Landscape Assessment for the Clearwater Valley of Montana

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SUMMARY

The Clearwater Resource Council (CRC) has conducted a landscape assessment for the Clearwater Valley planning area. The landscape assessment evaluated the Valley relative to addressing the objectives of enhancing, conserving, and protecting the natural ecosystems and rural lifestyle of the Clearwater River region. Included in this assessment is information on the distribution of a number of species of interest or concern (grizzly bear, Canada lynx, elk, bull trout, westslope cutthroat trout), and wildlife linkage zones. Wetland and riparian areas were delineated and are included as is information on forest cover types, tree sizes and densities, ecosystem diversity, forest habitat types, forest productivity, and soils information. Factors that can influence the development potential of sites in the Valley, including the wildland-urban interface identified in the Seeley/Swan Fire Plan (2004), slopes, and proximity to current infrastructure are included in the assessment. Locations in the Valley that have views of mountains and lakes as well as having proximity or frontage on water (lakes and major streams) were determined and mapped. Stream segments that support or influence important recreational fisheries for both native and desirable non-native species were identified and mapped as well. An economic background for the Seeley Lake area is discussed. The assessment identified resource values and other development limitations occurring on each 30m pixel as well as each legal section within the Valley, and these values were quantified and mapped, and a summary of the values occurring in each section is provided.

INTRODUCTION

The Clearwater Valley is a 248,727 acre watershed located primarily in Missoula County in Northwestern Montana, with some of the watershed (28,777 acres) also occurring in Powell County. The planning landscape included in this assessment includes an additional 20,136 acres of land within Missoula County that occurs east of the Clearwater River watershed, and north of Highway 200, extending to the Powell County line. These additional lands were included to assist Missoula County with land use planning, as these lands would otherwise fall outside of other planning regions. The total acreage contained in the Missoula County portion of the planning landscape is 240,086 acres. Figure 1 displays the Clearwater Valley, and the extended assessment area east of the Clearwater Valley but within Missoula County. In this assessment, reference to the Clearwater Valley includes the extended assessment area east of the watershed.

The Clearwater Valley is mixed ownership comprised of U.S. Forest Service (USFS), Plum Creek Timber Company (Plum Creek), State of Montana, and non-industrial private lands. The northern end of the Valley is located between the Mission Mountains Wilderness and the Bob Marshall Wilderness, bounded on the western side by the Mission Mountains and on the eastern side by the Swan Range (Figure 2). The southern end of the Valley includes a portion of the Blackfoot-Clearwater Wildlife Management Area administered by the MT Department of Fish, Wildlife, and Parks (MT FW&P). The Valley currently has approximately 22,297 acres of land in private lands, not considering the industrial forest lands of Plum Creek.

The Valley, with its connections to the Bob Marshall and Mission Mountain Wilderness areas and the Blackfoot-Clearwater Wildlife Management Area is an ecologically critical area within the Northern Continental Divide Ecoregion, also known as the Crown of the Continent. This ecoregion, and the Clearwater Valley, support a nearly complete component of native species, and are recognized for their high ecological values. Maintaining these ecological values has not only local, but national significance. As noted by the Mistakis Institute (www.rockies.ca), "the Crown is of international significance with respect to its biodiversity and landscape form. Species such as the grizzly bear and the gray wolf share the region with human communities and an array of industrial and commercial activities…As one of North America's largest ecological intact areas, there are clearly benefits of managing the Crown in a holistic fashion." The Sierra Club (www.sierraclub.org) stated: "The Crown of the Continent -- the Northern Rockies ecoregion -- is one of America's most precious natural treasures. Consisting of Glacier National Park and the Bob Marshall Wilderness Complex and bisected by the Continental Divide, this area nurtures an array of plant and animal species, as well as holding significant spiritual importance for the local Blackfeet Indians…Its significance cannot be overstated: It is one of the only intact ecosystems, that except for bison, is home to all of the species present when Lewis and Clark passed through." Ricketts et al. (1999) discussed the broader North Central Rockies Ecoregion identifying the primary concerns in this area as potential loss of connectivity among habitat blocks caused by resource extraction and development. They noted that major changes and disturbances in relatively small areas could have disproportionately large effects. The Clearwater Valley provides important habitat to a number of species, and is a critical linkage zone within the Crown, and potentially prone to such disproportional effects.

The Clearwater River basin is tributary to the larger Blackfoot and Clark Fork river basins but also represents ecologically distinct aquatic environments associated with a unique interconnected system of mid-elevation lakes. Because lakes and rivers may respond to environmental change in fundamentally different ways, the ecological and life history diversity of species tied to aquatic systems within the Clearwater Valley represents a disproportionately larger part of regional aquatic biological diversity than would be attributed to species occurrences alone.

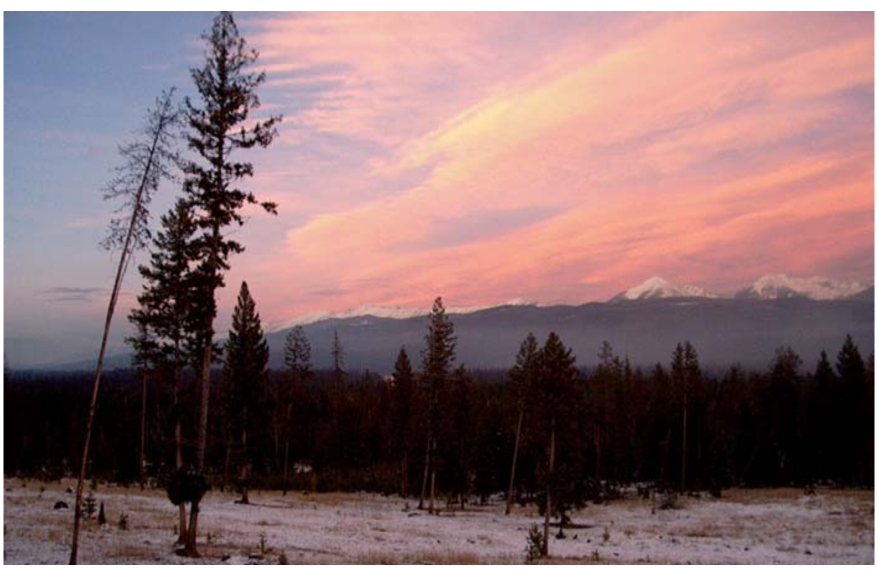

Figure 2. View of the Swan Range looking northeast from the Clearwater Valley near Seeley Lake, Montana.

The town of Seeley Lake is the center of the local population, having approximately 2,200 year-round residents (U.S. Census 2000, adjusted for growth) which increases to approximately 4,000 during the summer. This community has a strong sense-of-place. Its history was built around an economic reliance on the natural resources of the area, which continues today. It is a community where both residents and visitors make heavy recreational use of the surrounding wildlands and natural resources. Residents value the aesthetics, fish and wildlife, natural setting, rural lifestyle, recreational opportunities, and other existing amenities (Missoula County 2006). The Valley attracts a large number of visitors who utilize its abundant natural resources through water-related activities (fishing, swimming, boating), hunting,, hiking, snowmobiling, and other uses, which support a growing tourist industry. Forest products are harvested and processed in the Valley. The Valley, as with much of Western Montana, is seeing a rapid rate of population growth, which is fueling a substantial real estate and construction component of the economy. This growth is largely driven by an influx of people from outside the area, many of whom are buying or building second homes. This demand has driven up land and housing prices in the Valley. The community is concerned about maintaining the environment of the Valley, their rural lifestyle, and the natural resources that they utilize and value while also providing opportunities for appropriate growth and development (Missoula County 2006).

The Clearwater Resource Council (CRC) is a local collaborative initiative that was formed in January 2003. Its mission is to initiate and coordinate efforts that will enhance, conserve, and protect the natural ecosystems and rural lifestyle of the Clearwater River region for present and future generations. Goals of the CRC are to:

- Build community capacity to resolve issues,
- Create opportunities for interaction among citizens, businesses, and agencies,
- Build common ground by consensus process,
- Facilitate timely collection and dissemination of information,
- Enhance the understanding of cumulative effects of land management practices, and
- Develop and support responsible resource stewardship programs.

The CRC determined that to make the best informed decisions about natural resource issues, a comprehensive assessment of the Clearwater Valley was needed. Such an assessment should consider ecological and social objectives, and to the extent feasible, incorporate economic objectives. Ecological objectives should include information on forest and wetland ecosystems, streams, rivers, and lakes, and the habitat needs, population status, and linkage zones of species of interest or concern with particular focus on grizzly bear, Canada lynx, bull trout, westslope cutthroat trout, and elk. Social objectives include aesthetics and recreational activities and desired access to lands for hunting, fishing, hiking, horseback riding, snowmobiling, cross-country skiing, and sight-seeing. In addition, future land management should consider the potential risk to human lives and developments from wildfire. Economic objectives include maintaining the natural resource related industries such as tourism, recreation industries, and harvest and production of forest products, as well as the real estate and construction industries in the Valley. All of these relate to or influence the objective of maintaining the natural ecosystems and rural lifestyle of the Clearwater Valley.

Economic resource uses in the Valley include timber harvest, grazing of domestic animals, huckleberry and mushroom picking, trapping, and guiding. In addition, the recreational use of the Valley and its natural resources provide a major economic source. Grazing use is minimal and is generally not considered to be enough of an issue to require additional analyses, although this need could be perceived as important at some future time. Harvesting and manufacturing of forest products is a significant economic industry in the Valley and most of the non-wilderness lands in the Valley have had a substantial history of timber harvest. A detailed forest assessment for the Valley is needed which would determine past and current amounts and distributions of specific forest conditions. This analysis could be the basis for development of a forest management plan for the Valley that would identify desired future conditions across both the wildland-urban interface as well as wildlands, and could be used to project future supply of various forest products as well as the provision of forest ecosystem diversity and habitat for species of interest. Development of such an assessment and plan was beyond the current financial capabilities of the CRC, and was not completed as part of this assessment. The ecological, social, and economic contributions of huckleberry and mushroom picking have not been analyzed in this assessment, but as with grazing, are not thought to constitute a need at this time. Trapping and guiding are conducted under the oversight of Montana Fish, Wildlife, and Parks, and are not currently considered a needed component of an assessment. Additional economic analysis of the Valley that identifies the current sources of income for the population is a component of an on-going Seeley Lake Land Use Plan being developed by the Seeley Lake Community Council in cooperation with Rural Initiatives of Missoula County.

ACKNOWLEDGMENTS

This assessment of the Clearwater Valley was prepared with the input of the Land Use Committee of the Clearwater Resource Council . This committee was chaired by Scott Tomson, and has involved a number of individuals: Stan Nicholson, Mike Thompson, Jon Haufler, Jay Kolbe, Karen Linford, Chris Lorenz, Jim Berkey, George Frascas, Ron Bohlman, Caroline Byrd, Carol Evans, Mark Williams, Roger Marshall, Ron Cox, Carolyn Mehl, Jeff Aresty, Bill Wall, Geof Foote, and Ali Duvall. Subsequent revision was supported by Ladd Knotek, Shane Hendrickson, Karen Pratt and Bruce Rieman. The Ecosystem Management Research Institute (EMRI), a non-profit institute located in Seeley Lake, prepared drafts of this landscape assessment with partial funding provided by the Seeley Lake Community Foundation. EMRI staff involved in this effort included Jon Haufler, Scott Yeats, and Carolyn Mehl. Input on the assessment was provided by Vickie Edwards of the Missoula County Rural Initiatives and by Jerry Sorenson and Rett Parker of Plum Creek Timber Company.

NEIGHBORING INITIATIVES

The Clearwater Valley is situated between two neighboring landscapes which have initiated collaborative initiatives that have included various levels of landscape assessment. To the south of the Clearwater Valley, the Blackfoot River Valley, of which the Clearwater River is a tributary, has conducted various assessments through the efforts of the Blackfoot Challenge. The Challenge has compiled GIS information on various resources in the Blackfoot watershed. It is also conducting a watershed TMDL analysis that is providing important information on aquatic ecosystems. The Blackfoot Challenge and The Nature Conservancy have been involved in a major land transaction that transferred more than 88,000 acres of Plum Creek ownership to other owners including the USFS, MT DNRC, and private lands with accompanying conservation easements. To the north, the Swan River Valley has conducted an assessment through the efforts of the Swan Lands Committee of the Swan Ecosystem Center. This assessment has characterized high value lands at risk of development in the Swan Valley. It is important to recognize that the Clearwater Valley sits between these two other drainages, and as previously mentioned, is a component landscape within the Crown of the Continent ecoregion. While each valley has a unique landscape and issues, the close proximity and linkages mean that what happens in any one of these valleys will have an influence on the neighboring valleys, particularly in terms of some of the wildlife populations of interest and their population linkages within the ecoregion and to other neighboring ecoregions.

OBJECTIVES

The overall objective of this landscape assessment is to compile and synthesize information that can be used in land use planning, development review, resource management planning, and other planning and management activities. Specifically, this landscape assessment has the objectives of:

1. Compiling available information on ecological, social, and economic resource values for the Clearwater Valley,
2. Synthesizing available information into products that facilitate review and decision-making, and
3. Providing an on-going source for current information that can be used by land use planning, development review, and other resource management decision makers.

THE SETTING

The Clearwater Valley is comprised of the watershed of the Clearwater River, with expansion of the additional lands east of the watershed discussed above, and occurs primarily in Missoula County, but with some lands also in Powell County. The northern part of the Valley sits between the Mission Mountains on the west, and the Swan Range on the east. The northern boundary of the watershed is the divide between the Swan River watershed, which flows to the north into the Flathead River, and the Clearwater River that flows south into the Blackfoot River. Total area of the Clearwater Valley planning area is 268,863 acres (Figure 1).

The Seeley-Swan valleys were formed by continental glaciation when the Cordillerian ice sheet advanced through northern Montana. Smaller mountain glaciers formed in the Mission and Swan Mountain Ranges and moved along the Swan and Clearwater Valleys, as well. The geology of the Clearwater Valley is characterized by sloping glacial features of undifferentiated glacial drift composed of argillites, siltites, and quartzites. Soils are primarily deep, moderately coarse to medium textured. Figure 3 depicts soils for the Missoula County portion of the Clearwater Valley. Soils maps for Powell County are not available at this time. Included in the soil classification are soils identified as lowland or wetland types that have considerable constraints in terms of their development potential.

Climate of the area is moderately moist and cool. Total annual precipitation in Seeley Lake averages 21.44 inches, with 45% of this falling between April and September. Average seasonal snowfall is 122.6 inches in Seeley Lake. Seeley Lake averages at least 1 inch of snow on the ground for 123 days each year. Higher levels of precipitation and snowfall occur at higher elevations of the Valley. The average temperature in Seeley Lake on an annual basis is 41.3 degrees, with temperature extremes ranging from -40 degrees F to 100 degrees F. Most years will remain above freezing from late June through August, but freezing temperatures have occurred in 2 years out of 10 in every month of the year. Recent trends in climate have been consistent with anticipated effects of global and regional climate change. General warming, increased variability in total precipitation and dryer summers, could have important implications for both aquatic and terrestrial systems Mean temperature in July of 2007 was more than 2 F warmer than any year since 1948 when recording began at the Seeley Lake Ranger station.

Topography and elevation ranges of the Valley are diverse. The elevation of the Valley ranges from 3789 ft at the confluence of the Clearwater River into the Blackfoot River, and reaches a maximum of 9083 ft on Ptarmigan Point in the Swan Range. The Valley contains various ridges generally running north-south between the two defining mountain ranges (Figure 1).

The Clearwater River and several tributary streams connect a series of lakes in the Valley. Summit Lake and Clearwater Lake occur in the upper reaches of the Valley. Lakes connected along the Clearwater River include Rainy Lake, Lake Alva, Lake Inez, Seeley Lake, Salmon Lake, Elbow Lake, and Blanchard Lake. Other lakes in the Valley include Placid Lake, Lake Marshall, Big Sky Lake, Tote Road Lake, Harpers Lake, Hidden Lake, and a number of other smaller lakes.

The Valley was historically inhabited by Native Americans. Whether the Valley supported year-round use or was used seasonally and as a travel corridor is less clear. Native Americans primarily utilized areas in the Valley bottom. They commonly set fires in the Valley, an activity that influenced the historical fire regimes discussed below. The Clearwater Valley was first settled by European immigrants in the 1880's, when several ranches were established. Settlement expanded rapidly in the early 1900's. Information is available on various aspects of the settlement of the Valley. The Seeley Lake Historical Society, located in the Seeley Lake Historical Museum and Visitor Center located at 2920 MT Highway 83 south of the town of Seeley Lake is an excellent source for historical information on the development of the town and the Valley. Today, Seeley Lake is the largest community in the Blackfoot Watershed, with a resident population of 2,200 that grows to over 4,000 during the summer.

Land ownership is mixed in the Clearwater Valley (Figure 4). The USFS is the largest land holder, with 123,629 acres or 46% of the Valley. Plum Creek Timber Company is the second largest land owner, with 86,937 acres or 32% of the Valley. The state of Montana owns 31,198 (12%) of the Valley, with 19,782 acres of this managed by MT Department of Natural Resources and Conservation (MT DNRC), and 11,416 acres managed by MT FW&P. The US Bureau of Land Management (BLM) owns 160 acres (<1%) in the Valley. Non-industrial private lands comprise 22,297 acres or 8% of the Valley, with lakes covering the remaining 4,634 acres, or 2% of the Valley.

Aerial photography of the Valley from the summer of 2005 provides another look at current land use in the Valley and provides an opportunity to compare land use across property lines (Figure 5). These photographs were acquired through the U.S. Farm Services Agency's National Agricultural Imagery Program (NAIP). The photographs are true color and have a resolution of 1 meter.

METHODS OF ASSESSMENT

COMPILATION OF INFORMATION

The CRC has compiled available information for a landscape assessment from a number of sources. Available maps have been acquired from sources including Montana's Natural Resource Information System (NRIS), the USFS, Missoula County, Natural Resource Conservation Service, US Fish and Wildlife Service (USFWS), and others. Additional maps and information available from the
Figure 3. Soils

development of the Seeley/Swan Fire Plan were also included, where appropriate. Information on wildlife crossings of Highway 83 was obtained from a report prepared by the Western Transportation Institute (Huijser et al. 2006). Information on key areas for selected fish and wildlife species was obtained from existing maps, interpretation of research findings from past and on-going studies, as well as from input from biologists with the USFS, MT FW&P, USFWS, and the University of Montana. In particular, maps of linkage zones were reviewed by the following agency biologists: Mike Thompson (MT FW&P), Scott Tomson (USFS), Jay Kolbe (USFS and MT FW&P), Chris Servheen (USFWS) and Jamie Jonkel (MT FW&P). Home range information on lynx use of the Valley generated from a recent lynx telemetry study was requested and received from John Squires (USFS). Information obtained from grizzly bear telemetry work was obtained from Chris Servheen (USFWS). Information on rare plants in the Valley was obtained from Scott Mincemoyer with the MT Natural Heritage Program. Information on elk distributions and movements was obtained from NRIS maps with additional input from Mike Thompson (MT FW&P), Scott Tomson (USFS), Jamie Jonkel (MT FW&P), and from Hurley (1994). Information on distributions and habitat use by bull trout and westslope cutthroat trout and on streams important to recreational fisheries was obtained with particular input from Ladd Knotek (MT FW&P), Aubree Benson (U of M), and Ron Pierce (MT FW&P). Shane Hendrickson (USFS), Ladd Knotek, and Tara Comfort (NRCS) provided riparian and stream channel condition information. Mike McLane (MT FW&P) provided insights on water volume and water rights data. Information on aquatic invertebrates was obtained from David Spaglino with MT Natural Heritage Program. Other water quality information was obtained from Timothy Bryon (MT DEQ) and Brian MacDonald (Blackfoot Challenge). Maps of snowmobile trails were obtained from the USFS and the CRC trails committee with input from local snowmobile users. Data on population densities, economic activities, residential development, and other related information were primarily obtained from Missoula County as well as from U.S. Census data. Soils information was obtained from the NRCS SSURGO data source. Forest habitat types were determined from soil information as well as from habitat type designations from USFS stand information. Information on forests was compiled from several sources. Dominant vegetation of forest stands was compiled from both SILC3 and VMAP, two satellite interpretation vegetation maps created by the USFS for its Region 1.

These same maps were used for estimated sizes of dominant trees within forest stands. Large trees occurring on USFS and MT DNRC lands were mapped from stand inventory data of these two agencies. Forest productivity was derived from the habitat type map.

Viewsheds were generated in ArcGIS to identify points in the Valley that have a direct line of sight to 8 of the tallest peaks in the Swan Range. Viewsheds for lakes identified points in the Valley that have a direct line of sight to the major lakes in the Valley. Base elevation data came from the USGS National Elevation Dataset. Slopes in the Valley were obtained from a Missoula County GIS shapefile, to which a coarser delineation of slopes for Powell County was added manually. Location of powerlines was obtained from Missoula Electric Cooperative and mapped. Road maps were obtained from the Seeley Swan Fire Plan, as was the map of the Wildland/Urban Interface (WUI).

ANALYSIS OF INFORMATION

Considerable information was compiled and included in this assessment. In order to better assimilate this information for interpretation, data were combined in various ways and summarized in maps that weighed each 30m pixel as well as each section of the Valley. Each pixel and section was evaluated for the ecological resources occurring or using that point or section, and the sum of all of the ecological values calculated and mapped. In addition, potential considerations for land use planning including proximity to the power grid, location relative to the WUI, and location in relation to slope were determined and weighed. These weights were combined in a map. Finally, the ecological values map and the development constraints map were combined into a total values map, for both pixels and sections.

For calculations in sections, ecological and development constraint values were calculated for average values weighed by area for each value within the section. Some features (e.g., presence of streams supporting fish species of concern) are linear features that don't compute effectively on a section by section basis. For such factors, we buffered streams to incorporate influential watershed processes, totaled the area within buffers within each section, and weighted each section according to the totals. For pixels, 300-foot buffers on streams supporting or contributing to important habitat received the maximum weighting. Tributary streams were included where they contributed directly to primary spawning and rearing habitats but not where they contributed to seasonal rearing or migratory corridors. For sections, the full weight was used when the buffered stream area in a section was greater than or equal to 72 acres (equivalent to 1 mile of stream flowing through the middle of a section.) For buffers less than 72 acres, the weights were adjusted proportionately.

The weightings defined below were then applied to each factor in the assessment. Each variable was assigned weightings from 0-10 for each location in the planning landscape. These weightings put all values as potentially equal with each variable having a maximum value of 10. Intermediate amounts, uses, or proximity distances for some variables were assigned relative weightings. For example, crucial elk winter range was deemed the most important elk habitat component, and areas supplying this habitat were assigned a 10. Winter habitat that was not deemed "crucial" was assigned a 6. Crucial summer range was assigned an 8, as this was not deemed to be as potentially limiting to elk as crucial winter range. Elk summer habitat was assigned a 3, while non-elk habitat received no value. With the exception of genetically pure cutthroat trout, weights for stream habitats were derived from the relative values identified by MT FW&P in the prioritization matrix for the Integrated Stream Restoration and Native Fish Conservation Strategy for the Blackfoot River Basin (MT FW&P Update In Preparation 2008). Potentially pure cutthroat trout populations were identified by MTFW&P biologists; genetic confirmation is pending. Weightings for bull trout and migratory cutthroat habitats included stream segments that represented spawning, primary rearing or seasonal rearing, and migratory corridors.

The weightings were then combined to present an overall map of weights of assessment factors, both at the scale of the pixel, and for each section in the planning landscape. <u>It should be noted that these weightings have been assigned equal value across all variables, and the importance of one variable in an evaluation of the landscape may not be equal to another.</u> For example, lynx habitat may be considered more important for planning purposes than proximity to the existing power grid, yet both have received the same weighting for this analysis. Also, the importance of only one variable may override other variables in planning. For example, the Game Range is not lynx habitat nor is it in the grizzly bear recovery zone, yet its importance to elk is paramount. Thus, its value to elk means that this will preclude consideration of other potential uses of the game range, even if it has lower combined scores than some other areas that support grizzly bear and lynx habitat. With these considerations in mind, the combined scores for areas do allow for a visual depiction of where multiple factors occur, and can help provide a general view of the entire watershed for planning purposes. For each section in the watershed, the weightings assigned to that section for each variable are listed in Appendix 2. This provides for the ability to identify the specific variables that have resulted in a combined score for a section, and allows for the consideration of the importance of each of these variables for planning purposes. There are far too many pixels in the landscape area to list the values that contribute to scores for each pixel, so interpretation of the pixel map of combined scores requires a user to examine each of the underlying maps of resource or development constraints. For this reason, as well as the fact that many land use decisions are made at the section scale, both pixel and section analyses are included.

For ecological objectives, the following weightings were used:

- Wetland or riparian areas- for pixels areas were either wetland or not. For sections, wetlands were weighted as:
  - Less than 5% of a section: 0
  - 5-10% of a section 2
  - 10-15% of a section 4
  - 15-20% of a section 6
  - 20-25% of a section 8
  - >25% of a section 10

  Note that for wetland and riparian areas, these areas were buffered in the assessment with a 150 foot buffer (300 feet in width when extended to both sides of the stream) so that streams, which are a linear feature, would have a measurable area within each section or pixel. Also, lakes were similarly buffered with a 300 foot border, and only this 300 foot buffer area was included in the map of wetland and riparian areas. The lakes themselves do not contribute weightings to the wetland value.

- Grizzly bear habitat
    - Outside of grizzly bear habitat/linkage 0
    - Within grizzly bear habitat 4
    - Within grizzly bear recovery area 10
    - Within grizzly bear linkage zone 10

- Lynx habitat
    - Outside of lynx habitat/linkage 0
    - Within lynx habitat 10

- Elk habitat
    - Outside of elk habitat 0
    - Within elk summer habitat 3
    - Within elk winter habitat 6
    - Within crucial elk summer range 8
    - Within crucial elk winter range 10

- Wildlife linkage zones
    - Outside linkage zones 0
    - Within wildlife linkage zones 10

- Bull Trout habitats.
    - Outside bull trout habitat 0
    - Potential, or remnant habitats 3
    - Non core population habitats 7
    - Core population habitats 10
    -

Cutthroat trout habitats
- Outside cutthroat trout habitat 0
- Resident or remnant cutthroat trout habitat 3
- Migratory cutthroat trout habitats 5
- Genetically pure or potentially pure population habitats 10

For development constraints, the following rankings were used:

- Wildland/Urban Interface
    - Within the current WUI further than 0.5 mi of the edge 0
    - Within the WUI and within 0.5 miles of the edge 5
    - Outside the current WUI 10

- Slopes: For pixels, slopes greater than 25% received a weighting of 10. For sections:
    - Sections where slope was generally less than 10% 0
    - Sections where slope was generally 10-25% 5
    - Sections were slope was generally >25% 10

- Proximity to existing infrastructure
    - Within 0.5 mile of power grid 0
    - Within 1 mile of power grid 5
    - Greater than 1 mile from power grid 10

ASSESSMENT REVIEW

This assessment was presented in draft form at 3 public meetings in Seeley Lake. These meetings, conducted by the Clearwater Resource Council were announced in the Pathfinder, the weekly newspaper in Seeley Lake, as well as on posters placed in prominent places within the town the week prior to the meetings. A presentation on the assessment was also made to the Missoula County Board of Commissioners at an open meeting on December 1, 2005. Drafts of the assessment were provided to Plum Creek Timber Company, and were also available on the internet. The assessment was also presented to the Seeley Lake Community Council on February 13, 2006. Comments on the plan were accepted at any time during its development. While not all comments were incorporated into the assessment, every effort was made to include all pertinent factual information within the capability and scope of the assessment.

RESULTS

ECOLOGICAL ASSESSMENT

The Clearwater Valley lies within the southernmost portion of the Northern Continental Divide Ecoregion. This ecoregion contains some of the largest blocks of contiguous public land and wilderness areas in the continental U.S. and supports a rich biodiversity of both plants and animals. It has been identified as bioregionally outstanding, supporting some 2,203 terrestrial species including an estimated 48 endemics (Ricketts et al. 1999). It is recognized for its rich diversity of coniferous forest ecosystems and some of the most intact watersheds and aquatic ecosystems in the lower 48 states. The area is noteworthy for its populations of large carnivores including wolves, grizzly bears, wolverines, cougar, fisher, marten, and Canada lynx. It is also known for its populations of large herbivores including moose, Rocky Mountain elk, mountain goat, bighorn sheep, mule deer, and white-tailed deer. This ecoregion is one of the few remaining strongholds for the threatened bull trout and supports important populations of regionally declining westslope cutthroat trout. These species are supported by an array of terrestrial and aquatic ecosystems that still maintain many of their historical ecological processes and integrity. This region provides a unique opportunity to maintain nearly the full range of ecosystems and biodiversity that historically occurred in the area and an important element of biodiversity that is not well represented elsewhere.

Presently, many of the forests and watersheds in the Crown of the Continent are relatively intact. Some forest ecosystems have undergone changes due to logging, fire exclusion practices, exotic diseases, and exotic species. Substantial blocks of forest ecosystems still occur but some ecosystems exhibit different structures and species compositions relative to their historical conditions. Similarly, many riparian, wetland, and aquatic ecosystems are relatively intact, but many have been impacted by past mining, logging, urbanization, and road building activities as well as by changes in fire regimes and in changes to the numbers and influences of beaver populations. This ecoregion has maintained relatively high landscape linkage for fish and wildlife populations, which is a primary reason the populations of large carnivores still occur. However, in some areas this linkage has been reduced with the presence of major roads, railroads, residences, and other human alterations. Maintaining the ecosystem integrity and biological diversity of the Clearwater Valley is critically important, not only to the fish and wildlife of the Valley, but because of the regional and national significance of this important conservation area to the persistence of species such as grizzly bears, Canada lynx, wolverines, and bull trout, as well as the functional ecosystems on which they depend. Maintaining the conservation values of the Clearwater Valley will require not only the identification of key areas within the Valley, but also the role that the Valley plays within the broader ecoregion, and will require consideration of conservation planning in adjoining landscapes.

Lakes, Rivers, Streams, and Wetlands

The Valley supports a diverse and high quality network of lakes, streams, and wetlands, many connected by the Clearwater River. Figure 6 depicts the lakes, river, major streams, and mapped wetlands in the Clearwater Valley. Primary lakes, as mentioned previously, include Summit, Rainy, Alva (Figure 7), Inez, Seeley, Salmon, Beaver, Clearwater, Colt, Marshall, Hidden, Placid, Harper's, Tote, and Big Sky. Three lakes, Inez, Summit, and Placid have water control structures at their outlets to help maintain the height of the lake, but otherwise, the lakes are all natural. Seeley is the deepest lake, with a depth of 125 feet. The other major lakes have depths from 70-100 feet.

Water quality in the Clearwater Valley generally is perceived to be good, but current conditions and trends are not well documented. Water quality of the Clearwater drainage is important for domestic, recreational, and natural resource uses locally and to downstream uses. About 10 percent of the discharge in the Blackfoot River basin comes from the Clearwater drainage.

MT DEQ has written a TMDL report that summarizes current knowledge and condition of several streams, lakes and segments of the Clearwater River (MT DEQ February 2008). In 1996, five streams, one river segment, and two lake areas in the Clearwater drainage were identified as 303(d) water quality impaired. These included the lower 3.5 mile segment of the Clearwater River which was identified because of concerns with dewatering, and elevated sediment and temperature. Nutrient concerns were also noted for upstream areas. Blanchard Creek, Buck Creek, Deer Creek, Richmond Creek, and West Fork Clearwater River were also identified as impaired waters based on concerns for sediment. The report proposes TMDL standards for sediment in all of these streams except Buck Creek and identifies issues associated with land use practices, roads, and road crossings (section 10 of 2008 report).

Seeley Lake and Salmon Lakes also appeared on the 1996 list for 303(d) impaired waters because of concerns for nutrients, organic enrichment, and reduced dissolved oxygen. Further sampling has occurred on Seeley Lake, but the results of any recent analysis or raw data have not been located. Therefore no conclusion can be drawn about current water quality. Elevated nitrates are attributed to faulty septic systems in the area, but no evidence of increased algal and macrophyte growth is available. The drinking water system for the town of Seeley Lake takes water from the lake. Recent concerns regarding pollutants in the domestic water system (STORET data base) may be linked to byproducts of normal chlorination with elevated organic loading in the water supply.

Salmon Lake receives the outflow from Seeley Lake and the outflow from other developed areas such as Placid Lake, and Big Sky Lake subdivision (near Fish Lake). It may also be hydrologically connected to nearby potholes such as the old gravel mine area at Emerald Lake subdivision (Tote Road Lake). The TMDL report suggests further monitoring of Seeley and Salmon lakes to better understand lake conditions.

The Clearwater River is a 4th order tributary of the Blackfoot River that flows for 45.8 miles from the outlet at Clearwater Lake to its confluence with the Blackfoot River. The river was noted for supporting a multi-species fishery. It was also noted as an important area for bull trout and west slope cutthroat trout. Road crossings and fish passage capabilities were evaluated in 2005 through a sampling of road erosion capabilities and culvert conditions, including a number of sites within the Clearwater River watershed (River Design Group 2005) The report found approximately two-thirds of the sampled culverts (94 total) had either inadequate perch heights or inadequate culvert size to channel size ratios to facilitate fish passage. In addition, the study reported that Blanchard Creek, a tributary of the Clearwater River, had a very high number of roads within the watershed, and a high level of road crossings. Roads were determined to be a major source of sediment delivery to streams in the areas studied, with Blanchard Creek noted for its high rate of sediment delivery. Road densities are high throughout much of the private timber land in the basin as well (e.g. Figure 29) and may contribute to the depressed status of some native fish populations. The Lolo National Forest has recently established priorities for fish passage restoration on National Forest Lands, but those projects depend on the availability of funding which is often limited.

The timing and volume of flows in the river-stream system are determined by variability in precipitation, principally in the annual snow fall, vegetation across the basin, and human development. Peak flows have typically occurred in May and June. The Clearwater River no longer has flow gauging, but regional trends suggest total water yield and peak flows are highly variable. The Blackfoot has experienced a generally decreasing trend in annual discharge in the last 20-30 years, while a record volume was observed in 1997.

Figure 7. The Clearwater Valley contains numerous natural lakes, such as Lake Alva pictured here that provide for diverse aquatic ecosystems as well as supporting populations of fish species of concern.

Forests

The Clearwater Valley is extensively forested. It has supported harvesting for timber products since the early 1900's. The forests are diverse, ranging from dry ponderosa pine/Douglas fir forests on lower elevation and south facing slopes, to whitebark pine at the highest elevations. The Valley is particularly noted for the numbers and size of its western larch which occurred from the valley bottom to mid-slope on the surrounding mountain ranges.

Forest diversity within the Clearwater Valley was described in the Seeley/Swan Fire Plan (2004), and information from this plan is incorporated into this assessment. Figure 8 is a map of the current dominant forest types in the Valley. Figure 9 is a map of the sizes of trees and percent canopy coverage of forests in the Valley. Figure 10 is a map of habitat types (potential forest vegetation types) (Pfister et al. 1977) in the Valley.

An important factor in identifying the potential range of forest conditions that can occur on a landscape is an understanding of the influence of historical disturbance regimes on vegetation structure, species composition and spatial distribution. Within any given landscape, several different historical disturbance regimes may have operated to influence vegetation. Fire was the primary disturbance agent in this landscape directly influencing large-scale changes in forest species composition, structure and spatial distribution. Fire can be broken into three primary historical disturbance regimes influencing species composition and structure. These are the short-interval fire regime (avg. <25 years), the long-interval fire regime (avg. >100 years), and the mixed severity fire regime with intermediate fire return intervals creating forest patches displaying either short or long-term fire effects. While insects and disease were and continue to be important disturbance agents as well, their activities often contribute to the occurrence and severity of fire, and as such, these agents play a subordinate role to fire as disturbances in forest ecology of the Rocky Mountain west.

The short-interval fire regime was predominantly characterized by relatively frequent, non-lethal, low to moderate intensity fires that burned along the ground and remained within the understory. The frequency of these fires generally averaged between 5 and 25 year intervals, influencing both the species composition and vegetation structure within these forests.

The long-interval fire regime was characterized by an infrequent, lethal, high intensity fire that consumed both the understory and overstory as it moved across a landscape. Stand replacing fire regimes result in a short term, catastrophic effect on stand conditions, in contrast to the persistent, yet less obvious effects of the short-interval fire regime. The result of this impact was to set the stand back to an early successional stage and release plant species stimulated by severe fire events.

Much of the Clearwater Valley was influenced by the "mixed severity" fire regime. That is, depending on site conditions or position in the landscape, both non-lethal and lethal fires could occur within a mosaic of diverse stand conditions. This was typically common through the transitional portion of the environmental gradient where the lower elevation, drier sites are dominated by non-lethal fire regimes and the higher elevation, more moist sites were dominated by the lethal fire regime.

Human-induced changes and/or impacts have functionally suppressed, eliminated or changed many of the historical disturbance regimes throughout North America. The result has been the loss of many native ecosystems and their corresponding biodiversity. In the Clearwater Valley, the primary influence in this regard has been the suppression of fire for nearly 100 years as well as past logging that has changed the historical structure of many forest stands. Fire suppression programs have had profound effects on many ecological communities and ecosystem processes, but have the greatest influence in areas that historically supported the short-interval fire regime at the lower elevations of the Clearwater Valley.

Historical Forest Conditions

Historical forest conditions are best described through the identification of the types of forest that occurred on different ecological sites. Ecological sites are areas whose abiotic conditions (soils, temperature, moisture availability) are similar, allowing each type of site to support similar compositions of plants. One type of classification of ecological sites, widely used in the west is termed habitat types (Pfister et al. 1977). As mentioned, Figure 10 depicts a map of the habitat types of the Clearwater Valley.

A description of the historical conditions for each grouping of forest habitat types in the Valley is presented in Appendix 1. This review reveals that the warmer and dryer habitat types in the Valley historically supported ponderosa pine maintained by frequent understory fires. Habitat types with a higher level of moisture but still of the warm category tended to be influenced by mixed severity fire regimes. Where these types occurred near the Valley bottom and low elevations, fires were fairly frequent, and the composition of the stands was dominated by ponderosa pine, larch, and a few Douglas fir. Where these types occurred at higher elevations, in conjunction with cooler and moister types, fires were less frequent, ponderosa pine dropped out of dominance, and Douglas fir became a larger component of the stand. Many of these stands also maintained some lodgepole pine. The cool and moist habitat types had longer fire return intervals, and while a mixed severity fire regime occurred, it was characterized by more stand replacing fire patches (Figure 11) than understory burns.

Characterization of historical forest conditions in the Valley is important for setting desired ecosystem restoration goals, addressing fuel mitigation objectives, and understanding fire dynamics. A more complete analysis of historical conditions is recommended.

Figure 11. Fire was an important historical disturbance in the Clearwater Valley, and its past role in shaping forest ecosystem diversity is important to understand to properly classify and characterize the forests of the Valley.

Forest Productivity

The Clearwater Valley contains the diversity of forest habitat types described above, which varied in their potential productivity. Higher, colder sites have generally lower productivity, expressed in terms of potential timber production, than lower, warmer sites. Moister sites tend to have higher productivity than drier sites. Warm and cool, moist sites represent the most productive sites in the Valley, while warm and cool, dry sites have lower productivity. The soils underlying a site also influence productivity, as soils influence the nutrient availability as well as the water holding capabilities of the site. Figure 12 maps the expected forest productivity for sites within the Clearwater Valley based on soils and habitat type information. Most of the Clearwater Valley has relatively high productivity for trees.

Existing Forest Evaluation

As indicated above, the Clearwater Valley contains substantial areas of forest with high ecological integrity. However, existing conditions in the Valley also support a substantial amount of area where forest conditions are at risk from unprecedented catastrophic fire, and insect and disease risk outside of what occurred historically. In addition, some of the forest ecosystems that occurred historically in the Valley presently occur in very small amounts relative to their historical occurrences. Old growth forests are a concern throughout forest ecosystems in the lower 48 states. Old growth forests in the Clearwater Valley should be maintained. Areas of old growth for different forest types can be determined from the cover type map (Figure 8) and the tree size and canopy coverage map (Figure 9). For public lands (USFS and MT DNRC), existing stand information was used to identify areas dominated by large trees occurring on public lands, and is depicted in Figure 13. Additional analyses should be conducted to identify stands that contain adequate structure to qualify for old growth status.

Figures 14-16 present ecosystem diversity matrices that identify the various forest ecosystems that occurred in the Valley historically, their estimated historical amounts, and their estimated representation under current conditions. Estimates of current representation were made from available information, but should be determined more accurately based on more detailed analysis of stand data and mapping. This analysis should also determine a more accurate comparison of current conditions relative to historical conditions. Such analyses would provide a scientific basis for planning of future desired forest conditions in the Valley, and would also provide information on potential short and long term production of forest products.

<u>Wildlife and Fish Resources</u>

As mentioned, the Clearwater Valley has a high conservation value for its nearly complete component of native fish and wildlife. A number of species occurring in the Valley have national significance as indicated by their listing under the Endangered Species Act (grizzly bear, gray wolves, Canada lynx, bald eagle, bull trout). In addition, the westslope cutthroat trout is a species of concern for both MT FW&P and the USFS. Other species have tremendous local value for either hunting, fishing, wildlife viewing, or aesthetic reasons including big game species (elk, moose, mule deer, white-tailed deer, black bear), small game species (ruffed grouse, blue grouse, spruce grouse, snowshoe hare), carnivores (marten, cougar, fisher, wolverine, coyote, mink) and many other species of birds (e.g., common loon, golden eagle, sandhill crane, waterfowl). Maintaining the status of these species in the Valley is an important consideration for a land use plan, and one of the significant challenges for the plan. Species of concern (excluding species listed under the Federal Endangered Species Act) that can occur in the Clearwater Valley as identified by the MT Natural Heritage Program include: wolverine, fisher, northern leopard frog, white-tailed ptarmigan, black-backed woodpecker, olive-sided flycatcher, northern hawk owl, Lewis' woodpecker, harlequin duck, common loon, great gray owl, and northern goshawk.

Native fish occurring in the Clearwater Valley include bull trout, westslope cutthroat trout, northern pike minnow, peamouth, mountain whitefish, longnose sucker, and redside shiner (Berg, 2005). Additional native species of stream fish, including slimy sculpins and a taxonomically unresolved sculpin, are also known to occur (D. Schmetterling MT FW&P) but were not included in the Berg (2005) report. Non-native species include rainbow trout, brown trout, yellow perch, northern pike, largemouth bass, kokanee, brook trout, and pumpkinseed. Non-native species, especially northern pike, are causing significant impacts to native species. The only major lakes that have not been invaded by northern pike are Placid, Clearwater, Rainy, and Marshall (Berg 2005).

Grizzly Bear

Species listed under the Endangered Species Act are particularly important to factor into land use plans, as their status is important not only locally but nationally. The grizzly bear was listed as a threatened species in the lower 48 states by the USFWS in 1975. The Clearwater Valley is important for grizzly bears (Figure 17) in several ways. A Recovery Plan for the grizzly bear was prepared in 1982 and updated in 1993 (USFWS 1993). This plan identified grizzly bear recovery zones, one of which includes the northern part of the Clearwater Valley. In addition, the Clearwater Valley is recognized as providing critical linkage zones for grizzly bears moving within the Crown of the Continent ecoregion as well as to other adjoining ecoregions (Sandstrom 1996, Servheen 2001). Radio telemetry work has been conducted on grizzly bears in the Clearwater Valley. Movement information on 3 bears fitted with GPS telemetry collars was provided by Chris Servheen (USFWS). In addition, important grizzly bear movement areas were identified by Jamie Jonkel (MT FW&P) based on his work with this species in the area. These data, as well as data collected by the on-going grizzly bear DNA study clearly indicate grizzly bear use of most of the

Figure 17. The Clearwater Valley contains nearly a full complement of its native biodiversity and is particularly noted for its diversity of large carnivores, including grizzly bears.

Clearwater Valley, as well as its critical value in providing grizzly bear population linkages. Figure 18 displays important habitat areas and linkage zones in the Valley for grizzly bears. Edwards (2006) provided additional discussion of the importance of the Clearwater Valley to grizzly bears.

Canada Lynx

The Canada lynx was listed as a Threatened species under the Endangered Species Act in 2000 (Federal Register Vol. 65(58):16051-16086). Intensive snow track and genetic detection surveys conducted by MT State wildlife managers and Federal researchers indicate that the Seeley Lake area supports one of the highest densities of lynx in the contiguous United States (Squires et al. 2004, Squires et al. 2006, B. Giddings, MFWP, personal communication). In addition, the Seeley Lake population may represent one of the southernmost native breeding populations of lynx in the country (Figure 19). Historically, lynx ranged as far south as the Colorado Rockies although native populations are thought to have disappeared from much of Colorado, Wyoming, and southwest Montana by the 1980's (Ruggiero et al. 2000). The Seeley Lake lynx population may be critical to lynx recovery nationally by serving as a source for animals dispersing into formally occupied southern habitats. In addition to supporting a resident lynx population, the area facilitates lynx movements between the two wilderness areas that border the east and west sides of the valley.

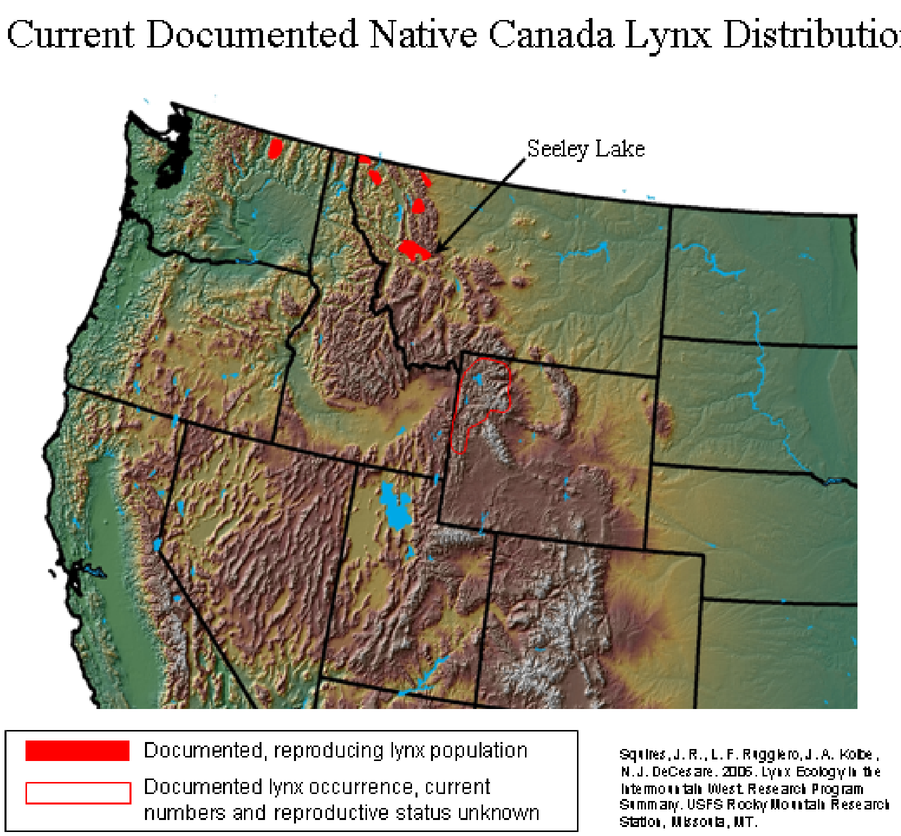

Figure 19. Current documented native Canada lynx distributions within the lower 48 states.

In 1998, scientists from the USFS Rocky Mountain Research Station (RMRS) began conducting intensive lynx research in the Clearwater Valley. Since that time they have deployed radio and GPS collars on over 80 lynx in the valley. RMRS researchers have since acquired the most detailed lynx movement, habitat use, and demographic data on the species collected to date in the contiguous United States. Lynx in the Seeley Lake population prey almost exclusively on snowshoe hares even though hare densities here are low relative to more northern areas (Squires and Ruggiero in press). Lynx used mid-elevation forested areas in the valley selecting strongly for moist forest stands with thick vegetative cover during all seasons. During winter and the spring denning season, older stands with complex midstories were especially important. Lynx avoided drier and open stand types during all seasons. Lynx in the Clearwater Valley had relatively small litters and kitten survival was low. Starvation, predation by mountain lions, and trapping and shooting by humans were the primary causes of lynx mortality (Squires et al. 2006)

Although lynx appear to tolerate moderate levels of human disturbance (Kolbe and Squires in press, Kolbe et al. in press), habitat modifications associated with forest management and residential development may negatively affect local lynx populations. Specifically, thinning of forest stands as a forestry treatment or to reduce fuels in the wildland-urban interface clearly reduces horizontal vegetative cover shown to be important to lynx and hares during all seasons. Lynx appear reluctant to use significant openings and residential development may create barriers to lynx movements. Similarly, increases in residential development in lynx habitat has the potential to significantly increase the incidence of human caused lynx mortality.

To define the current range of lynx in the Clearwater Valley, the USFS RMRS lynx research project provided a 90% kernel isopleth of 2800 high quality lynx telemetry locations from 75 lynx collected between 1998 and 2006. The map of this lynx distribution is shown in Figure 20.

Bald Eagles

The bald eagle is currently a threatened species under the Endangered Species Act, although it has shown strong recovery since its listing and is proposed for delisting. This species as well as the golden eagle are also covered by Bald and Golden eagle Protection Act. Several bald eagle nests have been occupied in recent years near Seeley, Placid, and Salmon lakes, and additional nesting sites within the Valley are likely. Specific nest sites have not been mapped for this assessment, but recognition of nesting sites and appropriate limitation of activities in adjacent areas is an important consideration for on-site management decisions.

Common Loon

The common loon is a species of special interest, and one of particular value to many residents. Loons are yearly residents of the Valley, and recently have nested on Rainy, Alva, Seeley, and Placid lakes. In addition, loons successfully nested on Summit Lake this past year (Scott Tomson, USFS, personal communication). The Montana Loon Society along with MT FW&P and the USFS monitor loons, and also hire a loon ranger to help tract their success and educate the public about their needs.

Elk, Mule Deer, White-tailed Deer and Moose

Elk, deer (mule and white-tailed) and to a lesser extent, moose, are important big game animals in the Valley. Figure 21 displays the various areas utilized seasonally by elk in the Valley, and the linkage zones used by all of these species for seasonal movements in the Valley. The Blackfoot-Clearwater Wildlife Management Area is considered crucial winter habitat for elk as well as mule deer and white-tailed deer. Moose are known to winter in central area of the Clearwater Valley, although specific areas are not well enough documented to include in a map. Several higher elevation areas have been identified as crucial summer areas for elk. Maintaining crucial winter and summer areas and the ability for elk (and other species) to move among these areas is a highly desired objective of the local community and an important planning consideration. Additional development in critical linkage zones could cause disruption of migration routes that could keep elk from accessing either crucial winter or summer habitat, requiring additional movement to reach summer or winter areas reducing their fitness, and result in a reduction in their numbers and shifts in their distribution in the Valley.

Linkage Zones

One of the most important but most difficult to document of wildlife needs is that of linkage zones. These areas provide for movement of animals, whether it is the regular seasonal movements of species such as deer and elk, mating movements of species such as grizzly and black bears, or dispersal movements of species such as grizzly bears, Canada lynx, wolverines, fisher, and many others. These latter movements often determine whether population of a species, such as wolverines or grizzly bears, occurring in an area such as the Mission Mountains maintains its population connectivity with other populations, or becomes isolated. A large body of scientific literature has been produced in the past 15 years addressing concerns with isolated populations (e.g., see Hanski and Gilpin 1994, Gutzwiller 2002, Beissinger and McCullough 2002) Isolated populations are more susceptible to population crashes where they lack demographic support from neighboring populations. Breeding patterns may be interrupted resulting in reduced fitness of individuals. Long term isolation can lead to genetic drifts or bottlenecks that can threaten population fitness. Therefore, maintaining linkage zones is one of the more pressing current needs in large scale conservation planning. As mentioned previously, the Clearwater Valley is known to be a critical area for providing linkage of a number of wildlife populations both within the Crown of the Continent ecogion, and to other adjacent ecoregions. Linkage zones can be disrupted by a variety of human activities including the presence of human residences or businesses, and the presence of major highways or other barriers to movements. For example, historical telemetry and observational information on elk identified a north-south linkage zone on the lower elevations on the east side of the Valley, east and south of Seeley Lake. However, with the increase in residential development, primarily in the Double Arrow Ranch area, this elk movement zone appears to have shifted further to the east. While elk have been able to adjust their movements around this development, future developments could further shift linkage zones, and at some point cause a disruption in the movement of this or other species.

Edwards (2006) summarized the findings of two years of crossing surveys conducted by Northwest Connections (www.northwestconnections.org) along five 100m sections of Highway 83 in the Valley. These five areas were located as follows:

- Between mileposts 29 and 31.5 (Clearwater-Swan divide)
- Between mileposts 26 and 28 (Clearwater Loop Road to Lake Alva)
- Between mileposts 23.7 and 24.7 (Lake Alva to Lake Inez)
- Between mileposts 20.6 and 21.2 (Findell Creek south), and
- Between mileposts 17 and 18.2 (Seeley Lake Ranger Station).

The Clearwater-Swan divide and Seeley Lake Ranger Station sections had tracks from the highest number of carnivore species. In all, these crossings included identified tracks of Canada lynx, bobcat, mountain lion, red fox, coyote, skunk, pine marten, and ermine.

The report prepared by the Western Transportation Institute (Huijser et al. 2006), discussed animal-vehicle collisions along Highway 83. While areas with high rates of collisions and important crossing areas may not be exactly the same (good crossing areas may not necessarily result in high rates of collisions, and thus be missed as collision areas, areas with high rates of collision may preclude successful crossings, and high rates of collisions result from both high utilization by wildlife and high traffic rates, so areas with less traffic will have lower rates relative to their use as crossings) there is generally a direct relationship between usage by animals and areas where they are hit by vehicles (animals have to be on a specific stretch of highway to be hit). While most of the animal vehicle collisions reported by Huijser et al. (2006) involved deer (94.5% white-tailed deer, 2.2% mule deer), other species were also noted (black bear, elk, mountain lion, coyote, and skunk) and while some species may differ in their selection of crossing areas, most species tend to select many of the same characteristics and cross in similar areas. For example, lakes can provide barriers to terrestrial species, concentrating crossings in zones between lakes. Information on crossing areas and species reported to use crossings was collected by Huijser et al. (2006) through review of maps with agency biologists and others working with wildlife in these areas. The Huijser et al. (2006) report identified a number of areas along Highway 83 where high rates of collisions occurred. These areas were incorporated into linkage zone maps.

Figure 22 displays identified wildlife linkage zones utilized by a number of species including elk, black bear, cougar, lynx (outside of the specified lynx linkage zone), deer, and others. This map was prepared from the information discussed above, elk movement information reported previously, and based on input and review by the agency biologists discussed previously. Many of the seasonal movements of species such as elk occur north-south in the Valley, with important movement areas occurring on the east side of the Valley between areas north of Seeley Lake and the Game Range, a movement area on the west side of Seeley Lake and Salmon Lake, crossing Owl Creek east of Placid Lake, and a general movement area west of Placid Lake curving into the Game Range above Blanchard Creek. A number of important east-west linkage zones have also been identified and are shown in Figure 22.

Bull Trout and West Slope Cutthroat Trout

Bull trout and westslope cutthroat trout are native salmonids that were once widely distributed throughout the northern Rocky Mountains. Bull trout was listed as a threatened species by the

USFWS in 1998. Westslope cutthroat trout have been petitioned for listing in parts of their range but are deemed unwarranted for listing at present. Westslope cutthroat trout still occur in approximately 60% of stream habitat in the native range, but many populations have been compromised by hybridization and subsequent genetic introgression with introduced (non-native) rainbow trout (Shepard et al., 2005). Westslope cutthroat trout are a "species of special concern" with MT FWP and a "sensitive species" in Region 1 of the USFS.

Both species exhibit a range of life history types characterized principally by expression of, or lack of, migratory behavior. Populations with migratory life histories typically spawn and rear offspring in smaller tributary streams. Juveniles rear in natal streams for one to several years. Older juveniles may migrate to larger rivers (fluvial life history) or lakes (adfluvial life history) to mature. At maturation, adults return to the tributaries to spawn (Figure 23) and may make subsequent migrations to and from lakes and rivers with spawning in multiple years. Some individuals or populations may stay in the natal or nearby streams throughout life and represent a "resident" life history. Migratory life histories tend to mature at larger sizes and can support larger more resilient populations because of increased fecundity. Migratory forms, however, also face greater risks by moving through environments supporting numerous predators and extreme environmental conditions that vary from year to year. The varied expression of life history represents an important component of biological diversity that contributes to the stability and persistence of populations in dynamic environments, such as the mountain streams of western Montana. The Clearwater River basin with the network of large lakes is unique in the Blackfoot and Upper Clark Fork basins because it supports all three life history forms. Because climate change and other environmental disruptions may influence lake, river, and headwater tributary systems in different ways, maintenance of this diversity may be an important hedge for long-term species and fisheries conservation. (e.g. Hilborn et al. 2005)

Figure 23. Bull trout on a redd in Morrell Creek in the Clearwater Valley. MT FW&P photo.

The Clearwater Valley supports several bull trout populations (Figure 24), but the status varies across the occupied streams Bull trout have the lowest temperature tolerances of any native fish in the Clearwater basin, and spawning and early rearing occur principally in larger, high elevation streams or other sites heavily influenced by ground water. Maintaining bull trout populations requires maintaining relatively large stream areas of cold water and limited sediment loads. Weaker populations may be threatened by invasion of, and hybridization with, non-native brook trout. Non-native brown trout may also directly compete with or prey on bull trout in nursery areas and migratory corridors. Populations can persist as isolated resident populations if the isolated stream habitats are extensive and in good condition, but migratory life histories and movement among populations appears to be important for long-term persistence of the species in many areas. Threats include damage to streams or stream banks, removal of shade over critical sections of streams, impacts from roads including sediment runoff, oil, salt or other chemical runoff, fragmentation of habitats through physical barriers to migration or extremely low flows, invasion of brook trout, brown trout or other species that may compete with or prey on juvenile bull trout, and the degradation of lakes that serve as important rearing areas. Developments near bull trout streams may cause impacts to this species through impacts to stream channels, flows, or water quality. Changes to the density of riparian vegetation and forest canopies surrounding streams and reduced flows because of water development can lead to substantial increases in stream temperatures. Increased nutrient loading in lakes can result in eutrophication and oxygen depletion that reduces or eliminates suitable rearing habitat for migratory forms.

On-going research by MT FW&P and the University of Montana has identified three primary areas currently utilized by migratory bull trout. Morrell Creek, and the West Fork and East Fork Clearwater rivers support significant populations of bull trout that move from natal habitats in these headwaters to mature in the major lakes. Historically, some fish may have moved to the Blackfoot River as well. The entire mainstem Clearwater River above Salmon Lake serves as an important migratory corridor and also supports some spawning and seasonal rearing. Bull trout movements are currently limited by two dams between Seeley Lake and Lake Inez. Biologists are actively trapping and passing migratory adults at one of these sites. Because these dams support local wetlands or maintain lake levels and may also limit the invasion of some nonnative species, a permanent solution restoring complete bull trout passage but retaining some of the benefits of the dams is still being discussed. Remnant bull trout populations still occur in Blind Canyon Creek, Boles Creek, Marshal Creek and Marshall Lake and Inez/Camp Creeks. Bull trout now appear to be locally extinct or at extremely low numbers in Trail , Deer, and Blanchard creeks. Predation by introduced northern pike which are now abundant in Salmon, Seeley and Inez lakes may have an important influence on bull trout (Berg 2005) and may contribute to the decline and even extinction of weaker populations. Long-term conservation of bull trout in the Clearwater will depend on the maintenance of the core populations. Restoration and maintenance of high quality habitats and/or open migration corridors for remnant and historically important streams could extend the productivity and long-term conservation prospects.

The westslope cutthroat trout is more widely distributed than bull trout and occurs throughout the lakes, river, and streams of the Clearwater Valley (Figure 25). Cutthroat spawn and rear in a wider range of tributary streams than bull trout and may commonly persist in isolated resident populations. Migratory cutthroat support a valuable sport fishery in the lakes and larger mainstem rivers and streams, but natural populations have been at low numbers in recent years. MT FWP periodically stocks hatchery fish to supplement the lake fisheries. This species, while not as sensitive as bull trout to changes in stream temperatures or habitat condition, is threatened by the same factors as bull trout. The combination of habitat degradation, invasive species, and migration barriers has contributed to substantial declines in abundance and distribution across the species range. Hybridization with introduced rainbow trout is a particular concern. Because hybrids are fertile, hybrid swarms (every individual is a hybrid) often result representing extinction of the local genetic resource. Hybrids still exhibit many of the ecological characteristics of native cutthroat trout and often support important fisheries. For these reasons conservation management of westslope cutthroat trout often attempts to conserve the evolutionary legacy of remnant, genetically pure populations above intentional barriers (i.e. preempt invasion of hybrid or rainbow trout) as well as the ecological value of larger migratory (and likely hybridized) forms in streams with full access to good quality river and lake habitats.

Amphibians

Several native amphibians, including long-toed salamander, Rocky Mountain tailed frog, Columbia spotted frog, and western toad, are known to occur in the Clearwater Valley. The Pacific tree frog occurs lower in the Blackfoot River basin and may occur here as well. The northern leopard frog is not recorded from the Clearwater valley, but the historic range is believed to include surrounding waters of the Blackfoot and Swan river basins (Werner et al. 2004). Northern leopard frogs have declined dramatically throughout the native range west of the continental divide and are now a species of special concern for both state and federal agencies. The extensive wetland areas of Clearwater Valley could be important habitat for many amphibians including those sensitive to environmental change, but further inventory will be needed to document important populations and habitats.

Aquatic Invertebrates

Information on aquatic invertebrates was provided by Dave Stagliano, MT Natural Heritage Program. The available information was for both the Clearwater River and the Swan River. Information is therefore provided here that includes reference to both the Clearwater and Swan Valleys. Aquatic invertebrates include a wide diversity of species, many of which are sensitive to changes in their environment. Unfortunately, little attention has been paid to inventory or monitoring of these species. The prevailing thought is that evaluating other target species (e.g. bull trout) will protect these lesser invertebrates in an “umbrella-style” of conservation, but this is not always the case with macroinvertebrates specialized to unique habitat conditions. Consequently, many of the dragonfly and damselfly species on the MT Species of Concern List are likely to occur in streams or wetlands of the Clearwater Valley, but lack of targeted surveys has kept their specific occurrences from being recorded.

Reaches of the main-stem Swan and Clearwater Rivers retain floodplain forests, a high degree of intact channel meandering, and strong groundwater interaction. It is safe to assume that naturally functioning stream reaches will contain the expected aquatic community, including the myriad species of invertebrates that exist within this medium-sized, valley stream type. The Small Mountain Stream Macroinvertebrate Community (Table 1) expected to occur in these streams include a diverse community of coldwater stenotherms and consists of members of the Pristine Mountain Stream (#58) and the Medium Mountain Stream Assemblage (#90) (MT Natural Heritage Database). The community indicator species are characterized by intolerant, large cobble and boulder, main channel, fast-current mayfly, stonefly and caddis species, *Baetis bicaudatus*, *Caudetella spp*., *Drunella spp., Epeorus spp, Cinygmula, Zapada spp. Megarcys, Doroneuria, Sweltsa, Paraperla, Micrasema, Neothremma, Parapsyche, Neophylax sp*., numerous *Rhyacophila sp*. groups, and the cold-water dipterans*, Rhabdomastix, Bibiocephela, and Glutops.* As the mountain streams proceed downstream and begin to warm (>15 °C), a dominance shift occurs to the Medium Mountain Stream Invertebrate Assemblage. Populations of the western pearlshell mussel have been reported from this stream type (Stagliano 2005). These community types have the potential to contain species of concern (Table 1), but as a distinct community, they represent a highly specialized group of organisms that are intolerant to disturbances within the watershed and will quickly disappear after logging or other riparian zone disruptions (i.e. housing development, cattle) cause any increased water temperatures to occur.

The lack of specific information on aquatic invertebrates is noted here. For example, a population of western pearlshell mussel was located in 2006 in the Clearwater River north of Seeley Lake (Dave Stagliano, MT Natural Heritage Program, personal communication) through recreational use of the area by a knowledgeable individual. This population appeared to be doing well. This reveals the need to conduct comprehensive invertebrate surveys in aquatic ecosystems of the Valley, including targeted wetlands, rivers, streams, and ponds.

<u>Plant Resources</u>

The Clearwater Valley is likely habitat for a number of plant species of concern. However, as with the aquatic invertebrates, available descriptions of the plant species of concern combined both the Clearwater and the Swan Valleys, so this information is presented in a combined form in this assessment, noting information specific to the Clearwater Valley were possible. The following is a summary of the vascular plant species of concern in the Clearwater and Swan Valleys (Seeley-Swan Valley) provided by Scott Mincemoyer (MT Natural Heritage Program).

The Seeley-Swan Valley supports numerous occurrences of globally rare and state rare vascular plant species, including almost 100 occurrences of water howellia (*Howellia aquatilis*), a federally threatened species. Currently, the area is known to support a total of 165 individual occurrences of 16 different Montana vascular plant Species of Concern (MTNHP 2006). This total includes 4 globally rare species and a dozen state rare vascular plants. Occurrences of these species of concern are known from federal, state and private ownerships in the area. Water howellia, an endemic species of the Pacific Northwest that is listed as a threatened species under the US Endangered Species Act, is found nowhere else in Montana except the Seeley-Swan Valley. The valley is known to support over half of the total range-wide occurrences of the species (Mincemoyer 2005). The Seeley-Swan (and Blackfoot River Corridor) also supports Howell's gumweed which is known only from this area in Montana and one other area in Idaho.

Plant Species of Concern currently known from the Seeley-Swan Valley:
Bidens beckii (water-marigold)
Botrychium crenulatum (wavy moonwort)
Botrychium montanum (mountain moonwort)
Brasenia scheberi (watershield)
Carex rostrata (beaked sedge)
Drosera anglica (English sundew)
Dryopteris cristata (Buckler fern)
Grindelia howellii (Howell's gumweed)
Howellia aquatilis (water howellia)
Lycopodium inundatum (northern bog clubmoss)
Nymphaea tetragona (pygmy water-lily)
Ophioglossum pusillum (adder's tongue)
Potamogeton obtusifolius (blunt-leaved pondweed)
Scheuchzeria palustris (pod grass)
Scirpus subterminalis (water bulrush)
Utricularia intermedia (flat-leaved bladderwort)

For additional information on these Species of Concern see the Rare Plant Field Guide available at: www.mtnhp.org

<u>Exotic Species</u>

The Clearwater Valley has many relatively intact natural ecosystems, with low levels of invasion by exotic species in terrestrial systems and varied levels of invasion by exotic species in aquatic systems. The Valley does support sizable areas supporting invasive weeds. The primary weeds that have invaded the valley are spotted knapweed, Canada thistle, and oxeye daisy. Other invasive exotics that are present but in smaller distributions include yellow and dalmation toadflax, hounds tongue, yellowflag iris, leafy spurge, St. Johnswort, orange hawkweed, and sulfur cinquefoil. Other invasive exotics occur in the Valley and threaten ecosystem integrity but have not yet been officially identified as noxious weeds, such as cheatgrass. No current comprehensive map exists of the distribution of exotic weeds in the Valley, with the exception of a map of weed locations along county roads, and mapping of yellowflag iris distribution along the lower Clearwater River. A number of homeowner associations have on-going weed control efforts, with levels of weed invasion quite variable across the various housing developments in the Valley. The USFS, MT FW&P, and MT DNRC all are concerned with invasive weeds, but many weeds still exist, particularly on state DNRC

lands. Plum Creek Timber Company controls weeds where they threaten to spread to neighboring lands, but have major weed infestations over many of their lands.

In addition to exotic plant species, several species of exotic fish are influencing the relationships of fish populations. in a number of locations. Northern pike, yellow perch, largemouth bass, brown trout, brook trout, and other species have been introduced into the Valley. Exotic species are particularly important in the lakes and may dominate the fish community in several of them. Predation by northern pike, for example, is seen as the most important factor in the decline of native species from Inez, Seeley and Salmon lakes (Berg 2005). Management of exotic fishes reflects a difficult compromise. Most were introduced, legally and illegally, because of their potential to support sport fishing opportunities. Exotic species like brown trout, rainbow trout, and kokanee salmon now support economically important and popular fisheries, in addition to that for native cutthroat trout and historically for bull trout. Most spawning and rearing habitat for the exotic fishes tends to be lower in the rivers or streams than for native bull trout and cutthroat trout.

Introduced parasites may also influence fish populations in the Clearwater River basin. Whirling disease is caused by a parasite and is known to kill juvenile salmonids. While most of the research has focused on cutthroat and rainbow trout, there is also evidence that recent declines in the mountain whitefish populations in the middle Blackfoot River basin are related to whirling disease. University of Montana and MT FWP are currently investigating this relationship. Sentinel cages were present in the Clearwater basin in 2007 to test for whirling disease, but those data are not available at this time.

Threats to Ecological Values

The Clearwater Valley clearly supports a high quality environment with abundant and clean water, high quality streams, diverse and moderately intact forest ecosystems, and nearly a full complement of native wildlife with good abundance of many desirable species. However, various threats to these ecological values exist. The greatest risk to the ecology of the Valley is the potential for substantial conversion of existing land uses to other uses, specifically the risk of substantial new development of residential or commercial activities within the Valley. Such conversions would result in:

- Reduction in amounts and integrity of natural forest, wetland, and aquatic ecosystems,
- Reduction in available habitat for many native species,
- Disruption of linkage zones for movements of some species by blocking movement areas through developments or by the increasing the level of use of roads such as Highway 83,
- Increased direct pressure on wildlife species due to such factors as higher numbers of homes where species such as bears become problems, increases in numbers of dogs and cats affecting native species, and increases in vehicle use of highways resulting in greater numbers of road kill or increased barriers to movements,
- Increased spread of exotic weeds through increases in traffic, roadways and their maintenance, and construction activities.
- Continued or expanded encroachment on riparian areas and disruption of stream channel and hydrologic processes important for maintenance of aquatic habitats
- Increased development of ground water and surface water with potential diversion and reduction of stream flows in critical fish rearing or migration habitats.
- Increased nutrient loading to streams and lakes accelerating eutrophication and degradation of habitat, recreational and aesthetic values, and domestic water supples

While some continued development is accepted as important and necessary, planning of appropriate amounts and locations is essential if ecological values are to be maintained.

Wildfire could substantially change the Valley. While stand-replacing fires historically occurred in some of the Valley, the current condition of some of the area, particularly at lower elevations, could produce fire intensities that are dramatically different from historical fire regimes. This is a threat to ecosystem integrity in a number of forest and riparian/wetland ecosystems, and could lead to a reduction in water quality in many aquatic ecosystems as well. Current efforts to address ecosystem restoration and fuel thinning programs are designed to mitigate this concern, but the amount of treatment needed will keep this threat at a significant level for some time to come.

Water quality in the Valley, and the related health of aquatic ecosystems and habitat of aquatic species could be impacted by a number of factors. Lack of water treatment capabilities in the growing town of Seeley Lake threatens water quality from inadequate septic systems in too high densities. Roads and their maintenance pose a risk to water quality. Roads, particularly poorly maintained gravel or dirt roads, contribute a disproportionate amount of sediments and other runoff into wetlands, streams, and rivers. Stream crossing of roads may require culverts that if not planned correctly can block fish passage. Carefully planning where new roads may be needed, maintaining the quality of existing roads, and decommissioning unneeded roads are all steps to maintain or reduce risks to water quality and aquatic ecosystems. Increases in human populations in new areas could contribute to a potential degradation of water quality through any of the above reasons if new developments are not properly planned and sited. Although water quality in much, if not most, of the Clearwater basin undoubtedly remains high, water quality for domestic use and other natural resources in some of the more developed sub-watersheds and the lakes is a clear point of concern. The lack of detailed water quality monitoring, clear knowledge of nutrient and sediment sources, and the full implications of further development are important issues for further work.

A relatively new threat is the use of ballast or wave boats. These boats have ballast tanks that are filled to create a large wake for water skiing, wave boarding, or tubing behind these boats. However, these large wakes cause significant damage to lakeshores, add sediment to lakes and rivers, and can flood nests of common loons and other species occurring in shorelines and wetlands bordering lakes.

Spread of exotic species threatens ecosystem integrity and habitat quality for many species. Coordination of control efforts among homeowners' associations, individual landowners, forest industry, and state and federal agencies will be necessary to effectively counter this threat. Developing watershed-wide control strategies and acquiring funding for control will help as well. Finally, educating the public about the risk of exotic species, methods of control, and methods of establishing desired vegetation and habitat conditions that reduce the ability of exotics to spread is an important task.

Climate change is likely to influence aquatic and terrestrial ecosystems in the Clearwater in important ways. General predictions from current climate models are for warmer, wetter winters and warmer, dryer summers throughout the region (Figure 26). Fire seasons are expected to be longer with the potential for more frequent and more extensive severe fire conditions. Snow packs are likely to decline and melt earlier in the year, changing the timing and availability of water for both natural and human systems. Because less water may be stored as snow, stream flows are anticipated to be lower during both runoff and summer low flow periods, potentially aggravating any conflict between human and natural uses of water. In recent years, very low flows in the Clearwater River and some tributaries resulted in stranding and apparently increased mortality of migratory bull trout. Biologists anticipate that both plant and animal communities will respond to climate-driven changes with some species contracting and others expanding their distributions. Recent research with bull trout, for example, suggests that populations will likely contract into the largest and highest (and coldest) stream networks, making the conservation of larger core areas particularly important. In general, however, there is still limited understanding of the full implications of climate change.

Water development and diversion represent a potential conflict between commercial, domestic, and natural resource values. There are more than 1,500 established water rights in the basin, including both surface diversion and groundwater (e.g. domestic wells) (Figure 27). The Seeley Lake Water District is the only commercially developed water system and draws its supply directly from the lake. The Water District has experienced problems in supply in recent years. Further water development with population growth could become important. The Clearwater Basin is presently closed to new surface water development, but domestic groundwater development is not constrained. Surface water diversions for agricultural and other non-domestic uses also impact flows and the connectivity of stream networks important for up- and down-stream migrating fishes. Unscreened diversions have a significant effect through reduced flows, increased temperatures, and entrainment of migrating individuals. MT FWP and the Big Blackfoot Chapter of Trout Unlimited are working with some landowners to mitigate the effects of some diversions, but others remain. Declining summer flows as a result of climate change could exacerbate the problems linked to stream flows and water availability for both human and ecological systems.

Maintaining and increasing forest ecosystem diversity is important to the overall maintenance and enhancement of biodiversity in the Valley, and to continue to provide the diverse habitat needs of the native flora and fauna of the Valley. Because streams and watersheds are tightly linked to riparian and upland forests, forest ecosystem diversity and health will contribute directly to the maintenance of diverse and productive aquatic ecosystems. Conservation and restoration of broad ecological diversity across all systems may be the best hedge possible for the uncertainties of climate change. As noted, some forest ecosystems that occurred historically in the Valley are not well represented at the present time. Fire as a forest process has been largely eliminated, and has impacted the composition, structure, and function of a number of forest ecosystems. Forest management and silvicultural practices that strive to achieve ecosystem restoration objectives on appropriate lands can address this need. Incorporating ecosystem integrity and forest stewardship considerations in fuel thinning and forest harvesting activities could also help to address the need for specific types of desired forest conditions. Developing specific forest ecosystem restoration goals through coordination and planning across ownerships in the Valley is an important additional planning need.

Identifying and maintaining representation of ecosystem diversity of all types in the Valley is important to maintaining ecosystem integrity and biodiversity. In addition to understanding and quantifying needs for forest ecosystem diversity, characterizing, quantifying, and planning for representation of riparian/wetland ecosystems and aquatic ecosystems is also needed. These tasks are beyond the current capabilities of this assessment, but could be accomplished with additional support.

Social Assessment

Recreational Activities

Both residents and visitors of the Clearwater Valley make extensive use of the natural resources in the area. The lakes, are heavily utilized for water sports, fishing, wildlife viewing, and for their scenic attraction. The forests in the Valley support use by large numbers of hunters, hikers, cross-country skiers, snowmobile users, ATV users, vehicle sight-seers, wildlife viewers, campers, huckleberry and mushroom pickers, horseback riders and a variety of other users. Maintaining these recreational opportunities is a very high priority for the residents of the Valley. It is also important to maintaining tourism in the Valley.

Figure 28 depicts the network of roads and snowmobile trails used for motorized vehicle access, ATV's, and snowmobiles. Areas that receive high use by the public for hunting or other off-road recreational activities should also be recognized, but good information on these high use areas was not available for this assessment.

Figure 29 represents streams that support important recreational fisheries in addition to each of the Valley lakes. These waters include areas important for spawning and rearing of both non-native and native migratory fish populations. Although non-native species may be less sensitive to habitat disruption than native species generally, they still require high quality, colder water to maintain productive populations. The areas we identified as important lands for the maintenance of these recreational resources include the mainstem habitats where most fishing and fish production is likely to occur as well as the tributaries that may influence water quality and availability. Identification of the streams supporting recreational fisheries values was based directly on MT FWP in the Integrated Stream Restoration and Native Fish Conservation Strategy for the Blackfoot River Basin updated in 2008 (In preparation).

A desirable feature of the land ownership in the past has been that Plum Creek lands have been open to use by the public. The residents of Seeley Lake have generally been very appreciative of this access. Changes to this access are a significant concern, particularly in areas that have received heavy use in the past. Passage over some roads is administered through cost-share agreements that exist between agencies and private landowners including Plum Creek (Figure 28). However, future access on these and other roads and lands could change with changing land ownership or uses.

Water Quality and Supply

Water quality in the lakes is clearly of central importance to the character and aesthetic values of the Valley. Nutrient enrichment and eutrophication of Seeley Lake is a concern, and further degradation could seriously compromise both human and natural resource values. Little information is currently available to judge the rate of degradation or the capacity for further development.

The town of Seeley Lake draws its water supply directly from the lake. Most other homes and developments rely on pumped ground water. Adequate supplies of domestic water could become an important issue in the future. An extended drought has resulted in extremely low flows in rivers and some streams. Further development of domestic water sources could aggravate those problems and the others already apparent for native fishes. Currently, the Clearwater Basin is closed to further surface water development but not domestic ground water development. Population growth will tax existing natural and human systems while continuing drought and climate change would only exacerbate any problems. Because forest and stream conditions in the basin can strongly influence water quality and yield, maintenance and restoration of healthy watersheds will be important to assure adequate water for both human and natural resource needs in the future. Study of surface and groundwater hydrology, primary water sources and the implications of water development on ground and surface water supplies, alternative storage or source areas, and the long term effects of climate variability also would be a useful element in further land use planning.

<u>Wildfire Risks</u>

Fire, as discussed above, has always been a disturbance element in the Valley. Fire will continue to occur in the forests of the Valley. How it will occur, and the risks it presents to human lives and property are something that can be influenced through management. In 2004, a cooperative planning effort involving all of the fire-control agencies in both the Clearwater and Swan Valleys produced the Seeley/Swan Fire Plan to address concerns about risks from wildfire. This fire plan identified an area of wildland/urban interface (WUI), where wildfire could directly impact human developments and have a significant risk to human lives. An analysis of fuel loadings, coupled with a rating of human densities, identified areas of highest risk within the WUI. The resulting map (Figure 30) depicts this WUI and the weighting of areas for fire hazard risks that incorporate fuel loadings, densities of residences, and the location of escape routes. This map also highlights the concern that significant expansion of the WUI could lead to new areas of significant risk, costs associated with increased requirements for fuel mitigation, and increased challenges and risks to fire control personnel. It would also require a revision to the cooperative fire plan and expansion of the identified areas of fuel mitigation. Costs associated with the expansion of wildland/urban interfaces are an important planning consideration. Costs of fuel reduction within the WUI can range from zero, where value of timber products can pay for the costs of thinning, to over $2,000/acre where no commercial timber products can be produced. In 2004, the Seeley Lake Fuels Mitigation Task Force received over $200,000 in fuel mitigation funds to treat private lands through fuel thinning on a 75% matching basis. It is estimated that this addressed less than 10% of the high risk fuel thinning need on private lands within the existing WUI. As forests grow and mature, fuels will continue to be added, making fuel mitigation an on-going need. Fire suppression costs also increase dramatically outside the WUI. Structure defense and other steps to product human lives and property add significant costs to wildfire control in these areas. Both of these factors mean that expansion of the WUI will come with significant increases in costs associated with fuel mitigation needs and with increased risks to human lives of residents and fire-fighters. Consideration of wildland fire risks and associated costs and fire control challenges need to be included in any future land use planning.

Economic Assessment

The Clearwater Valley has its economic center in the town of Seeley Lake. The economy of the Valley is diverse. The largest single employer is Pyramid Mountain Lumber which employs approximately 150 people. While this is the largest single employer, manufacturing and logging industries together employ less than 25% of the workforce. Besides Pyramid Mountain Lumber, other forest industry employers include independent loggers, trucking companies, and Plum Creek Timber Company, although the number of its employees working in the Valley has decreased substantially in the past 5 years. Other mills in the area that draw resources from the Clearwater Valley include the Plum Creek mill in Columbia Falls, the Stimson Timber Company mill in Bonner, the Smurfit-Stone paper plant in Missoula, and other smaller post and pole and other operations.

While forest products remain an important part of the economy of the Valley, their relative importance has been declining while other sectors have been growing. Tourism, which helps support retail trade, accommodations, and food service in the Valley, has been expanding. New construction and the sale of property are also important and growing sources of employment. An average of approximately 45 new homes has been built in the Valley each year since 1996 (Nicholson, Pathfinder, 9/21/02). Much of this construction has occurred in the Double Arrow Ranch development, the largest subdivision in the Valley. Governments, both county and Federal contribute to the economy, with the school system having approximately 50 on its payroll, the local Ranger District of the USFS supporting a workforce of approximately 45 people, and the Post Office employing several people. A number of home or telecommuting businesses have been established in the Valley. Finally, an increasing number of retirees are residing in the Valley and contributing to the economy.

Recreational amenities in the Seeley Lake area help support recreational-oriented businesses as well as providing considerable tourism. Seeley Lake maintains a number of resorts and motels as well as restaurants and shops that rely for a sizable amount of their business on recreation-related tourism.

The residents of the Valley are concerned about maintaining a healthy and diverse economy. Maintaining a forest products component requires having sufficient amounts of land in active forest management to provide the needed wood or fiber to support this industry. Some residents have expressed concerns that the economy should provide future opportunities for their children to remain and work in the area. Maintaining a diverse economy is important to achieve this objective. Concerns have been expressed that with increases in land and housing costs, that affordable housing may not be available in the future. Future planning must include consideration of such concerns in the plan.

To date, development of homes and cabins in the Valley has been confined to a small percentage of the acreage- approximately 4% of the lands in the Valley. Moreover, about 70% of this development has occurred in the town of Seeley Lake, the adjoining Double Arrow Ranch development, and smaller close-by developments. Much of the rest of the developed land in the Valley is in clusters primarily around lakes including Big Sky Lake, Placid Lake, and

Lake Inez. Thus the Valley contains a pattern of clustered development centered around a rural community, not residential sprawl.

New development in the Valley could help maintain and expand the existing economy, and make new additions to public facilities and infrastructure possible. New developments will also place new demands on local government service. A detailed analysis of economic benefits and costs associated with potential expansion of development is essential before any additional significant development is approved.

Housing

There are over 1731 houses, cabins, or trailers in the Clearwater Valley (Missoula County Data). Approximately 65% of these homes are owned by year-round residents with as much as 35% owned by part-time or vacation residents, based on the 2003 Census. The homes in the Valley are currently clustered in various housing areas. The largest are the Double Arrow Ranch and downtown area, but other neighborhoods include Big Sky Lake, Woodworth Road (Cozy Corner), Placid Lake, Lake Inez, Salmon Lake, Cresent Meadows, Eagle Point Ranches, and three clusters of homes in the Clearwater Junction area. This clustering means that while Seeley Lake has the highest population in the Blackfoot and Swan watersheds, only 8% is owned by individuals, with houses currently occurring on only 4% of the private parcels of land. Approximately half of the land parcels with homes or cabins are owned by local residents based on the mailing locations for tax statements (Nicholson, Pathfinder, 9/21/06).

Additional Assessment Factors

Compilation and consideration of ecological and social objectives identify areas that have high values for fish, wildlife, water quality, ecosystem integrity, or similar concerns. With the exception of fisheries, important recreational lands have not been mapped at this time. Economic objectives are complex, with concerns over maintaining a forest products base and diverse recreational opportunities in the Valley while also accommodating new development and concerns over affordable housing. Identification of sites that may have greater potential or suitability for development is an important part of an assessment. Various factors can contribute to the identification of such sites. Obviously, constraints from ecological and social objectives are important considerations. Similarly, site features such as topography and soils can dictate the feasibility of development. Figure 31 depicts slopes in the Valley that exceed 25%, an upper level for reasonable expectations for residential development. In addition to construction limitations, steeper slopes also complicate road building, increase potential for run-off from roads or construction sites into streams, wetlands, or lakes, and have a higher risk factor for wildfire. Wetland soils or streamside protection zones are also areas that should be avoided, and are depicted in Figure 3. Both of these are factors that can constrain the suitability of an area for certain land uses.

Views enhance a site's desirability for residential development increasing the value of the land for development. At the same time, construction on hillsides may decrease the quality of a viewshed to others with buildings and lighting reducing the quality of the viewshed. Some of these factors can be addressed by specific placement of residences on proposed sites. However, recognition of all of these considerations is important in an assessment of the Valley.

An additional consideration in an assessment is the current infrastructure in the Valley, specifically, the road network, power grid, and phone lines. Figure 32 displays roads and powerlines in the Valley.

In contrast to factors that can constrain the types of management or land use activities that could occur on a site, some sites have features that place them in greater demand for residential or commercial development, and thus would be expected to have higher values for such activities. Sites with views are more marketable than sites without views. Figure 33 depicts areas within the Valley with views of peaks over 8000 feet high in the Swan and Mission Ranges. Figure 34 depicts areas with views of one of the primary lakes (Salmon, Placid, Seeley, Alva, and Inez), although some of these views may not be currently visible because of the presence of tree cover. Sites within 500 feet of permanent water (streams, rivers, and especially lakefront) are depicted in Figure 35. Figure 35 also combines the viewsheds, eliminating any areas on slopes greater than 25%, with areas in close proximity to water. This map displays sites that may have a greater marketability for development for these aesthetic values. Conversely, these sites will also be more visible within the viewshed from other areas of the Valley. Sites with better proximity to power, good roads, and town tend to be more desirable than more remote properties accessible over poorer quality roads, potentially lacking power, and being more removed from other infrastructure (Figure 32).

Landscape Assessment

As discussed in the methods, overlays of GIS maps were made to determine combined locations of various variables. Figure 36 depicts the relative rating of each section of the Valley for its riparian/wetland values. Figure 37 and 38 depict the relative rating of each section of the Valley in terms of its wildlife values (grizzly bear, Canada lynx, elk, and linkage zones added together) for both pixels and sections. Figure 39 depicts the relative rating of fish habitat by section. Figure 40 and 41 depict the total ecological values of pixels and of each section of the Valley. Note that these two figures do not include the large tree variable, as this information was only generated for USFS and MT DNRC lands. Figure 42 and 43 depict the rating based on development constraint considerations (WUI, slope, and proximity to infrastructure). Figure 44 and 45 display the combined relative rating of the above factors, again, without including the large tree variable.

Figure 45 and Appendix 2 provide a summary of information compiled in this assessment. The depiction of this information by section is a relative coarse scale of analysis, but provides a way of identifying possible management or land use factors or concerns associated with each section of the Valley. Included in Appendix 2 is the information by section for large trees, even though these values were not included in the summary scores for each section. Many of these factors or concerns affect the entire section, while some of the factors or concerns may only be a consideration for parts of the section. However, sections with higher scores clearly have additional factors or concerns to be considered in future management or land use plans. The viewshed analyses and proximity to water sources identify sites with potentially greater attraction for residential development. Where these areas or greater attraction are associated with low scores for other factors, potential for future development appears to be greatest. Where these areas of greater attraction also have high scores for concerns, greater conservation conflicts may exist.

ASSESSMENT UPDATES AND REVISION

This assessment compiled the information available as of February 2008. It is expected that additional information will be generated for the Clearwater Valley in the near future. In addition, conditions for a number of variables will change over time, some faster than others. It is recommended that this assessment be reviewed, and if needed, revised, on a regular basis. At least a biennial review is suggested, with updates made to maps as appropriate. A major revision should be planned for at least every 5 years.

Pool on Morrell Creek. MT FW&P Photo.

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APPENDICES

Appendix 1. Description of historical forest conditions by habitat type groups

Warm, Dry Ponderosa Pine, Xeric Douglas-fir Habitat Types

This group of habitat types, (see Figure 9) representing only a small percentage of the fire plan area is at the warm, dry extreme of forest types in the Valley. Typically, these habitat types represent lower timberline conditions and in northwest Montana may occur as low as 2,000 feet in elevation. Upper limits may extend to about 5,400 feet on steep, dry, southerly aspects. Associated geology is quite variable and includes steep, rocky sites to glacially scoured ridge tops and ridge noses to moderately deep glacial till, with drumlins and moraines, to shallow and moderately deep residual soils. Geology and terrain appear to be limiting factors only to the extent of retaining sufficient soil moisture, which is the controlling influence.

Forests on these types were historically comprised of open stands of ponderosa pine. At the upper elevations of this habitat type, scattered Douglas-firs were associated with the pine. The undergrowth vegetation was characterized by grasses (bluebunch wheatgrass, elk sedge and pinegrass) and occasional shrubs (bitterbrush and snowberry). In contrast to other habitat types, all members of the shrub and herb layers occurred as components of the even drier shrub steppe or mountain shrub zones of vegetation. Consequently, this group of habitat types marks the lower transition between forest and non-forest.

These sites are severely limited in their tree-stocking capability and maintain a savannah appearance when fully stocked. Before Euro-American settlement interrupted the normal fire cycle, nearly all stands were likely in a savannah condition with grass-dominated understories. Historically, these sites burned at least every 5 to 25 years. Average densities ranged from 5 to 20 trees per acre. Historical patch sizes were characterized by small openings of less than 5 acres, within 20 to 200 acre stands of low-density trees. Low-intensity short-interval fires would result in few fire-sensitive shrubs, low fuel accumulations, and few tree seedlings and small saplings. Since the early 1900s, attempts to exclude fire have lengthened fire return intervals. Tree seedlings, small saplings, and fire-sensitive shrubs such as bitterbrush, and snowberry, have become more common and thereby have increased understory fuel loadings. When fires do occur, they are often of higher severity and result in conditions that rarely occurred historically.

Warm, Dry Douglas-fir Habitat Types

This group of habitat types represents the warm and dry Douglas-fir/ponderosa pine forests of northwestern Montana and is a relatively small component of the Valley (Figure 9). It characterizes the warm, mild environments of low- to mid-elevation forests but may extend upward to about 5,800 feet on dry, southerly aspects. These sites are typically well drained and vary from fairly deep glacial till associated with drumlins and moraines, to shallow and moderately deep residual soils.

The Douglas-fir habitat types were historically characterized by mixed stands of Douglas-fir and ponderosa pine but at lower elevations, Douglas-fir may have been absent due to fire effects. On moderate elevation sites, ponderosa pine, Douglas-fir and western larch are major seral species with small amounts of lodgepole pine, Engelmann spruce, or subalpine fir present as well. In unlogged stands, ponderosa pine, at low elevations, and western large, at moderate elevations, are usually the larger, older component with Douglas-fir ranging from sapling to mature trees. The undergrowth, if undisturbed, supports mainly rhizomatous shrub and grasses such as common snowberry, mallow, ninebark, pinegrass, or elksedge. Following a disturbance such as fire or logging, a wide variety of other shrubs, herbs, and grasses may be present.

Historically, these sites experienced frequent low-intensity underburns that excluded most Douglas-fir and killed many small ponderosa pines and western larch. Estimates of fire return intervals range from 15 to 45 years. These fires burned extensively throughout the low- to mid-elevation forests, being extinguished only by fall rains or lack of fuel due to previous fires. Under this burning regime, the stands remained open and park-like, consisting of mostly ponderosa pine, western larch and to a lesser degree, Douglas-fir in a variety of age classes. Stand density ranged from about 15 to 30 large overstory trees per acre. Trees often occurred in clumps, with irregular shaped openings among the relatively low density of trees. The potential for destructive wildfire, insect, or disease events was low. Due to their different responses to low-intensity burning, it is likely that shrub cover was less and grass cover was greater than under present conditions

Since Euro-American settlement, fires have become less frequent and stand conditions have changed dramatically, particularly in unmanaged stands. Here, the historical stand of widely spaced ponderosa pine or western larch is often still evident in the overstory as an older stand component. Between the pines, many smaller Douglas-firs and lodgepole pine have become established since the last underburn, which likely occurred in the late 1800s to early 1900s. Stand densities now range from 250 to 600 or higher, trees per acre, creating stressful conditions throughout the tree layer. Now the potential for destructive wildfire, bark beetle, spruce budworm, Douglas-fir tussock moth, dwarf mistletoe, and root rot events is quite high.

Cool, Moist Douglas-fir Habitat Types

Cool moist Douglas-fir sites are common in the Valley and represent the cooler extremes of the Douglas-fir zone (Figure 9). Subalpine fir is usually present on adjacent cooler sites. Cool, moist Douglas-fir sites may extend upwards to about 6,800 feet in elevation but are also common down to about 4,800+ feet in cold air drainages and frost pocket areas. At the lower elevation, nightly cold air patterns may be compensating for soil moisture.

Ponderosa pine is present as a major seral species only at the warmer extremes of these habitat types and is usually absent at the colder extremes. Lodgepole pine may be common on the cooler and more frost-prone sites. Trembling aspen along with lodgepole pine, may dominate early seral stands. In some cases, Douglas-fir is the only tree species capable of growing on the site. The undergrowth is characterized by shade-tolerant species such as mountain maple, mountain ash, and/or huckleberries. Many other disturbance-related species may be present, such as serviceberry, Scouler willow, thimbleberry, and chokeberry. On drier sites, undergrowth vegetation may be sparse with pinegrass and elksedge the most common species.

Historically, these sites likely experienced a mixed regime of both short-interval and long-interval fire regimes. Average short-interval fire regimes may have ranged from 17-102 years while long-interval fire regimes ranged from 150-400 years. Consequently, stand composition can vary from nearly pure stands of single-age lodgepole pine to mixtures of multi-age lodgepole or ponderosa pine with Douglas-fir or pure multi-age stands of Douglas-fir. The extended fire return intervals on some sites increase the opportunities for dwarf mistletoe and bark beetle infestations.

As a result of organized fire suppression, a shift to continuous, multi-story stands of Douglas-fir has greatly increased with the result being less opportunity for the diverse mosaic of vegetative conditions that result from a mixed fire regime. The probability of widespread stand-destroying fire has increased. Lack of fire has also increased the proportion of dense multistoried stands, making them more vulnerable to bark beetle attack and stand-destroying fire. Severity of dwarf mistletoe infection among these stands has also increased. In some areas, the increase has been dramatic, creating stands composed primarily of large witches brooms.

Warm, Moist Douglas-fir Habitat Types

In northwestern Montana, the warm, moist Douglas-fir group of habitat types is usually inter-fingered with the warm, dry Douglas-fir group and occurs wherever more favorable sites exist. This habitat type group is relatively uncommon in the Valley (Figure 9). These sites range in elevation from about 2,000 to 5,800 feet and occur on a variety of slopes and aspects but are most common on northerly aspects, toeslopes, and stream terraces.

In early seral stages, ponderosa pine is common at the warmer extremes, and western larch, Douglas-fir, and lodgepole pine are common on the cooler sites. Douglas-fir and on some sites, Engelmann spruce, dominate later seral stages. Small amounts of subalpine fir are often present on the cooler sites. Douglas-fir is the climax dominant throughout this group, depending on the habitat types.

Huckleberries, mainly dwarf huckleberry, are a major component of most mid to late seral undergrowths and are often accompanied by beargrass, Rocky Mountain maple, common snowberry, twinflower, or occasionally pachistima. A wide variety of early or mid seral shrubs, herbs, and grasses can appear following a major disturbance. For example, ceanothus, Scouler willow, and thimbleberry may develop high coverage following a wildfire. Sitka alder, common brome, and sweet-scented bedstraw can become conspicuous following logging.

Fire scar analysis and structure and composition of older stands suggest that historically, some of these sites experienced predominantly short-interval fires ranging from 17 to 102 years, particularly on the dryer sites. Here the underburns killed the small Douglas-fir and helped prolong the dominance of ponderosa pine, western larch, and even lodgepole pine. But long fire-free intervals also occurred, particularly on the wetter sites, and allowed Douglas-fir to develop dense multilayered overstories. Sites predominantly influenced by long-interval fires would have experienced return intervals ranging from 100 to 250 years. Under these circumstances, stand-destroying wildfire would have been a normal part of the forest cycle.

Historical patch sizes typically ranged from 5 to 50 acres on the short-interval fire sites and from 20 to 200 acres on the long-interval fire sites. Tree densities ranged from 15 to 60 overstory trees per acre, with more in riparian areas.

Warm, Moist Subalpine Fir Habitat Types

This group ranges in elevation from about 5,000 to 7,200 feet but may follow cold air drainages as low as 4,500 feet. This habitat type group is the most common in the Valley (Figure 9). These sites are found in moist, protected areas such as stream terraces, toeslopes, and steep, northerly aspects. Soils are variable and range from loess overlaying glacial tills and lacustrine sediments, to alluvial and outwash deposits on terraces.

Various mixtures of lodgepole pine, western larch, Douglas-fir, and Engelmann spruce comprise the seral tree layers. Any one of these tree species may be dominant, depending on stand history and local site conditions.

Seral shrub layers may be tall and dense, consisting largely of Sitka alder. Lesser amounts of mountain maple, mountain ash, and serviceberry may be present. In late seral and climax stages, menziesia dominates some sites, but usually lower-growing shrubs, such as blue huckleberry and Utah honeysuckle, are more common.

Historically, these sites experienced both short-interval and long-interval severity fires. Estimates of fire frequency range from 38 to 120 years on predominantly short-interval sites and 120-300 on predominantly long-interval sites. Generally, ignitions occurred on adjacent drier sites, and the fire was wind-driven onto these sites. Fire patterns could be small and patchy (100 acres or less) or uniform and extensive (5,000 to 100,000 acres), depending on the burning conditions. Sites influenced by predominantly short-interval (mixed severity) fires resulted in large gaps in the canopy and a mosaic of structures within the stand. The presence of western larch in the canopy is a good indicator of short-interval fires on these sites. Long-interval fires create a mosaic of even-aged structures across stands and are characterized by the presence of both seral and climax species.

Warm, Dry Subalpine Fir Habitat Types

Warm, dry subalpine fir sites are also common in the Valley (Figure 9). They are found at elevations between 4,800 and 7,500 feet and represent the warm, dry extremes of the subalpine fir zone. At their lower limits, these sites occur mainly on steep, northerly or easterly aspects but shift to southerly and westerly aspects at their upper limits. Sites at the lower limits are often controlled by cold air drainage and are strongly interfingered with Douglas-fir sites.

Douglas-fir is the predominant seral tree, and small amounts of ponderosa pine may occur on the warmer sites. At the cool, moist extremes, lodgepole pine and Engelmann spruce may appear in varying amounts but seldom dominate.

Tall, dense shrub layers are common, reflecting the relatively warm nature of these sites. Mountain maple and mountain ash are common in near climax stands, while beargrass, serviceberry and Scouler willow are common components of mid-seral grass and shrub layers. Ceanothus and pinegrass can develop high coverages on severely burned sites in early seral stages. The pinegrass can persist indefinitely on many of these sites, often dominating the herb layer.

The historical fire regime consisted of sites influenced by predominantly short-interval fires ranging from 38 to 71 years and long-interval fires ranging from 100 to 500 years. A mixture of short-interval and long-interval fire patterns can create a mosaic of seral stages at the landscape level. Cyclic bark beetle attacks on dense patches of Douglas-fir, lodgepole pine, and Engelmann spruce can contribute further to this mosaic. The influence of fire regime on the species composition and structure are similar to those exhibited in Warm, Moist Subalpine fir. Historical patch size ranged from 50 to 300 acres on short-interval sites and 5,000 to 100,000 on long-interval sites. However, with a recent history of fire suppression, these sites are losing their mosaic patterns and are becoming more uniform. Unless managed to maintain landscape diversity, these sites will increase their risk of extensive, stand-destroying fire and bark beetle epidemics, providing less opportunities for a mosaic of conditions at the landscape level.

Cool, Dry Subalpine Fir Habitat Types

These sites are common at mid to upper elevations of the subalpine fir zone (Figure 9). They represent cold, dry subalpine sites and range upwards to 7,800 feet in elevation but are also common down to about 4,500 feet in cold frost-pocket areas. At the lower elevations, these sites usually occur in the dry gentle terrain formed by glacial outwash in broad valleys.

At upper elevations, whitebark pine may be present in minor amounts, however in recent years its distribution has decreased as a result of mountain pine beetle and whitepine blister rust. In the moister areas, minor amounts of Engelmann spruce are common. At the cold, dry extremes, which are transitional to non-forested systems, lodgepole pine is the only tree present and is considered to be the climax species. Elsewhere, subalpine fir usually appears in varying amounts as the climax indicator species. Alpine larch occurs on rockslides and talus. Douglas-fir, western larch, and western white pine rarely occur on these ecological sites.

Shrub layers are usually sparse and consist mainly of low-growing huckleberries, such as dwarf huckleberry and whortleberry. The sparse low shrub layer reflects the cool temperatures and short growing seasons inherent to these sites.

Stand conditions predominantly influenced by long-interval fire regimes and mountain pine beetle attacks were the normal historical recycling process. Long-interval fires occurred about every 100 to 300 years. Short-interval fires occurred less often and on a frequency of every 35 to 300 years. Minor fire scars in these stands attest to the nature of these low-intensity, short-interval fires. Fires crept through these stands wherever fine fuels would carry a flame and then flared up wherever fuel concentrated in the denser patches of larger trees, usually those greater than eight inches in diameter. When these trees were killed, the beetle population subsided until another group of trees grew into the vulnerable size class. After each beetle event, the dead trees soon fell and provided an opening for more regeneration. In this manner, a mosaic of tree sizes and densities were maintained, which helped reduce stand uniformity and the widespread destruction of crown fires and bark beetle epidemics.