
Fort Peck Lake
Yellowstone
Watford City
Lake Sakakawea
Souris
Yellowstone Lake
Snake
Bear
Green
Lake Oa

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Integrated Restoration & Protection Strategy, version 10.2
Map prepared October 2011

N

0 50 100 200

Miles

Opportunity Scores

- 0.000 - 0.009 - Low
- 0.010 - 0.022
- 0.023 - 0.035
- 0.036 - 0.052
- 0.053 - 0.076
- 0.077 - 0.137
- 0.138 - 0.538
- 0.539 - 0.609
- 0.610 - 0.648
- 0.649 - 0.880 - High

- Towns
- Rivers
- Lake
- Subwatersheds not scored
- State boundary

Opportunity scores are relative. A high score indicates that a subwatershed has relatively high opportunities for restoration activity relative to other subwatersheds based on the specific evaluation criteria applied in a scenario.

Sheyenne National Grasslands

Region 1 IRPS version 10.2
Scenario 5a
Recreation - Safety

Kalispell
Coeur d'Alene
Plains
Missoula
Helena
Bozeman
Billings
Watford City
Lake Sakakawea
Fort Peck Lake
Yellowstone Lake
Flathead
Yellowstone
Missouri
Souris
Snake
Bear
Green
Lake Oa

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Integrated Restoration & Protection Strategy, version 10.2
Map prepared October 2011

N

0 50 100 200

Miles

Opportunity Scores

- 0.000 - 0.030 - Low
- 0.031 - 0.094
- 0.095 - 0.117
- 0.118 - 0.133
- 0.134 - 0.149
- 0.150 - 0.162
- 0.163 - 0.177
- 0.178 - 0.201
- 0.202 - 0.231
- 0.232 - 0.489 - High

Towns
Rivers
Lake
Subwatersheds not scored
State boundary

Opportunity scores are relative. A high score indicates that a subwatershed has relatively high opportunities for restoration activity relative to other subwatersheds based on the specific evaluation criteria applied in a scenario.

Sheyenne National Grasslands

Region 1 IRPS version 10.2
Scenario 5b
Recreation - Investment Protection

Kalispell
Coeur d'Alene
Plains
Missoula
Helena
Bozeman
Billings
Watford City
Fort Peck Lake
Lake Sakakawea
Yellowstone Lake
Flathead
Clark Fork
Yellowstone
Missouri
Souris
Snake
Bear
Green

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Integrated Restoration & Protection Strategy, version 10.2
Map prepared October 2011

N

0 50 100 200

Miles

Opportunity Scores

- 0.000 - 0.031 - Low
- 0.032 - 0.088
- 0.089 - 0.106
- 0.107 - 0.117
- 0.118 - 0.128
- 0.129 - 0.139
- 0.140 - 0.153
- 0.154 - 0.169
- 0.170 - 0.197
- 0.198 - 0.523 - High

- Towns
- Rivers
- Lake
- Subwatersheds not scored
- State boundary

Opportunity scores are relative. A high score indicates that a subwatershed has relatively high opportunities for restoration activity relative to other subwatersheds based on the specific evaluation criteria applied in a scenario.

Sheyenne National Grasslands

Region 1 IRPS version 10.2
Scenario 5c
Recreation Setting Restoration

Kalispell
Coeur d'Alene
Plains
Missoula
Helena
Bozeman
Billings
Watford City
Lake Sakakawea
Fort Peck Lake
Yellowstone Lake
Flathead
Yellowstone
Missouri
Souris
Snake
Bear
Green
Lake Oa

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Integrated Restoration & Protection Strategy, version 10.2
Map prepared October 2011

N

0 50 100 200

Miles

Opportunity Scores

- 0.000 - 0.026 - Low
- 0.027 - 0.038
- 0.039 - 0.050
- 0.051 - 0.065
- 0.066 - 0.085
- 0.086 - 0.109
- 0.110 - 0.136
- 0.137 - 0.169
- 0.170 - 0.219
- 0.220 - 0.541 - High

- Towns
- Rivers
- Lake
- Subwatersheds not scored
- State boundary

Opportunity scores are relative. A high score indicates that a subwatershed has relatively high opportunities for restoration activity relative to other subwatersheds based on the specific evaluation criteria applied in a scenario.

Sheyenne National Grasslands

Region 1 IRPS version 10.2
Scenario 5d
Scenic Integrity Restoration

Kalispell
Coeur d'Alene
Plains
Flathead
Missoula
Helena
Bozeman
Billings
Fort Peck Lake
Watford City
Lake Sakakawea
Souris
Yellowstone Lake
Snake
Bear
Green

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Integrated Restoration & Protection Strategy, version 10.2
Map prepared October 2011

N

0 50 100 200

Miles

Opportunity Scores

- 0.00 - 0.05 - Low
- 0.06 - 0.09
- 0.10 - 0.11
- 0.12 - 0.13
- 0.14 - 0.15
- 0.16 - 0.17
- 0.18 - 0.21
- 0.22 - 0.26
- 0.27 - 0.34
- 0.35 - 0.75 - High

- Towns
- Rivers
- Lake
- Subwatersheds not scored
- State boundary

Opportunity scores are relative. A high score indicates that a subwatershed has relatively high opportunities for restoration activity relative to other subwatersheds based on the specific evaluation criteria applied in a scenario.

Sheyenne National Grasslands

Region 1 IRPS version 10.2
Scenario 5e
Scenic Integrity Protection

Kalispell
Coeur d'Alene
Plains
Flathead
Missoula
Helena
Bozeman
Billings
Fort Peck Lake
Yellowstone
Watford City
Lake Sakakawea
Souris
Yellowstone Lake
Lake Oa
Snake
Bear
Green

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Integrated Restoration & Protection Strategy, version 10.2
Map prepared October 2011

N

0 50 100 200

Miles

Opportunity Scores

- 0.05 - 0.21 - Low
- 0.22 - 0.27
- 0.28 - 0.32
- 0.33 - 0.36
- 0.37 - 0.41
- 0.42 - 0.43
- 0.44 - 0.46
- 0.47 - 0.48
- 0.49 - 0.52
- 0.53 - 0.65 - High

- Towns
- Rivers
- Lake
- Subwatersheds not scored
- State boundary

Opportunity scores are relative. A high score indicates that a subwatershed has relatively high opportunities for restoration activity relative to other subwatersheds based on the specific evaluation criteria applied in a scenario.

Sheyenne National Grasslands

Region 1 IRPS version 10.2
Integrated Score
Themes 1-6

Kalispell
Coeur d'Alene
Plains
Flathead
Missoula
Helena
Bozeman
Billings
Fort Peck Lake
Lake Sakakawea
Watford City
Souris
Yellowstone Lake
Snake
Bear
Green
Lake Oa

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Integrated Restoration & Protection Strategy, version 10.2
Map prepared October 2011

N

0 50 100 200

Miles

Opportunity Scores

- 0.034 - 0.117 - Low
- 0.118 - 0.135
- 0.136 - 0.152
- 0.153 - 0.165
- 0.166 - 0.177
- 0.178 - 0.189
- 0.190 - 0.201
- 0.202 - 0.221
- 0.222 - 0.249
- 0.250 - 0.356 - High

- Towns
- Rivers
- Lake
- Subwatersheds not scored
- State boundary

Opportunity scores are relative. A high score indicates that a subwatershed has relatively high opportunities for restoration activity relative to other subwatersheds based on the specific evaluation criteria applied in a scenario.

Sheyenne National Grasslands

Region 1 IRPS version 10.2
Theme 1
Vegetation Resilience

Kalispell
Coeur d'Alene
Plains
Flathead
Missoula
Helena
Bozeman
Billings
Fort Peck Lake
Watford City
Lake Sakakawea
Souris
Yellowstone Lake
Snake
Bear
Green
Lake Oa

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Integrated Restoration & Protection Strategy, version 10.2
Map prepared October 2011

N

0 50 100 200

Miles

Opportunity Scores

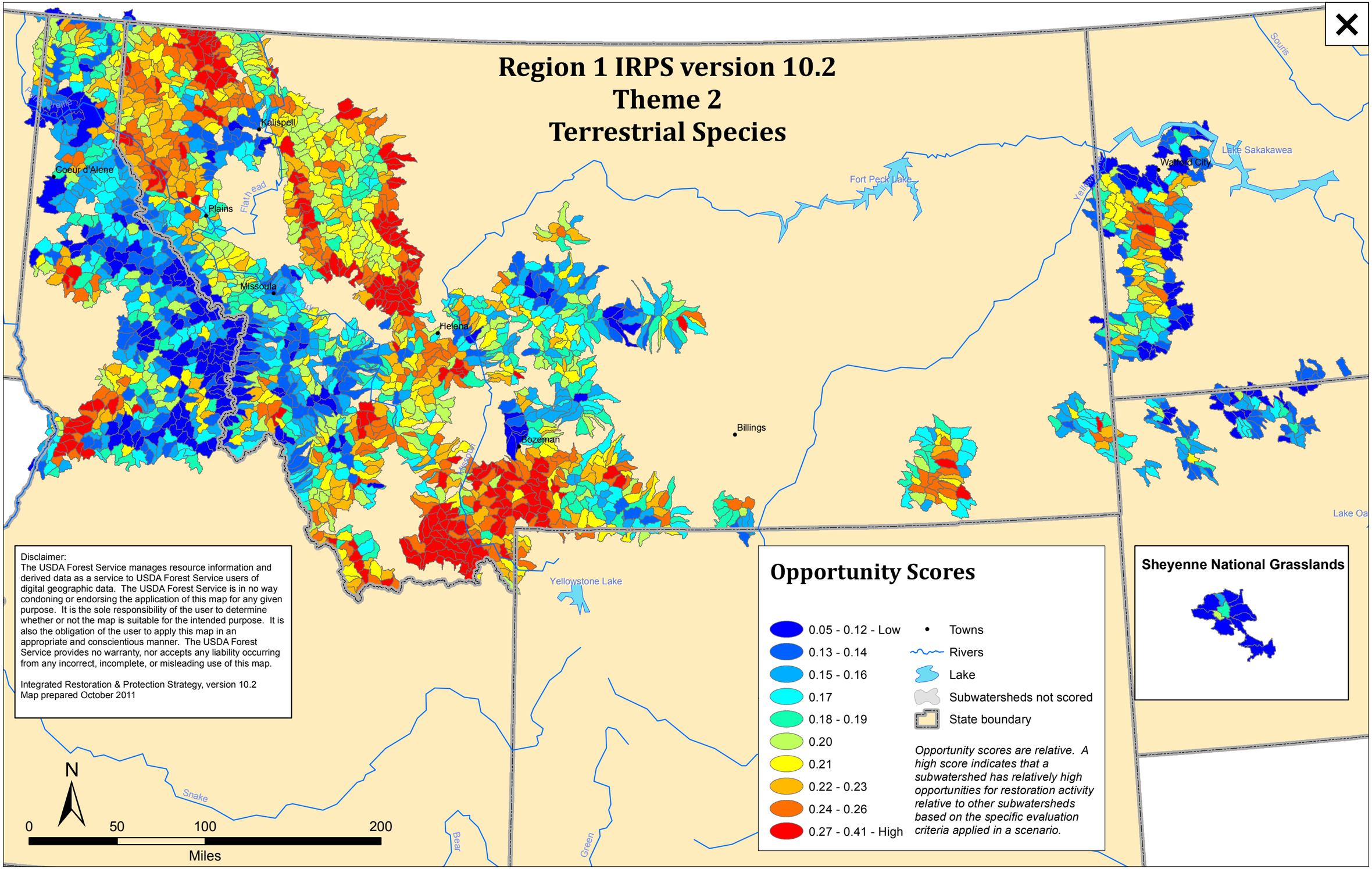
- 0.07 - 0.21 - Low
- 0.22 - 0.24
- 0.25 - 0.26
- 0.27 - 0.28
- 0.29 - 0.30
- 0.31 - 0.32
- 0.33 - 0.35
- 0.36 - 0.38
- 0.39 - 0.43
- 0.44 - 0.59 - High

- Towns
- Rivers
- Lake
- Subwatersheds not scored
- State boundary

Opportunity scores are relative. A high score indicates that a subwatershed has relatively high opportunities for restoration activity relative to other subwatersheds based on the specific evaluation criteria applied in a scenario.

Sheyenne National Grasslands

Region 1 IRPS version 10.2
Theme 2
Terrestrial Species



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Integrated Restoration & Protection Strategy, version 10.2
Map prepared October 2011

Opportunity Scores

- 0.05 - 0.12 - Low
- 0.13 - 0.14
- 0.15 - 0.16
- 0.17
- 0.18 - 0.19
- 0.20
- 0.21
- 0.22 - 0.23
- 0.24 - 0.26
- 0.27 - 0.41 - High

- Towns
- Rivers
- Lake
- Subwatersheds not scored
- State boundary

Opportunity scores are relative. A high score indicates that a subwatershed has relatively high opportunities for restoration activity relative to other subwatersheds based on the specific evaluation criteria applied in a scenario.

Sheyenne National Grasslands

Region 1 IRPS version 10.2
Theme 3
Watershed Management

Kalispell
Coeur d'Alene
Plains
Flathead
Missoula
Helena
Bozeman
Billings
Fort Peck Lake
Watford City
Lake Sakakawea
Souris
Yellowstone Lake
Snake
Bear
Green
Lake Oa

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Map prepared October 2011

N

0 50 100 200

Miles

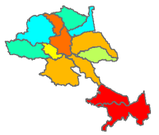
Opportunity Scores

- 0.00 - 0.04 - Low
- 0.05 - 0.06
- 0.07
- 0.08 - 0.07
- 0.08
- 0.09
- 0.10
- 0.11 - 0.12
- 0.13 - 0.14
- 0.15 - 0.34 - High

- Towns
- Rivers
- Lake
- Subwatersheds not scored
- State boundary

Opportunity scores are relative. A high score indicates that a subwatershed has relatively high opportunities for restoration activity relative to other subwatersheds based on the specific evaluation criteria applied in a scenario.

Sheyenne National Grasslands



Region 1 IRPS version 10.2
Theme 4
Aquatic Species

Kalispell
Coeur d'Alene
Plains
Flathead
Missoula
Helena
Bozeman
Billings
Fort Peck Lake
Watford City
Lake Sakakawea
Souris
Yellowstone Lake
Snake
Bear
Green
Lake Oa

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Map prepared October 2011

N

0 50 100 200

Miles

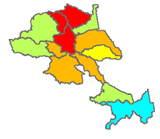
Opportunity Scores

- 0.00 - 0.02 - Low
- 0.03
- 0.04
- 0.05
- 0.06 - 0.07
- 0.08
- 0.09 - 0.11
- 0.12 - 0.41
- 0.42 - 0.47
- 0.48 - 0.62 - High

- Towns
- Rivers
- Lake
- Subwatersheds not scored
- State boundary

Opportunity scores are relative. A high score indicates that a subwatershed has relatively high opportunities for restoration activity relative to other subwatersheds based on the specific evaluation criteria applied in a scenario.

Sheyenne National Grasslands



Region 1 IRPS version 10.2
Theme 5
Recreation Settings & Opportunities

Kalispell
Coeur d'Alene
Plains
Flathead
Missoula
Helena
Bozeman
Billings
Yellowstone Lake
Fort Peck Lake
Watford City
Lake Sakakawea
Souris
Lake Oa
Snake
Bear
Green

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Map prepared October 2011

N

0 50 100 200

Miles

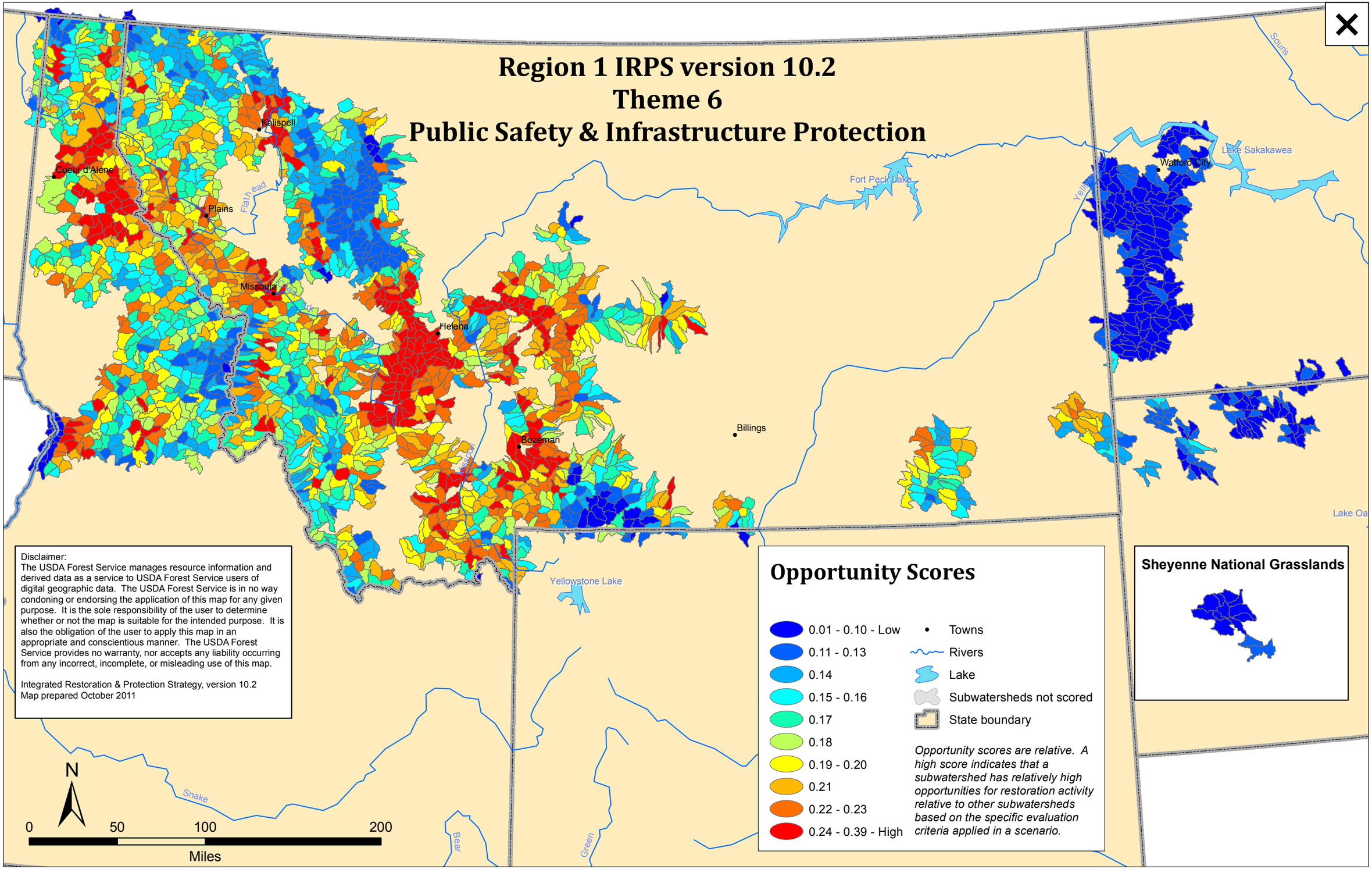
Opportunity Scores

- 0.02 - 0.10 - Low
- 0.11 - 0.13
- 0.14
- 0.15 - 0.16
- 0.17 - 0.18
- 0.19 - 0.20
- 0.21 - 0.22
- 0.23 - 0.25
- 0.26 - 0.28
- 0.29 - 0.41 - High

- Towns
- Rivers
- Lake
- Subwatersheds not scored
- State boundary

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Sheyenne National Grasslands


Region 1 IRPS version 10.2
Theme 6
Public Safety & Infrastructure Protection
Kalispell
Coeur d'Alene
Plains
Flathead
Missoula
Helena
Bozeman
Billings
Fort Peck Lake
Watford City
Lake Sakakawea
Souris
Yellowstone Lake
Snake
Bear
Green
Lake Oa
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Map prepared October 2011
N
0
50
100
200
Miles
Opportunity Scores
0.01 - 0.10 - Low
0.11 - 0.13
0.14
0.15 - 0.16
0.17
0.18
0.19 - 0.20
0.21
0.22 - 0.23
0.24 - 0.39 - High
Towns
Rivers
Lake
Subwatersheds not scored
State boundary
Opportunity scores are relative. A high score indicates that a subwatershed has relatively high opportunities for restoration activity relative to other subwatersheds based on the specific evaluation criteria applied in a scenario.
Sheyenne National Grasslands



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